



International
Energy Agency

Iraq Energy Outlook

World Energy Outlook Special Report

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Iraq is already the world's third-largest oil exporter. It has the resources and intention to increase its oil production vastly. Contracts are already in place.

Will Iraq's ambitions be realised? And what would the implications be for Iraq's economy and for world oil markets?

The obstacles are formidable: political, logistical, legal, regulatory, financial, lack of security and sufficient skilled labour. One example: in 2011, grid electricity could meet only 55% of demand.

The International Energy Agency has studied these issues with the support and close co-operation of the government of Iraq and many other leading officials, commentators, industry representatives and international experts. This special report, in the *World Energy Outlook* series, presents the findings.

The report:

- Examines the role of the energy sector in the Iraqi economy today and in the future.
- Assesses oil and gas revenues and investment needs.
- Provides a detailed analysis of oil, gas and electricity supply through to 2035, highlighting the challenges of infrastructure development and water availability.
- Spells out the associated opportunities and risks, both for world oil markets and for Iraq's economy and energy sector.

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9 October 2012

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

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International
Energy Agency

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International Energy Agency
9 rue de la Fédération
75739 Paris Cedex 15, France

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the work of the IEA.

This report was prepared by the Directorate of Global Energy Economics at the International Energy Agency (IEA). It was designed and directed by **Fatih Birol**, Chief Economist of the IEA. The analysis was co-ordinated by **Tim Gould** and **Dan Dorner**. Principal contributors to this report were **Sabah Al-Khshali** (seconded from Iraq's State Oil Marketing Organization), **Mustafa Al-Maliky** (seconded from Iraq's South Oil Company), **Ali Al-Saffar**, **Marco Baroni**, **Christian Besson**, **Alessandro Blasi**, **Laura Cozzi**, **Dafydd Elis**, **Capella Festa**, **Matthew Frank**, **Timur Gül**, **Jung Woo Lee**, **Paweł Olejarnik**, **Timur Topalgoekceli**, **David Wilkinson**, **Peter Wood** and **Akira Yanagisawa**. **Sandra Mooney** and **Magdalena Sanocka** provided essential support.

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Majeed A. Abdul-Hussain	Parsons Brinckerhoff
Falah Alamri	State Oil Marketing Organization, Iraq
Natik Al-Bayati	Prime Minister's Advisory Commission, Iraq
Abdulilah Al-Emir	Deputy Prime Minister's Office, Iraq
Jabbar Allibi	Independent consultant
Sefa Sadık Aytekin	Ministry of Energy and Natural Resources, Turkey
Nicholas Bridge	British Ambassador to the OECD
Kevin Carey	World Bank
Robert Cekuta	Department of State, United States
Tim Depledge	BP
Jonathan Elkind	Department of Energy, United States
David Ensign	Department of State, United States
Gabriele Franceschini	Eni
Christopher Guelff	Foreign and Commonwealth Office, United Kingdom
Hamah-Ameen Hawramany	Ministry of Electricity, Kurdistan Regional Government
Michael Howard	Ministry of Natural Resources, Kurdistan Regional Government
Ruba Husari	Independent consultant
Jana Hybaskova	Ambassador, European Union Delegation to Iraq
Jan-Hein Jesse	Clingendael Institute
Ahmed Mousa Jiyad	Independent consultant
Sami Kamel	General Electric

Ali H. Khudhier	South Gas Company
Kenji Kobayashi	Japan Automobile Importers Association
Raëd Kombargi	Booz & Company
Ken Koyama	Institute of Energy Economics, Japan
Jeff Larkin	Parsons Brinckerhoff
Claude Mandil	Former IEA Executive Director
Takahiro Mazaki	Mitsubishi Corporation
Hamish McNinch	Independent consultant
Salah Mohammed	Rumaila Operating Organization
Ed Morse	Citigroup
Asri Mousa	Independent consultant
Omar Moussa	Schlumberger
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Shohei Nishimura	Japan Oil, Gas and Metals National Corporation
Andrew Pearce	Parsons Brinckerhoff
Friedbert Pflüger	King's College London
Bill Ramsay	Former IEA Deputy Executive Director
Piet Ruijtenberg	ParPetro Consulting
George Sarraf	Booz & Company
Simon Stolp	World Bank
Tessa Terpstra	Ministry of Foreign Affairs, The Netherlands
Wim Thomas	Shell
James Turner	Department of Energy and Climate Change, United Kingdom
Jim Turner	Department of State, United States
Thamir Uqaili	Independent consultant
Coby van der Linde	Clingendael Institute, The Netherlands
Frank Verraastro	Center for Strategic and International Studies
Faisal Wadi	South Oil Company
Xiaojie Xu	Chinese Academy of Social Sciences

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Participants of the Iraq Energy Outlook workshop organised by the IEA in Istanbul, Turkey on 4 May 2012.

Comments and questions are welcome and should be addressed to:

Dr. Fatih Birol
Chief Economist
Director, Directorate of Global Energy Economics
International Energy Agency
9, rue de la Fédération
75739 Paris Cedex 15
France

Telephone: (33-1) 4057 6670

Email: weo@iea.org

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Iraq's energy sector holds the key to the country's future prosperity and can make a major contribution to the stability and security of global energy markets. Iraq is already the world's third-largest oil exporter and has the resources and plans to increase rapidly its oil and natural gas production as it recovers from three decades punctuated by conflict and instability. Success in developing Iraq's hydrocarbon potential and effective management of the resulting revenues can fuel Iraq's social and economic development. Failure will hinder Iraq's recovery and put global energy markets on course for troubled waters. This landmark special report, in the *World Energy Outlook* series, provides a comprehensive study of the opportunities and risks facing Iraq's energy sector.

Iraq's ambition to expand its oil and gas output need not be limited by the size of its hydrocarbon resources or by the costs of producing them. Contracts already in place with international companies imply an extraordinary increase in oil production capacity, to a level almost five times higher than today's 3 million barrels per day (mb/d), over the current decade. How this works out in practice will be determined by the speed at which impediments to investment are removed, clarity on how Iraq plans to derive long-term value from its hydrocarbon wealth, international market conditions and Iraq's success in consolidating political stability and developing its human resource base. Reaching output in excess of 9 mb/d by 2020 would equal the highest sustained growth in the history of the global oil industry and this report anticipates movement towards possible trajectories for oil output lower than that implied by current contracts.

In our Central Scenario, Iraq's oil production more than doubles to 6.1 mb/d by 2020 and reaches 8.3 mb/d in 2035. The largest increase in production comes from the concentration of super-giant fields in the south around Basrah. A resolution of differences over governance of the hydrocarbon sector would open up the possibility for substantial growth also from the north of Iraq, where contracts awarded by the Kurdistan Regional Government, though contested by the federal authorities, have made this one of the most actively explored hydrocarbon regions in the world.

Iraq stands to gain almost \$5 trillion in revenues from oil export over the period to 2035, an annual average of \$200 billion and an opportunity to transform the country's future prospects. Achieving the required level of oil production and export will require rapid, co-ordinated progress all along the energy supply chain. Adequate rigs will need to be available at the right time. Early investment in a challenging project to bring up to 8 mb/d of water inland from the Gulf to Iraq's southern fields will be essential to support oil production and to reduce potential stress on scarce freshwater resources. Sufficient oil storage and transportation capacity will be needed to accommodate the expansion in output and diminish the risk of over-reliance on the southern sea-borne route. The infrastructure and investment requirements in our High Case, which anticipates oil production of 9.2 mb/d already in 2020, are even more demanding.

The increase in Iraq's oil production in the Central Scenario of more than 5 mb/d over the period to 2035 makes Iraq by far the largest contributor to global supply growth. Over the current decade, Iraq accounts for around 45% of the anticipated growth in global output. Iraq becomes a key supplier to fast-growing Asian markets, mainly China, and by the 2030s Iraq is the second-largest global oil exporter, overtaking Russia. Deliberately creating spare production capacity cannot be an early Iraqi priority but when, in the longer term, the country's most pressing needs have been met, its aim to hold a reasonable reserve of spare capacity would bring new confidence to global markets.

Natural gas can play a much more important role in Iraq's future, reducing the dominance of oil in the domestic energy mix. Gathering and processing Iraq's associated gas – much of which is currently flared – will be a vital step. But associated gas, alone, will not be sufficient to cover Iraq's projected demand, which exceeds 70 billion cubic metres (bcm) in 2035 as gas becomes the main fuel for power generation. Iraq's gas balance and its opportunity to have a surplus for export depend on creating incentives to develop its non-associated gas resources. In the Central Scenario, gas exports start around 2020 and approach 20 bcm by 2035. The resources and market opportunities are there to expand exports further, as Iraq can potentially provide a very cost-competitive gas supply to neighbouring countries, to European markets and – via liquefied natural gas – to Asia.

Catching up and keeping pace with rising demand for electricity is critical to Iraq's national development. Power stations in Iraq produce more electricity than ever before but prolonged power cuts are still being experienced on a daily basis in many parts of the country. We estimate that Iraq needs 70% more net power generation capacity to meet demand fully. In our projections, if planned new capacity is delivered on time, grid-based electricity generation will catch up with estimated peak demand around 2015. Over the period to 2035, Iraq needs to install around 70 gigawatts of generation capacity and move away from a predominantly oil-fired power mix to more reliance on efficient gas-fired generation: without this transition, Iraq would forego around \$520 billion in oil export revenues and domestic oil demand would be more than 1 mb/d higher in 2035. With the exception of hydropower, deployment of renewable sources of energy is projected to remain below Iraq's potential.

High revenues from oil imply strong economic growth and create rising demand for energy; but oil and gas activities, in themselves, do not guarantee opportunities for Iraq's young and growing population. In the Central Scenario, Iraq's gross domestic product (GDP) in 2035 is five times larger (in real terms) than today, its energy demand four times higher, and its GDP per capita comparable with that of Brazil today. Rising incomes lead to an increase in consumption of electricity for household appliances and of fuel for the rapidly growing vehicle fleet and for industry. But the speed at which oil receipts are translated into greater and more diverse economic activity depends on the strategic path that Iraq follows. Stimulating much-needed reconstruction and economic diversification will require greatly strengthened institutions and rapid development of the human capacity to create

and pursue sound policies, to ensure efficient and transparent management of revenues and spending and to set the course necessary to encourage growth of the emerging non-oil sectors of the economy.

Iraq will need cumulative energy investment of over \$530 billion in the Central Scenario, equivalent to just over 10% of the projected revenue from oil and gas exports. The annual investment need is highest in the current decade, at more than \$25 billion per year on average, a significant step up from the estimated \$9 billion invested in Iraq's energy sector in 2011. The anticipated increase could be at risk if the government's efforts to modernise and reform Iraq's legal framework and institutions are delayed or frustrated, or if fluctuations in prices and oil revenue feed through into irregular capital spending.

Delay could cost \$3 trillion in lost national wealth for Iraq and bring difficult times to international oil markets. In our Delayed Case, energy investment increases only slowly from the levels seen in 2011, resulting in a much lower trajectory for oil production (reaching 4 mb/d in 2020 and 5.3 mb/d in 2035). The cumulative impact on Iraq's economy is a loss of nearly \$3 trillion compared with the Central Scenario, as export revenues are sharply lower, other industrial and services sectors fail to develop and the power sector makes slower progress in moving to cheaper and more efficient electricity supply. International oil markets tighten, characterised by higher and, in all probability, more volatile prices. These reach almost \$140 per barrel in 2035 in real terms, nearly \$15 higher than in the Central Scenario.

Energy resources provide Iraq with a means to revitalise its economy and take on a new global role and responsibilities that match its potential and the richness of its resource base. There is a strong alignment between the needs of the global market for growth in Iraq's production and the needs of Iraq for revenue to build the foundations of a modern and prosperous economy. Building such an economy and turning the country into a global energy powerhouse will not be an easy task, but this is a prize within the reach of the people of Iraq.

This report examines the energy outlook for Iraq, the way in which energy can contribute to the country's much-needed social and economic development over the coming decades and the way in which Iraq's energy can affect global oil and gas markets.

Chapter 1 sets the scene with an analysis of Iraq's energy sector today and the role that it plays in the national economy, supported by the best available data on the country's energy production and consumption. It highlights the multiple challenges facing Iraq's energy sector as the country recovers from decades of conflict that left much of the existing energy infrastructure either damaged or in a poor state of repair. It looks at the legal and institutional framework for the sector, the way that international companies have been contracted to develop some of the country's key oil and gas fields, and the issues that remain to be resolved in order to support future growth in production.

Chapter 2 assesses the prospects for growth in Iraq's oil and gas production. It discusses Iraq's resources, the factors that will affect the way that these are developed and provides detailed projections, broken down by geological basin and major field, for oil and gas output. The outlooks are analysed in terms of the requirement for new wells and drilling rigs, for new infrastructure for transportation, refining and export, and the need for water supply to maintain reservoir pressure. The chapter ends by quantifying the investment required in oil and gas, and assessing the institutional factors that could contribute to a delay in mobilising this investment.

Chapter 3 moves on to analyse Iraq's domestic energy prospects and sets out our projections for energy demand to 2035. It examines in particular the prospects for the power sector, the challenges of restoring an adequate supply of electricity to Iraq's households and businesses, and the fuel and policy choices, including greater use of natural gas, that can contribute to an efficient future power system. It examines policies on energy pricing, quantifies the cost of subsidies to fossil fuel and electricity consumption, the outlook for the different end-use sectors, buildings, industry and transport, and the impact of Iraq's energy development on the environment.

Chapter 4 sets out the national and global implications of the trends identified in the previous chapters. It looks at the role of energy in the broader context of Iraq's social and economic development, and the opportunities and risks presented by the large potential for oil export revenues. Building on the earlier assessment of Iraq's potential as a major energy supplier, it examines the scope for export of Iraq's oil and gas and the impact and importance of these exports on international markets.

Iraq today: energy and the economy

Old country, new start?

Highlights

- Iraq's prosperity will depend on its energy sector. It is estimated to have the fifth-largest proven oil reserves and the 13th-largest proven gas reserves in the world, as well as vast potential for further discoveries. These resources can fuel its social and economic development.
- Energy is already the cornerstone of Iraq's economy, with oil exports accounting for 95% of government revenues and equal to over 70% of GDP in 2011. The pace of Iraq's rehabilitation depends to a significant degree on the oil sector: how quickly production and exports are increased and how effectively revenues are managed. Iraq's oil production is now above 3 mb/d and it is the third-largest oil exporter in the world, with an increasing share of exports going to Asia. Even conservative projections of future oil production imply profound effects on the Iraqi economy.
- A key obstacle to Iraq's development is the lack of reliable electricity supply. Power stations produce more electricity than ever before, but supply is still insufficient to meet demand; power cuts are a daily occurrence and the use of back-up diesel generators is widespread. Building a modern electricity system, with sufficient generation capacity and supplies of fuel, is recognised as an immediate priority.
- Oil makes up more than 80% of Iraq's primary energy mix, compared with less than 50% in the rest of the Middle East. Despite the significant economic advantages of using natural gas instead of liquid fuels, particularly in electricity generation, almost 60% of gas production in Iraq was flared in 2011, as the facilities were not in place to gather it and make it available for productive uses.
- Iraq has ambitious investment plans for its energy sector, supported by an increasing number of international energy companies. In the last five years, oil production and exports have both increased by more than 40% and grid-based electricity supply around 70%. However, progress is still patchy and the state of Iraq's energy transport, storage and export infrastructure, while improving, continues to be a serious constraint.
- Meeting Iraq's energy policy objectives will require substantial progress across a wide front: improved institutions and human capacity, better co-ordination of decision making, a strengthened and unambiguous legal and regulatory framework, enhanced conditions to support participation by the private and financial sectors, and a broader political consensus on the direction of future policy. Success will make a huge difference to the future outlook for Iraq's energy sector and for its economy more generally, potentially putting it on a path to becoming a powerhouse of the regional and global energy system.

Iraq's energy sector¹

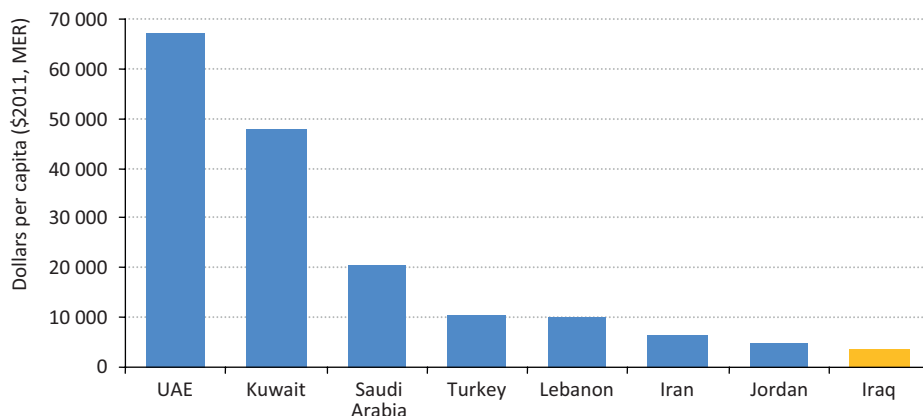
The energy sector is the cornerstone of Iraq's economy and the key to its future as it recovers from three decades punctuated by conflict (Figure 1.1). Three wars (with Iran from 1980 to 1988 and with US-led coalition forces in 1991 and 2003), international sanctions and internal instability have taken a severe toll. Living standards have fallen sharply, as Iraq's per capita gross domestic product (GDP) declined by more than one-fifth in real terms between 1980 and 2011, leaving this indicator as one of the lowest in the Middle East (Figure 1.2). Yet Iraq is also a country of immense potential. It has the fifth-largest proven oil reserves in the world and the 13th-largest proven gas reserves (and significant scope for further discoveries); the development of these resources can and should underpin Iraq's reconstruction and its social and economic development.

Figure 1.1 ▷ Iraq hydrocarbon resources and infrastructure



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

1. This analysis benefited from a high-level workshop held by the International Energy Agency (IEA) in Istanbul, Turkey on 4 May 2012.

Figure 1.2 ▷ GDP per capita for selected countries, 2011

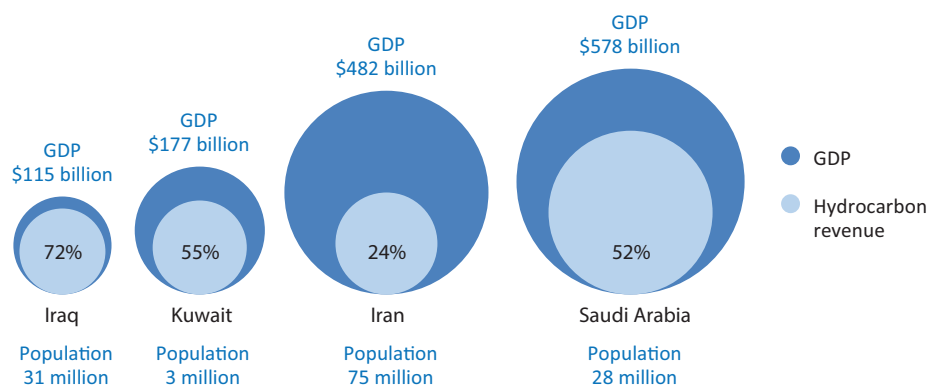
Note: GDP is measured at market exchange rates (MER) in year-2011 dollars.

Sources: International Monetary Fund (IMF) databases; IEA analysis.

The pace of Iraq's revival in the coming decades depends very heavily on the oil sector: how quickly production and export are increased and how the resulting revenues are managed and spent. By mid-2012, oil output was above 3 million barrels per day (mb/d), of which around 2.4 mb/d was exported. Iraq's improving stability, its huge resource base and contracts concluded with international companies to develop the country's major fields provide the foundation for a rapid increase in oil production in the coming years. Iraq will need to overcome a set of challenges relating to investment in infrastructure, institutional reform and the legal framework for the hydrocarbons sector, enhance human capacity and consolidate political stability and security.

Iraq's oil production over the coming years, even when estimated on a conservative basis, constitutes the core of its economy, as revenue from exports accounts for an overwhelming share of national wealth. In 2011, oil revenue accounted for around 95% of government income and was equivalent to more than 70% of Iraq's GDP. These figures are high even by the standards of other resource-rich countries in the Middle East (Figure 1.3). Sustained and growing export revenues are essential to meet the imperatives of reconstruction, as Iraq is still struggling to provide basic services, such as electricity and clean water. Over the long term, a central challenge for Iraq is to use its oil wealth to create a more diversified economy. Translating growth in oil receipts into prosperity for the people of Iraq is the promise and challenge.

Figure 1.3 ► Hydrocarbon revenue relative to GDP in selected countries, 2011



Note: GDP is measured at market exchange rates (MER) in year-2011 dollars.

Sources: IMF, UNPD, World Bank and national government databases; IEA analysis.

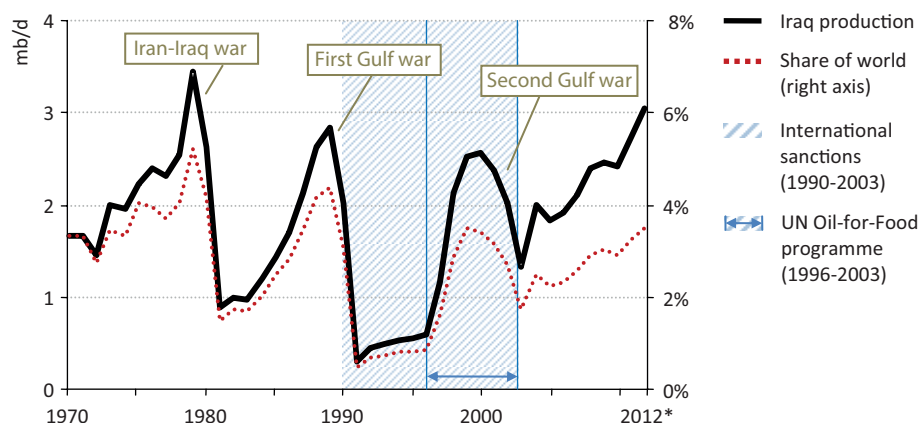
Overview of energy supply

Crude oil

The trajectory of Iraq's oil supply since 1980 confirms the malign influence of multiple conflicts, as production peaks have been followed by steep declines in every decade (Figure 1.4). As a result, Iraq has yet to surpass its historical peak of production in 1979, an average of 3.5 mb/d, and remains well below the 5.3% of global oil output that this represented (Box 1.1). Iraq's historical production record is dominated by just two super-giant fields²: the Kirkuk field in the north of the country, which has been producing since the 1920s, and the Rumaila field in the south, which began operation in the 1950s. Together, these two fields have produced around 28 billion barrels of oil, 80% of Iraq's cumulative oil production.

A snapshot of Iraq's oil supply for the month of June 2012 shows daily production at an average of 3 mb/d. During this period around 670 thousand barrels per day (kb/d) were delivered to domestic refineries, around 70 kb/d were used directly for power generation and over 2.4 mb/d were exported (Figure 1.5). Most of the export flows were made by tanker through offshore terminals and mooring systems in the south, but a smaller share was exported via the northern pipeline to the Turkish Mediterranean port of Ceyhan. This picture highlights the continued pre-eminence of the southern Rumaila field, with 1.3 mb/d of oil production, as well as the significant contributions from the nearby West Qurna (Phase I) and Zubair fields. Kirkuk makes a notable contribution to production in the north of Iraq, although its output has fallen back in recent times and is currently around 270 kb/d.

2. Super-giant fields are defined as those with ultimately recoverable resources greater than 5 billion barrels.

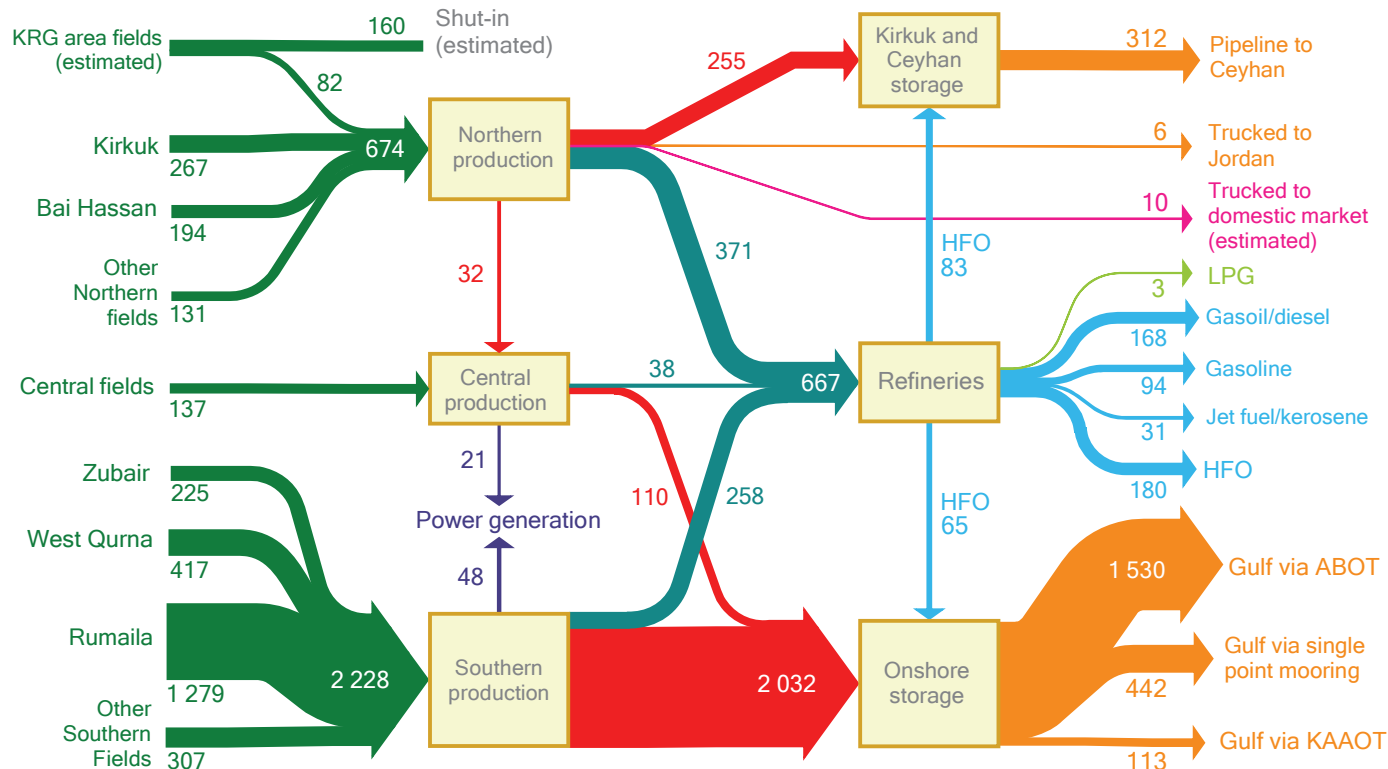
Figure 1.4 ▶ Iraq oil production

* Based on first five months.

Box 1.1 ▶ Breaking through the historical ceiling on Iraq's oil supply

Iraq's oil production and exports have consistently lagged behind the potential implied by its resources. In the early years, Iraq's oil output was determined by the investment choices of the Iraq Petroleum Company (IPC), made up exclusively of international companies, which held concessionary rights to oil production covering almost the entire country. The position of IPC went into decline after the Iraqi revolution of 1958, but the process of establishing greater national control over Iraq's resource wealth was a prolonged one, which lasted well into the 1970s. Following the creation of the Iraq National Oil Company (INOC) in 1964, Iraq started to develop the national expertise to operate and expand the country's oil output, with foreign companies eventually assisting as contractors. But the process was slow and the net result was that Iraq missed out on the region's oil boom that started in the late 1960s. In the mid-1960s, Iraq's oil output (1.3 mb/d) did not diverge widely from that of Saudi Arabia (2.2 mb/d). But Iraq had reached only 2 mb/d in 1973, by which time Saudi production was close to 8 mb/d.

Iraq had some success in the 1970s, bringing oil production towards the strategic goal formulated at that time of creating production capacity of 5.5 mb/d by 1983. But this goal was never realised, because of the Iran-Iraq war. A subsequent plan to raise capacity to 6 mb/d by the mid-1990s was, again, not realised, this time because of the 1991 Gulf war. National ambitions now extend beyond the levels foreseen in earlier plans, based on the availability of new technologies and a willingness to bring in international expertise.

Figure 1.5 ▶ Iraq average daily oil production and transportation, June 2012

Notes: Numbers shown on diagram are in kb/d. Changes in storage levels account for flow imbalances. Northern, central and southern production refers to regions in Iraq as shown on the map in Figure 2.1. NGL production is included. ABOT = Al-Basrah Oil Terminal; HFO = heavy fuel oil; KAAOT = Khor al-Amaya Oil Terminal.

Sources: Based on direct communication with Iraq's Ministry of Oil and company reports; IEA analysis.

More than 70% of Iraq's oil production comes from fields that are being operated by international oil companies under technical service contracts (see the later section, legal and institutional framework). Nineteen of these contracts have been awarded by the federal authorities, one in 2008 and the remainder as a result of four national licensing rounds since 2009. These contracts cover all the main southern fields as well as smaller oil and gas projects elsewhere in Iraq (but not Kirkuk). If all of these contracts deliver on their oil plateau production commitments, the result would be dramatic growth in Iraq's productive capacity in the coming years, with potential output of more than 12 mb/d from these projects alone before the end of the decade. In addition, the Kurdistan Regional Government (KRG) in the north of Iraq has concluded around 50 contracts, almost all of which are production-sharing contracts, covering areas in which there has hitherto been no substantial commercial production.³ The legitimacy of these contracts has been contested by the federal authorities, but exploration activities are, in many cases, well underway and some production capacity is already in place.

Oil products

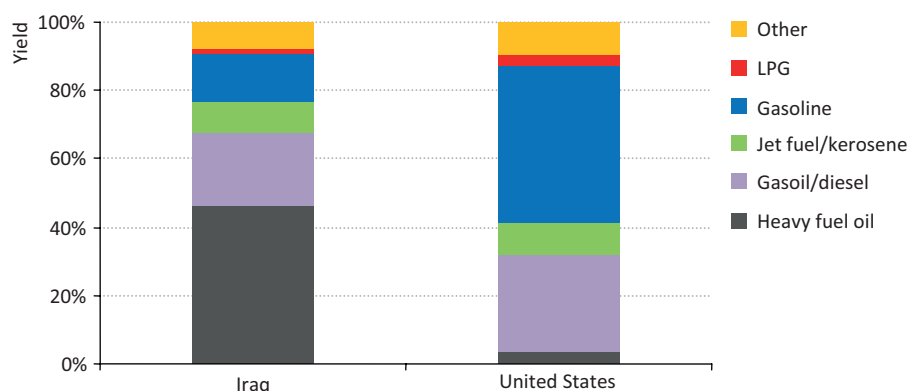
Oil supply to domestic refineries of around 670 kb/d in June 2012 was slightly higher than the 630 kb/d average delivered in 2011. The current nameplate capacity of Iraq's refineries stands at around 960 kb/d, but we estimate that only about 770 kb/d of this capacity is operational, with the country's three largest refineries at Baiji, Doura and Basrah accounting for around 70% of the total. These are supplemented by a large number of small topping plants, but these are unable to produce high-quality petroleum products. The downstream sector, like much of Iraq's essential infrastructure, has suffered the effects of long periods of under-investment.

The range of oil products produced by Iraq's refineries falls well short of its domestic needs and of the possibilities afforded by modern, more complex refineries (Figure 1.6). Around 45% of the products coming out of Iraqi refineries are heavy fuel oil, with gasoline accounting for less than 15% of the total. This product mix means that Iraq has to import around 8.5 million litres per day of gasoline and 2.6 million litres per day of diesel to meet demand.⁴ It also has a large surplus of heavy fuel oil for which it has no domestic use or export possibilities. In 2011, Iraq blended an average of 150 kb/d of heavy fuel oil into the exported stream of crude oil, lowering its quality and price. With product yields similar to those of an average refinery in the United States, Iraq could have avoided the shortfall of gasoline and diesel and eliminated its surplus of heavy fuel oil.

3. Actual oil output from the KRG area, as shown in Figure 1.5, was significantly below production capacity due to a dispute with the federal authorities that halted exports to international markets from this region in April 2012. Export shipments restarted in early August 2012 and continue as of the time of writing, but a number of underlying issues are yet to be resolved (see later section on legal and institutional framework).

4. Preliminary data for the first half of 2012 show a sizeable increase in diesel imports compared with 2011.

Figure 1.6 ▸ Average refinery product slate in Iraq compared to the United States, 2011



Sources: Iraq Ministry of Oil; US Energy Information Administration (EIA); IEA analysis.

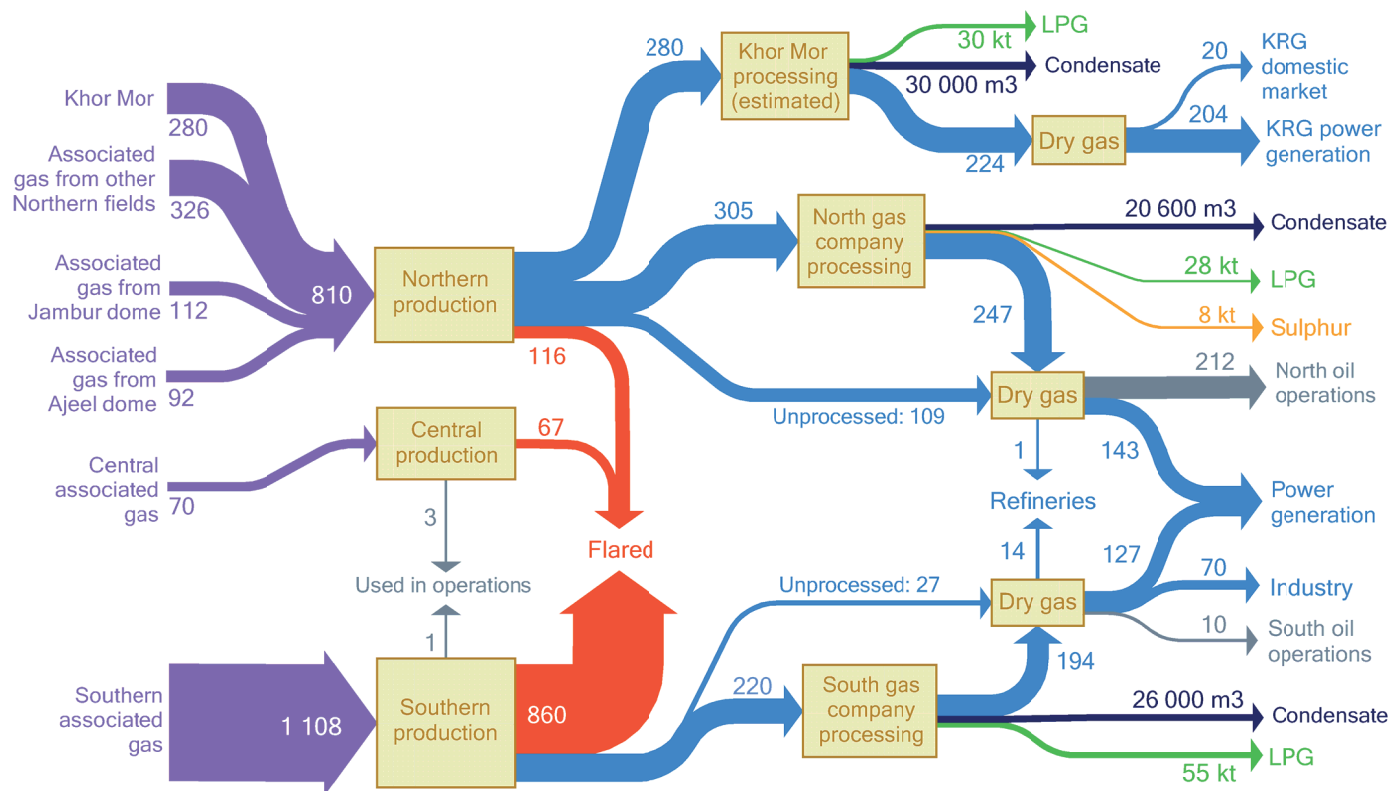
Natural gas

Iraq's gas production is dominated by associated gas and has therefore followed the rollercoaster profile of oil output. Historically, much of this gas was flared: Iraq began to invest in large-scale gas processing facilities only in the 1980s and maintenance and expansion of these facilities has not kept pace with the volumes produced. In June 2012, nearly 2 billion cubic metres (bcm) of gas were produced, with around 55% coming from southern oilfields (Figure 1.7). However, we estimate that, due to the lack of gas processing capacity, more than half of the gas produced was flared (rather than marketed and consumed productively). This monthly estimate is consistent with our estimates for 2011, where total production was around 20 bcm, of which around 12 bcm was flared. Flaring is hugely wasteful given the continuing shortfall in electricity supply in Iraq and has damaging environmental effects. Putting gas gathering and processing facilities in place, developing the gas transmission network and bringing online new gas-fired power plants are therefore urgent priorities for the authorities.⁵

Transport, storage and export infrastructure

The condition of Iraq's transport, storage and export infrastructure, although improving, has been a serious constraint on progress in the energy sector. Processing facilities, pumping stations, storage tanks and pipelines, where not destroyed outright, saw their condition deteriorate substantially in the 1990s, as international sanctions interfered with proper maintenance. Some spare parts and equipment were brought in under the terms of the United Nations Oil-for-Food programme and inventive and improvised solutions were often found to keep equipment running, but Iraq's effective oil export capacity is still below the levels reached in 1979.

5. Iraq has also joined the Global Gas Flaring Reduction Partnership, which supports efforts to reduce flaring.

Figure 1.7 ▷ Iraq monthly gas production and transportation, June 2012

Notes: Total production for the month of June 2012. All numbers shown on diagram are in million cubic metres (mcm) unless otherwise stated. Northern, central and southern production refers to regions in Iraq as shown on the map in Figure 2.1.

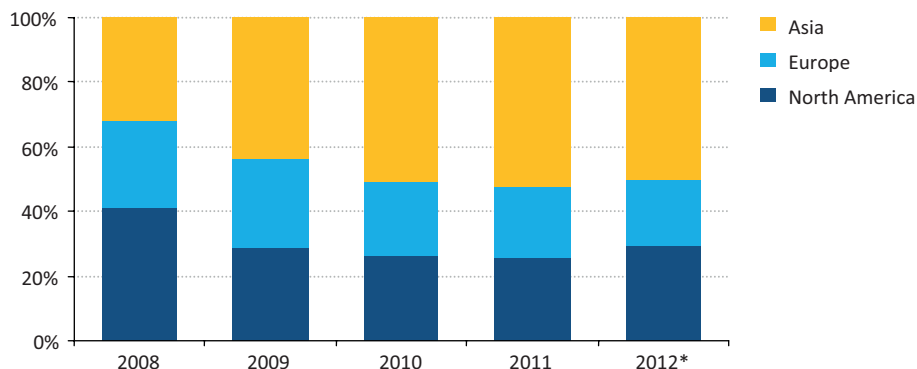
Sources: Based on direct communication with Iraq's Ministry of Oil and company reports; IEA analysis.

The lack of sufficient storage in the south of Iraq is a particular problem, as it means that any delays or weather-related interruptions to loading tankers at the offshore facilities can lead directly to a shut-down of production. In 2011, production at southern oil fields was curtailed regularly in response to infrastructure constraints. There are signs that this is improving, with new storage capacity being built at the main export depot at Fao and fewer curtailments observed so far in 2012; but further timely expansion of transportation and storage capacity is essential for Iraq's oil output growth.

Several projects are underway and southern export capacity was expanded in early 2012, when the commissioning of new offshore crude loading facilities, called single-point mooring systems (SPMs), brought nominal export capacity up to nearly 3.4 mb/d. However, not all of this can yet be utilised due to bottlenecks elsewhere. For the month of June 2012, around 442 kb/d of crude oil was exported by tanker via these new SPMs, using just over one-quarter of their capacity. The remainder of Iraq's sea-borne exports went through the existing offshore terminals, Al-Basrah Oil Terminal (ABOT) and Khor al-Amaya Oil Terminal (KAAOT). Iraq's other main export route is the northern pipeline route to Ceyhan, but only one of the twin pipelines is operational. The maximum available capacity along this route, according to the Ministry of Oil, is 600 kb/d, much less than the nameplate capacity of 1.6 mb/d. Actual flows averaged just over 300 kb/d in June 2012.

The southern fields are connected to central and northern Iraq via the Strategic Pipeline, a reversible, domestic link, which was intended to give Iraq the option of pumping Kirkuk crude southwards for export via the Gulf or of pumping southern crude northwards, for export via Turkey or to refineries around Baghdad. Damage to parts of the pipeline mean that it is currently used only to transport oil for domestic purposes, principally from the South Oil Company to the refinery at Doura, near Baghdad. The Strategic Pipeline is designed to carry 850 kb/d, but operating capacity is estimated to be much lower: actual flows in June 2012 were below 50 kb/d. Attempts to diversify oil export options have largely fallen victim to conflict and regional politics: 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 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.

Despite the problems with infrastructure, Iraq has been an increasingly important supplier of oil to global markets. Oil exports have rebounded in recent years, making Iraq the third-largest oil exporter in the world (after Saudi Arabia and Russia). An increasing share of these exports has been directed to fast-growing Asian markets, rising from 32% in 2008 to 52% by 2011 (Figure 1.8), while the shares going to North America and to Europe fell over the same period to 26% and 22% respectively.

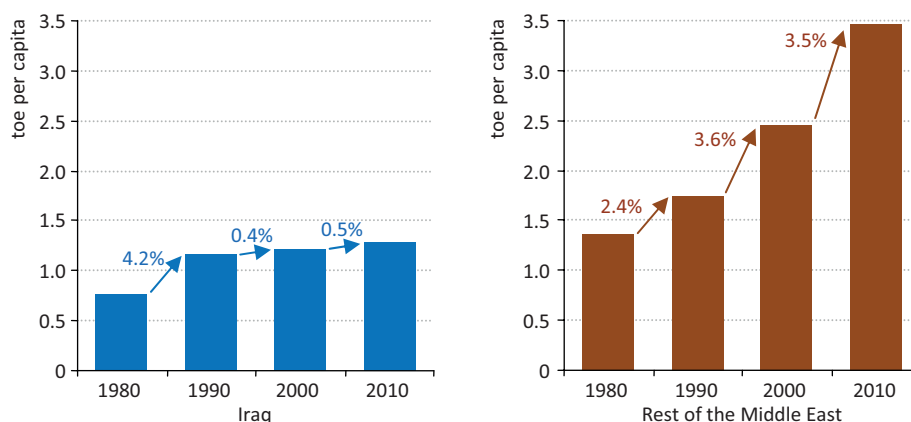
Figure 1.8 ▷ Iraq crude oil exports by destination market

* Based on first five months.

Sources: Direct communication with Iraq's State Oil Marketing Organization; IEA analysis.

Overview of energy demand

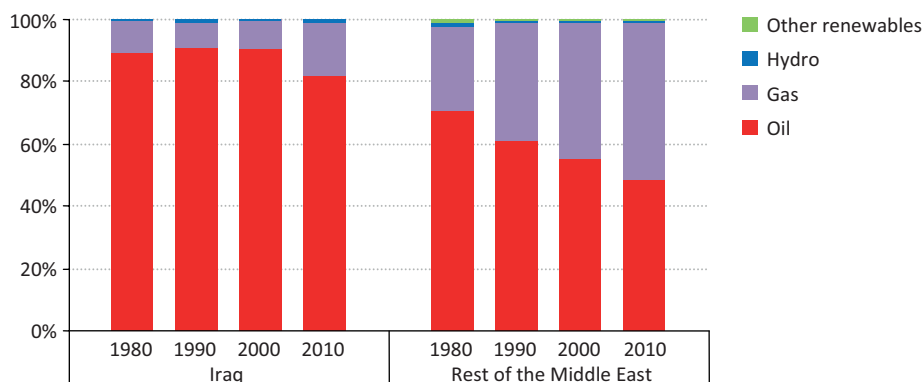
Energy consumption in Iraq has nearly quadrupled over the last three decades. But the rate of growth has been much less strong than elsewhere in the Middle East and the pattern of energy use has been frequently disrupted. As of 2010, primary energy demand for the country as a whole was 38 million tonnes of oil equivalent (Mtoe), or 1.3 tonnes of oil equivalent (toe) per capita. The per capita figure is lower than the global average of 1.9 toe and only a little more than one-third of the level in the rest of the Middle East (Figure 1.9). However, relative to the size of Iraq's economy, low productivity and efficiency means that national energy consumption is actually high by global standards: Iraq uses 0.4 toe to produce each \$1 000 of national output (based on market exchange rates in year-2011 dollars), nearly one-fifth higher than the Middle East average and twice the global average.

Figure 1.9 ▷ Primary energy demand per capita in Iraq and the Middle East

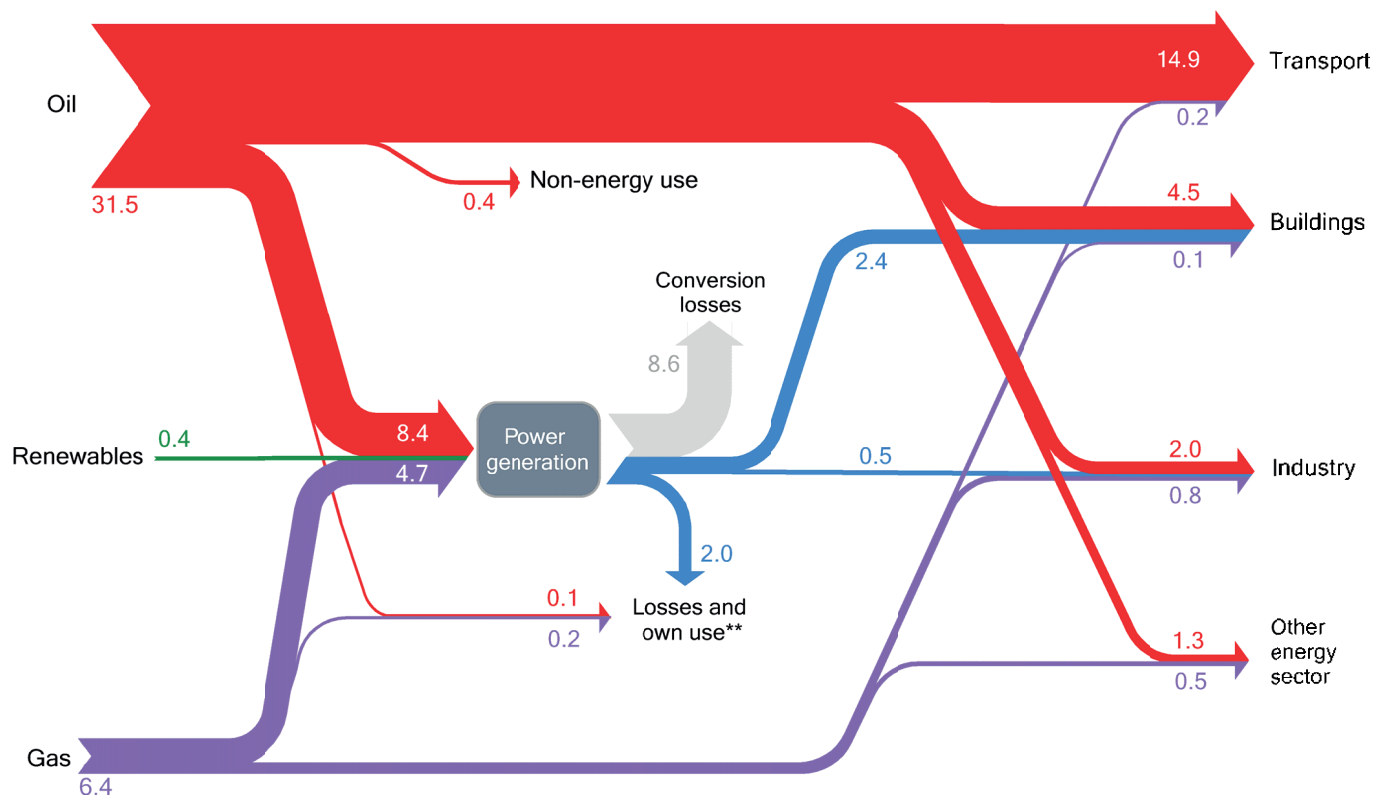
Note: The percentage figures are compound average annual growth rates.

Iraq's domestic energy consumption is dominated by fossil fuels. Over time, the general trend in the Middle East has been towards greater consumption of gas in the energy mix, gas often replacing oil for power generation as well as taking a greater share of industrial energy use. By 2010, the share of oil in the Middle East's primary energy demand (excluding Iraq) had fallen below 50% (Figure 1.10). Although Iraq has plans to increase gas production and use, oil still accounts for around 80% of primary energy demand. As elsewhere in the region, the share of non-fossil fuels in Iraq's primary energy mix is small, although there is some electricity generated from hydropower plants in the north of Iraq. These plants have gross installed capacity of 2.3 gigawatts (GW), but operating capacity is estimated at less than 1.5 GW, due to a combination of low water levels in reservoirs upstream, constraints imposed by the need to match irrigation flows and safety concerns (as in the case of Iraq's largest facility at Mosul).

Figure 1.10 ▶ Evolution of the energy mix in Iraq and the Middle East



On the basis of the available data (which have limitations), we have constructed a domestic energy balance for Iraq in 2010 (Figure 1.11). This shows that the sector consuming the largest amount of oil is transport, followed by power generation and buildings. Energy use in transport, which accounts for around 60% of total final consumption, is dominated by road transport. Iraq has seen strong growth in demand for gasoline as car ownership levels have surged in recent years; the country now has an estimated three million passenger light-duty vehicles, more than half of which have been imported since 2003. Most of the oil consumed in the main grid-connected power stations is heavy fuel oil (although some crude oil and gasoil is also used), while substantial amounts of gasoil are used to fuel private generators and large grid-connected diesel units. Oil use in buildings consists largely of liquid petroleum gas (LPG), which is widely used as a fuel for cooking, and kerosene for winter heating. Oil products are subsidised in Iraq, with the domestic price of gasoline being 28% of the price paid for imports and that of diesel 11%. The government took steps to reduce oil product subsidies in 2007 and this appears to have helped dampen demand, but we estimate that the value of subsidies to Iraq's oil consumption, based on the prices available on international markets, was around \$20 billion in 2011 – equivalent to around thirteen weeks of oil export revenue.

Figure 1.11 ▷ Iraq domestic energy balance*, 2010 (Mtoe)

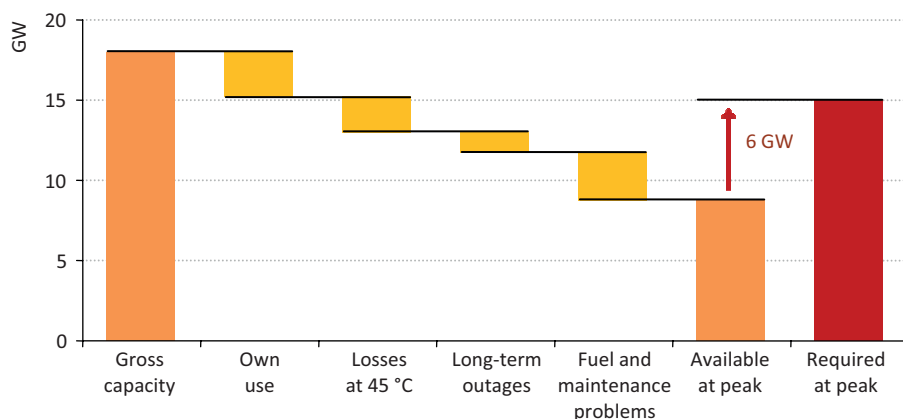
* Oil exports, oil product exports/imports and electricity imports not shown. Gas flaring not shown. ** Includes losses and fuel consumed in oil and gas production, generation lost or consumed in the process of electricity production, and transmission and distribution losses.

Industrial energy use is very low in Iraq at just over 3 Mtoe and has been stagnant at around these levels since the early 1990s. Iraq's industrial base consists largely of state-owned assets across a range of sectors, from heavy industry (including iron and steel, fertiliser, chemicals, petrochemicals, cement, glass and ceramics) to light industry (textiles, leather, furniture, dairy products, etc.), but with outdated technology that makes them ill-equipped to compete in a market environment. Many of these enterprises are operating at well below their nominal capacity (or not at all). The government has tried to attract investment to rehabilitate (and in many cases reopen) facilities and modernise equipment, but with limited success so far.

Electricity

One of the main obstacles to Iraq's economic and social development is the lack of reliable electricity supply. Despite a significant increase in grid-based electricity capacity in recent years (peak net daily production in 2011 was around 70% higher than 2006), it is still far from being sufficient to meet demand. We estimate that the net capacity available at peak in 2011 was around 9 GW while the estimated net capacity required to meet peak demand was 15 GW, resulting in a need for around 6 GW more available capacity – an increase of around 70% (Figure 1.12). This is before taking account of the increase in demand likely to occur as the electricity supply becomes more reliable. Building additional generation capacity, and ensuring that it has adequate supplies of fuel, is the immediate priority for the power sector in Iraq.

Figure 1.12 ▶ Iraq difference between gross installed generation capacity and available peak capacity, 2011



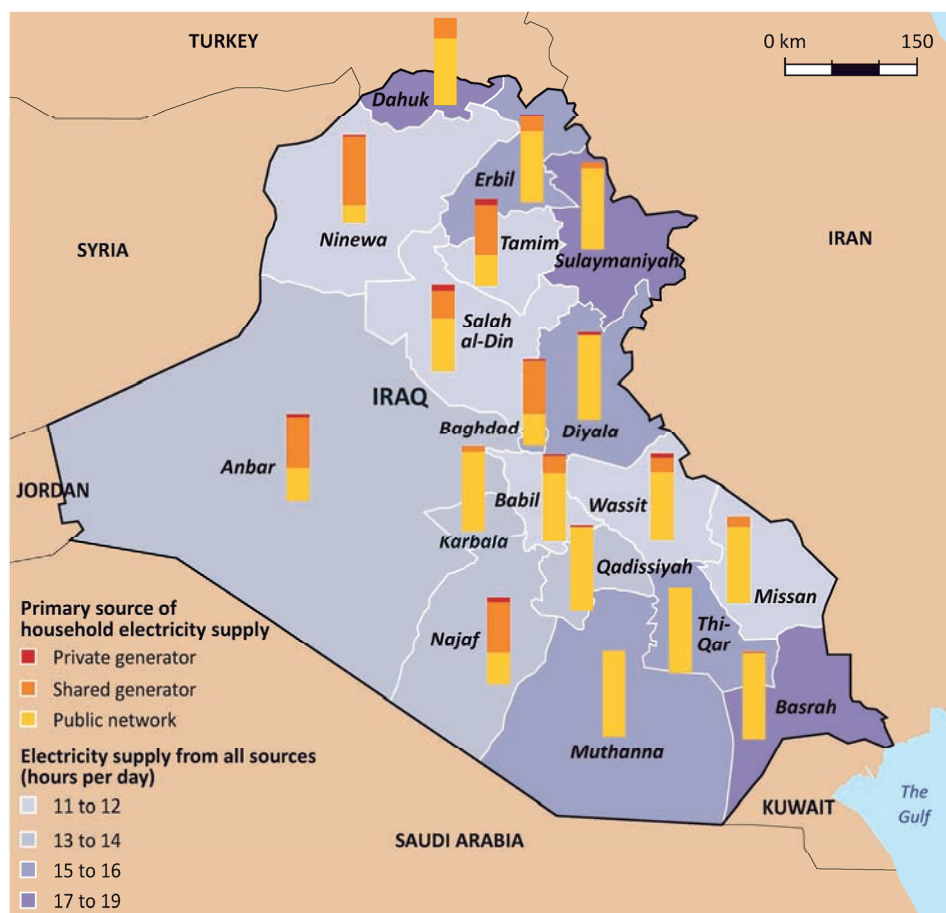
Notes: At high ambient temperatures, the maximum achievable output from thermal power plants declines compared to their production under normal conditions. In Iraq, peak demand occurs on hot summer days, when the ambient temperature is typically around 45 °C. Because of this, the theoretically available capacity of power plants has to be reduced at times of peak demand to reflect their output at this temperature.

To try and fill some of the electricity supply gap, around 90% of Iraqi households supplement the public network with private generators, either a private household generator or a shared generator operating at neighbourhood level (IKN, 2012). The generation provided from such sources is difficult to quantify, but we estimate that in 2011 shared generators accounted for 3 terawatt-hours (TWh), on top of the 37 TWh of consumption that came from the grid. In central Baghdad alone, a 2009 survey estimated that approximately 900 megawatts (MW) of private generation was available for use (Parsons Brinckerhoff, 2009a). Private generators currently play an important role in reducing Iraq's shortfall in electricity supply (helping to reduce the number of blackouts) and also to bring benefits in terms of flexibility and providing electricity access to rural areas. However, even though private generators receive subsidised fuel from the government, the price of the electricity they provide to consumers is considerably higher than grid electricity: the same 2009 survey suggested that residential customers were paying ten to fifteen times more for the electricity supplied from private generation than from the grid. As well as being an expensive way to provide electricity, diesel generators also contribute to local air pollution.

Even with the use of non-grid generation, the average availability of electricity to end-users (from all sources) was limited in 2011 to around eleven to nineteen hours per day, varying across the country (Figure 1.13). Electricity supply in the Kurdistan Regional Government (KRG) area is increasingly reliable, although cut-offs still occur at times of peak demand. Reliability is also higher than average in some southern governorates, notably in Basrah. At the other end of the scale, electricity supply from all sources was reported to be twelve hours per day or less in six governorates, accounting for 30% of Iraq's population. An additional challenge for Iraq is that electricity demand is seasonal, with the highest peak occurring in the summer months as a result of very high temperatures in much of the country. During the summer, peak hourly electricity demand could be expected to reach levels around 50% above the average demand level, increasing the gap between grid-based electricity supply (operating at capacity) and demand.

Existing generation, distribution and transmission infrastructure is in need of rehabilitation and upgrading, as well as rapid expansion, to catch up with and meet growing demand for electricity. Just over half of Iraq's existing nominal generation capacity pre-dates 1990; a further 47% has been added since 2000; a mere 2% (250 MW) was added during the entire 1990s, during which time the state of the existing generation stock also deteriorated significantly. Recent capacity additions have helped to improve the overall efficiency of the sector, but it is still low by international standards and conversion losses represent a significant item in Iraq's energy balance (Figure 1.11). The efficiency of gas-fired plants in particular is currently 31% (compared with around 55% achievable for new combined-cycle gas turbines under good operating conditions). There are largely separate electricity grids for the KRG area and the rest of Iraq, with distinct strategies for their development. There are also different policy approaches to providing grid electricity within Iraq, with independent power producer (IPP) contracts having played a useful role in increasing electricity supply from the grid in the KRG area in recent years.

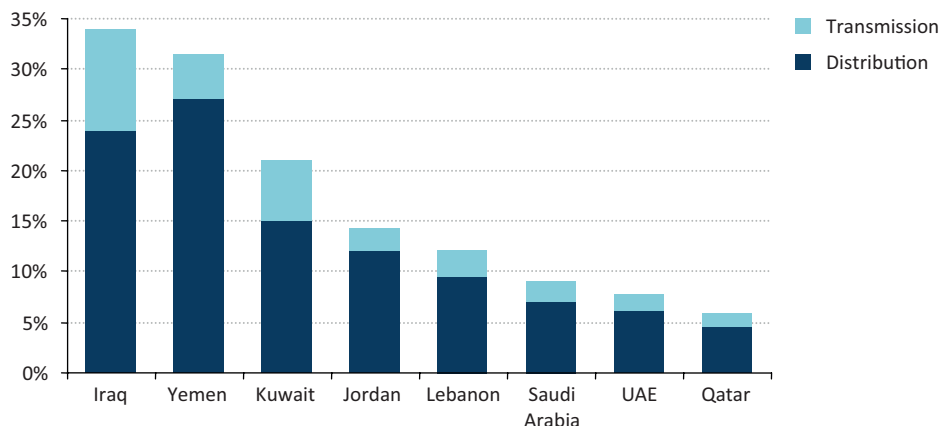
Figure 1.13 ▶ Iraq source and reliability of electricity supply by governorate, 2011



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Sources: IKN (2012); IEA analysis.

Electricity transmission and distribution losses in Iraq are the highest in the Middle East region (Figure 1.14), in large part because of damage sustained during the 1991 Gulf war, subsequent sabotage and a lack of maintenance. The performance of the high-voltage transmission system remains relatively robust, with the network of 400 kilovolt (kV) transmission lines in reasonable working order in terms of functioning and reliability, though not in terms of attaining modern levels of efficiency. Cross-border connections with Iran and Turkey allow for some electricity imports, which amounted to almost 6 TWh in 2010. However, the distribution network, which is designed to connect 98% of Iraqi households to the grid, has been severely degraded.

Figure 1.14 ▷ Electricity losses by type in selected countries, 2010

Note: The split between transmission and distribution losses is estimated for Saudi Arabia and the UAE.

Sources: Arab Union of Electricity (2010); IEA databases and analysis.

Prices for electricity from the grid are heavily subsidised in Iraq, reflecting historical pricing patterns and the political impossibility of raising prices while the quality of service is so low. Electricity provided from the grid to household consumers is charged on a sliding scale, starting from \$0.017 per kilowatt-hour (kWh) for consumption up to 1 000 kWh per month, with higher prices for consumption above this threshold. Average per household consumption in Iraq's residential sector in 2010 (the last year for which we have data) was only 800 kWh per year, so most households consume all or most of their electricity at the lowest price band. This price is almost ten times lower than the OECD average household electricity price in 2010 of \$0.16 per kWh. Since grid-based electricity is relatively cheap compared with electricity sourced from private and shared generators, end-users have an incentive to concentrate their consumption, so far as possible, at times when grid-based electricity is available, exacerbating problems with system reliability. Payment discipline is also relatively weak – it is estimated that tariff revenue is collected only on around one-third of the electricity that enters the distribution network – and there are many illegal network connections. The high proportion of residential consumers who use grid electricity without paying at all means that the effective rate of subsidy is even higher than is implied by the low tariff level. The tariff for industrial users is a flat rate of \$0.10 per kWh, much higher than for the residential sector.

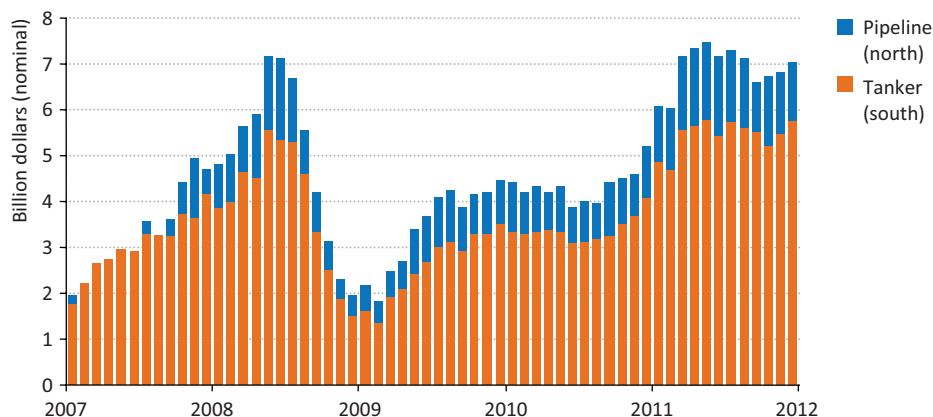
The context for Iraq's energy development

The economy

The heavy dependence of Iraq's economic development on the success of its oil sector makes the economy highly dependent on the prevailing conditions in the global oil market. Monthly oil export revenues are subject to sharp swings (Figure 1.15); price falls in

late-2008 and early-2009 cut Iraq's revenue sharply, forcing the federal government to cut back quickly on planned expenditure. Oil revenue volatility is typically transmitted to the non-oil economy through fiscal policy, which means that the sound management of national finances is essential to mitigating this risk. Figure 1.15 also shows the high dependence of Iraq's economy on its sea-borne exports in the south.

Figure 1.15 ▶ Iraq monthly oil export revenues by route



Note: Iraq also receives additional revenue from exporting a small amount by truck.

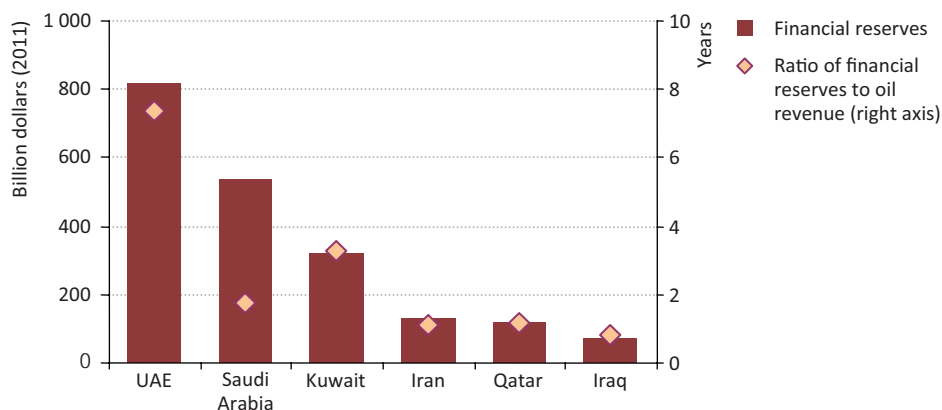
Sources: Direct communication with Iraq's State Oil Marketing Organization; IEA analysis.

As in many oil exporting countries, the oil price that Iraq requires in order to match oil revenues to planned government expenditure – its fiscal breakeven price – has increased in recent years and is getting closer to the actual market prices. This increases its vulnerability to a decline in oil prices. Governments with large financial reserves (such as central bank reserves, used primarily for backing a national currency, or sovereign wealth funds, often used to serve a broader range of government objectives) can potentially use these resources to help smooth out mismatches between government revenues and expenditures, but Iraq's ability to do this is relatively limited. Based on 2011 data, Iraq's central bank reserves were less than oil revenues in the same year, whereas Saudi Arabia had closer to double the coverage, Kuwait more than three times and the United Arab Emirates seven times (Figure 1.16).

While oil export revenues are equivalent to more than 70% of GDP, the oil and gas sectors account directly for less than 2% of total employment. Although there are many jobs created indirectly (via suppliers, service companies and so on), the largest impact that oil has on the broader labour market is via the revenues that enable Iraq to maintain one of the largest public sectors in the world relative to its population. The public sector workforce has more than doubled since 2003 and the associated wage bill has increased as a share of GDP, from around 15% in the mid-2000s to 30% in 2012. Sustainable and balanced growth in the economy requires increased diversification away from oil, into other

industrial sectors and services, as well as the improved performance of labour-intensive sectors such as agriculture. Policies to facilitate growth in the private sector, particularly small and medium enterprises are required. However, the business environment in Iraq, as it stands today, puts a brake on entrepreneurial activity: the costs of doing business are high relative to those in many other countries, mainly as a result of security concerns, the unreliable provision of essential services (such as electricity), regulatory obstacles, bureaucratic delays and poor access to finance. Iraq was ranked 164 out of 183 countries in the *Doing Business 2012* survey (World Bank, 2012).

Figure 1.16 ▷ Number of years cover for oil revenues from financial reserves in selected countries, 2011



Notes: Financial reserves estimates include central bank reserves (used primarily for backing a national currency) and, where appropriate, the estimated value of sovereign wealth funds (often used to serve a broader range of government objectives). While Qatar has a relatively low number of years cover, it also has the lowest fiscal breakeven oil price of the countries shown.

Sources: IMF, SWF Institute and Development Fund for Iraq databases; IEA analysis.

Legal and institutional framework

The legal framework for the energy sector operates within the overall boundaries established by the 2005 constitution, which establishes a federal democratic system of governance, with the KRG area accorded the status of a federal region. According to the constitution, oil and gas resources are “owned by all the people of Iraq in all the regions and governorates”. The federal government, with the producing governorates and regions, is tasked with the management of oil and gas extracted from present fields and with the necessary strategic policies to develop Iraq’s oil and gas wealth in a way that achieves the highest benefit to the people. However, the constitution does not explicitly cover the question of jurisdiction over hydrocarbon exploration and development, and has been subject to various interpretations. In the case of electricity production and distribution, the environment and water resources, the constitution shares responsibility between the federal and regional authorities.

Various drafts of new federal hydrocarbons legislation have been under discussion since 2006.⁶ Under these drafts, co-ordination between the federal level and the regions would be entrusted to a Federal Oil and Gas Council, but no consensus has yet been reached on the Council's composition and competences.⁷ The complex debate over control and decision-making authority in the hydrocarbons sector has become intertwined with broader issues, notably the question of revenue sharing between the centre and the regions. The package of hydrocarbon laws under consideration also includes possible reforms to the sector's institutional structure, notably the (re-)creation of an Iraq National Oil Company (INOC) as a state-owned company managing all of the state interests in current and new fields and operating with a degree of financial and administrative autonomy. The delay in passing new hydrocarbon laws means that for the moment a federal system of resource development (based on technical service contracts) co-exists uneasily with the approach followed by the Kurdistan Regional Government (based on production-sharing contracts consistent with its own legislation from 2007), whose legitimacy has been contested by the federal government (Box 1.2).

Box 1.2 ▶ Technical service contracts and production-sharing contracts

Technical service contracts and production-sharing contracts are among the instruments used by major resource holders to develop their oil and gas. Direct comparisons between them are complicated by the variety of terms and the impact of key variables, notably the oil price and the size of field. But, at their core, the difference is that technical service contracts provide a fee per barrel of oil produced to the contractor as remuneration for work done (although the timing and nature of this remuneration can vary considerably), while production-sharing contracts provide returns based on the value of the oil/gas found or produced. The production-sharing contract holder therefore sees both the upside benefit and downside risk of oil price fluctuation, as well as geological, technical and other market risks. In both types of contract, the financing of exploration and development costs is borne by the outside investors (state investors are generally “carried” by the outside investors) until the resource is brought to market, at which point developers receive remuneration and cost recovery in the form of either cash or oil production (payment in kind). Resource holders with discovered fields of low geological risk often favour technical service contracts. Offering fixed remuneration technical service contracts for exploration is less common (but not unknown), as it can be difficult to strike the right balance between risk and reward without a clear view of the size and quality of potential resources.

6. In the absence of new legislation, a range of laws that predate the constitution (some of which date back decades) are also still applicable.

7. In August 2012, a special parliamentary committee was established in Iraq with the intention of trying to overcome the impasse in discussions over new federal hydrocarbon laws.

Nineteen technical service contracts have been awarded by the federal government to date, each to a consortium led by an international operating company (Table 1.1). One of Iraq's state-owned operating companies is present, with a 25% stake, in each of these consortia. Key parameters of the technical service contracts are the initial production target ("initial target" in Table 1.1), the plateau production commitment ("plateau target") and the maximum remuneration fee per barrel ("max. fee"). The initial target is important because it provides the trigger for the reimbursement of costs and the payment of fees, incentivising operators to reach this level as quickly as possible. Four projects (Ahdab, Rumaila, West Qurna Phase I and Zubair) have already reached this initial threshold. The maximum remuneration (in dollars per barrel of oil equivalent) is fixed in each contract, with the level falling as the overall profitability of the contract increases (measured in terms of the ratio of cumulative income to cumulative expenditure). The plateau production commitment is the amount that the consortium has agreed to produce, although the amounts that have been contracted are considered in many cases to be higher than those likely to be achieved in practice: the remuneration fee can be reduced in the event that production during the plateau production period is lower than agreed.

Table 1.1 ▶ Contracts awarded by federal authorities for hydrocarbon exploration and development

Bid round	Project or licensing block	Operator	Type	Production*			
				Initial Target	June 2012	Plateau target	Max. fee**
One (2009)	Ahdab	Petrochina	Oil	25	129	140	6.00
	Rumaila	BP	Oil	1 173	1 279	2 850	2.00
	West Qurna (I)	ExxonMobil	Oil	268	417	2 825	1.90
	Zubair	Eni	Oil	201	225	1 200	2.00
	Missan Group	CNOOC	Oil	97	91	450	2.30
Two (2009)	West Qurna (II)	Lukoil	Oil	120	-	1 800	1.15
	Majnoon	Shell	Oil	175	21	1 800	1.39
	Halfaya	Petrochina	Oil	70	34	535	1.40
	Gharraf	Petronas	Oil	35	-	230	1.49
	Badra	GazpromNeft	Oil	15	-	170	5.50
	Qairayah	Sonangol	Heavy oil	30	2	120	5.00
	Najmah	Sonangol	Heavy oil	20	-	110	6.00
Three (2010)	Akkas	KOGAS	Gas	1.03	-	4.1	5.50
	Mansuriyah	TPAO	Gas	0.78	-	3.1	7.00
	Siba	Kuwait Energy	Gas	0.26	-	1.0	7.50
Four (2012)	Block 8	Pakistan Petroleum	Gas-prone	n/a	-	n/a	5.38
	Block 9	Kuwait Energy	Oil-prone	n/a	-	n/a	6.24
	Block 10	Lukoil	Oil-prone	n/a	-	n/a	5.99
	Block 12	Bashneft	Oil-prone	n/a	-	n/a	5.00

* Production figures are in kb/d for oil projects and bcm per year for gas projects. ** The maximum remuneration fee (Max. fee) is in US dollars per barrel of oil equivalent.

Commentators largely agree that the federal authorities have driven a hard bargain with international oil companies in these contracts. The agreed maximum remuneration fees are at low levels per barrel of oil produced, meaning that the overwhelming share of the revenue generated is retained by the government; but this is offset, in part, by the prospect of high volumes, the expectation that the fields are of such size and quality that there is little technical risk and the consideration that companies are not taking on price risk or exploration risk. In most cases, the bidding process and hard bargaining has been followed by contract implementation, but some companies have explicitly or implicitly reviewed their positions in the south. Statoil has sold its stake in the West Qurna Phase II project. ExxonMobil, operator of the West Qurna Phase I project, has engaged to pursue exploration opportunities in the KRG area, as have Total (part of the consortium for the Halfaya field with Petrochina) and GazpromNeft. The federal government has made it clear that no company with activities in the KRG area is allowed to bid in the national licensing rounds for projects in the rest of Iraq, but the implications for companies with existing contracts are not clear.

The KRG has awarded around 50 contracts for hydrocarbon exploration and development, mostly to medium-size international companies.⁸ The bulk of these are production-sharing contracts for exploration blocks, and the terms reflect the possibility that no commercial hydrocarbons will be found and that the contract holder will carry the burden of all costs with no remuneration. The subsequent terms, after a commercial discovery has been made, are generally assessed as generous, but not unprecedented.⁹ The KRG has also awarded service contracts for the development of the Khor Mor and Chemchemal gas fields, the former of which was producing at the time the contract was signed.

There are international examples of both types of contractual arrangement (technical service contracts and production-sharing contracts) within national approaches to resource development. This in itself is a reason to imagine that accord should be attainable on the appropriate contract form (or forms). However, arguments about the details of the contractual arrangements are secondary to more fundamental questions about which entities should have the power to authorise and conclude such contracts in the first place, and the consequences that arise for Iraq from the absence of a consistent country-wide policy in such a strategic sector.

The areas of difference between the federal government and the KRG have been thrown into sharper relief as oil production from the KRG area has grown, as this has raised the issue of the destination market for this production (production in the KRG area exceeds local demand) and also the payment of recoverable costs under the KRG contracts. The federal government controls the export of hydrocarbons and the associated revenue

8. Since 2010, some large international oil companies have started to acquire licences in KRG: Murphy Oil and Marathon in 2010, followed by Hess, Repsol and ExxonMobil in 2011, and stakes in existing licences acquired by Chevron, Total and GazpromNeft in 2012.

9. At an oil price of \$90 per barrel, the government take on a typical KRG contract has been estimated at 83% (Genel Energy, 2011).

through the State Oil Marketing Organization (SOMO). Agreements in early-2011 resulted in some claims for costs from KRG producers being paid by the federal government and oil from the KRG area being exported through the pipeline to Ceyhan (the volumes were scheduled to be up to 100 kb/d in 2011 and up to 175 kb/d in 2012). These arrangements came under strain from continued disagreements over the appropriate mechanism for auditing costs and broader questions of revenue sharing and, as a result, exports from the KRG area via SOMO channels were suspended in April 2012. These restarted in early August and agreement was reached in September that could see export volumes from the region rise to 200 kb/d for the rest of 2012, accompanied by a resumption of cost recovery payments. However, the underlying issues relating to hydrocarbon governance remain to be fully resolved. Efforts by the KRG to market oil or gas directly to international buyers would run contrary to the federal claim to sole authority over hydrocarbon exports.

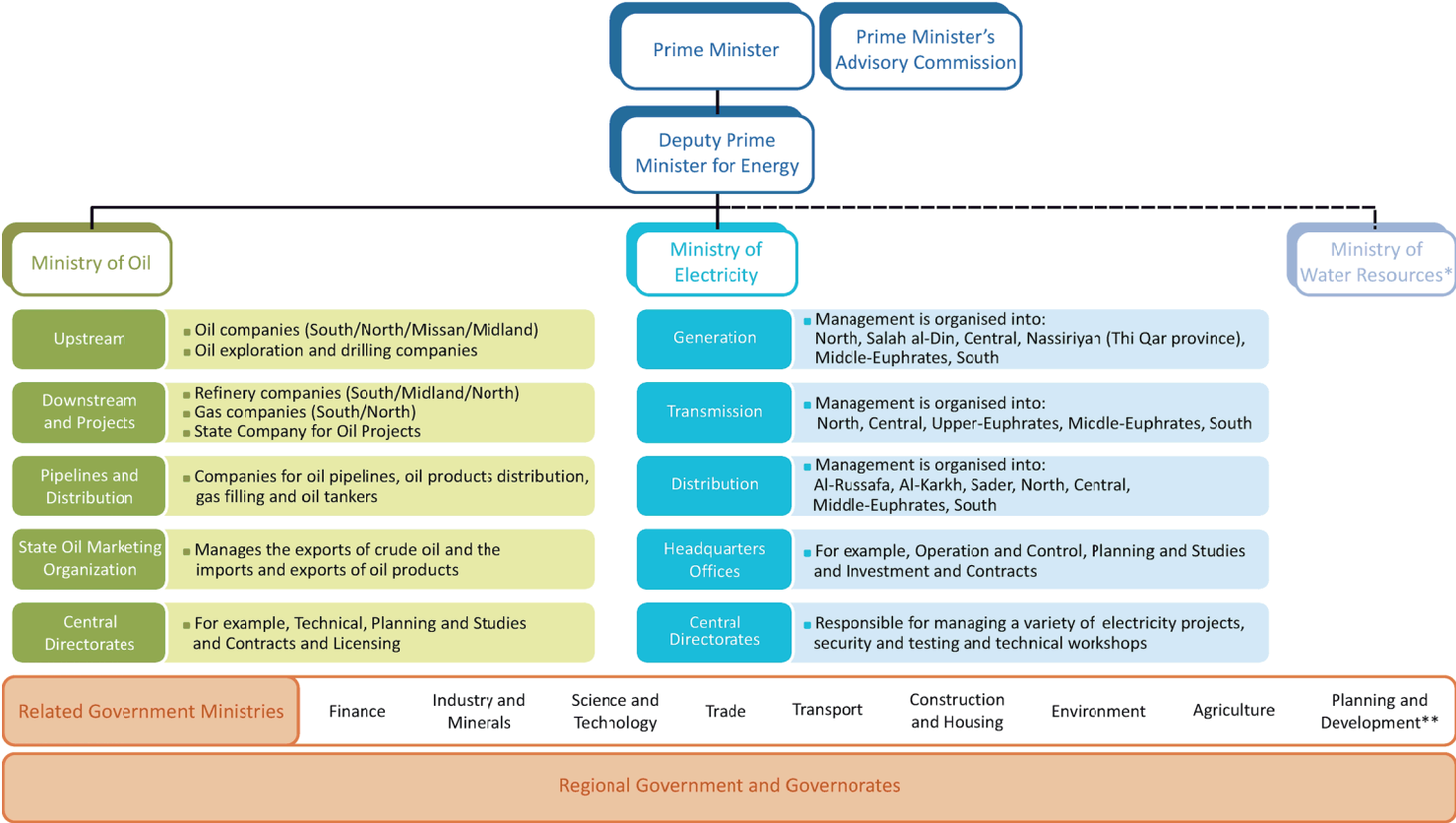
Another difficult issue that is yet to be resolved is that of the disputed territories. These straddle the borders of the “Green Line”, a boundary relating to KRG-controlled territories that were recognised in the 2004 Transitional Administrative Law (the precursor to the constitution). The Kurdish presence extends beyond the Green Line, with parts of these territories thought to hold considerable oil and gas resources but, with uncertainty over who administers them, projects here could face higher legal risk.

Institutions

The key institutions for the energy sector in Iraq are the Ministry of Oil (for the hydrocarbons sector) and the Ministry of Electricity (for the power sector), which both report to the Deputy Prime Minister for Energy (Figure 1.17). These ministries combine policy making, regulatory and operational functions, including – in the case of the Ministry of Oil – direction and supervision of regional state-owned oil production companies (the South Oil Company in Basrah, the North Oil Company in Kirkuk, the Missan Oil Company in Missan, the Midland Oil Company in Baghdad), the State Oil Marketing Organization, which manages the exports and imports of crude oil and oil products, and the South and North Gas Companies, which process gas. The institutional picture could be affected substantially by the adoption of new federal hydrocarbons legislation. At a regional level, the KRG has its own Ministry of Natural Resources and Ministry of Electricity.

The need to improve Iraq’s institutional capacity has been recognised as an important priority by the Iraqi government. It is closely linked to the broader issue of human resource development in Iraq. In the 1970s, Iraq had one of the highest per capita levels of post-graduate qualifications in the world, but the quality of the education system, in common with other Iraqi institutions, has deteriorated since. Moreover, many highly-trained Iraqis left the country during the years of conflict and instability. A generational gap is evident, with little parity between the senior professionals, educated before the onset of the multiple wars, and those educated since. The government is trying to remedy this situation, but it will take considerable time. In Iraq’s energy institutions, there is a scarcity of skills across a number of areas, including procurement and project management, which

Figure 1.17 ▷ Iraq main government institutions related to the energy sector



* The responsibility of the Deputy Prime Minister for Energy, but with a broader remit than energy. ** Includes Central Statistics Organization.

are essential to the repair and expansion of Iraq's energy infrastructure. This can result in decision making, even on relatively minor issues, being concentrated in the hands of a small number of senior officials, a situation which can lead to procedural and project delays. Policy making is also hampered by occasionally inconsistent and incomplete energy data (Box 1.3).

Box 1.3 ▶ Iraq energy data

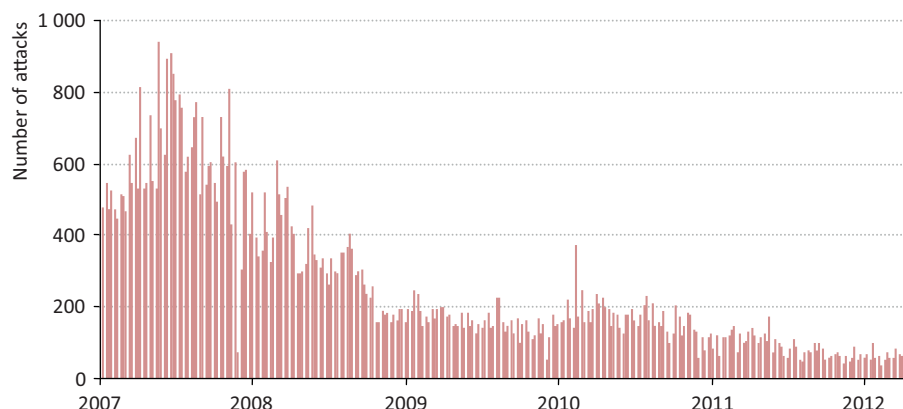
Obtaining robust data on energy supply and demand is an essential starting point for competent energy sector analysis, but the quality of Iraq's energy data varies widely by sector. Our research reveals that data on oil production and export are relatively reliable, though there are still some inconsistencies in the crude and product balances. Data on gas production and consumption is less readily available, particularly outside the power sector. Information on final energy consumption is generally hard to find. A further complication is that data are often collected and published separately by the KRG, risking differences in methodology and coverage which can make it difficult to establish with confidence a single dataset for the whole of Iraq.

The situation is improving thanks to the efforts of the Iraqi authorities and to the increasing number of surveys, such as household expenditure surveys and enterprise surveys, and one-off analytical studies that have been completed as inputs to policy making: examples of the latter are detailed master plans for the electricity sector (Parsons Brinckerhoff, 2009b and 2010), and master plans that are now being prepared for water and transport. Thanks to excellent co-operation from the Iraqi government, we have had access to a wealth of information for this report, which has allowed us to reconcile various anomalies and to put into the public domain a consolidated picture of Iraq's energy production and use. Continued efforts to improve the consistency and reliability of Iraq's energy data will be essential for effective policy making and the implementation of an integrated energy strategy.

Security

The security situation has been, and will continue to be, crucial to the development of both Iraq's energy sector and the economy overall. In general, the number of security incidents in Iraq has declined markedly in recent years but the risk of violence remains an important concern for companies working in the energy sector, necessitating close attention and considerable expense (Figure 1.18). The security risks are by no means uniform across Iraq, with the number of incidents in the key oil-producing province of Basrah and, even more so, in the KRG area, being lower than in and around the capital. There is also a legacy of landmines and unexploded ordnance in Iraq. Under the terms of contracts signed with the federal government, international oil companies are obliged to survey and clear any areas relevant to oil exploration and production that are suspected of being contaminated (UN Inter-Agency Information and Analysis Unit, 2012).

Figure 1.18 ▶ Total number of attacks in Iraq (weekly)



Source: UN Inter-Agency Information and Analysis Unit.

Environment and water

The natural environment has not been spared the degradation observed elsewhere in Iraq. Changing weather patterns, deforestation, poor farming and water management practices and an under-developed institutional/legal framework have all had negative impacts. The consequences are seen in such things as desertification (the decline of arid but productive land until it becomes barren), reduced supplies of clean water, reduced agricultural output and the greater prevalence of disruption from dust and sandstorms. Transport congestion, inefficient industrial plants and extensive use of diesel generators all contribute to local pollution in urban areas. Population growth, internal migration, a growing economy and the expected growth in the exploitation of Iraq's natural resources all have the potential to exacerbate these trends.

The energy sector contributes directly to the environmental challenge, be it from water/soil contamination and gas flaring in the course of oil and gas production, the extensive burning of crude oil and petroleum products in power generation (including local generation) or leaded fuels of low quality consumed by an ageing transport fleet. We estimate Iraq's energy-related CO₂ emissions to be about 100 million tonnes (Mt) in 2010 (excluding gas flaring). In addition, Iraq flared 11 bcm of gas in 2010, resulting in an estimated 25 Mt of CO₂ emissions, nearly equivalent to the annual emissions of 3.7 million cars. Despite steps in the right direction, including provisions in contracts with international oil companies to reduce flaring, environmental considerations remain subordinate in energy policy making.

Competition for limited resources makes water availability and use important issues in Iraq. Around 60% of Iraq's water resources come from outside its borders, in the form of the Tigris and Euphrates rivers, though water scarcity in Iraq is not attributable solely

to the actions of countries further upstream: the amount of water available per capita in Iraq is still high by regional standards and this has contributed to inefficient methods and technologies for water use, exacerbated by the poor state of Iraq's existing water infrastructure and the effect of recent conflicts. Agriculture is the sector with by far the largest water needs, as well as the largest potential for more efficient use. There is no price on water for most agricultural users and inefficient irrigation methods are widespread. There are also shortages of water for households. Nearly two-thirds of households use the public network as their main drinking water source, yet 25% of these households receive less than two hours of water per day (IKN, 2012). Public network use is particularly low in the south of the country, which is downstream of all other activities and sees less rainfall. Although water requirements for the energy sector are small by comparison, Iraq's vulnerable situation, particularly in the south, could be exacerbated by the water injection needed to raise and maintain oil production and, to a lesser extent, by water use in the power sector, particularly if the water used is drawn from sources for which there are competing uses (see Chapter 2). In the case of the Kirkuk and Rumaila oil fields, fresh water is already being used for water injection.

Projecting future developments

Building on the data presented here, of the actual state of Iraq's energy economy, subsequent chapters project how the sector might evolve in the period to 2035. The basic analytical approach to those projections is one that seeks to illustrate the range of possible outcomes which might derive from today's uncertainties and draw out the implications for policy makers.

For this analysis, the structure of our World Energy Model¹⁰ has been adapted to accommodate some specific features of Iraq's energy situation and to allow for a more disaggregated view of oil and gas supply. New areas for quantitative analysis have also been developed, notably to derive assumptions about Iraq's GDP growth from different oil production trajectories and to assess when the gap of unmet electricity demand from the grid can be closed. The scope of the Iraq model has been narrowed in some areas where data is more limited, such as energy use in industry and households. On the supply side, the main resource-rich areas of Iraq have been modelled individually to allow for a more detailed consideration of Iraq's production outlook and potential.

We have labelled the main product of our analysis of Iraq the **Central Scenario**; but we also develop two cases which illustrate outcomes falling either side of this scenario (Box 1.4).

10. For which a model for Iraq's energy system has been developed.

Box 1.4 ► Overview of the Iraq Central Scenario and cases

The Iraq outlook sets out detailed projections for the period to 2035 (the *Outlook* period) for:

- A **Central Scenario** that reflects our judgement about a reasonable trajectory for Iraq's development, based on an assessment of current and announced policies and projects. We are cautious in assessing the prospects for full implementation of these policies and projects, bearing in mind the many institutional, political and economic difficulties that could arise.

In addition, we discuss at various points in the text:

- A **High Case**, in which we take a more favourable view on the prospects for energy sector development. In this case, Iraqi oil production rises rapidly to surpass 9 mb/d by 2020 and increases further to a level around one-quarter higher than the Central Scenario by the end of the *Outlook* period. We analyse the implications of this case for investment in Iraq's energy supply infrastructure, for Iraq's domestic economic prospects and energy demand, and the potential impact on global energy markets.
- We also present findings of a **Delayed Case**, in which investment in Iraq's energy sector rises only slowly from the levels seen in 2011. For the projection period as a whole, investment is around 60% of the level in the Central Scenario, acting as a significant constraint on the pace at which the sector develops. We analyse the implications of this case for Iraq's domestic economic and energy demand prospects, and the potential impact on global energy markets.

GDP and population

For our *Iraq Energy Outlook*, variations in the assumptions about GDP growth (Table 1.2) reflect the predominant role of revenues from the oil sector in the Iraqi economy and the way that different projections for oil supply correspondingly produce different outcomes for the national economy as a whole.

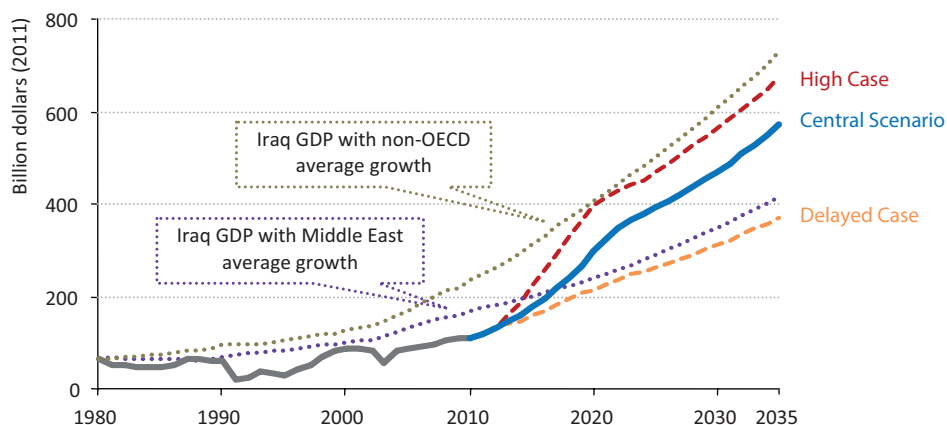
Table 1.2 ► Growth rates* for Iraqi oil output and GDP by scenario

		2000-2010	2010-2015	2010-2020	2010-2035
Central Scenario	Oil output	-1.3%	11.7%	9.6%	5.0%
	GDP	2.4%	10.0%	10.6%	6.9%
High Case	Oil output	-1.3%	20.1%	14.8%	6.4%
	GDP	2.4%	15.1%	13.8%	7.6%
Delayed Case	Oil output	-1.3%	4.6%	3.3%	1.7%
	GDP	2.4%	5.9%	5.9%	4.7%

* Compound average annual growth rates.

Iraq's troubled history over the past three decades has held back its economic development. If Iraq's economy had developed at the same rate as the Middle East average since 1980, then it would have been more than 50% larger in 2010; if it had developed over this period in line with the average for non-OECD countries, its economy would have been more than twice as large. The implication of our GDP assumptions for the Central Scenario and for the High Case is that Iraq makes up for some of this lost time (Figure 1.19). In the Central Scenario, Iraq catches up and, around 2017, overtakes its notional GDP path from 1980 based on Middle East average annual growth. In the High Case, Iraq gets back to a path closer to one based on average non-OECD growth since 1980. In the Delayed Case, however, Iraq remains short of these benchmarks.

Figure 1.19 ▸ Variations in Iraq's GDP growth by scenario



We assume in all cases that Iraq makes gradual progress with the diversification of its economy, although the oil sector continues to exercise a predominant role in GDP. The share of value added provided by services increases from current levels as Iraq's economy develops. The GDP outlooks presented here are contingent on Iraq consolidating and extending the gains achieved in recent years in terms of security and political stability. They also depend, particularly in the High Case, on Iraq managing effectively the risk that very rapid growth in oil receipts prejudices the development of other parts of the economy or of national institutions. This challenge is particularly important because of demographic trends in Iraq; the median age is eighteen (compared with a world average of 29) and more than 40% of the population is under fifteen years of age. The opportunities afforded this new generation of Iraqis will be critical. In our scenarios, we assume that the population of Iraq almost doubles over the projection period from around 30 million in 2010 to around 58 million by 2035. The population changes that Iraq has seen in recent decades (mass emigration and significant numbers of internally displaced persons) could have been the basis for varying our population assumption across different future cases. However, we have elected not to do so as this would make it more difficult to draw comparisons between the various projections.

Policies

The challenges of reconstruction are no less daunting than the scale of reconstruction itself. They are also wide ranging, covering issues such as ensuring security, effective economic management, structural reform of an economy that is dominated by the public sector and heavily centralised, the need for extensive legal and regulatory reform, institutional reform and effective implementation, and the need to overcome political differences. The extent to which each of these challenges is overcome is very uncertain, yet critical to Iraq's future.

The longer-term outlook for Iraq is difficult to assess when so much of the attention of policy makers has understandably been on short-term imperatives. However, evidence of rather longer-term thinking is emerging, both on national development priorities and, specifically, on the outlook for the energy sector. An important manifestation of this shift was the completion of a National Development Plan for 2010 to 2014 (Ministry of Planning

Box 1.5 ► Strategic thinking for Iraq's energy sector

The Iraqi vision for the energy sector is that it should act as a motor for national development, providing revenues from export that can be used to provide secure and reliable domestic energy supply and to promote the diversification of the national economy and employment. The National Development Plan and the statements of senior Iraqi policy makers give some indication of the main strategic objectives for this sector:

- A rapid increase in oil production and export; there are different views as to what target should be adopted, but no divergence of views on the central importance of such an increase to Iraq's economic development.
- Sufficient supply of gas, via associated gas, development of non-associated gas resources and reductions in flaring, to provide for growing demand for power generation, for industrial development (such as petrochemicals) and for export.
- Efforts to replace and expand oil and gas reserves through increased exploration.
- Create reliable and adequate storage, transportation and export capacities in time to accommodate oil and gas development plans.
- Expand and modernise refining capacity to provide the range of oil products to support a growing Iraqi economy.
- Increase power generation capacity, and improve transmission and distribution, so as to meet increasing demand for electricity and provide reliable, high-quality service.

Among the key challenges in meeting these objectives will be to ensure the co-ordination and sequencing of investments in different parts of the energy sector, the mobilisation of the huge investments required, and the integration of social and environmental concerns. These have been central points for discussion in the development of Iraq's Integrated National Energy Strategy.

of Iraq, 2010), which contains objectives for a range of policy areas, including a medium-term vision for the energy sector, and has been an important source of guidance for our policy assumptions. This plan has been followed by work on a more detailed Integrated National Energy Strategy, co-ordinated by the Prime Minister's Office, which had not been published at the time of writing (Box 1.5).

In the Central Scenario, we assume that Iraq makes substantial progress towards its declared objectives, taking into account additional assumptions in related policy areas (Table 1.3). We also consider a range of institutional, economic, logistical and regulatory factors that will affect the likelihood and speed of meeting these aims in full. The High Case retains the overall analytical framework, but takes a generally more favourable view about the extent and pace at which the various obstacles to a rapid transformation of the energy sector might be overcome. In the Delayed Case, cumulative investment in Iraq's energy supply is around 60% of the level foreseen in the Central Scenario. This could be attributable to a more difficult political or regulatory environment, poor co-ordination, or slow contracting and delivery of projects in the energy sector. As a consequence, the growth in oil supply is slower than in the Central Scenario, as is the increase in gas supply, and there is also an impact on the power sector.

Table 1.3 ▶ Main assumptions for Iraq in the Central Scenario

Policy area	Assumptions
Energy prices	<p>The average IEA crude oil import price – a proxy for international oil prices – rises to \$120/barrel (in year-2011 dollars) in 2020 and \$125/barrel in 2035.</p> <p>Gradual progress towards a partially liberalised market for oil products.</p> <p>A gradual, partial removal of subsidies to electricity begins after full domestic electricity supply is ensured.</p> <p>The price of gas increases slowly in real terms, as the government maintains the rate of subsidy, seeking to incentivise its use in power generation and in the industrial/transformation sectors.</p>
Oil supply	Slower targeted ramp-up in production than implied by current contracts, accompanied by a review of the requirements for individual fields (see Chapter 2)
Gas supply	<p>Priority is given to gas use for domestic power generation, followed by industrial use.</p> <p>Gas flaring is gradually reduced.</p>
Power generation	<p>Peak demand for electricity in 2011 was estimated at 70% higher than the amount actually supplied from the grid.</p> <p>The relative prices of gas and oil products mean that gas is used increasingly in the power sector as it becomes more available domestically, while the share of oil in the generation mix falls.</p> <p>Beginning in 2015, combined-cycle gas turbines enter the generation mix, either through conversions from existing gas turbines or as new plants.</p>
Refining	New refinery capacity starts to become available from 2019.
Industry	An Iraqi petrochemicals industry is expanded from 2020, and industries such as fertilisers and cement grow in line with our general assumption of gradual economic diversification.
Transport	There is a gradual rehabilitation of the road and rail networks.

Iraq oil and gas resources and supply potential

How much is enough?

Highlights

- Iraq's ambition to expand its oil and gas output over the coming decades is not limited by the size of its hydrocarbon resources nor by the costs of producing them, which are among the lowest in the world. Contracts and field development plans imply an extraordinary increase in production. How this develops in practice will be determined by the speed at which impediments to investment are removed, clarity on how Iraq plans to derive long-term value from its hydrocarbon wealth, international market conditions and Iraq's success in consolidating political stability and developing its human resource base.
- In our Central Scenario, Iraq's oil production increases to more than 6 mb/d in 2020 and reaches 8.3 mb/d in 2035. In the High Case, production surpasses 9 mb/d already in 2020, before rising to 10.5 mb/d in 2035. Meeting these trajectories (the High Case in particular) will require rapid, co-ordinated progress in many areas to ensure the timely availability of rigs, sufficient water for injection to maintain reservoir pressure, and adequate storage, transportation and export capacity.
- Anticipated production increases are driven mainly by super-giant fields in the south, but here the requirements for water injection to support oil production are high, at 9 mb/d in the Central Scenario by 2035 and 11 mb/d in the High Case. Early investment is essential to bring water from the Gulf to the southern fields and reduce potential stress on freshwater resources.
- The KRG area in the north of Iraq is now one of the most active exploration regions in the world. Resolution of current differences between the regional and federal governments would open up the possibility for this area to deliver substantial output growth. In our projections, the outlook is for production of between 500-800 kb/d in 2020 and between 750 kb/d-1.2 mb/d in 2035.
- Iraq's production of natural gas is projected to grow to almost 90 bcm in 2035 in the Central Scenario and to almost 115 bcm in the High Case. The largest share is associated gas from southern oil fields around Basrah, bolstered by new gas processing capacity that reduces gas flaring; but we also project rising volumes of non-associated gas production, particularly in the north of Iraq.
- In the Central Scenario, cumulative oil and gas sector investment during the period 2012-2035 is almost \$400 billion (an average of \$16 billion per year); in the High Case this figure rises to \$580 billion (\$24 billion per year). This represents a large step up from the estimated \$7 billion spent in 2011. If investment were to remain closer to 2011 levels, as in a Delayed Case, Iraq's oil output would rise much more slowly, reaching only 4 mb/d in 2020 and 5.3 mb/d in 2035.

Oil

Reserves and resources

The petroleum geology of Iraq is similar to that of the rest of the Middle East region: as Africa and the Arabian plate moved towards Eurasia over geological times, the ancient Tethys ocean was slowly closed, creating an exceptional combination of good source rocks, reservoir rocks of a variety of characteristics (both sandstones and carbonates) and strong cap rocks keeping the hydrocarbons in place. The movement of the Arabian plate towards Eurasia created the Zagros Mountains in Iran and, to the west/southwest of that, the three main hydrocarbon basins of Iraq:

- The Zagros foldbelt, immediately west of the mountains, with a series of gentle folds, including the super-giant Kirkuk reservoir and the fields in the Kurdistan Regional Government (KRG) area. It runs close to the Iranian border in the east and takes in most of the northern part of Iraq. In subsequent tables in this chapter, it is labelled Northern Zagros and referred to as “North”. The foldbelt itself continues into Iran, where it is also a prolific hydrocarbon province, rich in both oil and gas.
- The Mesopotamian foredeep basin, which is where most of Iraq’s super-giant fields have been found. Although not geologically separated, we split this basin between Southern Mesopotamia (referred to as “South”), the region near Basrah where most of the fields operated by international companies are located, and Central Mesopotamia (“Centre”), extending across the alluvial plains of the Euphrates and Tigris rivers around Baghdad. The geological basin extends into Iran, Kuwait and Saudi Arabia. It is generally more oil prone than gas prone.
- The Widyan Basin-Interior Platform, to the west, broadly overlaps with the Western Desert, extending into Saudi Arabia. It is the least explored of the three main basins and is thought to be more gas-rich than oil-rich. In this report, it is referred to as the Western Desert or “West”.

Iraq’s contribution to global oil supply over the coming decades is not limited by the size of its subsurface hydrocarbon potential. The country’s proven reserves are already sufficient to support a major expansion in production and may represent only a small part of the overall hydrocarbons potential. Much of Iraq remains unexplored or, at least, greatly under-explored compared with other major oil-producing countries. In October 2010, Iraq’s Ministry of Oil increased its figure for the country’s proven reserves to 143 billion barrels, almost 25% more than the previous 115 billion barrels (proven reserves shown in Table 2.1 are further updated for production and new developments in the KRG area to the end of 2011). The new reserve estimate gives Iraq the fifth-largest proven oil reserves in the world and the third-largest conventional proven oil reserves after Saudi Arabia and Iran (O&GJ, 2011a; BP, 2012).

Figure 2.1 ▷ Iraq main hydrocarbon basins and fields



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The extent of ultimately recoverable oil resources in Iraq is subject to a large degree of uncertainty. The figures presented in Table 2.1 are derived from the United States Geological Survey (USGS) 2000 assessment and subsequent updates; we use USGS data as the primary input to the *World Energy Outlook* series because it is the only source that covers many countries and regions using a consistent methodology. From this source, IEA analysis puts the level of ultimately recoverable resources at around 232 billion barrels (crude and natural gas liquids), of which 35 billion barrels had already been produced at the end of 2011. This leaves a figure for remaining recoverable resources of just under 200 billion barrels, almost three-quarters of which consists of proven reserves. The remainder, around 55 billion barrels, is made up of anticipated reserve growth (to the extent that this is not already included in the proven reserve number) and undiscovered resources.

Table 2.1 ▸ Iraq oil resources by region and super-giant field*
(billion barrels)

	Proven** reserves, end-2011	Ultimately recoverable resources	Cumulative production, end-2011	Remaining recoverable resources	Remaining % of ultimately recoverable resources
Southern Mesopotamian	107	135	18	116	86%
West Qurna	43	44	1	43	98%
Rumaila	17	31	14	17	54%
Majnoon	12	12	0	12	99%
Zubair	8	10	2	8	80%
Nahr Umr	6	6	0	6	98%
Central Mesopotamian	12	19	0	18	99%
East Baghdad	8	8	0	8	100%
Northern Zagros Foldbelt	24	66	17	49	75%
Kirkuk	9	23	14	9	38%
Western Desert	0	13	0	13	100%
Total Iraq	143	232	35	197	85%

* Figures include crude oil and natural gas liquids (NGLs). Super-giant fields are defined as those with ultimately recoverable resources greater than 5 billion barrels. ** Proven reserves are approximately broken down by basin, based on information provided by the Iraqi Ministry of Oil, supplemented with company presentations for fields in the KRG area.

Sources: Data provided to the IEA by the US Geological Survey and the Iraqi Ministry of Oil; IEA databases and analysis.

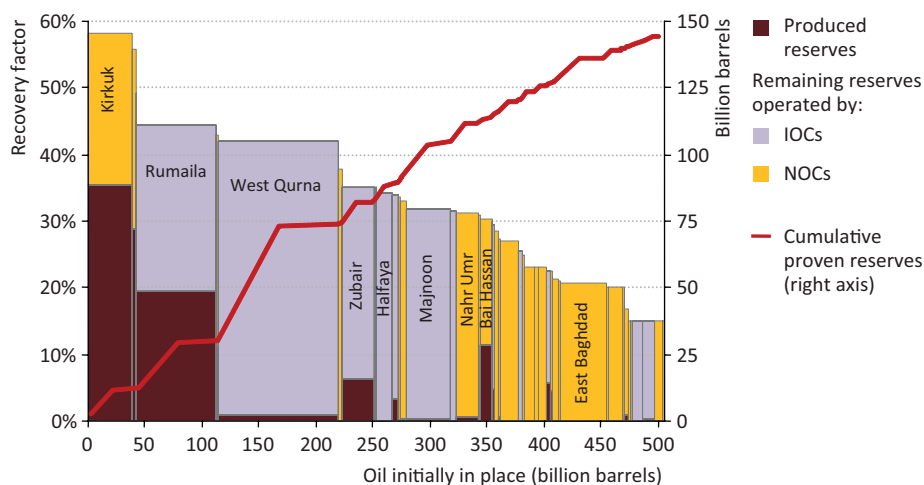
Estimates from other sources of Iraq's undiscovered oil resources are considerably higher. Alongside its announcement of 143 billion barrels of proven reserves, the Ministry of Oil stated in 2010 that Iraq's undiscovered resources amounted to some 215 billion barrels. A detailed study by Petrolog, published in 1997, reached a similar figure and did not include the parts of northern Iraq in the KRG area or examination of the stratigraphic traps that are numerous in central and western regions of the country (O&GJ, 2011b). Even using the more conservative USGS figure, Iraq has thus far produced only 15% of its ultimately recoverable resources, compared with 23% for the Middle East as a whole.

Exploration efforts can be expected to add substantially to proven reserves over the coming decades. Of 530 potential hydrocarbon-bearing geological prospects identified by geophysical means in Iraq only 113 have been drilled, with oil being found in 73 of them (O&GJ, 2011b). Although it is reasonable to assume that the most promising structures were drilled first, it is also likely that new seismic data and more sophisticated analysis of historical data will increase the number of structures that may be considered hydrocarbon-bearing. Prior to the recent surge in exploration activity in the KRG area, more than half of the exploratory wells in Iraq had been drilled prior to 1962, a time when technical limits and a low oil price gave a much tighter definition of a commercially successful well than would be the case today.

For the past three decades, the world's reserves growth has come more from known fields than from new discoveries and most of these barrels were found in super-giant oilfields. As well as techniques for secondary and tertiary recovery that can increase the volume of oil that is ultimately recovered from reservoirs under development, drilling deeper into discovered fields offers opportunities to increase the reserves in Iraq: the country's currently known reserves are almost entirely found in rocks of the Cretaceous, Paleogene or Neogene periods and the deeper geological layers have seen only very limited exploration.

According to data from the Ministry of Oil, Iraq's proven reserves are spread across 66 fields, with total oil-in-place at these fields exceeding 500 billion barrels. This implies an average recovery factor of around 35% (Figure 2.2). Five super-giant fields in the south of Iraq – Rumaila, West Qurna, Zubair, Majnoon and Nahr Umr – account for 60% of the total proven reserves. The other main reserve-holding fields are East Baghdad, in the centre, and the longstanding producer, Kirkuk, in the north. Of the total remaining reserves, around two-thirds are in fields being operated by international companies. These include most of the larger fields with higher anticipated recovery factors,¹ a reasonable indication that these are the fields that are easiest to develop.

Figure 2.2 ▸ Iraq oil reserves by field, end-2011



Notes: IOCs = international oil companies; NOCs = national oil companies. This figure includes data from 66 fields, but only the largest are indicated by name.

Sources: Data provided to the IEA by the Iraqi Ministry of Oil; IEA databases and analysis.

This chart includes only a small figure for proven reserves from recent discoveries in the KRG area, which we currently estimate at around 4 billion barrels. However, as a result of the contracts awarded by the regional government, this is now one of the most actively

1. The exceptions are Kirkuk, in which international oil companies have no stake, and the Najma and Qayara fields (two IOC-shaded bars to the right-hand side of the figure), which are smaller heavy oil fields.

explored regions in the world; the present, modest figure for proven reserves can be expected to increase substantially in the coming years. The Kurdistan Regional Government states that oil resources in the region amount to 45 billion barrels. This figure includes a large allowance for resources to be identified as a result of future exploration and arising from secondary recovery.

Production costs

The cost of developing Iraq's oil fields is very low by international standards. The super-giant fields being developed in the south are some of the largest in the world, bringing large economies of scale to their exploitation. Moreover, the geology is relatively uncomplicated when compared with major ongoing projects elsewhere in the world, for example the Kashagan field in Kazakhstan, where the reservoir is deep and at very high pressure, or deepwater pre-salt developments in offshore Brazil. Iraq's fields are all onshore and, as in the case of the fields around Basrah, are often located in relatively unpopulated and flat terrain, reducing the costs of wells, pipelines and other facilities. The oil produced is of a medium grade, requiring no specialist upgrading, and can be pumped and handled quite easily.

Table 2.2 ▶ Indicative oil development and production costs in selected countries

	Type of project	Scale of project (mb/d)	Capital cost* per barrel of capacity (\$2011/bbl)	Operating cost** (\$2011/bbl)
Iraq	Expansion super giant (south)	1.00	7 000-12 000	2
	New super-giant (south)	1.00	10 000-15 000	2
	Mid-size (north)	0.25	15 000-20 000	2-3
Saudi Arabia	Generic expansion	0.50	15 000	2-3
Brazil	Deepwater pre-salt	0.25	70 000-80 000	15-20
Kazakhstan	North Caspian offshore	0.25	70 000-80 000	15-20
Canada	Canadian oil sands with upgrading	0.25	100 000-120 000	25-30

* Capital cost per barrel of plateau rate production capacity. ** Operating cost includes all expenses incurred by the operator during day-to-day production operations but excludes taxes or royalties that might be levied by the government as well as other compensation to the operator, such as remuneration fees.

Source: IEA analysis.

The southern fields are all located within easy reach of coastal export facilities, keeping the primary export pipelines relatively short (whereas secondary export routes are much longer). Such proximity to an international port is an important consideration not only for getting the crude to market, but also for bringing in equipment, in this case via the Shatt Al-Arab waterway that extends up from the Gulf to beyond Basrah. This ease of access is in marked contrast to the logistical difficulty of bringing heavy equipment to many other parts of the world, for example to the Caspian region or to fields in northern Russia. There are also well-established fabrication yards and other industrial facilities within relatively easy reach.

Apart from the super-giant Kirkuk field, the oilfields in the north are smaller (although still large by international standards²), often containing 0.5 to 1.0 billion barrels of recoverable oil. The region's favourable geology is yielding wells with high initial oil production rates, in many cases higher than are reported elsewhere in Iraq; but the cost of bringing oil to market is nonetheless higher than in the south because of the need for additional expenditure on infrastructure and supply logistics, given the distance to the nearest ports.

Uncertainties above the ground, related to politics, security and the performance of Iraq's institutions, temper the geological and geographical advantages described above, and can add significantly to the cost and difficulty of executing projects. But this does not diminish the fact that, from a technical perspective, oil projects in Iraq are among the more straightforward and least-cost in the world, both in terms of the capital cost per unit of new production capacity and the operating expense.

Production

Development plans and contracts already in place imply an extraordinary increase in Iraq's oil production over the coming years. This increase would come from fields operated under the technical service contracts awarded in the national licensing rounds, from fields managed directly by the national oil companies³ and from fields or prospective areas held under production-sharing contracts in the KRG area. On the basis of a detailed examination of 46 Iraqi fields,⁴ we found that – if all of these proceed according to their currently envisaged schedules – oil production capacity in Iraq would reach 14.6 million barrels per day (mb/d) by 2020, almost five times the 3 mb/d being produced as of mid-2012. Given that the largest production commitments were volunteered by international companies during the licensing rounds and subsequently incorporated in binding technical service contracts (see Box 1.2 in Chapter 1), the Ministry of Oil has solid grounds for the formal position that, well before the end of the decade, Iraq should have more than 12 mb/d of production capacity from fields covered by technical services contracts alone.

Iraq's resource base can support an expansion of this magnitude; but there is a range of constraints – infrastructure, institutional, logistical and security – that cast doubt on whether an expansion at this pace is achievable. It is also reasonable to ask whether such a vertiginous path corresponds to Iraq's interest in deriving maximum value from its hydrocarbon wealth. It would mean, for example, that Iraq's major discovered fields (with the exception of Kirkuk and East Baghdad) not only reach peak production at the same time, but also that their post-peak declines broadly coincide. In order to provide a stable

2. The Shaikan field is currently being appraised and could come close to super-giant status.

3. These are the South, North, Midland and Missan oil companies, all of which are state-owned and part of the Ministry of Oil.

4. These include all the fields currently producing in Iraq, as well as all those that have been tested and have field development plans in place.

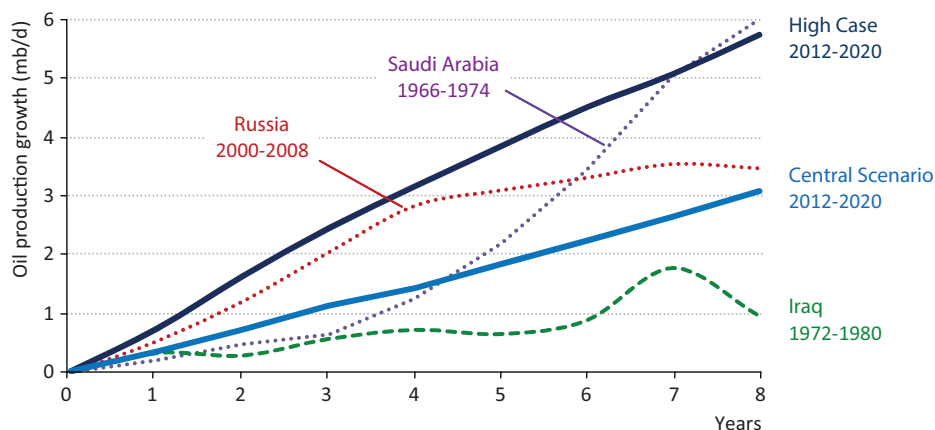
long-term export revenue stream, there are arguments in favour of sequencing the build-up from the various fields so as to reach a lower combined production plateau, but one that could be sustained for longer.

Alongside the above-ground factors within Iraq that might hold back output, the capacity of international markets to absorb the growth in Iraq's production could also be limited. There are arguments for allowing production capacity to run ahead of actual output, creating spare capacity that can play an important role for the stability of global markets; but, beyond a certain point, Iraq could face the possibility that spare capacity becomes redundant capacity, a particularly inefficient use of scarce investment capital in the case of Iraq. The role of Iraq's oil production in global markets is considered further in Chapter 4.

Given these uncertainties, the Iraqi authorities are considering optimal oil output paths and strategies for the future, taking into account reservoir characteristics and production economics at the various fields, infrastructure priorities and constraints, projections for market needs, as well as broader considerations such as the country's fiscal requirements, the need to maximise value from national resources and the contribution that the oil sector can make to economic development and employment. We anticipate that these deliberations will result in a slower targeted ramp-up in production than implied by current contracts and that this process will be accompanied by a review of the requirements for individual fields. Decisions on the detailed field development plans and enhanced redevelopment plans that are due to be submitted in 2012-2013 by operators under the technical service contracts will be important in determining future production profiles and resource management policies.

We have developed two detailed trajectories for Iraq's possible future oil production.⁵ The Central Scenario is based on strong progress with capacity additions throughout the projection period, reflecting our judgement of the time required for projects to be executed in the developing circumstances of Iraq and taking account of any constraints arising from international market conditions. Achieving this trajectory requires a significant, co-ordinated growth in investment all along the energy supply chain: we analyse, in particular, the inter-linked requirements for increased upstream activity (drilling rigs and wells), for water that is injected to maintain reservoir pressure and for new transportation, storage and export capacity. In the High Case, we examine what would be required for Iraq to reach production in excess of 9 mb/d by 2020. Both the Central Scenario and the High Case see increases in oil output greater than anything achieved in the past by Iraq, with the Central Scenario well above the growth achieved in the 1970s (Figure 2.3). Achieving the High Case would match the highest sustained growth in the history of the industry – that of Saudi Arabia between 1966 and 1974.

5. The possibility of delays in investment, which would bring oil output below the levels anticipated in the Central Scenario, are discussed in the concluding section of this chapter.

Figure 2.3 ▶ Iraq production outlook to 2020 in context

The production profile in both cases, broken down by producing basin, involves a rapid increase to 2020, then a slower rate of output growth thereafter to 2035 (Table 2.3). Given the volume of projects underway or under consideration, Iraq has the potential to meet this output growth in a variety of ways, with greater or lesser contributions from individual fields and regions. How this evolves in practice will depend on commercial negotiations and political decisions, the detailed outcome of which we have not attempted to anticipate. The breakdown by region and by field in our projections is proportional to the future ambitions expressed in existing contracts, company announcements and development plans, with the downside risks and upside potential discussed in the text. Existing discoveries are more than sufficient to support these oil production profiles, so we have not anticipated contributions from undiscovered fields except in the KRG area (included in “North” in Table 2.3), where there is a large amount of exploration underway and planned.⁶

Most of the increase anticipated in both scenarios comes from the large southern fields: the “Big 4” of Rumaila, West Qurna, Zubair and Majnoon contribute more than two-thirds of Iraq’s projected production in 2035, slightly higher than their present share (most of which comes from Rumaila). A strategy to prioritise the lowest-cost sources of production could result in an even larger share for the major southern fields, but – because of the fast anticipated growth – this is also the area where constraints related to infrastructure, logistics and water availability could have the largest impact, potentially bringing down production levels below the range of our projections.

6. This means, for example, that we have not taken into consideration possible contributions to the oil balance from the exploration blocks included in the fourth bid round. There is, however, a larger contribution from yet-to-find fields to natural gas production and some volumes of natural gas liquids from these fields are included in the oil balance.

Among the major fields:

- **Rumaila** is well positioned over the next decade to maintain its pre-eminence in Iraq and its standing as the second-largest producing field in the world, after Saudi Arabia's Ghawar. It has a very productive main reservoir (for which the recovery factor could be well in excess of the 44% estimate from the Ministry of Oil that is used in Figure 2.2), and at least two other oil-bearing formations that have been identified but not yet developed. Its production history means that its capacities and potential are well understood and its access to export infrastructure well established. It also has more natural water support than other major fields in the region. The maximum remuneration fee per barrel, at \$2 per barrel, is – along with the fee agreed for Zubair – the highest for the large southern fields. In our projections, output ranges between 1.7-2.2 mb/d in 2020 and a gradual decline starts from the mid-2020s.
- **West Qurna** is, in geological terms, a northward extension of the Rumaila field. It is split, for development purposes, by the Euphrates River, with the southern part (Phase I) contracted to a consortium led by ExxonMobil and the northern part (Phase II) by Lukoil. Thus far, there has been production only from the southern area, currently at 400 kb/d, but the combined plateau production commitments of the two phases amount to more than 4.5 mb/d. Our projections are more modest initially, at 1.5-2.5 mb/d in 2020 before reaching 3.2-4.6 mb/d in 2035, the wide range reflecting our concerns over the availability of transportation infrastructure and water for injection. There is a risk that production growth could be slowed by Statoil's exit from the consortium operating Phase II and by uncertainty over ExxonMobil's position in the Phase I project.
- **Zubair** was one of the first major discoveries in the region but it has remained in the shadow of its larger neighbour, Rumaila, with historical production rarely exceeding 200 thousand barrels per day (kb/d). A technical service contract for the field was awarded to a consortium led by Eni in 2009. Our projections for 2020 range from 500-750 kb/d and around 700 kb/d for 2035.
- **Majnoon** has seen only very limited production since its discovery (by Petrobras) in the 1970s. Development is complicated by the large amount of unexploded ordnance in the area, a legacy of the 1980s war with Iran. A consortium led by Shell is now working to raise production, initially to 175 kb/d (the threshold for cost-recovery payments). Shell is reportedly in negotiations with the Ministry about lowering the plateau production commitment for the field from its current 1.8 mb/d. Our projections are between 550 kb/d-950 kb/d in 2020 and 700 kb/d-1 mb/d in the 2030s.

After these four super-giants, the next largest contribution in the south comes from the Halfaya field, which is located in the Missan governorate and operated by a consortium led by PetroChina. Production has started from newly built facilities, ahead of the original project schedule. We project that output from Halfaya reaches between 150-275 kb/d in 2020 and 200-325 kb/d in 2035 although, given the rapid progress thus far, these projections could well be exceeded if the connecting infrastructure to export facilities is available on time.

Production from the central region of Iraq is expected to remain under 350 kb/d, with the major contributors being the Ahdab field, operated by PetroChina (which increased production rapidly in 2012 to reach its target plateau of 115 kb/d), and the Badra field, operated by GazpromNeft (where first production is expected in 2013). Further growth from this region is held back as we do not anticipate major progress with the region's super-giant East Baghdad field that underlies the capital. It was offered in the second national licensing round but did not receive any bids. Output from the west of the country is marginal, consisting only of some natural gas liquids produced later in the projection period as part of new natural gas developments.

Table 2.3 ▸ Iraq oil production by region in the Central Scenario and the High Case (mb/d)

Central Scenario	2011	2015	2020	2025	2030	2035
South	2.0	3.2	4.8	5.4	5.8	6.4
Big 4	1.8	2.8	4.2	4.7	5.1	5.6
Centre	0.0	0.2	0.2	0.2	0.2	0.3
North	0.7	0.8	1.1	1.3	1.4	1.6
West	0	0	0.01	0.01	0.02	0.02
Total	2.7	4.2	6.1	6.9	7.5	8.3

High Case	2011	2015	2020	2025	2030	2035
South	2.0	4.6	7.3	7.6	7.8	8.1
Big 4	1.8	4.0	6.4	6.6	6.8	7.1
Centre	0.0	0.2	0.3	0.3	0.3	0.3
North	0.7	1.0	1.6	1.7	1.9	2.1
West	0	0.01	0.02	0.02	0.03	0.03
Total	2.7	5.9	9.2	9.6	10.0	10.5

Notes: The figures provided and discussed are for actual oil production and not for production capacity. The "Big 4" includes production from Rumaila, West Qurna, Zubair and Majnoon.

Around a quarter of Iraq's production in 2011 came from the north of the country (Figure 2.4), primarily from the Kirkuk and Bai Hassan fields. This northern share declines to one-fifth by the end of the projection period, but the geography of Iraq's northern output changes substantially in our projections with the rise in production under contracts awarded by the KRG (Box 2.1). Production from other northern fields grows at a slower pace. The super-giant Kirkuk field includes three large production areas, two of which are operated by the North Oil Company, with the third (the Khurmala dome) being developed under a contract awarded by the KRG. In the absence of firm development plans, we project that production from the areas operated by the North Oil Company rises only slightly from current levels.

Box 2.1 ► Outlook for oil production in the KRG area

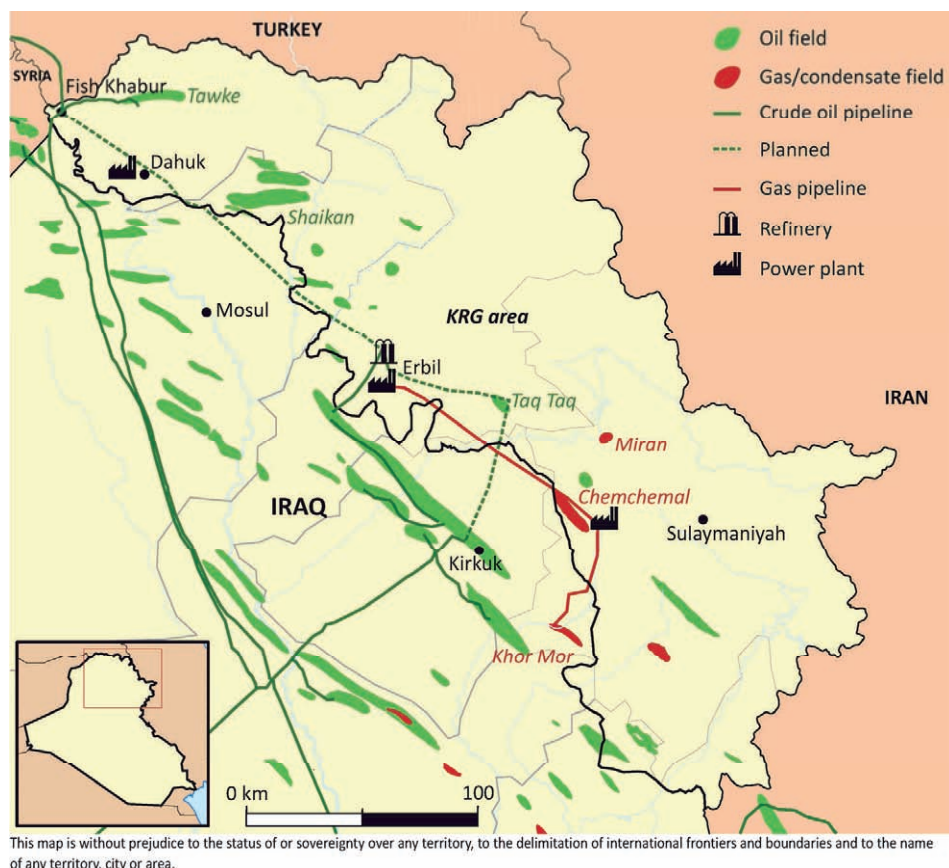
With 23 rigs drilling exploration wells in mid-2012 (more than double the number from early-2011), the KRG area is now one of the most intensive areas for oil and gas exploration in the world, reflecting high expectations of significant discoveries in the heavily folded and faulted subsurface of the northern Zagros foldbelt. The regional government has awarded around 50 contracts with international companies to explore for and produce oil, and has stated its ambition to raise the region's production to 1 mb/d by 2015, based on existing discoveries, and to 2 mb/d by 2019, based on existing and expected discoveries (our projections are more conservative). The largest discovery to date has been the Shaikan field, which could have as much as 12-15 billion barrels of oil in place, although further drilling will be required in order confidently to assess the resources. There are currently five fields that are producing under contracts awarded by the KRG: Tawke, Taq Taq, the Khurmala dome of the Kirkuk field, Shaikan (early production) and condensates from the Khor Mor gas field (Figure 2.4). The Sarqala field is undergoing extended well tests and five additional fields are expected to be in early production tests by the end of 2012.⁷

Our projections for oil production from the KRG area are contingent on resolution of the current deadlock between the regional government and Baghdad over governance of the hydrocarbons sector, which have generated disputes over the modalities and payment for cost recovery and export (see Chapter 1). A harmonious resolution would open up the possibility for the KRG area to deliver substantial output growth in the longer term, not least because it would facilitate the arrival and operation of larger international companies. A stable framework for export, an area in which the federal government claims exclusive authority, is essential to mobilise the multi-million dollar investments that are required. In the case of the Shaikan field, contract-holder Gulf Keystone estimates that full field development may cost up to \$10 billion (they hope to reach initial production of 100 kb/d through investment of around \$500 million). As long as there is no certainty that future output can be converted into a reliable revenue stream, investment will, at best, be made only in small increments. Our projections for oil from the KRG area (included in "North" in Table 2.3) see production rising to between 500-800 kb/d in 2020 and 750 kb/d-1.2 mb/d in 2035.

Aside from the complex political considerations, the outlook for the KRG area is also constrained by the time needed to put in place the necessary production and transportation infrastructure. With the exception of a small-capacity link between the Tawke field and the Iraq-Turkey export pipeline, there is very limited pipeline infrastructure in the region and most oil is transported by truck. A number of proposals exist to tie in existing fields to the main Iraq-Turkey pipeline, either through connections around the Kirkuk area (a link from the Taq Taq field is under construction) or, alternatively, through new connections that would bring oil directly to the main pumping station at Fish Khabur near the Turkish border.

7. Production capacity in the KRG area as of mid-2012 is estimated at 250 kb/d.

Figure 2.4 ▸ Northern Iraq oil and gas fields and infrastructure



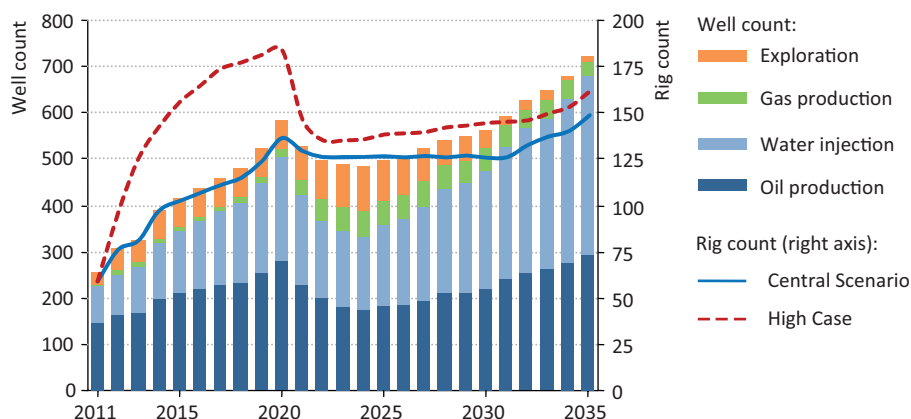
Wells and other upstream facilities

Bringing on new production and compensating for the natural decline in output from existing facilities requires new wells and surface equipment to gather the produced hydrocarbons and to separate out natural gas from the crude oil. To meet the production profile of the Central Scenario, Iraq requires, on average, 500 kb/d of additional capacity every year to 2020 while in the High Case, the average annual requirement is close to 900 kb/d. After 2020 the pace of overall output growth is lower, but more investment is required each year to combat natural decline and maintain production levels.

The number of producing wells in Iraq has risen sharply in recent years: in 2010 Iraq recorded 1 526 producing wells and just a year later 1 695 wells, an increase of 169 (OPEC, 2012). This is a testament to the improving security situation and the surge in development activity that followed the signing of the technical service contracts in 2009 and 2010. Substantial repair work was immediately undertaken as operators worked urgently to reach the initial production threshold, after which they could recover costs.

Large numbers of wells are required, not only for oil and gas production but also for water injection at oil fields, as well as for exploration activities (Figure 2.5). In the Central Scenario, the number of wells needed continues to rise until around 2020, by which time the rig count in Iraq is projected to reach 135, compared with the current figure of around 80. After 2020, the flattening of the production profile brings a temporary reduction in the number of oil wells required, but in-country rigs could be re-deployed for exploration, for non-associated gas production (which expands rapidly in the 2020s), or to create spare oil production capacity. The addition of 55 drilling rigs by 2020, all requiring experienced crews and support services, would be a sizeable but still manageable task for Iraq: in the last ten years, the Middle East as a whole (excluding Iraq) has been adding around ten rigs a year. In the 2020s, the number of wells required to meet the Central Scenario starts to increase again as the average productivity of a new well is assumed to decline (from the current average, around 3 kb/d, to 2 kb/d) and the number of water injection wells, relative to producers, increases as the fields mature. However, Iraq manages with around 130 to 140 rigs until close to the end of the projection period.

Figure 2.5 ▸ Wells by type and rig count required in the Central Scenario



Notes: These figures do not include well workovers, *i.e.* major maintenance or remedial work on existing wells, or the rigs required for these operations. There are currently around 30 workover rigs in Iraq.

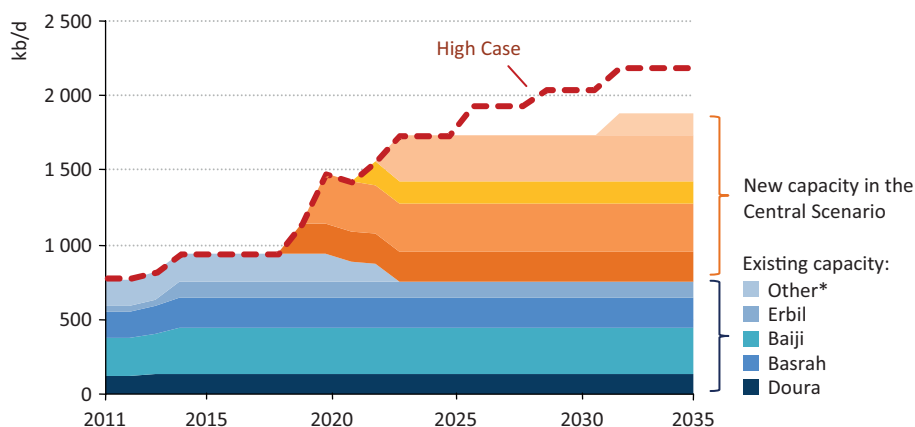
In the High Case, the total annual requirement for wells rises much more quickly in the coming years to over 800 by 2020, drops back sharply as output growth slows in the early 2020s, before growing again towards 800 in 2035. To achieve this, the rig count would need to more than double to 180 by 2020, before falling back. Sourcing this number of additional rigs and drilling crews in the coming years would be a considerable challenge, particularly for the short-lived peak in drilling towards 2020.

Crude oil conversion and bringing oil to market

A part of Iraq's new oil infrastructure is required to cater for the anticipated rise in domestic demand, with the largest share going to the rehabilitation of Iraq's refining sector. Thus far the government's attempts to attract large-scale private investment have not been successful: Iraq's three main refineries in Doura (near Baghdad), Basrah and Baiji remain in urgent need of upgrading. The main addition in recent years has been the 40 kb/d refinery in Erbil (now being expanded to 100 kb/d), but the bulk of investment made has been in even smaller-capacity topping plants, which can be built quickly but have not made a dent into Iraq's deficit of some key oil products, particularly gasoline, at a time when domestic demand is growing rapidly.

In addition to projects aimed at upgrading and de-bottlenecking the existing refineries, design work is at various stages for large projects in Karbala (140 kb/d), Nassiriyah (300 kb/d)⁸, Kirkuk (150 kb/d) and Missan (150 kb/d) that would increase refinery capacity by almost 750 kb/d. Legislation offers investors the possibility of both a 5% discount on the average crude export price and 50-year operating licences, while the government is also considering a system of remuneration to investors based on a fixed fee per barrel. As yet there has been no firm commitment to the projects on offer. In order to provide the margins that could justify these projects, potential investors have indicated that they favour larger complexes than those proposed by the government and freedom to export petroleum products (given that oil product prices on the domestic market remain subsidised).

Figure 2.6 ▶ Iraq refinery capacity in the Central Scenario



* Refers to smaller-volume refinery capacity, *i.e.* topping plants.

8. The Ministry of Oil has announced plans to include construction of this refinery as part of the Nassiriyah oil field development project, which is expected to be offered in an upcoming licensing round.

In our projections, we assume that this investment does go ahead, but later than currently envisaged by the authorities. In both the Central Scenario and the High Case, the first of Iraq's new refineries becomes operational in 2019, setting the scene for the start of decommissioning of Iraq's smaller, topping refineries (Figure 2.6). In the High Case, capacity continues to grow throughout the 2020s, reflecting the higher domestic demand for oil. The modernisation and expansion of Iraq's refinery capacity in our projections brings a significant improvement in the product slate, increasing the share of gasoline produced relative to heavy fuel oil (see Chapter 1). This is sufficient to reduce the country's reliance on imports of gasoline and diesel, but does not allow for significant export of oil products.⁹

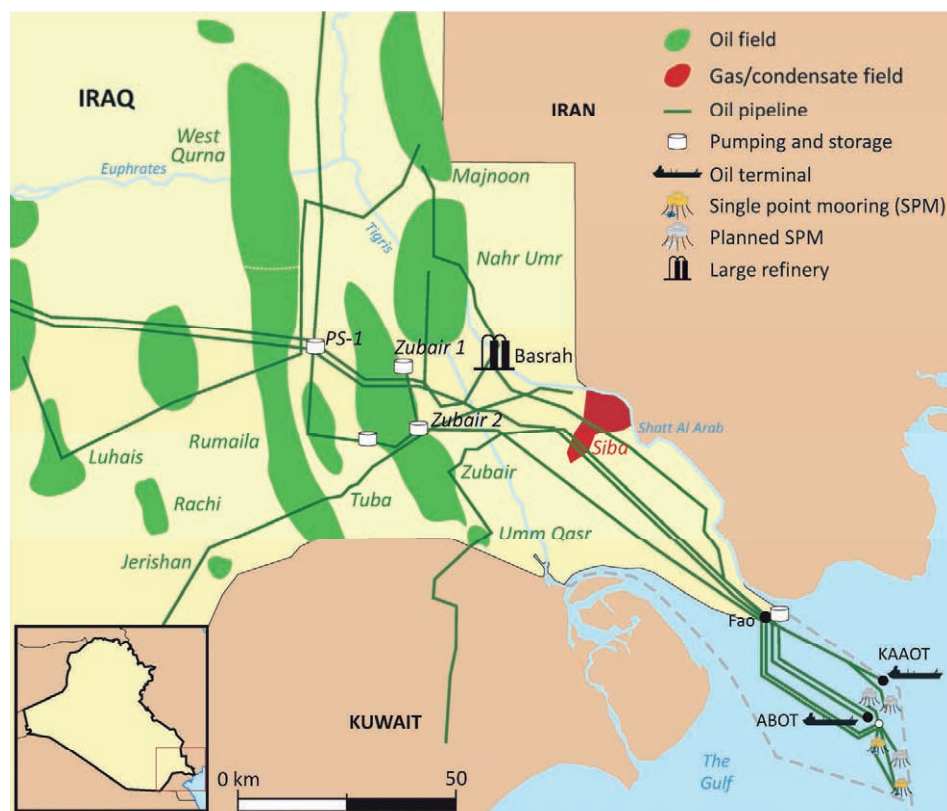
Bringing Iraq's crude oil production to international markets is another major challenge. By 2017 (2014 in the High Case), our projections suggest that Iraqi exports will exceed the historical export peak of 3.3 mb/d reached in 1979, but this will depend on substantial additional investment to remove potential infrastructure bottlenecks, particularly in the south. There are three links along the supply chain that could constrain export from the main southern fields and hence production: the network of pipelines, storage facilities and pumping stations that provide a connection between the fields and the main export depot at Fao, the available pumping and storage capacity at Fao itself and the offshore export facilities for loading tankers (Figure 2.7). All of these constraints are being addressed, but not at the same pace.

Expansion of offshore crude loading capacity has made the most progress, with the commissioning of two single-point mooring systems in early 2012. The Ministry of Oil plans to add another three mooring systems and to expand the capacity of the existing offshore terminals at Khor al-Amaya (KAAOT) and Al-Basrah (ABOT). Once complete, with new or expanded pipelines linking them to onshore facilities, these projects would bring Iraq's sea-borne export capacity to 8 mb/d, a level sufficient to accommodate the exports projected in both the Central Scenario and the High Case.

The Fao terminal is a critical link between the onshore fields and the offshore loading facilities, but longstanding plans to rebuild storage and pumping capacity at this depot are only now coming to fruition. Twenty-four new storage tanks are envisaged (each of 58 thousand cubic metres, for a total capacity of more than 8 million barrels). The first set of eight tanks has been constructed, but the facility is set to begin large-scale operation only in 2013 once pumps and other ancillary equipment have been installed. The delay has necessitated the construction, for the new single point mooring systems, of interim pipelines bypassing the terminal. As a consequence, oil is pumped onto tankers directly from more than 100 km onshore and any halt to offshore loading (which can often be weather-related) can force a reduction in production at the fields.

9. For the moment, there are no plans to create a large export-oriented refining capacity of the sort that exists elsewhere in the Middle East. The logical place to site such a facility would be around Basra, but it would require dedicated export infrastructure for oil products; this would be only a longer-term possibility given other infrastructure priorities.

Figure 2.7 ▸ Southern Iraq oil and gas fields and infrastructure



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Infrastructure challenges further onshore include pipelines and equipment that are in a poor state of repair and inadequate in capacity, some missing links to accommodate output from new fields like Halfaya and Majnoon, and a shortage of storage and pumping capacity. Individually, none of these projects is technically complex or difficult to implement; but collectively they demand a high level of integrated planning and timely execution in order to avoid limiting the productive potential of the major southern fields (see concluding discussion in this chapter on institutions and project lead times).

The second historical axis for oil export from Iraq has been the northern route to the Mediterranean port of Ceyhan in Turkey. Rehabilitation of this route and raising its capacity from the current 600 kb/d to 1 mb/d is included in the Ministry of Oil's plan for export infrastructure to 2014; but this date is likely to be pushed back, as detailed feasibility work on Iraq's pipeline export options started only in 2011. Iraq is interested in developing a range of routes to market, with enhanced linkages between the north and south of the country (Box 2.2), but it is not yet certain which routes will be developed. Options on the table include not only the development of the existing route to Ceyhan, but also

rehabilitated or new capacity to the Mediterranean via Syria or, possibly, across Jordan (or Saudi Arabia) to the Red Sea. The infrastructure choices facing Iraq need to be shaped by the range of crudes produced and by Iraq's evolving oil marketing strategy (see Box 4.2 in Chapter 4).

Box 2.2 > The Strategic Pipeline

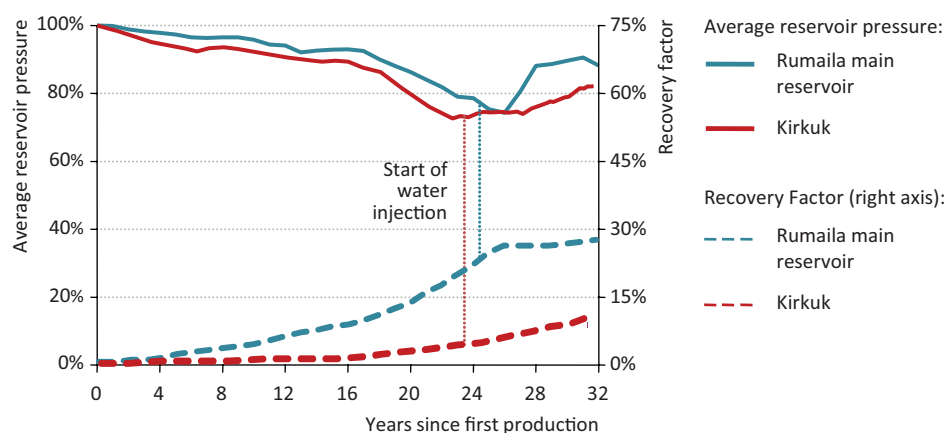
The anticipated need for a large increase in southern export capacity over the coming years brings with it the risk of over-reliance on the Straits of Hormuz for access to world markets. Development of alternative routes to market makes sense both for commercial and security reasons and the strategic position of the government is that Iraq should have at least three independent outlets to market for its crude exports: a major route through the Gulf and two pipeline routes (either both to the Mediterranean, or one to the Mediterranean and one to the Red Sea). Accompanying this expansion of export routes, a sizeable capacity (of up to 2.5 mb/d) should be kept available to shift oil from south to north, or vice versa. A large-capacity Strategic Pipeline, separate from the domestic transportation network, has been proposed as a way to link the different systems. Currently, some oil from the south is refined in central Iraq, but there is no functioning link with the northern export route. A new Strategic Pipeline, though it would cost around \$1.5 billion to construct (with capacity of 2.5 mb/d over a distance of 650 km), would give Iraq valuable flexibility in marketing its oil for export. In the event of disruption to export along an existing route, the Strategic Pipeline, if it allowed Iraq to sustain exports of 2 mb/d by switching routes, would generate revenue equal to the initial investment in little more than a week.

Water requirements

The medium-term prospects for Iraq's oil production, from its southern fields in particular, are closely tied to the availability of sufficient water for injection to support reservoir pressure.¹⁰ Both the historical mainstays of Iraq's oil production, Kirkuk and Rumaila, have required water injection. In the case of Kirkuk, reservoir pressure at the field dropped significantly after production of only around 5% of the oil-in-place (Figure 2.8). After an initial experiment with gas injection, engineers implemented a water injection project that reversed the decline in reservoir pressure and allowed production to continue at a high rate. Rumaila had produced more than a quarter of its oil-in-place before water injection was required, because its main reservoir formation (at least its southern part) is connected to a very large natural aquifer which has helped to push the oil out of the reservoir.

10. As oil is produced, the space it leaves behind in the reservoir rock needs to be filled, otherwise well flow rates will decline, gas will come out of solution from the oil and the ultimate recovery factor, *i.e.* the percentage of oil initially in place that will ultimately be produced, can be reduced significantly. If pressure support is not available naturally, for example from an aquifer connected to the reservoir, it needs to be provided by injecting gas or, more commonly in Iraq and around the world, by injecting water.

Figure 2.8 ▸ Reservoir pressure and recovery factors prior to and after the start of water injection at the Rumaila and Kirkuk fields



Note: Recovery factor is the percentage of oil initially in place that has been produced; the recovery factor shown for Rumaila is for the main reservoir and therefore differs from the figure for the field as a whole.

Sources: Al-Naqib *et al.* (1971); Mohammed *et al.* (2010); IEA analysis.

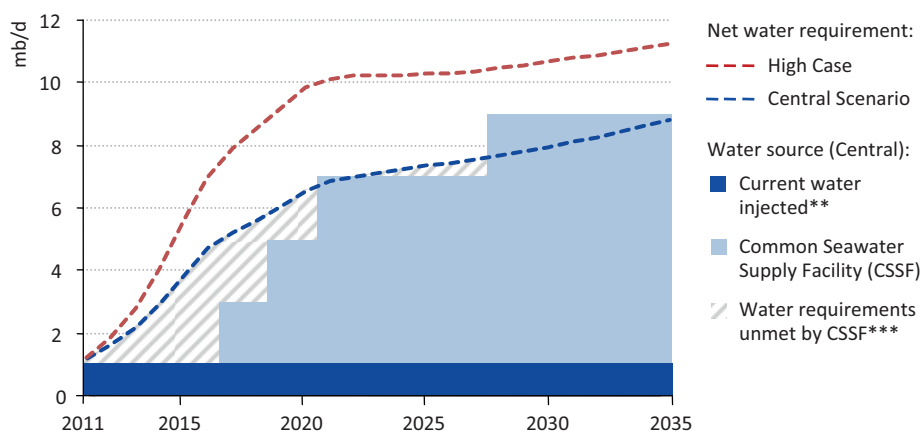
Water requirements for most of Iraq's oil fields will fall between these two cases. To meet the oil production levels in our Central Scenario, we estimate that Iraq's net water injection requirements will increase from 1.6 mb/d in 2011 to more than 12 mb/d in 2035.¹¹ Water needs for oil field injection are highest in southern Iraq (where water resources are also most strained), where they grow to about 9 mb/d at the end of the *Outlook* period (Figure 2.9). In the High Case, the net water requirements are correspondingly greater, rising to almost 16 mb/d for the country as a whole in 2035 and surpassing 11 mb/d for the fields in the south.

Future water injection plans in southern Iraq involve the construction of a Common Seawater Supply Facility (CSSF), which would treat seawater from the Gulf and pump it more than 100 km inland for use in the oil production areas. This solution is strongly favoured over other water sourcing alternatives: it provides a secure water supply, independent of future water availability; it reduces stress on freshwater resources, freeing them for other uses; and it achieves economies of scale, through the construction and operation of a single facility to provide the bulk of southern oilfield water needs. Iraq's total water injection needs in 2035 equate to around 2% of the combined average flows of the Tigris

11. This estimate is based on production and water injection data from Iraq's southern fields provided by the Ministry of Oil and by operators. The average replacement ratio is 1.5, *i.e.* 1.5 barrels of water must be injected to fill the "space" in the reservoir created by the production of 1 barrel of oil. This is applied across all oil production in Iraq. This estimate is net of produced water, *i.e.* we assume that the most economically advantageous approach is to treat and re-inject all the water that is produced along with the oil. If the produced water is not re-injected, then, in most cases, it will require additional treatment to remove oil and salts before being suitable for reuse (for agriculture or other purposes). To the extent that produced water is put to other uses, the net water injection requirement will, obviously, rise.

and Euphrates rivers (current flows measured in central Iraq), or 6% of their combined flow during the low season. While withdrawals at these levels might at first sight appear manageable, these rivers also have to satisfy other, much larger, end-use sectors, including agriculture (where water use is currently very inefficient).

Figure 2.9 ▶ Net water requirement* in southern Iraq oil fields by source in the Central Scenario



* Represents water brought in from sources external to the oil field, i.e. produced water that is re-injected is excluded. ** The Karmat Ali facility is the primary current source of water supply. The facility produces 0.9 mb/d from the Shatt al-Arab waterway and there are plans in place to raise its capacity to 2.2 mb/d in 2013. *** Sources may include aquifers or surface water.

The anticipated capacity of the CSSF is 10-12 mb/d, to be built in phases; but the start date for the operation of the facility remains uncertain. ExxonMobil withdrew from its role as co-ordinator of the project in early 2012 and, although a new project management contract is set to be awarded by the government before the end of 2012, the time required for detailed design and engineering work and project implementation is likely to be long. Saudi Aramco's Qurayyah Seawater Plant Expansion provides a reference for the potential timeline: this was a 2 mb/d expansion of an existing facility and took nearly four years from the awarding of the front-end engineering and design contract (May 2005) to the time that water first began to flow (early 2009). Given the importance attached by the Iraqi authorities to the CSSF, we anticipate relatively rapid progress with this project, but estimate that a likely start-date for an initial 2 mb/d phase of the CSSF is 2017, considerably later than initially planned.

In the Central Scenario, 8 mb/d of CSSF capacity is required, with subsequent phases (after the initial 2 mb/d) assumed to take two years to complete and the last tranche being added in the late 2020s. In the High Case, the overall capacity required would be 10 mb/d and the timeline for building to this level would extend into the 2020s, lagging well behind the higher water requirements in this case. Water that is not supplied from the CSSF would need to be sourced from aquifers and surface water (potentially made available by

expanding existing facilities, such as the Karmat Ali facility in the south). Amounts up to 5 mb/d would be required from these sources in the High Case, considerably more than in the Central Scenario. Delay in planning and implementing the CSSF, beyond that already anticipated here, would quickly create additional demands on alternative sources of water.

To the extent that water injection needs are not met, reservoir pressure in unsupported fields falls (how quickly depends on the response of individual fields), thereby causing well flow rates to decline and making it more difficult to raise oil output. Other consequences might include higher gas production as a result of falling reservoir pressure (which would, if no facilities are in place to gather and process the gas, mean an increase in flaring) and, if water flooding is ignored to the point that reservoir damage occurs, a potential reduction in the volume of oil that can ultimately be recovered from the fields.

Natural gas

Reserves and resources

Iraq's proven reserves of conventional natural gas amount to 3.4 trillion cubic metres (tcm), or about 1.5% of the world total (Table 2.4), placing Iraq 13th among global reserve-holders. Around three-quarters of these proven reserves consist of associated gas, with the rest in a small number of non-associated fields. Iraq did not revise its figure for proven gas reserves in 2010 at the time of the upward revision of proven oil reserves, although it would have been reasonable to have done so, given the high share of associated gas. Geographically, Iraq's proven gas reserves are concentrated in the south, mostly as the large associated gas reserves in the super-giant fields of Rumaila, West Qurna, Majnoon, Nahr Umr and Zubair. The composition of the gas associated with oil production varies considerably between the north and the south of the country. Associated gas in the south has a relatively high content of natural gas liquids (NGLs).¹² The gas produced in the north is somewhat drier, but also requires treatment in order to make the gas marketable.

Ultimately recoverable resources are estimated to be considerably larger, at 7.9 tcm, of which around 30% is thought to be in the form of non-associated gas. This means that almost 40% of the resources yet to be found are expected to be in non-associated gas fields. The breakdown of our estimated figure for ultimately recoverable resources between the main Iraq's regions shows the continued predominance of the southern region, but also the potential of non-associated gas resources in both the northern and western parts of Iraq. Exploration and appraisal of these resources is at a very early stage and production is limited (in the north) and non-existent (in the west), but both these areas are considered strong prospects. Due to the higher revenues earned by the oil sector, gas has historically been a secondary consideration for the government; but attention to gas is growing as domestic demand increases, in particular for power generation.

12. According to data provided by the South Gas Company, the unprocessed associated gas consists, on average, of 70% methane and 30% NGLs, of which 15% is ethane and 8% propane.

Table 2.4 ▶ Iraq gas resources by region and super-giant field (bcm)

	Proven* reserves, end-2011	Ultimately recoverable resources**	Cumulative production, end-2011	Remaining recoverable resources	Remaining % of ultimately recoverable resources
Southern Mesopotamian	2 202	4 298	351	3 947	92%
West Qurna	780	1 139	18	1 121	98%
Rumaila	332	838	288	550	66%
Majnoon	203	388	2	386	99%
Zubair	156	334	39	295	88%
Nahr Umr	193	379	4	375	99%
Central Mesopotamian	179	700	1	700	100%
East Baghdad	126	367	1	367	100%
Northern Zagros Foldbelt	993	2 027	158	1 869	92%
Kirkuk	248	256	154	102	40%
Western Desert	60	906	0	906	100%
Total Iraq	3 435	7 932	510	7 422	94%
<i>Associated</i>	<i>2 558</i>	<i>5 279</i>	<i>505</i>	<i>4 773</i>	<i>90%</i>
<i>Non-associated</i>	<i>876</i>	<i>2 653</i>	<i>5</i>	<i>2 649</i>	<i>100%</i>

* Proven reserves are broken down approximately by basin, based on information provided by the Iraqi Ministry of Oil. ** Ultimately recoverable resources (URR) for associated gas is derived from oil URR and known gas-oil-ratios. This gives higher associated gas URR than the USGS analysis. As the total URR is derived from the USGS data, this results in a lower non-associated gas URR, which may be underestimated by several hundred billion cubic metres (bcm).

Sources: USGS; data provided to the IEA by the US Geological Survey and the Iraqi Ministry of Oil; IEA databases and analysis.

Production

Iraq's declared aim for the gas sector is to utilise a valuable domestic resource in support of its economic development, with the power sector a strong priority for gas use, followed by domestic industry. Iraq also aims to become an exporter of natural gas. In our projections, Iraq's marketed gas production (net of flaring, venting and reinjection) is expected to increase significantly over the projection period, from less than 10 billion cubic metres (bcm) in 2010 to almost 90 bcm by 2035 in the Central Scenario, and close to 115 bcm in the High Case (Table 2.5). These projections depend on Iraq putting in place the gas infrastructure to capture and process the rising volumes of associated gas, mainly from the southern oil fields, and successfully developing non-associated gas fields. At the oil production levels anticipated in the Central Scenario and the High Case, the volumes of associated gas, alone, are not sufficient to realise Iraq's ambitions.

Gas production in the south of Iraq is closely aligned with the outlook for oil production, with an additional contribution expected from the Siba field, which is the only non-associated field currently appraised in the area. The share of the south in Iraq's gas production rises to a high point of 70% in 2020 in the Central Scenario, before falling back

later in the projection period as non-associated gas production in other regions rises. The major sources of non-associated gas are in the north of Iraq, particularly in the KRG area. There is also a modest expansion in the west, where resources are thought to be large, but large-scale production is held back in our projections by the difficulty, thus far, to attract investors to exploration blocks and the distance from major demand centres.

Table 2.5 ▶ Iraq gas production by region in the Central Scenario and the High Case (bcm)

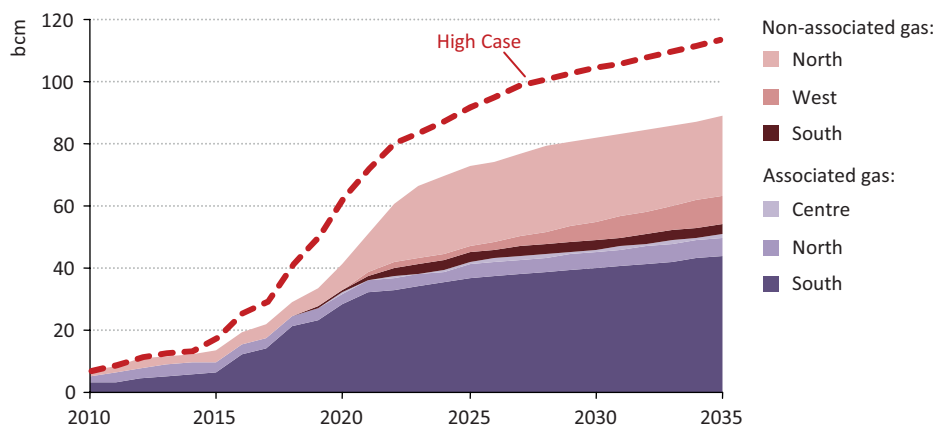
Central Scenario	2010	2015	2020	2025	2030	2035
South	3	7	29	40	43	47
Centre	-	-	0.5	0.5	1	1
West	-	-	0.3	2	6	9
North	4	7	12	30	32	31
Total	7	13	41	73	82	89
<i>Of which associated</i>	5	10	32	42	46	51

High Case	2010	2015	2020	2025	2030	2035
South	3	10	45	53	55	58
Centre	-	-	0.5	1	4	6
West	-	-	0.3	4	7	10
North	4	9	17	35	39	40
Total	7	18	63	92	105	114
<i>Of which associated</i>	5	13	49	55	59	62

Investment in Iraq in new or rehabilitated gas processing facilities has not kept pace with increases in oil output and, as of 2012, the country has the capacity to process around 8 bcm of gas per year. There is only a very limited national distribution network. Our projections point to the need, over the projection period, for processing capacity to increase by more than ten times in the Central Scenario, and by more than thirteen times in the High Case. They also require the timely development of a transport network to the power plants and industrial facilities that will account for the bulk of Iraq's domestic consumption.

The implication of these projections is that 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 well sized and located and that the richer components of the natural gas stream – condensate, liquefied petroleum gas (LPG) and, once there is a market for it, also ethane – are separated and used productively in the national economy.

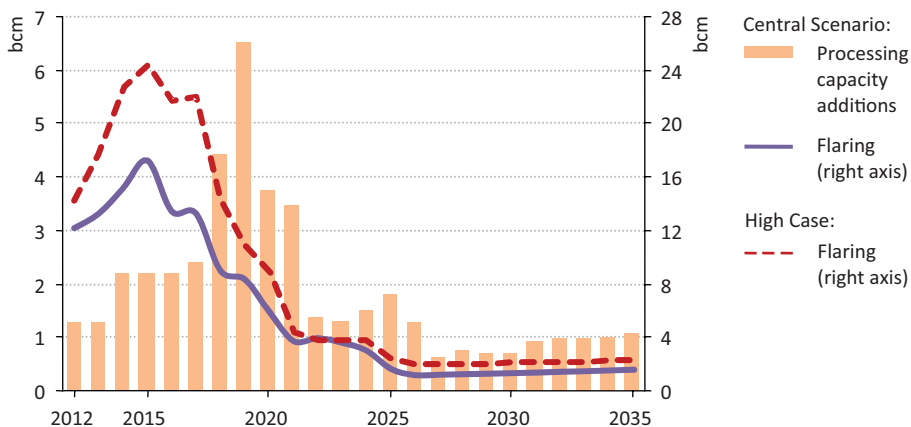
Figure 2.10 ▶ Iraq gas production in the Central Scenario



Associated gas

Iraq does not exploit all the associated gas that is currently being produced (much of which is flared), and faces a major task ahead to gather and process all the associated gas that will become available as oil production ramps up. The speed at which Iraq adds gas gathering and processing capacity will determine the pace at which it can realise its ambition to reduce gas flaring (Figure 2.11). In the Central Scenario, the projected addition of almost 30 bcm of annual processing capacity over the coming decade brings the volume of gas flared down below 4 bcm by the early 2020s, with flared volumes peaking in 2015 at around 17 bcm. In the High Case, more than 40 bcm of gas processing capacity is assumed to be added by 2020 but, because of higher projected oil output, the volumes of flared gas are higher, reaching a peak of 25 bcm in 2015.

Figure 2.11 ▶ Iraq associated gas processing capacity additions and flaring reduction in the Central Scenario



Box 2.3 ▸ Basrah Gas Company

2

The Basrah Gas Company (BGC), a joint venture established between the South Gas Company (51%), Shell (44%) and Mitsubishi (5%), is designed to provide an answer to a part of Iraq's gas needs by gathering and processing the associated gas from three southern fields (Rumaila, Zubair and West Qurna Phase I), much of which is currently flared. The short-term objective is to rehabilitate 30 existing facilities and two major processing plants in North Rumaila and Khor al Zubair previously operated by the South Gas Company; but, as oil production increases, investment in new capacity will be essential to reach the planned throughput of 20 bcm of gas per year.¹³ Total planned investment is \$13 billion, with the possibility of an additional \$4 billion for an LNG export plant if there is sufficient gas available beyond that required to meet Iraq's domestic needs.

A significant challenge for the BGC is to align the interests of the different parties involved. The technical service contracts for the fields initially supplying gas to the BGC do not include a remuneration fee for gas production, so the contractors have little commercial incentive to make gas readily available (albeit a strong public image incentive to reduce flaring). Moreover, while there is a flow of flared gas ready to be captured today, BGC's longer term investment decisions have to allow for the uncertainty over the timing and volumes of future associated gas output, both heavily dependent upon the trajectory of oil production.

The economic challenges BGC faces are similarly complex: low domestic gas prices (that are fixed at just over \$1 per million British thermal unit (MBtu)) do not in themselves offer sufficient value to underpin the investment required. Instead, the company must rely on the returns it can earn from the higher value of the natural gas liquids extracted from the raw gas (condensate and LPG) and on a set of formulae, linked to the price of fuel oil, that determine the net price South Gas Company pays for the gas processed by BGC.¹⁴ This price is higher than the domestic gas price (at an oil price of \$100 per barrel, South Gas Company pays more than \$2/MBtu), but the net value to Iraq is still substantial, primarily because gas displaces oil in power generation, freeing the oil for export at world market prices. Although BGC does not itself market any gas within Iraq, it remains dependent on how quickly demand develops – in particular how quickly gas-fired power capacity will be built and when the connecting infrastructure will be put in place.

13. This figure could be increased if additional gas volumes become available. We assume that BGC continues to process all gas from the three southern fields once their associated gas production exceeds this amount (soon after 2020 in our Central Scenario) and that additional gas processing capacity is developed to cater for other southern fields (whether within BGC or as part of a separate arrangement).

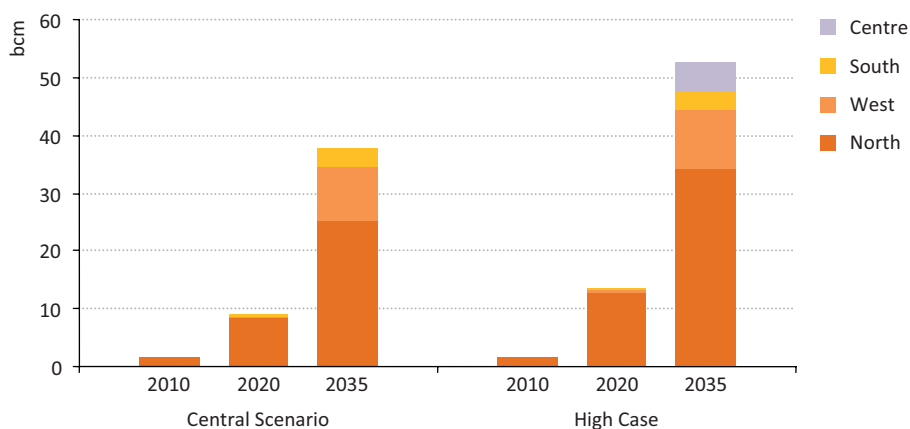
14. As well as having a 51% stake in BGC, the South Gas Company is also the entity that sells raw gas to BGC and that purchases processed gas from it.

The cumulative volume of gas flared during the years 2012–2020 in the Central Scenario is about 110 bcm; in the High Case, it is close to 160 bcm. If this gas were to be substituted for oil in Iraq’s power generation, allowing the oil to be exported, the implied value of this flared gas is \$70 billion in the Central Scenario and more than \$100 billion in the High Case. This lost value provides a compelling reason for Iraq to move as quickly as it can to make early additions to gas processing capacity. This is the objective of the Basrah Gas Company (Box 2.3), although the area of operation of this company, as currently envisaged, does not cover all of Iraq’s southern fields. Additional regulatory and institutional measures will be needed to encourage and require productive use of all Iraq’s associated gas.

Non-associated gas

Iraq’s non-associated gas production rises from a very low base to almost 40 bcm in the Central Scenario and to more than 50 bcm in the High Case (Figure 2.12). The bulk of this output comes from the north of the country, primarily from the KRG area: by 2035, total gas production from fields awarded by the KRG reaches 20 bcm in the Central Scenario and 29 bcm in the High Case, the overwhelming majority of which is non-associated.¹⁵ The main discovered fields that are anticipated to contribute to production over this time are Khor Mor, Chemchemal and Miran in the KRG area, the Mansuriyah field (also included in the north in our projections), the Akkas field in the west, and the Siba field in the south. All of these are contracted to international operators. We also make allowance for production from fields that are yet to be found, in particular from the KRG area, given the high level of exploration activity underway.

Figure 2.12 ▶ Iraq non-associated gas production by region in the Central Scenario and High Case



15. As in the case of oil production, the projection for the KRG area is highly contingent on the resolution of outstanding issues with the federal authorities regarding hydrocarbon governance and access to markets.

Thus far, the offer of gas exploration and development opportunities through the national licensing rounds has enjoyed only mixed success. The Akkas and Mansuriyah gas fields were included in the first national licensing round, but were awarded (together with Siba) only after being re-offered in the third round, with slightly improved terms.¹⁶ In the fourth licensing round in 2012, seven exploration blocks considered gas-prone were on offer, only one of which was awarded (in central Iraq to a consortium led by Pakistan Petroleum). None of the six exploration blocks in the west of Iraq received bids. More attractive conditions may be proposed in a future licensing round.¹⁷ The authorities may need to undertake prior exploration activities in prospective areas so that the risks and opportunities for potential investors are better understood. Over time, a more market-oriented electricity sector and a higher domestic gas price would provide stronger incentives for investment in gas for domestic use.

In the meantime, the main impetus to develop Iraq's non-associated gas resources has come from companies with an eye on the higher value offered by international markets (see Chapter 4). This has certainly been the case in the KRG area, where the region's gas resources have been proposed as a way to meet Turkey's gas demand and to fill pipelines onwards to southeast Europe. Even in the absence of clarity over the legal prospects for export, there are provisional proposals on the table to build gas export infrastructure from the Chemchamal, Khor Mor and Miran fields to the Turkish border. In other parts of Iraq, the possibility of export also appears to have been an important consideration for bidders, even though the structure of the technical service contracts on offer theoretically gives operators less of a stake in the eventual destination of the gas produced (as their remuneration is fixed). An example is the award of the contract for the Siba field in the south to a consortium led by Kuwait Energy, which has argued in favour of exporting this gas to Kuwait using a short cross-border gas pipeline from Rumaila that was built in the mid-1980s (but unused since 1990). While the evident interest in gas export (and in the valuable natural gas liquids that come with the produced gas) can be harnessed by policy makers to secure investment in Iraq's gas resources, they will need to safeguard adequate volumes for domestic use. More broadly, a national strategy for the gas sector – bringing together the anticipated levels of domestic demand and a vision for supply and infrastructure development – would help to clear away some of the uncertainties that impede large-scale investment.

Oil and gas investment

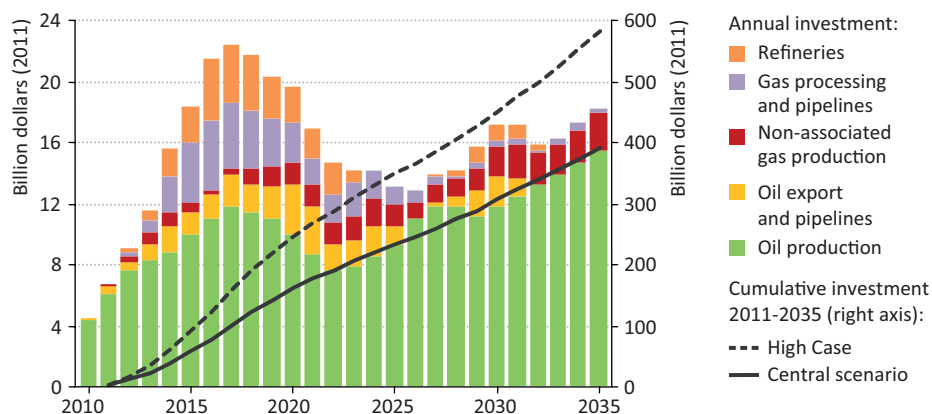
The projections in the Central Scenario and, even more so, in the High Case require very substantial levels of investment. In the Central Scenario, cumulative oil and gas sector investment during the period 2012-2035 amounts to almost \$400 billion (in year-2011 dollars); in the High Case, this figure rises to almost \$600 billion (Figure 2.13). A combination

16. The removal of signature bonuses and changes in the valuation of petroleum and gas offtake arrangements in the third round helped to attract interest in these fields.

17. Government officials are reportedly considering a fifth national licensing round.

of the speed at which production increases to 2020 and the incremental spending that is required to modernise infrastructure and refining capacity means that the investment requirement is spread unevenly over the projection period. The peak comes in the years between 2015 and 2020, when the required level of annual average investment in oil and gas is more than \$20 billion in the Central Scenario. This effect is even more pronounced in the High Case, where the annual level of spending required between 2015 and 2020 is more than \$30 billion. These levels of investment represent a large step up from oil and gas spending in 2011, which was an estimated \$7 billion.

Figure 2.13 ▸ Iraq oil and gas investment in the Central Scenario



In our estimation, more than 90% of future investment in oil and gas will ultimately be paid for by the Iraqi treasury, either directly or via the cost recovery and fee arrangements made with the various companies operating in the Iraqi upstream (the main potential exception to this is the refining sector, where Iraq is looking for private investment). However, the responsibility for managing and executing projects at each stage of the value chain varies. In the upstream, this rests with the companies and consortia developing or exploring the various fields. Water supply is likewise the responsibility of individual operators, although in the south the economies of scale mean that a common approach has been chosen. Implementing transportation, storage and export projects is ordinarily taken on by entities responsible to the Iraqi Ministry of Oil.¹⁸

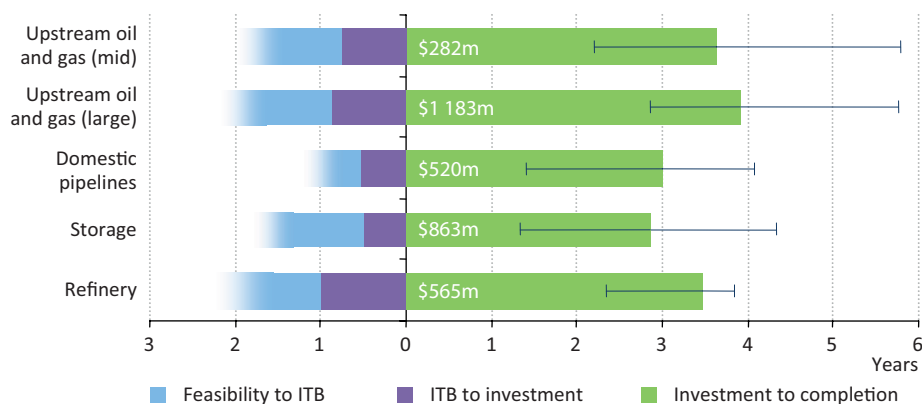
This division of responsibilities is not unusual in itself, but – if Iraq is to achieve a rapid increase in oil production and export capacity – it puts a premium on good performance by a range of public and private actors and on effective government decision making and co-ordination. The projected rate of increase in investment may stretch to the limit existing capacities within the various state entities that are responsible for project and contract management, many of which do not have a large body of officials with the necessary experience or training. There is a complementary risk that the companies charged with the

18. The exceptions are small tie-ins from individual fields to the main infrastructure and larger-scale privately built pipelines planned in the KRG area.

implementation of projects may encounter a range of bureaucratic obstacles, leading them to reconsider whether their ratio of reward to risk is attractive enough, compared with other investment opportunities.

To understand the scale of the task over the coming years, we undertook a detailed analysis of project preparation and completion timelines from across the Middle East, involving 216 large-scale investment projects that have been tendered since 2000 in Saudi Arabia, Qatar, the United Arab Emirates and Kuwait. We also examined the status of more than 140 projects at various stages of preparation in Iraq itself. For the oil and gas projects examined, we found that oil or gas upstream projects in the Middle East might take around two years from the first feasibility study to the final investment decision and then another two to six years to complete in full, with the average completion time being between three to four years. The timeline for refinery projects in the region was similar, but with the projects surveyed taking, on average, under four years to complete. Projects in domestic oil and gas transportation and storage were generally quicker to implement (Figure 2.14). In Iraq, a significant number of projects were re-tendered or cancelled at the project preparation stage but, where projects reached final investment decisions, the lead times were not untypical for the region. The sample size in each area was not large enough to draw firm conclusions about project completion times.

Figure 2.14 ▶ Average oil and gas project preparation and completion times in the Middle East



Notes: The periods measured are from the start of feasibility studies to the invitation for contractors or suppliers to bid on a defined project (the ITB or invitation-to-bid); then from the ITB to a final investment decision; then from a final investment decision to the completion of a project. The top and bottom 5% of the sample were excluded and the error bars show the range of completion times for the remainder. The figures represent the average size of the projects considered in each sample.

Sources: IEA analysis; Zawya database.

The implication of this analysis is that, as of mid-2012, the bulk of the projects that will determine Iraq's oil output to 2015 should already have reached a final investment decision or should be in the final stages of contract award. In addition, a sizeable contingent of

the projects that will determine the supply trajectory during the latter part of the current decade should be at various stages of feasibility planning. The current signs are that, while progress is being made, there are important projects that have yet to be sanctioned. The Common Seawater Supply Facility is an important example. In the upstream, our analysis of recent contract awards shows that, so far in 2012, investment in 880 kb/d of new upstream facilities has been sanctioned, for the West Qurna (Phase II), Zubair and Badra fields. These facilities are expected to start to come on-stream in late 2013 and contribute to a further increase in production in 2014 and 2015. The number and scale of upstream project awards thus far in 2012 is higher than the levels seen in previous years. Overall, the scale of upstream projects awarded over the period 2010-2012 is broadly consistent with the levels of output anticipated in the Central Scenario. If the spending commitments seen thus far in 2012 are maintained (*i.e.* annual commitments to support new capacity of 900 kb/d), this would bring medium-term upstream capacity additions to the levels anticipated in the High Case.

Realising sustained growth in investment will, nonetheless, be a constant battle. The rate at which oil and gas investment will grow in the coming years will be affected by a wide range of factors, from questions of politics and security to everyday logistical and administrative concerns. A large number of these factors need to be moving in a positive direction in order to achieve a rapid increase in oil and gas production, since any missing elements or uncertainties in the regulatory framework will entail delays and a preference for smaller (often sub-optimal) tranches of investment.

If institutional, political or other obstacles prevent Iraq from moving oil and gas investment significantly beyond the levels seen in 2011, the anticipated growth in oil and gas production will not materialise at anything like the expected speed. To illustrate the downside risks, we examined the implications of a Delayed Case, in which annual oil and gas investment initially remains close to the levels attained in 2011, *i.e.* around \$7 billion per year, and rises only gradually over the period to 2035. In this case, oil production continues to grow, but reaches only 4 mb/d in 2020 and 5.3 mb/d in 2035, 3 mb/d lower than in the Central Scenario by the end of the projection period. The implications of this case for Iraq's domestic energy balance and for international markets are covered in subsequent chapters.¹⁹

To mitigate the possibility of delay, a key priority for Iraq is to build up its capacity to manage investment projects (including enhanced capabilities in such areas as planning, budgeting and auditing, financing, procurement and environmental assessment) and to ensure that projects have a supportive environment for implementation (including some degree of insulation from macroeconomic risks – see Chapter 4). Further progress with defining a strategic vision and legislative framework for the hydrocarbons sector is also essential to promote co-ordination and common endeavour among the range of public and private actors shaping the future of Iraq's oil and gas.

19. Investment in other parts of the energy sector, including for power generation, is also assumed to occur later in the Delayed Case.

Iraq: fuelling future reconstruction and growth

An economy reaching full power, but when?

Highlights

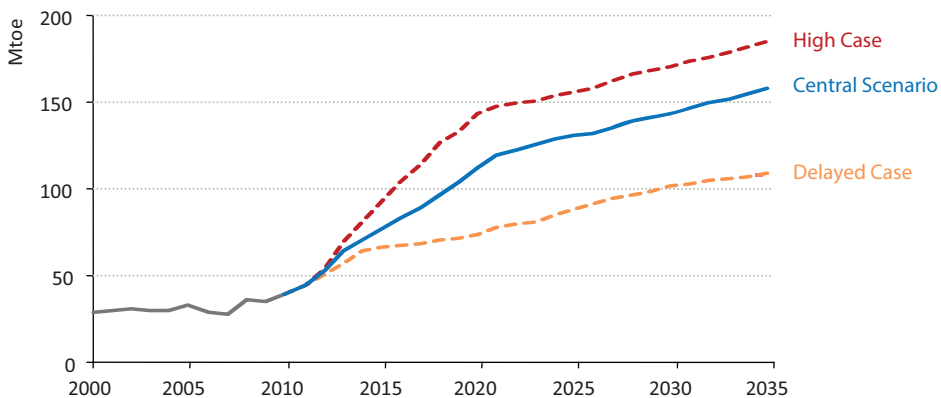
- Iraq's domestic energy demand is projected to rise rapidly in the coming decades on the back of strong economic growth. In the Central Scenario, Iraq's energy demand is more than four times higher than 2010 by 2035, reaching 160 Mtoe, growing from being slightly greater than that of Kuwait to that of Italy today.
- Natural gas moves from sideshow to centre stage in Iraq's energy mix, with demand reaching more than 70 bcm in 2035. It becomes the main fuel for power generation, replacing oil and freeing up valuable resources for export. Fossil fuels dominate the energy mix, with hydropower and other renewables playing a small supporting role.
- An extensive effort enables installed gross power generation capacity in Iraq to almost quadruple by 2020 and reach more than 80 GW by 2035. Gas-fired power plants emerge as the lowest cost generation technology and, over time, Iraq moves from a predominantly oil-fired power generation mix to major use of gas, both in gas turbines and more efficient combined-cycle gas turbines (CCGTs). Without this transition, domestic oil demand would be around 1.2 mb/d higher in 2035 and Iraq would forego around \$520 billion in cumulative oil export revenues.
- If planned new capacity is delivered on time, grid-based electricity generation will catch up with currently estimated peak demand around 2015, but it will take longer to build the necessary capacity buffer to allow for maintenance and unplanned outages without disruption.
- Iraq's power sector requires investment of more than \$6 billion per year on average to 2035, but half is needed before 2020. Most of the investment is required in new generation capacity, but just under 40% goes to improving the transmission and distribution network, where efficiency gains can save the equivalent of the annual fuel input to six CCGT power plants.
- End-use energy consumption in Iraq more than doubles by 2020 and almost quadruples by 2035. A five-fold increase in the number of passenger cars in Iraq, from around three million today, underlies a rise in total oil demand to around 1.7 mb/d in 2020 and 2 mb/d in 2035. Pent-up demand for housing and household appliances bolsters residential energy use, while energy-intensive industries, such as cement, fertiliser and petrochemicals progressively attract increased investment.
- We estimate that, if action is not taken to phase out fossil fuel consumption subsidies in Iraq, they will triple to nearly \$65 billion in 2035.

Overview of energy demand trends

This chapter presents energy demand projections for Iraq to 2035. It begins with an overview of energy demand trends, based on our Central Scenario, but noting also contrasting results in our High Case, where Iraq experiences a more rapid increase in oil and gas production, and in our Delayed Case, where we assume that lower levels of investment in Iraq's energy sector act as a significant constraint on the pace at which the economy develops.¹ Concentrating then on the Central Scenario, the chapter continues by examining the critical issue of the outlook for the power sector in Iraq and considers prospects in each of the main end-use energy sectors, transport, industry and buildings. An examination follows of the environmental outlook associated with the Central Scenario in terms of energy-related emissions and water use. The chapter concludes by briefly examining the most significant variations in sector-level energy demand trends and energy-related emissions in the High Case and the Delayed Case respectively.

Iraq's total primary energy demand moves into a new and prolonged phase of strong growth in the Central Scenario, increasing by nearly 6% per year to reach 160 million tonnes of oil equivalent (Mtoe) in 2035 – more than four times higher than in 2010 (Figure 3.1). Energy demand in the current decade alone grows by more than two-and-a-half times, reflecting rapid growth of the economy, fuelled by the proceeds of swift growth in hydrocarbon supply and a growing population. Energy demand growth moderates to an extent in the second half of the *Outlook*, as growth in the economy throttles back slightly as the pace of growth of oil production begins to diminish. Energy demand growth in Iraq outstrips that of its neighbours, resulting in its share of the Middle East total going from 6% in 2010 to 16% in 2035. Iraq's total energy demand grows from being slightly greater than that of Kuwait (with 3 million people) to that of Italy today (60 million people).

Figure 3.1 ▶ Iraq total primary energy demand by scenario



1. Chapter 1 defines the Central Scenario, High Case and Delayed Case in more detail.

In our High Case, faster oil production growth pushes economic growth higher and energy demand more than trebles over the current decade, reaching 187 Mtoe by 2035 – 17% higher than in the Central Scenario. Additional oil and gas export revenues stimulate higher government spending, and public and private consumption, resulting in the greater energy consumption. By contrast, in the Delayed Case, the flatter oil production growth profile results in slower economic growth and energy demand and Iraq's fuel mix also changes more gradually, as new power generation and gas processing facilities are built more slowly.

A common theme in the Central Scenario and the alternative cases examined is that fossil fuels continue overwhelmingly to dominate Iraq's energy economy between now and 2035 (Table 3.1). In the Central Scenario, fossil fuels still account for 99% of Iraq's energy mix in 2035 (58% oil, 41% natural gas), compared to 95% in the rest of the Middle East and 75% globally. Iraq has some limited electricity generation from hydropower, focused in the north of the country, and a small contribution from other renewables.

Table 3.1 ▶ Iraq primary energy demand by fuel and scenario (Mtoe)

	1980	2010	Central Scenario			High Case	Delayed Case
			2020	2035	2010-35*	2035	2035
Oil	9	32	75	92	4%	114	69
Gas	1	6	37	66	10%	71	39
Hydro	0.1	0.4	0.5	1.2	4%	1.0	1.3
Biomass	0.0	0.0	0.1	0.1	8%	0.1	0.1
Other renewables	0.0	0.0	0.1	0.3	n.a.	0.3	0.2
Total	10	38	113	160	6%	187	110

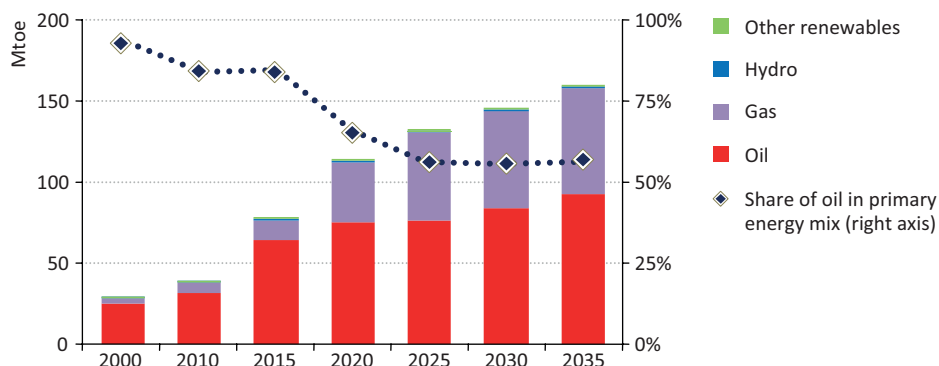
* Compound average annual growth rate.

The dominance of fossil fuels comes as no surprise in this hydrocarbon-rich country, but there are some shifting patterns of consumption over the projection period. In the Central Scenario, oil demand in Iraq more than doubles in the next ten years, to around 1.7 million barrels per day (mb/d) by 2020, and goes on to exceed 2 mb/d in 2035. In the period to 2020, demand growth is driven by transport and the power sector. Oil demand growth moderates to just over 1% per year after 2020, reflecting contrasting trends: a large and rapid decline in oil consumption in power generation (as natural gas availability increases), offset by a less rapid, but still significant, increase in consumption in end-use sectors, particularly transport. In the High Case, oil demand reaches 2 mb/d in 2020 and 2.5 mb/d in 2035, while it reaches only 1.6 mb/d in 2035 in the Delayed Case but retains a larger share of Iraq's overall energy mix.

In all scenarios, natural gas becomes a major pillar of the domestic energy economy. In the Central Scenario, gas demand increases by around 10% per year on average (Figure 3.2), reaching 39 billion cubic metres (bcm) in 2020 and 72 bcm in 2035. Natural gas accounts

for around half of all energy demand growth in Iraq over the *Outlook* period, its share of Iraq's primary energy mix growing – at the expense of oil – from less than 20% in 2010 to more than 40% in 2035. Within these overall figures, demand varies across the country and through the year: there is a large summer peak in electricity demand (air conditioning), a smaller winter peak (heating) and variations from the north to the south, reflecting different climate conditions.

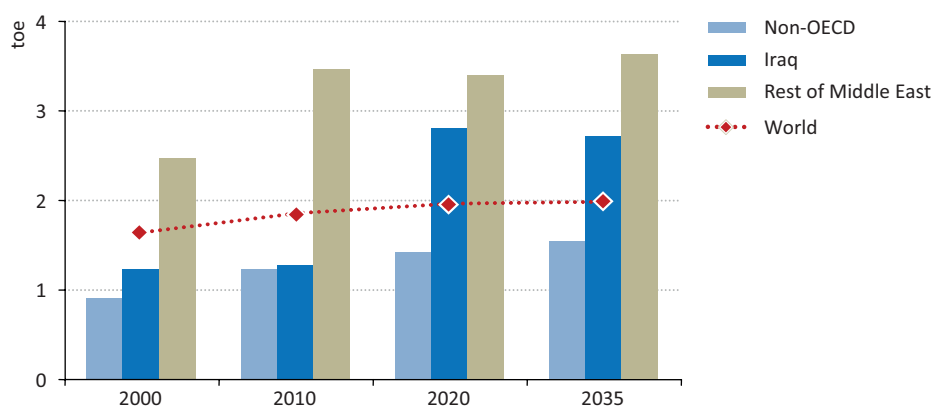
Figure 3.2 ▶ Iraq total primary energy demand by fuel in the Central Scenario



While the outlook for natural gas demand is strong, much depends on the extent and timing of adequate domestic supply (see Chapter 2). Delays on the supply side would have important implications for other fuels. If, for example, Iraq were not to achieve the switch to natural gas in its power sector posited in our Central Scenario, instead continuing to burn heavy fuel oil and crude oil at similar levels of efficiency to today, then this would come at a considerable cost in terms of lost oil export revenue over the *Outlook* period. In the High Case, natural gas demand reaches 55 bcm in 2020 and around 78 bcm in 2035. Gas use increases much more slowly in the Delayed Case, rising to 42 bcm in 2035, primarily as a result of lower availability of associated gas (due to the flatter oil production profile) and less rapid development of Iraq's non-associated gas resources. The switch to gas use in power generation is much less marked in this case.

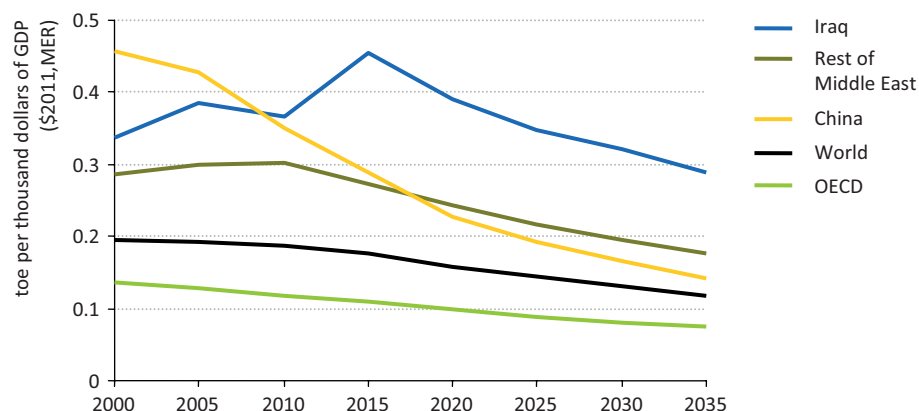
In the Central Scenario, total primary energy demand per capita more than doubles in Iraq over the next decade, rapidly overtaking the world average in the process but stabilising at a level below that of the rest of the Middle East (Figure 3.3). The rapid increase is attributable to the combination of fast demand growth generally (including meeting currently unsatisfied demand) and intensive use of relatively-inefficient oil-fired power generation plant. As these trends weaken, and more efficient power plants are adopted, per capita energy demand stabilises at around one-third above the global average.

Figure 3.3 ▶ Total primary energy demand per capita in selected countries in the Central Scenario



The energy intensity² of Iraq's economy was nearly double the global level in 2010. While its level was comparable with that of China, energy intensity in China is on a continuing improving trend, while Iraq's worsens early in the *Outlook* period, as it catches up with the existing overhang of unmet energy demand, before then improving gradually to 2035 (Figure 3.4). Even then, Iraq's energy intensity is more than double the projected global average at that time. In the High Case, additional economic growth outpaces the increase in energy demand early in the *Outlook* period, but reaching a very similar level to the Central Scenario by 2035. In the Delayed Case, the slower pace of GDP growth and of structural change in energy use means it does not even achieve the level of improvements in energy intensity seen in the Central Scenario.

Figure 3.4 ▶ Energy intensity in selected countries in the Central Scenario



Note: MER = market exchange rates.

2. Energy intensity is an (imperfect) indicator of the energy efficiency of an economy. It is measured here as energy consumed (tonnes of oil equivalent) per thousand dollars of GDP, measured at market exchange rates (MER) in year-2011 dollars.

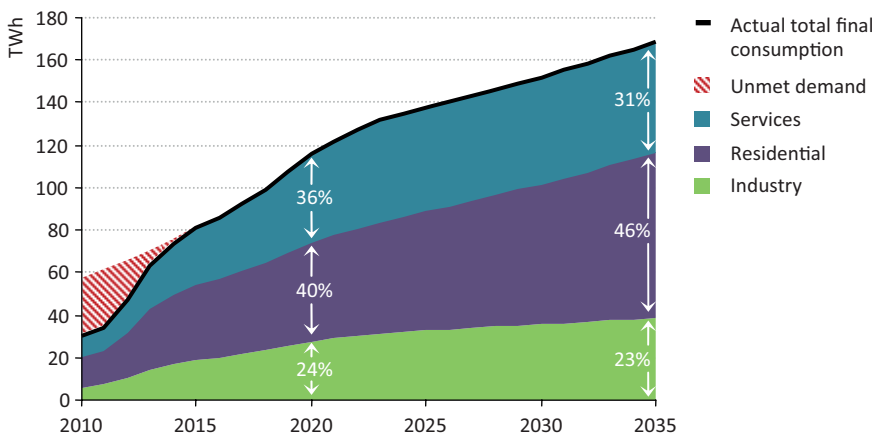
Outlook for the power sector in the Central Scenario

Developments in the power sector are of central importance to the outlook for Iraq. In the near term, the challenge is to provide an adequate supply of grid electricity to households and businesses, eliminating the considerable shortfall in generation relative to demand that has resulted from under-investment and war damage limiting supply, while economic and population growth have boosted demand (see Chapter 1). The solution adopted needs to develop Iraq's power system in a way that best supports its future economic and social development, in particular, by making sound choices over the technologies and fuels used to generate power, by improving network infrastructure and by reforming the electricity market.

Electricity demand

We estimate that electricity demand in Iraq was around 57 terawatt-hours (TWh) in 2010, but that the installed electricity generation capacity was able to satisfy only 58% of that level, around 33 TWh. Final electricity consumption grows five-fold in our Central Scenario, reaching just under 170 TWh in 2035 (Figure 3.5). Consumption growth averages more than 6.5% per year over the *Outlook* period, but the rate of growth is twice this level to 2020; responding to economic growth, population growth and the closing of the gap between demand and available supply. Of the three end-use sectors, industry's consumption increases fastest. From a relatively low starting point, it reaches seven times the level of 2010 by 2035. The residential sector retains the largest share of consumption over the period. It accounts for more than 45% of final consumption in 2035.

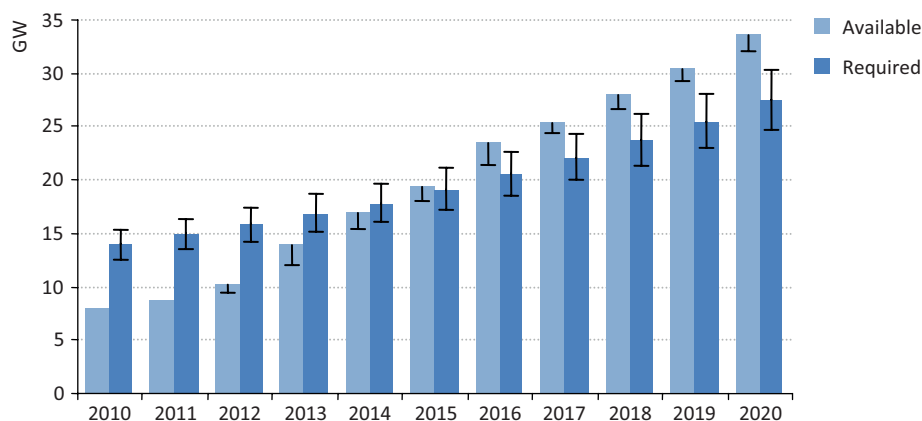
Figure 3.5 ▶ Iraq total final electricity consumption by sector and estimated unmet electricity demand in the Central Scenario



Meeting demand for electricity with reliable and continuous supply is the main immediate concern for Iraq's electricity sector. As a result, extensive activity is underway to build new generating capacity. If the planned new capacity is not delayed, we estimate that grid-

based electricity generation will catch up with peak demand around 2015 in the Central Scenario (Figure 3.6), though this date is subject to uncertainties on both the supply and demand sides. Because peak demand is not currently met, it cannot be measured and can only be estimated. If demand proved to be 10% lower than is assumed in the Central Scenario, available capacity would exceed peak demand in 2014, all other things being equal; but if it proved to be 10% higher, equilibrium would not be reached until 2016. On the supply side, the timing of the commissioning of new plants (especially relative to the summer peak) is an important factor, as is the availability of fuel and any unexpected technical problems at existing plants. Whereas most electricity systems have a margin of 10-20% of spare capacity in order to guarantee stable supply, in the Central Scenario, Iraq achieves a 15% capacity margin only in 2017. Achieving the planned improvement in grid electricity would have a considerable impact on private diesel generators: their use declines rapidly once full grid supply is achieved.

Figure 3.6 ▶ Iraq net generation capacity available at peak and capacity required to meet peak demand in the Central Scenario



Notes: Error bars for “Required” represent $\pm 10\%$ of Central Case demand. Error bars on “Available” assume half the new capacity added comes online after the summer peak.

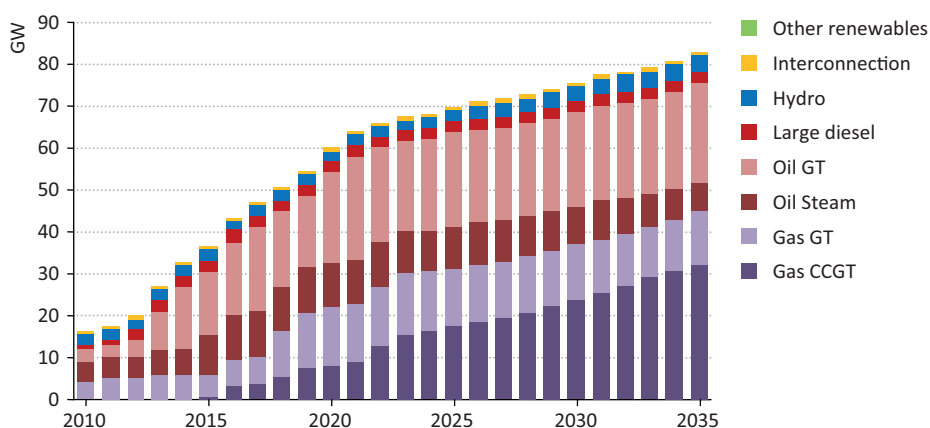
Iraq has two largely separate transmission systems: one in the Kurdistan Regional Government (KRG) area and the other covering the rest of the country. The electricity supply-demand balance in the KRG area is evolving differently to the rest of the country. Peak demand in the KRG area was estimated to be 2.9 gigawatts (GW) in 2011 (compared with 15.2 GW for the rest of Iraq). In the same year, peak supply in the KRG area was 2.3 GW, or over 80% of the estimated peak demand. In the rest of Iraq, peak supply in 2011 was 45% of estimated demand. Capacity additions are continuing in the KRG area and, as a result, it is likely that a continuous electricity supply will be achieved there sooner than in many other parts of Iraq.

Electricity generation

Generation capacity

In the Central Scenario, the gross capacity of grid-connected power plants grows quickly from 16 GW in 2010 to 60 GW in 2020, and then to 83 GW in 2035 (Figure 3.7). There is also a considerable shift in the technologies used. Early in the *Outlook* period, capacity from gas turbines (GTs)³ grows quickly, reflecting projects currently under construction, projects for which contracts have been signed and the short-term government plans currently in place (Box 3.1 and Figure 3.8): in the period 2011-2015, two-thirds of new capacity additions are GTs burning crude oil, gasoil or heavy fuel oil (HFO).

Figure 3.7 ▶ Iraq grid-connected gross generation capacity in the Central Scenario



Notes: Large diesel refers to grid-connected diesel generators rather than small private or community generators. Despite their name, large diesel generators typically burn gasoil or HFO. Gas GTs include plants converted from oil GTs; gas CCGTs include plants converted from gas GTs. Interconnection refers to connections between Iraq and neighbouring countries.

GTs burning oil possess a number of characteristics that make them attractive to meet Iraq's immediate needs. They are modular technologies with relatively short construction times and low capital costs, which means that a large amount of capacity can be added quickly while minimising the call on the government's budgetary resources (Table 3.2). HFO, gasoil and crude oil in power generation also have advantages as fuels in the short term, given the lack of availability of natural gas and the relatively plentiful supply of HFO from refineries, crude from oil fields and, as required, gasoil from imports.

3. Throughout the power sector outlook for Iraq, there is an important distinction between the generation technology used and the fuel it consumes, which may change over time. Gas turbines (GTs) can burn natural gas and liquid fuels, such as HFO and crude oil. In this text, we therefore distinguish between gas GTs and oil GTs. Similarly, diesel generators are capable of burning a number of fuels other than diesel: in Iraq they use gasoil and HFO.

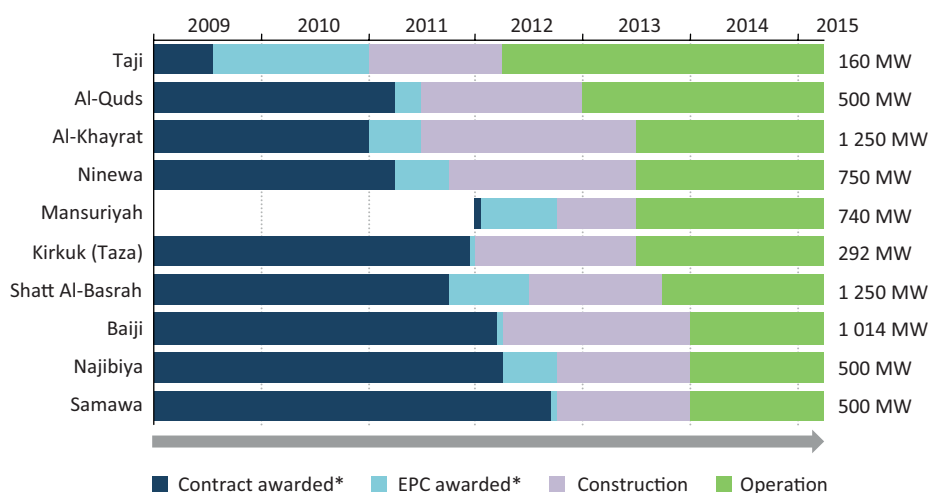
Box 3.1 ▸ Iraq near-term surge in power provision

Several different approaches have been used in order to achieve a rapid build up in Iraq's power generation capacity.

In 2008, the Ministry of Electricity procured a large number of gas turbines under so-called "Mega Deals" from GE and Siemens. For the power plants included in these deals, a separate contracting process was then undertaken to award engineering, procurement and construction (EPC) contracts to other companies for the installation of the turbines. Administrative delays in this second phase have added considerably to the time required to install new generation capacity: in some cases the time taken to award the EPC contracts was longer than the construction time for the plant itself.

Another approach, the independent power producer (IPP) model, has been used successfully as a commercial structure for power plants in the KRG area, with the government retaining responsibility for fuel supply and offering a specific rate of return on capital to the owner of the plant. The IPP model has been explored in the rest of Iraq, but not adopted successfully.

Figure 3.8 ▸ Expected completion time of selected power plants in Iraq



* Time elapsed from date of award.

Notes: EPC is an engineering, procurement and construction contract. The contract for Mansuriyah was awarded separately from the Mega Deals and an EPC contract was signed directly with the manufacturer, Alstom. All plants are gas turbines.

Sources: Zawya and Middle East Economic Digest databases; Special Inspector General for Iraq Reconstruction annual reports; IEA analysis.

Table 3.2 ▸ Capital costs, efficiency, and construction times for the main types of new generation technologies in Iraq

	Capital cost (\$/kW)	Efficiency	Construction time
Gas turbine	900	36%	1.5 years
Combined-cycle gas turbine (CCGT)	1 200	57%	2.5 years
Steam turbine	1 900	39%	4 years
Diesel generator	1 800	38%	1 year
Hydro	3 700	n/a	4-7 years

Notes: Capital costs include interest during construction and “soft” costs such as legal expenses and EPC. Efficiencies are representative of the maximum currently attainable by each technology under standard conditions. Environmental factors, such as temperature, and operating conditions may mean that actual efficiencies achieved are lower.

Sources: Iraq Electricity Masterplan (Parsons Brinckerhoff, 2010); IEA analysis.

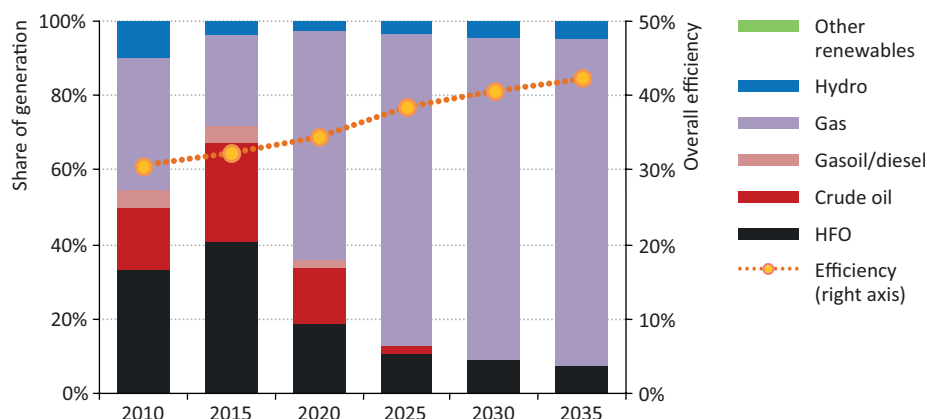
Beyond 2015, there is a marked shift in the generation technologies installed, driven primarily by the increased availability of natural gas to the power sector. This shift towards natural gas occurs partly through the construction of new gas-fired GTs and combined-cycle gas turbines (CCGTs), and partly as some oil-fired GTs are converted to burn natural gas instead of liquid fuels. In the Central Scenario, over 9 GW of GTs originally commissioned as oil-fired plants are converted by 2020 to use natural gas as a fuel. In addition to the increase in gas-fired GTs, the share of gas-fired CCGTs in the capacity mix increases considerably, growing from zero in 2010 to more than 32 GW – 40% of installed capacity – by 2035. Some of this increase is achieved by upgrading GTs. The first GT to CCGT conversion project, in Erbil, is underway, with another, in Sulaymaniyah, expected to start soon. Conversions from GTs to CCGTs entail additional capital costs but increase the efficiency of the plant considerably: for GTs installed in the period to 2015 in Iraq, this could result in a 44% increase in gross generation for the same fuel input. A small number of additional steam turbine and grid-connected diesel plants are added in the period to 2016, as a result of the government’s short-term plans; beyond this there are no additions of these technologies given their high costs of generation relative to gas-fired technologies.

Generation by fuel

In the Central Scenario, Iraq’s annual gross generation of electricity grows from around 50 TWh in 2010 to over 200 TWh in 2020, an increase in electricity output comparable to that expected in the European Union over the same period. As noted, there is an important accompanying shift in the fuel used. Iraq’s current electricity generation comes primarily from liquid fuels: heavy fuel oil, crude oil and gasoil accounted for 57% of generation in 2010. Natural gas accounted for 33% of the mix. In the near term, most of the growth in electricity generation depends on liquid fuels: gross generation from crude oil and refined products more than triples to 100 TWh in 2015 – around 70% of the electricity output projected for that year (Figure 3.9).

This expansion of liquid fuels means that the share of natural gas in the power generation mix actually falls in the near term to just below 25%. However, in the period after 2015, this trend is reversed rapidly as an increasing amount of natural gas becomes available. The availability of gas as a fuel, at lower cost, means that it establishes itself as the dominant base-load and mid-load fuel by around 2020, with oil capacity used to meet demand only in the peak demand periods. The use of liquid fuels for power generation peaks around 2015 and then declines steadily. The share of gas increases to around 60% of the mix in 2020 and to nearly 85% by 2025, retaining this share for the rest of the period. The increase in the share of gas generation is accompanied by an increase in overall efficiency, which grows from 30% in 2010 to 42% in 2035, due largely to the introduction of CCGT technology. The marked reduction in HFO use after 2020 occurs as upgrades to Iraq's refining capacity come on stream, reducing the share of HFO in refining output.

Figure 3.9 ▷ Iraq electricity generation by fuel and overall efficiency of power generation in the Central Scenario



Electricity generated from hydropower made up nearly 10% of supply in 2010 (nearly 5 TWh). Capacity is projected to increase modestly over the *Outlook* period, and as a result hydro generation reaches 14 TWh in 2035, with a focus in the north of the country, where there is also potential for some small-scale hydro in more remote communities. This projection is sensitive to decisions taken in other countries that affect water flows entering Iraq. While Iraq has a large increase for non-hydro renewables, particularly solar, the costs of exploiting this for power generation remain high relative to alternative fossil fuel technologies. Due to this, and based on existing policies, there is only a small increase in non-hydro renewables, such as solar, over the *Outlook* period (Box 3.2).

The improvement in efficiency and the shift from oil to natural gas help to limit the environmental impact of electricity generation. In 2010, the CO₂ emissions-intensity of the Iraqi power sector was 700 grammes of carbon dioxide per kilowatt-hour (gCO₂/kWh), higher than the Middle East average, which stood at 680 gCO₂/kWh. By 2035, it reaches 442 gCO₂/kWh, a 37% reduction and a major decline, even by international standards.

Box 3.2 ► The role of renewables in Iraq

Renewable energy sources, almost all of which is hydro, play a small but important role in Iraq's existing electricity generation mix, accounting for nearly 5 TWh of generation in 2010.

A number of sites have already been identified as having potential for new hydroelectric plants, two of which – the Bekhma and Badoush dams on the Tigris River – saw the start of construction during the 1980s, but work was abandoned in the wake of the sanctions imposed in the 1990s. There is considerable potential for expanding hydroelectricity in the KRG area, as well as some opportunities in the rest of Iraq, but projects are very capital-intensive and water availability is constrained. Future dam construction will depend primarily on the extent and security of upstream water supply and the water management policies of the Ministry of Water Resources, with electricity generation being an associated benefit of projects undertaken primarily for other purposes. In the Central Scenario, an additional 2 GW of hydro capacity is installed over the *Outlook* period. The rapid growth of generation from other sources means that hydro's share of the generation mix falls to around 5% by 2035.

Iraq has very good solar resources. Even though the Middle East's best solar irradiance is farther south – in Saudi Arabia and Yemen for example – Iraq's average solar irradiance is similar to that in north Africa. Iraq also has some history of research into solar power (which was curtailed significantly during the decades of wars and sanctions). Today, solar research activities are sponsored by the Ministry of Electricity and the Ministry of Science and Technology. The Ministry of Electricity has a number of off-grid solar research stations, with capacity of a few tens of megawatts (MW). Despite the strength of the resource, grid-connected solar electricity generation – either through photovoltaics (PV) or concentrating solar power (CSP) – will remain a very high-cost option, compared to fossil fuels. Our Central Scenario assumes a small amount of solar PV capacity – less than 50 MW – is added by 2035.

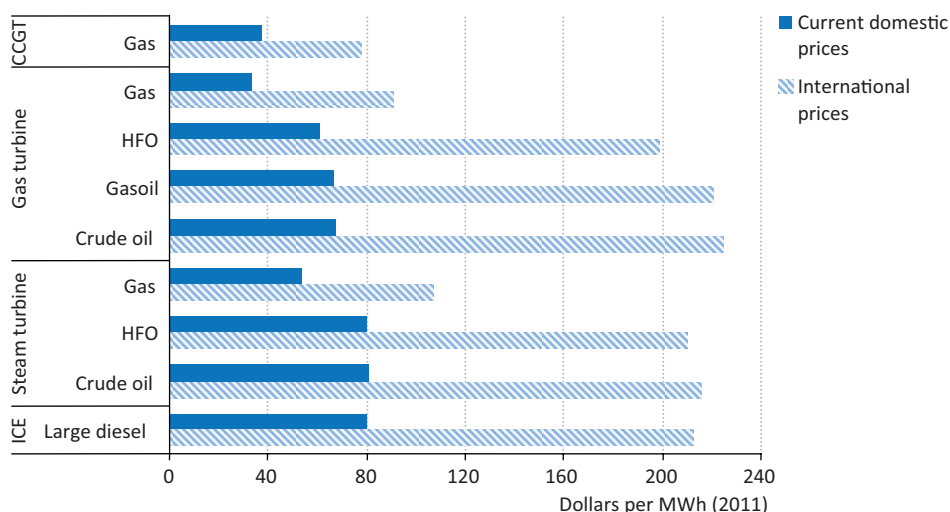
Outside the electricity sector, solar water heating is likely to be a highly attractive option for buildings if subsidies for fossil-fuel alternatives are phased out. Wind speed in Iraq is relatively low and the biomass resource is moderate. Our Central Scenario does not assume any large-scale development of wind or biomass resources during the *Outlook* period, though international collaboration could help to change this picture. Iraq became a signatory in 2009 to the international convention creating the International Renewable Energy Agency (IRENA), paving the way to full membership of the organisation when the agreement is ratified.

Generation costs

Any fossil fuel used for power generation in Iraq is fuel that cannot be sold for export. The full cost of fossil-fuelled electricity generation to the Iraqi economy therefore depends on the international export value of the fuels used, rather than subsidised domestic fuel prices. In 2010, around 160 kb/d of oil was burned in power plants; at international market prices this had a value of over \$4 billion. By 2015, 520 kb/d of oil is expected to be used in power generation, with an international market value of \$22 billion. The planned shift to natural gas – which is already envisaged by the government and provided for in the Electricity Masterplans drawn up for the Iraqi power sector (Parsons Brinckerhoff, 2009a and 2010) – is driven by the relative costs of competing generation technologies, which are themselves strongly influenced by the relative value of oil-based fuels and natural gas in Iraq: per unit of energy, oil has a considerably higher export value than gas.

Combining the fixed costs, operational and maintenance costs, and fuel costs of new generation plants allows the total costs per unit to be compared. Using international oil and gas prices and considering the main generation technologies and fuels available in Iraq, gas-fired CCGTs emerge as the lowest cost base-load technology. Based on international prices in the Central Scenario, they have a levelised cost of \$77 per megawatt-hour (MWh) in 2020 (Figure 3.10). For plants operating only at peak periods, gas-fired GTs are the most economic at international fuel prices, due to their lower capital costs.

Figure 3.10 ▶ Levelised cost of base-load plants with international fuel prices in 2020 (Central Scenario) and current domestic fuel prices in Iraq



Note: CCGT = combined-cycle gas turbine; ICE = internal combustion engine.

Fuel prices for the power sector are currently set by the government at a level considerably below their international market price. Even at these subsidised fuel prices, gas-fired generation is more economic than oil as a base-load generation technology. In addition to

the direct costs of oil, liquid fuels have several technical disadvantages relative to gas. Oil corrodes generating equipment more than gas, shortening the lifetime of the plants and increasing the cost and the amount of time per year that has to be spent on maintenance. For Iraqi plants, this may be expected to increase the duration of annual planned outages from 1-2 weeks to 5-6 weeks. The cost of replacement parts is also estimated to increase five-fold.

Transmission and distribution

Iraq's transmission network is divided into two. The network in the north is managed by the Ministry of Electricity in the Kurdistan Regional Government, while the rest of the country is served by another grid managed by the Ministry of Electricity of the federal government. Interconnection between the two transmission networks is very limited. Despite periodic attacks against them, Iraq's transmission networks are in relatively good working condition, so future investment is expected to be directed primarily to improving efficiency and reliability, and increasing capacity to accommodate new demand and generation. In order to have enough transmission capacity, with a reasonable degree of redundancy, Iraq is likely to need around an additional 28 000 kilometres (km) of 400 kilovolt (kV) and 132kV lines between its main demand centres, such as Baghdad, Basrah and Mosul.

The distribution networks are seriously degraded, particularly outside the KRG area, suffering from poor design, lack of maintenance and theft of electricity. Losses in the distribution network are particularly high compared to most countries in the Middle East (see Chapter 1). As well as the waste of energy associated with such losses, the degraded condition of the distribution network means the supply to consumers is of poor quality, including low voltage levels and frequent disconnections. In addition to repairing the existing networks, the booming growth in electricity demand will require considerable expansion of both the transmission and distribution networks. Undertaking the repair and maintenance of the existing networks and expanding them to meet new demand will require a large number of well-trained staff as well as institutional reform. It has been recommended, for example, that a distribution code be adopted that sets uniform standards and procedures for upkeep of the distribution network (Parsons Brinckerhoff, 2010). Capacity building initiatives have the potential to play a positive role in the power sector and beyond, such as the Centre of Excellence for research and training on energy proposed within a joint declaration by the European Commission and Iraq on an enhanced strategic energy partnership.

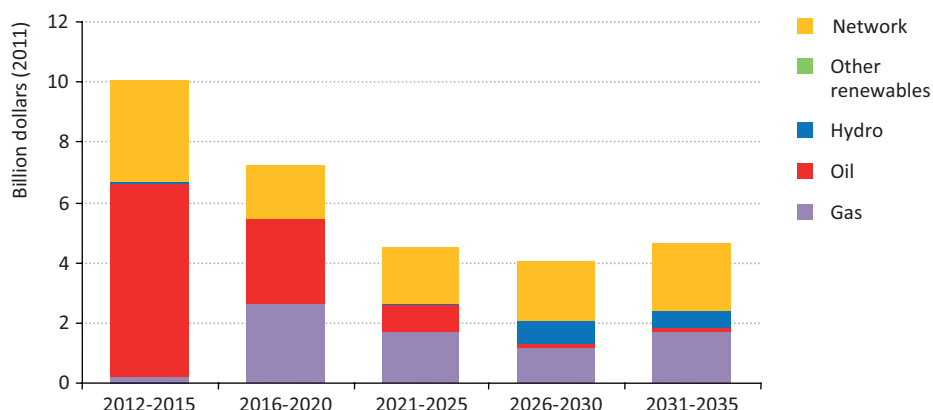
In addition to the important wider economic benefits to be derived from a reliable supply of electricity, improving the design, maintenance and operation of the transmission and distribution networks should reduce system losses, thereby avoiding the construction of unneeded generation capacity and unnecessary use of fuel for generation. In the Central Scenario, we assume that measures to improve new and existing network infrastructure – which would include adoption of technical standards, institutional reforms and training of engineering staff – lead to a fall in network losses over the *Outlook* period

from 34% to 29%. Although this figure is still considerably higher than the Middle East average, which reaches 16% by 2035, the associated saving in fuel is 3.3 Mtoe in 2035: equivalent to the annual fuel input to six CCGT power plants.

Investment in the power sector

Cumulative investment of over \$140 billion will be required in the power sector over the *Outlook* period (Figure 3.11). This is 35% higher than Iraq's total GDP in 2010, but is only around 3% of its expected oil export revenues over the period. The need to make up for past under-investment and to meet rapidly growing demand means that half of the total investment needs to take place prior to 2020 – averaging \$8.5 billion a year. This large commitment is vulnerable to increases in cost or decreases in revenue to fund it (see Chapter 4). Typically, customers' payments would be a key source of revenue to fund such investment, but the price of electricity in Iraq is low and payment enforcement is weak (Box 3.3).

Figure 3.11 ▶ Iraq annual average investment in power generation capacity and electricity networks in the Central Scenario



In the period to 2020, nearly three-quarters of investment in power plant capacity is in oil-fired installations, mostly oil-fired GTs. A significant amount of this capacity is later converted to use gas as a fuel, though some of it is retained as oil-fired peaking plants. A quarter of the investment goes to new dedicated natural gas plants, shared almost equally between GTs and CCGTs. From 2020, the pattern of investment changes, with almost two-thirds of power plant investment going towards gas-fired capacity, and an increasing share going to either new CCGTs or GT-to-CCGT conversions. Investment in hydropower is concentrated in the period 2026 to 2035, making up 30% of the investment in generation capacity during this period. Electricity networks represent a little under two-fifths of total power sector investment.

Box 3.3 > Reforming the power sector

Beyond addressing the immediate need to add capacity quickly to the network, efforts are under way to put the electricity sector on a legal and regulatory footing that will facilitate its development over the coming decades. Two relevant laws have been drafted and are currently under consideration. The first is the Ministry of Electricity Law, which would restructure the Ministry of Electricity. The second is the Electricity Regulation Law, which would establish a regulatory office for the electricity sector, with responsibility for monitoring the sector, licensing participants, enforcing technical codes, and resolving disputes and consumer complaints. Other instruments of governance will also need to be developed and implemented. A positive step in this direction has been taken with the drafting of a grid code, setting out detailed technical standards for the use of the electricity network.

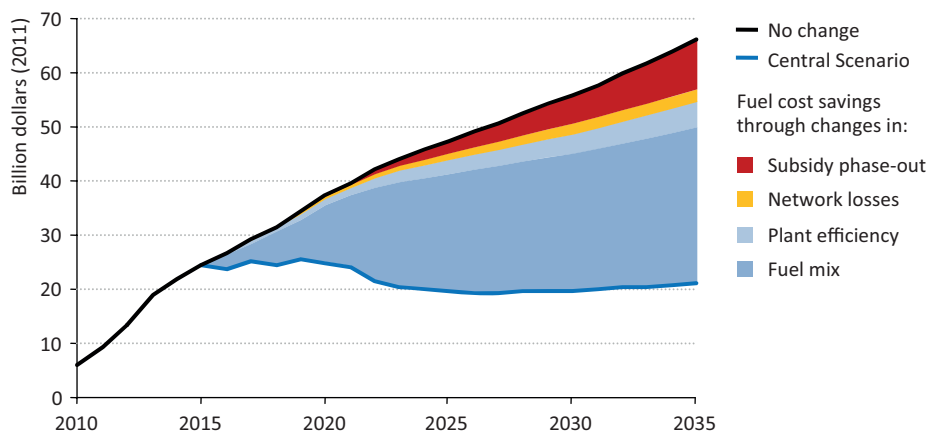
Electricity metering, billing and payment collection is an additional issue in need of urgent attention. Electricity consumption in many households and businesses is not metered, while readings for those that do have meters are taken infrequently. Even where customer use of electricity is metered, billing and collection of payments is not comprehensive, partly because of inadequate information technology systems for billing and tracking payments. It is too difficult at present to distinguish unofficial use of grid electricity from technical losses arising from problems with the network. It will be politically difficult to address the problem of payment collection fully and vigorously while electricity supply remains seriously inadequate, but plans need to be laid for robust action once circumstances permit.

Effective implementation will be needed across the board to establish a stable and well governed electricity sector, a process itself dependent on hiring and retaining well trained staff. Successful reform of the sector will create the investment climate necessary to encourage the private sector to shoulder more of the burden in future.

Measuring the value of changes in the power sector

Compared with a case in which the power generation mix does not change from 2015 to 2035, the collective impact of the changes in technology, fuel mix and efficiency in the Central Scenario, reinforced by reduced end-user subsidies, is to lower oil demand in the power sector by 1.2 mb/d by 2035. The cumulative export value of the fuel saved over the *Outlook* period is \$520 billion (Figure 3.12). The savings come mainly from changes in the fuel mix, as the increased availability of natural gas means that the share of oil in electricity generation falls from over 70% in 2015 to under 10% in 2035. There are also efficiency gains (mainly from using CCGTs instead of GTs for generation) that increase the technical efficiency of the power sector from 30% to 42% in 2035; this improvement reduces overall fuel demand by more than one-fifth by 2035. Reducing transmission and distribution losses results in a 7% reduction in the amount of generation required by the end of the period. The reduction in end-user price subsidies for electricity results in additional fuel savings that yield additional export revenues (Spotlight). In addition, the amount of capital investment needed in generation capacity is reduced.

Figure 3.12 ▸ Export value of fuel saved in the power sector as a result of changes from 2015



SPOTLIGHT

What is the potential cost of maintaining fossil fuel subsidies in Iraq?

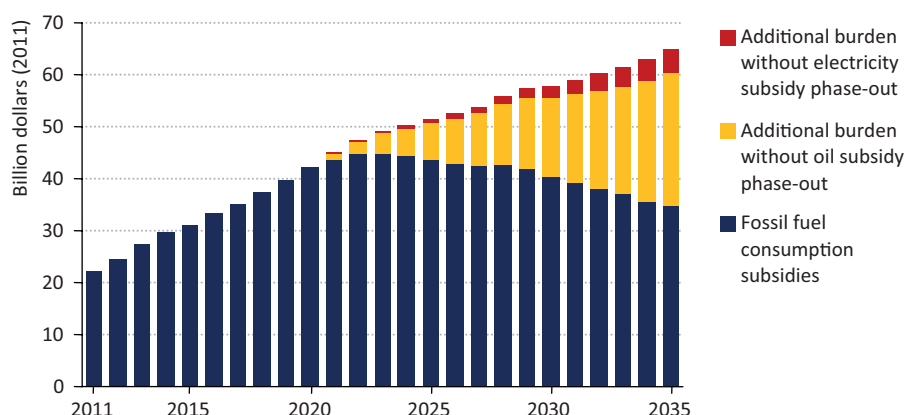
We estimate that the value of fossil fuel subsidies in Iraq in 2011 was around \$22 billion. While not the most pressing issue facing Iraq in the short term, the perspective to 2035 shows the enormous cost of maintaining subsidies at equivalent levels throughout the projection period. The experience of other countries in the Middle East suggests that, without measures to moderate energy demand (with gradual moves to market-related pricing at the top of this list), there is a risk of runaway consumption growth, the associated subsidies cutting government revenues that could be allocated much more productively elsewhere.

In our Central Scenario, we assume a partial but incomplete subsidy phase-out in Iraq over the projection period, based on government statements and our assumptions for other oil exporters in the Middle East. The subsidy rate for electricity begins to decline from around 2020 to around approximately half the level of today in 2035, with a similar pattern of reduction for oil subsidies. In the case of natural gas, we assume that the rate of subsidy remains unchanged, as the government seeks to encourage its use in power generation and in the industrial and energy transformation sectors. The partial phase-out means that the projected cost of subsidies in 2035 is \$35 billion (around 6% of GDP), rather than nearly \$65 billion (nearly 12% of GDP). The cumulative benefit to Iraq (fiscal and opportunity costs) is \$214 billion over the *Outlook* period (Figure 3.13), although the value of these subsidies is nearly \$1 trillion over the period as a whole.

There are a number of distinct trends underpinning these trajectories. Over the next decade, oil subsidies are seen to increase by the largest amount, as domestic demand grows strongly and the international oil price increases gradually. Electricity and natural gas subsidies are also expected to increase (gas subsidies increase to \$5 billion in 2035),

due to growing demand and increasing international fuel prices (which are used to derive our reference prices), even as the rate of subsidy remains fixed. Around 2020, the trends begin to change. Electricity demand is fully met, allowing currently very low prices to be increased gradually. New refinery capacity comes online in increments (reducing oil product imports), and products on the domestic retail market are priced, increasingly, at commercial rates. Natural gas largely replaces oil in the power generation mix, which lowers the subsidy burden because of the lower international reference price of gas relative to that of oil.⁴ Overall, the total value of subsidies in our Central Scenario peaks before 2025 and then declines gradually.

Figure 3.13 ▶ Iraq fossil fuel consumption subsidies in the Central Scenario



Outlook for end-use sectors

Transport

Oil demand grows more strongly in transport than in any other sector, increasing by 6% per year on average to reach 1.2 mb/d in 2035 (Figure 3.14). By 2035, Iraq's oil demand in transport is greater than that of Japan, even though it is projected to have significantly fewer vehicles. This reflects a lack of policies targeting fuel economy improvements and comparatively high average vehicle mileage. It also indicates the potential impact that new policies, aimed at increasing efficiency and promoting public transport, could have in restraining demand growth in this sector (potentially supporting increased oil exports).

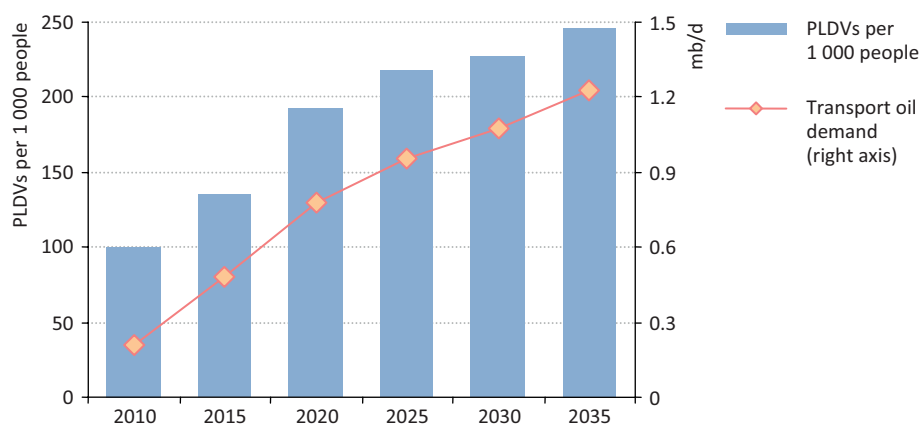
The largest consumers of oil in Iraq's transport sector are passenger light-duty vehicles (PLDVs), of which there were an estimated three million on the road in Iraq in 2010.⁵ Around 35% of households in Iraq have a private car, with higher shares in the

4. The savings identified as being due to subsidy phase-out in Figure 3.12 relate to lower volumes of fuel required, as a result of lower demand in the power sector. In Figure 3.13, they are captured as the value of the fossil-fuel subsidies rather than the international value of the lower fossil fuel demand.

5. Direct communication with the Iraqi government.

KRG area (46%) and in Baghdad (40%), and an average of 30% in other governorates (Iraq Central Statistics Organization, 2012). The level of vehicle ownership is already quite high, at 100 vehicles per 1 000 inhabitants, just below the Middle East average, but more than double the level in China and nine times higher than in India. Iraq relies on vehicle imports – around 150 000 cars and pick-up trucks were imported in 2011 – and, while the picture is changing, the typical car imported at present is the Saipa Saba from Iran (a small vehicle with fuel consumption of up to 9 litres per 100 km, depending on the drive cycle) or a second-hand car.

Figure 3.14 ▶ Iraq PLDV ownership and oil demand in transport in the Central Scenario



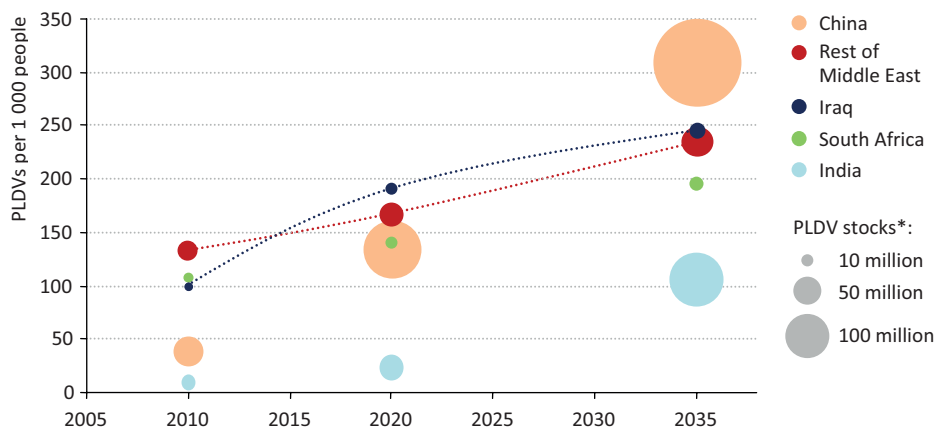
Note: PLDV = passenger light-duty vehicle.

In our Central Scenario, the number of PLDVs in Iraq grows strongly, reaching around 8 million in 2020 and over 14 million in 2035. Vehicle penetration also increases, overtaking the average level of the Middle East and reaching more than 190 PLDVs per 1 000 people in 2020 and nearly 250 per 1 000 people in 2035 (Figure 3.15). This increase is driven by high average GDP growth, of around 7% per year, limited alternative means of transport and an increase in the population of working age. Road freight activity (in million tonne-kilometres) is also set to more than triple to 2035. An important qualification to these projections arises from the fact that Iraq's road transport system is already in pressing need of rehabilitation and modernisation and its road density is relatively low, at around 0.1 km per square kilometre of land surface. Slow progress in re-building this network will constrain growth in road transport.

Iraq is expected to increasingly open up to regional and international transport, particularly aviation and road transport, in support of broader economic development. Its limited coastline will become increasingly busy with seaborne freight, oil exports in particular. Rail represents an opportunity for Iraq but its future is highly uncertain. Rail provided an important channel for personal mobility and freight traffic in Iraq until the 1980s, but the performance of the network has since collapsed and passenger usage is only a fraction

of the previous level. Rehabilitation of the rail network offers an opportunity to facilitate economic growth, reduce the pressure on road transport and, potentially, to link into other rail projects in the region; but it would also require substantial investment. In our Central Scenario, we assume that the railway network expands only modestly, leaving most freight traffic and individual mobility dependent on road transport.

Figure 3.15 ▶ PLDV ownership and stocks in selected countries in the Central Scenario

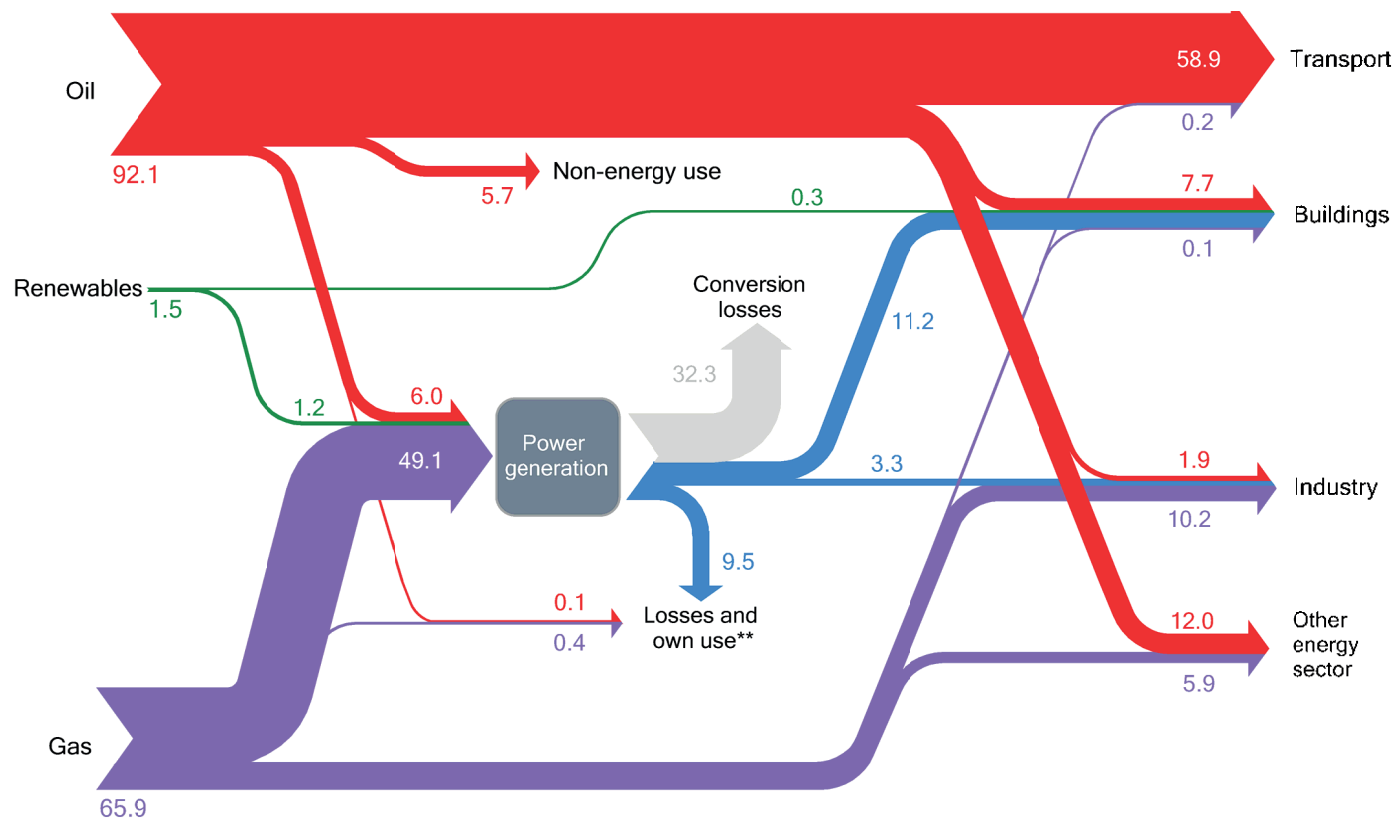


* Size of bubble reflects total stock of PLDVs.

Industry

Despite industry's habitual role as one of the foundations of an economy, in Iraq this sector consumed only slightly more than 3 Mtoe in 2010, around the same level as in 1990. This statistic reflects under-investment and disrepair that has left a legacy of under-utilised and largely uncompetitive assets. As a result, current assets do not provide any reliable guide to future activity. The level of public investment and how far Iraq goes to create a business climate conducive to private sector investment will be the critical determinants of future industrial energy demand.

In our projections, energy consumption in Iraq's industry sector increases by more than 6% per year, to reach just over 15 Mtoe in 2035 (Figure 3.16), with consumption being a mix of natural gas, natural gas liquids and electricity. The trend in industrial demand growth follows that of the economy more generally, being strong to 2020 and then slower for the remainder of the projection period. It is important to distinguish between the dominant oil industry in Iraq, which grows by 5% per year on average, and the much smaller non-oil industry, which sees growth of around 8% per year. Despite this stronger growth, the non-oil sector accounts for only one-quarter of total industry value-added in 2035. The trend towards private sector participation, already contributing towards growth in oil and gas production, is expected to spread gradually to other industrial sectors. The cement industry is a case in which private sector participation is beginning to occur, stimulated by an emerging boom in construction.

Figure 3.16 ▷ Iraq domestic energy balance* in the Central Scenario, 2035 (Mtoe)

*Oil exports, oil product exports/imports and electricity imports not shown. Gas flaring not shown. ** Includes losses and fuel consumed in oil and gas production, generation lost or consumed in the process of electricity production, and transmission and distribution losses.

In the Central Scenario, demand for hydrocarbon feedstock for fertiliser and petrochemicals grows to nearly 5 Mtoe in 2035,⁶ with growth concentrated in the period after 2020. Iraq has adopted the policy objective of building up industrial infrastructure that can use and add value to the country's hydrocarbon sector, seeking to derive comparative advantage from low input costs. Our projections suggest that, once processing facilities are in place, Iraq would have ample supplies of ethane fully capable of supporting a petrochemical industry selling particularly into Asian markets, where petrochemical and fertiliser demand is expected to grow. However, Iraq's existing petrochemicals sector is very small and will take time to develop, particularly given other investment priorities and the challenge of gaining a position in regional and global markets. As in many other sectors, a successful build up of the petrochemical industry in Iraq will depend on significant long-term investment and confidence as to the secure long-term availability of feedstock. The development of the Saudi petrochemical sector by SABIC is a good example of the challenges and opportunities, while also illustrating the long time required to develop higher value-added sectors and to move beyond basic commodities.

Buildings and other sectors

In our Central Scenario, the buildings sector (for this analysis, it includes the residential, services and agriculture sectors), sees demand increase from around 7 Mtoe in 2010 to over 19 Mtoe in 2035. The main factors underpinning the projected increase in consumption are population and economic growth, urbanisation, new housing supply and burgeoning appliance ownership. Iraq is currently short of between 1 million and 3.5 million housing units (Ministry of Planning, 2010). Several large-scale housing projects are either planned or under construction. This significant level of expected construction creates an important opportunity to incorporate high energy efficiency standards, rather than locking in inefficiency in capital stock that has a long lifetime. International standards already exist in this area. Consumers could then have lower electricity consumption and therefore lower bills, and less investment in power generation capacity would be needed.

In the Central Scenario, the share of electricity in total energy consumed in the buildings sector grows from 35% to 58%. Improved reliability of cheaper grid-based electricity gives a boost to demand, with households buying a greater range of appliances and using them more often. Air conditioning will remain a key component of consumption, along with other consumer goods; for example, the proportion of households owning a computer, now generally below 20% (IKN, 2012), is expected to increase. As with building standards, the introduction of energy performance standards for household appliances, especially air conditioning, is an obvious priority.

6. This implies investment in three large-scale crackers for ethylene production (running at 100% ethane), as well as additional midstream infrastructure (pipelines, fractionators) and downstream processing plants. This would bring Iraq's petrochemical output to a level greater than that of Qatar today.

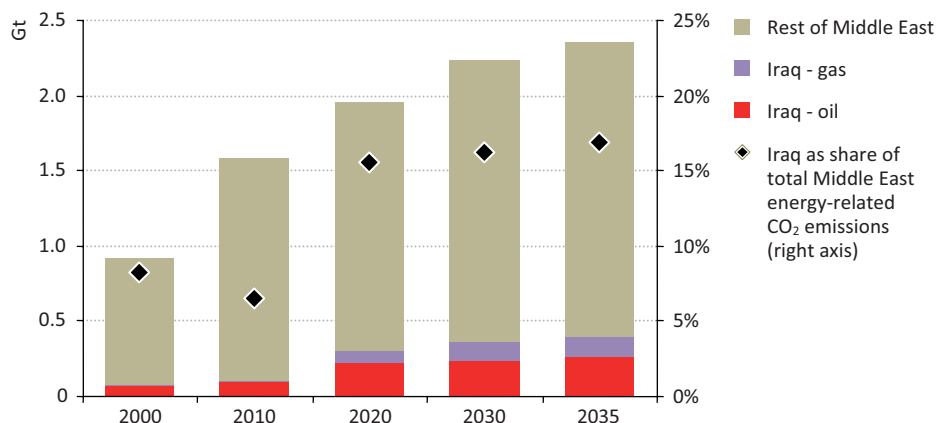
Liquefied petroleum gas (LPG) is widely used as a cooking fuel in Iraq and we project LPG demand to remain strong, reaching more than 210 kb/d in 2035. Iraq has imported LPG for several years and this is projected to continue until around the end of this decade when, due to increased natural gas processing capacity, Iraq moves from being an LPG importer to a net exporter.

Environment

Energy-related emissions

Iraq's energy-related CO₂ emissions are projected to increase in the Central Scenario from around 100 million tonnes (Mt) in 2010 to just over 400 Mt in 2035 (Figure 3.17).⁷ They grow to account for nearly 17% of Middle East energy-related CO₂ emissions in 2035 and a little more than 1% of global emissions – a high figure compared to Iraq's 0.3% of the global economy and 0.7% share of the global population. The increase in CO₂ emissions slows after 2020, as a result of lower economic growth, a move to more efficient power plants and a gradual reduction in fuel and electricity subsidies. Gas flaring reduces over time, coming down to below 4 bcm by the early 2020s, resulting in a reduction in related emissions (see Chapter 2).

Figure 3.17 ▶ Iraq energy-related CO₂ emissions by fuel and its share of Middle East emissions in the Central Scenario

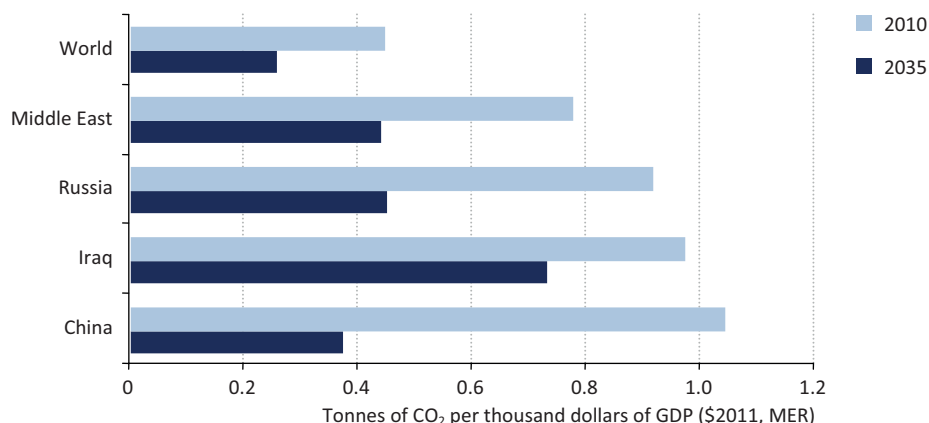


Reliance on fossil fuels, together with out-of-date technologies and a lack of energy efficiency standards, made Iraq one of the most carbon-intensive economies in the world in 2010. However, Iraq's carbon intensity is set to improve significantly, falling by a quarter by 2035 (Figure 3.18). This improvement is related mainly to the rapid growth in the size of Iraq's economy (based on investment in modern equipment), but changes in patterns of energy consumption also play a role. The most important of these is the shifting fuel mix in electricity generation, as natural gas displaces liquid fuels. The projected reduction in

7. Figures for energy-related CO₂ emissions cover only the productive use of energy and so do not capture the effect from reduced flaring of natural gas that is anticipated in the early years of the projection period.

private generation in the power mix also brings local pollution benefits, but a significant increase in road transport has an opposite effect. Substantially modifying the link between an expanding economy and increases in energy use and CO₂ emissions is an important challenge for Iraq, and one that will require policies directly aimed at the inefficient energy practices and technologies that are commonplace in the region – often the policies already mentioned, such as action to move towards end-user prices for energy that reflect the market value of the energy consumed, standards for energy-efficient appliances (in particular, for air conditioners, given their significant role for electricity demand) and fuel-efficiency standards for vehicles.

Figure 3.18 ▶ Carbon intensity in selected countries in the Central Scenario



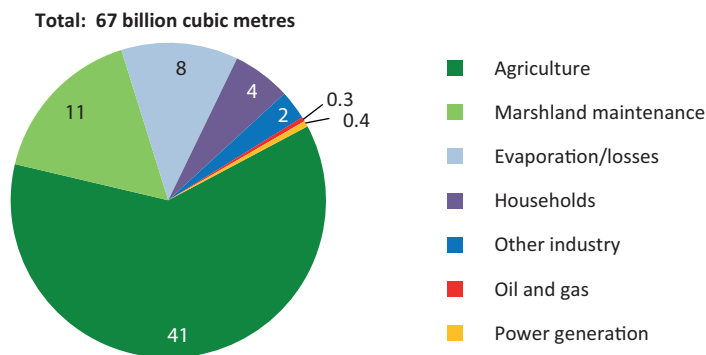
Water use

Water and oil are both important determinants of Iraq's future prosperity. A growing economy and population will result in an increasing overall requirement for water and energy. Available water supply has long been a concern, with water flow from the Tigris and Euphrates rivers expected to continue to fall over the projection period. However, water shortages facing Iraq are not attributable solely to developments further upstream, but also to inefficient methods used in agriculture and elsewhere.

Water requirements to support energy sector activities (oil and gas production and power generation) constitute just over 1% of Iraq's overall needs in 2015 (Figure 3.19) and so are not expected to be a determining factor in its water strategy. To take one example, growth in water requirements for cooling in power generation is not expected to match the pace of generation expansion, as CCGTs, in particular, have low water requirements relative to many other technology options, including the oil-fired power plants that they are often expected to replace in the Central Scenario. The development of hydroelectric capacity in Iraq's power sector will be strongly linked to water policy choices (see Box 3.2). However, water could still become an important factor in Iraq's energy strategy, especially in the south of the country, where water injection is needed to maintain oil production but freshwater supply is relatively scarce. To reduce excessive demand on freshwater in

the south, early and ongoing investment is required to draw supplies of seawater from the Gulf for energy purposes (see Chapter 2). In the future, Iraq may also be expected to invest in some desalination capacity, mainly in the south, to help meet the growing demand for potable water, but the scale and timing is uncertain.

Figure 3.19 ▷ Iraq water requirements, 2015



Note: The requirement for oil and gas is for the anticipated production in the Central Scenario.

Sources: Iraq Ministry of Water Resources; IEA analysis.

High Case

In our High Case, the rapid increase in oil production (see Chapter 2) feeds back into a significantly higher trajectory for GDP growth: Iraq's economy grows to well over five times its current size, with GDP being around \$100 billion higher in 2035 than in the Central Scenario (Table 3.3). Iraq experiences GDP growth of over 14% per year to 2020 (much more rapid growth than that experienced by China in the last decade) and averages nearly 8% growth per year over the projection period as a whole.

Table 3.3 ▷ Iraq key domestic energy indicators by scenario

	2011*	Central Scenario		High Case		Delayed Case**	
		2020	2035	2020	2035	2020	2035
GDP (MER, \$2011 billion)	115	289	552	384	649	186	331
Primary energy demand (Mtoe)	44	113	160	144	187	74	110
Oil demand (mb/d)	0.8	1.7	2.1	2.0	2.5	1.2	1.6
Gas demand (bcm)	8.5	39	72	55	78	18	42
Installed electrical capacity (GW)	17	60	83	69	86	48	63
Electricity generation (TWh)	55	202	277	233	301	142	208
CO ₂ emissions (Mt)	123	304	402	380	477	202	277

* 2011 figures are estimates. ** For discussion of the Delayed Case, see the concluding section to this chapter.

The main domestic energy implications of the High Case are:

- More rapid economic growth driven by oil revenues sends energy demand even higher, particularly in the period to 2020. Total primary energy demand is over 140 Mtoe in 2020 – more than one-quarter higher than the Central Scenario – and nearly 190 Mtoe in 2035.
- Natural gas and oil are called upon to meet almost all of the additional energy demand, with a small additional contribution from hydropower. The increase in natural gas consumption is driven largely by power generation, but also by increased consumption in industry.
- Oil consumption is pushed higher by increased demand for transport, with PLDV ownership per 1 000 people reaching almost 300, nearly three times today's level. By 2035, Iraq's primary energy mix is 61% oil, 38% natural gas and 1% hydro and other renewables – a slightly higher reliance on oil than in the Central Scenario.
- Installed electricity generation capacity quadruples during the period to 2020, a huge increase. More GT capacity is installed early in the *Outlook* period, but there is also more rapid conversion to CCGT plants around 2020, resulting in a faster improvement in the average efficiency of the power sector.
- Additional generating capacity and increased electricity consumption largely offset one another in the near term, meaning that Iraq does not manage to fully meet electricity demand from the grid any more quickly than in the Central Scenario, still closing the demand gap around 2015.
- Almost all of the increase in energy demand is met from fossil fuels, meaning that – in the absence of additional policy changes – more rapid growth in the economy does not equate to a better outlook for renewables or CO₂ emissions, which are around 25% higher than the Central Scenario in 2020 and close to 20% higher in 2035.

The main uncertainty affecting the High Case is whether Iraq can succeed in turning a very rapid rise in export revenue into greater national prosperity and, importantly, whether much higher required levels of energy-sector investment can be achieved. The experience of other resource-rich countries suggests a flood of oil generated wealth can, in some circumstances, offer substantial opportunities to improve social and economic welfare; but it can also have unintended and undesirable consequences for macroeconomic stability, for national institutions and governance and for the development of non-oil sectors of the economy (Chapter 4).

Delayed Case

In the Delayed Case, we look at the contrary and cautionary possibility that stubborn obstacles delay energy sector developments. It tests the consequences if investment in Iraq's energy sector were to rise only slowly from the levels seen in 2011. The reality of the risk is recognised by the Iraqi government, as noted in the foreword to the National Development Plan 2010-2014: "Over the past few years, Iraq has demonstrated the

inability to manage the annual budget, allocate investments, and has struggled to create an economy that allows for progress and development” (Ministry of Planning, 2010). Delay in investment may occur because of a combination of factors, such as frustration of the government’s efforts to modernise and reform Iraq’s legal framework and institutions. These constraints could be progressively lifted, allowing Iraq to move back towards a trajectory consistent with the Central Scenario (or even the High Case) at a later time. But if the low investment assumption is extended throughout the projection period, almost half of the cumulative investment in the Central Scenario is lost, resulting in consistently slower growth in oil production (reaching 4 mb/d in 2020 and 5.3 mb/d in 2035) and slower progress in the construction of new electricity capacity. In this Delayed Case:

- Reduced oil export revenues dampen Iraq’s GDP trajectory, with growth being around 2% lower per year on average than in the Central Scenario. As a result, total primary energy demand grows much more slowly, reaching 74 Mtoe in 2020 and 110 Mtoe in 2035.
- Iraq’s energy mix is slower to change. Oil retains its predominant position for longer, with a 75% share of primary consumption in 2020 (compared with 67% in the Central Scenario) and a 63% share in 2035 (compared with 58%). This reflects the later appearance of additional gas supply and processing infrastructure.
- The slower development of gas infrastructure means that liquid fuels play a larger role in power generation for longer, which reduces their availability for export to 2.7 mb/d in 2020 and 3.8 mb/d in 2035. Delays to power generation projects mean that full electrification is achieved one year later than in the Central Scenario, despite the fact that electricity demand is lower.
- The delay in putting in place new gas processing facilities also means a more prolonged period of gas flaring. Over the projection period as a whole, total flared volumes are higher than in the Central Scenario, even though oil production (and therefore associated gas output) is considerably lower.

Overall, the cumulative impact on Iraq’s economy is a loss of nearly \$3 trillion relative to the Central Scenario, as export revenues are sharply lower, other industrial and services sectors fail to develop quickly and the power sector makes slower progress in moving to cheaper and more efficient generation.

Implications of Iraq's energy development

What does Iraq's energy mean for Iraq, and the world?

Highlights

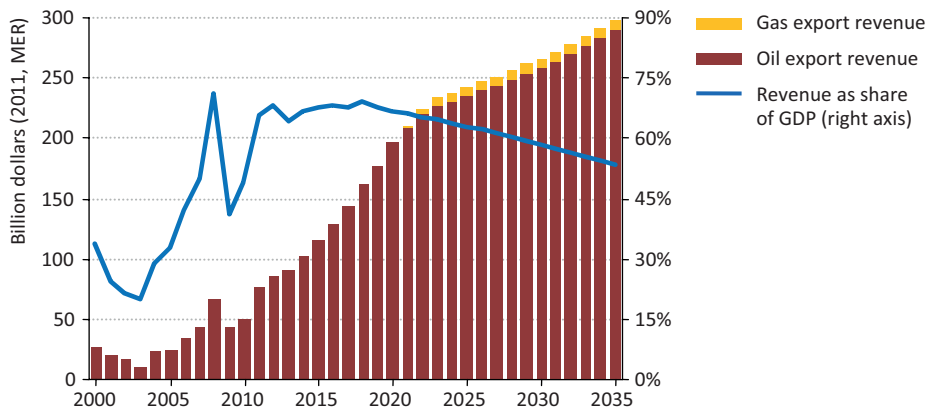
- Iraq stands to gain almost \$5 trillion in revenues from oil exports over the period to 2035 in the Central Scenario. Revenues of this magnitude offer a transformative opportunity to Iraq if they can be used to stimulate much-needed economic recovery and diversification.
- To realise this opportunity, Iraq will need strengthened institutions and human capacity, sound long-term strategies for the energy sector and for the economy, and ensure efficient and transparent management of revenues and spending. Direct employment in the hydrocarbons sector will generate only a small fraction of the jobs that Iraq needs for its youthful and growing population.
- Iraq will need cumulative investment of over \$530 billion in new energy supply infrastructure to 2035. The bulk of this investment is in upstream oil, followed by the power sector. The annual requirement is highest in the current decade. Much of this investment is expected to be financed from the state budget: during the period to 2016, we estimate that Iraq will face a net financing requirement of \$27 billion to meet the levels of spending required.
- Iraq adds 5.6 mb/d to global oil supply by 2035 in the Central Scenario, a larger contribution to global supply growth than any other producer. Iraq becomes the second-largest global exporter after Saudi Arabia and a key supplier to fast-growing markets in Asia. Without such supply growth from Iraq, oil markets would be set for very difficult times, characterised by higher and, in all probability, more volatile prices that would reach almost \$140 per barrel in 2035 in real terms.
- In the High Case, Iraq's ambitions provide for near-term production to increase much more quickly. Growth in output from Iraq over the current decade would be enough to account for more than three-quarters of the growth in supply anticipated in this period in the Central Scenario. Non-OPEC oil supply is also expected to grow, at least in the medium term.
- Gas exports from Iraq start around 2020 in the Central Scenario and approach 20 bcm by 2035. The resources and market opportunities are there to expand exports further, as Iraq can potentially provide a very cost-competitive source of gas supply to neighbouring countries, to European markets and – via LNG from the south – to Asia.

Energy in Iraq's economic and social development

The Central Scenario

The anticipated increase in oil production in Iraq is set to generate exceptional growth in export revenues over the coming decades. In the Central Scenario, these revenues total almost \$5 trillion in the period to 2035 (in year-2011 dollars), increasing from around \$80 billion in 2011 to more than \$200 billion per year in the 2020s and closing in on \$300 billion by 2035 (Figure 4.1). Revenues of this magnitude create a transformative opportunity for Iraq, with the potential to support much-needed economic recovery and diversification. On a cumulative basis, \$5 trillion is 10% of global revenues from oil trade to 2035; it is half the amount that China is projected to spend on oil imports over the same period and more than the oil import bill of India. This trajectory would mean that Iraq's share of total OPEC revenue is set to grow from the current 7% to around 18% by 2035. Iraq's gross domestic product (GDP) in 2035 would be five times larger (in real terms) than now, and its GDP per capita would rise to a level comparable with that of Brazil in 2010.

Figure 4.1 ▶ Iraq oil and gas export revenues in the Central Scenario

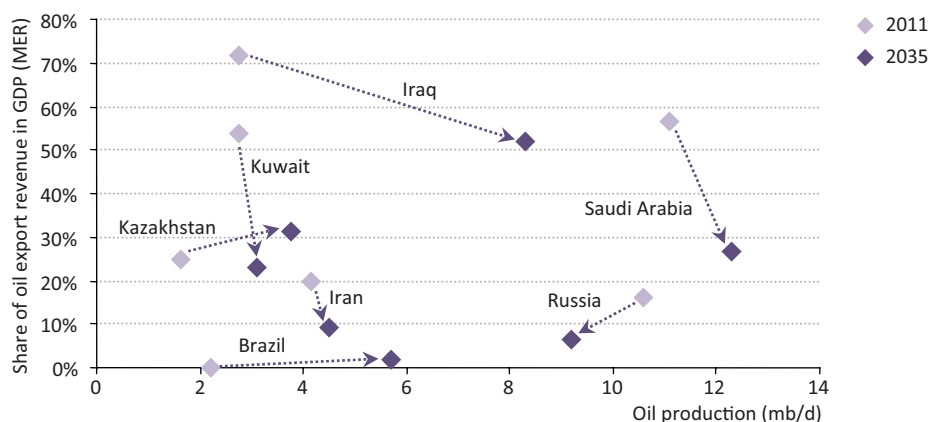


Note: GDP is measured at market exchange rates (MER) in year-2011 dollars.

But, even if realised, these revenues come with significant risks attached. They constitute a very large share of Iraq's national wealth, equivalent to around two-thirds of GDP in the early years. This figure is set to decline over the projection period, but the share of export revenue in GDP is projected to remain above 50%. This is very high by international standards: the figure for Iraq in 2035 is around the level of Kuwait in 2011 and well above the indicators for other major oil-exporting countries (Figure 4.2). With a large and growing population, Iraq needs to develop a self-sustaining and productive economy beyond the oil sector, a task that can actually be complicated by the scale of these oil revenues (quite apart from their dependence on potentially volatile international prices). There is a well-recognised threat to resource-rich countries, sometimes referred to as the "resource curse", the reality of which is evident in the economic performance of other countries relying

heavily on wealth derived from natural resources, particularly those where institutional capacity is weak (Humphreys, *et al.*, 2007). Iraq will need to remain keenly alert to these pitfalls if it is to achieve successful and sustainable national development on the basis of its oil wealth.

Figure 4.2 ▶ Oil production and export revenue as a share of GDP in selected countries in the Central Scenario, 2011 and 2035

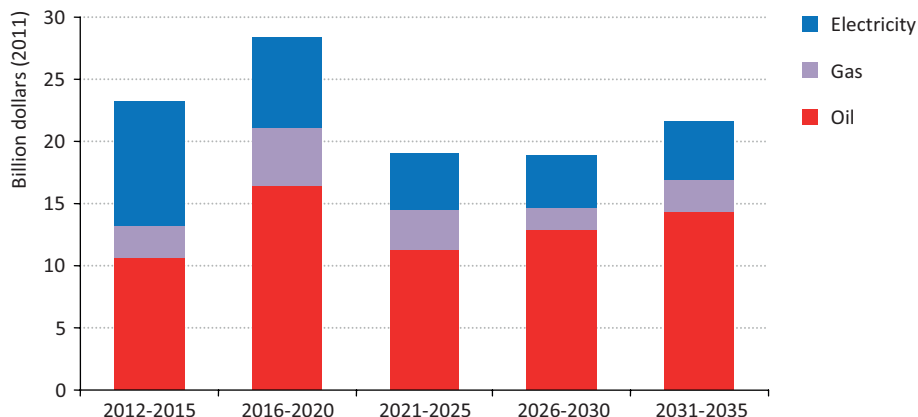


The investment required to raise production and generate the estimated revenues is concentrated in the early part of the projection period, at a time of simultaneous need to rehabilitate existing energy infrastructure that is often in a poor state of repair. In the Central Scenario, the cumulative investment requirement for the energy sector in the period to 2035 is \$530 billion, more than \$22 billion per year on average (Figure 4.3). Spending during the years between 2016 and 2020 is considerably higher, at \$28 billion per year, and can be compared with our estimate of just over \$9 billion invested in Iraq's energy sector in 2011 (oil, gas and electricity). The implication is that, during the period to 2020, a sum equivalent to more than one-fifth of Iraq's export revenues needs to be ploughed back into the energy sector each year. After 2020, the average ratio of energy investment to export revenues is lower – less than 10% – which is below the level observed in 2011.

Much of this investment is expected to be financed from the Iraqi treasury, whether directly or through re-payments of costs initially incurred by contractors. This is not the only way that Iraq could meet its infrastructure investment needs: an alternative would be to put in place a legal and policy framework that could encourage the private sector to assume more financial risk. Such a shift in policy has not been built into our scenarios, although the required strengthening of the business environment and the financial sector would serve the important supplementary purpose of contributing to wider economic diversification. On the present strategic approach, the adequacy and timing of investment in the energy sector depends to a large degree on the overall condition of public finances,

with energy competing with other substantial claims on government spending: Iraq has a large and growing public sector, with a huge requirement for capital investment in other areas.

Figure 4.3 ▶ Iraq annual average investment in energy supply infrastructure in the Central Scenario



As noted above, economies that rely heavily on commodity exports to finance investment have to allow for the potential volatility of international prices: oil-export driven economic growth can be thrown off course by abrupt shifts in prices. If Iraq meets the overall level of capital spending implied by the Central Scenario (including allowance for the much higher investment in the energy sector) and keeps current government expenditure at today's levels, then it will face a net financing requirement over the period to 2016 of \$27 billion. Such a net financing requirement should be well within Iraq's capabilities in the Central Scenario, though an oil price below the levels assumed in this scenario or one that is subject to sharp fluctuations could create difficulties. Swings in revenue can all too easily feed through into irregular capital spending, as there are even more constraints on cutting current expenditure, the bulk of which consists of public sector salaries.¹ In 2009, for example, a 31% decline in revenue, compared with 2008, led to a 12% fall in total Iraqi expenditure, with capital spending bearing the brunt of the reduction. If problems with the fiscal balance were to go so far as to cast doubt on uninterrupted operation of the mechanism for the recovery of costs under the technical service contracts, this could swiftly induce operators to hold back on their own investment or, at least, spend in smaller increments.

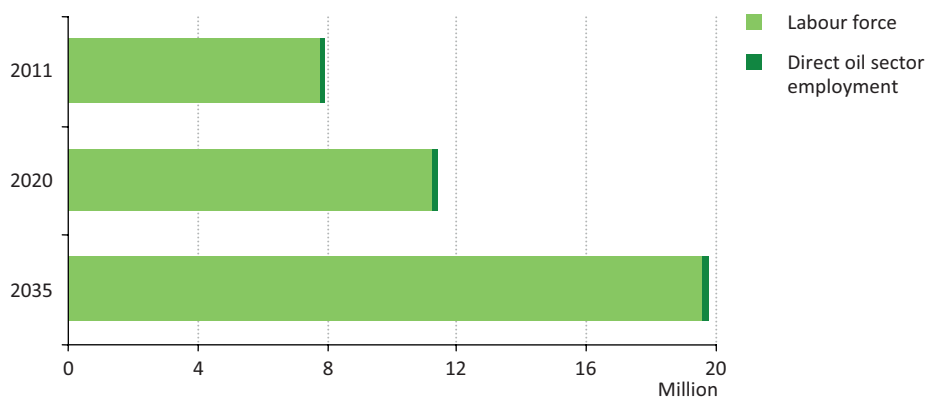
Another constraint is institutional; in recent years, Iraq's federal budget has consistently forecast a deficit but ended the year in surplus, in part because the federal government

1. Public and state-owned enterprises account for around 40% of total employment and the associated wage bill represents two-thirds of the state budget.

has spent just 60-70% of the capital expenditure that it had planned for.² This shortfall has been due to weaknesses in budget preparation, management and implementation in the various ministries. If this pattern were to be repeated in the coming years in the energy sector, the projected levels of energy investment in the Central Scenario would not be realised, investment moving instead towards the trajectory of the Delayed Case. The large and rapid build-up in the administrative capacity required to manage not only the expected surge in revenue but also its efficient expenditure is an urgent and major challenge for Iraq.

Though the hydrocarbons sector will generate enormous income for Iraq, it cannot generate anything like the employment opportunities that the country needs. As noted in Chapter 1, the oil and gas sectors currently employ no more than 2% of Iraq's workforce, with direct employment of around 125 000, of which around 100 000 work in state-owned companies engaged in production, refining, processing and distribution, and the rest in private sector operating or service companies. This compares with a current Iraqi workforce of just under 8 million. As the hydrocarbons sector is not labour-intensive, this ratio will continue and may even worsen as a youthful Iraqi population reaches working age over the projection period. Based on our population assumptions, the labour force will increase to over 11 million in 2020 and 20 million in 2035.³ On average, Iraq's economy has to generate opportunities for half a million net additions to the labour force each year. In 2035, total direct employment in the oil and gas sectors may reach up to 200 000 (Figure 4.4). While the oil sector will support a much larger number of jobs in related construction, manufacturing and other service sectors, it is clear that the answer to Iraq's pressing social and economic needs will need to be found elsewhere.

Figure 4.4 ▶ Iraq labour force and estimated direct oil sector employment in the Central Scenario



2. A contributing factor has also been (with the exception of 2009) a higher oil price, and consequently higher revenues, than had been assumed in budget calculations.

3. It is likely that a greater share of the working-age population will seek employment as education levels improve and more women enter the job market.

How can the energy sector help create wider opportunities elsewhere in the economy? The first and most important contribution is through the provision of modern, reliable energy services, particularly of electricity. In the Central Scenario, the shortfall in power supplies from the public network is eliminated around 2015, releasing the share of household and business spending that currently goes into more expensive local diesel generation. Second is through judicious use of Iraq's oil revenues, *i.e.* wise strategic choice of priorities for public spending. Alongside investment in functioning electricity and gas networks and a modern refining system, these revenues can develop other assets to underpin economic and social development, such as modern telecommunication and water networks, transport systems and public education. They would therefore contribute one important element of a supportive environment for the nascent private sector. Constant vigilance will be required to safeguard against the dangerous luxury of believing that such revenues make it possible to afford a very large public sector, risking the crowding-out of productive growth of the non-oil sectors of the economy.

As part of an overall economic strategy, the development of downstream oil and gas activities and energy-intensive industrial sectors can provide one element of economic diversification. This could be a viable path for Iraq, given the availability of energy inputs and feedstock at competitive prices. In the Central Scenario, we assume progress is made in this direction, notably with the development of a petrochemicals industry in the 2020s, but it is not without risk: Iraq is a relatively late mover and, in some cases, is looking to gain a foothold in markets with well-established regional players. Moreover, basic chemicals production offers relatively little in the way of employment. Realising a larger potential for job creation can be achieved by moving further down the product chain (into intermediates and plastics), but the manufacture of more sophisticated products also requires a more sophisticated policy environment to secure the necessary large-scale investment, as well as early efforts to ensure that sufficient skilled Iraq personnel are available.

At present, a large share of Iraq's energy spending goes on imported machinery, equipment and services. Given the speed at which Iraq expects to increase oil production and electricity generation, high reliance on imports is inevitable in the short- to medium-term as competitive alternatives are, in many cases, not available on the domestic market. Iraq's supply industry, in common with all parts of the economy, fell behind its regional and international peers during years of conflict and sanctions, losing a lot of expertise through emigration. Iraq can make up this lost ground, but the pace at which this happens will depend on how effectively government policy facilitates the development of local suppliers and how it chooses to promote a higher level of local content (Box 4.1).

Box 4.1 ▸ Gaining local benefits from Iraq's energy investment boom

The energy investment anticipated in Iraq requires a large number of components and inputs that could increasingly be supplied from within the country itself. Typically, up to half of investment spending in the oil and gas sectors consists of steel products and other materials, such as cement and aggregate; another fifth consists of equipment such as pumps, compressors and control systems; the rest is spent on construction labour, rigs, project management, and freight and shipping. Iraqi companies can expect to take on more in many of these areas, initially within Iraq itself but with the longer-term objective of expanding into the wider Middle Eastern market.

Iraq has long experience in oil field operations and steps to expand are already being taken: for example, the Iraq Drilling Company, a state-owned company that is part of the Ministry of Oil, has set up partnership agreements with an international oil services company. The process of developing capacity will require investment in training, technical and engineering education⁴ and supportive conditions for new business development. There are some encouraging signs. In 2012, Iraq awarded two contracts, worth \$280 million, for the construction of new factories in the south that will produce oil and gas pipe. If implemented effectively, the initiative announced in September 2012 to create near Basrah a specialised and secure free zone for the hydrocarbons sector could also help to attract businesses that manufacture, store or service oil and gas field equipment.

At present, there are no measures in place in Iraq that mandate a certain level of local content in energy sector projects. In some countries, measures of this kind have been introduced as a legislative requirement; but, in Iraq's circumstances in the oil and gas sectors, they could also be considered as conditions in future licensing rounds or field development plans. Any such requirement needs to be designed with care so that it acts as a genuine spur to local contracting, not running so far ahead of local capacity that it acts as an obstacle or cost barrier to project implementation. Where public authorities finance projects directly, their own procurement policies (which tend for the moment to favour state-owned enterprises) can provide an important means of building up independent domestic suppliers and contractors.

In our calculation of Iraq's GDP growth, which is based primarily on developments in the oil sector, we have assumed a gradual increase in the local content of investment spending, such that it reaches 45% by 2035. If this share were to rise more quickly, reaching 55% by the end of the projection period, around 1% would be added to Iraq's GDP, an extra \$4 billion in national output in 2035.

4. Existing technical service contracts oblige contractors to support a Training, Technology and Scholarship Fund that is intended to provide education and training opportunities in petroleum engineering and operations to Iraqi nationals. Total payments to this fund are currently around \$60 million per year.

Economic development in the High and Delayed Cases

The High Case brings more rapid GDP growth to Iraq, but also implies a greater concentration of economic activity in the hydrocarbons sector until the early 2020s, thus actually reducing economic diversification until the latter part of the projection period. Oil export revenues rise to a level above 80% of GDP in 2015 and stay above 70% of GDP until the mid-2020s, when oil production growth tapers off. By the end of the projection period, the share of oil export revenue in GDP comes down to a level comparable to that of the Central Scenario.

In the High Case, oil exports generate an additional \$610 billion in the period to 2020 and an additional \$1.8 trillion over the projection period as a whole, compared with the Central Scenario (despite a slightly lower oil price assumption in this case, see next section). The potential positive impacts are clear, but the scale of this huge windfall could exacerbate problems with revenue management and the development of the non-oil sectors of the economy. There would be a higher bill for investment and the concentration of capacity additions in the period to 2020 could further increase unit costs. There would need to be a step-change in Iraq's institutional capacity in order to manage in an efficient and timely way the vastly increased capital budget: investment in the energy sector during the period between 2015 and 2020 would need to be at average levels of more than \$40 billion each year, more than four times higher than our estimate of total energy investment in 2011.

Table 4.1 ▶ Key energy export, revenue and investment indicators from the projections for Iraq

	2011	Central Scenario		High Case		Delayed Case	
		2020	2035	2020	2035	2020	2035
GDP (MER, \$ billion)	115	289	552	384	649	186	331
Oil production (mb/d)	2.7	6.1	8.3	9.2	10.5	4.0	5.3
Oil export (mb/d)	1.9	4.4	6.3	7.1	7.9	2.7	3.8
Gas production (bcm)	9	41	89	63	114	18	49
Gas export (bcm)	0	2	17	8	37	0	7
Billion dollars (2011)		2012-2035		2012-2035		2012-2035	
Oil sector investment		319		503		178	
Oil export revenue		4 880		6 644		3 288	
Gas sector investment		71		81		35	
Gas export revenue		106		211		17	
Power sector investment		142		154		103	

Notes: MER = market exchange rate; mb/d = million barrels per day; bcm = billion cubic metres.

Although not part of our full-scale projections, the High Case accentuates the possibility (which is present also in the Central Scenario) that developments in the oil sector might run ahead of those in the rest of the energy sector. The oil sector has stronger foundations

for higher output – in the form of existing contracts with skilled international companies – than might be achieved in other sectors (despite the various impediments, discussed in Chapter 2, could hold back oil output growth). Compared with gas and electricity, operations in an export-oriented oil sector are less dependent on domestic policy and the institutional environment, so long as reliable access to international markets is ensured. Rapid increases in oil output, with the associated growth in revenues, could even be the occasion for holding back investment in other parts of the energy economy (as well as the economy as a whole) by appearing to lessen the urgency of upgrading inefficient technologies or changing inefficient practices, such as the large-scale use of oil in power generation. If realised, the combination of higher oil production with a slower pace of change in other sectors would be a worrying development for Iraq, as the increasing dependency on a single commodity would be symptomatic of the onset of the “resource curse”.

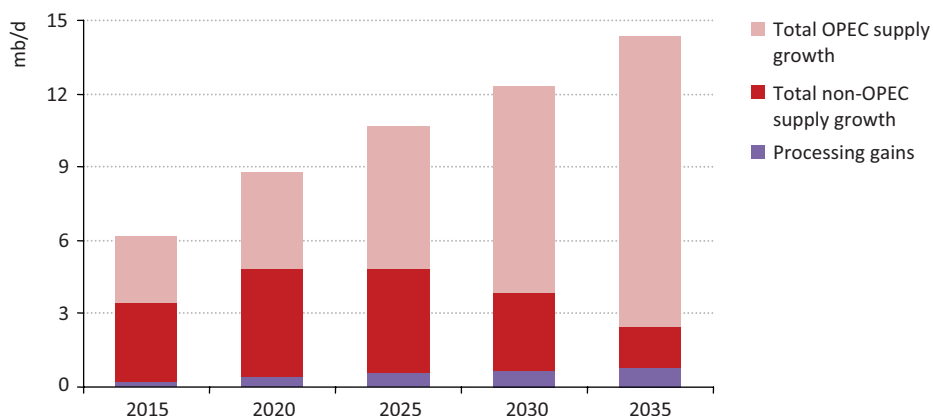
In a Delayed Case, oil export revenue is almost \$1.6 trillion lower over the projection period than in the Central Scenario, despite higher international prices, resulting from tighter oil markets. Annual spending on energy investment rises compared with 2011 but remains well below the levels required for the Central Scenario, reaching average levels of \$13 billion over the projection period as a whole. Overall, the power sector absorbs a slightly higher share of investment spending than in the Central Scenario, which creates the potential for stress on public finances as the balance in spending shifts away from the high revenue-generating oil sector. The share of oil export revenue in GDP, though, remains stubbornly high at around 60% (this indicator falls to a lower level by 2035 in both the Central Scenario and the High Case).

Iraq's impact on international oil markets

The international market context is a crucial consideration in assessing the prospects for Iraq's oil output. On the demand side, the speed and location of global oil consumption growth in the Central Scenario implies for Iraq a continued shift in orientation towards markets in the Asia-Pacific region, to which around 50% of Iraq's oil exports go at present. While recognising any exporter's interest in diversity of markets, Iraq's position as the major provider of additional barrels of oil to the world market means that it will naturally be drawn to the high-growth markets, notably China and India, where growth in global oil consumption will be concentrated.⁵ In the same period, overall demand for oil in European and North American markets declines by around 1% per year and the demand for imported oil in North America falls much faster, because of growth in indigenous production.

5. Chinese oil companies are active in Iraq's upstream: CNPC is a partner in the consortium development of the Rumaila field and operator of Ahdab; Petrochina is operator of Halfaya and CNOOC of the Missan Group. These fields account for more than 2 mb/d of Iraq's anticipated production in 2020 in the Central Scenario. India's Reliance has two licences (Sarta and Rovi) in the KRG area.

Figure 4.5 ▶ Growth in OPEC and non-OPEC supply in the Central Scenario



Note: 2010 is used as the base year for this chart to exclude the impact of temporary market exigencies in 2011, such as the loss of supply from Libya and the high level of non-OPEC outages.

On the supply side, the major trend of importance to Iraq in the near term is the rise in non-OPEC production, driven by the rise of unconventional oil, especially light tight oil,⁶ in North America and anticipated increases in output from Brazil and, to a lesser extent, Kazakhstan. For the next few years, the projected growth in non-OPEC supply is sufficient to meet a significant part of incremental global demand. However, towards 2020, non-OPEC oil supply starts to tail off, requiring substantial growth in production of crude oil and natural gas liquids (NGLs) from the OPEC countries. Compared with a baseline of 2010, the requirement for additional production of crude and NGLs from OPEC countries rises substantially, starting from the latter part of this decade, and reaches around 4 million barrels per day (mb/d) in 2020 and almost 12 mb/d 2035.

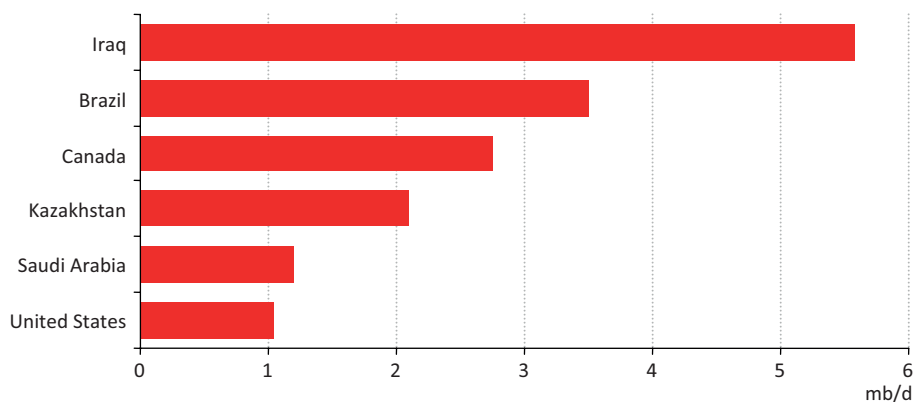
The Central Scenario

Over the period to 2035, Iraq is set to become one of the main pillars of global oil output. On the basis of the projections in the Central Scenario, Iraq, by some distance, plays the largest role in global oil supply growth over the period to 2035 (Figure 4.6), at the end of which only ten countries in the world are projected to produce more oil than they did in 2011.⁷ The growth in Iraq's output of 5.6 mb/d over this period is more than 2 mb/d higher than that of Brazil and is double that of Canada.

6. Light tight oil is produced from shale, or other very low permeability rocks, with technologies similar to those used to produce shale gas.

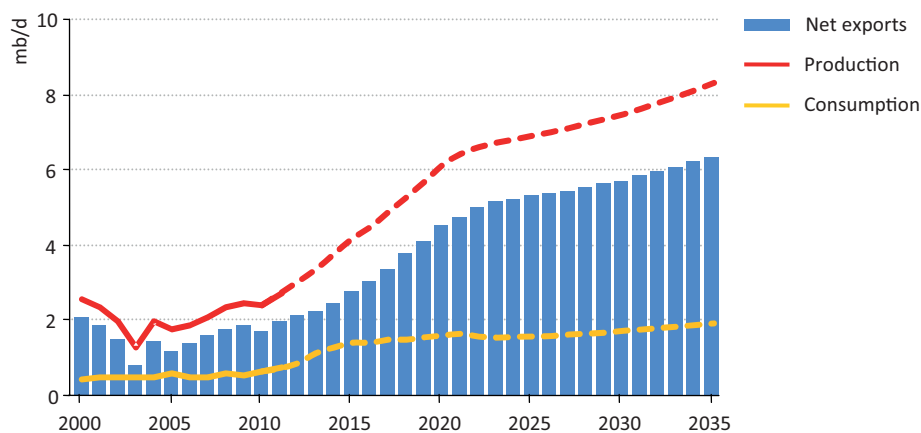
7. The other producers with higher projected production in 2035 than in 2011 are Venezuela, Kuwait, the United Arab Emirates and Libya, the latter's contribution amplified because of low production in the base year.

Figure 4.6 ▷ Major contributions to global oil supply growth to 2035 in the Central Scenario



Offsetting projected internal demand in Iraq from projected supply in the Central Scenario allows Iraq's oil exports to increase substantially during the projection period, with the steepest period of growth starting around 2015 and continuing into the early 2020s, after which growth is more gradual. Iraq's exports rise to 4.4 mb/d in 2020 and 5.2 mb/d in 2025, finishing the projection period at 6.3 mb/d (Figure 4.7). In the period to 2015, a larger share of incremental oil production is absorbed on the domestic market, primarily for power generation, but this temporary increase slows (and is then reversed in the power sector) as larger volumes of natural gas become available.

Figure 4.7 ▷ Iraq oil balance in the Central Scenario



These projections also make Iraq the largest contributor to global oil export growth. As a result, Iraq is set to overtake Russia around 2030 to become the second-largest global oil exporter, behind Saudi Arabia. Virtually all of the oil exported at present from Iraq is crude oil and we anticipate that this will continue to be the case (Box 4.2).

Box 4.2 > Crude quality and marketing options

The crude oil produced by Iraq varies in quality and density, meaning that the country's ability to combine crudes into a consistent blend is an important element in maximising export values. At present, Iraq exports two different crudes, Basrah Light (with a contractual American Petroleum Institute [API] gravity of 34°) by tanker from the south and Kirkuk Blend (which is actually lighter, with a contractual 36° API, than its southern counterpart) by pipeline to the north. However, it often has to offer discounts to compensate for the specification of the delivered oil being heavier than the contractual figures, as a result of heavier crudes and heavy fuel oil being blended into the export stream.

Over time, our production profile implies that a greater variety of crudes will be produced in Iraq, including a larger share of heavier crudes. Most production thus far has been from a geological formation (the Zubair, not to be confused with the field of the same name) containing an intermediate density crude around 35° API. But as this formation is gradually depleted, so new supplies are set to come in larger volumes from the shallower Mishrif layer, which generally contains heavier crude (with an API gravity in the mid to high 20s), together with more limited quantities from the deeper Yamama layer (which is lighter). The expected quality variation is not so great as to cause difficulties for buyers of Iraqi crude since we anticipate that much of Iraq's export crude will go to markets in Asia, where demand is growing most quickly and where the large, modern refineries can handle crudes with a range of specifications. Nonetheless, in order to ensure that it captures the maximum value from its exports, Iraq will need to anticipate in its marketing strategy these changes in the quality of its oil production. For the moment, it may be optimal to manage the heavier crude stream by blending it, but – as the share of heavier oil increases – it may become more advantageous to avoid blending the heavy oil, selling it separately, and maintaining the integrity and consistency of the distinct streams.

The strategy adopted by the government will have an impact on the delivery and surface facilities required. If the overriding objective is to diversify export routes, avoiding over-reliance on the Straits of Hormuz, this would point to the early addition to (or expansion of) overland export routes to the Mediterranean. However, our projections suggest that the highest market value for Iraq is to be found in the other direction, towards Asia. This would suggest giving a priority to establishing dedicated facilities to handle an additional crude export stream by tanker from the south. These options are by no means mutually exclusive, but Iraq needs to make a judgement between market and strategic considerations to determine priorities for infrastructure spending.

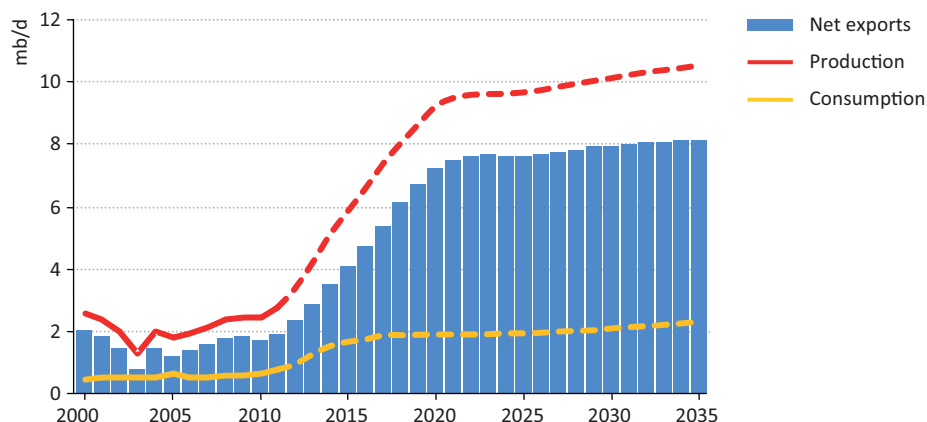
In the Central Scenario, Iraq can meet the lion's share of the required growth in OPEC supply of crude and NGLs during the period to 2020. After 2020, the incremental production is shared more broadly among OPEC countries, with Iraq accounting for just over a quarter of the increase. Iraq's claim to incremental OPEC supply over the current decade is buttressed by the need for export revenue to finance its recovery after decades of conflict and stagnation (a period during which the absence of Iraqi capacity contributed to the build-up of large financial reserves and wealth funds in many other producing countries). If Iraq's exports grow as foreshadowed in our projections in the Central Scenario, estimated revenues earned by the rest of OPEC remain well above \$1 trillion per year throughout the projection period, rising steadily after 2020 to over \$1.3 trillion in 2035.

Despite the inevitable uncertainty over future market conditions, it can be said with some confidence that the needs of the global market for growth in production from Iraq along the lines of the Central Scenario are in line with Iraq's own needs for export revenue to support its own reconstruction and development. Realising the projections in this scenario would represent a major contribution from Iraq to the stability of global oil markets.

Iraq's oil market impact in the High and Delayed Cases

In the High Case, the projected level of Iraqi oil production and exports is substantially higher than in the Central Scenario, particularly in the period to 2020 (Figure 4.8). As production rises to more than 9 mb/d in 2020, projected exports rise to above 4 mb/d already in 2015 (approximately the level reached in the Central Scenario in 2020), and are more than 7 mb/d in 2020. Production growth of this magnitude would represent a much larger share of global incremental oil supply, more than three-quarters of the total anticipated increase to 2020 in the Central Scenario. This is also a period during which there is significant anticipated growth in non-OPEC supply. If Iraq were to capture the incremental market share to this extent, in order for OPEC to keep its share of global production at the level anticipated in the Central Scenario the rest of OPEC would need to reduce production up to 2020 well below the level in 2010. In the High Case that we have modelled, part of the additional increase in Iraq's output (compared with the Central Scenario) is indeed accommodated by adjustments by other OPEC producers, but not all of it. As a result, there is a shift in the global balance between supply and demand, producing a lower trajectory for the international oil price than that assumed in the Central Scenario. In the High Case, the international price is around \$115 per barrel in 2020, remaining around these levels to 2035. As a result of lower prices, oil consumption is slightly higher, reaching 101 mb/d by the end of the projection period.

Figure 4.8 ▶ Iraq oil balance in the High Case



Global market uncertainties must be taken into account. To the extent that growth in global oil use is faster than we project – or growth in global supply from other producers lower than we anticipate – the requirement for incremental Iraqi oil would increase. These circumstances could result from faster than expected economic growth over the coming years, governments failing to implement announced policies to constrain the growth in oil consumption or a change in upstream prospects (as, for example, the moratorium on deepwater drilling following the Deepwater Horizon disaster in the Gulf of Mexico). Alternatively, the Iraqi authorities could seek to manage market impacts to some extent by opting to develop spare production capacity over and above actual output, reducing the volumes exported but retaining some flexibility to respond to short-term market needs (Spotlight). Deliberately creating spare production capacity is unlikely to be an early Iraqi priority but, if in the longer term the country's most pressing needs have been met, Iraq's aim to hold a reasonable reserve of spare capacity would bring new confidence to global markets.

The projections in the Delayed Case present a very different outlook for oil markets, which – without the growth in supply from Iraq projected in our Central Scenario – would be heading for troubled waters. In a Delayed Case, Iraq's oil production, though it continues to rise, reaches only 5.3 mb/d by 2035, 3 mb/d short of the level expected in the Central Scenario. Supply from Iraq at the levels projected in the Delayed Case would act to tighten oil markets considerably over the projection period, producing a significant increase in the international oil price. This is 3% higher than in the Central Scenario in 2020 and 11% higher by 2035 (almost \$140 per barrel in real terms in 2035 or \$240 per barrel in nominal terms). There is also likely to be a significant increase in price volatility.

Why invest in spare oil production capacity?

Iraq's contribution to global oil markets depends not only on its capacity to produce, but also on its potential to respond to market needs by adjusting output. This means retaining some spare oil production capacity, ready to be deployed as and when Iraq judges that responding to additional market needs best serves its national interest. At present, the major share of global spare oil production capacity rests with Saudi Arabia, but Iraq has set the strategic aim also to develop a degree of flexibility.⁸

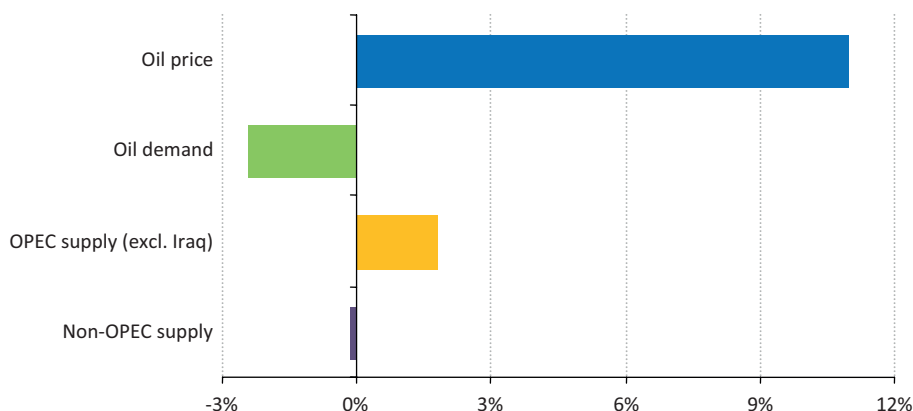
Spare production capacity is an international public good that provides a buffer against sudden or unforeseen market developments and, like the oil stocks held by importing countries, some insurance against the impact of disruptions to supply. Avoiding price spikes and consequent demand destruction is demonstrably in the interest of oil producers as well as consumers, but spare production capacity can be difficult to justify since – by definition – there is no reliable revenue stream associated with this investment.

To the extent that a rise in Iraq's production displaces supply by other producers, Iraq could well have an indirect impact on global levels of spare capacity before it develops any of its own. The timing of any Iraqi decision deliberately to create its own spare capacity is uncertain: given Iraq's pressing needs in other sectors of the economy, this is unlikely to be a viable proposition in the short- to medium-term, though it could ultimately be an important opportunity. We estimate that a barrel per day of oil production capacity in Iraq costs, on average, \$10 000–\$15 000 (in year-2011 dollars). This means that the upstream investment required to build 1.5 mb/d of spare capacity would be between \$15–\$22.5 billion. For comparison, oil export revenue in the Central Scenario is projected to be around \$200 billion in 2020.

Prices at these levels would have an impact on global oil demand in the Delayed Case, which reaches 94 mb/d by 2020 (0.5 mb/d lower than the Central Scenario) and 97 mb/d by 2035 (2.4 mb/d lower), primarily as a result of reduced growth in the transport sector. The response from consumers is a mix of conservation (for example via reduced driving distances), faster penetration of more efficient technologies and switching away from oil to alternative fuels. The shortfall in Iraq's supply, compared with the Central Scenario, means additional reliance on other producers to raise output, and this would be anticipated to come primarily from OPEC countries (an additional 700 thousand barrels per day [kb/d] by 2035). The strain on markets becomes increasingly evident in the period from 2020 onwards, as the global market starts to rely on a smaller number of producers for additional production.

8. The technical service contracts concluded by the federal authorities and the production-sharing contracts with the Kurdistan Regional Government include provisions allowing the authorities to curtail production. However, the modalities to compensate contractors for capacity built but not used are not clear, in some cases, and not yet tested in practice.

Figure 4.9 ▶ Key oil market indicators in 2035 in the Delayed Case, compared with the Central Scenario



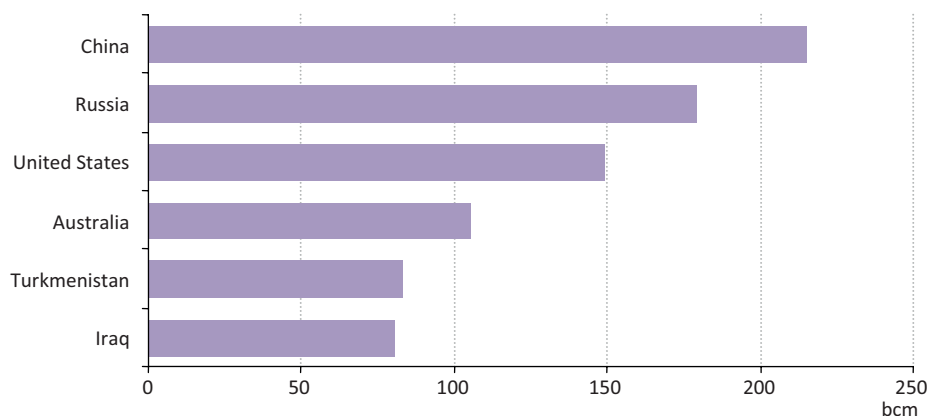
Iraq's impact on international gas markets

Natural gas plays an increasingly important role in Iraq's energy balance in all the scenarios and cases examined. Marketed gas production in Iraq in the Central Scenario rises to almost 90 billion cubic metres (bcm) in 2035, a full 80 bcm higher than in 2011. This rate of increase is one of the fastest in the world and only five countries achieve faster absolute growth over this period (Figure 4.10). Among major gas producers, none comes close to matching Iraq's ten-fold increase in marketable gas output (albeit from a very low base).⁹ Iraq's projected production in 2035 consists of roughly equal shares of associated and non-associated gas. As noted in Chapter 3, gas provides an important substitute for oil use in the domestic market, freeing up the more valuable and more easily exported commodity.

Whereas in the oil sector domestic consumption remains small compared to anticipated levels of production and export volumes can be counted upon to grow fast, the perspectives for gas are less clear-cut. There is still significant uncertainty over the extent to which gas will be used in the domestic market for electricity and industrial uses and how quickly gas flaring will be reduced. Moreover, according to our projections, the associated gas that will be produced along with rising oil production will not be sufficient in itself to allow for gas export. In the Central Scenario, cumulative production of associated gas is enough to cover only around 70% of anticipated demand from within Iraq over the period to 2035. As discussed in Chapter 2, the development of Iraq's non-associated gas resources will therefore be the key to determining the prospects for, and extent of, potential gas export.

9. The ten-fold increase in marketable gas production should be seen in the context of the volumes of gas that are currently flared. Iraq's total gas production (including flaring) is today close to 20 bcm, so we are in practice projecting that total output will be about 4.5 times larger than today, but with a significant reduction in gas flaring.

Figure 4.10 ▷ Growth in natural gas production in selected countries in the Central Scenario



In the Central Scenario, rising gas production is accompanied by increased use of gas in power generation until the latter part of this decade, with a surplus in the national balance available for export from 2020.¹⁰ Gas export is stable around 10-15 bcm during the 2020s, before rising again after 2030 to reach 17 bcm by the end of the projection period (Figure 4.11). The growth in gas processing capacity also means that Iraq will become a substantial producer of liquefied petroleum gas (LPG), which is widely used in Iraq and in the region as a fuel for cooking and heating and, increasingly, also within the petrochemicals sector. From its current position requiring LPG imports of around 33 kb/d in 2011, Iraq becomes a net exporter in 2016 and, by 2035, is expected to export around 220 kb/d.¹¹

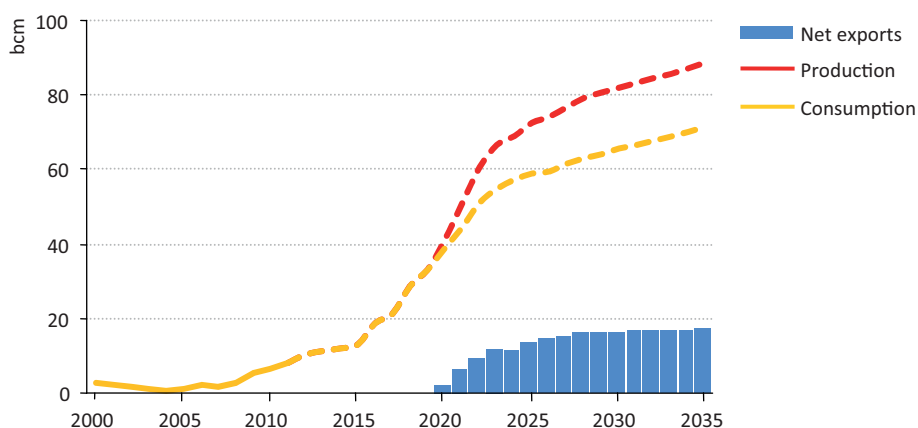
For policy makers and potential investors in the sector, a key question to be clarified is how Iraq will manage the trade-off between the low value of gas on the domestic market – which needs to be supplied first – and the more attractive returns available on export markets. This requires a clear strategic vision on how the gas supply-demand balance might best evolve (which, because of the importance of associated gas, therefore depends to a significant degree on the trajectory targeted for oil production) and on the incentives in place for non-associated gas production. There is also the question of how decisions regarding gas export

10. There are plans in place for gas imports to central Iraq via a new pipeline from Iran, primarily for use in power generation. Volumes of up to 25 million cubic metres per day have been agreed in principle for a period of five years, which would boost gas availability until domestic supplies become available (and free up some of the oil that would otherwise be used for power generation). The longer-term perspectives are not clear. If imports from Iran were to continue beyond the agreed five-year period, this could allow for a commensurate increase in Iraq's gas exports.

11. LPG (a mixture of propane and butane) is a product both of gas processing and oil refining. Exports of LPG – as well as condensate and other natural gas liquids – are included in the volumes and revenue calculations for oil. Iraq's projected output of 440 kb/d (15 million tonnes [Mt] per year) in 2035 would make it one of the world's leading LPG producers: global LPG production in 2010 was 7.7 mb/d (240 Mt), with Saudi Arabia the largest producer in the region at 700 kb/d (21 Mt).

will be taken, an aspect of the vexed issue of overall governance of the hydrocarbons sector and the differences between the federal authorities and the Kurdistan Regional Government (KRG). Clarity on these questions, already vital for successful oil exploitation, could bring forward and expand the prospects for gas export from Iraq, while continued uncertainty will push them back. A further possibility is that Iraq might use part of any gas surplus to generate electricity for export to neighbouring countries: over relatively short distances, exporting “gas-by-wire”, *i.e.* gas-fired electricity, can be competitive with “gas-by-pipe”.

Figure 4.11 ▶ Iraq gas balance in the Central Scenario



The geography of gas production within Iraq is important. In the south of the country, the overall perspectives are closely tied to the outlook for oil and associated gas production, how quickly the currently flared volumes are captured and processed and decisions on gas-consuming industrial development in the area around Basrah. As part of the investment plan for the Basrah Gas Company, Shell and Mitsubishi have proposed a southern export facility, with a capacity of 4 million tonnes (Mt) of LNG per year (around 5.5 bcm per year). Such a gas export project would require a large up-front investment in liquefaction and export facilities, provisionally estimated to cost more than \$4 billion. There is also the southern non-associated Siba gas project, awarded in the third national licensing round to a consortium led by Kuwait Energy, some of the production from which could be allocated for export to nearby Kuwait.

In the west of Iraq, the main potential source of gas for export is the Akkas field, near the border with Syria, the development of which was awarded in the third national licensing round to a consortium led by Korea’s KOGAS. The debate over the Akkas field illustrates well the potential for friction between the aims of providing gas for domestic supply or for export: responding to the possibility that gas from Akkas might be earmarked for supply to Syria, the authorities in Anbar province (where the field is located) argued that gas should

be primarily used on the local market for power generation and to promote industrial development. The result (as reflected in the deal signed with KOGAS in 2011) was to prioritise supply of produced gas to Anbar's power plants, leaving scope for any surplus to be exported. For the moment, unrest in Syria has closed the debate about export, leaving a question mark over the source of demand for any uncommitted gas produced in the Western Desert. Our projections for this part of Iraq see gas production picking up only after 2020.

Although the resources in the west may be of comparable size, the main potential for non-associated gas production in Iraq over the projection period is in the north of the country, particularly in the KRG area. Turkey provides a large, proximate export market, with an increasing need for imported gas, as well as a conduit to markets in the rest of southeast Europe and, further, to the European Union. A report for the European Commission (Mott MacDonald, 2010) identified Iraq as a very promising source of gas supply to the European Union, suggesting trade volumes in 2030 at 15 bcm (in a base case) and 30 bcm (in an optimistic scenario), figures that are broadly in line with our own projections. Northern Iraq is seen as the most likely initial source of gas, with a second phase potentially involving also associated gas from southern fields.

The potential for gas production in the north is undoubtedly high and the possibility of export is generating strong interest from international investors in gas projects. The prospects and timing for export are though subject to considerable uncertainty. The Khor Mor and Chemchemal fields, for which contracts have been awarded by the KRG, represent a significant share of the region's gas potential in the medium term (and Khor Mor is currently producing). These are being developed under a technical service contract which provides for gas to be sold for local power generation at very low prices. Mobilising investment to develop the fields requires a perspective on monetising the natural gas liquids (an LPG plant was commissioned in 2011), a change in the pricing of gas for the local market, or clarity on the conditions for natural gas export. For the moment, however, the dispute that has meant only intermittent use of federal channels for oil export from the KRG area, due to the differences between the KRG and the federal authorities (who insist that they alone have constitutional authority for international energy trade), has cast a similar shadow over gas export. Moreover, raising the price paid for local consumption of gas involves a no less politically challenging decision to increase the price of electricity paid by end-users and would, in any case, be unlikely to raise the value of the gas to that available on international markets.

Potential gas export markets and routes

If and when Iraq does start to export its gas, it will have a wide range of available markets, with many of its neighbours dependent on imports of gas to meet their domestic needs. Four of Iraq's neighbours are currently reliant upon imports (Turkey, Jordan, Kuwait and Syria) and Saudi Arabia also faces a looming deficit of gas. Gas consumption in the

Middle East as a whole has been increasing at more than 8% per year over the last three decades and, although this annual growth is expected to slow as gas markets become more mature, gas use in the region as a whole is still projected to rise by more than 70% in the period to 2035. There are, therefore, robust drivers for regional trade, underpinned by the consideration that export would, in many cases, require only short cross-border interconnections.

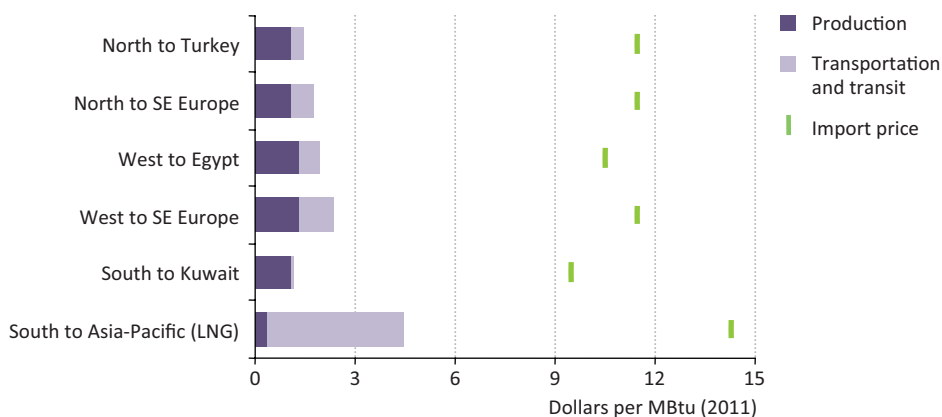
There are, though, relatively few of these links in place and energy trade among the countries of the Middle East remains far below its potential. Many energy flows in the past have been interrupted by politics or conflict. Iraq's only existing gas export pipeline is a case in point: a link between Rumaila and Kuwait was completed in the mid-1980s to transport Iraqi gas to Kuwait, but it has been inoperative since Iraq's invasion in 1990. This legacy of political risk is likely to continue to hamper the development of energy trade (including electricity trade) within the region. A further potential constraint on export to Middle Eastern markets is the seasonality of electricity and gas use, with many countries – including Iraq – experiencing higher demand in the summer months. Where the export volumes are sourced in whole or in part from associated gas (in which case the operator has much less discretion to vary gas output), reliable export to these countries would require investment in sufficient storage to match the variations in demand.¹²

In the Central Scenario, Turkey and other European markets are expected to require substantial additional volumes of imported gas. The likelihood of new gas transportation capacity across Turkey to accommodate export volumes from Azerbaijan offers an opportunity for tie-ins from northern Iraq, and the possible extension of these pipeline routes into southeast Europe provides an opening for Iraq to become a supplier to European gas markets, which are projected to require almost 200 bcm in additional gas imports as demand rises and indigenous production falls. To the south, LNG export would provide Iraq with an entry to the fast-growing markets in the Asia-Pacific region.

Our analysis of the cost of delivering gas from Iraq to a variety of possible regional and international markets in 2020 suggests that it can be very competitive (Figure 4.12). The highest supplied cost is that of LNG to Asia-Pacific markets, primarily because of the large investment required in liquefaction capacity; this option does, though, offer flexibility in terms of destination and access to the higher prices assumed to be available in Asia-Pacific markets, compared with Europe. The analysis shows that the delivered cost of pipeline gas exported to any of the regional markets, including markets in southeast Europe (assumed here as the western border of Turkey with Bulgaria or Greece) would be well below the price assumed for these markets in 2020.

12. This storage could be either in the importing or the exporting country. At present, Iraq has no underground gas storage: a facility built in the 1980s in the Kirkuk region for LPG, which held a surplus during summer months for retrieval during periods of peak demand in the winter, is no longer in use.

Figure 4.12 ▷ Indicative delivered supply costs and prices for Iraq gas export, 2020



Notes: All costs are indicative, in year-2011 dollars. Dry gas costs are assumed to be low because gas production and processing in Iraq is generally accompanied by substantial output of natural gas liquids. Supply costs for individual projects could vary significantly, depending on their detailed design. The source of the gas is assumed to be non-associated gas fields, with the exception of southern production feeding into a possible LNG plant, which is assumed to be associated gas. Production costs do not include taxes or royalties. The cost of shipping LNG to the Asia-Pacific market is an average of the cost of transportation to the Indian and Chinese markets. The bulk of the cost, in any case, consists of the cost of facilities for LNG liquefaction. Import price assumptions for 2020 are from the Central Scenario. MBtu = million British thermal units.

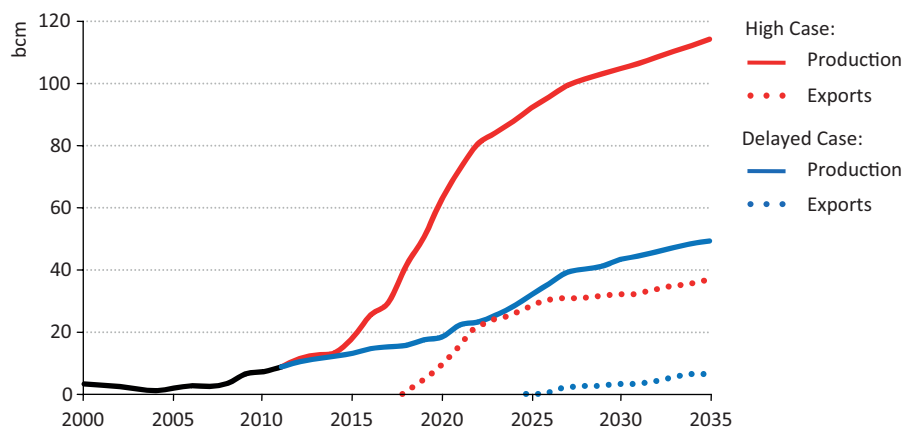
Variations in the High Case and the Delayed Case

In the High Case, the volume of gas available for export is pushed higher as the increase in production (both from associated and non-associated gas) is larger than the projected increase in domestic demand (from higher GDP growth). Gas export also starts slightly earlier than in the Central Scenario, in 2019, and reaches 25 bcm by the mid-2020s and 37 bcm by the end of the projection period. By contrast, in the Delayed Case, associated gas is held back by lower oil production, while opportunities in non-associated gas are deemed unattractive or too risky because of prolonged uncertainty over the conditions for investment and export. In this case, production is initially able to keep pace with (lower) domestic gas demand, but a surplus emerges only after the mid-2020s, with projected exports reaching 7 bcm by 2035 (Figure 4.13).

Although attention will rightly be focused on oil output as a key indicator of Iraq's energy performance in the coming years, progress in developing the gas sector – both as a fuel for domestic use and eventually also for export – may in practice be a more reliable indicator of the quality of Iraq's institutions and policies. This sector highlights more than any other the challenges of policy co-ordination, requiring that gas availability match the growth of new sources of gas demand (in power generation and industry) and takes account of the growth of modern refining capacity (to absorb otherwise surplus heavy fuel oil). If Iraq

does not succeed in managing these challenges, there will be a range of lost opportunities across the energy sector as a whole, likely to result in increased domestic oil demand (with implications also for oil exports and for Iraq's fiscal position). If Iraq does succeed in developing a viable domestic gas sector, this will be a substantial step not only in moving the country away from high direct dependence on oil but also a signal that the institutional capacity is there to take on other challenges facing the Iraqi energy sector and the economy as a whole.

Figure 4.13 ▸ Natural gas production and export in the High Case and the Delayed Case



Units and conversion factors

This annex provides general information on units and general conversion factors.

Units

Emissions	ppm	parts per million (by volume)
	Gt CO ₂ -eq	gigatonnes of carbon-dioxide equivalent (using 100-year global warming potentials for different greenhouse gases)
	kg CO ₂ -eq	kilogrammes of carbon-dioxide equivalent
	gCO ₂ /km	grammes of carbon dioxide per kilometre
	gCO ₂ /kWh	grammes of carbon dioxide per kilowatt-hour
Energy	boe	barrels of oil equivalent
	toe	tonne of oil equivalent
	Mtoe	million tonnes of oil equivalent
	MBtu	million British thermal units
	MJ	megajoule (1 joule x 10 ⁶)
	GJ	gigajoule (1 joule x 10 ⁹)
	TJ	terajoule (1 joule x 10 ¹²)
	kWh	kilowatt-hour
	MWh	megawatt-hour
	GWh	gigawatt-hour
	TWh	terawatt-hour
Gas	mcm	million cubic metres
	bcm	billion cubic metres
	tcm	trillion cubic metres
Mass	kg	kilogramme (1 000 kg = 1 tonne)
	kt	kilotonnes (1 tonne x 10 ³)
	Mt	million tonnes (1 tonne x 10 ⁶)
	Gt	gigatonnes (1 tonne x 10 ⁹)
Monetary	\$ million	1 US dollar x 10 ⁶
	\$ billion	1 US dollar x 10 ⁹
	\$ trillion	1 US dollar x 10 ¹²

Oil	b/d	barrels per day
	kb/d	thousand barrels per day
	mb/d	million barrels per day
Power	W	watt (1 joule per second)
	kW	kilowatt (1 Watt x 10 ³)
	MW	megawatt (1 Watt x 10 ⁶)
	GW	gigawatt (1 Watt x 10 ⁹)
	TW	terawatt (1 Watt x 10 ¹²)

General conversion factors for energy

Convert to:	TJ	GWh	MBtu	Mtoe
From	multiply by:			
TJ	1	0.2778	947.8	2.388 x 10 ⁻⁵
GWh	3.6	1	3 412	8.6 x 10 ⁻⁵
MBtu	1.0551 x 10 ⁻³	2.931 x 10 ⁻⁴	1	2.52 x 10 ⁻⁸
Mtoe	4.1868 x 10 ⁴	11 630	3.968 x 10 ⁷	1

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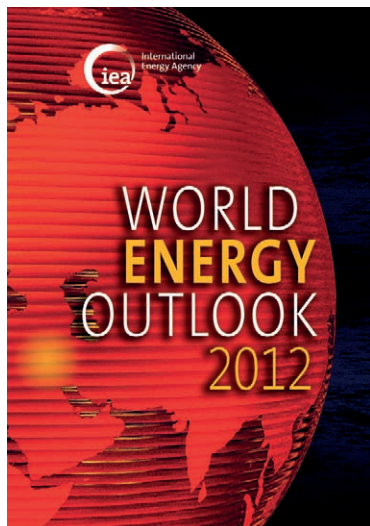
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