Iraq's Energy Sector

A Roadmap to a Brighter Future

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Foreword

In 2012, the International Energy Agency (IEA) released the first in-depth study of Iraq's energy sector. We had an exceptional opportunity to engage with Iraq and produced a unique perspective on the country's outlook, covering the role of energy in Iraq's economic and social development as well as the increasingly important role that Iraq was set to play in global energy affairs. That project is still the source of immense pride for me, and represents one of the highlights of my career.

Since that study, Iraq has managed to increase its oil production by nearly half. This is an enormous achievement at a time when Iraq was battling ISIL and contending with a period of volatile oil prices that severely affected its economy. These results are a testament to the country's tenacity and determination, which gives me hope for what can be achieved in the future.

Our updated report underlines that Iraq will continue to be central to the stability of global oil markets. We also analyse the potential for Iraq to use its natural gas wealth much more productively than it has until now. However, while the oil and gas sectors are fundamentally important, our focus in this analysis is firmly on the electricity sector, which has suffered from decades of underinvestment and underperformance.

Improving the security of electricity supply by reducing the blackouts suffered by most Iraqi families is one of the most urgent challenges facing policy makers. Our analysis identifies ways to alleviate immediate strains on the system, while also setting a pathway towards a more reliable, affordable and sustainable power system in the longer term. This report makes pragmatic and realistic recommendations to the Iraqi government to achieve these goals.

I am convinced that the positive convergence of a number of factors, not least of which is the major improvement in the security situation, offers Iraq a huge opportunity to remedy these issues.

The findings of this report are those of the IEA alone, but the process of producing it has been a collaborative one in which the team has worked closely with counterparts across Iraq. I would like to extend my appreciation to all those that provided their support.

My sincere hope is that the findings in this report will help Iraq build a productive and vibrant society on the foundation of reliable, affordable energy. My colleagues and I at the IEA stand ready to help Iraq on this journey.

Dr. Fatih Birol
Executive Director
International Energy Agency

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Findings and recommendations

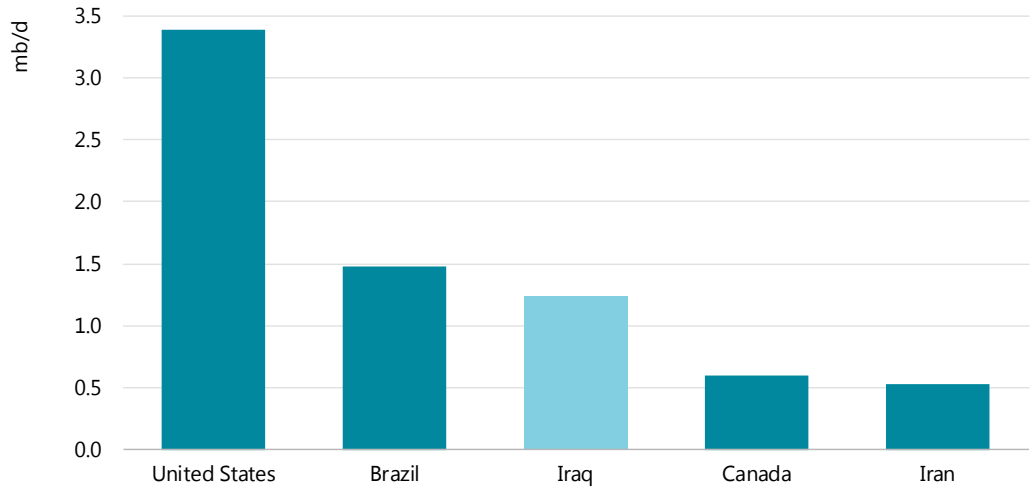
A changing context for Iraq's energy outlook

- A changing global energy system is posing critical questions for Iraq. The shale revolution in the United States, technological change, the drive for greater energy efficiency and the long-term response to environmental challenges all imply sustained pressure on development models that rely heavily on hydrocarbon revenues.
- Iraq also faces a profound need to develop its domestic energy infrastructure, in particular in the electricity sector. The task of doing so has been complicated greatly by the war against ISIL and by the rollercoaster ride in oil prices since the last *Iraq Energy Outlook* was published in 2012, and the squeeze that these factors have exerted on state capital expenditure.
- The risks of high dependence on volatile hydrocarbon revenue have prompted the authorities to renew a commitment to reform and diversify the Iraqi economy. There are some signs of progress but this remains a huge long-term challenge. How Iraq meets the expectations of a youthful and growing population, in a changing policy and market environment, is a critical question both for Iraq and for global energy markets and security.
- The reform agenda for producer economies is much broader than energy, but relies on a well-functioning energy sector. For Iraq, maintaining upstream investment and the advantages of a large, low-cost resource base are vital, but so are pricing, efficiency and a host of changes in the electricity sector.

Oil and gas

- Iraq's oil sector has navigated well a very turbulent period in the last decade, managing to nearly double its output despite the war against ISIL and large swings in the oil price. As a result, Iraq has accounted for around one-fifth of the net increase in global supply over this period, and is now the fifth largest producer in the world.
- In our projections, Iraq's production increases by around 1.2 million barrels per day (mb/d) over the next 10 years. This is a smaller increase than that seen over the last decade, but still cannot be taken for granted. The next phase of Iraq's oil development will depend not only on international market conditions, but also upon three factors that are within the grasp of the Iraqi authorities: ensuring sufficient water for injection; attracting foreign capital; and a conducive political and security environment. In reaching almost 6 mb/d of production in 2030, Iraq would overtake Canada and become the world's fourth-largest producer.
- Progress on provision of adequate water for oil recovery is essential. Without it, production rates could struggle to climb much beyond their current levels. To reach the projected production levels, Iraq would need an additional 3 mb/d of water for injection into reservoirs.

Top five countries by increased oil production, 2018 to 2030



Iraq makes the third-largest contribution to the increase in global oil supply in the period to 2030.

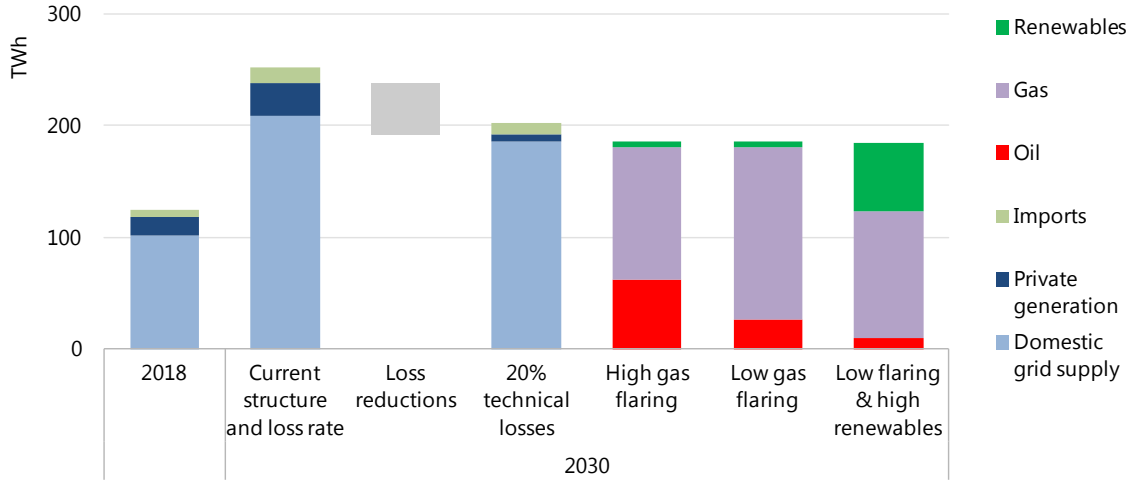
- Iraq's refining sector is not well matched to the country's needs. Only 60% of the nominal 1 mb/d of refining capacity was utilised in 2018, and the product slate is weighted heavily towards heavy fuel oil. This means high dependence on imports for many of Iraq's oil product needs, at a current annual cost of some USD 2-2.5 billion. The full rehabilitation of the Baiji refinery would help remedy the most immediate pressures. However, without an increase in upgrading or hydrotreating facilities, the surfeit of heavy fuel oil may be increasingly problematic for Iraq, especially given the likely plunge in global demand for this product as a result of new quality specifications for international marine bunker fuels.
- Iraq is not short of natural gas, but it continues to use gas far less – and far less productively – than most of the countries in the region. Rising oil production has meant an increase in gas flaring to some 16 billion cubic metres (bcm) per year. The Basrah Gas Company has made recent progress and is now capturing and processing around 10 bcm of gas per year. But these efforts will need to be accelerated, particularly when considering the growing need for gas in power generation and the costly reliance on pipeline imports.
- In our outlook, Iraq's marketed gas production increases to around 50 bcm over the next decade. Given that Iraq's associated gas is ethane-rich, progress in the upstream could support a significant expansion in petrochemicals output as well. How Iraq produces and uses its gas is a bellwether for the overall process of reform and modernisation.

Electricity

- Constrained budgets and damage wrought by war mean that Iraq is not producing enough electricity to satisfy demand. Rising demand is widening this gap, with Iraq's population growing at a rate of over 1 million per year. Where incomes allow, local neighbourhood generators are used by many households to remedy this issue, but this is a costly stop-gap measure. Over the period to 2030, electricity demand is set to double, reaching about 150 terawatt hours (TWh) (17.5 gigawatts [GW] average throughout the year).

- The International Energy Agency has carried out an in-depth analysis to identify short-term and medium-term measures that can alleviate the most immediate pressures in the electricity sector.
- The most severe and immediate shortfalls in supply can be mitigated by: the rapid initiation of network maintenance, targeting a small number of high-impact upgrades; the rapid deployment of new mobile power units; the upgrading of some existing power plants; and the enforcement of tariff regulations for all neighbourhood generators.
- Over the longer term, without changes to the current structure of electricity supply and improvements to the network, then domestic generation, imports and neighbourhood generation would need to double by 2030, for a total supply of over 250 TWh. However, there are many opportunities to improve on this outcome.
- There is huge potential to cut network losses, which are among the highest in the world: reducing these losses by half would help to improve dramatically the efficiency of grid supply, effectively increasing available capacity by one-third.
- On the supply side, more gas needs to be captured and put to use in efficient power plants. And, last but not least, Iraq needs to take advantage of its abundant renewables potential and increase the share of solar photovoltaics (PV) – in particular – in the power mix. Bringing the share of renewables up to 30% of electricity supply by 2030 would bring environmental gains without increasing total costs for electricity supply. Compared with continuing the current structure of electricity supply, reducing network losses and relying more heavily on gas and renewables would free up 9 bcm of gas for other uses in 2030, plus 450 thousand barrels per day (kb/d) of oil for export.

Potential pathways for electricity supply in Iraq to 2030



Targeted efforts are necessary to achieve affordable, reliable and sustainable electricity supply

Policy recommendations

Overall:

- Make an efficient, well-functioning energy sector the bedrock of a more diversified and prosperous Iraq, based on: the revenues from adequate and timely investment in the upstream; a much more productive use of the nation's gas resources; and a step-change in the affordability, reliability and sustainability of electricity provision.

Oil and gas:

- Expedite the development of projects that can deliver water to the southern fields for oil recovery, notably the Common Seawater Supply Project, while encouraging companies to enhance efforts on produced water reuse and recycling.
- Push for full implementation of gas flaring reduction projects over the next two years. Clarify ownership of produced gas and responsibilities for its productive use; develop mechanisms to monetise ethane.
- Expedite full restoration of the Baiji refinery, which would increase Iraq's operational refining capacity by 30% and reduce the USD 2-2.5 billion bill for annual oil product imports.

Electricity – short term:

- Take four measures to enhance the immediate resilience and operational performance of the electricity system:
  - Step up network maintenance, focusing on a small number of high impact areas.
  - Purchase mobile solutions for rapid availability and locational flexibility.
  - Remunerate maintenance and efficiency upgrades for existing power plants.
  - Enforce tariff regulations for all neighbourhood generators.

Electricity – medium term:

- A continuous focus on network refurbishment, maintenance and upgrades.
- Refurbish existing power plants to close the gap between available and installed capacity.
- Increase tariff collection for network connections, and reform grid and neighbourhood tariffs to incentivise more efficient use of electricity and bring down peak demand.
- Incentivise investment in new capacity by offering accelerated capital recovery.
- Develop a renewable energy industry, starting with a first round of solar PV and wind projects to build confidence, and then build on proven successes.

Chapter 1: Energy in Iraq today

Introduction

Iraq has a central role in global energy markets. The most comprehensive review of this role and Iraq's immense potential for economic and social development following decades of conflict was developed by the International Energy Agency (IEA) and published in *Iraq Energy Outlook 2012* (IEA, 2012). This report examines the situation since then. Why is the IEA revisiting the topic in 2019? The short answer is to reflect on the changes that have taken place in Iraq and in international markets in the intervening period. These changes have been profound.

Notably, the rollercoaster ride in world oil prices has severely affected Iraq's fiscal revenues and its ability to progress its long-term economic development plans. In the same period, Iraq had to divert considerable attention and resources to fighting a war against ISIL. Therefore, the starting point for this analysis has been recalibrated to take into consideration a set of local circumstances that are fundamentally different to those in our previous review. As well, there have been significant changes in global energy markets. While the rise of US tight oil was flagged in the 2012 report as the "major [oil supply] trend of importance to Iraq in the near term", here we update our assessment of what changing energy market dynamics mean for Iraq. This report sheds light on the crucial role Iraq still occupies as a producer and major supplier needed to meet global oil demand.

Considerable progress has been made in a number of areas since 2012. In the oil sector, production has increased by half, to reach almost 5 million barrels per day (mb/d) by end-2018, propelling Iraq to the status of the world's third-largest crude oil exporter. But progress has not been uniform across energy sectors. Electricity generation increased by almost 90% between 2012 and 2018, but the gap between supply and peak demand is wider today than in 2012. Particularly in the summer months, power supply to meet peak demand is inadequate and this is a major concern for citizens across the country.

As well as serving as an update to the *Iraq Energy Outlook 2012*, this report highlights and evaluates the various the options available to policy makers to strengthen the prospects for Iraq's energy sector. It provides recommendations for the government's consideration in pursuit of its immediate, medium and long-term priorities.

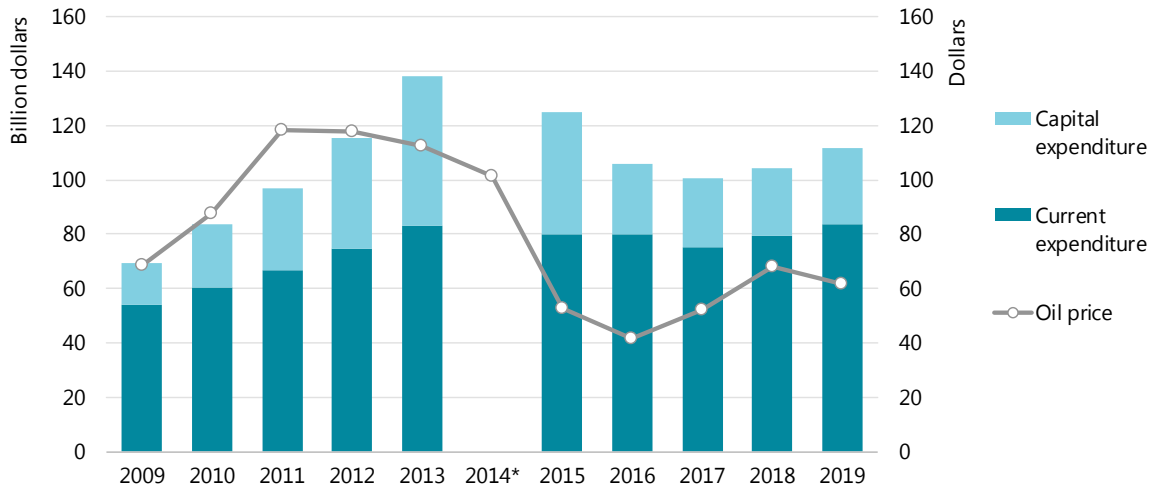
Energy and the economy

Macroeconomic trends

The energy sector is integral to the broader Iraqi economy. Oil and gas account for almost 60% of gross domestic product (GDP), 99% of export earnings and 90% of government revenues (World Bank, 2017): the Iraqi economy is one of the most oil-dependent in the world. The relationship between hydrocarbon revenues and the national budget is crucial and explains some of the broad macroeconomic pressures that have prevailed during times of revenue volatility (for example when oil prices dropped in 2014, the start of a period of lower oil prices).

Government expenditure has closely tracked movements in oil prices, rising when they were high and falling when they were low. Such "pro-cyclical" fiscal policy has important implications for the economy as whole. At the low point in the recent oil price cycle, Iraq's monthly oil revenue fell to less than US dollars (USD) 2 billion, while fiscal obligations (e.g. salaries, pensions, social spending) were more than USD 6 billion per month, leaving a USD 4 billion deficit to honour basic spending (discounting any expenditure on capital projects). Iraq financed the deficits through a mixture of increased borrowing (including from international financial institutions) and tapping its international reserves, which fell by USD 33 billion in 2016 compared with 2013 levels.

Figure 1. Federal government budget in Iraq, 2009-19



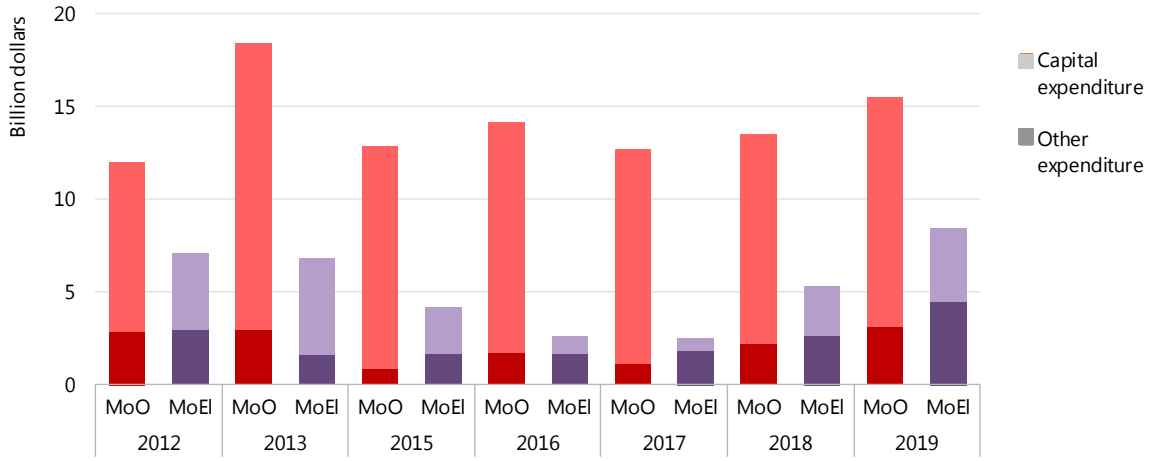
* Iraq did not pass a budget in 2014, so there are no spending data for the year.
Note. The oil price reflects the IEA average price. The oil price for 2019 is the January to March average.
Source: National Accounts.

Government spending patterns have been closely correlated to oil price movements.

Between 2009 and 2013, when oil prices were rising, the size of the federal budget doubled as the state increased employees and raised public sector salaries. Lower oil prices from mid-2014 forced a major fiscal retrenchment. Despite a significant year-on-year increase, in 2019 the federal budget is around 20% smaller than in 2013. The previous decision to increase spending on public salaries and entitlements proved difficult to reverse when revenues from oil declined. The burden of the retrenchment in Iraq has disproportionately fallen on the allocation for capital expenditure, which is now half its 2013 level, while the amount allocated to current expenditure (largely made up of salaries and pensions) has remained relatively stable (Figure 1). The inability of the government to provide fiscal stimulus during the period of relatively low oil prices hit domestic consumption, and economic growth fell from an average of 7.6% in 2013 to just 0.7% in 2014.

The energy sector portfolios have not been immune to this fiscal retrenchment. The annual capital budget allocated to the Ministry of Oil, which is charged with remunerating international oil companies, was one-fifth lower in the 2015-18 period than in 2013, thus affecting Iraq's ability to pursue its long-term oil and gas development targets. The effect has been even starker in the Ministry of Electricity, where the budget for capital expenditure is down by more than 60% compared with 2013 levels (Figure 2).

Figure 2. Capital and current expenditure allocated to the oil and electricity ministries in the federal government budget, 2009-19



Notes: MoO = Ministry of Oil; MoEl = Ministry of Electricity. Iraq did not pass a budget in 2014, so there are no spending data for the year.

Source: National Accounts.

The Ministry of Oil has maintained a relatively healthy capital budget through the oil price downturn, but spending has fallen sharply in the electricity sector.

In the first 11 months of 2018, the Iraq government spent five times more on salaries, pensions and social welfare than it did on capital projects. The USD 10 billion it disbursed for capital projects represents only half the amount allocated in the 2018 budget. This illustrates not only that allocation is diminished, but also that it is unable to efficiently spend available capital. This is somewhat less of an issue in the oil sector, which accounted for three-quarters of government capital spending over the last three years (while non-oil investment amounted to less than 5% of the government's total spending over the same period) (Iraq Oil Report, 2019).

Demographic trends

Since the *Iraq Energy Outlook* in 2012, the population has expanded by over 5 million and is now growing at a rate of 1 million per year. More than 40% of the population is under the age of 14. This young and growing population could provide the vitality needed to propel innovation and economic growth, though this is contingent on an economy that is able to create productive jobs in accord with demand. This has not been the case so far, as the rapid growth in the population of working age has not been matched by growth in private sector job creation, and instead, Iraq has relied on the public sector to keep a lid on unemployment. The public sector has expanded from around 1.2 million employees in 2003 to about 3 million today. This has placed considerable strain on the federal budget – more than USD 30 billion in 2018 – equivalent to over one-third of the country's estimated net income from oil and gas that year. Many of the jobs created in the public sector do not add to economic productivity, contributing to a significant decrease in labour productivity over the last five decades, with productivity now at around half the level it was in 1970. Furthermore, despite the significant increase in public sector jobs, youth unemployment remains high at around 40%, which could add significant strain if unaddressed in the years ahead.

Iraq's population is expected to increase by nearly 15 million by 2030. If we assume that in 2030 the public sector employs the same proportion of the labour force as today, the public sector

wage bill would increase by almost 150%, even without any real increase in average salaries, to reach USD 72 billion in 2030 (equivalent to around 40% of its expected net income from oil and gas in 2030).

Environment

Iraq has suffered significant environmental degradation over the span of several decades. Water shortages, exacerbated by rising domestic demand, poor water management (especially in agriculture), aging infrastructure, a changing climate and the construction of dams upstream have become a key constraint to economic development and one of the leading causes for public disquiet in recent years. Roughly 70% of Iraq's water supply originates from neighbouring countries. The Ministry of Water Resources estimates that Iraq's river levels have fallen by up to 40% in the last 20 years.

The quality of the water available is also deteriorating, placing further constraints on available ground and surface water supply. Reduced river flows have allowed seawater to encroach upstream, increasing the salinity of the freshwater. This combined with the continuous discharge of industrial wastewater, sewage and agricultural runoff has reduced the quality of the water beyond what the World Health Organization (WHO) deems safe for drinking. In 2018, over 100 000 people were hospitalised in Basra due to conditions related to poor water quality, while in some areas of Iraq the concentration of total dissolved solids was fifteen-times above the maximum acceptable level for drinking water. The shortage of potable water and unreliable electricity supply were the primary causes of large protests in Basra in mid-2018.

The quality and quantity of water also affect Iraq's energy sector. In 2018, operations were curtailed at power plants and its largest oil refinery when salt levels in water were four-times higher than operable limits (S&P Global Platts, 2018). The oil industry is increasingly concerned that a lack of water might stymie production (see water availability for oil production section in Chapter 2).

The energy sector contributes directly to the environmental challenge. Gas flaring alone releases an estimated 30 million tonnes of carbon-dioxide (CO_2) emissions into the atmosphere (see Box 1 in Chapter 2). In Baghdad, the levels of fine particulate matter (PM2.5), considered to be particularly damaging to human health, are more than seven-times the maximum recommended levels established by WHO standards. A heavy reliance on neighbourhood generators[1], often diesel-powered, contributes to poor air quality; a study of air quality found that gasoline and diesel engines account for over half of carbonaceous aerosols (Hamad et al., 2015). This provides an additional incentive to pursue a clean, more efficient grid-based supply (see Chapter 3).

Security

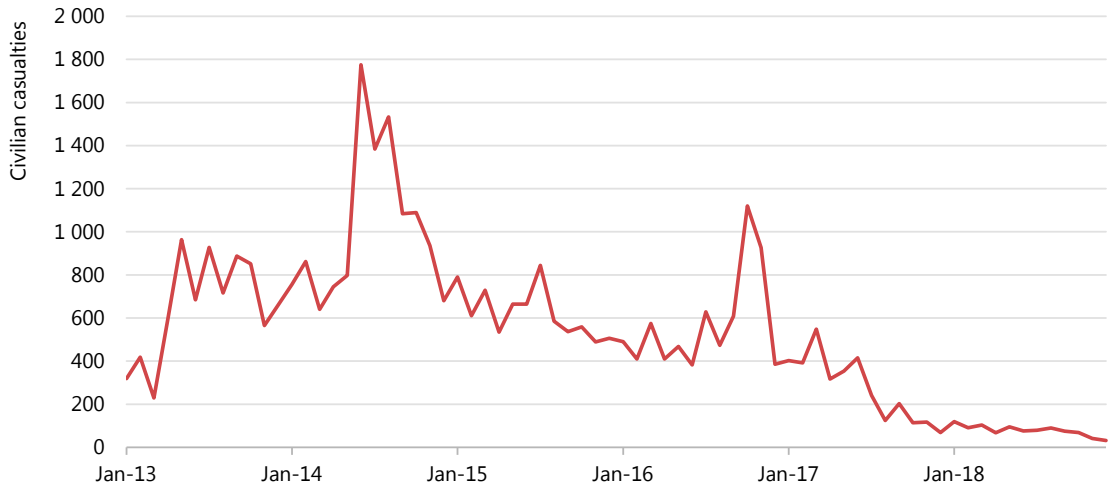
In addition to the movements in the price of oil, the most significant variable affecting Iraq's energy outlook since 2012 has been the evolving security situation. Terrorist attacks were a frequent feature in many of Iraq's main cities in 2012, reaching a crescendo in mid-2014 with the capture and occupation of Mosul and large parts of the north and west area by ISIL, which at its height was in control of around one-third of Iraq's territory.

[1] These are local generators that typically privately owned and operated. They operate on a subscription basis, whereby households contract a capacity, usually in amperes, for which they pay a monthly rate. They are run heavily during brownouts.

The full liberation of Iraq in 2017 came at a considerable cost in lives and infrastructure. An estimated 4.5 gigawatts (GW) of generating capacity suffered damage and around one-fifth of the transmission network was rendered inoperable in the war. Iraq's largest refinery at Baiji (310 000 barrels per day of capacity) was severely damaged in 2014, but has since been partially rehabilitated. The security and political instability in the north also affected operations in Kirkuk, Iraq's oldest oil field, as control of territory passed from central government to the Kurdistan Regional Government (KRG) and then back again.

Recently the security situation has improved dramatically; by end-2018, the monthly average of civilian casualties fell to its lowest level since 2003 (Figure 3). Political accommodation between the central government and the KRG has, for the time being, been found. For example, the two authorities have agreed a revenue-sharing deal in the federal budget in 2019 that also commits the KRG to contribute 250 thousand barrels per day (kb/d) of its oil production to federal exports. The calming of tensions has also led to an agreement whereby oil produced by the central authorities can be transported to Ceyhan on Turkey's Mediterranean coast using the KRG pipeline, with around 50-100 kb/d currently being exported via this route.

Figure 3. Monthly civilian casualties in Iraq



Source: United Nations Iraq.

There has been a substantial transformation in the security situation across the country, with civilian casualties now at the lowest levels in years.

Changes in the energy sector since 2012

Oil and gas sector

Since our review in 2012 (IEA, 2012), oil production has increased by more than 50% to 4.7 million barrels per day (mb/d); Iraq accounted for one-in-every-five barrels of global incremental oil supply in the period, second only to the United States. There have been some notable changes to Iraq's oil sector ambitions, priorities and plans, as well as the cast of companies working to achieve them on the ground.

The most consequential change is the significant downward revision of the target plateau rates stipulated in the first and second bid rounds signed in 2012, which implied production of over

12 mb/d by 2017. Although these plateau rates were mostly considered aspirational[2], a confluence of factors led to renegotiation of the terms of the technical service agreements with international oil companies. First, the fall in oil prices that started in mid-2014 meant that Iraq could not provide the levels of capital needed for the targeted production growth, particularly at a time when the state needed to substantially increase defence spending for the war against ISIL. Perhaps as importantly, the significant increase in US shale production and slowing global oil demand (both of which triggered the fall of oil prices) contributed to the view that major capacity increases, in what could have become spare capacity, as the most prudent way to allocate scarce capital in the medium term.

As a result, Iraq negotiated down the plateau targets for a number of its most prominent producing fields, reducing the overall production level to 6.4 mb/d, 40% below the original agreement. The renegotiated terms also increased the licence term for most operators (Table 1). In several instances, international oil companies (IOCs) that were looking to sell off their interests did so, most notably Shell as operator of the Majnoon field and its 20% stake of West Qurna-1 in 2018. Today around half of Iraq's oil production is operated by IOCs, down from around 65% in 2012. The IOCs have tended to be replaced by national oil companies from China and Russia that operate internationally or by Iraqi national oil companies, the largest of which is the Basra Oil Company (BOC). In the case of Majnoon, the Shell departure provided an opportunity for Iraq's national oil companies (NOCs) to expand their role in major oilfield development. Currently, about 25% of oil production in Iraq is operated by foreign national oil companies and 20% by Iraqi NOCs.

Table 1. Revised terms for fields awarded in first and second bid rounds

Field	Previous plateau target (mb/d)	Revised plateau target (mb/d)
Halfaya	0.535	0.4
Rumaila	2.85	2.1
West Qurna-1	2.325	1.6
West Qurna-2	1.8	1.2
Zubair	1.2	0.7
Gharraf	0.23	0.23

Source: Ministry of Oil.

Both the low oil price environment and increased competition for international capital in oil projects with the rise of US tight oil production (among other prospects) also led Iraq to explore options to modify its technical service agreements (TSAs) to better align the state's interests with those of the companies. While the remuneration structure in the TSAs put a relatively low ceiling on returns to companies during times of high oil prices, the terms of the agreement also provided little incentive for companies to rein in costs when prices were low. This became particularly problematic for the capital-constrained Iraqi government when oil prices declined. To help address this issue, the Petroleum Contracts and Licensing Directorate of the Ministry of Oil offered a new contract as part of its 5th bid round in April 2018. This contract established a link between the prevailing oil price and the remuneration offered. Further, for the first time, it offered a royalty element and also linked the cost recovery element to oil prices, such that a lower rate of 30% is applied at oil prices below USD 21.50/barrel, rising to 70% at an oil price of

[2] The Central Scenario of the *Iraq Energy Outlook* (IEA, 2012) anticipated strength supply growth in Iraq, but did not assume that the targets set out in the plateau would be met.

USD 50/barrel and above. It is not yet clear whether this new contract structure will prevail, the 5th bid round saw 6 of 11 blocks on offer awarded, but these agreements are yet to be ratified.

Iraq has not had the same success in developing its associated and non-associated natural gas resources. As oil production soared, so has the amount of associated gas produced, but the capacity to capture and process this gas has not kept pace. Gas flaring increased from 12 billion cubic metres (bcm) per year in 2012 to around 16 bcm in 2018 (just over half of all gas produced). The inability to utilise its gas riches, at the same time as it has reoriented its power generation fleet from oil to gas, has led to an increasing gas deficit and Iraq now relies on imports from Iran to meet demand. This has introduced a number of vulnerabilities to Iraq's energy system; payment issues in mid-2018 led Iran to cut exports, which significantly exacerbated electricity shortages during peak seasonal demand in Iraq.

Some recent progress is noted in the start of operations of the Basrah Gas Company (BGC) to capture and process associated gas at the three "round 1 fields" of Rumaila, Zubair and West Qurna-1. By end-2018, the BGC was capturing close to 10 bcm, providing dry gas feedstock to power generators and facilitating liquefied petroleum gas exports. BGC has taken a final investment decision to increase capacity to 14.5 bcm in two years and has plans to increase this to 16.5 bcm by 2023, helping to significantly reduce flaring at the fields in which it operates. Plans to increase gas processing and use in other fields are uncertain. The operators of the Nassiriya field have announced plans to eliminate flaring entirely by 2021 and awarded a contract to Baker Hughes for gas processing facilities for 2 bcm. However, under the current contract terms, operators have no obligation to capture or use associated gas beyond their own requirements.

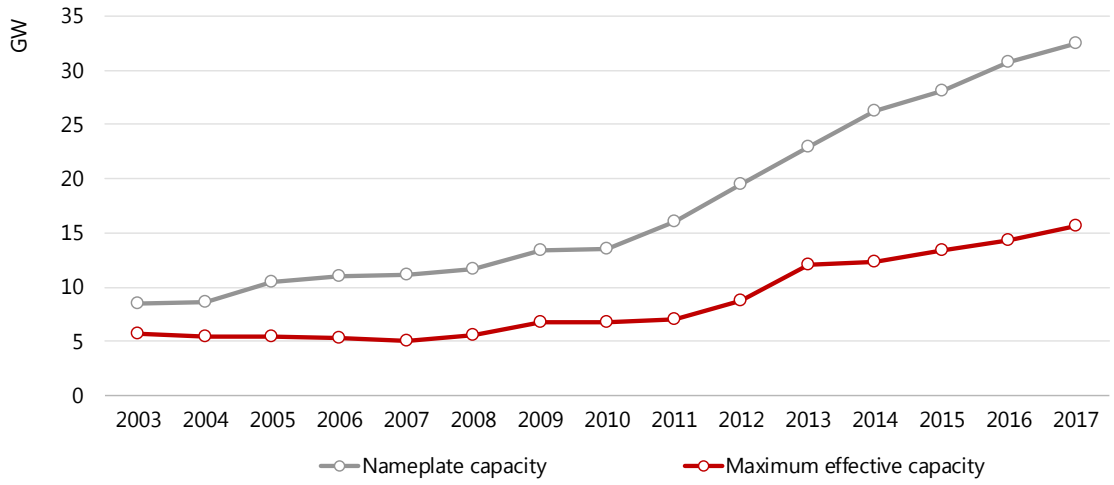
The situation with non-associated gas is mixed. The war against ISIL meant that the operators of Akkas to call for *force majeure*, before production began. The government is now in talks with the companies to return. In the Kurdistan Region, however, the Pearl Consortium, which operates the Khor Mor gas field, now produces 4 bcm, which facilitates a power generation surplus for the Kurdistan Regional Government. The consortium has plans to increase production to 9 bcm by 2022.

Electricity sector

Electricity supply is a standard by which progress across Iraq can be measured. Significant additions to the generation fleet have been made since the *Iraq Energy Outlook 2012*, with available capacity expanding by 8 gigawatts (GW) (or 90%) between 2012 and 2018.[3] However, this has not been matched by improvements in the condition of the power grid or reductions of losses (technical and non-technical), which at around 50-60% are among the highest levels in the world. This means that the effective increase in capacity was 4 GW. Meanwhile, peak demand has increased by 80% and the gap between supply and peak demand is larger today that it was in 2012, translating to a situation that has barely improved for the average consumer (Figure 4).

[3] Nameplate capacity increased by 13 GW, with the difference being accounted for by losses associated with fuel switching and poor plant maintenance.

Figure 4. Nameplate capacity and effective generation capacity, 2003-17



Sources: National statistics; Platts.

The significant difference between installed and effective capacity reflects deferred maintenance and fuel switching.

Two shifts since 2012 are notable. Oil and liquid fuels like heavy fuel oil accounted for about 70% of power generation in 2012. Owing to an aggressive rollout of multi-fuel generation units (that can burn oil or gas), natural gas-fired generation has increased significantly: in 2018, it accounted for over 55% of generation, compared with just 20% in 2012. This increase in multi-fuel capacity provides the power system with operational flexibility that is welcome with the uncertainties that Iraq faces. However, as gas flaring in the fields in the south continues to be a pronounced issue, there is a general shortage of natural gas and some of generating units have been burning liquids rather than gas. This reduces the plant efficiency and increases wear-and-tear on equipment that requires increased maintenance.

The second shift has been increased dependence on neighbourhood generators, which we estimate provide 20% of demand. At a tariff that amounts to USD 600-1 200 per megawatt-hour, this option is several times more expensive than the conventional grid power supply.[4] Charging around Iraqi dinar (IQD) 25 000 (USD 20) per ampere of capacity, a household looking to augment its grid supply with a neighbourhood generator might pay over USD 300 per month for the 15 amperes it would need to power two air conditioning units, as well as a refrigerator and lights. In effect, neighbourhood generators captured annual revenues of around USD 4 billion in 2018. This is equal to the amount allocated to electricity sector in the federal budget for capital expenditure in 2019.

Continued expansion in power generation capacity has not shown signs of slowing. At the start of 2018, more than 7 GW of power generation capacity were under construction. These are predominantly gas-fired, but also 1 GW of oil-based generation. There are plans for additional 16 GW of capacity additions.

[4] Depending on whether the regulated tariff of IQD 8 000 per ampere or the commonly charged IQD 25 000 per ampere is considered.

Although welcome, increasing generation capacity alone cannot solve the problem of power shortages in Iraq. Power cuts (including scheduled brownouts to manage supply) are frequent and reflect the poor state of the transmission and distribution networks. This is the source of significant frustration in the summer months when demand for cooling peaks and supply is inadequate. Indeed, outages are commonly cited as being among the most important causes of protests. In summer 2018, anger at the paucity of public services, including electricity and clean water, led to unrest in Basra. The government is very aware of the need to make significant progress in time for summer 2019. This was the motivation for its request of both Siemens and General Electric to provide power sector development plans that outline measures for the immediate (including improving the efficiency of the current fleet and deployment of small mobile gas generating units), as well as long-term plans to optimise the electricity sector. We explore the short- and medium-term options available, and compare the costs and efficacies of each in Chapter 3.

Chapter 2: Prospects for the oil and gas sector

Introduction

The oil sector is integral to the wellbeing of the entire Iraqi economy and will remain so well into the future. Iraq's long-established competence in managing this sector bodes well. The country can build on the already significant growth it has achieved over the last decade – under extraordinarily challenging circumstances – to become again one of the fastest-growing oil producers in the world. Iraq's potential is huge but the road to increased production is not without obstacles: from making sure that water is available for reinjection, to ensuring that oil is efficiently produced and consumed. Iraq is also in urgent need of overhauling its refining sector to make rising oil production serve growing appetite for refined products.

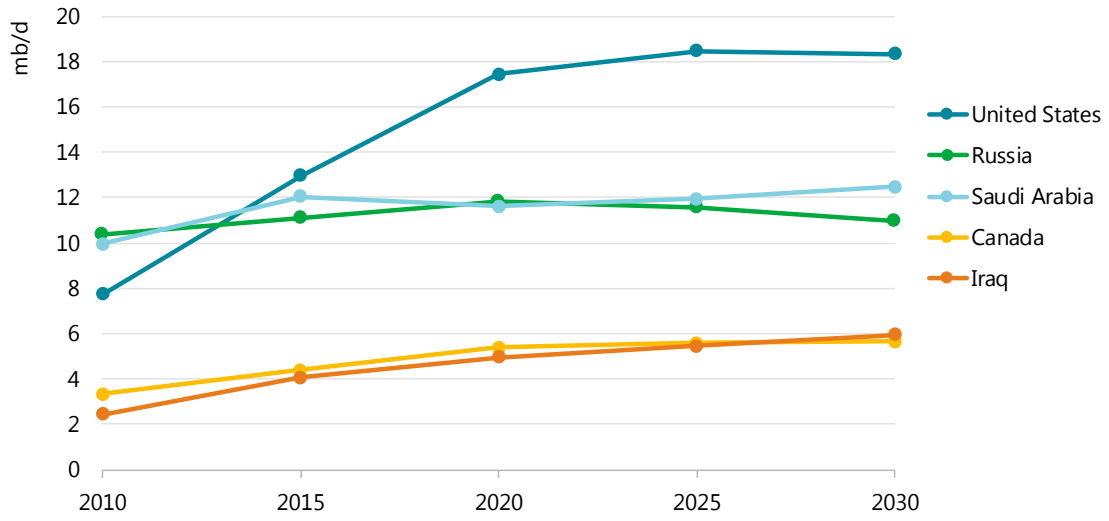
The anticipated increase in oil production will bring with it a commensurate increase in associated natural gas. The amount of attention Iraq has paid to gas in the past, as well as the volumes that have been produced, has sorely lagged behind that of oil. There have been some notable improvements in the rate of gas capture recently, but still, more gas is flared today than is brought to market. How Iraq produces and uses its gas will be a bellwether for the overall progress of energy sector reform and modernisation. As well as being essential to industry, natural gas can underpin a more reliable, efficient and affordable electricity sector, which in itself is can be the single most powerful catalyst for economic diversification, growth and job creation across the country.

Outlook for oil production to 2030

Despite the formidable challenges it has faced, Iraq has nearly doubled its oil production over the past decade to 4.7 million barrels per day (mb/d), alone accounting for a fifth of the net increase in global supply. Today it ranks as the fifth-largest source of global oil supply (Figure 5). The next stage will depend largely on four core issues: sufficient water availability to inject into reservoirs to boost production; international oil market conditions; attracting investment, including foreign capital and expertise; and maintaining and strengthening political stability. In reaching almost 6 mb/d of production in 2030, Iraq would overtake Canada as the world's fourth-largest producer.[5]

[5] This reflects a scenario shaped by current and announced policy intentions around the world (i.e. the New Policies Scenario in the IEA World Energy Outlook). This incorporates Iraq's Nationally Determined Contribution (NDC) to cut its CO_2 emissions by 14% from its "business as usual" scenario in 2035. The New Policies Scenario does not come close to achieving the energy-related Sustainable Development Goals. Strengthening of policy actions globally– notably in relation to climate change – would alter this outlook.

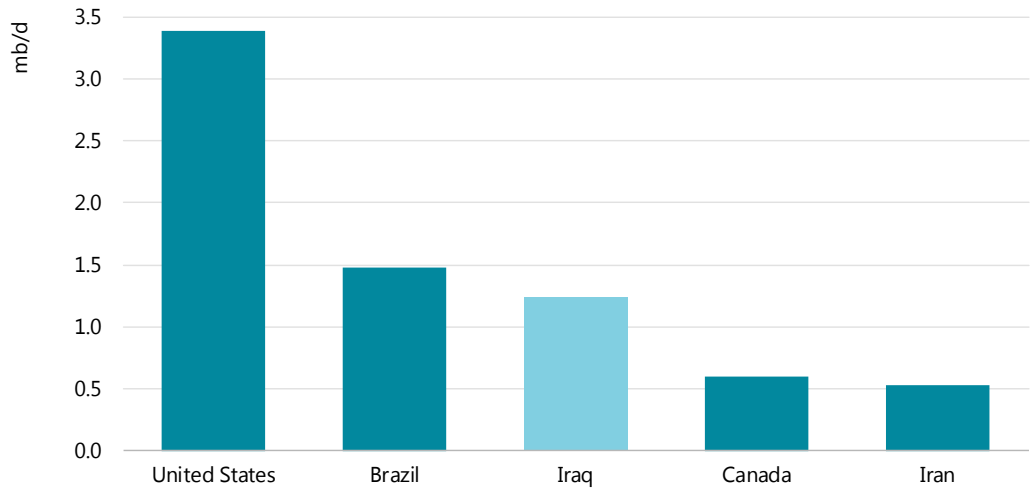
Figure 5. Iraq strengthens its rank as a leading oil producer



Iraq could overtake Canada to become the fourth-largest oil producer by 2030.

Myriad above-ground hurdles can add significantly to the cost and difficulty of executing hydrocarbon projects in Iraq. However, this does not diminish the fact that, from a technical perspective, oil projects in Iraq are among the lowest cost in the world. Iraq's production is expected to grow by around 1.2 mb/d over the next ten years. This is slower than the 2.4 mb/d increase delivered since 2010, but it would still provide world markets with the third-largest increment of additional oil over the period, after the United States and Brazil (Figure 6). If achieved, production in 2030 would represent around 6% of global oil output, up from 5% now and less than 3% in 2010.

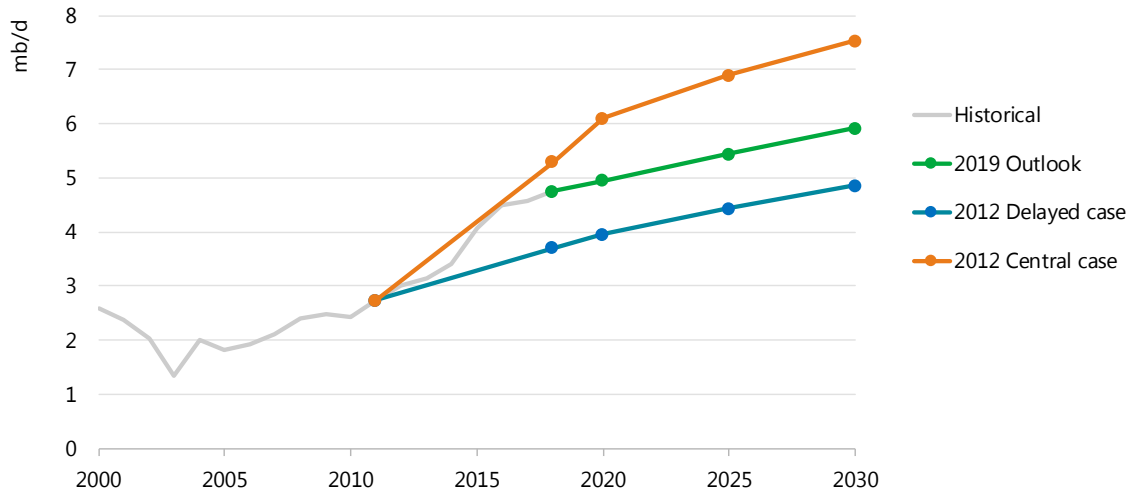
Figure 6. Top-five countries by increased oil production, 2018 to 2030



Iraq makes the third-largest contribution to global oil supply in the period to 2030.

When we last examined the prospects for oil production in Iraq in detail in 2012, our Central case projected that production would rise to over 6 mb/d in 2020 and 7.5 mb/d in 2030 (Figure 7) (IEA, 2012). Despite the fall in the oil price from 2014 and the rise of ISIL, Iraq's production today lies close to this Central case. Looking ahead, production in 2030 lies midway between this Central case and the alternative Delayed case. This is partly because of the reductions in plateau targets for many of Iraq's main fields and partly because of the greater level of competition for capital in other countries (such as tight oil in the United States). There are also a number of domestic challenges, such as adequate water supply and transport infrastructure, which need to be resolved to achieve further production growth. Iraqi NOCs have successfully expanded production at a number of the fields they operate but creating attractive financing conditions to encourage inward capital investment by international oil companies (IOCs) will remain critical to continue material levels of production growth.

Figure 7. Oil production outlook compared with the scenarios in *Iraq Energy Outlook 2012*



Oil production is expected to reach nearly 6 mb/d by 2030, midway between the Central and Delayed cases in the 2012 review.

Box 1. Reserves and resources

Estimates of ultimately recoverable oil resources are inherently subject to a large degree of uncertainty. Nonetheless, it is clear that Iraq's contribution to global oil supply over the coming decades will not be limited by the size of its subsurface hydrocarbon potential. These resources are contained in three main hydrocarbon basins:

- Northern Zagros Fold Belt, which includes the supergiant Kirkuk reservoir and the fields in the Kurdistan Regional Government area.
- Mesopotamian Basin, where most of Iraq's supergiant fields have been found. This is often separated into the "South" region near Basra and the "Centre" area that incorporates the alluvial plains around Baghdad.
- Widyan Basin-Interior Platform, also known as the Western Desert (or "West"). This is the least explored of the three main basins and is thought to be more gas rather than oil prone.

Main hydrocarbon basins and fields in Iraq

Proven reserves alone are sufficient to support a major expansion in production. Reported reserves were steady at around 115 billion barrels throughout the 2000s (despite ongoing production) and in 2010 Iraq's Ministry of Oil increased proven reserves by around 25% to 143 billion barrels. There have been a number of minor revisions since and the most recent estimate of proven reserves is just under 150 billion barrels. Iraq's share of global proven reserves has fallen marginally since the 1990s, given larger revisions elsewhere, but it is still the fifth-largest proven reserves holder and the third-largest holder of conventional oil reserves.

According to data from the Ministry of Oil, Iraq's proven reserves are spread across more than 70 fields. Yet, just four supergiant fields in the South region – Rumaila, West Qurna, Zubair and Majnoon – account for over 55% of total proven reserves. The other main proven reserve fields are East Baghdad in the Centre, and the long-standing producer, Kirkuk, in the North.

Reserves are only one element of the resource potential; anticipated reserve growth (to the extent not already included in the proven reserve data) and undiscovered volumes are also key factors. Much of Iraq remains unexplored or significantly under-explored compared with other major oil producing countries and so there remains a large potential for future discoveries. Our estimate of the remaining ultimately recoverable resources in Iraq stands at just over 200 billion barrels (including both crude oil and natural gas liquids).

Iraq oil resources by region and supergiant field (billion barrels)

	Proven reserves, end-2017	Ultimately recoverable resources	Cumulative production, end-2017	Remaining recoverable resources	Remaining % of URR
Southern Mesopotamian	**113**	**164**	**25**	**139**	**85%**
West Qurna	47	55	3	53	95%
Rumaila	17	35	16	19	55%
Majnoon	13	15	1	15	96%
Zubair	7	11	3	8	70%
Central Mesopotamian	**13**	**19**	**0**	**18**	**98%**
East Baghdad	9	10	0	10	98%
Northern Zagros Fold Belt	**23**	**62**	**19**	**42**	**69%**
Kirkuk	7	25	16	8	34%
Western Desert	0	1	0	1	100%
Total Iraq	**149**	**246**	**45**	**201**	**82%**

Note: Proven reserves are approximately broken down by basin, based on information provided by the Iraqi Ministry of Oil, supplemented with company presentations. Figures include crude oil and natural gas liquids. URR = ultimately recoverable resources

Sources: Iraqi Ministry of Oil; IEA databases and analysis.

Water availability

The increase in oil production envisaged in this outlook could remain aspirational unless huge quantities of water are available for field injection. Despite its significant level of production, many of Iraq's oil fields have relatively low recovery factors (the ratio of oil that is extracted to the volume of original oil in place). Almost 80% of its producing fields have an ultimate recovery factor of 15 -40% (Mills and Walji, 2018). Secondary oil recovery, whereby water is injected into the oil formation to increase or sustain reservoir pressure, is needed to boost recovery factors and maintain or increase production rates. International standards place the average amount of water needed at around 1.3-1.5 barrels of water to every barrel of oil extracted. Iraq has relied on water injection since the early 1960s, especially in fields in the South and Centre where the composition of most of the reservoirs is well suited to this method of secondary recovery (Mills and Walji, 2018). There are other advanced methods available that can boost recovery factors, such as enhanced oil recovery, but these are generally not suitable for the current conditions in Iraq's fields and tend only to be applied after secondary recovery techniques have been fully applied.

Therefore, the adequacy of water supply will be a key determinant of oil production growth in Iraq. But, increasing competition from other users for water resources, ongoing drought and reduced river flows from upstream dam building means that operators can no longer rely on river water for field injection purposes. To compensate, plans were drafted in 2011 to build the Common Seawater Supply Project (CSSP) that would process seawater from the Gulf and transport it to the largest oil fields in the South to be used for injection.

Changes of ownership, alterations, conflict and other issues have delayed the CSSP. However, it remains central to Iraq's ability to meet its ambitious oil production targets. The BOC, a national oil company, has taken responsibility for the CSSP and put it to tender with the hopes that a

final contract would be signed in 2019. The first phase is expected to take at least three years to construct and aims to pipe 5 mb/d of treated seawater to fields across Basra and to Nassiriya, with the potential to increase to 7.5 mb/d of seawater with an estimated cost of roughly US dollars (USD) 5 billion.

Given the critical importance of water to maintaining (or increasing) production in so many of Iraq's oil fields and the delays in the CSSP, many IOCs have looked to alternative solutions. For example, BP took over management of the Qarmat Ali Water Treatment Plant and renovated the plant, pumping stations and associated pipelines. It also added an extension and the new facility is now capable of treating up to 1.3 mb/d of river water. Water from this facility primarily goes to the Rumaila field although around 14% goes to the Zubair field and up to 300 thousand barrels per day (kb/d) is sent to BOC for industrial uses. Currently, Rumaila requires around 1.4 mb/d of water to support its oil production from the north of the field, which produces around 1 mb/d (i.e. around 1.4 barrels of water for each barrel of oil produced). The main production in the south of the field is currently from the original Main Pay Reservoir, which is supported by a natural aquifer.

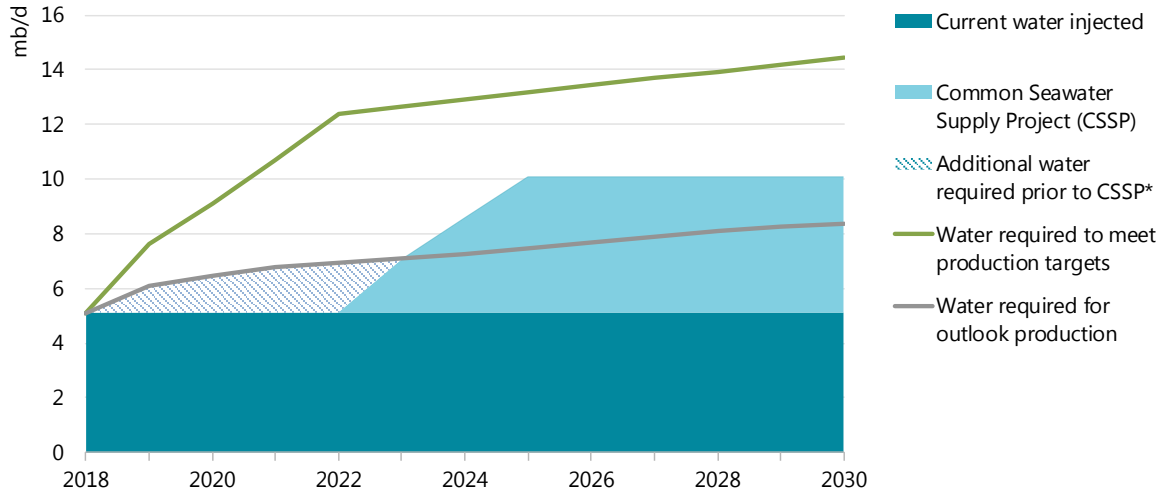
In many ways, the Rumaila field is illustrative of the importance of water for oil production and the challenges operators have in securing adequate supply. Future growth in Rumaila will come from the Mishrif reservoir in the South, which is comprised of medium-heavy oil and will likely have a steep decline rate (details in the following section). Much higher water injection rates therefore will be needed to support production (Mehdi, 2018).This is likely to require access to the CSSP, although there is room to increase the production capacity at the Qarmat Ali Water Treatment Plant to around 2.7 mb/d water for Rumaila and other fields. BP also has plans to build a series of plants that would treat produced water from the well to be reused for injection. This should provide around 300 kb/d of water in the first phase, with the option to increase capacity in the future. The Zubair field is also using the same treatment method at its newly installed degassing stations.

In total, we estimate that over 8 mb/d water will be required by 2030 for Iraq's oil production, up from 5 mb/d used today (Figure 8). There is a near-term water supply gap that will need to be met by other sources until the CSSP is brought online around 2023. Potential options expanding existing facilities, using industrial water or increasing the rate of reuse and recycling of produced water. Water could also be sourced from aquifers or surface water; however, this is unlikely to be a tenable long-term solution, given the existing supply constraints, demand by other sectors and concern about the sustainability of freshwater use. Thus, while alternative sources of water could be found to help support increased production in the short-term, continued delay on the CSSP is likely to affect the ability to grow production for key fields including Rumaila, West Qurna-1 and -2 and Zubair.

If the 5 mb/d of water from the CSSP project comes online as expected, Iraq should have enough water to support our projected oil production in 2030. It is unlikely, however, given the existing infrastructure and expected timeline of construction for the CSSP, that there will be enough water to meet the 2022 production plateau targets. Meeting these targets will require more than 12 mb/d of water in 2022, leaving a gap of around 7 mb/d of water. Even after the CSSP comes online, an additional 4 mb/d of water will need to be sourced from other options or from a greater use of produced water in order to sustain the plateau targets by 2030.

Water availability will continue to be a challenge. Water is an important social and political issue and demand is increasing in all end-uses. It is critical for the oil industry to ensure the effective and efficient management of water, including making much better use of recycling and reusing produced water.

Figure 8. Total water injection requirements for oil production in Iraq



Note: *Until the CSSP is brought online, water will need to be met by other sources such as produced water, expansion of existing water treatment facilities, industrial water etc.

Bringing the CSSP online in a timely manner will be critical to provide the water needed to expand oil production, but far more would be needed to meet official production targets.

Outlook for oil production by region

South

Iraq's oil fields in the South contain some of the world's least expensive and easiest oil to extract, most notably, the "big 4" oil fields of Rumaila, West Qurna, Zubair and Majnoon. Rumaila and West Qurna are ranked among the top-15 largest oil fields globally based on remaining reserves. The big 4 fields combined account for 60% of Iraq's oil production today and an estimated 70% of the increase in Iraq's production to 2030.

Rumaila, currently producing 1.5 mb/d, retains its dominant position in Iraq and its standing as the second-largest producing field in the world, after Saudi Arabia's Ghawar. This 70-year-old field has a very productive main reservoir for which the recovery factor could surpass 50%. It also has a natural annual decline rate of more than 20%, so production has to be increased by around 300 kb/d each year to compensate. BP, which operates the field, has managed to reduce the cost of production to USD 3.5/bbl from USD 5.6/bbl when it started work there a decade ago. Some of the efficiency gains have come through digitalisation of operations at the field. Water is one of the biggest hurdles for Rumaila and increasing production requires additional water handing and separation facilities.

West Qurna is a northward extension of the Rumaila field in geologic terms. It is split, for development purposes (by the Euphrates River) with the southern part (Phase 1) contracted to a consortium led by ExxonMobil and the northern part (Phase 2) led by Lukoil. The southern area is producing around 450 kb/d, far below its revised plateau target of 1.6 mb/d. The northern part is producing around 400 kb/d, a third of the way towards its amended target. In Phase 1, Schlumberger is expected to drill 30 wells. In Phase 2, Lukoil awarded two drilling contracts to Bohai Drilling Engineering, a Chinese company, as part of the field's final development. Our projection is for combined production to rise to just over 1 mb/d in 2030, reflecting lingering concerns over the availability of water for injection and transport infrastructure.

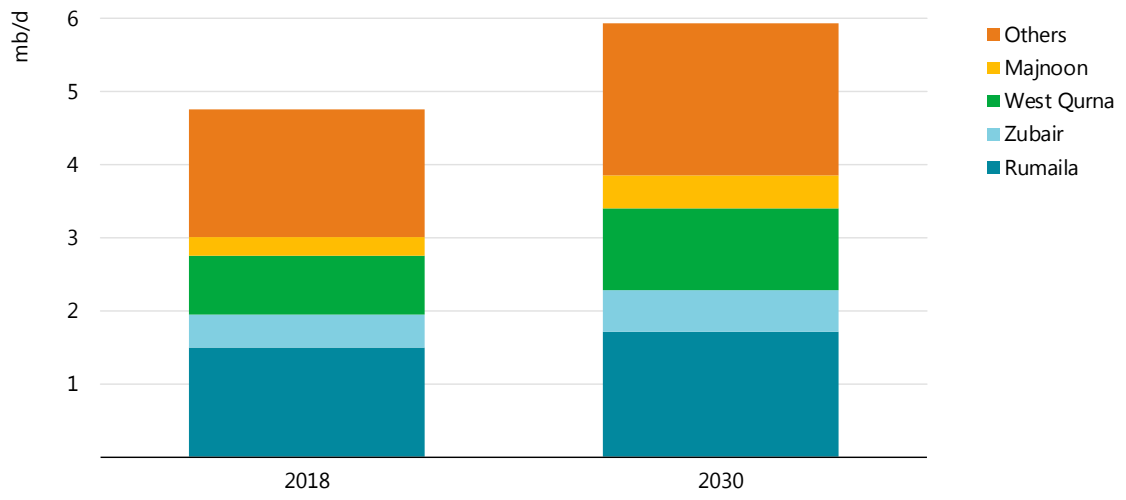
Zubair was one of the first major discoveries in the region but it has remained in the shadow of its larger neighbour, Rumaila. Eni, an Italian multinational oil and gas company, is leading development of the field, which is producing around 450 kb/d, compared to a target of 850 kb/d. For now, it is sourcing about 170 kb/d of water from Qarmat Ali water treatment facility. ENI is building a 380 megawatt (MW) power plant at Zubair, with plans to provide any excess power generated to the national grid to supply other operations. Our projection is for oil production of around 600 kb/d in 2030.

Majnoon, discovered by Petrobras in the 1970s, has been transformed from a battlefield into an oil field and is now producing around 240 kb/d. Development of Majnoon, has been complicated by the large amount of unexploded ordnance in the area, a legacy of the 1980s war with Iran. Iraq's BOC now operates the fields following Shell's departure in mid-2018, and is looking to boost output to 400 kb/d in several years while also cutting costs by 30%. A substantial drilling effort is gathering pace to underpin this expansion. Schlumberger is expected to drill 40 wells. Unlike the other big 4 oil fields, Majnoon is not in urgent need of new water facilities to expand production. Our projection is for production of 450 kb/d by 2030 (Figure 9).

Elsewhere in the South, **Halfaya** has provided a substantial amount of growth in oil production and is climbing towards its plateau level of 400 kb/d. A third central processing facility has lifted capacity at the green field operated by China National Petroleum Corporation (CNPC) to 450 kb/d. CNPC is building a 150 MW power plant at the field, four 30 000 barrel tanks and six additional flow lines. The field's development has raised production of heavy oil that feeds into the Basra Heavy export grade launched in 2015 that has an API gravity of around 23° and makes up nearly a quarter of total Basra exports.

At the **Missan** field, the China National Offshore Oil Corporation is striving to boost output by up to 140 kb/d by 2020. The fields of **Fakka**, **Buzurgan** and **Abu Ghirab** are now pumping about 200 kb/d in total. So-called "national effort" fields in the south, such as **Nassiriya,** are set for higher output, with ambitions to raise production from 90 kb/d to 200 kb/d. The Ministry of Oil is also discussing the possibility of an integrated project at Nassiriya that involves building a 150 kb/d refinery.

Figure 9. Production from Iraq's "big 4" supergiant oil fields



Iraq's big 4 supergiant fields contribute over 70% of expanded oil production to 2030.

The Ministry of Oil is continuing its plans for the multi-billion dollar Southern Iraq Integrated Project (SIIP). The aim of the SIIP is to boost output from the Nahr Bin Umar and Ratawi oil fields from current combined levels of 80 kb/d to 500 kb/d. The revenue generated would finance the upgrading of infrastructure in the south, including the Gulf export terminals, which can ship nearly 4 mb/d. The SIIP also includes a water injection project (at this point separate from the CSSP) that would treat water from the Gulf and distribute it to the oil fields in the South.

Exploration efforts are also gaining pace, with the federal government signing six preliminary deals with companies to explore for oil near the border with Iran and Kuwait. The contracts are pending approval by the cabinet's energy committee before submission to the full cabinet. Once given the go-ahead, it will take several years for most of the fields, located in southern and central Iraq, to start pumping.

Blocks awarded in previous licence rounds in 2012 are showing signs of promise. Lukoil is keen to launch the early production phase of Block 10, which would bring its Eridu field on stream within two years. The field, the largest discovery made in Iraq in decades, is expected to produce nearly 300 kb/d. The per barrel remuneration fee at Block 10 was among the highest of all Iraq's Technical service agreements (TSAs) at USD 5.99/bbl compared with USD 1.15/bbl at the Lukoil-operated West Qurna-2. Bashneft International, a unit of the Russian oil company Rosneft, announced in 2018 an oil discovery in Block 12 in southern Iraq after completing its first exploration well.

Centre

Production from the Centre region of Iraq is expected to remain under 300 kb/d (4% of estimated total Iraq production in 2030). The major contributors are the **al-Ahdab** field, operated by CNPC (producing around 130 kb/d today) and the **Badra** field, operated by Gazprom Neft (producing around 90 kb/d today). Further growth from this region is constrained, as we do not anticipate major progress with the region's supergiant **East Baghdad** field that underlies the capital. The Ministry of Oil signed a deal in 2017 with Zhenhua Oil to raise capacity at East Baghdad from 10 kb/d to 40 kb/d within five years.

North

Just under a fifth of Iraq's production in 2018 came from the North, primarily from the Kirkuk and Bai Hassan fields. Efforts to tap the region's resources have been frustrated by the 2014-17 battles with ISIL, as well as the dispute between the federal government and the Kurdistan Regional Government (KRG) over the control of land and oil. Complicated geology has also hindered the development drive.

The North region share of around a fifth of Iraq's oil production holds steady through the period to 2030, with an increase in production under contracts awarded by the KRG and a slight boost to the Kirkuk area fields. Our projections for oil from the KRG area see production rising to around 600 kb/d in 2030.

Production at **Kirkuk** (excluding the Khurmala dome) slumped to around 300 kb/d in 2019 from 900 kb/d in 2001 after years of dumping unwanted crude and products into this highly fractured reservoir. The oil field, producing since the 1920s, is composed of three main geological formations, or domes: Khurmala, Baba Gurgur and Avana. Khurmala straddles Erbil province and is administered by the KRG under a 2008 agreement with Baghdad. There are plans to raise production capacity to 1 mb/d (from 500 kb/d today), comprised of an increase of 170 kb/d at the Khurmala dome and 330 kb/d from elsewhere.

Apart from the supergiant Kirkuk field, the oilfields in the North are smaller (although still large by international standards), often containing 0.5 - 1.0 billion barrels of recoverable oil. However, the cost of bringing the oil to market is higher than in the South because of the need for additional expenditure for infrastructure and supply logistics. Along with the agreement between the Ministry of Oil and BP to boost production at Kirkuk is a plan to develop the neighbouring fields of **Bai Hassan**, **Jambour** and **Khabbaz**.

The **Qayara** field, which lies around 100 km south of Mosul and was temporarily under the control of ISIL, has a short-term production target of 60 kb/d, double its current production level. Qayara is operated by Sonangol, an Angolan company, under a 2010 contract that was resumed after the lifting of *force majeure* from early 2014 until late 2017.

As for Kurdistan, although the KRG is still burdened with billions of dollars of debt racked up during the financial crisis, its production has recovered to around 450 kb/d. Output has risen from the **Khurmala** dome (now at 170 kb/d), operated by the KAR group, and the swift development of the **Peshkabir** field, operated by the Norwegian oil and gas company DNO, has helped offset natural declines at **Tawke**. DNO's **Taq Taq** has been in sharp decline, falling from 130 kb/d in 2014 to around 20 kb/d in 2019. The **Sarqala** field, operated by Gazprom Neft, has risen from 5 kb/d to more than 20 kb/d today. At the heavy oil producing **Shaikan** field, output is slipping.

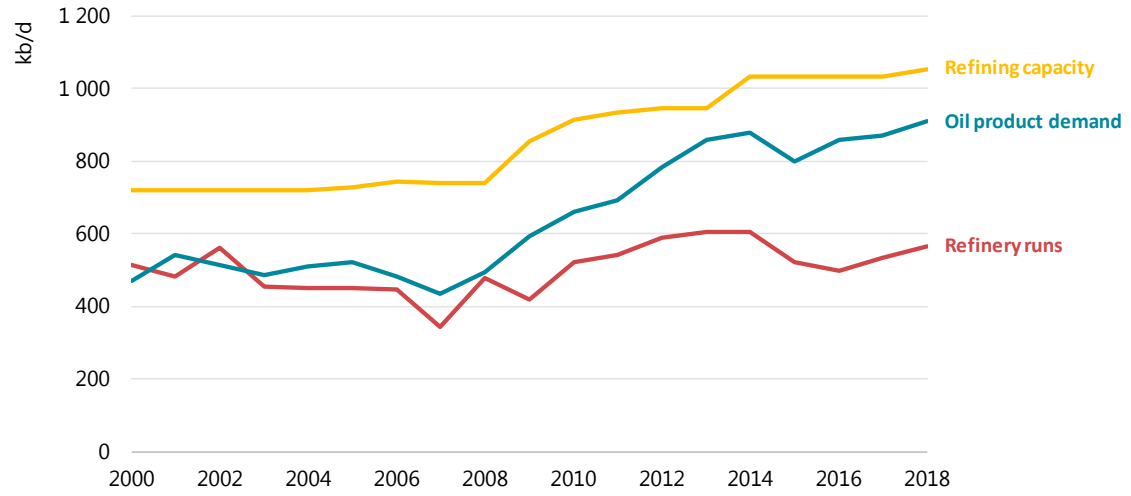
The KRG's oil sector received a substantial lift with the arrival of Rosneft. The Russian state company began committing billions in 2017 by securing exploration contracts, purchasing oil and agreeing to construct a gas pipeline. Rosneft also purchased 60% of Kurdistan's oil export pipeline to Turkey. Investment in new pumping stations has boosted capacity from 700 kb/d to 1 mb/d, which is sufficient to handle all of the export growth anticipated from the North. In mid-November 2018, the Iraqi North Oil Company restarted exports of Kirkuk crude, halted for a year by a dispute between the KRG and the federal government. In the longer term, the federal government plans to build a new oil pipeline linking the fields of Kirkuk to Ceyhan in Turkey. Iraq halted use of its main northern export route to Ceyhan in 2014 after ISIL forces swept through the region and badly damaged sections of the line.

Refining and trade

Total refining capacity in Iraq is around 1 mb/d, although only about 60% of this was utilised in 2018. Even with an increase in refining capacity as from 2008, refinery runs have remained below 600 kb/d since 2000. During this period, oil product demand has more than doubled to over 900 kb/d (Figure 10). As a result, Iraq is spending USD 2-2.5 billion per year to import refined products (Mehdi, 2018). For the world's fifth-largest crude oil producer, this is an abject situation that needs to be resolved.

Many major refineries were damaged during the war against ISIL and can only operate at a fraction of their nameplate capacity. The Baiji refinery, Iraq's largest refinery with nameplate capacity of 290 kb/d, was severely damaged and was offline until 2018 when it resumed partial operation at around 70 kb/d. Accelerating the full restoration of the Baiji refinery would immediately raise Iraq's operational refining capacity by over 30%. Among the other refineries, the Basra refinery is the largest in terms of operational capacity at 200 kb/d followed by the Daura refinery with capacity at 140 kb/d. Most other refineries are small and do not have upgrading capability.

Figure 10. Oil product demand and refinery runs in Iraq



Note: Refining capacity is based on nameplate capacity and includes non-operational capacity.

Iraq's refinery output has grown by 10% since 2000 while oil product demand has doubled.

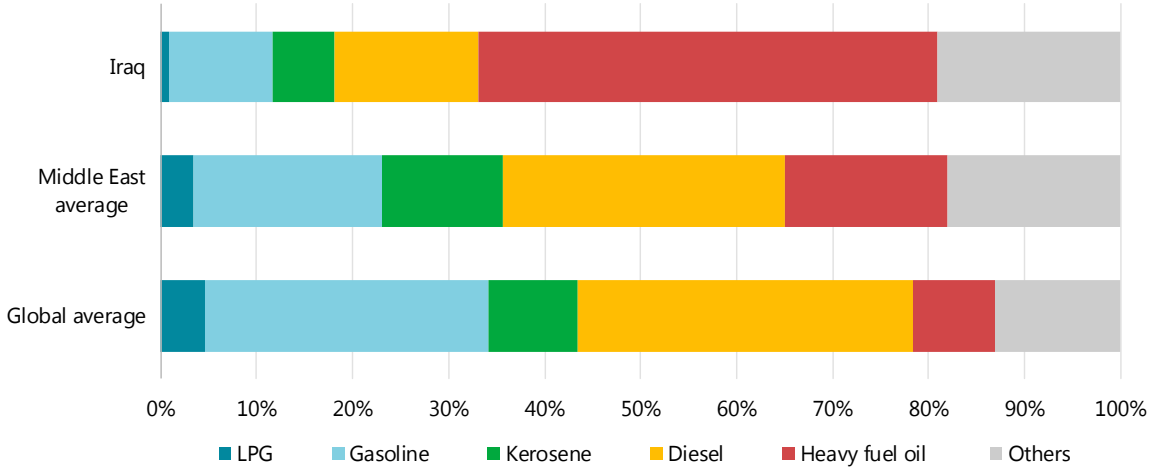
Besides the high level of non-operational capacity, the other major issue facing Iraq's refining sector is lack of upgrading and hydrotreating facilities.[6] Total upgrading capacity relative to primary distillation capacity is less than 10%, lower than the Middle East average of 23% and far below the global average of over 40%. Likewise, the ratio of desulphurisation capacity to primary capacity is among the lowest in the world. The natural consequence of this is very high yields of low-value outputs and low yields of high-value outputs: heavy fuel oil (HFO) accounts for around half of the refinery outputs while products in high demand – notably gasoline, diesel and kerosene – together represent only one-third. This contrasts with global average yields, where gasoline, diesel and kerosene together account for almost 70% of outputs and HFO for less than 10% (Figure 11).

The most pressing issue for Iraqi refineries is to find a way to make use of their excess HFO that contains a high level of sulphur. Global demand for HFO is set to decline sharply from 2020 when the International Maritime Organization (IMO) regulation limiting the sulphur content of marine fuels enters into force. In the New Policies Scenario of the *World Energy Outlook 2018*, demand for HFO in marine bunkers more than halves in 2020, erasing around 2 mb/d of demand from the market (IEA, 2018a). This would raise the prospects of a major drop in HFO prices and squeeze the opportunities for Iraq to export HFO to global markets.

Given the lack of storage capacity and transport pipelines for HFO, dealing with the surplus HFO that will likely emerge is a major challenge. Options that have traditionally been employed include reinjection of HFO into oil fields (which can boost recovery) or blending it into the crude oil stream for exports. This brings down the quality of the crude oil, which has a negative impact on export prices. It also makes the quality of Iraqi crude exports less predictable, an obstacle for importers. Opportunities to expand these options are likely to shrink over time as the country begins to develop increasingly heavier crude oil.

[6] Upgrading reduces the fraction of heavy residues produced from refining a barrel of crude oil while hydrotreating removes sulfur and other contaminants from refined products.

Figure 11. Refinery product mix in Iraq compared with regional / global averages, 2018



Note: Others include naphtha, asphalt, petroleum coke, wax, etc.

Iraqi refineries produce significantly more low-value products such as heavy fuel oil and much less of high-value products such as gasoline, kerosene and diesel.

One alternative is to use the excess HFO in power generation. While the use of HFO in the power sector has many negative environmental consequences (unless it displaces even more polluting crude oil burn), amid a lack of gas supply, HFO could contribute to alleviating Iraq's acute electricity shortages, especially for peak demand in the summer months. With the anticipated drop in HFO prices after 2020, which is expected to last for a few years, increasing HFO use in the power sector could provide a relatively cost-effective way to satisfy peak demand. Nevertheless, this would still require some investment to ensure infrastructure connectivity between refineries and power plants. In 2018, Iraq used an estimated 240 kb/d of HFO for power generation (IEA, 2019). Increasing utilisation of power plants running on HFO or dual fuels could consume 40 kb/d of additional HFO in 2021 (see Chapter 3).

HFO markets are expected to gradually rebalance after 2020, and so the use of HFO in the power sector is likely at best only a temporary solution to surplus HFO volumes. Alongside making more gas available for domestic demand, there is an urgent need to upgrade the refining system to provide greater yields of high-value products and better serve domestic demand.

The Iraqi government aims to boost refining capacity to 1.5 mb/d by 2021. There are many proposed projects for new refineries or upgrades to achieve this. The expansion of the Basra refinery (70 kb/d) is at a relatively advanced stage of development and the contract for the Fao refinery (300 kb/d), which also includes a petrochemical plant, has been signed with two Chinese companies. However, most other projects face a number of challenges to attract sufficient investment and are experiencing significant delays. The Karbala refinery (150 kb/d) had stalled over payment disputes since 2014 and resumed construction just recently. The Missan refinery (150 kb/d) has not made any progress since 2013. We expect that as Iraq progressively improves the investment climate for refineries, and as new refineries come online, refinery runs will double between 2018 and 2030. Doing so would put the country's net oil products trade balance in positive territory by 2030.

Crude oil production is expected to grow at a faster pace than refining activity, and so crude oil exports are likely to expand. Iraq is already the third-largest crude oil exporter in the world. Its crude oil exports rose to record highs of more than 4 mb/d in 2018, with shipments of Basra crude oil from southern oil fields reaching an unprecedented 3.6 mb/d. In our outlook, Iraqi crude oil exports grow to 4.4 mb/d in 2030 (Table 2).

Table 2. Iraq crude oil production, refinery runs and crude oil exports (mb/d)

	2018	2025	2030
Crude and condensate production	4.6	5.3	5.5
Refinery runs	0.6	0.8	1.1
Crude oil exports	3.9	4.4	4.4

In 2018, the federal government and the KRG reached an agreement to resume the export of Kirkuk oil to Ceyhan (Turkey) via the KRG pipeline, which can handle up to 1 mb/d of export flows.[7] The export system in the South – the al-Basra Oil Terminal (ABOT) and four single point mooring (SPM) buoys – is currently able to cope with export flows from fields in the South and could likely handle an additional 0.4 mb/d. Beyond this small addition, however, Iraq's potential for increasing exports is limited by the existing infrastructure. New pipelines, storage tanks and export outlets are needed to expand volumes that can be sold to international markets.

Previous attempts to diversify oil export options have largely fallen victim to conflict and regional politics. For example, a pipeline from southern Iraq to the Saudi Arabian port of Yanbu on the Red Sea was commissioned in 1990 but closed after Iraq's invasion of Kuwait and later was expropriated by Saudi Arabia. Another westward export system, built to the Mediterranean ports of Banias in Syria and Tripoli in Lebanon, likewise ran into political difficulties and has been largely inoperative since 1982 although there are renewed interests in rehabilitating these pipelines.

There are a number of plans underway to develop new infrastructure. Japan's Toyo Engineering Corporation is carrying out a study on raising storage capacity at Fao from its current 6 million barrels to 12 million. Another project is under tender to build an artificial island off the coast that would create additional storage and improve logistics.

For pipelines, the 1 mb/d Sea Line project financed by the Japan International Cooperation Agency aims to link the main oil storage depot at Fao to the al-Basra Oil Terminal, one of the SPM buoys and the Khor al-Amaya terminal. While this will help to alleviate existing bottlenecks, the project has been on hold for many years. BOC is also carrying out studies to construct two additional Sea Line projects, each with capacity of 1 mb/d, which would replace the two existing old pipelines to the ABOT.

Over 60% of Iraqi crude exports are currently shipped to Asia with the remainder being sold to Europe and the United States. China and India are among the biggest buyers of Iraqi crude oil: in 2018, exports to China rose by 20% and Iraq overtook Saudi Arabia as the largest crude oil supplier to India. Iraq aims to continue to increase sales to growing Asian markets. In 2018, the State Oil Marketing Organization began to sell destination-free Basra cargoes – preferred by

[7] For the moment, flows are limited to 90-100 kb/d due to disputes on remuneration, revenues and the North Oil Company's utilization of Kirkuk oil for domestic refining or re-injection.

buyers as they can be resold – priced against the official selling prices for Asian buyers.[8] It also has plan to set up a trading office in Singapore, leveraging the experience from two trading joint venture operations – with Russia's Liatsco and China's Zhenhua Oil – that have been scrapped recently. Today's exports are mostly medium-sour crudes (Basra Light), but future exports are set to be more diverse with the addition of a heavier grade (Basra Heavy) and a new light grade.[9]

Petrochemicals

The global demand for petrochemical products is likely to rise robustly for many years, and so multiple countries in the Middle East are seeking to expand petrochemical operations. There are many potential advantages for those that do so. It improves prospects for higher and more resilient margins, and it contributes to economic diversification. In Saudi Arabia, for example, chemical products represented some 60% of non-oil export revenue in 2017 (IEA, 2018b). Iraq's gas is naturally rich in ethane – a key feedstock for petrochemical production – and so Iraq also has the potential to build a major, competitive petrochemical industry.

To achieve a stable supply of low-cost ethane feedstock, a first step is to reduce gas flaring to allow the gas to be used for productive purposes. Gas processing facilities are also needed to separate dry gas and natural gas liquids (NGLs). Another step is to build facilities to process NGLs to extract the ethane, liquefied petroleum gas (LPG) and other products.

In 2015, Shell signed a USD 11 billion deal to build the Nebras petrochemical plant in the South oil hub around Basra. With a planned capacity of 1.8 million tonnes of petrochemical products, it is expected to be one of the world's largest petrochemical plants if completed. The project is part of a wider scheme to aggregate gas from fields in the South and build an integrated gas system. However, while the plan represents something of an exception for Shell given its withdrawal from upstream oil operations, progress has been slow. Shell is still reviewing the viability of the project amid concerns of cost escalation. Once a final investment decision is made, it will likely take five to six years for the plant to come online.

Accelerating progress on proposed projects would not only provide a sizeable non-oil revenue stream to Iraq, but also add significant value to schemes that aim to unlock its gas potential. The prospects for petrochemicals critically depend on Iraq's ability to reduce gas flaring and invest in gas processing facilities; the future for petrochemicals and natural gas therefore are closely interlinked.

Outlook for natural gas production to 2030

Iraq is not short of natural gas. However, it uses gas far less and far less effectively than most countries in the region. Resources and reserves are large. Gross volumes of gas produced are also significant. But even as the country faces significant shortfalls in electricity generation, more than half of the gas that is extracted in Iraq today is flared, while it imports gas from neighbouring Iran.

[8] For example, European buyers need to bid against the official selling prices for Asia rather than for Europe. This could favour Asian buyers.

[9] There is also a plan to rename Basra Light to Basra Medium and introduce a new light grade to strengthen Iraq's position in global export markets.

In 2017, proven reserves of gas were 3.5 trillion cubic metres (tcm), predominantly associated gas that is produced along with oil from the supergiant fields in the South hydrocarbon region. These reserves would be enough to supply nearly 200 years of Iraq's current consumption of gas (as long as flaring is minimised). However, proven reserves do not provide an accurate picture of Iraq's long-term production potential (and, too, today's consumption is not a good guide to what Iraq might use in future). Our review suggests that the underlying resource base – ultimately recoverable resources – is significantly larger, at 8 tcm. The bulk of this is associated gas, but these estimates also include large volumes of non-associated gas in both the northern and western parts of Iraq. Exploration and appraisal of these non-associated resources is at a very early stage.

Gas has traditionally been a junior partner in Iraq's energy resource discussion. It is much less lucrative per unit of output than oil, it is also more cumbersome to transport and its use requires a complex process of co-ordination along the value chain. As Iraq amply demonstrates, this alignment is difficult to get right. The most common problem is that there is no infrastructure in place to allow for the productive use of associated gas, hence the persistence of large-scale flaring. But there are also examples of the reverse, where an end-user (typically a gas-fired power plant) is built and ready to operate, but no gas is available. A power plant in Mansuriyah, near the Iranian border in Diyala province, was supposed to receive gas from the non-associated Mansuriyah field, for which a contract for development was awarded in 2010. However, production from this field has been delayed and instead the power plant runs on gas imported from Iran.

The short-term incentives for Iraq to develop a better functioning gas market are strong. Iraq continues to suffer power shortages and the unrest in Basra in mid-2018 underlined that social and economic risks that accompany unreliable power. Moreover, importing gas from Iran is expensive and politically sensitive, costs that are difficult to justify given Iraq's gas resource wealth.

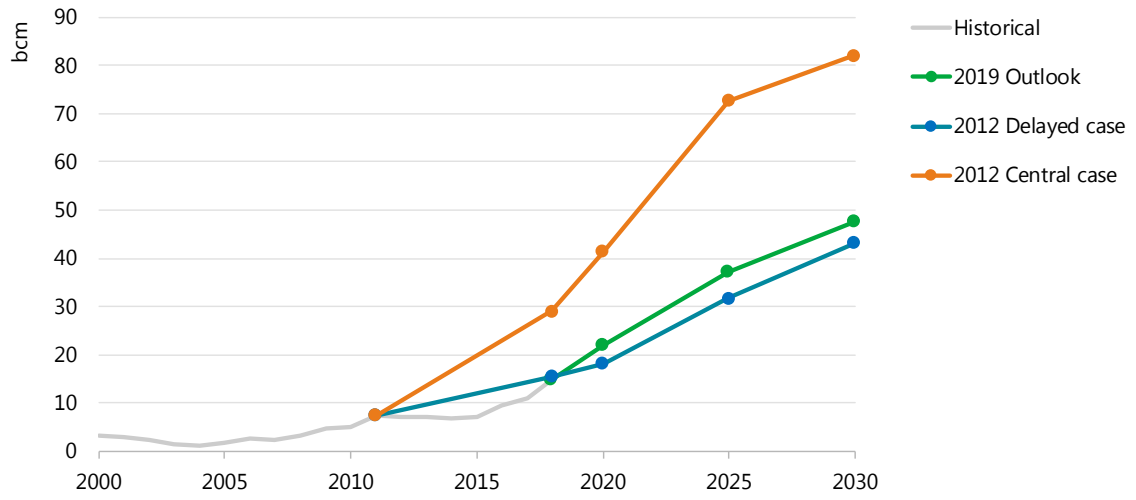
The longer term case for Iraq to use its natural gas potential is even more powerful. As examined in Outlook for Producer Economies: World Energy Outlook Special Report (IEA, 2018b), the potential significance of natural gas is broader than the direct income that it can bring; it can underpin an industrial strategy in a way that oil cannot, and in this sense can be an important conduit to economic diversification and employment.

Our gas outlook to 2030 is based on the assumption that Iraq's natural gas ceases to be an occasionally useful by-product of oil production, as in the past, and becomes a more pivotal and autonomous part of Iraq's energy strategy. This will require integrated planning from the government to ensure that the production, capture and processing of gas proceed in a coherent way, that processing plants are appropriately sized and located, and that the richer components of the natural gas stream – condensate, LPG and, once there is a market for it, also ethane – are used productively. It will also require that gas availability is well synchronised with demand from end-uses (notably in power generation and industry) as well as with the build-up of midstream infrastructure.

In our projections, Iraq's marketed gas production (net of flaring, venting and reinjection) is expected to increase significantly over the period, from 15 bcm today to almost 50 bcm by 2030 (Figure 12). There are signs in the latest data of an uptick in Iraq's output, but this projection is still lower than the Central Scenario in the Iraq Energy Outlook, 2012 and much more closely matches the Delayed case to 2030 (IEA, 2012). This downward revision is not a reflection on the size or quality of the underlying resource base, but it does reflect the relatively slow progress made in capturing and processing the rising volumes of associated

gas, mainly from the oil fields in the South, and the difficulty in successfully developing non-associated gas fields. These are key variables that will determine Iraq's gas production outlook.

Figure 12. Natural gas production outlook to 2030



Gas production increases lag those of oil. Reducing flaring could bring substantial new gas volumes to market.

Associated gas

Associated gas production rises from the current 11 bcm to nearly 40 bcm in 2030. This is partly a reflection of the oil outlook, notably the steady rise in output from the large southern fields. However, it also indicates marked progress with efforts to capture and process more associated gas. By late 2018, the Basrah Gas Company (BGC) was processing and producing the equivalent of around 10 bcm of gas per year. In January 2019, the shareholders in BGC (Iraq's South Gas Company with 51%, Shell with 44% and Mitsubishi with 5%) announced their intention to increase the volume to around 14 bcm by 2021. The initial investment efforts of BGC were focused on rehabilitating existing infrastructure previously operated by the South Gas Company; but investment in new facilities will be essential to reach the new target.

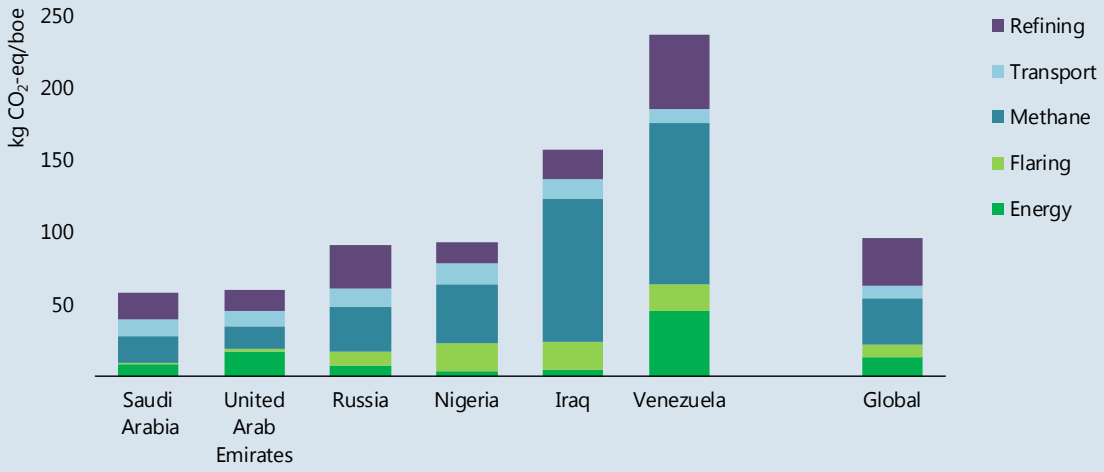
The target for BGC output, agreed with the Iraqi government, is around 20 bcm of gas per year, focusing on associated gas from three fields: Rumaila, Zubair and West Qurna. Delays in the implementation of this project have led Iraq to consider other options to reduce gas flaring (Box 2) and to monetise the flared gas. One proposal is to transport gas via a short pipeline to an NGL plant in Kuwait (Rumaila is only 20 kilometres from the border), and thereby to cover some remaining war compensation payments. Although negotiations on the topic have been confirmed, it is not clear if the deal with Kuwait will go ahead.

Box 2. Failing to care for gas can put Iraq's oil at a disadvantage

Extracting oil and gas, processing it and getting it to consumers can consume large amounts of energy. Given the importance of oil extraction to Iraq, this energy can represent a larger portion of total energy demand than in many countries. Keeping this element of demand in check can provide substantial cost savings. But it can also help with the environmental credentials of their oil and gas output.

Even though Iraq's oil is relatively easy to extract, the emissions intensity of its oil production is 50% higher than the global average. Gas flaring and methane emissions are the two key reasons. Today we estimate that around 17 bcm of gas is flared in Iraq – nearly double the volume of gas that is successfully brought to market. Flaring is particularly wasteful in a country that remains short of electricity: the volumes that are currently flared could fuel around 4.5 GW of gas-fired power generation, enough to power three million homes. Furthermore, flares are not 100% efficient and so a small portion of the gas is often not combusted and is released to the atmosphere as methane. Along with other sources of fugitive and vented methane emissions that occur during oil production, these add substantially to the emissions intensity of the oil sector in Iraq. Consumers around the world are starting to pay attention to this issue: while fossil fuels will remain in the energy system for some time, oil and gas that is produced in a clean and environmentally conscious manner is likely to enjoy advantages over other sources of supply. If Iraq were to eliminate flaring and venting, the emissions intensity of its oil production could be one of the lowest in the world.

Well-to-wheel emissions intensity of oil production and processing in selected countries



Notes: kg CO_2-eq/boe = kilogrammes of CO_2 equivalent per barrel of oil equivalent. One tonne of methane is assumed to be equal to 30 tonnes of CO_2-equivalent (the 100-year global warming potential).

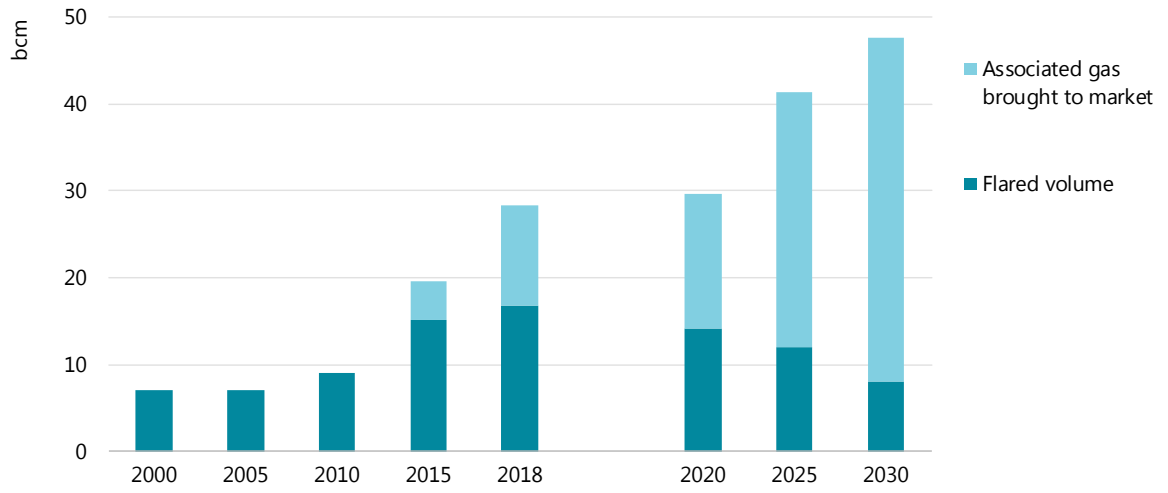
Source: IEA (2018a).

Emissions intensity of oil production in Iraq is among the highest in the world; reducing flaring and venting are key to amelioration.

The Iraqi government signed on to the World Bank's "Zero Routine Flaring by 2030" initiative in May 2017, and has been a long-standing member of the Global Gas Flaring Initiative. But past commitments to end flaring have been missed: the deadline for ending flaring in southern Iraq

has already been extended from 2016 to 2022. Nevertheless, there are signs of progress elsewhere; the KAR Group is looking to more than double gas output from the northern Khurmala oil field in 2019, along with the announcements by the BGC. Based on our assessment of existing political, regulatory, market, infrastructure and financial conditions, the volume of gas flared could fall markedly within the next few years and drop to less than 10 bcm in 2030 (Figure 13). These volumes can be brought to market and lead to a much greater role for associated gas in overall gas production in Iraq.

Figure 13. Natural gas flaring and volumes of associated gas brought to market



As proposed initiatives are implemented, flared volumes peak and fall to less than 10 bcm in 2030 while associated gas volumes brought to market grow to nearly 40 bcm.

Non-associated gas

The three main non-associated gas fields in Iraq are Akkas in the West, Mansuriyah in the Centre, and Siba in the South. Of these, only the Siba field has started commercial production (in 2018). Siba is operated by the Kuwait Energy Company, along with Turkish Petroleum AO (TPAO) and the local Maysan Oil Company. There are also some promising fields in the KRG, notably Khor Mor, Chemchemal, Miran and Bina Bawi.

Apart from Siba, development of most of these fields has been plagued with setbacks; highlighting the difficulty of non-associated gas development in Iraq. In our projections, non-associated gas output rises quickly in the next few years (from the current low level of 3.5 bcm to 8 bcm by 2022), but production growth stagnates thereafter. A more market-oriented electricity sector and a higher domestic gas price would provide stronger incentives for investment in gas for domestic use and could spur further non-associated gas projects.

The case of Akkas in the West is perhaps the most clear-cut. The Korea Gas Corporation (KOGAS) had the rights to develop the field, but the area in which it is located was under the control of ISIL from 2014 until late 2017 when it was retaken by Iraqi forces. Damage and security issues, including extensive land mines and other ordnance, are likely to hinder development in the area for some time.

The Mansuriyah field also faced uncertainties with security and TPAO (which was leading a consortium that also included KOGAS and the Kuwait Energy Company) halted much of the

development work on the field in 2014. The authorities have been eager for work to resume, and eventually announced in 2018 that the contract with the consortium was being cancelled and that state-owned companies would develop the field on their own. There has been a strong political push to start gas output from the field in order to supply local power plants and bolster electricity security.

In the KRG, non-associated gas development got off to a strong start with Khor Mor. Production of gas and condensates began in 2008, and LPG output in 2011. However, a dispute between the consortium and the KRG after the fall in international oil and gas prices (resolved in arbitration in 2017) held up progress. In March 2019, the Pearl Consortium, led by United Arab Emirates' Crescent Petroleum and Dana Gas, announced that they had signed a new 20-year gas sales deal that would see output rise to more than 6 bcm by 2021 and 9 bcm by 2022; output from the neighbouring Chemchemal field is also covered by the agreement.

Gas produced in the KRG has been consumed locally thus far, but a 2013 intergovernmental gas sales agreement between Turkey and the KRG opened the possibility of export. This agreement anticipated that exports of 4 bcm per year would begin in 2017, a target that was not met. The possibility of gas export to Turkey remains on the table, and prospects were heightened when Russia's Rosneft announced in 2018 that it would take the lead in building the necessary infrastructure.

The Pearl Consortium would be well placed to benefit if such an export route were available. The Miran and Bina Bawi fields, contracted to Genel Energy, have also been prominent in discussions about exports, although field development plans have yet to be agreed with the KRG. In addition to multiple political uncertainties, there are also questions concerning the extent of demand for gas exports from Iraq. The outlook for Turkish gas consumption is not quite as bullish as it was in 2013, and the attraction of Iraqi gas as a diversification option for more distant European markets may be diminished by Rosneft's involvement. Our projections are consistent with some small volumes of gas export from northern Iraq, starting in the early to mid-2020s.

Box 3. Energy needs for water desalination

Despite the gap between the supply and demand of water, desalination currently plays a limited role in Iraq. Many of the desalination plants it does have are in a state of disrepair – 13 built during reconstruction have not worked since they were finished in 2006 – and new plants that are under construction are years behind schedule. For example, a new 1.3 mb/d reverse osmosis (RO) plant that is under construction in Basra, which would be the largest of its kind in Iraq, was supposed to be complete in early 2017 but has been delayed due to payment issues. Nevertheless, given the limited quantity and growing salinity of the available water sources – in Basra 100 000 people were hospitalised from contaminated water in 2018 – and the importance of water for Iraq's well-being and economic advancement, desalination is likely to play a much larger role in the future.

By 2030, we estimate that desalination will provide around 10% of Iraq's total water supply. Desalination is an energy-intensive process and energy demand for desalination rises to over 5 million tonnes of oil equivalent in 2030 (from negligible levels today). Most of the water produced via desalination in Iraq is projected to come from membrane-based RO desalination that relies heavily on natural gas-based power generation and gas-based thermal desalination (multi-stage

flash distillation or multiple-effect desalination). As such, more than 10% of Iraq's total gas production in 2030 is used for desalination. However, desalination does not have to remain wedded to natural gas, especially if the gas can be better used elsewhere. For example, to increase the share of renewables in power generation, co-generation plants could be paired with RO technologies to provide operational flexibility. This would also allow the system to be used as a demand response facility as the water storage tanks could also serve as energy storage during times of excess electricity production.

In addition, it is likely that Iraq will require more mobile small-scale desalination units to deal with the deteriorating quality of its rivers. A combination of declining freshwater flows, increasing salinisation, ongoing discharge of industrial wastewater and sewage, and agricultural runoff has reduced the quality of the water beyond the World Health Organization safe drinking water standards. Nonetheless, for desalination to play a larger role in Iraq's water supply, current challenges related to financing, security and contracts will need to be resolved.

Investment in oil and gas

The oil price cycle of the last decade has been directly reflected in the capital investment in Iraq's oil and gas sector. Investment levels peaked in 2014, at just over USD 20 billion, but have since fallen significantly, averaging around USD 12 billion per year. Part of this decrease was absorbed by industry-wide cost deflation, and so the net effect on projects would likely have been smaller than the headline of capital decline would suggest. Nevertheless, the drop in the oil price led to some delays in remuneration by the Ministry of Oil to IOCs for past investments, which in turn led to some reluctance by IOCs to commit further capital. The cost reductions and opportunities for production growth in US tight oil resources also diverted potential capital investment away from Iraq. Along with security issues related to ISIL and political instability in the north, these factors led to the reduction in plateau production targets that had been agreed between the government and IOCs, and to a drop in investment in real terms.

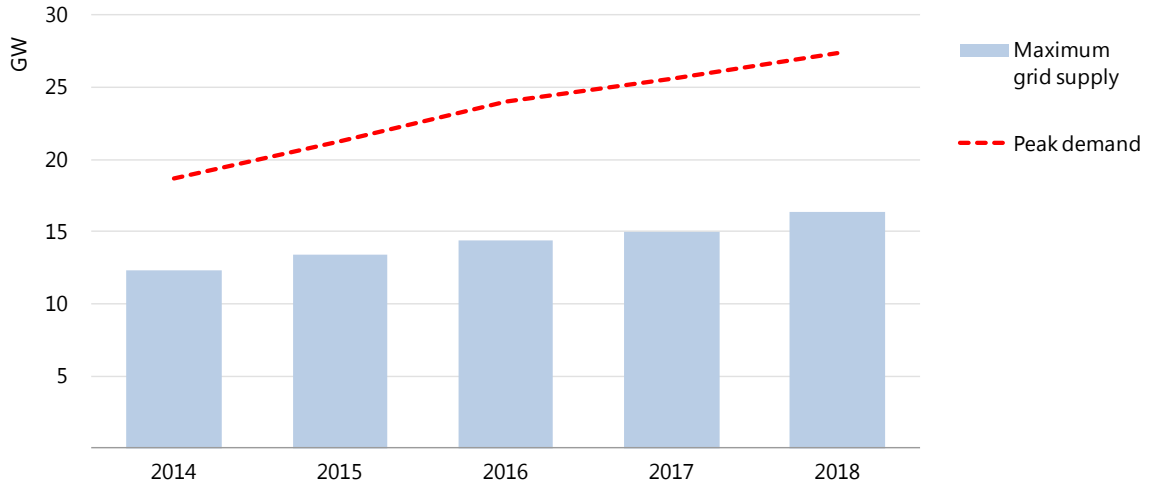
Looking forward, annual upstream investment in oil and gas between 2018 and 2030 averages USD 15 billion. Of this, a rising share is directed to gas projects, facilitating the 35 bcm increase in production over the period. One priority in the near and medium term is investment in large-scale water treatment projects to supply water for reinjection in the oilfields in the South region. Investment in such projects can yield huge dividends. For example, the CSSP, a facility that could provide 5 mb/d of water at an estimated capital cost of around USD 5 billion, could unlock crude oil production of over 400 kb/d by 2030 and generate an estimated USD 50 billion in cumulative revenue to 2030.

Chapter 3: Prospects for the electricity sector

Introduction

Iraq's power sector faces significant challenges. Outages remain a daily occurrence for most households, as increasing generating capacity has been outrun by increasing demand for electricity, spurred in particular by high demand for cooling in the hot summer months. Over the past five years, the size of the gap between peak electricity demand and maximum grid supply of power has widened, even though available supply has increased by one-third (Figure 14). Investment in infrastructure, particularly the distribution networks, has lagged behind what is required, as budgets were constrained due to period of low oil prices. Meanwhile, tariff collection, where it exists, has not been sufficient to supplement the capital budget. This creates a negative cycle whereby lower revenues lead to lower capital investment, which in turn limits available supply and revenues.

Figure 14. Peak demand and maximum power supply from the grid, 2014-18



Source: Iraqi Ministry of Electricity.

The gap is widening between peak demand and grid supply, even with recent expansion of generation capacity.

Small-scale oil-based generators play a critical role in supplementing grid supply, helping to alleviate some of the most acute shortages in the peak summer months. In 2018, the combined total of small generators was 5 GW. About two-thirds of the total are privately owned and referred to as neighbourhood generators, with direct connections provided to paying

households and businesses. About one-third of the small generators are owned by government entities, mainly to meet their own electricity needs.[10] Together, these assets close half of the gap between peak demand and grid supply. But they are an extremely expensive option for consumers. Given their high costs and limited availability, most households across the country are unable to rely on neighbourhood generators to fill the entire gap from the insufficient grid supply and have to forgo desired energy services (frequently the use of energy-intensive air conditioners).

The grid supplied more than 80% of the electricity consumed by households in 2018, yet makes up a tiny share of consumer's electricity bills. Consider the example of an upper-middle class household in an urban centre (Figure 15). Such a household might consume around 16 000 kilowatt-hours (kWh) of electricity per year, with three-quarters of it to provide cooling in the summer months.[11] Such a household could, on average, rely on the grid to supply around 12 000 kWh (assuming an average supply of 14 hours per day across the year), with neighbourhood generators providing the remaining 4 000 kWh.[12] This household's consumption would put it in the top tier of grid supply tariffs, pegged at around IQD 120 000 (USD 100) per year. Supplementing its grid supply, for an average of around 10 hours per day over the year, this household might expect to pay as much as USD 4 000 per year to the neighbourhood generator. Neighbourhood generator charges are as much as IQD 25 000 per ampere of capacity despite regulations in place that call for lower charges.[13] These fixed charges translate to around USD 1 000 per MWh for the example household, putting them among the most costly sources of electricity anywhere in the world. Combined, the example household pays an average price of USD 240/MWh for electricity delivered, which is eight-fold the average residential electricity price in the Middle East region today.

A similar situation applies to all households in Iraq. Despite efforts to provide a progressive tariff scheme to households – intended to make electricity more affordable for low-income households – the average electricity price paid per kWh of consumption is relatively constant across consumption levels due to the large role of expensive neighbourhood generation. This means that efforts to reduce the contribution or costs of neighbourhood generators could improve electricity affordability for most, if not all, households.

Without immediate and concerted action, these pressures are likely to inflate, as rapid population growth and economic development bring increased demand for electricity. Achieving stable, affordable and reliable electricity supply is vital not just to serve the basic needs of the Iraqi households and to improve living conditions, but also to stimulate economic growth. Businesses and industries are reliant on reliable and affordable supplies of electricity, and, alongside oil and gas, will be a driving force of the economy in the future. Without reliable grid supply, many firms must meet their own needs, an additional cost to doing business in Iraq.

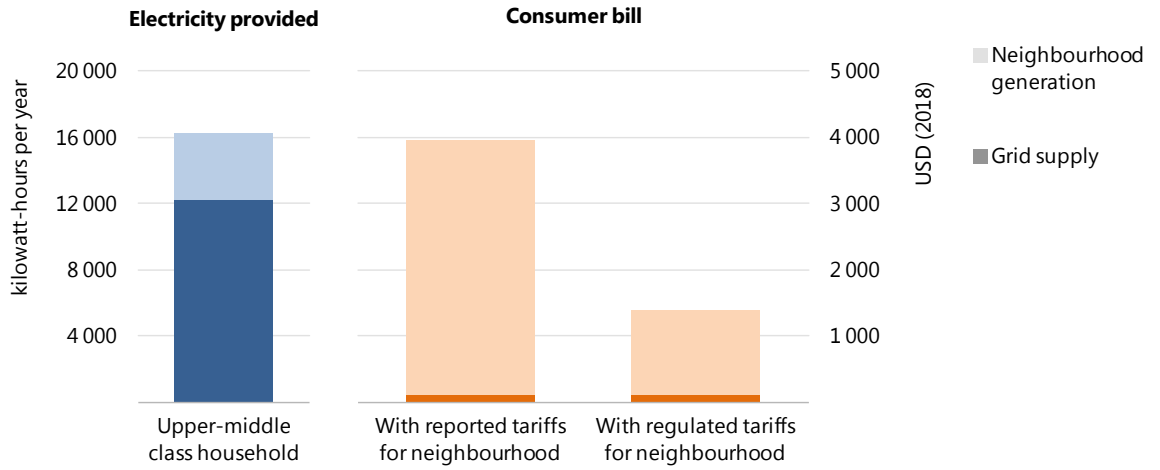
[10] In addition, the upstream oil and gas industry produces electricity on-site in many cases to meet its own needs.)

[11] The remaining 4 400 kWh are for appliances, lighting, televisions and other electrical devices.

[12] Estimated on the basis of an annual contract for a connection of 16 amperes, utilised to a high degree for half the year to provide cooling and to a much less degree in cooler months.

[13] There are regulations in place for neighbourhood generators, at IQD 8 000 per ampere, but enforcement is limited and actual prices charged often exceed IQD 24 000 per ampere.

Figure 15. Consumer bills and electricity provided from the grid and neighbourhood generation for an upper-middle class household, 2018



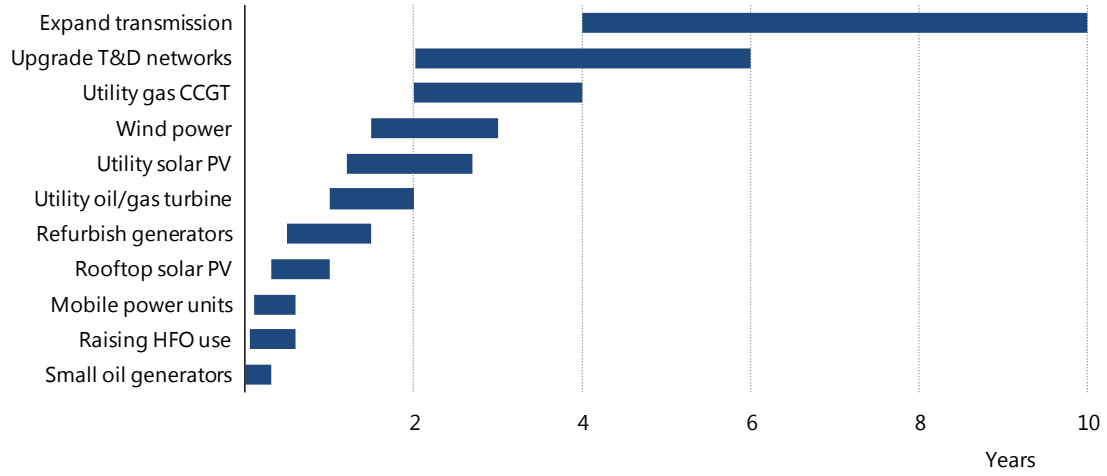
For a given household in Iraq, the grid provides the majority of electricity, but more than 90% of the consumer's electricity bill goes to expensive neighbourhood generation.

Addressing the immediate needs

Alleviating the power shortages to meet peak demand in the summer months is a significant priority of the Iraqi government. Here, there is room for cautious optimism, as a number of options are available to remedy the immediate shortfalls (Figure 16). We have explored these options and considered how they can be deployed in a manner that compliments long-term planning for a reliable and affordable system. Addressing the immediate imperative is vital, but should not detract from the importance of pursuing long-term targets simultaneously.

Before considering supply-side options, programmes to encourage energy conservation and efficiency should be given due priority, as they can deliver immediate benefits and are consistent with longer term goals. For example, supporting high-efficiency cooling equipment should be a priority for the immediate as well as other strategic plan time frames. In addition to conservation and efficiency, efforts should be made to free up available supply for the most critical uses. Wherever possible, consumers should be encouraged to shift non-essential demand away from peak hours, enabling more households to have cooling during the hottest periods of the day. This may require campaigns to increase consumer awareness of energy efficient equipment and the potential reductions of their electricity bills.

Figure 16. Technology options to improve electricity supply by time to complete project type



Notes: T&D = transmission and distribution. CCGT = combined-cycle gas turbines. PV = photovoltaics. HFO = heavy fuel oil.

Implementing a basket of readily available measures could boost power supply to meet peak demand.

Improving transmission and distribution networks could provide immediate gains. Identifying the weakest parts of the grid, and concentrating efforts on improving the state of distribution networks could provide returns even in the short term. Losses in the electrical system are astronomical. Technical losses are estimated at about 40%, with the vast majority in distribution networks. This means that the amount of electricity produced that is lost before it reaches the consumer stands at more than 40 terawatt-hours (TWh), four-times the total neighbourhood generation in Iraq. If these losses were reduced to levels similar to the regional average, the total electricity supply of 125 TWh in 2018 (split between domestic generation, imports and neighbourhood generation) would have been sufficient to meet nearly all electricity demand except for the hottest months of the year. Non-technical losses refer to electricity that is delivered to consumers but is not metered, accounting for an estimated 20 TWh of electricity consumption. Improving the state of distribution systems should be the top priority for Iraq's power supply in the immediate, medium and long term, as it is critical to make the best use of the available power assets. Any work that temporarily reduces the capabilities of the networks, however, should take place outside of the peak summer period to ensure the maximum available grid supply during times of high demand.

The available capacity of the existing power plant fleet should be maximised, as some improvements can be made in short order. Currently, there are 16.4 GW of available capacity in Iraq, but this is only half of the total installed nameplate capacity. The difference between the installed and available capacity is the result of high ambient temperatures, poor maintenance or lack of available high-quality fuel. Launching an immediate maintenance campaign with the associated funds made available to rehabilitate or upgrade the efficiencies of existing plants (for example by installing chillers or converting open-cycle to combined-cycle facilities) could substantially increase available capacity.

Ensuring that all available capacity is in operation should be a top priority. Where multi-fuel units are being underutilised due to lack of feedstock, heavy fuel oil could be used as a substitute to maximise output. Although this is not an ideal situation, and causes plants to run at well below their design efficiency levels, it would help alleviate the harshest strains in the

peak summer months. Furthermore, the abundance of HFO in Iraq, (and the constrained international market for this product) means that the opportunity cost of burning HFO is lower than it otherwise would have been.

In terms of new capacity, deploying mobile power units and small generators should also be considered, as it can be done in a few months. While more expensive on a levelised cost basis than large stationary power plants, the speed at which these can be deployed makes them an attractive option for meeting immediate needs. To moderate capital availability limitations, the procurement of energy could be re-introduced through independent power producers, rather than purchasing the units themselves (Box 5). Even at attractive terms for developers, this would reduce the financial burden of addressing the immediate needs. The locational and operational flexibility of these units also means that they will be useful for years to come under a wide range of development pathways. Initially, they can be located where power shortages are most acute. Looking forward, they can be moved to address the most pressing issues, not only in terms of shortage, but also in terms of potentially alleviating points of grid congestion. Eventually, they could facilitate the increased deployment of variable renewables like solar photovoltaic (PV), address evolving system needs or even provide off-grid supply in remote communities.

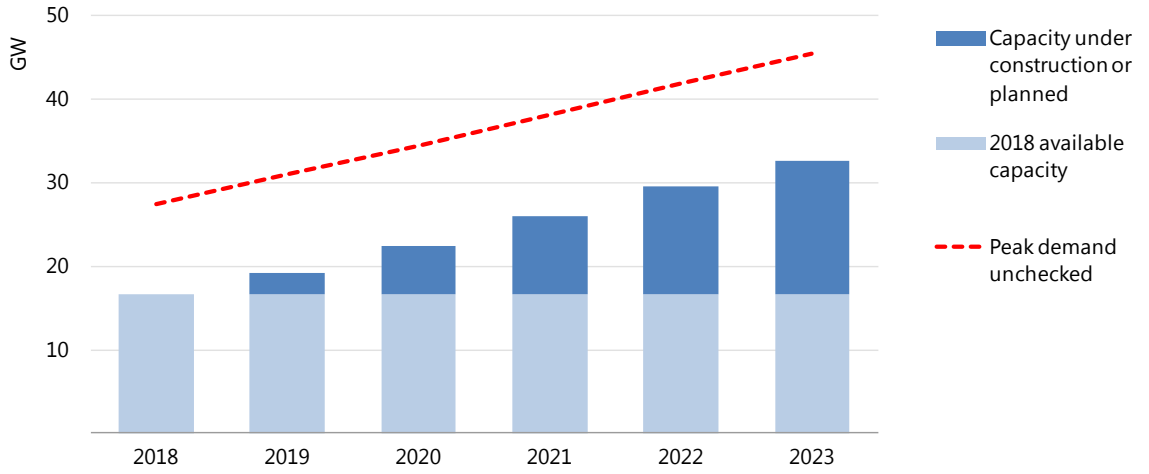
Supply-side efforts could increase the available power supply by 4-6 GW in a matter of months, closing the gap between supply and demand by as much as half. Available capacity at existing power plants could be raised by approximately 2 GW. Several gigawatts of new mobile units could be deployed across Iraq. Any improvements to the distribution network would effectively lift the available capacity further for these additions, as well as making better use of the 16.4 GW of available capacity already in place. Any demand-side measures that are able to deliver peak shaving in the coming months would further reduce the gap.

The affordability of electricity could also be substantially improved in the immediate term, alongside gains in reliability. The main lever to reduce cost to consumers is through neighbourhood generators, which are currently providing an estimated 10 TWh of electricity to end-users. In total, currently households could be paying more than USD 4 billion for the additional electricity services from neighbourhood generators. Enforcing existing tariff regulations for neighbourhood generators would cut the electricity bills for most households by two-thirds. If successfully applied to all neighbourhood generators, this would reduce the associated cost to consumers to less than USD 1.5 billion. Encouraging consumers to direct these savings into energy efficiency investments, particularly cooling equipment and insulation, could translate these near-term financial wins into longer-term electricity reliability gains.

Options for the medium term

Looking beyond the immediate priority of ensuring the smallest possible gap between supply and the summer peak demand, Iraq has a range of options to address its power sector challenges in the medium term. More options become available to moderate energy demand growth, improve networks, and increase the use of interconnections with neighbouring countries, and to expand available grid capacity from existing plants as well as new construction. Given the high costs of neighbourhood generation, it is vital that the focus shifts to ensuring the growth of grid-based supply, increasing the reliability of services to consumers and improving affordability.

Figure 17. Peak demand and available power capacity in Iraq, 2018-23



Sources: Iraqi Ministry of Electricity; IEA analysis.

Realisation of power plants under construction and planned is not sufficient to bridge the gap between available supply and peak demand.

Closing the gap between peak demand and available supply is not to be taken for granted. Without efforts to keep demand growth in check, peak demand and electricity consumption are projected to increase by 50% in the next five years and by over 90% from 2018 to 2030. This rapidly increasing demand means that Iraq's challenge of bridging the gap between supply and demand is a moving target in itself. Currently, there are about 20 GW of new power generation capacity either under construction or planned in the medium term. Even where these are successfully completed on-time, a significant gap between power supply and demand would remain in 2023 (Figure 17). Additional efforts will be needed to bridge the gap. To support growing demand and electricity supply, existing transmission and distribution networks will need to be upgraded and expanded.

Incentivising conservation and efficiency

Moderating electricity demand growth will be critical to eliminating power shortages. Cooling demand is already a key driver of peak electricity demand, and as the population increases and incomes rise, it will be the main driver of demand growth for years to come. Ensuring that high-efficiency units meet new demand would have a significant impact on peak demand growth. Subsidising the most efficient equipment would be prudent and cost-effective means of supporting a reliable electricity system. Providing consumers and businesses with appropriate signals to use electricity more efficiently is an important avenue to improve the situation in the power sector. For grid supply, expanding the tiered tariff system would serve to provide a strong incentive to moderate household consumption, as well as financially rewarding energy efficiency measures (Box 4).[14] For neighbourhood generation, reforms that

[14] In the long run, real-time price signals would be an efficient means of incentivising consumer behaviour, but would require substantial investments in the distribution grids and deployment of smart metres to households and businesses.

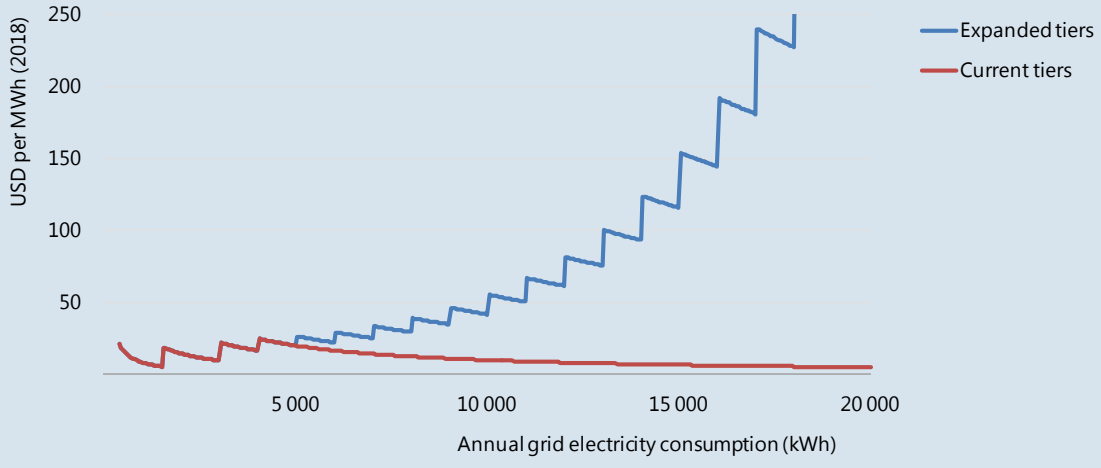
link charges with consumption rather than the size of connection would encourage conservation and limit peak demand growth.[15]

Box 4. The case for grid tariff reform in Iraq

Despite efforts to provide a progressive tariff scheme, the current tier system for electricity tariffs implemented by the Iraqi Ministry of Electricity keeps the total cost for supply fixed for any level of consumption above 4 000 kWh per year, meaning that the effective price per unit of energy delivered declines with higher levels of consumption. This provides no incentive for consumers to limit their electricity use once they have surpassed 4 000 kWh, a relatively low level considering high cooling demand for much of the year. Furthermore, considering the outsized contribution of neighbourhood generation in consumer electricity bills, the average electricity price paid per kWh in total is broadly constant across consumption levels, undermining the government's efforts to ensure that low-income households shoulder a smaller burden.

One way of ensuring a tariff structure that is truly progressive is to expand the current scheme to include additional tranches based on consumption levels with incremental increases for each 1 000 kWh of consumption by a set rate of escalation. For example, currently the amount paid for electricity increases by 50% when consumption rises from 3 001 kWh to 4 001 kWh. Such an increase in cost could also be introduced when moving from 4 001 kWh to 5 001 kWh per year, and so on. Even if the increased tariffs remained far below the amount needed to fully recover the cost of supply, such a policy would provide multiple benefits. First, it would introduce an incentive to use electricity more efficiently, potentially serving to reduce peak demand. It would also ensure that as consumers demand more electricity and are able to pay more, that they do pay more.

Tariffs for grid supply of electricity by consumption level in Iraq



Note: Expanded tiers apply an escalation rate of 33% to the tariff for each additional 1 000 kWh of annual consumption.

Sources: Iraqi Ministry of Electricity; IEA calculations.

[15] Where consumers pay an illustrative connection fee of IQD 1 000 per ampere and then are charged a fee equivalent to around USD 200/MWh consumed.

Expanding the number of tariff tiers would substantially increase revenues to the government, which could be used to strengthen the power supply system by funding the much-needed investment in the sector, and thus provide a more reliable electricity supply. This would create the virtuous cycle of reducing the role of neighbourhood generators and improving the affordability of electricity.

Expanding available grid supply

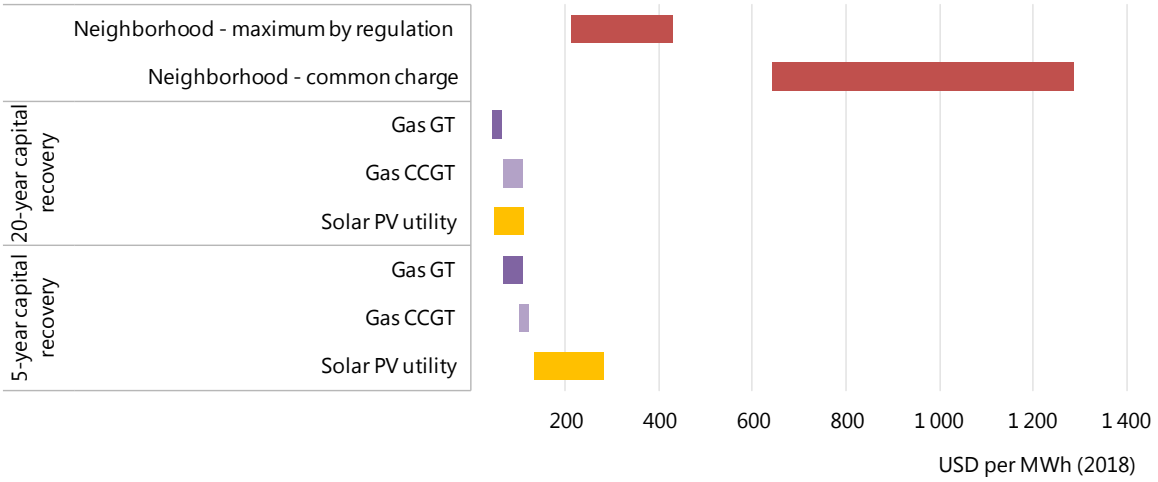
Investment in transmission and distribution networks should be a central priority in the medium term and beyond. Improving the state of distribution networks through maintenance and refurbishment requires substantial investment, but sustained efforts over several years would be handsomely rewarded. An aggressive maintenance programme for lines and substations would bring a continuous stream of benefits, some of which would be delivered within the first year of the initiative. Reducing losses by five percentage points from current levels would effectively raise the available capacity by more than eight percentage points, making the most of both existing and new power plants.

Available grid capacity will need to increase in order to eliminate the current shortage and to meet new demand, even with successful efforts to moderate demand growth and improve distribution networks. Closing the 16 GW gap between available and nameplate capacity to a large extent for the existing fleet would offer a cost-effective pathway to expand grid supply. Over the span of two to three years, most options to increase the available capacity of existing power plants become possible. Continuing near-term efforts, efficiency upgrades should be pursued for all applicable power plants, including chillers and more advanced measures. In some cases, extensive rehabilitation will be needed. In such cases, downtime should be co-ordinated to minimise impacts on shortages and funds should be made available to ensure maintenance can be undertaken at ideal times. In terms of fuels, natural gas should be used to the maximum extent possible, raising power plant efficiency and reducing wear-and-tear and maintenance costs for existing power plants.

New power generation capacity will also be needed to close the gap between grid supply and demand. Given the extremely high cost of neighbourhood generation, even where charges follow current regulations, a variety of sources of electricity would offer potential cost savings. A comparative analysis of the levelised cost of electricity (LCOE) shows that the LCOE of an open-cycle gas turbine ranges between USD 40-60/MWh[16], while more efficient combined-cycle gas turbines show a LCOE range of USD 70-110/MWh (as lower fuel costs are more than offset by higher construction costs). Both these options are substantially less expensive than the prevailing neighbourhood generators, whose LCOE range is USD 640-1 300/MWh (Figure 18). Rooftop solar PV systems also offer potential for consumers to reduce their electricity bills, and should be part of the broader basket of solutions for the power sector.

[16] Depending on the cost of natural gas, ranging between USD 2-4 per million British thermal units.

Figure 18. Neighbourhood generation costs compared to the levelised costs of electricity from utility-scale generation technologies, 2020



Note: GT = gas turbine; CCGT = combined-cycle gas turbine; PV = photovoltaics.

Neighbourhood generation provides a critical supplement to grid supply, but its high costs offer opportunities to improve electricity services while also lowering costs.

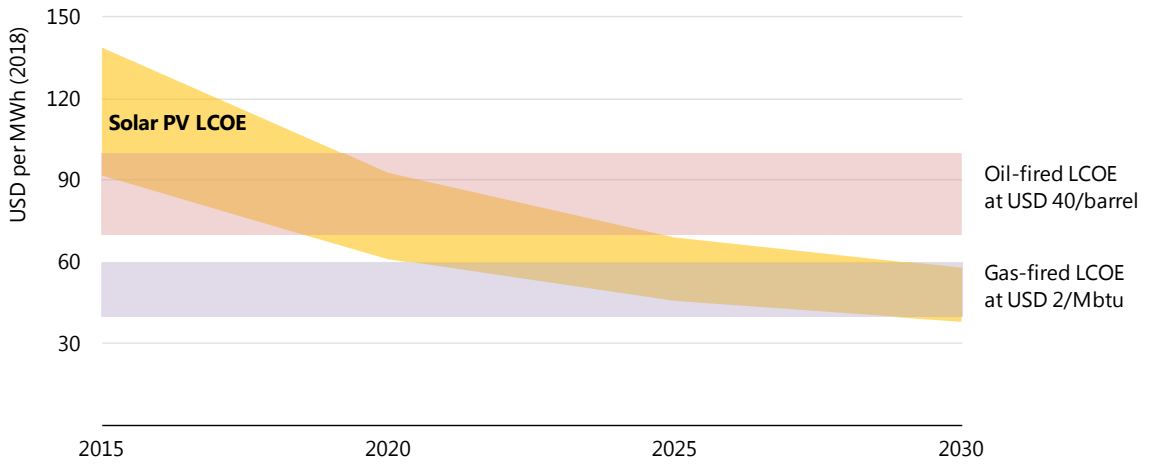
Should Iraqi policy makers opt for an aggressive pursuit of private investment in power generation, for instance by offering much shorter cost recovery terms of five years (rather than the industry standard of 20-25 years), this would still offer significant potential for cost savings to consumers. With relatively low construction costs, the LCOE of open-cycle gas turbines would rise to USD 75-105/MWh, around 90% less than neighbourhood generators. Pursuing this route, combined with tariff reforms that increase revenues, would allow the Ministry of Electricity to focus the capital expenditure allocated to it by the federal budget on other essential areas, including the network, where private sector involvement is often more difficult to incentivise (Box 5).

The potential savings for consumers depends also on the level of network losses. With technical losses of about 40%, the delivered cost of electricity to end-users would be two-thirds higher than the LCOE described (and therefore reduced cost savings). For example, for a power plant that produces electricity at an LCOE of USD 100/MWh but delivers only 60% of output to consumers, the average cost per unit delivered is USD 167/MWh. Even under regulated prices, open-cycle gas turbines, CCGTs and solar PV all offer significant savings. Reducing technical losses to 20% (well above the 14% average in the Middle East), would lead to a delivered cost that is just one-quarter higher than the LCOE, effectively making any source of grid supply less expensive to consumers.

Renewables, including solar PV and wind power, are increasingly attractive propositions for most electricity systems. This is particularly true in Iraq, where solar resources are very good, and where renewables offer the opportunity to improve the reliability and affordability of electricity. The falling costs of renewables offer opportunities to reduce the average cost of electricity supply while also increasing export revenue opportunities. Previous efforts to encourage solar PV development have not been successful to date, including feed-in tariffs offered in 2017, but demonstrate the growing interest in this technology in Iraq.

Solar PV is already on equal footing with oil-fired generation in terms of levelised costs of electricity, and would soon outcompete it if the solar market in Iraq were developed (Figure 19). At an oil price of USD 40/barrel, the LCOE of oil-fired generation in Iraq ranges from USD 70-100/MWh[17], meaning that solar PV is essentially competitive already. Competition with gas-fired power plants would be more challenging, but even where gas is priced at USD 2 per million British thermal units (MBtu)[18], solar PV would be able to match the cost of gas-fired generation by 2030.

Figure 19. Solar PV levelised costs relative to oil- and gas-fired generation in Iraq, 2015-30



Note: LCOE = levelised cost of electricity. LCOEs for oil- and gas-fired power plants are based on a range of operational efficiencies.

The falling costs of solar PV offer opportunities to make electricity more affordable, free up oil and gas resources for export, and to improve the reliability of electricity supply through diversification.

Solar PV costs have been declining rapidly around the world, including in the Middle East, and are expected to continue to fall. In the past five years, the average construction costs for a utility-scale solar PV project have fallen by 50% across the region, to about USD 1 300/kW in 2018. Considering the high-quality solar resources, this implies an LCOE of around USD 70/MWh on average, a small fraction of the cost of neighbourhood generation in Iraq.

Support policies that help lower the cost of capital can lower the LCOE of solar PV substantially. Auction schemes for solar PV in the Middle East have produced some of the lowest prices in the world to date. For example, in the United Arab Emirates, a project was awarded a contract in 2016 at just USD 24/MWh. These projects have been able to achieve such low levels because of falling technology costs and, critically, price guarantees that enable low-cost financing. They may also benefit from additional preferential conditions, such as low-cost land. By 2025, solar PV costs (including all costs and standard financing) in the Middle East are projected to fall by about one-third, to about USD 50/MWh on average.

[17] Units with low efficiencies nearing 30%, for example those where maintenance has been limited, would have LCOEs close to the upper-end of the range.

[18] International export opportunities may offer a higher netback price than USD 2/MBtu, improving the prospects for solar PV.

Large-scale solar PV projects have not been developed to date in Iraq, and so there is some inherent uncertainly on the construction costs of new projects. However, there is ample clarity on the cost of the solar panels, a global commodity whose manufacturing is concentrated in Asia, serving solar PV projects in many countries around the world. They can be transported at relatively low cost, which results in similar panel prices around the world. Project development costs are more uncertain, as new supply chains would need to be established and the initial projects in a country without experience in the field are likely to come at a cost premium. Where this premium is 20%, a solar PV project coming online in Iraq in 2020 would cost an estimated USD 60-90/MWh.

Achieving the lower end of this range is largely dependent on the quality of the site, the ease of transporting materials to it, successful procurement of low-cost solar panels and inverters and the availability of trained personnel for installation. The completion of several projects would allow solar PV costs to converge quickly towards other experiences in the region as the market matures. Experience is largely transferrable across regions for solar PV, which could provide an opportunity to capitalise on the broad experience of international developers in achieving low costs in Iraq. Improving the financial health of the power sector would also improve opportunities for solar PV development, as it would increase certainty that the government would be able to fulfil contract terms as an off-taker, leading to more attractive financing terms.

Wind power could also be an attractive option for Iraq in terms of costs. Wind resources are modest across Iraq, but recent technology improvements including low wind speed turbines and digitalised wind farm design are expanding the potential areas for development. A wind power industry has not been developed to date in Iraq, and so like solar PV would incur a cost premium as it develops. However, with a LCOE ranging from USD 60-90/MWh, wind power would compete well with oil-fired generation and provide an attractive way to further diversify the power mix. This would be important to enable a higher share of renewables in the generation mix, as solar PV generates power during daylight hours only unless energy storage systems are included. Developing wind power in addition to solar PV would also help to expand capital available for power sector investment as it could enlarge the number of private players active in Iraq. Improving wind resource assessments and completing initial feasibility studies of wind power in Iraq would provide significant boosts to developing the wind industry.

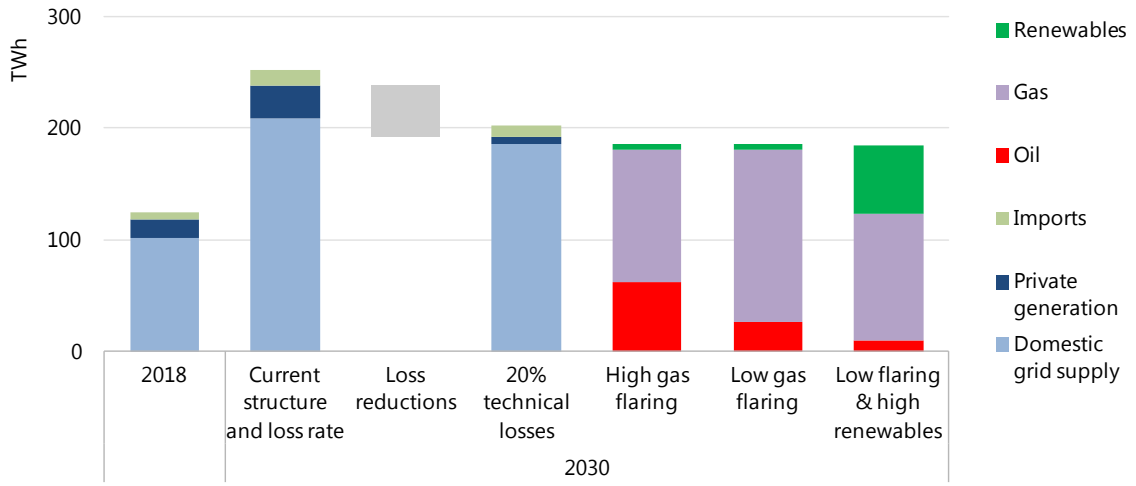
Towards reliable, affordable and sustainable electricity in the long term

There are a number of pathways available for the future of electricity supply in Iraq. The most affordable, reliable and sustainable path requires cutting network losses by at least half, strengthening regional interconnections, putting captured gas to use in efficient power plants and increasing the share of renewables in the power supply mix. In the long term, all options are available to improve the situation in the power sector. Comprehensive programmes should be undertaken to thoroughly modernise and expand transmission and distribution networks to address the current issues, reflect evolving needs and lay the groundwork for the future. Meeting rising demand will be a continuous challenge going forward, but taking positive steps forward in the near term would set Iraq's power sector on a different path, one that leads to desirable outcomes for consumers, industry, government and the Iraqi economy at large.

By 2030, electricity consumption is projected to increase to about 150 TWh, from 75 TWh in 2018. If the current structure of electricity supply persisted, domestic generation, imports and

neighbourhood generation would need to double, for a total supply over 250 TWh (Figure 20). If technical losses stalled at 40%, it would mean that more than 80 TWh would be lost before reaching consumers, a larger amount than total electricity consumption today. The increase in oil-fired generation would raise oil product consumption from about 300 kb/d in 2018 to over 500 kb/d. Gas consumption for power generation would rise from 25 bcm to 36 bcm in 2030. Even maintaining the current structure of electricity supply is not to be taken for granted, as it would require more than doubling recent levels of power sector investment to avoid falling further behind.

Figure 20. Steps towards a reliable, affordable and sustainable electricty supply in Iraq by 2030



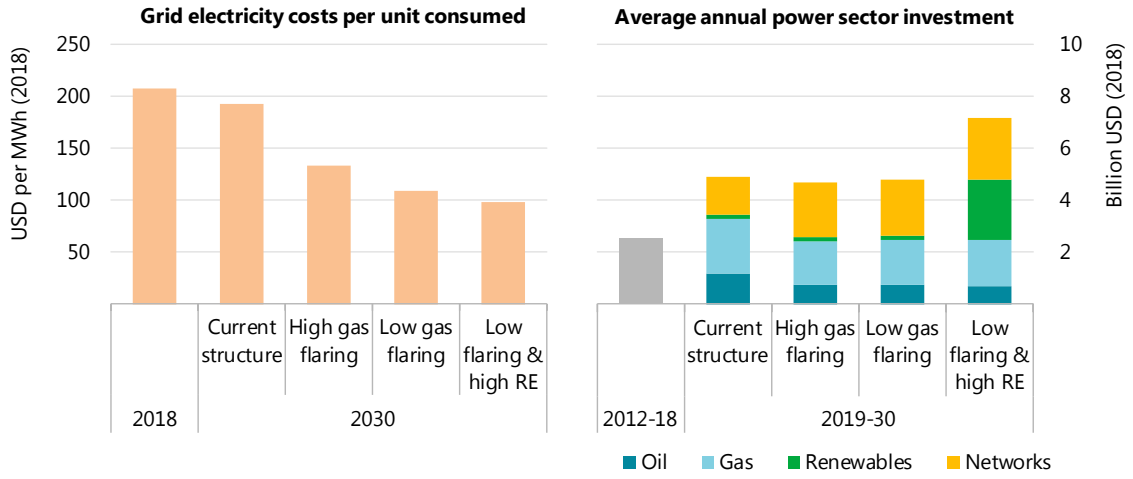
Achieving an affordable, reliable and sustainable electricity supply is possible with targeted efforts to reduce network losses, to use captured gas in power generation and to promote renewables.

Reducing network losses is a priority matter to improve the state of the power sector in Iraq. Cutting losses provides a boost to any supply-side expansion, making it easier to meet electricity demand growth. Given that technical losses in Iraq are one of the highest levels in the world (around 40%), there is potential to cut these by half or more by 2030. Yet, this would still put the level of losses well above leading countries in the Middle East, which have achieved system losses closer to 10%. Cutting losses in half would enable domestic grid supply to meet a higher share of demand throughout the year, limiting the need for expensive neighbourhood generation. While the average level of power sector investment would be similar to that needed to maintain the current structure, allocating more to networks would drive down the average costs of electricity per unit of consumption by one-third. Where grid tariff reforms have been established, these savings could be passed on to consumers through prevailing tariffs. Reducing network losses also saves fuel. In a situation where only modest progress is made to capture associated natural gas in southern Iraq and put it to productive use, oil would continue to play a central role and the power mix would look similar to that of today. In such a case, cutting losses in half would reduce oil consumption by nearly 200 kb/d and gas consumption by 6 bcm in 2030, freeing up those resources for potential export with a value of USD 5-10 billion depending on prevailing market prices.

A second step forward would be to expand the use of natural gas in power generation where it is coordinated with progress in gas capture projects. Gas that is flared today would provide a cost-effective fuel to meet growing electricity demand. In a low flaring case, converting open-cycle

gas turbines to combined-cycle designs would make the best use of the more reliably supply of gas. Increasing the share of gas-fired generation in grid supply from below 60% in 2018 to 80% in 2030 would raise gas consumption to 38 bcm. This would cut oil consumption in power in 2030 by another 170 kb/d, increasing potential export revenue by several billion dollars, as well as contributing to reduce average grid electricity supply costs (Figure 21).

Figure 21. Average grid electricity supply costs (2018 and 2030) and power sector investment in Iraq by case, 2019-30



Note: RE = renewable energy-based generation. Grid electricity supply costs decline under the current structure due to limiting the amount of gas imports from the highest-cost sources.

The more reliable and sustainable electricity system choices would require a larger injection of capital investment, but would also produce the lowest system costs of all options.

A third step towards a brighter electricity future in Iraq would be to emphasise the development of renewable energy power generation technologies. The development of 21 GW of solar PV and 5 GW of wind power by 2030 would improve the affordability, reliability and sustainability of electricity supply. It would also make oil and gas resources available for use in domestic industries (particularly gas) or for export. Deploying this level of solar PV and wind power would increase the share of renewables to 30% of electricity supply in 2030. Thermal capacity in place today or developed in the medium term would continue to serve consumers well in the case where variable renewables are developed rapidly. In addition to providing energy, the dispatchability of gas-fired plants would provide the bulk of flexibility services to the power system, essential for fully integrating solar and wind output. This diverse power mix would offer reliability advantages, provide electricity to consumers at the lowest average cost, while also freeing up oil and gas for other uses or export. Compared with maintaining the current structure, an additional 9 bcm of gas would be available plus 450 kb/d of oil. Together, these could offer well over USD 10 billion in additional export revenue. Achieving the desirable outcomes of this outlook requires a high and sustained pace of capital investment to 2030, some three-times the current level, underscoring the fundamental need to establish a credible framework for power sector investment (Box 5).

Box 5. Building a credible investment framework for Iraq's power sector

Power sectors that rely to a large extend on revenues from public funding are subject to the same constrains as a general public budget, namely economic cycles, with revenues often unpredictable, and the use of funding for maintenance and capital expenditure often used as a flexibility tool to adjust to budget cycles. Currently, investment in the power sector in Iraq depends largely on the federal government budget, which is dependent on oil prices, and where the funds compete with other needs, such as health and education. One of the conditions to bring sufficient investment, either from third parties or from the government, is to have sufficient revenue coming from the electricity sector in order to cover the minimum amount of expenditure needed to efficiently operate the system and to honour contracts.

To date, apart from five independent power producers (IPPs) outside of the Kurdistan Regional Government region, electricity sector investment has relied exclusively on the government budget. The period of low oil prices from mid-2014 severely constrained the amount of capital available for investment (falling to a low of USD 900 million in 2016). This is far below the level required to rebuild and operate an efficient power sector capable of satisfying the needs of Iraq's growing population. Policy makers may well consider a range of pragmatic approaches, to not only attract the necessary investment and reduce the burden on the federal budget, but also to ensure that capital that is allocated is spent efficiently.

There is a wide expanse of accumulated experience from countries facing similar challenges (i.e. increasing demand, substantial distribution losses and low collection rates) that have managed to establish effective models to attract power sector investment. There is no one best approach, as each situation must find the appropriate balance that considers political constraints and public sector capabilities. Some examples provide a useful illustration of how the private sector has been brought in to share the development and operation risks:

Community-owned distribution networks

New Zealand provides an interesting example of how local communities have engaged in the provision of electricity. For most of the 20th century, power generation in New Zealand was provided by the state while distribution and retail activities were undertaken either by electric power boards, whose members were locally elected, or directly by municipal authorities. Since 1987, the municipal bodies (known as the Electricity Supply Authorities) have been permitted to buy electricity from private generators. Since 1994, end-users have been able to choose their retail supplier. The structure of the distribution companies has experienced little change and locally elected members are in charge of overseeing the good management of the companies.

Independent power producer model

Many countries and jurisdictions run the power sector as a single company, integrating every activity of the power sector from generation to transmission, distribution and retail. Even in this model, most have made some use of IPPs. There are two main advantages to this model; it allows the transfer of the construction and operation risks to the owner of the plant, while also allowing for the capital cost to be spread across the lifetime of the plant.

Thailand and Mexico (prior to its 2013 reform) are good examples of countries that have taken advantage of IPPs, with various contractual arrangements, while keeping the rest of the value chain segments (transmission, distribution and retail) with in public authorities . In both countries the state-owned enterprises, the Electricity Generating Authority of Thailand (EGAT) and the *Comisión Federal de Electricidad* (CFE) in Mexico, still invest in generation assets, while IPPs are a complementary source of investment. In the case of Mexico, only thermal plants were contracted through IPPs and hydropower facilities were developed exclusively by CFE. India, which has a wholesale market, has an investment model that relies on power purchasing agreements based on a very similar model.

Iraq has had several unsuccessful attempts at auctioning potential IPP projects. Addressing the issues that have stifled private investment would be necessary to ensure success in the future.

Mixed models of investment in generation

France is an interesting example where *Électricité de France* (EDF), the state-owned incumbent, is responsible for most of the transmission and distribution networks in the country. EDF is the largest retailer and generator, but it competes with private entities in the wholesale and retail markets. The EDF business segments have separate accounting, and the subsidiary RTE, the grid system operator and transmission company, has a corporate governance structure that provides impartial operation of the system. This is another example of a model where the legal framework takes advantage of investment coming from both state-owned enterprises and private parties.

Fully privatised model

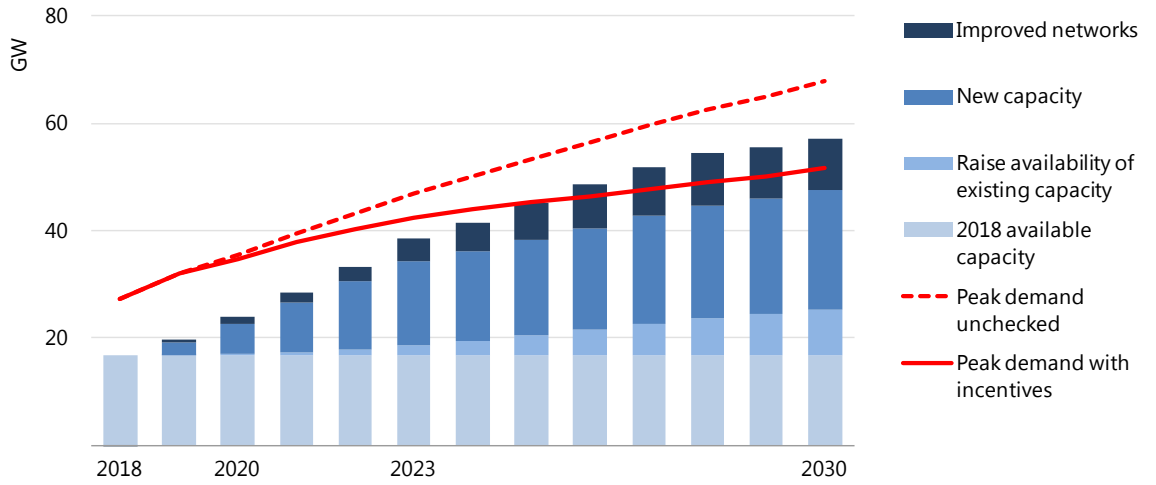
Brazil has an impressive record of investments in the power sector over the last two decades and its experiences are illustrative. Some assets were not privatised and remain the sole responsibility of the state-owned utility, Eletrobras, including nuclear facilities and some distribution areas. However, the model of investment for the whole power sector relies mainly on private parties to run the system and to bring the money necessary to pay for its costs.

In Brazil, the backbone of the investment model is the 54 distribution companies that are responsible for collecting the revenue necessary to ensure the system's good functioning. These companies also act as the off-takers of power purchasing agreements, which are auctioned and awarded to the lowest bid. The 20-30-year contracts provide the certainty needed by investors who are responsible to build and operate the generation plants. As with the IPP model, generators bear the construction and operation risks. The technology to be auctioned is chosen by the Brazilian planning entity, EPE, which maintains responsibility for the long-term adequacy of the power system.

As a complement to this approach, since 1999, Brazil has also carried out an extensive transmission expansion programme, auctioning more than 280 lots of transmission lines, with an average length of 328 kilometres. This programme has underpinned the successful development of more than 80 000 kilometres of high voltage transmission. As with the generation auctions, this process delivered important savings on the total cost of the infrastructure construction.

Iraq's ongoing electricity shortages despite substantial capacity additions, highlights two issues: the difficulty of fully closing the gap between supply and demand without investing heavily in the network to reduce losses; and perpetual challenge of expanding supply to meet unchecked growth in electricity demand, fuelled by population growth and rising incomes. The first issue is well understood and we have illustrated the gains that are possible. But to increase the chances of achieving a reliable electricity supply, measures must also be taken to address rising demand for electricity. Left unchecked, the rise in peak demand will continue to outpace the cumulative effects of new capacity and network improvements through to 2030. This highlights the imperative to boost end-use efficiency and to provide effective incentives to shave the demand peak in the summer with measures that reform grid and neighbourhood tariffs, and that ensure comprehensive bill collection for power provided. Where measures are taken to both curb demand growth and increase available capacity, Iraq could establish a capacity margin by 2030 (where available capacity exceeds peak demand). At that point, grid supply would be available to most consumers 24 hours per day (Figure 22).

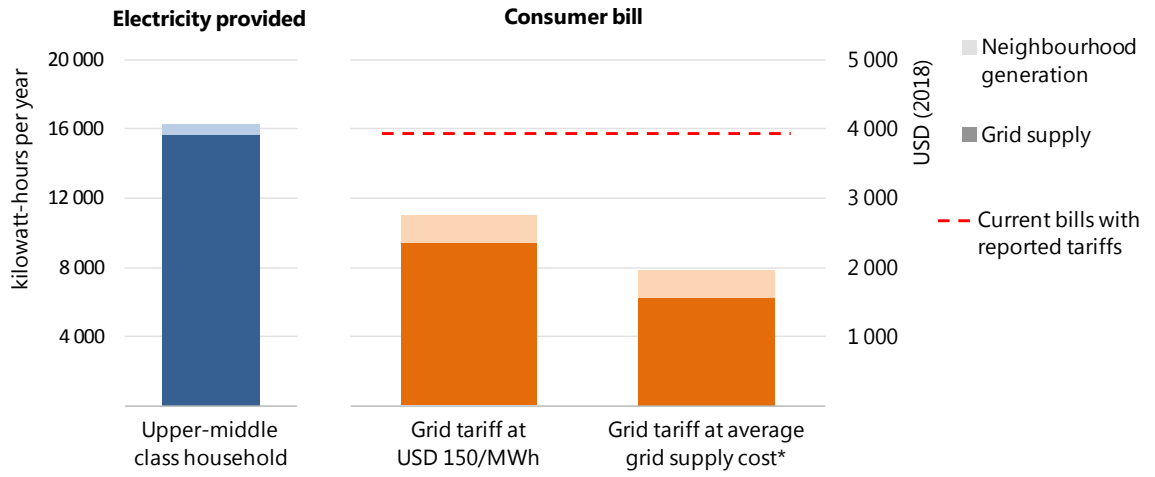
Figure 22. Available electricity supply and peak demand to 2030



Mitigating the growth in peak demand through reforming tariffs and incentivising more efficient use of energy is essential to ensure that supply can meet peak demand in the next decade.

The affordability of electricity would be dramatically improved in the case where electricity from the grid becomes more reliable, as it would drastically cut the reliance on expensive neighbourhood generators. A basket of the immediate, medium and long-term options that are available to Iraq, among others, includes: effective regulation of neighbourhood generators; reform of the (grid) electricity tariff structure; and careful shaping of the power generation mix. Effective implementation could translate to significantly lower overall consumer bills for electricity, even if the tariff is structured to fully cover the cost of supply. This illustrates that, with a holistic policy approach that aims to tackle weaknesses across the supply chain, a more efficient, reliable and sustainable system would also be one in which the consumer benefits with bills that are 30-50% lower than today (Figure 23).

Figure 23. Electricity provided by the grid and neighbourhood generators, and assoociated consumer bills for a sample household in 2030



*Grid tariff of USD 100/MWh matches the cost of grid electricity supply to consumers in the low flaring and high renewables case.

Targeted tariff reform and regulated neighbourhood generation could propel an electricity system where households pay less for electricity than today while paying a higher share of grid supply costs.

The power sector in Iraq faces a number of difficult challenges and without concerted action, the situation is likely to continue to deteriorate. On one hand, this is reason for serious concern, as reliable electricity is a cornerstone of modern economies. On the other hand, the current state of Iraq's power system also provides reason for optimism, as there are opportunities for improvements in many areas. Not least of these is the current reliance on expensive neighbourhood generation that provides less than 15% of electricity consumed but captures more than 90% of household spending on electricity. In effect, by transferring the revenues currently captured by neighbourhood generators to state utilities, Iraq's electricity system would be nearly solvent. Practically speaking, taking some steps forward in the near term, such as increasing collection rates and reforming grid tariffs, could underpin a virtuous cycle that could dramatically improve the long-term outlook for the electricity sector in Iraq. Increasing revenue from electricity sales could be re-invested into the distribution networks and power plants, raising the available power supply from the grid and sales, leading to further increases in revenue and so on. With enough steps on this path, the power sector could eventually become self-financing and provide a reliable, affordable and sustainable supply of electricity that could spur strong economic growth and development in Iraq.

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