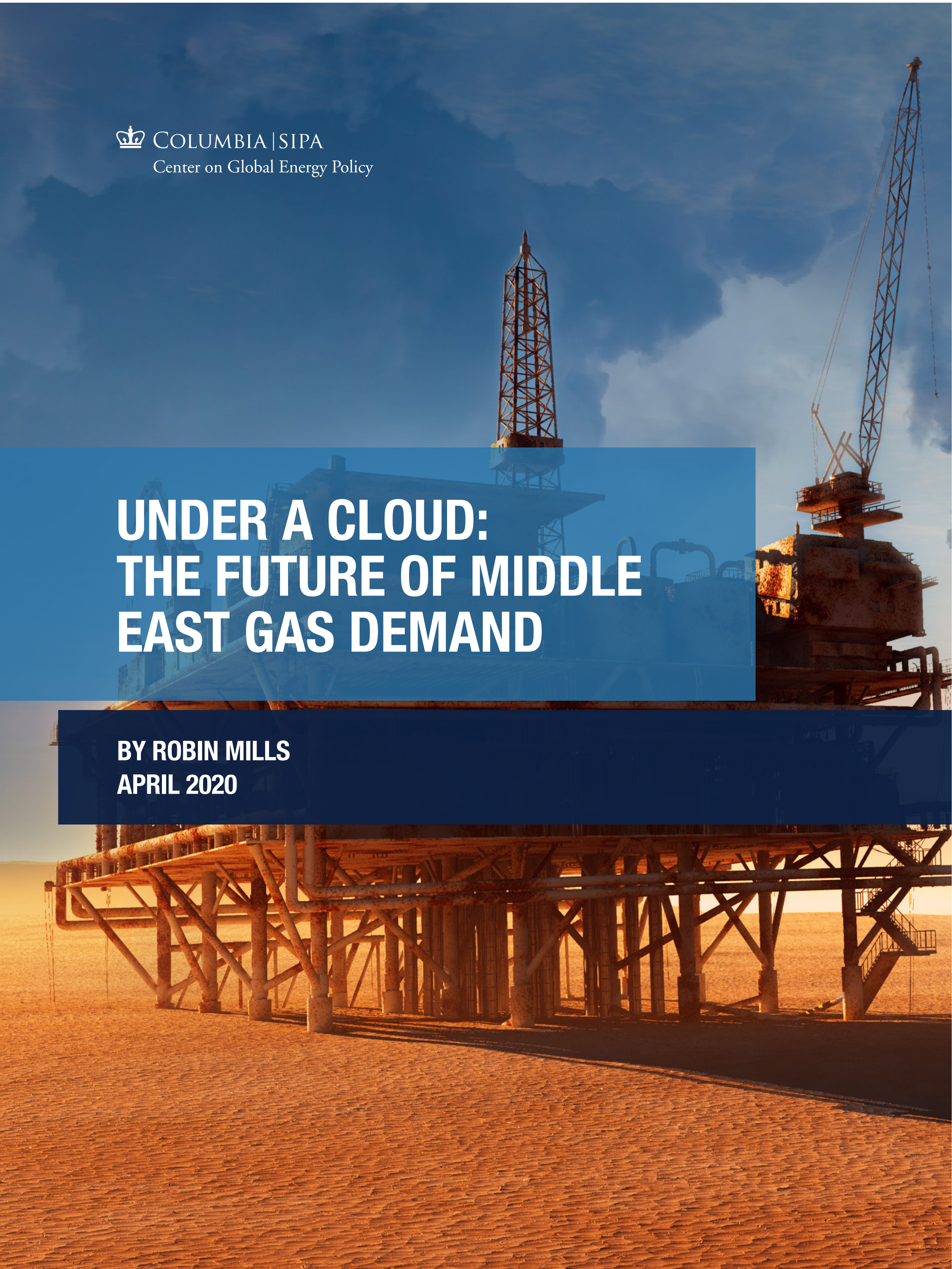

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UNDER A CLOUD: THE FUTURE OF MIDDLE EAST GAS DEMAND

BY ROBIN MILLS
APRIL 2020

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EXECUTIVE SUMMARY

During the early years of the 21st century, the Middle East emerged as a fast-growing center not just of natural gas production and exports but also of demand. Including Egypt, total growth in annual demand from 2000 to 2017 was greater than any region except Asia, a feat more surprising when considering the region's relatively small population and economy. That's about to change, however. After two decades of rapid expansion of natural gas consumption in the Middle East, growth should drop through 2035 due to four factors: improved efficiency, higher gas prices, slower economic growth, and alternative generation.

Demand growth was driven by low, subsidized gas prices intended to spur economic growth, encourage energy-intensive industrialization, and share some benefits with the local population. But budget deficits and unsustainably rising domestic energy consumption have encouraged regional governments to cut subsidies and introduce efficiency policies, particularly since the fall in oil prices in late 2014. Industrial demand growth is also poised to fall as the Middle East's key competitive advantage was its low energy and feedstock cost.

The analysis undertaken in this paper to project future gas demand in the Middle East yields significantly lower estimates than forecasts by a number of international bodies (IEA, GECF, BP, ExxonMobil), especially post-2030. Important findings include:

- Gas demand in the power sector could essentially plateau during the 2020s, with the other main consuming sector, industry, also slowing sharply, based on conservative assumptions on efficiency and demand growth, and aggressive but not unreasonable projections for renewables penetration.
- Higher gas prices and shortages, along with great improvements in the costs of renewable energy, have led Middle Eastern countries to explore alternative power generation, particularly solar but also wind, waste, nuclear, and coal. After a series of false starts, renewables are now gaining real momentum.
- Increases in regulated gas prices can also spur general improvements in power plant efficiency, including upgrades and the replacement of most simple-cycle turbines with more efficient combined-cycle plants.
- For the Gulf Cooperation Council (GCC) states, heavily dependent on desalination for water supplies, there has been growing interest in reverse osmosis (RO) desalination as opposed to the traditional thermal methods, usually co-generated with thermal power plants. RO is more energy-efficient and decouples water from electricity production.
- Middle East industrial gas demand is harder to forecast than power because of its dependence on government-sponsored megaprojects. Governments may still subsidize certain sectors amid higher gas prices for reasons of employment and economic diversification. Otherwise, demand growth will have to come from a wider variety of less gas-intensive industries. Regional producers will find it increasingly important to

target and create industrial gas demand.

- Lower Middle East demand growth would free up supply to increase natural gas exports from the region. However, this would depend on whether the new generation of higher-cost gas resources in the region would be competitive in international markets, and whether new production projects would still go ahead if they were not required domestically.
- Countries that move faster on curbing gas demand and boosting domestic output may find markets in neighbors if they can overcome the commercial and political problems that have hampered past intra-regional pipelines. The region is unlikely to become a major LNG demand center, although LNG imports will continue and even grow in some countries.

INTRODUCTION

This study covers Middle Eastern countries (Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen) plus the immediately adjoining East Mediterranean (Egypt and Cyprus). The Palestinian territories are not explicitly covered because of a lack of disaggregated data. This territory equates to BP's definition of "Middle East" plus Egypt and Cyprus, and has been selected since it shows some common features in the gas producing basins and markets, it is interconnected (though to a very limited degree) by gas pipelines and electricity lines, and because the inclusion of the other North African countries or Turkey would broaden the scope too much and require consideration of the complicated relationship to the European gas market.

The Middle Eastern gas market can be roughly segmented into three.

1. The Gulf Cooperation Council (GCC) countries—Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE)—are wealthy, major oil exporters. Qatar, the UAE, and Oman also export LNG. They are connected by the GCC electricity grid, and Qatar exports pipeline gas to the UAE and Oman.

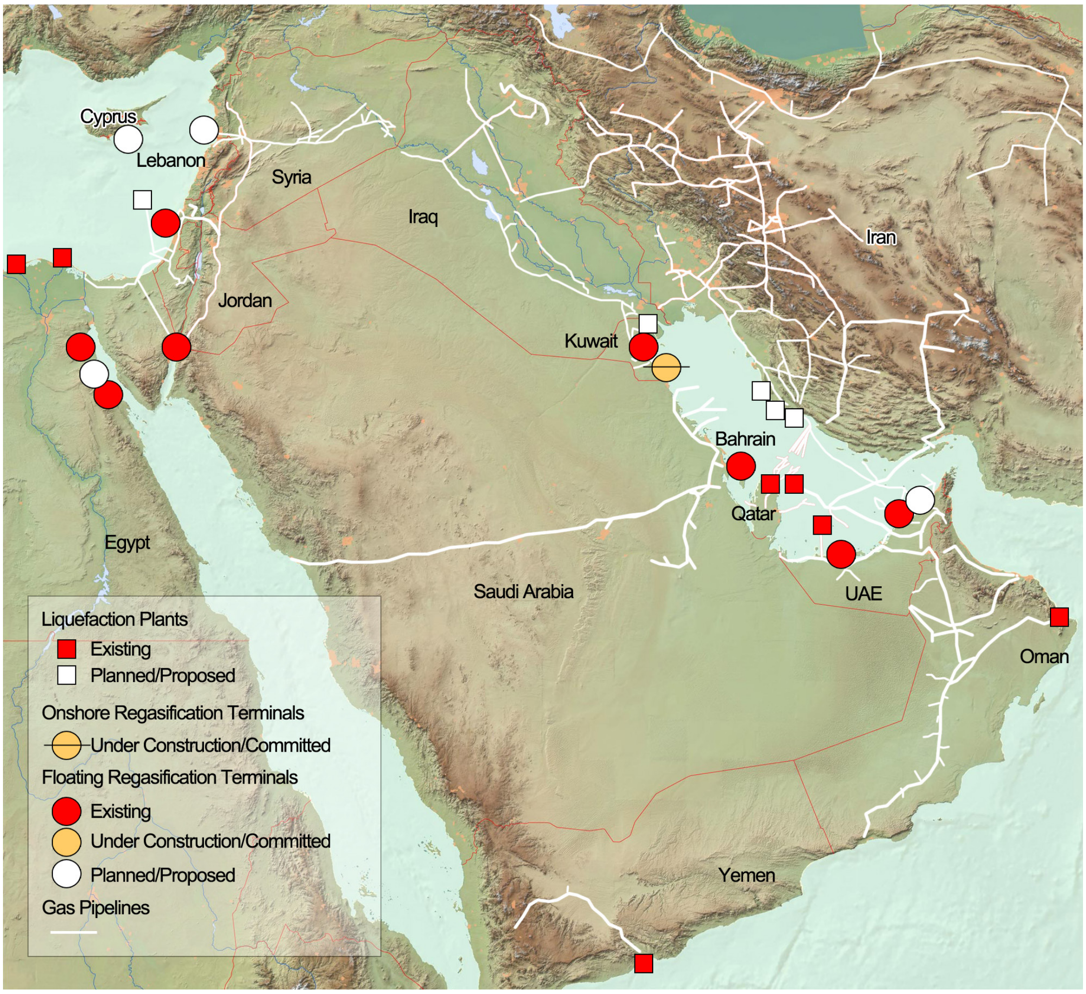
2. Iran exports gas and electricity to Iraq (and Turkey, not part of this study). Both Iran and Iraq are populous countries, less wealthy per capita than the GCC, and leading oil exporters, though suffering from a variety of political, economic, and environmental problems.

3. The Levant or Eastern Mediterranean includes Egypt, Jordan, Israel, and the Palestinian territories, Syria, Lebanon, and Cyprus. Egypt, Israel, and Cyprus have all made significant offshore gas discoveries in recent years and are proceeding to develop pipeline exports to each other and Jordan, while Lebanon is exploring the same basin, and Gaza (Palestinian territory) has one undeveloped offshore gas field. They are net oil importers, and only Egypt and, before its civil war, Syria produced significant amounts of oil. Egypt was exporting gas by pipeline through Jordan to Syria and Lebanon; sales to Jordan resumed in September 2018, and exports to Syria and Lebanon could also restart depending on a resolution to the war in Syria. Israel and Cyprus are relatively wealthy while the other countries are less so (and Syria, of course, has suffered disastrously from conflict).

Finally, Yemen is an isolated market, also beset by war, which formerly exported LNG. It halted exports after January 2015; the LNG plant is believed to be undamaged, but security conditions make a restart impossible for now.

Figure 1 shows the Middle East's gas pipelines and LNG export and import terminals (note that the two Egyptian liquefaction plants and the pipeline from Iran to Iraq are not shown). Even some of the pipeline connections that are shown here, notably Iran-UAE, Iraq-Kuwait, and Jordan-Syria-Lebanon, are not functional. Only Iran has a really extensive domestic gas network; the other countries have a few main trunk lines to take gas to large point consumers (power plants and industry).

Figure 1: Middle East gas pipelines and LNG terminals as of March 2020



Source: Qamar Energy, with input from Anne-Sophie Corbeau, "Regional Gas Industry Issues and Opportunities: The Future of Gas in the Middle East," KAPSARC, March 30, 2017, accessed March 16, 2020, https://www.igu.org/sites/default/files/6-the-future-of-gas-in-the-middle-east_20170330.pdf.

The 2018 World Energy Outlook by the International Energy Agency (IEA) assessed the outlook for Middle East gas production and demand compared to other projections and this study in table 1. Note that the IEA's definition here does not include Egypt, Cyprus, or Israel, so the figures from the present study are shown both with and without these countries for comparability. The starting figures for 2016/2017 vary between reports because of different definitions (for instance, BP excludes gas converted to liquid fuels), different treatment of NGLs, varying conversion factors, and the inclusion or exclusion of some small regional markets.

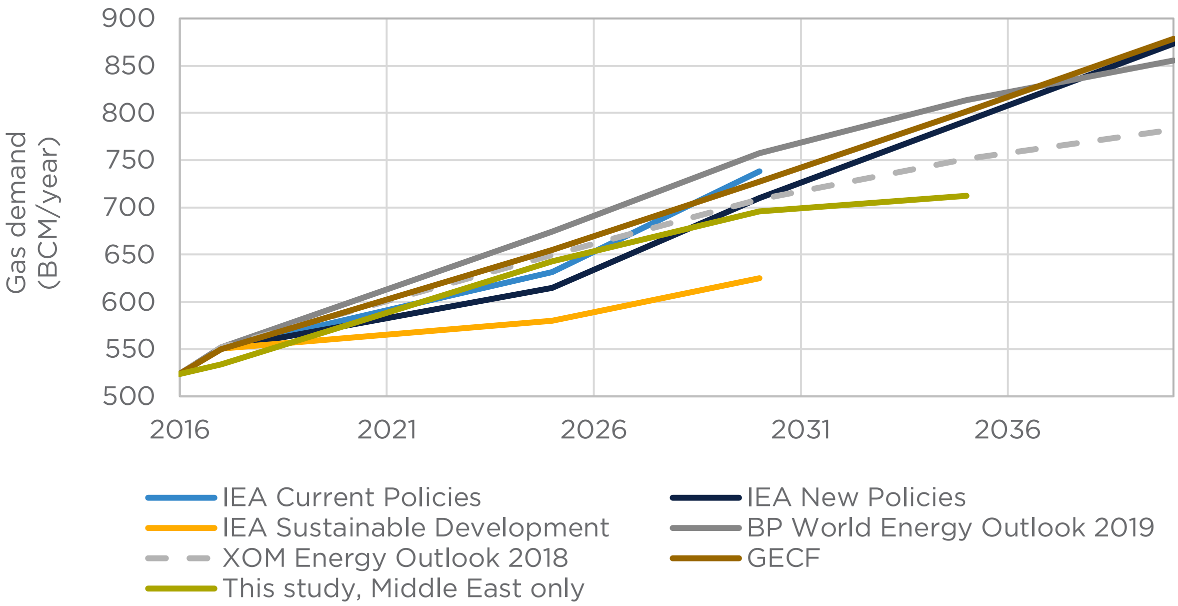
In all the IEA's scenarios, demand growth accelerates after 2025, with more growth in the five years 2025–30 than the eight years 2017–25. The studies of BP, ExxonMobil, Rystad Energy, and the Gas-Exporting Countries Forum (GECF) also show strong growth; that by DNV (for a slightly larger set of countries) has lower growth, with a decrease after 2035. McKinsey has Middle Eastern demand growing 1.1 percent annually during 2017–35, or total growth of about 117 BCM, with more than half of this growth, 70 BCM, occurring from 2017–22 and a sharp slowdown thereafter. The Oxford Institute for Energy Studies, which covered the Gulf, has a much higher estimate of demand growth, mainly because of much higher expectations for Saudi Arabia, Iraq, and Iran.

Table 1: IEA World Energy Outlook and other studies compared to this study

BCM/year	Production			Demand						Exportable Surplus[1]		
	2017	2025	2030	2016	2017	2025	2030	2035	2040	2017	2025	2030
IEA Current Policies	620	727	847	477	501	575	672			119	152	175
IEA New Policies	620	709	817	477	501	560	646		795	119	152	175
IEA Sustainable Development	620	673	726	477	501	528	569			119	145	157
EIA Reference[2]	631	626	685	487	496	532	578	626	674	135	94	107
BP World Energy Outlook 2019	660	770	885	509	536	655	736	790	831	124	115	149
XOM Energy Outlook 2019[3]					546	622	678	731	770			
GECF[4]	608	745	823	479	503	599	665	733	803	105	146	158
Rystad[5]	609		898		506		747			103		151
DNV Energy Transition Outlook 2018[6]	*822*	*1018*	*1174*	*592*	*592*	*674*	*749*	*758*	*714*	*230*	*344*	*425*
McKinsey[7]					536	606		653				
Oxford Institute for Energy Studies, Gulf only[8]	645		1127		515		899			130		228
This study, Gulf only[9]				515	525		679					
This study, excluding Egypt, Israel, Cyprus	660	770	885	524	534	643	696	712		126	127	189
This study, all countries				584	603	738	814	860				

The forecasts are also compared graphically in figure 2, all rebased to the same demand in 2016 to permit rough comparability. This study is in the middle of forecasts until the mid-2020s but then slows sharply while most other forecasts have steady or even accelerating growth.

Figure 2: Comparison of forecasts (rebased to 2016)



This paper does not examine the region's gas *production* prospects in detail. However, this can be illustrated using the BP World Energy Outlook's production figures, combined with the present study's demand, to give the exportable surplus. (DNV's projected exportable surplus is much higher, presumably because it includes the two important gas-exporting countries Algeria and Libya.)

Ceteris paribus, a decrease in domestic gas demand would of course leave more gas for export or oil displacement (or decrease imports), as shown in the table. But given that numerous gas production projects are predicated on meeting domestic demand and that the required facilities for export (whether international pipelines or LNG liquefaction plants) would be considerably more expensive and complicated, it is likely that lower regional gas demand will also be partly matched by lower production, i.e., that some planned gas projects will be cancelled or production will be shut-in.

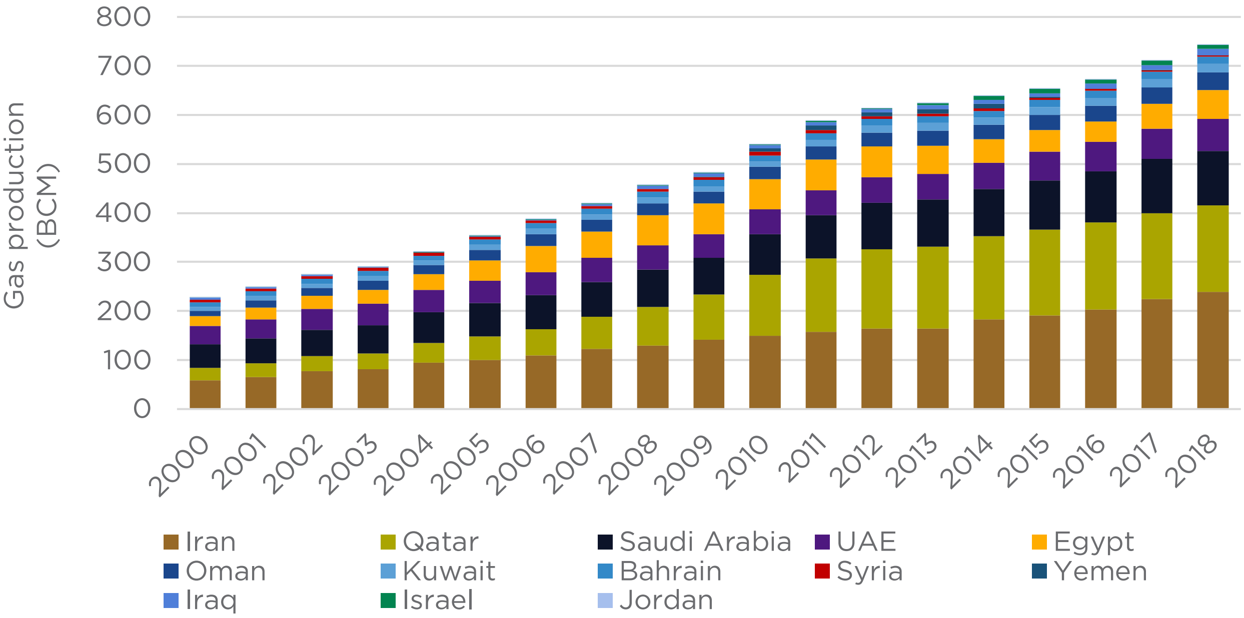
GAS OUTLOOK

Recent History 2000–19

Middle Eastern gas demand rose rapidly during the early years of this century (7.7 percent annualized growth in marketed gas consumption during the 2000–10 period for the countries covered in this study[10]) and at a slower but still rapid rate since (4.3 percent annualized growth during 2010–18[11]). Growth was impelled by the regional oil boom, leading to population growth (primarily an influx of expatriate workers in the Gulf), economic growth, and energy-intensive industrial development. Rapid demand growth was also encouraged by heavy subsidization of gas, electricity, and water in most of the region.

As cheap supplies of legacy associated gas were allocated,[12] new production of non-associated gas grew quickly, leading to an overall expansion in output (figure 3) but supply failed to keep up with demand in many regional countries. Only Qatar was able to expand its gas exports substantially (Iran did so to a limited extent in the last few years). Development of cross-border pipelines was slow and sometimes interrupted by sabotage and political disputes. Several countries, including Egypt, Jordan, Saudi Arabia, Kuwait, and parts of the UAE, ran into gas shortages, which required burning expensive liquids for power. LNG imports, via floating storage and regasification units (FSRUs), became increasingly popular as a fast and flexible way to fill the gas demand gap. Since 2009, Kuwait, Dubai (UAE), Jordan, Israel, Egypt, and Abu Dhabi (UAE) have become LNG importers, and Bahrain, Sharjah (UAE), and possibly Cyprus and Lebanon are likely to join in the next few years. Meanwhile, although Qatar is set to increase its LNG export capacity again in the early 2020s, exports virtually ceased from Egypt in 2014–15, ceased entirely from Yemen due to its civil war, fell below capacity in Oman because of lack of feedstock, and came under question in Abu Dhabi as its main sales contract expired in 2019.

Figure 3: Middle East gas production



Sources: Energy Information Administration, BP Statistical Review of World Energy 2019, Joint Organisations Data Initiative, Gas Exporting Countries Forum Annual Report 2019, Qamar Energy analysis

The question is whether these regional trends—of rapid increases in demand, outpacing domestic production and requiring increased imports—will continue. This is important for projections of LNG demand as the region has emerged as a fast-growing center for imports.

Gas Production

This paper is not intended to examine or forecast regional gas production in detail, but a brief review is important to set the scene. Domestic production is expected to rise strongly in most though not all regional countries due to new discoveries, unconventional gas development, increased flared gas capture in Iraq, the expansion of existing fields, and the delayed impact of new field developments made to meet recent years' domestic demand gaps. Reform of gas prices paid to producers incentivizes new developments.

Cost for new developments are higher for those for gathering associated gas or developing relatively straightforward, large non-associated gas fields in the past. The gas price paid by Egypt for Zohr, for instance, ranges from $4–5.88/MMBtu depending on oil prices;[13] Israeli buyers pay from $4–$6.5/MMBtu;[14] Saudi unconventional gas costs are suggested to be $5–8/MMBtu,[15] though as noted below, Aramco is receiving $3.84 for its new northern non-associated gas; onshore sour gas in Abu Dhabi has been suggested to cost $5/MMBtu;[16] and the $20 billion capital cost quoted for ADNOC's offshore sour gas development suggests overall costs in the range of $7–9/MMBtu.[17] Iran, Qatar, and associated gas gathering in Iraq can still realize very low costs.

Saudi Arabia has expressed a desire to replace oil entirely in its power sector with a combination of gas and renewables and even to become a gas exporter of 30 BCM before 2030[18] by concentrating on the development of unconventional gas to 31 BCM annually over the next decade[19] and possibly its newly-announced offshore Red Sea gas finds.[20] Saudi Aramco compares the Jafurah basin, east of the Ghawar field, to the Eagle Ford of South Texas,[21] and Baker Hughes estimated the country's gas shale resources at 18 trillion cubic meters (645 trillion cubic feet).[22] It intends to raise raw gas output from 129 BCM to 238 BCM by 2026 (equating to about 142 BCM of sales gas), the next increment being the Fadhili gas plant at the end of 2019 (26 BCM of raw gas, 15.5 BCM of sales gas). Its gas network is planned to be expanded to the west coast to serve currently oil-fired power plants.[23] As a simple illustration, replacing existing use of crude and fuel oil[24] as targeted, ignoring efficiency gains and demand growth, would require about 55 BCM per year of additional supplies.

The **UAE** has likewise expressed an intention to become self-sufficient in gas by 2030[25] by expanding the existing Shah sour onshore field with Occidental, developing offshore sour gas fields intended to yield 15 BCM by the mid-2020s in partnership with ENI, Lukoil, Wintershall, and OMV,[26] onshore shale from a concession with Total which may also yield 10 BCM by 2030,[27] sour gas from the onshore Bab field (5 BCM[28]), and production from the gas caps of its large offshore oil fields along with new exploration blocks. In February 2020, it announced a large conventional/unconventional shallow gas find between Abu Dhabi and Dubai with 2.27 trillion cubic meters of gas in place[29] while Sharjah also made a discovery in partnership with ENI. The planned rise in oil production capacity to 5 million bbl/day by 2030 would, if utilized, increase associated gas output though possibly also require more gas injection for improved recovery. Imports in 2018 were 18.2 BCM of pipeline gas (16.4 BCM in 2017) and 1.05 BCM of LNG (down from 3 BCM in 2017), offset by 7.4 BCM of LNG exports.[30]

As noted, **Qatar** will add 33 million tons per year (45 BCM) by 2024 from its planned four-train LNG expansion and another 16 Mtpa by 2027.[31] **Oman's** tight Khazzan field, operated by BP, has restored the Sultanate's LNG exports to capacity, and along with further development of the Ghazeer section of the field, Shell, Total,[32] ENI, and BP are working on other tight gas projects. With increased gas availability, Oman plans to debottleneck its existing 10.4 Mtpa of LNG facilities to add 0.5 Mtpa by the end of 2019 and an additional 1 Mtpa by 2021. Growth will, however, partly be offset by declines in mature fields. **Kuwait** has been developing the deep, tight, sour Jurassic reservoirs in its north with an initial target of 5 BCM, though recurrent problems in parliamentary approval are likely to hold up progress. **Bahrain** announced in April 2018[33] the discovery of offshore unconventional oil and gas and deep onshore gas, with 388 billion cubic meters of gas in place offshore and 283–566 BCM in place onshore.[34] The offshore tight oil and gas reservoir probably extends into Saudi and Qatari waters.

Iraq (excluding the Kurdistan region whose oil, gas, and power industry operates largely autonomously) has made only limited progress in non-associated gas development partly due to insecurity around two major potential developments: Akkas in the Anbar province and Mansuriyah in Diyala. Associated gas production has risen significantly with the expansion of oil output and, though flaring continues at high levels, the efforts of the Basrah Gas Company, supplemented by others, have seen increasing volumes captured for domestic use, primarily power generation. The recent signature of the fifth bid round fields should lead to the development of existing gas discoveries around the province of Diyala.

The Kurdistan Region of Iraq (KRI) has reached agreement with the Pearl Petroleum consortium to expand output at the Khor Mor and Chemchemal fields, adding an additional 5 BCM from Khor Mor, 2.5 BCM for use within the KRI and 2.5 BCM for the rest of Iraq or export. These fields, along with Miran and Bina Bawi (Genel Energy) and Topkhana (Repsol), could form the basis for an export project to Turkey with a pipeline to be built by Rosneft, with potential volumes building up to 20–30 BCM (assuming a sufficient market). Alternatively some of this gas could be sent to Iraq outside the KRI.

In **Iran**, phases 13, 14, and 22–24 of the supergiant South Pars field are somewhat delayed but should add about 50 BCM. The 20 BCM Phase 11, held up by the exit of Total and CNPC over US sanctions, is refusing to continue, likely delaying start-up to 2023 or afterwards. Total national production had reached 292 BCM (on an annualized basis) in January 2019, the peak demand period,[35] and was 224 BCM during 2017.[36] The new South Pars phases therefore represent about a 30 percent boost to total production. However, after that, there are few firm major projects, and sanctions will continue to obstruct progress. Iran's inability to export or store condensate also appears to have limited gas production over the 2019–20 winter period. Iran flared 17.7 BCM in 2017,[37] but again, progress on gas gathering is contingent on availability of finance.

Syria's gas production had been rising strongly in the years before the war, reaching 8.4 BCM in 2010.[38] Current raw gas output rose from 3.1 BCM in 2018 to 6 BCM per year in early 2019 (equating to 4.7 BCM of sales gas), and the Assad regime's petroleum minister Ali Ghanem targets an increase to 10.6 BCM by 2023[39] (8.3 BCM, i.e., about the pre-war level, assuming the same equivalence of raw to sales gas). Most of the gas fields and processing facilities are under Assad government control; a few are in the territory of the Kurdish-led Syrian Democratic Forces, though territorial control could change hands.

Egypt's giant deepwater Zohr field, which reached its plateau of 33.1 BCM by the end of 2019, has turned around the country's gas balance, enabling it to cease LNG imports and recommence LNG exports as well as send gas to Jordan (or, in future, redelivering Israeli gas) by pipeline. Further exploration drilling and licensing of new areas in the Nile Delta on and offshore, Red Sea, and western Mediterranean offshore are ongoing. However, given high decline rates at legacy fields, national production will again drop in the early to mid-2020s if there are no significant new developments.[40]

The Glaucus find in **Cyprus** now gives the country three significant discoveries (with Aphrodite and Calypso) which could meet local needs as well as be exported to Egypt or possibly LNG. A consortium led by Total (with ENI and Novatek) is due to drill offshore **Lebanon** in 2020,[41] and a further bid round is scheduled for early 2020.[42] While the Tamar field is now meeting most of **Israel's** domestic demand, the giant Leviathan and smaller Karish and Tanin fields are also moving to development with further exploration continuing in 2019, resulting in a new discovery at Karish North. These fields are intended to supply additional domestic gas as well as search for markets in Jordan and Egypt or possible exports further afield.

Yemen's 6.7 Mtpa (9.1 BCM) LNG plant has been shut down since 2015 because of insecurity at the producing fields and along the pipeline route, although it is understood that the plant itself has not sustained damage.

Subsidy Reform and Alternative Energy Competitiveness

Subsidy reforms in the region are quite recent, making it difficult to assess their impact on demand (Krane and Monaldi provide a useful summary up to 2017,[43] and Krane further explores the issue in his 2018 book[44]). It had long been maintained[45] that subsidies for a range of commodities, including transport fuels, gas, LPG, electricity, water, and food, in the MENA region were part of a "social contract" that was intended to share the benefits of domestic energy resources with the populace in return for political quiescence and to provide a minimum standard of living for lower-income citizens. Cheap natural gas permits low electricity prices (which are sometimes doubly subsidized, i.e., below the full cost of generation even allowing for low-cost fuel). In addition, cheap energy was intended to encourage industrialization and to provide jobs and economic and export diversification. The rise of large industrial champions, usually but not always state-owned, has created a set of influential lobbyists for continuing cheap energy.[46] For these reasons, subsidies were seen as politically untouchable. The Arab revolutions beginning in 2011 further discouraged attempts at reform that might provoke discontent.

However, in recent years, the fiscal and environmental burden, the prospect of domestic consumption cannibalizing oil and gas exports,[47] desires to move toward more value-added and high-tech industries, and strong encouragement from international agencies[48] has led to subsidy reductions and reform in most regional countries. Fiscal pressure has been particularly acute for net oil and gas importers such as Egypt (a gas importer during 2015–18) and Jordan. The fall in oil prices in 2014–16 increased the financial pressure on exporters but also increased the feasibility of subsidy reform, firstly by creating a sense of urgency and secondly by narrowing the gap between domestic and international prices, so reducing the severity of adjustment. In a few cases, such as Egypt, external pressure (the IMF) has encouraged subsidy removal.[49] Some authors have suggested that the supposed inviolability of subsidies was in fact rather a guideline that could be overridden by expedience and policy design.[50]

Gas prices to consumers (primarily power plants and industry) remain administratively set by the government or national oil and gas company throughout the region almost without exception (Israel has contracts between private gas-producing companies and users, while Egypt recently permitted large users to contract directly with gas importers). Therefore subsidy reform in the region is implemented by raising these regulated prices of gas, electricity, and water.

The first major nationwide reform was conducted by **Iran** under President Ahmadinejad in December 2010.[51] Prices for natural gas, electricity, and water were raised by 3–10 times (tariffs are tiered by consumption level), and gasoline and diesel prices were also increased. It was planned that natural gas prices would reach 75 percent of export parity and that electricity tariffs would cover the full cost of service. Consumers were compensated by cash handouts paid to their bank accounts, the intent being that the savings in greater energy efficiency would more than make up for the government's expense in handouts. Further subsidy reforms were carried out by the administration of President Rouhani in March 2014, with price increases of 20–25 percent.

Dubai was also an early reformer. From 2008, a tiered tariff scheme was introduced, increasing electricity prices by 65 percent and water tariffs by 33 percent in the top tier for expatriate users, prices were raised by 15 percent in December 2010, and from 2011, a fuel surcharge was introduced to reflect the higher cost of imported LNG. The other emirates have also raised prices, though those for Abu Dhabi remain at about half the Dubai level. From the start of 2018, value-added tax (VAT) of 5 percent has been applicable on electricity and water bills in the UAE. The top consumption band in Dubai now pays 0.46725 AED/kWh, including VAT (12.7 USc/kWh).[52]

Saudi Arabia raised electricity and water prices at the start of 2016, mainly increasing rates for high-consumption brackets (from about 3.3 USc/kWh to 5.5-8.2 c/kWh[53]), then approximately tripled prices for the lower-consumption levels of residential, commercial, and agricultural accounts at the beginning of 2018 as well as introducing 5 percent VAT.[54] In the Saudi case, the impact on lower-income citizens was cushioned by the Citizens Account, a cash transfer program similar to Iran's, which pays around 1000 Saudi riyals (about US $270) monthly to eligible households.[55]

Because of the higher cost for new gas production, as noted above, and the growing share of LNG imports at world prices, many regional governments have moved to increase wholesale natural gas prices. This has generally been done in stages and by pooling lower-cost legacy gas and more expensive new gas to arrive at an average price. Rising prices have met opposition from industry, which has complained of lower competitiveness, particularly as prices remain at divergent levels between countries and even between different UAE emirates.

Saudi Arabia raised gas prices from $0.75 to $1.25 in 2016[56] and will implement a new pricing scheme in 2020 whereby the price paid to Aramco for associated gas falls to $0.31/MMBtu but the price of northern non-associated gas rises to $3.84, southern non-associated gas to $1.52, and Fadhili non-associated gas to $3.81.[57] Electricity tariffs were raised by 67 percent (for a medium-tier consumer) and water by 50 percent.

Bahrain has raised gas prices to industry to $3.25/MMBtu in 2018, with a further rise to $4 by 2021 planned,[58] raised electricity prices in 2016, and introduced 5 percent VAT in 2019. **Oman** has increased natural gas prices from $2/MMBtu for industry and $1.50/MMBtu for power to $3/MMBtu by 2017.[59]

After various cuts in subsidies for fuel, electricity, gas, and water, **Egypt** now says it will phase out electricity subsidies entirely by 2022.[60] Prices have been raised several times, and the latest phase, from July 2019, will increase them about 32 percent on average. The highest consumption band will pay EGP 1.45/kWh (8.6 USc/kWh), a level considered unsubsidized. In July 2014, gas prices to industries were raised by up to 75 percent, with the price for cement plants rising from $6 to $8 per MMBtu, ceramic, glass, and metal industries from $4 to $7 per MMBtu and for power generation from $1.8 to $4.5 per MMBtu. Gas for fertilizers and petrochemicals was priced at $4.5 per MMBtu, and for food, textiles, and pharmaceuticals, it remained at $5 per MMBtu.[61] In July 2018, the top consumption tranche for piped gas to residential and commercial users was raised from about $3.60 to $4.80 per MMBtu.[62]

The trend towards reducing electricity subsidies in the region will limit end-user demand growth, and it also encourages deployment of distributed renewables, so far mostly in the industrial and large commercial sectors. It also allows the government to raise fuel prices to the utility (usually state-owned) while maintaining its financial viability; higher fuel prices then encourage improved efficiency and the deployment of alternative generation where this is lower cost.

These subsidy reform programs are accompanied by energy efficiency schemes, which typically include measures such as building codes, appliance standards, replacing incandescent lights, audits and retrofits, district cooling, and the introduction of energy service companies (ESCOs). Qatar's Tarsheed is claimed to have saved 6295 GWh of electricity, 33.22 million m3 of water, and 1.72 BCM of natural gas in 2018.[63] The Saudi Energy Efficiency Center (SEEC) claims a 7.1 percent energy intensity improvement in petrochemicals, steel, and cement[64] and a flattening in electricity consumption for residential and commercial cooling.

So far, more sophisticated utility tariffs are rare in the region. Several countries have tiered pricing, which penalizes higher residential and commercial consumers. Time-of-day and seasonal pricing is employed to a limited extent for large industries. Varying pricing, in future combined with smart meters, could cut peak demand and so limit the use of inefficient peaking gas/oil-fired turbines and balance peak solar input more effectively, helping renewable penetration.

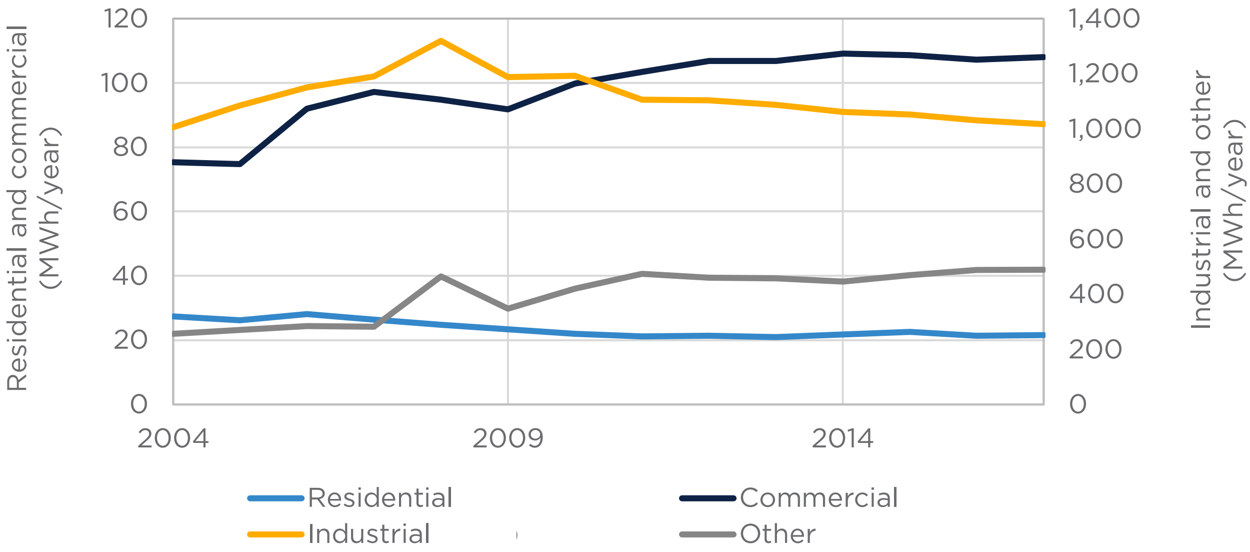
Such steep percentage price increases in several regional countries, albeit from low bases, should have produced a sharp drop in consumption. In practice, the effect has been complicated and hard to judge, but it is important to examine the recent historic record to judge what effect future subsidy reform may have on demand.

In the case of Iran, high inflation and the collapse in the value of the rial eroded the price increases, subsequent sanctions on Iran reduced economic growth, and there was nonpayment of bills.[65] There have also been attempts to eliminate the cash compensation for higher-income households.[66] In most of the other regional countries, inflation and currency depreciation have not been serious issues, but economic growth has slowed because of the 2014 fall in oil prices, and expatriate workers have left (from Saudi Arabia in particular). Tiered pricing schemes and differential pricing between citizens and expatriates complicate the task of isolating an "average" price. The income effect on consumption is blurred by cash compensation schemes. The concurrent efficiency programs, the shifting of public holidays and the fasting month of Ramadan through the year, and varying weather between years also make it hard to separate out the separate influences.

Following the subsidy reform,[67] Iranian electricity consumption (assuming generation is a reasonable proxy for consumption) fell very slightly in 2011 (-0.04 percent), even though GDP growth was quite robust (3.3 percent). In comparison, in 2010, GDP growth was 6.6 percent and electricity demand up 6.3 percent; in 2012, economic growth was -6.6 percent (because of sanctions), and electricity consumption rose 5.6 percent. Annualized growth in consumption during 2003–10 was 6.5 percent (GDP growth 4.7 percent), and in 2011–17 only 3.7 percent (GDP growth 2.3 percent), so there is no obvious effect of the subsidy reform over the longer term, once allowing for slower growth. Residential gas use rose 7.5 percent annually during 2003–10 and 3.6 percent annually in 2011–17, suggesting a somewhat slower rate of consumption growth, but this could also be influenced by the lower economic growth and by completion of gas connections to most Iranian households during the period. Residential gas consumption rose strongly in 2011 (up 7 percent from 41 BCM to 44 BCM), perhaps because the subsidy reform happened with half of the winter season already over, but it did drop sharply in 2012 (down to 40.6 BCM).

The impact of Dubai's price rises is also hard to interpret because of a rapid building boom which changed the property stock, the effects of the 2008–9 global financial crisis, the post-2014 economic slowdown, and likely changes in the composition of the expatriate community that makes up most of the Emirate's population. A fall in per-customer electricity use in 2009 is seen (figure 4) after the price rises but coinciding with the economic crisis; industrial and residential consumption per customer has fallen quite steadily since 2008. Growth in peak demand for both water and electricity was, though, much slower in 2011 than other years.

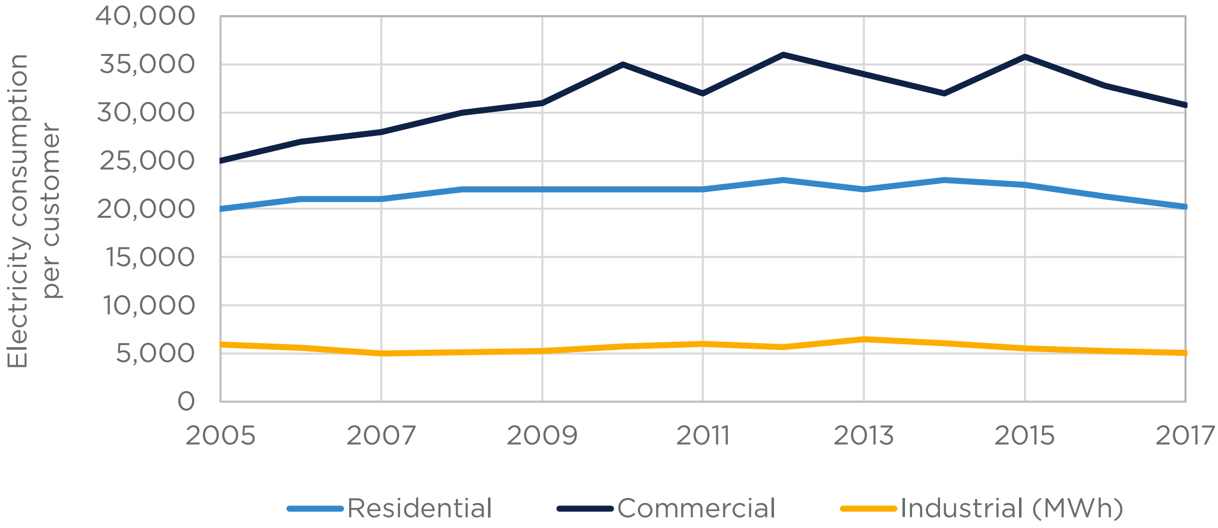
Figure 4: Dubai electricity consumption per customer



Source: Dubai Electricity & Water Authority (DEWA)

Saudi electricity consumption per capita, which had been rising steadily for years, fell in 2016 and 2017 following the price increases (figure 5), and peak demand also dropped in 2016 from 62.26 GW to 60.83 GW, though it rebounded to 62.1 GW in 2018.

Figure 5: Changes in per-customer electricity consumption in Saudi Arabia (residential and commercial in kWh, industrial in MWh)



Source: Data from Electricity and Co-Generation Regulatory Authority (ECRA)

Atalla and Hunt review residential electricity demand in the GCC[68] and find that price elasticity is very low, possibly because the low starting prices make electricity expenditure only a small share of household income. They do suggest that "even if prices were raised, the impact on curbing residential electricity growth in the region is likely to be very small given the low estimated price elasticities—unless, that is, prices were raised so high that expenditure on electricity becomes such a large proportion of income that the price elasticities increase (in absolute terms)." They also suggest that targeted efficiency measures would be more effective. Their work is consistent with low price elasticities found and used in the present study and with the somewhat unclear results of the Iranian, Saudi, and Dubai reforms; the impact of price reform on residential electricity demand is therefore not large though not negligible. The present study, though, does not specifically include non-price efficiency measures, which would give scope for larger savings, particularly if combined with subsidy reform.

Gas Consumption

Conversely to this strong supply picture, demand growth is likely to be negatively affected by four factors. **Economic growth** in the major oil exporters has slowed because of the 2014–16 oil price slump, which also affects neighboring countries via lower remittances and flows of tourism and investment. Demand in Syria, Yemen, and parts of Iraq has, of course, been badly hit by war, although it could rebound with post-war reconstruction, while Iran's economy has been badly affected by US sanctions, and Lebanon entered a financial crisis in late 2019. The effects of the 2020 COVID-19 coronavirus outbreak and the oil price crash could significantly harm regional growth, while in the longer term, the deceleration in Chinese expansion and the prospect of stagnating global oil demand suggest a future of generally lower oil prices and hence a slower Middle Eastern economy.

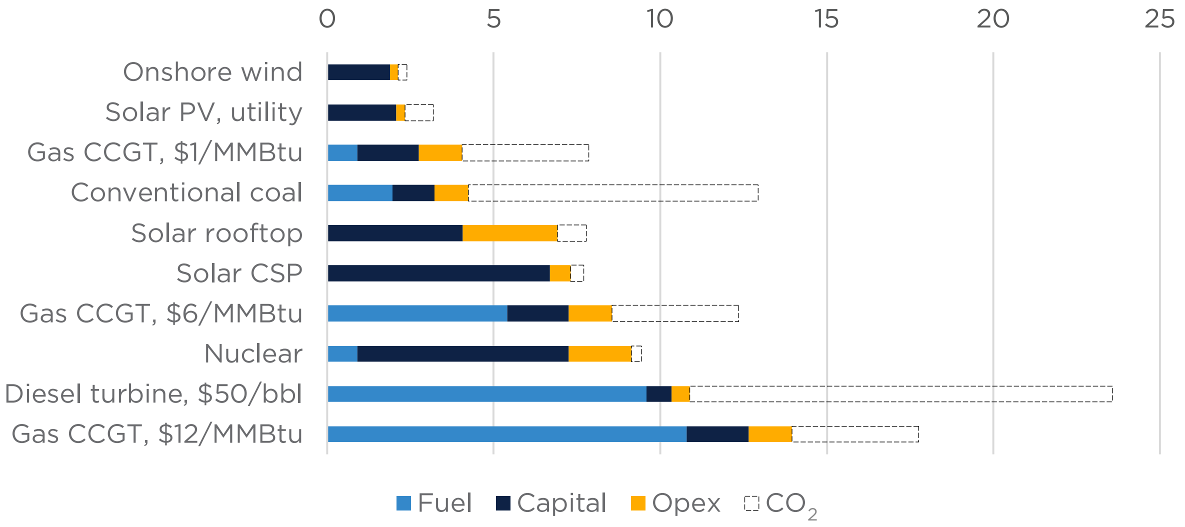
Reduction in subsidies for gas, liquid fuels, electricity, and water, as well as improving collection of dues, encourages greater efficiency and less wasteful consumption. Subsidies are being reduced because of their fiscal unsustainability and because Middle Eastern countries are increasingly developing more costly resources (shale, tight, and sour gas) and are exposed to world gas prices via LNG imports.

Alternative power generation, including renewable (mostly solar and wind), nuclear, and coal power, is being introduced to diversify the region's near-total reliance on oil and gas because of an outright lack of gas in some cases, the economic and security cost[69] of reliance on high-priced imports, the growing cost-competitiveness of renewables, and (to some extent) environmental concerns. The efficiency of the region's gas-fired plants is gradually improving, and a shift toward reverse osmosis (instead of cogeneration with thermal plants) for desalination would further improve power plant efficiency and flexibility.

Figure 6 shows estimated power generation costs by the type of technology under typical Middle Eastern conditions. Of course, project types, financing models, and so on vary widely, but this chart indicates the strong competitiveness of renewable energy. Solar PV and CSP have set a number of world cost records in the region, but even onshore wind in a good location, as with Saudi Arabia's Dumat Al Jandal project, has achieved record low bids. The region, of course, does not yet apply carbon pricing, but the lifecycle carbon footprint of each technology (at $100/ton CO_2) is added as a rough proxy for environmental impact and in case carbon restrictions are introduced in some regional countries within the study period.

These figures are levelized costs of electricity (LCOE), accounting for capital, operating, and fuel costs plus return on capital. They are informed by recent bid prices,[70] some of which may not reflect the costs for plants actually delivered around 2019–20 (they may be overoptimistic "strategic" bids or "loss-leaders" or incorporate expected near-term cost reductions). However, given the recent pace of cost reductions, costs are likely to fall below these levels within a few years. The LCOE also does not reflect the costs of grid integration or storage, which are likely to be low at current small renewable shares, but could become significant at higher penetration levels.[71] The current study does not attempt to calculate the "optimal" or lowest-cost electricity system for Middle Eastern countries or to calculate the full system cost of the assumed or target electricity generation mixes.

Figure 6: Power generation costs (LCOE) under typical Middle Eastern conditions



Source: Qamar Energy estimates based on reverse-engineering reported bid prices, US EIA; life-cycle CO_2 costs assumed at a hypothetical $100 per ton (no country in the region currently imposes a carbon price, other than Cyprus, which is in the EU Emissions Trading Scheme), emissions factors from: the University of Texas at Austin Energy Institute, "Nuclear and wind power estimated to have lowest levelized CO_2 emissions," November 7, 2017. Accessed March 16, 2020. https://energy.utexas.edu/news/nuclear-and-wind-power-estimated-have-lowest-levelized-co2-emissions.

Key points from this chart are that solar PV and, in the right places, onshore wind are lower in total cost than the fuel price of gas-fired power unless the gas is very cheap. PV costs are expected to continue falling, even if slightly offset by rising financing costs; current and possible future innovations include bifacial modules, which boost output in desert conditions by about 15 percent, high-efficiency perovskite cells, hybrid solar thermal-PV systems, AI-led weather forecasting and output optimization, robotic installation, and cleaning. DNV forecasts Middle Eastern capital costs per unit of capacity to fall by 33 percent for solar PV, 7 percent for solar thermal, and 24 percent for onshore wind from 2018 to 2035, and this outlook for solar thermal in particular appears conservative given the improvements already achieved.

Therefore even with gas prices of $3 per MMBtu or so, utility-scale solar PV would still be economically viable purely on fuel savings discounted over a twenty-year period. Rooftop solar is more costly but would benefit from savings on transmission and distribution and is also far cheaper than the traditional diesel generators.[72]

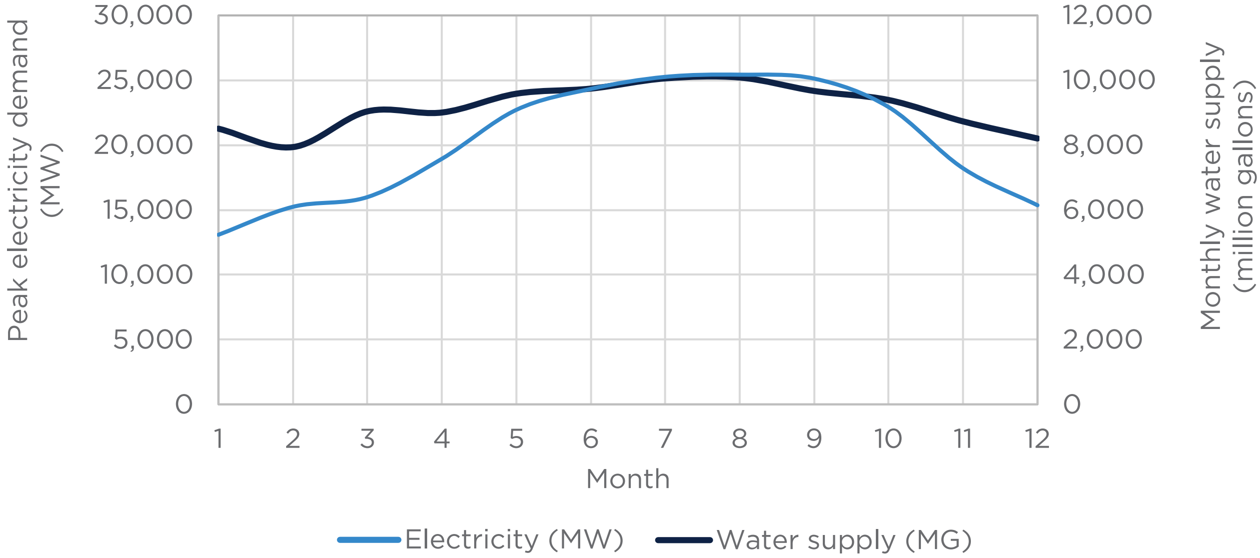
Solar CSP, based on Dubai's achieved bid price, is cheaper than gas-fired power at moderate gas prices representative of likely LNG import prices or unconventional gas, and with storage, it can provide nighttime power too. Dubai does not have the region's best solar resource for CSP, so Jordan, Egypt, and western Saudi Arabia could probably achieve lower costs. Integrated solar combined cycle (ISCC) plants, using solar to boost the efficiency of gas-fired plants, have achieved very competitive costs at Duba (43 MW solar from total 605 MW capacity) and Waad Al Shamal (50 MW from 1390 MW) in Saudi Arabia,[73] of less than $1600 capital costs per kW, and the 3600 MW Taiba plant (of which 180 MW is CSP) is in development. Egypt's Kuraymat plant from 2011 has 20 MW of solar from 140 MW of overall capacity,[74] and Iran's Yazd plant combines 17 MW of solar from a total 308 MW. The introduction of more large-scale CSP projects will reduce costs by building experience and the supply chain.

Coal, based on Dubai's project, is also cheaper in levelized cost than all but the cheapest gas if carbon and other pollution costs are ignored. Nuclear power is considerably more expensive, and the delays in the UAE's program would probably push these costs up further; nevertheless, it is still probably lower-cost than oil-based power or very high-cost gas. Next-generation nuclear, including small modular reactors, might be able to achieve substantially lower costs.[75]

This indicates that renewables in particular, which are technically straightforward and quick to build, should achieve a significant share in the region's lowest-cost generation mix. This is even before considering their low carbon footprint and manageable local environmental impacts. Given solar PV's good match to Middle Eastern demand patterns and the potential of CSP for nighttime use, they could achieve a high level of penetration without incurring large system integration costs. Renewable and battery costs are expected to continue falling; coal or gas with carbon capture and storage (CCS) or advanced nuclear power could play a role, but the costs of these are more uncertain.

Figure 7 and figure 8 illustrate the effect of desalinated water cogeneration in affecting thermal plant efficiency. Electricity demand has a much more peaked annual profile than water demand: peak monthly electricity demand is 94 percent above the minimum, while peak water demand is only 27 percent above the minimum. Therefore in winter, cogeneration plants have to be run solely to generate water. Switching to reverse osmosis driven by electricity would remove this requirement. Since water is easier to store than electricity, this also helps in managing demand and integrating variable renewables: reverse osmosis plants can be turned off at times of high electricity demand and run preferentially at times of low demand.

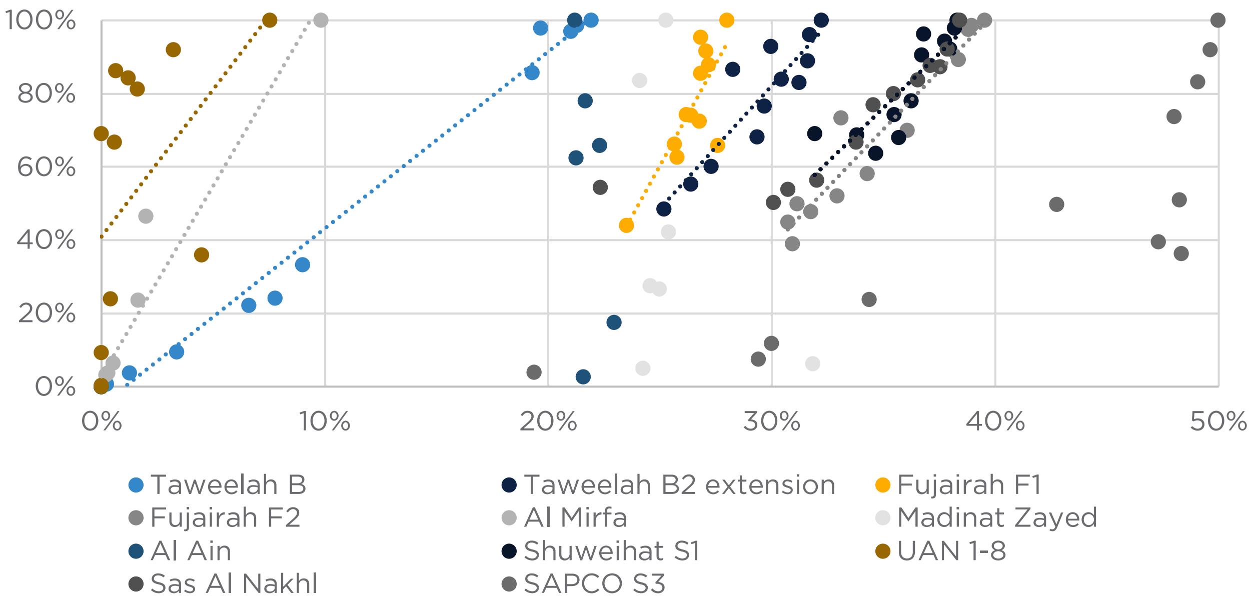
Figure 7: Monthly peak electricity and water demand for Abu Dhabi Water & Electricity Company (ADWEC), 2015



Source: Calculations from data in ADWEC Statistical Report 2015

For the plants with cogeneration, efficiency improves with utilization factor as the periods of low utilization (in winter) reflect the plant being run mostly for water rather than electricity production. The plants without cogeneration (Al Ain, Madinat Zayed, SAPCO S3) do not show this relationship. Also, the most efficient plant overall, SAPCO S3, is a modern plant without cogeneration.

Figure 8: Monthly thermal generation efficiency in ADWEC plants (2014) versus utilization



Source: Calculations from data in ADWEC Statistical Report 2015

Industrial demand growth is likely to be lower than previously because of the reduction in subsidies and the consequently lesser international competitiveness of industries reliant on low-cost bulk feedstock, including petrochemicals, fertilizers, aluminum, steel, and cement. It is not expected that existing industries will be forced to close as they represent sunk capital, they are important components of the wider economy and diversification plans, and governments will probably ensure they are shielded from levels of gas or electricity prices that would make them uncompetitive. However, new investment in energy-intensive industries predicated mainly on below-market feedstock costs will become increasingly rare. Existing industries will come under stronger pressure to improve energy efficiency and perhaps to adopt renewables (or coal, in the case of cement) where they offer lower costs.

These factors interact. Reduced investment in bulk industries will also lower their associated electricity demand. As well as the impact of subsidy reform on industrial gas demand, lower industrial growth also hits overall economic growth. Higher gas prices make alternatives, particularly renewables and coal, more appealing as well as encourage more efficient generation and the use of reverse osmosis.

One countervailing factor is **climate change**. The region is generally becoming hotter, which will increase demand for air-conditioning, partly offset by reduced demand for gas in heating (mostly in Iran). Lower freshwater availability is likely to increase the use of desalination, particularly in countries such as Egypt and Jordan.

This paper now turns to examine the region's gas demand prospects in more detail.

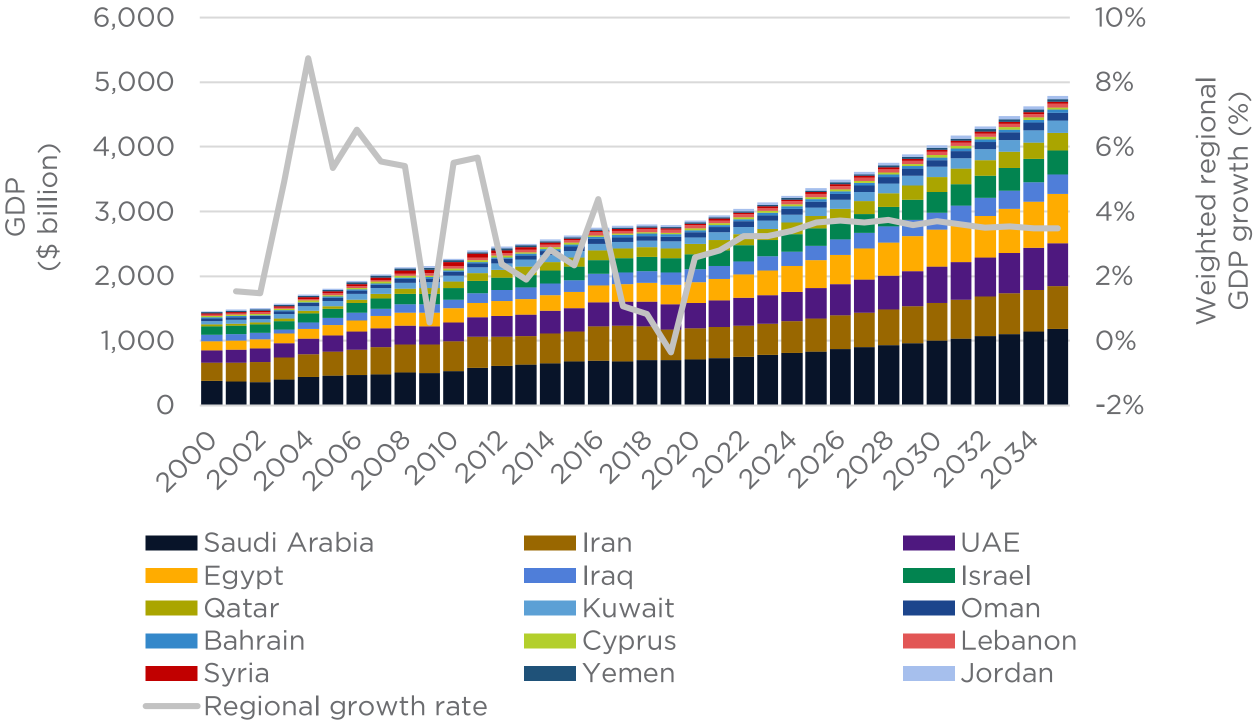
METHODOLOGY

Power Generation and Consumption

Modelling was carried out in Excel. Power demand has been forecast to 2035 based on correlations of historic demand per country against GDP, population, oil production, oil price, and heating and cooling degree days.[76] GDP and population forecasts have been taken from the World Bank and historic electricity consumption from the International Energy Agency (IEA) and BP. Post-war reconstruction in Syria and Yemen is assumed to begin effectively in 2021.[77] Population growth rates are expected to slow in every country,[78] partly due to lower fertility rates and partly to less migration to the labor-importing, oil-exporting states as their economies mature and slow down.

The resulting regional GDP is shown in figure 9; growth rates are forecast to recover from the relatively low levels of 2012–19 caused by regional unrest and falling oil prices but do not rebound to the very high levels achieved during 2003–8 and 2010–11. Regional GDP estimates from the World Bank and others have not yet been updated for the effects of the COVID-19 outbreak and sharp drop in oil prices, and confident predictions are very difficult; short-term growth at least is likely to be substantially lower. Long-term regional GDP is dominated by Saudi Arabia, Iran, the UAE, and Egypt and to a lesser extent by Iraq, Israel, Qatar, and Kuwait. Long-term average regional growth rates above 3 percent may still be optimistic in view of the aftereffects of the viral crisis and the possibility of a stagnation or drop in world oil consumption.

Figure 9: Projected regional GDP (real, constant US$ 2010)



Source: World Bank; recent country reports (World Bank, "Lebanon," Macro Poverty Outlook 163 [2019] http://pubdocs.worldbank.org/en/757651553672394797/Lebanon-MEU-April-2019-Eng.pdf, and other editions); Qamar Energy calculations

The impact of subsidy reform was assessed depending on a view for each country of when subsidy reform would start (if it has not started already); gas prices are then assumed to be increased up to 10 percent annually until reaching international parity. For LNG-importing countries, international parity is assumed at $6–8/MMBtu, including the cost of transport and regasification as a long-term view of LNG prices; for LNG-exporting or self-sufficient countries, parity is assumed at $3/MMBtu, allowing for the full-cycle cost of constructing and operating new LNG export facilities.[79] The fuel component of electricity prices, assuming that gas is the marginal general source, is then increased accordingly, and price elasticities from the literature applied to determine the impact on demand.[80]

The power generation mix to 2035 has been projected for each country based on current plants and those under construction or likely to proceed plus a view on future developments based on national plans and targets with realistic constraints. Oil-fired power is assumed to be phased out at a rate of 10 percent annually for those countries still using oil and where gas is available (LNG becomes available in Cyprus in 2022, based on current plans for import terminals, and offshore fields could be producing by about 2025).

A separate sensitivity assesses the impact if major oil-burning countries, notably Saudi Arabia, are not able to secure sufficient gas to replace oil. It is possible that Saudi Arabia and perhaps Kuwait and Iraq might for a short period during 2020 step up their burning of fuel oil as it becomes cheap and unsellable following the International Maritime Organization's regulation restricting the sulfur content of ship bunker fuels, but, the caveats regarding Saudi Arabia apart, the trend to reducing oil in the power sector can be assumed to resume thereafter.

Coal, nuclear, and waste-to-energy[81] are introduced based on current plans without assuming any addition: the UAE, Oman, and Egypt are introducing coal, Jordan oil shale (here treated like coal), and the UAE, Saudi Arabia, and Egypt nuclear power (Jordan's nuclear ambitions are here disregarded due to the major technical and financing challenges[82]). Additional scenarios are considered without new coal, nuclear, and renewables. (Although new renewables will certainly be built, this scenario illustrates the impact on gas demand of renewable growth.)

Renewables, divided into hydroelectric, wind, solar thermal (CSP[83]), and solar photovoltaic (PV), are introduced based on current national plans and targets, which typically run to 2030,[84] industry associations,[85] and other expert views.[86] Adjustments are made where these appear unrealistically high. Waste-to-energy (WTE), which is only partly renewable, is also included. For instance, in this study, the Saudi 2023 target has been put back to 2024 and the 2030 target to 2032. Further renewable installations to 2035 are continued at the same rate as in previous years. Allowance has been made for rooftop solar PV (e.g., under the Shams Dubai scheme[87] or Oman's Sahim program) as well as for utility-scale solar.

Waste-to-energy could possibly expand further in some countries for which data was not available, such as Egypt, but its contribution is small. Onshore wind power is forecast to be deployed mostly in Saudi Arabia, Egypt, Iran, Iraq, Jordan, Kuwait, and Oman.[88] However, offshore wind, not specifically included here, could also contribute and would help in balancing the expansion of solar given its different diurnal and seasonal pattern.

Rehabilitation of existing hydroelectric facilities in Iraq and Syria is included, but no new hydro is included except in Iran. Pumped hydroelectric storage facilities exist in Iran (Siah Bishe, 1040 MW; the 1000 MW Ilam facility is under consideration[89]) and are under construction or consideration in the UAE (Ras Al Khaimah and Dubai[90]), Egypt (Ataqa), and Saudi Arabia (Magna and Baysh[91]), but these are not specifically modeled. The use of other renewables, such as geothermal,[92] may have a niche role, and KA CARE's 2013 plan[93] in Saudi Arabia targeted 1 GW by 2040, but they are not included here, except for Iran, which has a 5 MW plant in operation.[94] Non-electricity use of renewables—especially solar thermal to generate steam for heavy oil recovery, already a major project in Oman, and rooftop solar water heating (already popular in Cyprus and Jordan and now mandated for new construction in Dubai)—has also not specifically been included. Building-integrated hybrid solar PV and thermal methods and "natural" air-conditioning could also reduce cooling loads.[95] Although the deployment of renewables could be expected to increase in the scenarios without coal or nuclear, this has not been included.

Maximum capacity factors (the share of annual generation as a percentage of nominal capacity, allowing for maintenance, hours of sunlight, and weather) are assumed at 20 percent for solar PV (probably a little conservative[96]); 30 percent for solar thermal (which could be very conservative if thermal storage is widely used to take capacity factors up to about 60 percent[97]); hydroelectric is based on historic figures per country, which are low due to regional water shortages and very variable between years, but average 53 percent for Egypt, 27 percent for Lebanon, 19 percent (pre-war) for Syria, 20 percent for Iran, 22 percent for Iraq, 40 percent for Israel, 40 percent for Jordan;[98] 30 percent for wind;[99] and 90 percent for thermal generation including nuclear.

Solar PV is capped at 20 percent of total generation, probably a conservative assumption in the longer term, to reflect the difficulty of balancing with demand. The region has generally a good fit of solar insolation to demand, which rises during the day and with summer air-conditioning. A limited amount of storage (pumped hydro and batteries), demand management, solar CSP with storage, and interconnections should allow meeting early evening demand peaks. However, more seasonal storage will be required for spring and autumn periods when, in later years, solar PV will exceed instantaneous demand.

Otherwise, variable renewables adoption is not assumed to be constrained by grid or demand-balancing issues. Levels of renewable capacity achieved are around the 10–30 percent share of total generation, which has already been successfully integrated in other countries.[100] Higher shares are eventually reached in a few countries (96 percent in Jordan by 2035, 85 percent in Cyprus, 60 percent in UAE), but the assumption is made that this can be integrated by some combination of storage (CSP with thermal storage, pumped hydro, batteries, other thermal and chemical storage), remaining flexible generation, flexible desalination with water storage, demand management, and international interconnections. Some combination of shedding of surplus generation, energy storage, or trading would become important in the later years for the UAE, with 62 GW of installed renewables and nuclear against forecast peak demand of 43.4 GW (and lower in the early spring when solar generation is still strong). Grid reinforcement and upgrades will be required; Jordan announced a moratorium on new renewables in January 2019 while it completes a grid study[101] and is building a transmission corridor to bring solar and wind power from the south to the main population centers around Amman. Similarly the Egyptian Electricity Transmission Company is conducting studies with Siemens on integrating its new 1.47 GW solar park at Benban in southern Egypt into the grid.[102]

Table 2 compares selected countries' renewables targets with the forecasts by the International Renewable Energy Agency (IRENA) and those arrived at in this study. Given the early stage of renewables efforts in most countries, and the policy- and subsidy-driven challenges (rather than the technical and economic ones), there is clearly a wide divergence of opinion. Some government targets appear unambitious, such as Bahrain's, Qatar's, and Lebanon's for 2030; others appear very challenging, especially in the short term. The total for the selected countries in this study by 2030 is somewhat higher than the IRENA sum (taking their "Reference Case" for Egypt instead of their Remap, which has 42 GW more), at 117.5 GW versus 106.3 GW, but not enormously so.

Table 2: Renewables targets and forecasts by country

Country	RE Targets[103]					Total		IRENA[104]	This Study		Target Date
	Wind GW	PV GW	CSP GW	Biomass & Waste GW	Geothermal GW	GW	%	GW	GW	%	
Bahrain	0.05	0.2		0.005 *(biogas)*		0.255	5%		1.1	17%	2025
								0.7	1.9	25.5%	2030
	0.3	0.68		*0.01* *(biogas)*		1.456	10%		2.8	31.8%	2035
Oman	1.15	1.5					10%		3.0	23%	2024
								5.5	7.9	37%	2030
Kuwait							5%		0.2	1%	2020
	0.7	4.6	5.7	0	0	11	15%	8	11	31.6%	2030
Qatar		1.8				1.8	20%		1	7%	2024
								3.1	1.9	11.2%	2030
Saudi Arabia						9.5	10%		16.1	16.4%	2023
		20				27.3					
	16	40	2.7			58.7		25	49.7	36.9%	2030
	9	16	25	3 *(waste-to-energy)*	1	54	30%				2040
Abu Dhabi		1.5				1.5	7%				2020
Dubai		1				1	7%				2020
		5				5	25%				2030
UAE Total								30	30	35.2%	2030
Egypt	13.3	3	0.1			16.4	20%		7.2	10.4%	2022
								34-76	13.7	16.0%	2030
	20.6	31.75	8.1			60.45	42%		20.4	21.3%	2035
Jordan	0.6	1.2		0.05		1.85	10%		1.9	29.2%	2020

CONTINUED ON NEXT PAGE

Country	RE Targets[103]					Total		IRENA[104]	This Study		Target Date
	Wind GW	PV GW	CSP GW	Biomass & Waste GW	Geothermal GW	GW	%	GW	GW	%	
Lebanon	0.2	Rooftop 0.1; 0.15 PV farm	0.05		0.013	0.5013	12%		0.53	16.2%	2020
	0.45	Rooftop 0.15 MW; 0.3 PV farm	0.1		0.015	1.015	12.5-30%		1.23	22.2%	2030
Total *(excluding Jordan & Lebanon)*								106.3	117.5		2030

As further comparisons, SolarPower Europe puts Saudi PV additions during 2019–23 at 4.6-11.4-14.4 GW (low, medium, and high cases),[105] compared to this study's 11.9 GW; the UAE at 5.41 GW (medium case) compared to 5.9 GW in this study; and Egypt at 4.36 GW, compared to 1.56 GW in this study. The IEA sees potential in Iraq for 21 GW of solar PV and 5 GW of wind by 2030[106] compared to 7 GW and 1.5 GW in this study.

Additional combined-cycle gas turbine (CCGT) capacity is then assumed added to meet peak electricity demand plus a 15 percent reserve margin. In the cases of Egypt, Iran, and Iraq, the rate of CCGT deployment is constrained to a maximum annual amount to reflect likely practical constraints. For the purposes of the reserve margin, wind and solar PV are not considered as dispatchable, though in practice they could contribute partly to firm capacity given the region's patterns of demand. Deployment of energy storage, including pumped hydro and batteries, and grid integration between countries with different demand patterns or on different time zones will also allow variable renewables to provide firm capacity.

Generation is then assumed dispatched in merit order with renewables first, then waste, nuclear, coal, and finally gas/oil. In the case of Israel, however, gas is assumed dispatched before coal due to plans to phase out coal. For those countries burning significant amounts of oil, notably Saudi Arabia, Kuwait, and Iraq, a declining amount of oil is dispatched before gas, assuming that constraints on gas availability at some locations at peak times or in general will persist.

Gas generation efficiency is assumed to begin at its actual 2017 figure in each country and improve by 0.45 percent annually (half the historic rate of improvement in Oman), reaching a maximum of 50 percent (a conservative assumption as almost 60 percent is achievable under suitable conditions with modern plants, though probably not on an annual average[107]). This is due to upgrades in existing plants, the deployment of modern CCGTs replacing older plants, and better operational and dispatch practices, all encouraged by higher gas prices. Improved efficiency also reflects the gradual introduction of reverse osmosis desalination plants, which reduce the requirement to run inefficient thermal plants for water production.

Technical losses in transmission and distribution can also be reduced. This is particularly significant in Iraq where 40 percent of generated power is lost in transmission and distribution,[108] 19 percent of this to technical losses. The proportion of technical losses in Iraq is assumed to drop 2 percent annually after 2017[109] (i.e., 19 percent losses in 2018 become 18.6 percent in 2019). Loss reduction is not considered for the other countries, though it could also contribute to electricity and gas savings.

Cross-border electricity trade in the region is generally limited. It has been included in the historic statistics, but the projections assume it only continues at previous levels. More use of trade does, however, represent an opportunity to improve overall generation efficiency (dispatching more efficient plants first), save on required backup capacity, and integrate a higher share of renewables.

Carbon dioxide emissions from the power sector are calculated from the projected combustion of gas, oil (assumed to be equivalent to residual fuel oil number 5; some is diesel and crude oil, which would slightly change the result), and coal (assumed to be equivalent to the average US power generation mix; the emissions from Jordan's oil shale will be higher, making this a slight underestimate), using emissions factors from the US Environmental Protection Agency.[110] Waste-to-energy is assumed to be carbon-neutral. This study covers CO_2 emissions only, not, for instance, fugitive methane; it covers only emissions from the power sector (gas, oil, and coal) and from gas combustion in industry, residences, and transport, not other sources of carbon dioxide.

Industry

Large specific industrial users of gas (aluminum, methanol, direct reduced iron, refinery hydrogen, ammonia, cement, certain chemicals, gas-to-liquids) have had past and future demand estimated from reported figures and output-based benchmarks, allowing for plans for future expansion or new plants. Some countries, notably the UAE, Saudi Arabia, and Iran, have large plans to increase petrochemical capacity, but these will consume ethane, LPG, and naphtha more than methane. Rising gas prices as subsidies are withdrawn will tend to limit the economic viability of new gas-intensive industries, but to an extent government can still decide to continue supplying low-cost gas to the industrial sector.

For other industrial gas demand, a relationship with GDP and population has been derived and used to forecast future demand. This allows for some increasing contribution of industry to GDP as efficiency improves. In addition, oil use in industry (which is only really significant in Saudi Arabia) is assumed phased out at 10 percent annually as for oil in power. Non-energy (feedstock) use of oil is not phased out.

Some sectors—notably cement in the UAE, Oman,[111] and Egypt—have already made a significant switch to coal and waste (refuse-derived fuel) in the face of higher gas costs. If not constrained by carbon policies, this is expected to continue, but no conversion of other industries (e.g., steel) to coal has been assumed. Other large gas-consuming industries may emerge, for instance the production and export of hydrogen, or more gas-to-liquids plants (Shell has signed a memorandum of understanding for a 45,000 bbl/day GTL plant in Duqm, Oman, to come onstream in 2026, which would require roughly 5 BCM per year of feedstock[112]), and these have explicitly been included where plans seem reasonably assured. DNV estimates 5.7 PJ of annual hydrogen demand (all in transport) in the Middle East and North Africa by 2035 (up from 0.065 PJ today), which, at typical steam reforming efficiencies of approximately 80 percent, would require a negligible 0.2 BCM of natural gas to produce.[113] However, the region could also be exporting hydrogen to other areas.

The oil and gas sector is itself a major consumer of oil, gas, and electricity to run its operations. Electrification and connection to the national grid is being pursued in places, including the UAE. Figures for own use of gas in oil production are often not readily available. Electrification and grid connection will raise apparent electricity demand but will save on the use of inefficient turbines at oil production sites as well as allow for more indirect use of renewable-generated electricity. Carbon dioxide injection for enhanced oil recovery, being pursued most actively in the UAE, frees up natural gas from injection; since injection gas is not treated as demand, this change would show up in this study as extra marketable production.

As with the power sector, the industrial sector has a significant opportunity to reduce gas (and diesel) use with renewables, including distributed solar PV (replacing captive generation) and solar thermal (as in the Bill Gates-backed company Heliogen[114]), geothermal or waste for process heat, and steam generation for enhanced oil recovery (as in Glasspoint's 1 GW thermal Miraah project at the Amal field[115] and the planned 2 GW thermal project at Mukhaizna,[116] both in Oman). Distributed PV at industrial sites is included in the total PV estimates, but other renewable use in industry has not explicitly been modeled in this study. Off-grid renewables at remote oil installations, mines, construction sites, military bases, telecommunications towers, border posts, small islands and resorts, water pumps, and farms are likely to grow significantly but will generally displace diesel rather than gas.

Residential and Transport

Only one country in the region has a substantial residential gas market—Iran, due to its cold winter climate, consumed 61 BCM of residential gas in 2017. Gasification has reached close to 100 percent of residences, and gas is used for cooking as well as space and water heating. Egypt and Oman have limited amounts of residential gas use, and allowance is made for northern Iraq to develop some use for winter gas heating. Markets might also develop in parts of Cyprus, Lebanon, Jordan, and Israel, but they are likely to be small and not considered here.

Transport, with compressed natural gas (CNG) vehicles, is likewise minor in the region. Iran consumed 8.3 BCM in 2017, Egypt 0.4 BCM; otherwise, use was insignificant. Israel has ambitions to increase CNG use in cars, but apart from growth in existing markets, further expansion of gas in ground transport is not considered here.

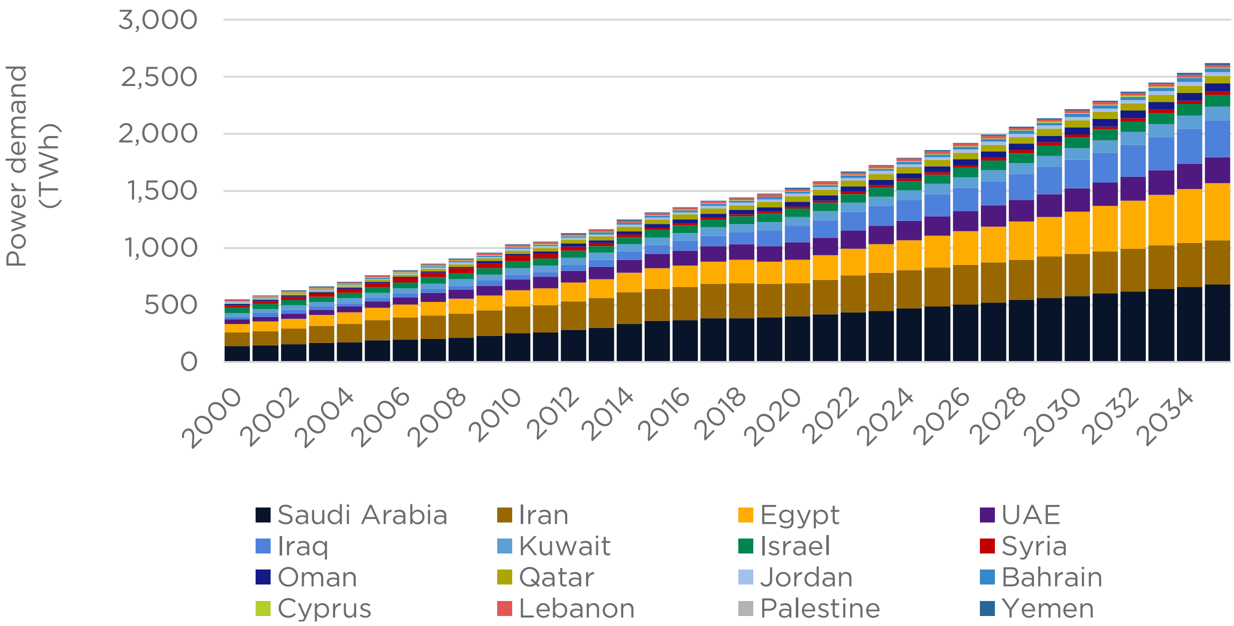
LNG ship bunkering may develop, particularly in the UAE, Qatar, Egypt, and Oman. Global adoption has been assumed at 1 percent annually,[117] international bunker fuel demand has been assumed to grow in each country in line with GDP, and the calculated LNG market share is then applied. This excludes a (probably small) share of domestic shipping. It also excludes the plans of some countries, notably Qatar, Oman, and perhaps Egypt, to expand into LNG bunkering.

RESULTS

Power

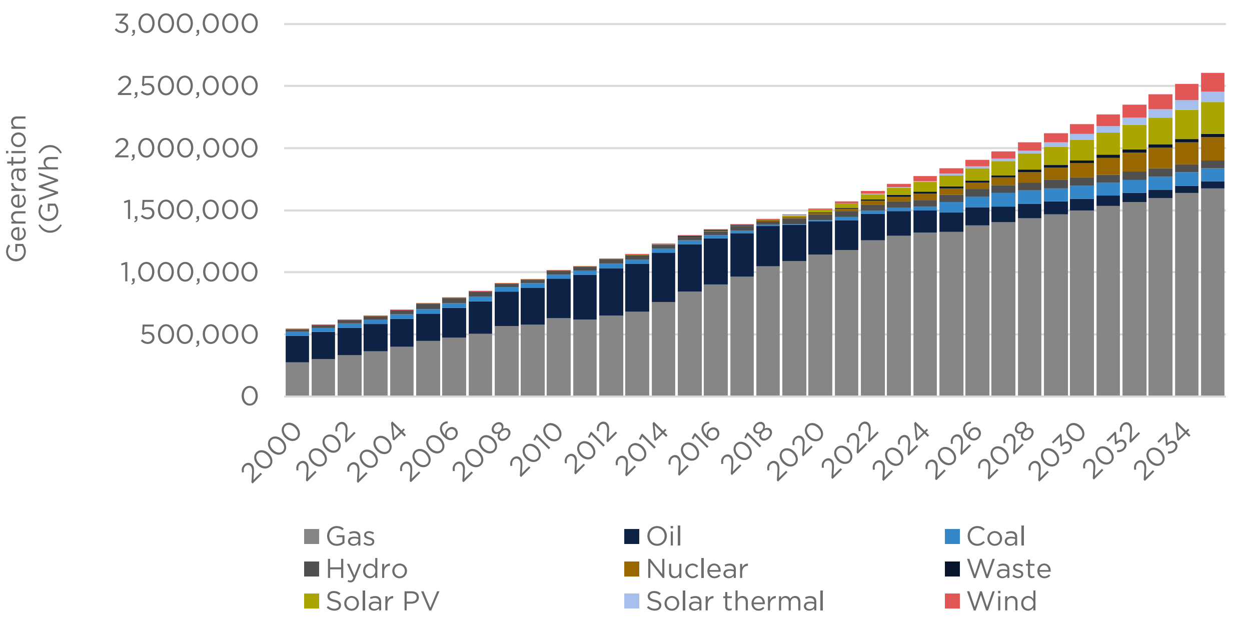
In the base case, electricity demand continues growing relatively strongly (figure 10). Regional demand is dominated by Saudi Arabia, Iran, Egypt, and the UAE, with Iraq becoming important later on. Iran's growth slows down due to sanctions-induced recession and efficiency measures and Saudi Arabia's due to a slowing economy, an exodus of expatriate workers, and subsidy reductions. Demand in Egypt and Iraq, however, grows strongly as supply constraints ease. But overall, annual growth rates in electricity demand during 2018–35 are about half of those realized in 2000–18.

Figure 10: Projected power demand by country



There is expected to be a fast expansion in non-gas generation in the region (figure 11).

Figure 11: Generation by method, historic and forecast



Sources: Historic: IEA; forecast, this study

This is suggested by committed national plans on renewables, nuclear and coal, the rising cost of gas, and the growing competitiveness of renewables.

The Middle East is the only global region still obtaining a large share of power generation from oil—about a quarter (table 3). However, oil's contribution has already been shrinking, and the countries still relying significantly for power generation on oil—Egypt, Saudi Arabia, Kuwait, Iraq, Iran, Cyprus, and Lebanon—plan to phase it out in favor of gas and renewables.

Hydroelectric's further expansion, primarily in Iran and potentially in Iraq, is constrained by water shortages. Apart from the start of the UAE's nuclear reactors (assumed delayed to 2021), further nuclear capacity is possible in Egypt, Saudi Arabia, and Iran; it is included here but faces significant political and economic challenges. Coal is being replaced by gas in Israel, with plans to phase it out by 2025,[118] but Egypt and the UAE (Dubai) are constructing new coal-fired plants, and Jordan is building oil shale (grouped with coal in table 3).

Table 3: Projected power generation by method

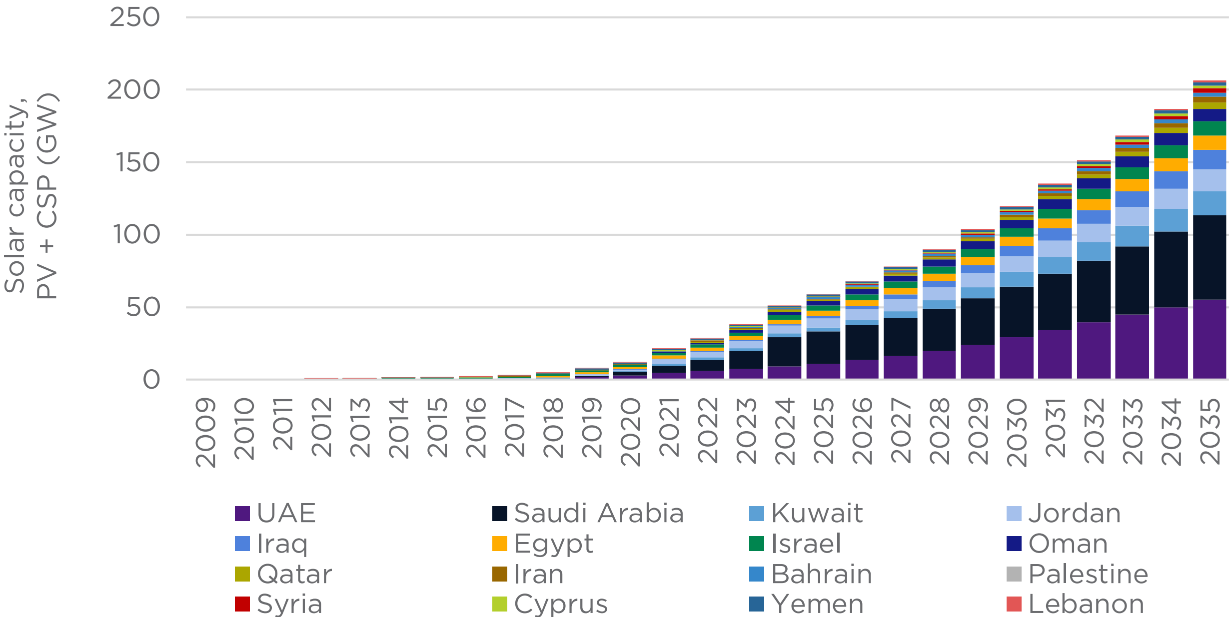
	Generation (TWh)		Share	
	2017	**2035**	**2017**	**2035**
Coal*	22.7	105.4	1.6%	4.0%
Oil	351.1	55.3	25.3%	2.1%
Gas	965.4	1667.0	69.5%	64.3%
Nuclear	7.1	183.7	0.5%	7.0%
Hydro	32.4	65.6	2.3%	2.5%
Wind	3.8	149.4	0.3%	5.7%
Solar PV	3.7	252.8	0.3%	9.7%
Solar CSP	0.3	88.2	0.02%	3.4%
Other Renewables & Waste	2.8	29.3	0.2%	1.1%
Total	**1389.3**	**2344.1**	**100%**	**100%**

**And oil shale in Jordan.*

Not surprisingly, renewables growth is set to be led by solar, particularly PV. While CSP's contribution is here shown as relatively small, this reflects the early stage of its development and its relatively high costs. It could well take a larger share if the cost reductions obtained in Dubai's first bid are continued, if ISCCs are used more widely, and as the advantages of storage for evening/night generation are realized. Wind also has good prospects in Saudi Arabia (with world record low bid prices), Egypt, Jordan, and potentially Iran and Iraq. There is growing attention to waste-to-energy, but its forecast contribution is small.

The region's total solar capacity reaches 62 GW by 2025 and 215 GW by 2035 (figure 12), a bit less than Asia's entire installed capacity in 2017; this obviously represents a massive expansion on current levels. However, the implied average installation rates (3.6 GW annually for Saudi Arabia on average, 3.3 GW per year on average for the UAE, and less than 1 GW annually for each of the other countries) do not appear excessive. The UAE, for instance, already has almost 3 GW of solar PV under tender in 2020, excluding rooftop projects. 4.22 GW of solar power was under construction in MENA during 2019,[119] while Wood Mackenzie forecasts 53 GW to be added across the region by 2024[120] compared to the projection here of 51 GW. Of course, these projections do not allow for a likely short-term slowdown in solar construction because of the COVID-19 crisis and possible budget constraints after that, though these will also reduce power and gas demand.

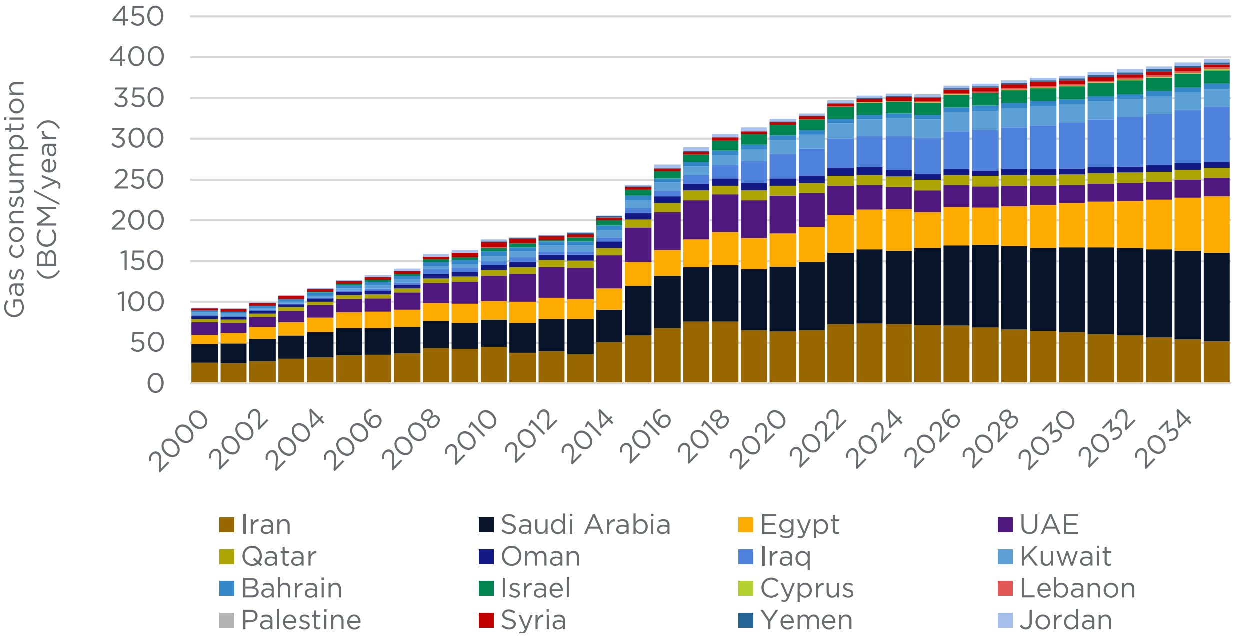
Figure 12: Projected solar capacity (PV and CSP) by country



For wind power, Wood Mackenzie forecasts 13.5 GW built between 2019–28 in the Middle East of which 6.2 GW is in Saudi Arabia,[121] compared to this study's 21.5 GW of which 10.6 GW is in Saudi Arabia.

As noted, the efficiency of gas generation is expected to increase significantly, and the assumptions here may even be conservative given the low standard of most of the existing fleet and the potential for upgrades to combined cycle with reverse osmosis for desalination. Projected gas demand in the power sector is shown in figure 13.

Figure 13: Projected gas consumption in the power sector per country



The very rapid expansion of gas consumption in the power sector in 2014–18 was mainly led by the availability of additional gas in Saudi Arabia, Iran, Egypt, Iraq, and Israel. During the 2020s, the combination of a slower growth in the requirement of electricity from gas (with the introduction of alternative generation) and improved generation efficiency can lead to a plateauing of gas demand even as oil is largely phased out.

This pattern, though, varies significantly by country. Relatively slow demand growth in the UAE, combined with aggressive introduction of solar, coal, and nuclear and the switch to reverse-osmosis desalination, greatly reduces gas in the power sector by 2035. In contrast, a fast-growing population and economy in Egypt leads to rising gas use despite growth in renewables, coal, and nuclear. Closing the electricity supply-demand gap in Iraq also demands a major increase in gas burning.

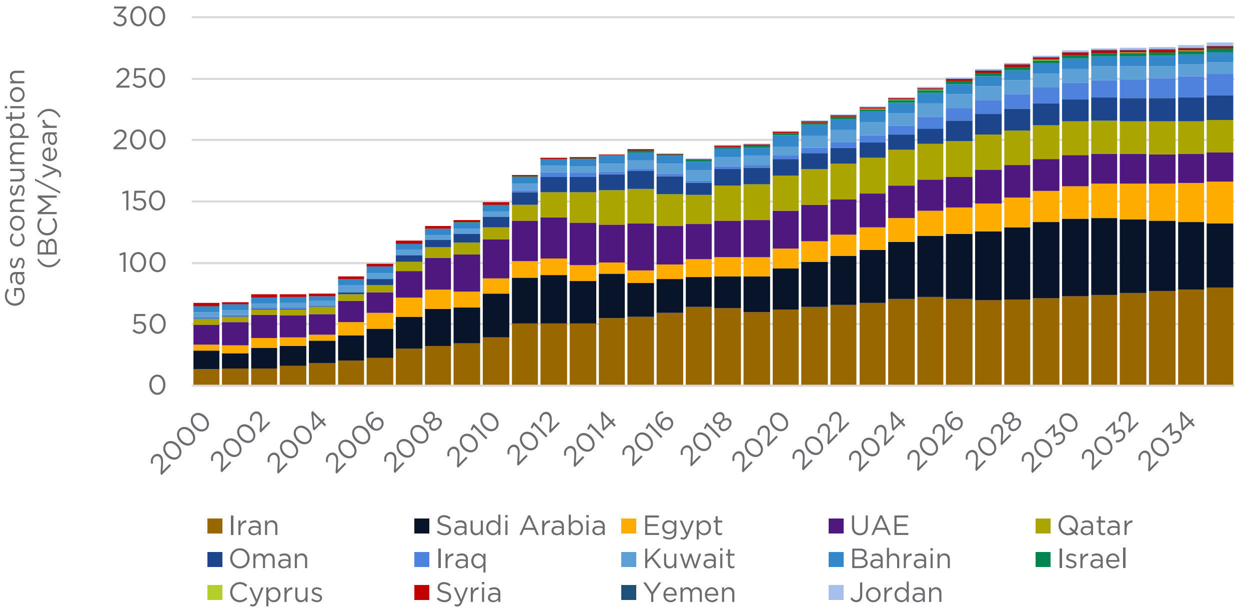
Saudi Arabia is the most significant user of oil in the power sector. 0.912 million bbl/day of fuel oil and crude oil plus a further amount of diesel was used in power generation in 2018, down a little from 2014–17. Former energy minister Khalid Al Falih announced in January 2019 that oil-burning would be virtually eliminated over the next decade, with a move to a generation mix of 70 percent gas, 30 percent renewables.[122] However, there is limited gas transmission infrastructure to the west coast. About 10 GW of new oil-fired capacity is under construction currently, including the 4 GW Jizan integrated gasification combined-cycle plant, which is in the southwest, a location remote from the gas grid, and will use refinery vacuum residue.[123] The kingdom's oil-burning is therefore likely to prove more resilient than Mr. Al Falih's statement, slowing the rise of gas use. The National Renewable Energy Program does seem to focus on installation of solar power in central and western locations, i.e., those currently most reliant on oil instead of gas.[124] Saudi Aramco's bond prospectus indicates oil forming 23.3 percent of power generation in 2030, as against 7 percent in this study, assuming the 10 percent annual phase-out. The prospectus[125] indicates gas at 68.3 percent of power generation in 2030, as against this study's 70 percent, and renewables at 8.4 percent with no role for nuclear by 2030 (the remainder of the generation in the present study is 19 percent renewables and 4 percent nuclear). Gas-fueled power generation grows at 3.4 percent annually during 2017–30 in Aramco's view, versus 4.8 percent in this study.

Industry

Gas demand growth in industry primarily focuses on Saudi Arabia and Iran. Iran has seen a slowdown because of shortages of feedstock (until the past couple of years) and delays in completing new industrial projects due to sanctions. Its future growth is heavily dependent on an easing of those sanctions. Saudi growth has slowed recently but may resume if the industrialization segment of its "Vision 2030" is successful. Saudi Aramco forecasts industrial gas demand growth at 5.3 percent annually from 2017–30, while this study estimates 7.7 percent.[126] Egypt, the UAE, Qatar, Oman, Kuwait, and Bahrain are significant but much smaller users of industrial gas. Iraq's consumption as projected here is small but could rise given its large population and need for reconstruction and employment.

As noted, industrial demand growth is heavily reliant on government plans and their willingness to support the sector with inexpensive gas versus their desire to boost efficiency and raise revenues by cutting subsidies. The gas-based megaprojects of the past two decades, focused on ultra-cheap gas and including basic industries such as fertilizers, methanol, ethylene, cement, aluminum, and steel, are unlikely to recur except in countries that are able to maintain prices for new feedstock well below world market levels—Qatar, Iran, and perhaps Iraq. Instead, new industrial demand will have to focus on mixed-feed crackers (ethane, naphtha, and LPG) with a wider product slate plus a wider variety of smaller projects where gas is only a secondary input. Boosting the share of very cheap renewables-based electricity may be able to sustain the competitiveness of power-intensive products, notably aluminum, but this would displace rather than sustain gas demand.

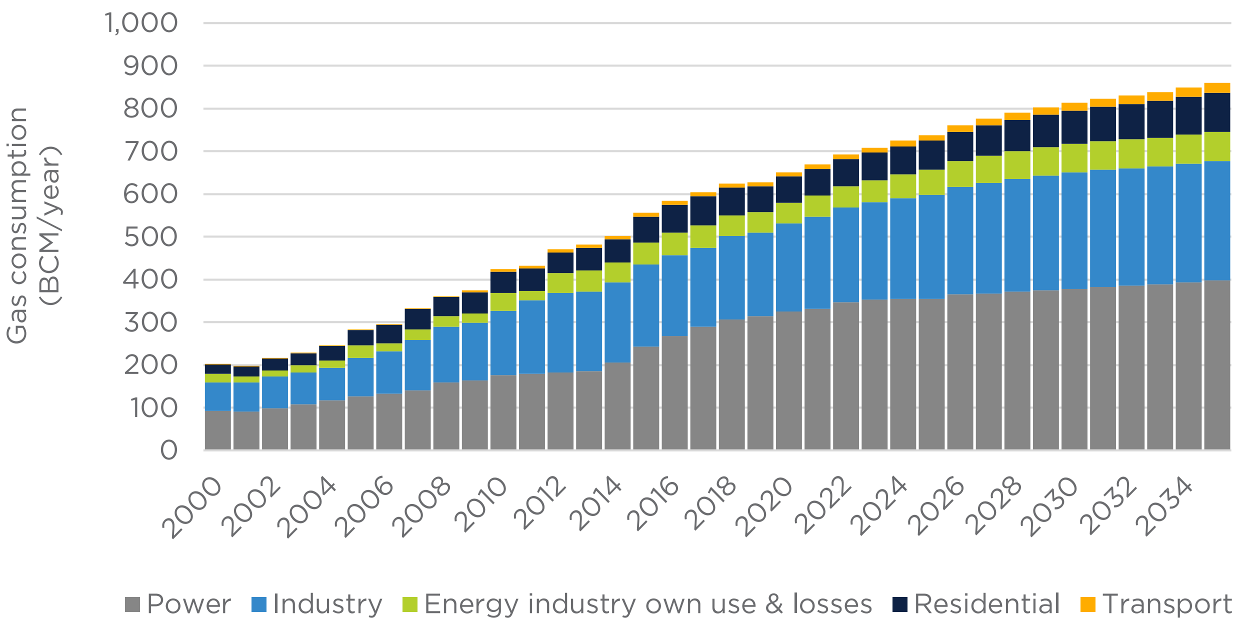
Figure 14: Projected gas use in industry by country



Overall Demand and Sensitivities

Gains in industry are still projected to drive overall regional gas demand growth (figure 15). Nevertheless, even reasonably strong growth in industrial consumption still gives a sharp overall slowdown in demand. Residential gas use, nearly all in Iran, grows steadily but at about 2 percent per year, much less than historic rates of more than 6 percent, because of economic recession, slower population growth, subsidy reform, efficiency improvements, and the saturation of gas connections. Regional transport use, again mostly in Iran, grows strongly but remains a minor component. LNG bunkering reaches 4 BCM in 2030 and 7 BCM in 2035, mostly in the UAE. This is about 11–13 percent of forecast global LNG bunker demand by 2030, slightly more than the region's current share of the world's oil bunkering.

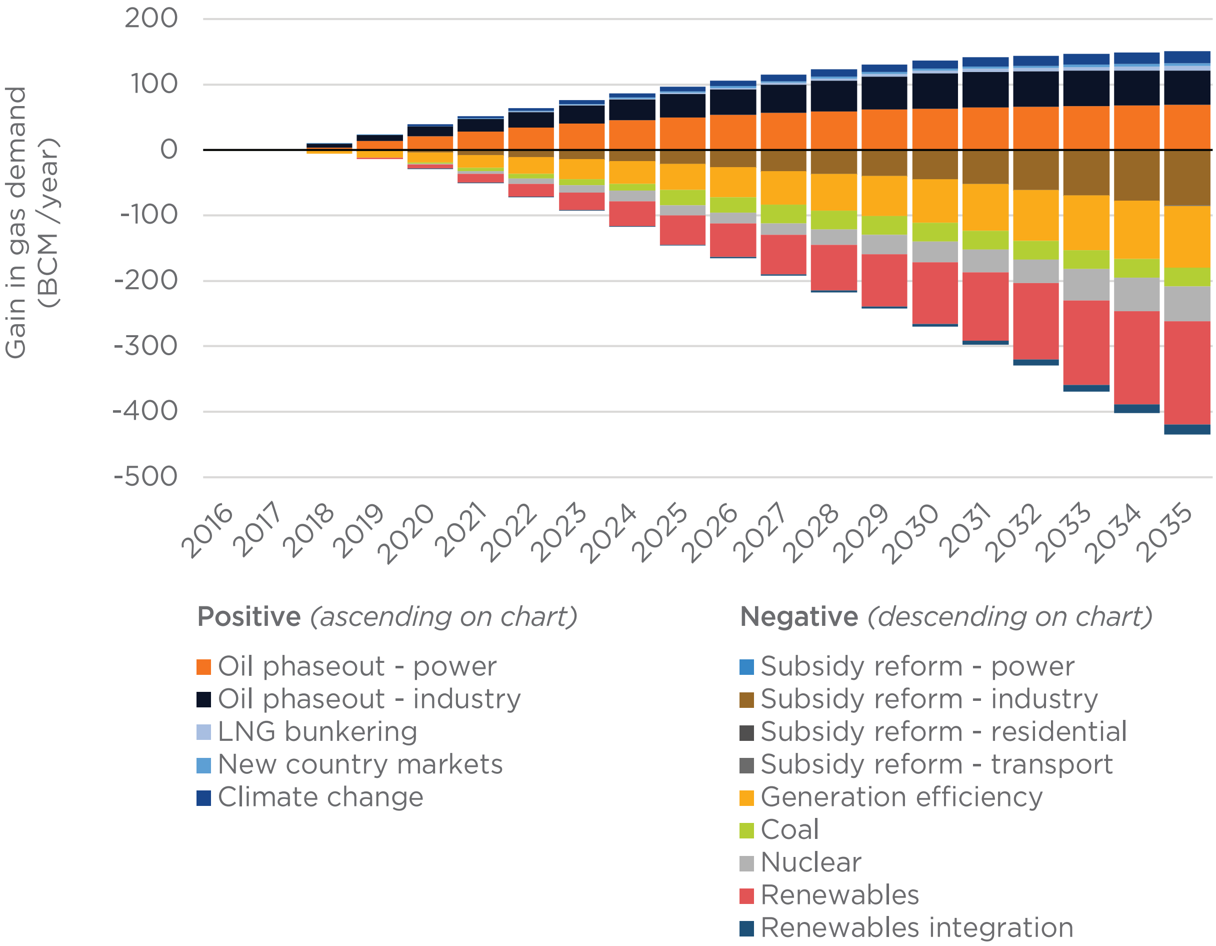
Figure 15: Projected regional demand for gas by sector



As a comparison, this study has 2030 gas use at 230 BCM in Iran, 173 BCM in Saudi Arabia, 67 BCM in Qatar, 51 BCM in the UAE, and 193 BCM for other Middle Eastern countries (excluding Egypt and Cyprus); Rystad has 370 BCM in Iran, 131 BCM in Saudi Arabia, 62 BCM in Qatar, 71 BCM in UAE, and 114 BCM in others.[127] Saudi Aramco forecasts its domestic gas demand growth at 3.7 percent annually, reaching about 150 BCM in 2030.[128] A Stanford study from 2017 forecast Iran's total demand (excluding exports and reinjection) at about 310 BCM in 2030.[129]

The magnitude of impact on gas demand in the power sector of the different measures is shown in figure 16. The new markets (Lebanon and Cyprus) add 4 BCM and LNG bunkering 7 BCM. Climate changes add 19 BCM by boosting air-conditioning demand (partly offset by reducing heating demand in Iran). Phasing out oil ultimately adds about 69 BCM annually to regional gas demand in the power sector and 52 BCM in industry. Generation efficiency is the most important early lever for reducing gas demand, saving about 95 BCM annually by 2035. Subsidy reform saves about 85 BCM by 2035 by its effect of reducing electricity and industrial gas consumption (this excludes other impacts, such as increasing the viability of renewables or more efficient generation). Coal displaces about 29 BCM of gas (obviously at the cost of higher CO_2 emissions), of which 6 BCM is from projects currently in construction, nuclear 53 BCM (12 BCM from projects currently in construction). But renewables have the largest—and growing—impact, displacing 157 BCM by 2035. Relaxing this study's 20 percent limitation on solar PV generation ("Renewables Integration") saves about another 16 BCM by 2035 (indicating that grid constraints on solar PV adoption do not drastically limit its potential during the forecast period). Of course, the lesser impact of coal and nuclear is partly an artifact of the decision not to consider expansion of these types beyond existing plans while allowing indefinite renewable expansion, but this is predicated on a realistic view of their current economic and environmental challenges.

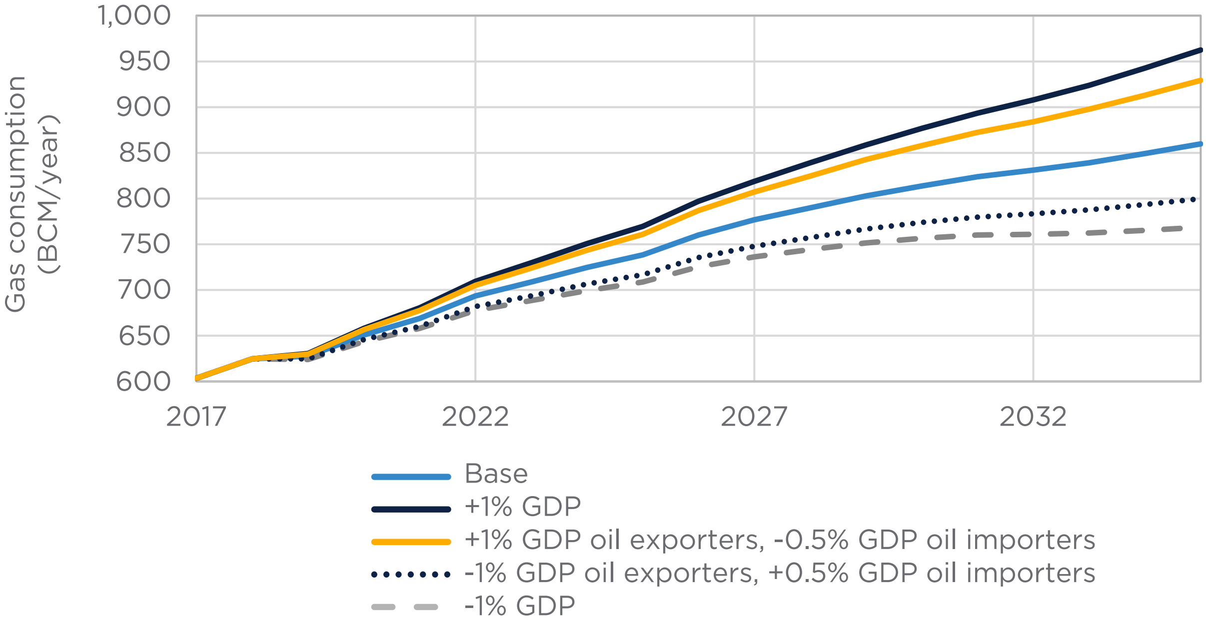
Figure 16: Impact on regional gas demand of different changes



Economic growth rates are an important driver of gas demand. Oil-importing countries in the region (Egypt, Jordan, Israel, Lebanon, Cyprus, Syria) suffer from higher oil prices due to elevated energy costs and import bills, but this is buffered to varying degrees by remittances from expatriate workers in oil-exporting countries, from spillover trade and investment, and from their own oil and gas production.

As a simple illustration, figure 17 shows regional gas consumption under a range of GDP and oil price scenarios. Cases with higher oil prices boost GDP growth in oil exporters and diminish it in oil importers, but this is partly offset by flows of remittances and investment to the importers. The effects shown here may be an underestimate since population growth in the GCC also depends on economic growth (by attracting migrant labor).

Figure 17: Regional gas consumption under different economic growth scenarios



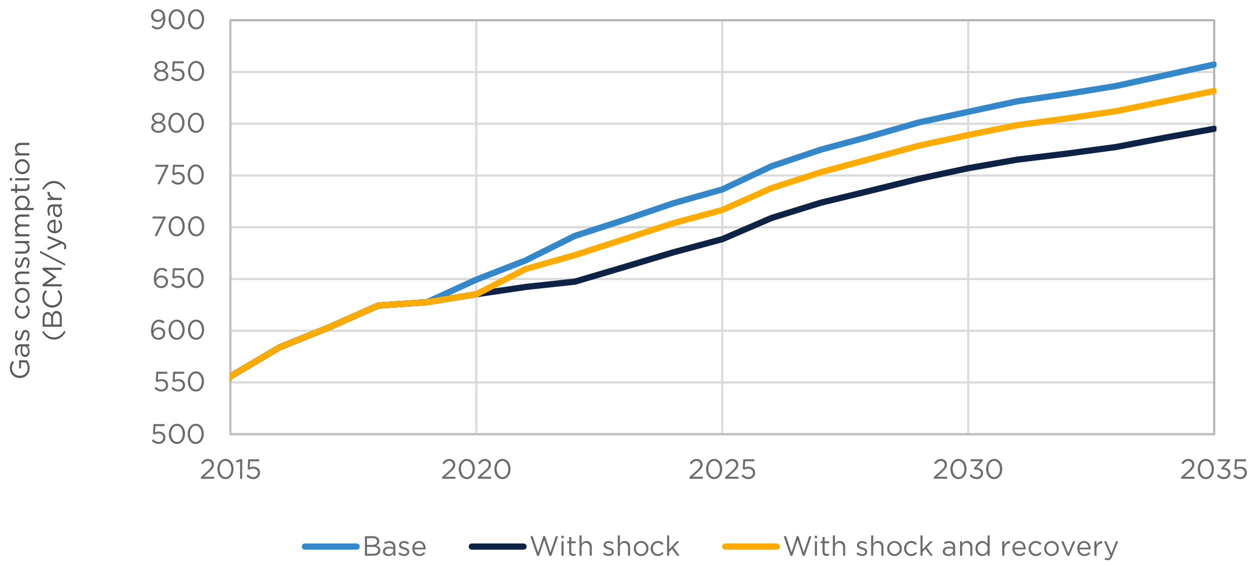
Source: Calculated from this study's gas demand model using the historic correlations of demand per country and sector to oil price and GDP growth

In the case of lower growth rates overall, regional gas demand would plateau from about 2030. A negative oil shock (lower prices) would lead to gas consumption slowing from about 2030 onwards as higher consumption mostly in Egypt partly offsets reductions in the GCC, Iran, and Iraq. However, higher overall regional growth could add nearly 100 BCM of consumption to the 2035 level, approximately Saudi Arabia's entire current demand.

The effect of the 2020 COVID-19 outbreak and oil price drop is shown in figure 18. It is very early to assess the impact of these combined shocks, but for illustration, this chart shows (a) a base case without the shock, (b) a shock in which the Brent oil price averages $30/bbl in 2020 and 2021, and GDP growth is 10 percent lower for oil exporters and 5 percent lower for oil importers in 2021 and 5 percent lower for exporters and 2.5 percent lower for importers in 2021; and (c) a shock-and-recovery case, where the Brent price averages $30/bbl in 2020 and $40 in 2021, GDP growth is 10 percent lower for oil exporters and 5 percent lower for oil importers in 2020 and 5 percent higher for exporters and 2.5 percent higher for importers in 2021. The shocks, even with recovery, permanently reduce regional gas demand by up to 25 BCM in 2021 and 62 BCM in 2035.

This does not account for possible other effects, such as delays in new power (gas or renewable) or industrial projects as a result of the disruption caused by the virus. The UAE's coal and nuclear plants are close to completion and not likely to be seriously delayed, but future projects could be set back, particularly in the worst-affected countries such as Iran. However, in this case, GDP and demand for electricity and gas will also be reduced.

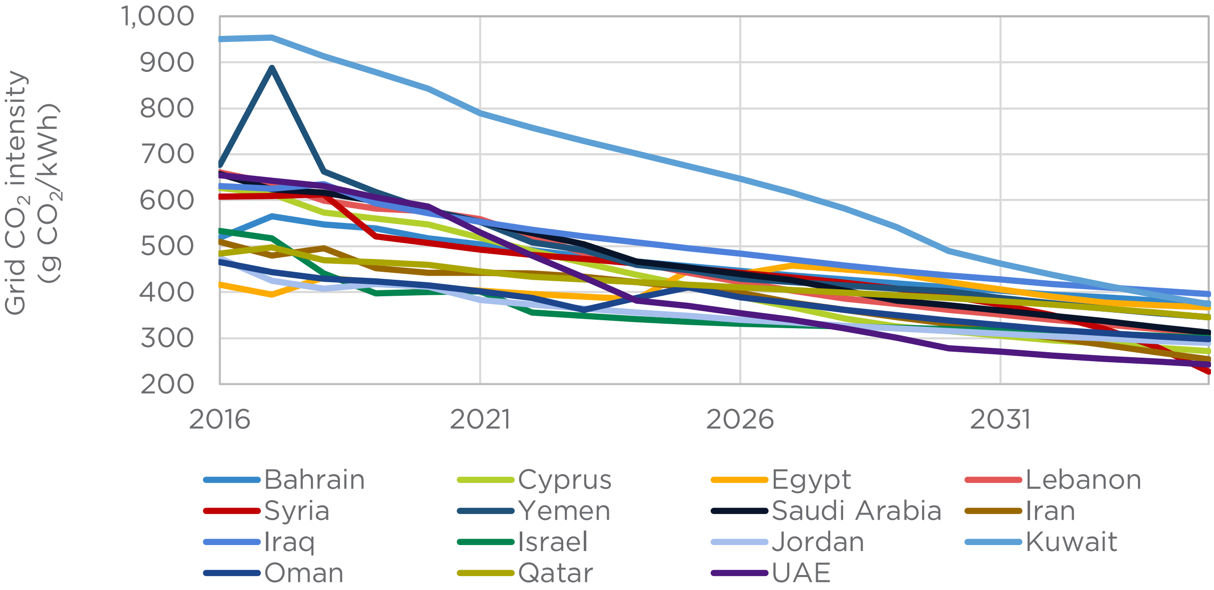
Figure 18: Regional gas consumption with COVID-19 shock



Impact on CO_2 Emissions

Improved efficiency and the introduction of nonfossil generation reduces the grid intensity (grams of CO_2 emitted per kWh generated) for all the countries, partly offset by coal in the countries that introduce it (figure 19). The pattern is uneven, though. Egypt's grid intensity worsens as coal comes in, then improves again as renewables and nuclear gain; Kuwait's, initially the highest, eventually falls with renewables, while Jordan's, Cyprus's, and the UAE's fall to quite low levels. The range in 2018 is from 400–661 gCO_2/kWh, falling to 107–377 gCO_2/kWh by 2035. For comparison, figures for gCO_2e/kWh were South Africa (mostly coal) 961; China (mostly coal and hydro) 620 in 2017; Turkey (mixed coal, hydro, and gas) 543; USA 476 (gas, coal, nuclear, wind, hydro, solar); UK (gas, wind, and nuclear) 277; Brazil (mostly hydro) 93; and France (mostly nuclear) 47.[130]

Figure 19: Projected electricity grid carbon intensity per country



Source: Calculated from this study's gas and power model per country, assuming the base case generation mix with nuclear, coal, and renewables as described above. It covers only carbon dioxide emissions and therefore is somewhat lower than calculations including other greenhouse gases.

Overall, CO_2 emissions from the region's power sector are set to rise but at a much slower rate than in recent years. Estimated emissions of 810 Mt in 2018 rise slightly to 840 Mt in 2035 (889 Mt if oil is not phased out; 796 Mt if oil is phased out and no new coal is introduced). Industrial consumption of gas will keep overall emissions rising (as well as emissions from sectors not covered in this study, notably transport). If carbon capture, use, and storage (CCUS) is introduced on more power or industrial sites, this would reduce emissions and improve the emissions factors shown in figure 19.

Uncertainties

There are a number of factors that could shift regional demand upward or downward. There are the obvious changes to the factors discussed above, for instance that economic and population growth could be faster or slower, geopolitical problems could disrupt countries (as has happened with Syria and Yemen), subsidy reform could be accelerated or delayed, world gas prices could be higher or lower, and so on. As table 4 suggests, the weight of factors, particularly on the technology side, is more toward decreasing gas demand than tending to increase it.

Table 4: Factors decreasing, increasing gas demand

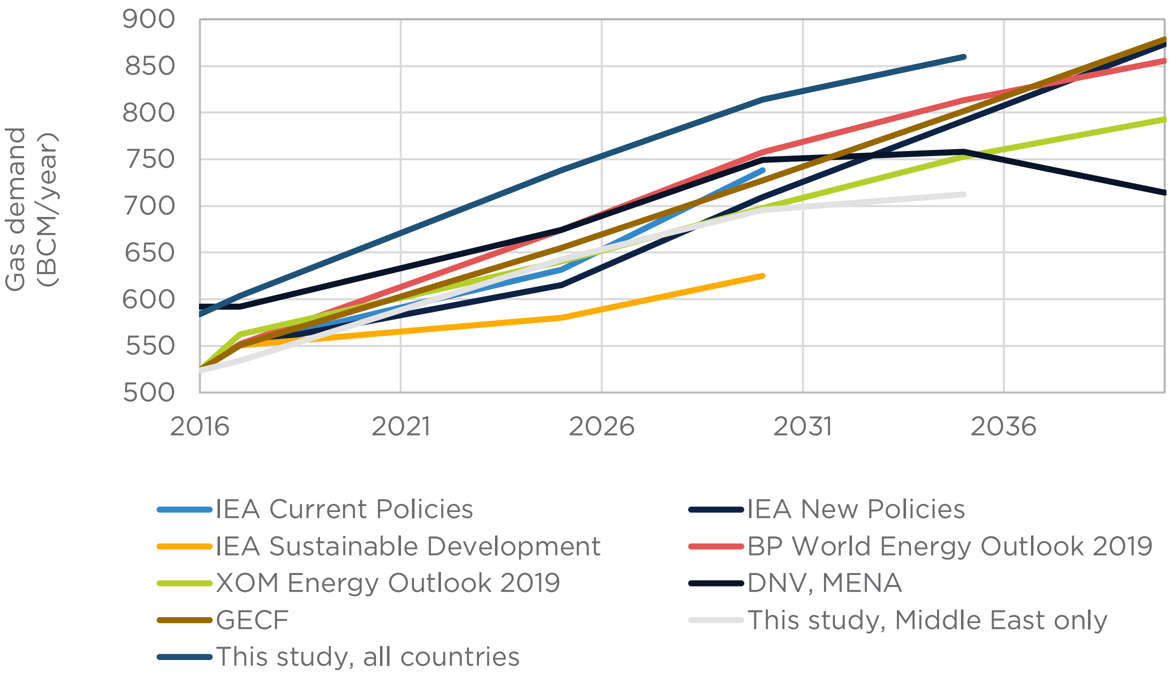
Decreasing gas demand	Increasing gas demand
Population shrinkage by departure of GCC expatriate workers as economies slow and policies favor citizen employment	Faster population growth in smaller GCC states due to an influx of expatriate workers if economic growth revives
Deployment of renewable-driven desalination[131]	Greater requirement for desalination, particularly in countries with little use today (Egypt, Iraq, Iran, Jordan, Syria, Yemen, Lebanon)
Introduction of carbon taxes or other greenhouse gas emissions reduction policies (though these would possibly increase gas demand in the few regional countries using coal or large amounts of oil)	Slower power demand growth reduces the perceived urgency of expanding renewables, coal, and nuclear capacity
Further improvements in renewables be-yond the incremental, including for example low-cost batteries or thermal storage that lower grid integration costs	Difficulties in renewable grid integration that limit its overall share
Increased use of coal and possibly in new markets, including conversion of cement industry	Further large, low-cost gas discoveries (such as Zohr in Egypt) that encourage do-mestic reliance on gas
	Development of novel uses of gas, e.g., hydrogen production
Return to fuel-oil burning driven by availability of cheap fuel post IMO-2020 implementa-tion	Faster phase-out of oil in power generation, particularly in Saudi Arabia, Kuwait, and Iraq
Easing of sanctions on Iran which would al-low for more international investment in re-newable energy deployment	Faster economic growth in Iran as a result of the lifting of sanctions
Serious geopolitical/security issues in one or more regional countries	Faster post-war reconstruction in Syria and Yemen
Greater regional electricity integration that would save on inefficient generation and facilitate use of renewables	Development of intra-regional gas pipelines, e.g., from Iran and Qatar to neighbors, bringing lower-cost gas to deficit countries
Replacement of gas for enhanced oil recov-ery by e.g., carbon dioxide injection, solar steam generation	Increasing use of gas for enhanced oil recovery (gas injection and steam generation for heavy oil)
Deployment of advanced nuclear power (e.g., SMRs)	Deployment of carbon capture use and storage. Would make gas (and coal) more environmentally viable and cut CO_2 emissions but likely raise costs and fuel con-sumption (depending on progress in carbon capture technologies)
Widespread deployment of electric vehicles, using batteries to balance renewable energy	Widespread deployment of electric vehicles, raising electricity demand
Renewable energy deployment beyond the power sector, including e.g., low-cost CSP for process heat and desalination; geother-mal for desalination and cooling; solar ther-mal cooling for buildings	Large-scale export of electricity from the region, raising overall power generation needs

CONCLUSIONS AND IMPLICATIONS

This study has shown that, under quite moderate assumptions for the pace of deployment of non-gas generation, efficiency gains, subsidy reform, economic growth, and with quite an aggressive phase-out of oil as fuel gas consumption growth in the regional power and industrial sectors is set to slow significantly. Indeed, with further policy changes and technological and cost gains in renewables and energy storage, gas demand could be lower still.

As figure 20 shows, this study (line "This study, Middle East only") arrives at substantially lower long-term gas demand projections for the comparable countries than the IEA, BP, or ExxonMobil (note these have all been rescaled to give the same starting demand in 2016). It is above the IEA's "Sustainable Development" scenario. However, this study's projection does not require any exceptional effort on the part of regional governments to achieve "sustainability;" instead, it just assumes the continuation of existing policy trends on subsidy reduction, energy efficiency, and the deployment of renewables where economically justified.

Figure 20: Comparison of gas demand projections



The rapid growth in the renewable sector can be sustained for most countries to significant penetration levels (30–40 percent of capacity), particularly when accounting for reasonable improvements in energy storage technologies over the next fifteen years. For a few countries forecast to reach very high renewable shares, greater grid integration with neighbors will likely be required. This may shift some gas demand between countries while keeping the regional total about the same. Extra-regional electricity exports are also possible but face challenges of distance and politics. Finally, surplus electricity could be converted to an exportable product such as hydrogen.

Industrial demand is still set to grow, though this depends on maintaining competitive pricing despite rising input costs of gas (whether imported LNG or higher-cost domestic gas). Replacing oil currently used in industry will support gas demand, though this would require extension of the gas grid particularly in the west of Saudi Arabia. Large, new projects predicated on very cheap feedstock will only be possible in a few countries such as Iran, Iraq, and Qatar or if the government provides specific price concessions since blanket subsidies have generally proved too costly and inefficient.

Several regional countries are planning aggressive expansions in gas output for domestic use—notably Saudi Arabia and the UAE. In the East Mediterranean, Israel, Cyprus, and Egypt, and perhaps Lebanon in future are competing for the same regional markets, which are either small (Jordan, Lebanon, Cyprus, and Israel), largely self-sufficient (Egypt), or politically quite inaccessible (Turkey and, for now, Syria).

This does suggest that hopes of the region's becoming a major LNG demand center are overstated. For instance, Snam forecast an increase in the Middle East's LNG imports of 9.5 Mtpa between 2018 and 2030[132] (about 13 BCM per year), doubling 2017's imports of 17 BCM (plus 8.2 BCM to Egypt). Shell sees Middle East plus African LNG imports rising by about 45 BCM by 2040.[133] However,

- Dubai's LNG imports have fallen over the past two years, leading a fall in total UAE imports of 1.6 Mt in 2018 versus 2017[134] and 0.7 Mt in 2017 versus 2016[135] (they rose in 2019, but this was probably the temporary effect of opportunistically taking advantage of low prices to fill storage and of a technical interruption in the Dolphin pipeline[136]). Development of the new Jebel Ali gas find could also reduce LNG import requirements;
- Egypt's LNG imports have virtually ceased (and exports have resumed) because of expansion of its own production;
- Jordanian imports (3.4 Mt in 2017, 2.6 Mt in 2018) could be replaced by supplies through the pipelines from Egypt and/or Israel;
- Lebanon's planned terminals have been held up, but again its demand could instead be met by its own production, if exploration is successful, by a pipeline from Cyprus, or, political situation permitting, from Egypt via Jordan and Syria;
- Bahrain's 6 Mtpa LNG terminal is intended to start in 2020,[137] but it also hopes to develop its own unconventional gas;
- Sharjah has targeted a 2020 start-up for 3-4 Mtpa capacity but made a new onshore gas discovery with ENI in January 2020,[138] and is potentially a recipient of surplus gas from Abu Dhabi;

- Kuwait is a significant importer (4.3 Mt in 2017,[139] 3.5 Mt in 2018,[140] and expanding its 5.8 Mtpa terminal to 11.3 Mtpa by 2021) despite its domestic Jurassic gas expansion; and
- Saudi Arabia's ambitious plans to scale up gas use may lead it to turn to LNG imports in a modest way[141] but probably not on a large scale because of the impact on cost-competitiveness and supply security, with a preference for developing the kingdom's unconventional gas (Jafurah and others).

Much has been written on regional gas pipelines and particularly the failure of the Middle East to develop a widespread pipeline network because of political and commercial problems. With demand rising more slowly and major plans for production expansion, some countries may now move from the shortage of recent years to a glut. This may lead them to explore exports to neighbors, and indeed the UAE and Saudi Arabia have recently discussed a pipeline link,[142] perhaps including Oman and Kuwait. A connection between Bahrain (using its LNG terminal) and eastern Saudi Arabia is possible.[143] The Eastern Mediterranean countries have also been making gradual progress on repairing and creating pipelines between them. But cost-competitive renewables probably put potential gas-buying countries in the stronger bargaining position.

Otherwise, some regional countries could expand LNG exports, but apart from those that are restarting or debottlenecking existing plants (Egypt [in future also re-exporting Israeli and/or Cypriot gas], Oman, and potentially Yemen), only Qatar appears to have the abundance of low-cost resources required to build new plants (Oman may construct a small-medium plant for LNG bunkering). Iran will likely continue to be prevented by internal bureaucracy and sanctions. Cyprus's recent finds might give it an opportunity for LNG exports, perhaps in combination with Israel if it can overcome the hurdles of costs and regional politics and if pipeline projects do not materialize. But in general, LNG exports based on high-cost (deepwater and shale[144]) gas resources will struggle to compete with new projects in North America and East and North-West Africa.

As the region shifts from a shortage of gas with low regulated prices, to, overall, a surplus with higher market-influenced prices, opportunities for new production will open up. But this production will demand a much more active and competitive marketing effort. Potential opportunities identified here include the following:

Large potential (20–70 BCM/year by 2035)

- Faster phase-out of oil in power generation and industry
- New regional and perhaps extra-regional markets by pipeline
- Debottlenecking and new LNG trains—but only in countries with very low-cost gas production (primarily Qatar)
- Replacing planned new coal power on cost and environmental performance
- Meeting growing power demand in deficit countries—particularly Iraq, also Lebanon

Medium potential (10–20 BCM/year by 2035)

- Highly efficient new gas-fired generation, possibly with carbon capture and storage with CO_2 used for enhanced oil recovery
- Steam generation for heavy oil recovery—but competes with solar steam
- New moderately gas-intensive industry
- Post-war reconstruction in Syria, Yemen, and northern Iraq
- Development of residential gas markets, including Egypt and the Kurdistan region of Iraq
- LNG ship bunkering and LNG/CNG road fuel
- New industries such as hydrogen
- Extra-regional electricity exports

Markets can grow, but the explosive subsidy-fueled growth of the past two decades is a thing of the past. Commercial creativity, marketing skill, cross-border coordination, and cost control will rise to prominence as in other gas-consuming regions. Regional gas pricing will have to evolve to become more transparent, flexible and reflective of true market conditions, at least by linking to import/export parity. This will eventually allow an evolution toward true traded gas markets that will properly allocate surpluses to the highest value uses. With a potential excess of gas and renewable energy, extra-regional gas and electricity exports can gain (or regain) prominence as long as delivered costs are competitive and political barriers overcome. The regional gas industry, including both the leading national oil and gas companies, and international firms, will have to adjust their plans to this new reality.

NOTES

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8. The six GCC states (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE), Iran, and Iraq.

9. The six GCC states (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE), Iran, and Iraq.

10. Using BP Statistical Review of World Energy 2019 figures.

11. Using BP Statistical Review of World Energy 2019 figures.

12. Regional oil output grew 0.9 percent per year during 2000–10 and 2.6 percent per year during 2010–18, therefore growth in associated gas output was well short of gas demand

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