Outlook for Producer Economies 2018

What do changing energy dynamics mean for major oil and gas exporters?

World Energy Outlook Special Report

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A career in energy means, on occasion, returning with fresh eyes to some familiar themes. For many years, I have been following the efforts made by countries that rely heavily on revenues from oil and gas to diversify their economies. This is a longstanding ambition for many producers, and progress has been made.

But changes in today's energy sector – from the shale revolution to the renewable energy revolution – are giving these efforts new momentum and urgency.

This report in the *World Energy Outlook* series is very timely. It highlights the strategic importance of these ambitious reform programmes for economic and social development. It underscores the risks that can arise from excessive reliance on volatile hydrocarbon income, as the current situation in Venezuela amply demonstrates.

What comes through clearly is that energy is at the heart of the reform process, even if the ultimate aim of reform is to diminish reliance on hydrocarbons. Energy provides the means to reform and can also provide an enduring source of comparative advantage.

The report also highlights a shared interest in a positive outcome: this is an issue with wide-ranging implications for energy security, for the global economy and for the pathways to reach sustainable development goals.

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A changing energy system is posing critical questions for many of the world's largest oil and gas producers. The shale revolution in the United States, technological change, the drive for energy efficiency and the long-term response to climate change all imply sustained pressure on development models that rely heavily on hydrocarbon revenues.

This report focuses on "producer economies", defined as large oil and gas exporters who are pillars of global supply and rely on hydrocarbon revenues to finance a significant proportion of their national budgets. Circumstances and outlooks vary widely, but these economies tend to be less diversified and more vulnerable to price shocks than other economies. We mainly concentrate our analysis on six countries: Iraq, Nigeria, Russia, Saudi Arabia, United Arab Emirates and Venezuela.

The rollercoaster in oil prices over the last decade has brought into sharp relief some structural weaknesses in these countries. Since 2014, the net income available from oil and gas has fallen by between 40% (in the case of Iraq) and 70% (in the case of Venezuela), with wide-ranging consequences for economic performance. Major swings in hydrocarbon revenue can be deeply destabilising if finances and economies are not resilient.

The risks of high dependence on volatile oil and gas revenue have prompted a number of countries to renew their commitment to reform and diversify their economies. There are signs of progress; how these producers respond to a changing policy and market environment is crucial not only for their own future prospects, but also for global energy markets, energy security and the achievement of global sustainable development goals.

The imperative for reform remains strong in the New Policies Scenario, our main scenario[1], even in a relatively benign context of gradually rising hydrocarbon demand and prices. Net income from oil and gas grows, particularly after the mid-2020s when oil production from the United States is projected to plateau. Yet the arguments for economic diversification remain persuasive given the continued risks of market volatility, long-term policy uncertainty, and – particularly in Nigeria, Iraq and Saudi Arabia – the pressing need to create employment opportunities for a large and youthful population.

The risks multiply in a lower oil price environment. In a case in which oil prices settle in a $60-70/barrel range, net oil and gas income never recovers to 2010-15 levels, leading to a cumulative $7 trillion loss in revenue over the period to 2040 compared with the New Policies Scenario. Without far-reaching reforms, this would translate into large current account deficits, downward pressure on currencies and lower government spending. In the Middle East, the downside economic risk equates to a $1 500 drop in average annual disposable income per person.

Accelerated energy transitions would put further pressure on hydrocarbon volumes as well as prices. In a Sustainable Development Scenario[2], much stronger policies on fuel

[1] The New Policies Scenario describes where existing policies and announced policy intentions might lead the energy system over the period to 2040.

[2] The Sustainable Development Scenario outlines an integrated approach to achieving international objectives on climate change, air quality and universal access to modern energy.

efficiency and fuel switching, including rapid growth in electric mobility, lead to an early peak in oil demand and curb growth in natural gas. Overall hydrocarbon revenues to 2040 are similar to those in a low oil price world, but the case for economic diversification is inescapable.

The reform agenda for producer economies is much broader than energy, but relies on a well-functioning energy sector. Maintaining investment and the advantages of a large, low-cost resource base are vital. Some producer economies – notably Iraq, Nigeria and Venezuela – face major hurdles in bringing sufficient investment to their upstream sectors. There are few signs on the horizon of the macroeconomic or policy changes that would arrest the decline of oil output in Venezuela, where production has halved since 2016.

Periods of higher prices due to under-investment or geopolitical disruption offer the possibility of temporary relief for producer economies, but they also present a clear downside. They ease the pressures for reform while simultaneously accelerating the policy momentum behind alternatives to oil and gas, especially in some of the emerging energy demand giants in Asia that are particularly sensitive to price swings. Recent history suggests that higher prices would encourage new, higher cost production in other parts of the world, setting the stage for prices to fall again.

Pricing reform and energy efficiency offer major opportunities to rationalise consumption and encourage more diversified growth, without foregoing the economic opportunities to capitalise on abundant energy resources. In the Middle East, effective implementation of efficiency policies and deployment of the region's huge solar potential can also help to meet the rapid projected growth in demand for energy services, especially for cooling.

Moving further downstream in the oil value chain to refining and petrochemicals is a major focus for many producing economies. The Middle East sees an increasing share of both global refinery and petrochemical output in our main scenario. Investment in non-combustion uses of oil, such as petrochemicals, opens up new revenue streams and provides a hedge against the risk of a possible contraction of transport oil demand.

It should not be taken for granted that the comparative advantage in energy of major producers disappears during energy transitions. These countries can produce some of the least costly and least emissions-intensive oil and gas, and could choose to play a leading role in energy technology development, including areas such as carbon capture, utilisation and storage and hydrogen supply.

More than at any other point in recent history, fundamental changes to the development model in resource-rich countries look unavoidable. The process of change promises to be complex and challenging, and in many cases requires major improvements to the institutional foundations for private sector growth. Inaction or unsuccessful efforts to reduce reliance on hydrocarbon revenue would compound the risks facing both producer economies and global markets. Successful reform would also have multiple implications for energy markets and for efforts to reach global environmental goals. There is much at stake.

Energy is a vital input to all economies around the world. But there are some economies in which the production of energy itself, and in particular the revenue associated with oil and natural gas export, is the lifeblood of the system. This special report, part of the *World Energy Outlook-2018* series, explores the outlook for these hydrocarbon-dependent economies in a world in which a combination of the shale revolution and long-term uncertainty over demand for oil and gas are intensifying pressures for change. How these pressures evolve, and how producer economies respond – in our judgement – are crucial variables for the vitality of the producer economies, as well as for energy markets, energy security and the achievement of global sustainable development goals.

Which are the producer economies?

There are many oil and natural gas producers around the world, but for this analysis, we identify those countries that are most susceptible to large structural shifts in price or demand for oil and gas.[1] We therefore established three criteria, which countries needed to meet concurrently:

- They are large producers of oil and/or natural gas.
- Oil and natural gas exports make up at least one-third of total exports of goods.
- Revenues from oil and natural gas contribute at least one-third of the country's total fiscal revenue.

High reliance on external revenue is a crucial consideration. Domestic sources of revenue imply productive sectors of the national economy. External revenue, if large enough, however, can support an economy even without a strong productive domestic sector (Beblawi and Luciani, 1987). Under these circumstances, there is a risk that the functioning of such states focuses more on the distribution and allocation of rents than on the creation of the conditions for enterprise, leading to a narrow and undiversified economic structure.

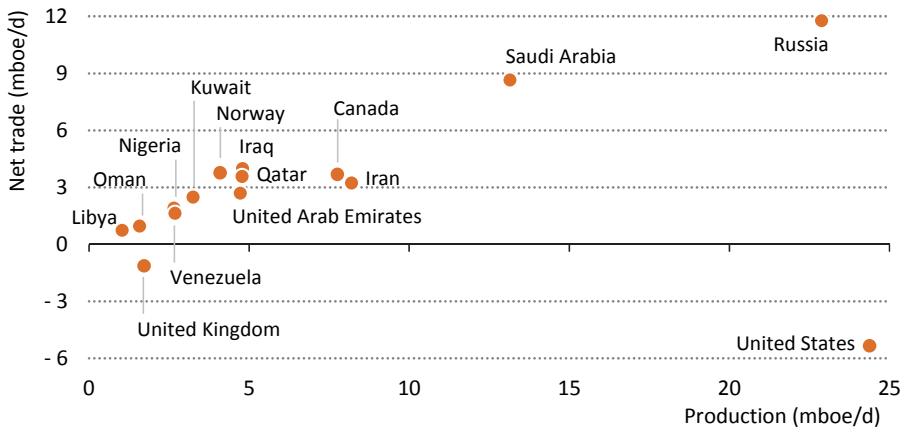
Not all large producers are net exporters of oil and gas, as in the case of the United States, even if the shale revolution is edging it towards net export status (Figure 1). By the same token, not all net exporters rely on the revenue from oil and gas to such an extent that it shapes their economic structure and prospects. Canada and Kuwait, for example, had similar levels of net exports of oil at around 2.5 million barrels per day (mb/d) in 2017, but the role of these exports in the respective economies is dramatically different. Oil and gas exports account for more than 90% of total exports in Kuwait, while the comparable figure in Canada is less than 15%. Similarly, oil and gas revenue accounts for 90% of fiscal revenue in Kuwait but less than 5% in Canada (Figure 2).

Using these criteria, we identified a number of large oil and gas producers and exporters whose economies are strongly dependent on hydrocarbon revenue: Angola, Azerbaijan,

[1] This report does not consider coal producers. This is in part because coal does not allow for the same capture of rent, and because the industry tends to be a much larger employer in many producing countries.

Iran, Iraq, Kuwait, Nigeria, Oman, Russia, Saudi Arabia, Turkmenistan, United Arab Emirates and Venezuela. This is a very diverse group and this *World Energy Outlook Special Report* concentrates mainly on **Iraq**, **Nigeria**, **Russia**, **Saudi Arabia**, **United Arab Emirates** and **Venezuela**[2], while drawing on examples from a range of others.

Figure 1 ▷ Oil and gas net trade and production in selected countries, 2017



Not all large producers of oil and natural gas are major net exporters: the United States is the main exception

Notes: mboe/d = million barrels of oil equivalent per day. Net trade is the difference between production and demand (including international marine and aviation bunker fuels).

The countries on which this report focuses are not necessarily those that are most vulnerable. Rather, they illustrate the range of starting points and circumstances among a group of countries that vary significantly by size and relative dependence on oil and natural gas, as well as by other variables such as demographics, financial savings and current economic performance.

In response to changing market and policy conditions, many producer economies have announced reform initiatives designed precisely to reduce dependence on hydrocarbons: the Saudi "Vision 2030" is a prime example. The scope and ambition of such plans vary widely by country. The strengths, vulnerabilities and the range of potential strategic responses among producer economies offer a broad perspective on the way that the future might evolve.

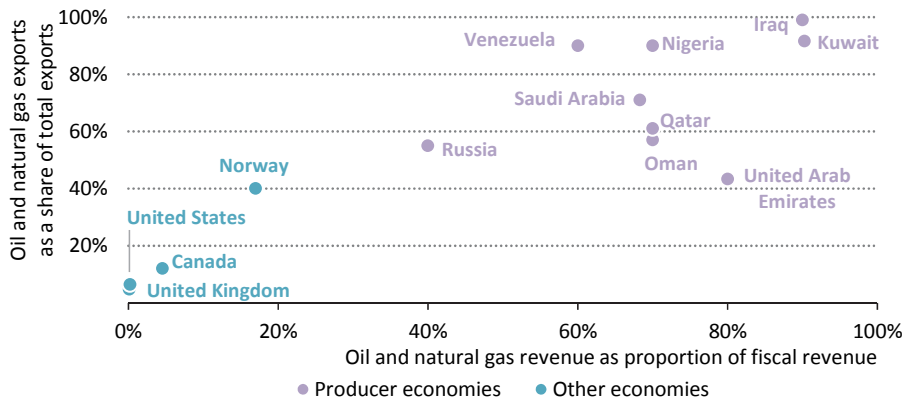
The size of net income[3] from oil and natural gas is a leading indicator used throughout this analysis. This is defined as the difference between the costs of oil and gas production,

[2] These countries are referred to as the "six producer economies" in this report in order to distinguish them from the wider group of oil and natural gas producing countries.

[3] This definition of net income is also referred to in the literature as oil and natural gas "rents"; it coincides with the definition used in the World Bank's "World Development Indicators".

including a normal return on capital, and the value realised from its sale on either domestic or international markets. This net income changes over time and between various scenario projections, depending on the cost and volume of production, as well as both the international and domestic price, including any applicable energy subsidies. Table 1 shows the abrupt swings in such income between the 2010-14 period and 2015-17, due to a sharp fall in prices.

Figure 2 ▷ **Oil and gas exports as a share of total exports and oil and gas revenue as a share of fiscal revenue in selected countries, 2017**



We define "producer economies" as those where oil and gas make up a significant share of both total exports and fiscal revenues

Notes: For Russia, the oil and natural gas revenue as a share of fiscal revenue refers to the federal budget, which we have considered for the sake of consistency with other countries covered in this report. Revenues from oil and natural gas account for around 20% of Russia's consolidated budget, which includes revenues and expenditures in the Russian regions.

Sources: Extractive Industries Transparency Initiative submissions; national accounts; World Bank.

Structure of the analysis

The producer economies that are the focus of this analysis are the bedrock of the world's hydrocarbons supply, playing a critical role in developing and bringing oil and natural gas to the world's consumers. Yet there are multiple uncertainties affecting the outlook for hydrocarbons and the revenue flows that sustain producer economies, not only because of fluctuating prices – a perennial concern – but also because of questions concerning long-term demand. We address these key uncertainties by framing the discussion in this report around three scenarios.[4]

[4] Additional detail of the design of these scenarios is included in the 2018 edition of the *World Energy Outlook*, which will be available 13 November 2018. See: www.iea.org/weo/.

Table 1 ▷ Estimated net income from oil and natural gas for selected countries

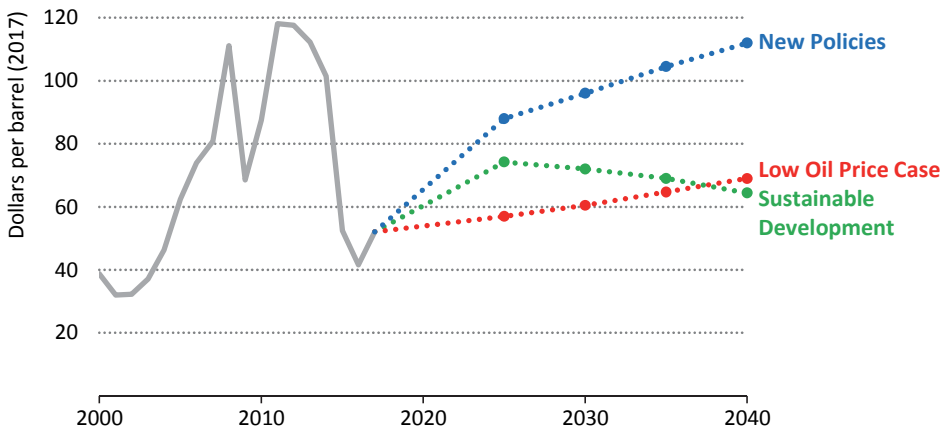
	Production 2017		Average total: 2010-14 ($2017 billion)		Average total: 2015-17 ($2017 billion)		O&G net income as share of GDP ($2017, PPP)		O&G net income on a per-capita basis ($)	
	Oil (mb/d)	Gas (bcm)	From export sales	From domestic sales	From export sales	From domestic sales	2010-14 average	2015-17 average	2010-14 average	2015-17 average
Iran	4.7	214	66	14	35	15	6%	3%	1 049	620
Iraq	4.6	8	78	7	53	6	17%	9%	2 583	1 575
Kuwait	3.0	17	86	3	39	5	32%	15%	26 211	10 856
Nigeria	2.0	43	65	7	18	8	7%	2%	429	142
Oman	1.0	36	26	13	9	7	24%	9%	11 121	3 631
Russia	11.4	694	273	145	102	55	11%	4%	2 915	1 089
Saudi Arabia	12.0	94	295	5	129	8	19%	8%	10 323	4 254
United Arab Emirates	3.8	62	92	14	43	12	18%	8%	12 110	5 967
Venezuela*	2.2	24	62	0	16	0	11%	3%	2 069	517
Norway	2.0	128	80	8	31	4	25%	9%	17 721	6 619
United Kingdom	1.0	42	0	35	0	11	1%	0%	543	171
United States	13.2	760	0	245	0	155	1%	1%	779	478

Notes: O&G = oil and gas; mb/d = million barrels per day; bcm = billion cubic metres. Net income from export sales is calculated for net exporters and shows as 0 for net importers. An explanation of the methodology is available in Annex B. *Production figures for Venezuela are for 2017, but the fast-changing situation there means that there has been a significant fall since then, with production estimated at 1.3 mb/d in August 2018.

The **New Policies Scenario** provides a measured assessment of where today's policy frameworks and ambitions, together with the continued evolution of known technologies, could take the energy sector in the period to 2040. The policy ambitions include the likely effects of announced policies as of August 2018, as expressed in official targets or plans, and incorporate the commitments made in Nationally Determined Contributions for the Paris Agreement. It does not speculate as to further evolution of these positions, nor does it focus on achieving any particular outcome: it simply looks forward on the basis of announced policy ambitions.

In this scenario, equilibrium prices for oil and natural gas (in the context of rising global demand for both commodities) rise gradually from today's levels. The pace of oil demand growth slows markedly, but there is no peak in global consumption. Demand for natural gas increases strongly and accounts for a quarter of global primary energy demand by 2040. Renewable sources of energy grow quickly, especially in the power sector, where wind and solar photovoltaic (PV) become the cheapest form of new generation in many countries. Alternatives to hydrocarbons also gain traction, with a sharp rise in electric cars (as well as buses and two/three wheelers) tempering oil use for passenger transport. Overall, however, against a backdrop of rising global energy needs, equilibrium prices for oil and natural gas increase steadily (Figure 3).

Figure 3 ▷ **Average IEA crude oil price by scenario and case**



The oil price trajectory varies widely between scenarios, reflecting their different supply, demand and policy elements

A **Low Oil Price Case** illustrates the uncertainty over future price levels. Here the oil price settles in a range between $60-70/barrel and natural gas prices are $0.5-1.5 per million British thermal unit (MBtu) lower than in the New Policies Scenario. Factors on both the supply and demand sides allow for this lower equilibrium price. On the supply side, we assume higher shale resources in the United States, which allows production of tight oil and

shale gas to exert sustained downward pressure on global prices. We also assume a faster pace of technology learning in the upstream (this could, for example, be associated with a rapid and widespread uptake of digital technologies to improve efficiency and keep down costs). On the demand side, the Low Oil Price Case assumes a more rapid uptake of efficiency measures and fuel-switching opportunities than in the New Policies Scenario, notably for electric vehicles. It also assumes that additional policy measures are taken in order to offset the stimulating effect of lower prices on consumption. Although prices are lower in this case, global demand trends are not dramatically different to those in the New Policies Scenario.

The **Sustainable Development Scenario** stress tests the future of producer economies in a different way. This scenario starts from some key outcomes and then works back to the present to see how they might be achieved. The outcomes in question are the main energy-related components of the Sustainable Development Goals, agreed by 193 countries in 2015:

- Achieving universal access to modern energy by 2030.
- Reducing dramatically the premature deaths due to energy-related air pollution.
- Delivering on the Paris Agreement. The Sustainable Development Scenario is fully aligned with the Paris Agreement's goal of holding the increase in the global average temperature to "well below 2 °C".

The Sustainable Development Scenario sets out the major changes that would be required to deliver these goals simultaneously. As such, it incorporates not only price effects for oil and gas (as in the Low Oil Price Case), but also a major change in the volumes demanded. In this scenario, oil demand peaks in the near term and then declines to around 70 mb/d by 2040, while natural gas consumption rises by only one-quarter the amount projected in the New Policies Scenario.

The analysis is presented in two chapters with supporting information in the annexes.

Chapter 1 looks at the situation in major producer economies today, analysing in particular some of the pitfalls that come with high reliance on oil and natural gas export revenue.

Chapter 2 provides an overview of the results of the scenario modelling to 2040 and then considers the strategic responses that could mitigate vulnerabilities and create new opportunities, in particular in the energy sector. It concludes with a consideration of the implications of successful diversification, and the consequences of partial or incomplete reform.

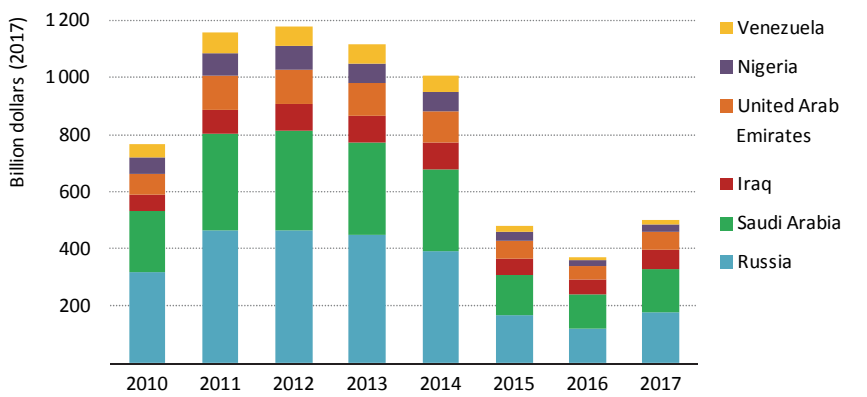
Producer economies today

Standing still is not an option

SUMMARY

- This report focuses on "producer economies", large oil and natural gas producers and exporters that are pillars of global supply and that rely on revenues from hydrocarbons to finance a significant proportion of national budgets. They are characterised by a high reliance on external revenue, which tends to diminish incentives to develop strong productive domestic economic sectors.
- Circumstances and outlooks vary widely, but these economies are often less diversified and more vulnerable to oil price shocks than others. We mainly concentrate in the analysis on six countries: Iraq, Nigeria, Russia, Saudi Arabia, United Arab Emirates and Venezuela.
- The oil price cycle of the last decade brought into sharp relief some structural economic weaknesses in the producer economies. On average, incomes from oil and gas have fallen since 2014 by between 40% (in the case of Iraq) and 70% (in the case of Venezuela, where the fall was exacerbated by a steep decline in production) (Figure 1.1). In response, a number of countries have put forward ambitious plans to reform and diversify their economies.

Figure 1.1 ▷ Net income from oil and natural gas in selected producer economies



The downturn in oil prices that began in 2014 led to sharply lower net incomes from oil and natural gas in key producer economies

- Recognition of the need to pursue economic diversification is by no means new, but the urgency with which reform was pursued in the past has tended to follow the oil price cycle, with the imperative diminishing when prices rose. Now, however, the

shale revolution in the United States, technological change, energy efficiency gains and the long-term response to climate change and air pollution challenges are all raising questions about the future trajectory of hydrocarbon demand and prices.

- Producer economies have not performed significantly better in economic terms than non-producers in recent years, despite having access to vast revenue streams from oil and gas. This is in part because of:
  - The revenue volatility introduced by commodity price cycles. As recent examples from Venezuela and Iraq demonstrate, the upside of an (often inefficient) expansion in spending during boom times can be followed by painful cutbacks when prices fall.
  - Relatively low labour productivity. Among the Middle East producers, overall labour productivity has actually declined since 1970, in part because of a high share of public sector employment.
  - Wasteful use of energy. Energy can be a major source of comparative advantage for producer economies, but the tendency to maintain artificially low prices leads to distorted incentives for investment and consumption. In Russia, nearly three-times more energy is required to generate a unit of gross domestic product (GDP) than the world average. Subsidies not only push energy use up, but tilt energy balances in favour of oil and gas, particularly in the Middle East, slowing the development of region's huge renewable energy potential.
- Previous efforts to diversify producer economies have made progress, but the drop in oil prices that began in 2014 galvanised a number of key producers, including Saudi Arabia, to launch ambitious reform programmes that aim to increase the growth of the non-hydrocarbon economy. If successful, they would fundamentally alter their economies and societies.
- This special report aims to analyse how future market dynamics may shape the vulnerabilities and strategic responses of producer economies. We explore three trajectories to 2040:
  - In the New Policies Scenario, our base case, oil and gas prices rise gradually, driven by higher demand.
  - The Low Oil Price Case assumes greater US shale supply and upstream cost efficiencies, as well as subdued oil demand growth due to a stronger policy push in favour of efficiency and fuel switching, allowing oil and gas markets to find equilibrium at a lower price.
  - The Sustainable Development Scenario sees the world move more aggressively towards a low-emissions future, with impacts both on hydrocarbon demand and prices.

Pitfalls for producer economies

There has been considerable variation in how resource wealth and economic policies have been managed in producer economies, and there is no single model that is common for all. The six countries that we focus on in this report – Iraq, Nigeria, Russia, Saudi Arabia, United Arab Emirates and Venezuela – are very diverse, with very different characteristics, strengths and challenges. However, there are three areas that have traditionally been difficult for countries with large hydrocarbon export revenues, which we examine in turn:

- Revenue volatility
- Job creation and productivity
- Energy pricing and efficiency.

1.1 Revenue volatility

The relationship between hydrocarbon revenues and national budgets is a crucial one for producer economies. A combination of volatile revenues and, in some cases, an inadequate policy response to this volatility is a major potential source of vulnerability. In the absence of clearly designed policies to regulate spending, producers have tended to follow one-year spending plans, meaning that government expenditure rises while prices are high and come down when they fall. This "pro-cyclical" spending policy has important implications for the entire economy (Box 1.1). When oil prices trend lower and the economy needs a stimulus, the decline in government spending exacerbates the impact on domestic consumption as a whole (see section 1.4, Economic performance and plans for reform).

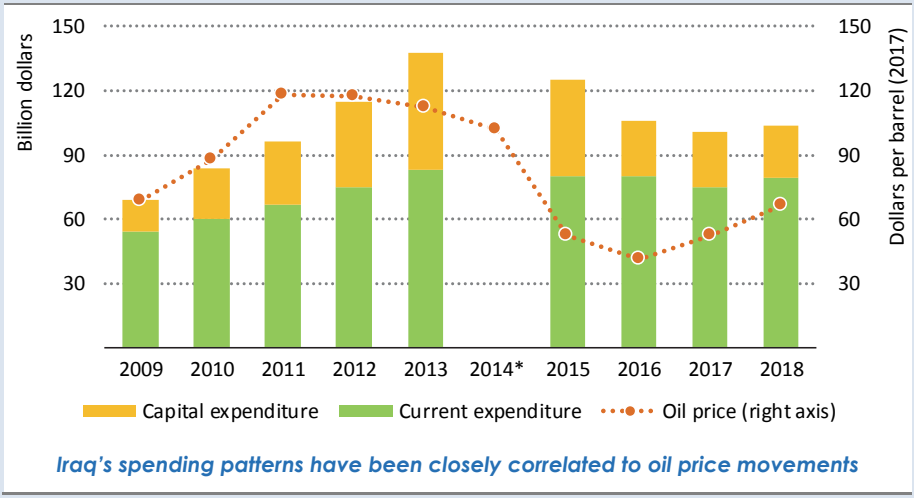
Box 1.1 ▻ Perils of a pro-cyclical fiscal policy

Iraq provides a good example of how revenue volatility can complicate economic management. Between 2009 and 2013, when oil prices were rising, the size of the state budget doubled (Figure 1.2). Since then, a lower oil price has forced a major retrenchment and the state budget is now around 25% smaller than in 2013. Decisions to increase spending on public salaries and entitlements during a period of high oil prices are generally difficult to reverse when prices decline, and the burden of the retrenchment in Iraq has disproportionately fallen on the allocation for capital expenditure: it is now less than half its 2013 level, while the amount allocated to current expenditure (largely made up of salaries and pensions) has remained relatively stable. The budget allocated to the Ministry of Oil, which is charged with remunerating international oil companies, has fallen by a quarter in this period, affecting Iraq's ability to pursue its long-term oil and gas development targets.

One way of mitigating the impacts of oil price volatility on spending and growth is for policy makers to implement multi-year spending plans, or to set limits on annual spending increases. In 2016, the United Arab Emirates became the first Arab country to

release a five-year budget, and it did so partly to smooth the impacts of revenue fluctuations on expenditure. Another way of mitigating the impacts is to introduce counter-cyclical fiscal policies, where governments trim spending and raise additional revenues during the years in which commodity prices are high, to give them the option of increasing spending and reducing taxes to stimulate growth during leaner years.

Figure 1.2 ▷ Federal government budget in Iraq



*Iraq did not pass a budget in 2014, so no spending data exist for this year. Notes: Oil price for 2018 is the January to August average. The oil price reflects the IEA average price.

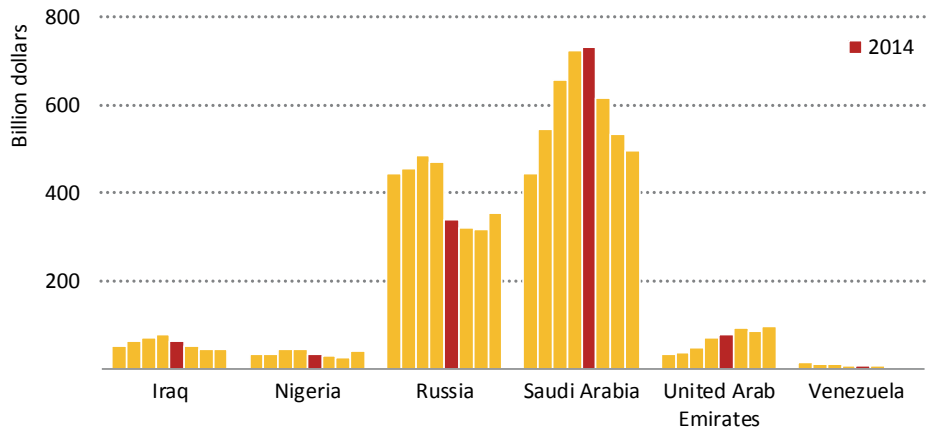
Source: National accounts.

Several large producers, including, Iraq, Qatar, Saudi Arabia and United Arab Emirates (UAE) maintain a currency peg to the US dollar, while Kuwait pegs to a basket of currencies. This has provided an anchor for economic management, but also limited the possibilities for these producers to use monetary policies such as increasing or decreasing the interest rate to stimulate or cool their economies when needed. Instead, these economies are left only with government spending as a way to stimulate economic growth (via a mixture of spending on infrastructure projects through the capital budget, and spending on wages and salaries through the current budget). In contrast, floating exchange rates in Russia and Nigeria have been used effectively to allay pressures resulting from the lower oil price environment.

Building up savings during times of high commodity prices provides a way to repair gaps in national finances if and when prices fall. There are various ways in which this can be done, but not all producer economies developed such buffers during the years leading up to 2014, when oil prices began to fall. When prices drop, foreign exchange reserves become one of the most important lines of defence for these countries to address budgetary gaps, spending needs and currency stabilisation (particularly in the large producers that maintain

a currency peg). The data on these reserves show that Iraq, Nigeria and Venezuela were highly vulnerable in 2014 to any change in market conditions, while Russia, Saudi Arabia and the UAE had greater means available to respond (Figure 1.3).

Figure 1.3 ▷ Foreign exchange reserves, 2010-2017



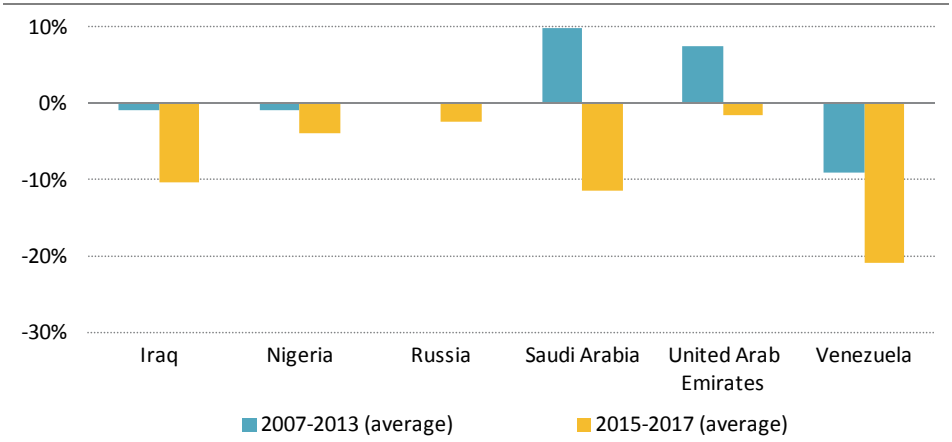
Where available, foreign exchange reserves were tapped early after oil prices began to fall in 2014 to defend exchange rates, finance budget deficits and stabilise national currencies

Sources: International Monetary Fund; Central Bank of Nigeria; Saudi Arabian Monetary Authority.

The foreign currency holdings of some major producer economies have been drawn down significantly since 2014. In Saudi Arabia, for example, reserves peaked at over $730 billion in 2014 and had fallen by some 30% by 2017. Nearly $240 billion was used to cover a large budget deficit created by lower oil export revenues, to add to the sovereign wealth fund to prepare for large overseas investments and to defend the currency peg (Box 1.2). Considerable gains in reserves in early 2018 and increased lending to the private sector suggest major financial pressures are easing. Nevertheless, despite efforts to consolidate spending, Saudi Arabia is still running a significant deficit, and it has turned to domestic and international bond issuances to help finance its budget.

Many major producer economies were running sizeable budget deficits even before the 2014 decline in the oil price (Figure 1.4). Venezuela provides a classic example of the problems that can arise if governments rely too much on assumed future oil and gas revenues. Its programmes succeeded in lifting the living standards of many of its poorest citizens, but were financially unsustainable, and Venezuela now faces a period of profound economic contraction. The oil price decline is often blamed for these problems, but it would be more accurate to say that it has highlighted and exacerbated pre-existing vulnerabilities.

Figure 1.4 ▷ Fiscal balances as a share of GDP in selected producer economies



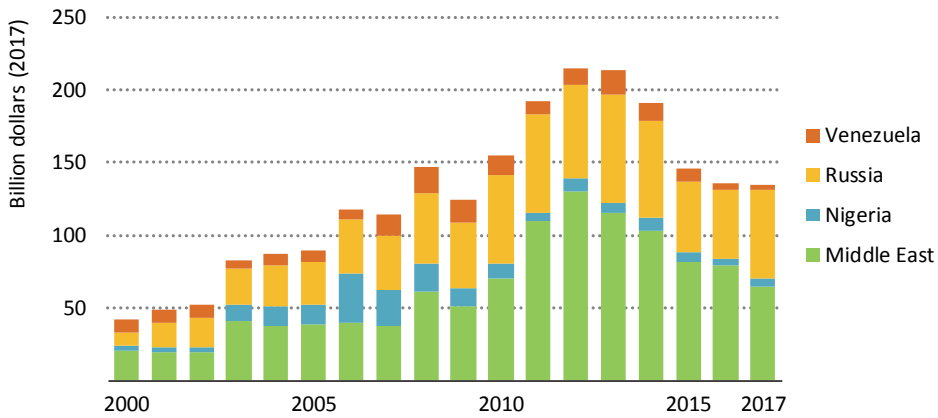
Key producer economies have seen a significant decline in their fiscal balance since the 2014 downturn in oil prices

Source: International Monetary Fund.

The impact of lower revenues has been felt in a reduction in capital spending in many sectors in producer economies, including the energy sector. Short-term expenditure policy has dampened the appetite of countries to co-finance large projects or to enter into joint ventures with international companies. In the Middle East, Nigeria, Russia and Venezuela, upstream oil and gas investment fell by one-third between 2015 and 2017, compared with the average seen between 2010 and 2014 (Figure 1.5). The pace and volume of this decline varied considerably by region, company and asset type, with overall development costs and countries' fiscal regimes being important factors in determining the size of decline.

- In the Middle East, large producer economies have been fairly resilient, benefiting from cost deflation in the supply chain, which allowed for steady rates of activity even at lower investment levels. This was accompanied in some countries by moves to increase the efficiency and streamline operation of national oil companies.
- In Russia, resilience has been bolstered by a falling exchange rate – the majority of upstream investments are in rubles, so exporters were able to maximise dollar earnings to support continued investment and production growth. Ruble investments increased during the period of lower prices, providing a boost to oil and gas production capacity.
- In Nigeria, investment levels suffered because of a difficult investment climate and relatively high-cost resources.

Figure 1.5 ▷ Upstream oil and natural gas investment in selected regions



Upstream oil and natural gas investment has declined in recent years in many producer economies, a trend offset only in part by falling upstream costs

Box 1.2 ▷ Role of sovereign wealth funds

Sovereign wealth funds (SWFs) can be an effective tool for producer economies to manage windfall revenues by providing a way to channel surplus revenues from oil and gas exports to help counter commodity price volatility and diversify revenue streams. There is no one-size-fits-all approach for fund management – each producer economy has its own objectives and investment philosophies.

Generally there are three broad categories of SWFs:

- Savings funds, which transfer revenues into a diversified portfolio of financial assets aimed at protecting and growing the wealth for future generations.
- Stabilisation funds, which attempt to protect the market from commodity price volatility and address budgetary shortfalls.
- Strategic development funds, which are used to channel revenues towards domestic development of infrastructure and industry, with the aim of diversifying the economy.

Savings funds are by no means a new concept. Kuwait created a "Future Generations Fund" in 1976 into which 10% of all state hydrocarbon revenues are transferred for investment. The Abu Dhabi Investment Authority (ADIA) in the UAE manages a global portfolio of more than two dozen asset classes estimated at over $790 billion. Saudi Arabia's Public Investment Fund has some of the same characteristics as ADIA, but it also makes domestic investments. With more than $250 billion in assets already under management, it is set to be the main conduit for investments made under the auspices of "Vision 2030".

Russia's sovereign wealth fund also serves a dual purpose, acting as a facility for savings and stabilisation. Its Reserve Fund was established in 2008 to draw on oil and gas revenues during boom years and to cover budget deficits during lean years. At the end of 2017, Russia's finance ministry used the Reserve Fund to address a growing budget deficit, transferring the remainder to the National Wealth Fund (NWF), a second fund established to cover medium-term pension payments. Following this move, the NWF became a dual purpose fund. Russian authorities are seeking to protect the approximately $66 billion fund by introducing a budget rule requiring excess oil and gas revenues to be diverted into the fund to help stabilise reserves and complement central bank foreign currency and gold holdings. The combined effect has been to stabilise the currency and provide a buffer in the event prices fall again. But the country is also reviewing options to develop this strategy and take on greater investment risks during periods of higher oil prices.

Each country with a SWF faces the challenge of getting the balance right between using money to develop and diversify its economy on the one hand, and investing money for future generations on the other, taking account of its own circumstances and its judgement about likely future demand for hydrocarbons. This challenge underlines the case for strong institutions to promote the most effective management of these funds.

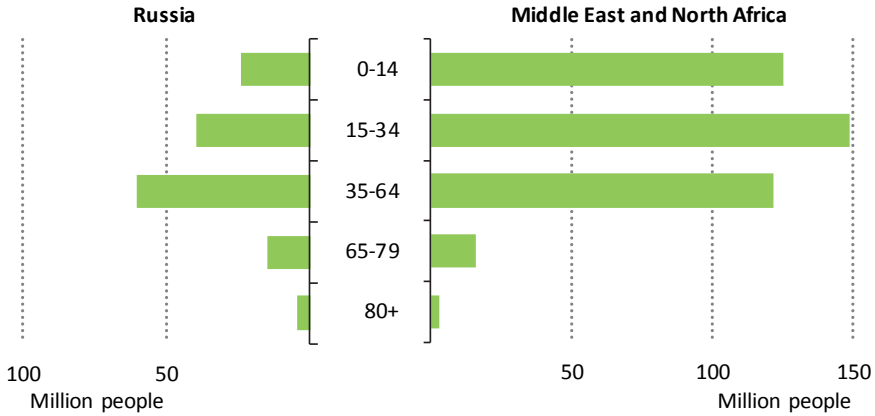
1.2 Job creation and productivity

Demographic trends are crucial to the future opportunities and challenges facing producer economies (Figure 1.6). In the Middle East and North Africa (MENA) region, population growth has averaged 2% per year since 1990 (0.7 percentage points higher than the world average), leading to a population increase of 180 million over the last 25 years. This rate of increase means that the MENA region is now among the youngest in the world: today, 60% of the population is under the age of 25, and the median age is 22 (compared with a global average of 28). This could act as a catalyst for economic change and a spur to growth. However, if countries are unable to create productive jobs fast enough to meet demand, and if as a result there are high levels of youth unemployment, this could be a major source of strain.

Among Middle East producers, demographics play a significant role in determining the relative vulnerability of the economies. With large numbers of young citizens set to join their labour markets in the years ahead, producers like Saudi Arabia and Iraq face the need to diversify their economies and create new productive jobs. In both countries, the growth in the working age population over the last two decades has not been matched by growth in private sector job creation, and these countries instead have seen significant growth in public sector employment.[1] In Iraq, for example, the public sector has grown from

[1] The situation is very different in the smaller Gulf producers, and government-led job creation has been able to keep a lid on unemployment: youth unemployment in the UAE, for example, is only 5.1%, compared with nearly 35% in Saudi Arabia (International Labour Organization).

Figure 1.6 ▷ Population by age group in Russia and the MENA region, 2015

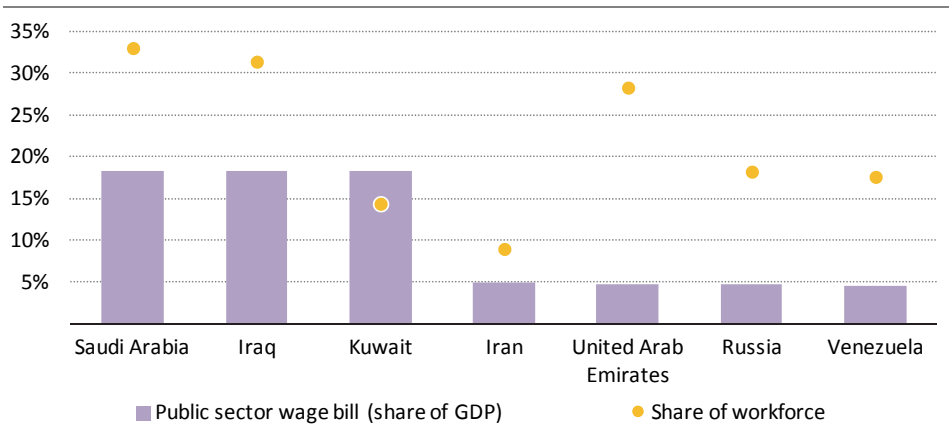


The youthful population in the Middle East and North Africa could bring a major boost to growth if economic opportunities are there, or become a destabilising force if they are not

Source: United Nations Population Division.

1.2 million employees in 2003 to around 3 million today. This places enormous strain on the state budget, costing over $30 billion in salaries in 2016, equivalent to 60% of the country's net income from oil and gas that year (Figure 1.7). Over the last ten years, more than 430 000 jobs on average each year were created in Saudi Arabia, but most of these were taken up by an expatriate labour force, doing little to allay the pressures of an expanding indigenous workforce.

Figure 1.7 ▷ Public sector employment and wages in selected producer economies, 2016



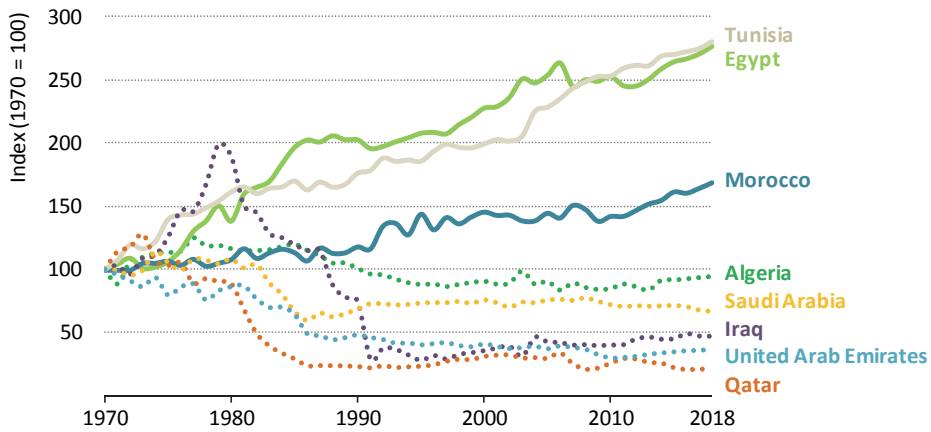
Saudi Arabia's wage bill amounts to almost one-fifth of GDP, and a third of the workforce is employed by the state

Sources: International Labour Organization; International Monetary Fund; national governments.

Nigeria has seen even higher rates of population growth than the Middle East since 1990, nearly doubling in that period to reach more than 185 million people in 2016. Russia's demographic trajectory points in the opposite direction than the other large producers, with an ageing population that is in decline. This creates its own dilemmas, in particular in terms of the financing of pensions and healthcare costs.

Producer economies generally have seen relative declines in labour productivity, which suggests that many of the public sector jobs that have been created are not adding significantly to economically productive activity. The balance of employment across the private and public sectors is also shaped in many instances by a large gap in average wages, with public employment offering higher pay: across the Gulf Cooperation Council (GCC) countries[2], for example, the gap between average public and private wages is often between 150% and 250% (IMF, 2017). The differences in labour productivity are particularly stark when comparing producer economies in the Middle East and North Africa with other countries in the region that import oil and gas (Figure 1.8).

Figure 1.8 ▷ Labour productivity in selected MENA countries



Across the board, oil and gas exporters have seen a relative drop in labour productivity, while non-exporting MENA countries have seen an improvement

Source: The Conference Board Total Economy Database, March 2018.

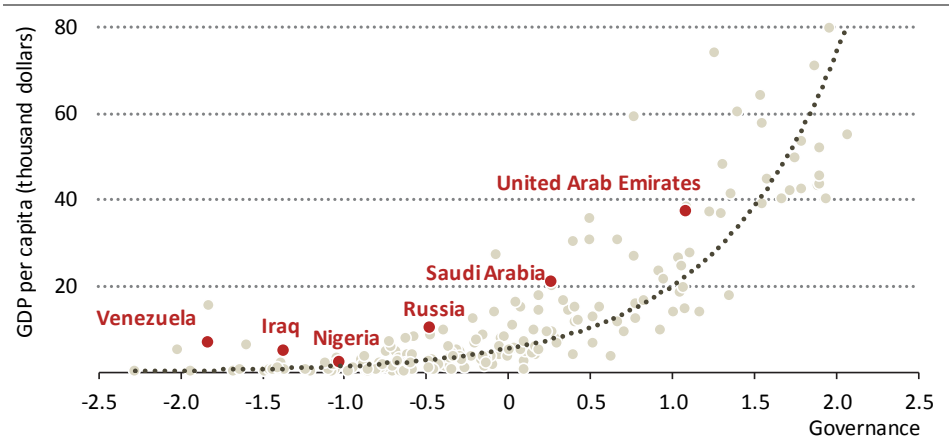
One important way to promote higher labour productivity is to stimulate private sector investment and job creation. Indeed, this is central to recent reform plans, including Vision 2030 in Saudi Arabia, which aims to increase the private sector's share of GDP from 40% to 65% and to raise foreign direct investment to 5.7% of GDP (from 3.8% today). Moves to switch the emphasis away from a state-led economy will require producer

[2] The GCC countries include the governments of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

economies to ensure that they have an environment that is conducive to business. At present, no producer economy ranks in the top-20 of the World Bank's Ease of Doing Business global rankings, a composite measure of indicators that reflect business sentiment. In the Global Competitiveness Index compiled by the World Economic Forum, United Arab Emirates (17th), Saudi Arabia (30th) and Russia (38th) are ranked reasonably well, but many other producer economies languish in the lower parts of the global league table.

It is worth noting in this context that the evidence suggests that there is a broad correlation between governance – defined as government effectiveness, regulatory quality and the rule of law - and economic performance (Figure 1.9). By and large, the higher the ratings on the three governance indicators, the wealthier a country is likely to be.

Figure 1.9 ▷ Governance scores and per-capita GDP, 2016



Producer economies tend to have higher rates of per-capita income than countries with similar levels of governance

Notes: The score for governance is an average of three indicators (with possible scores from a low of -2.5 to a high of +2.5) prepared by the Worldwide Governance Indicators project, which combines the views of a large number of enterprise, citizen and expert survey respondents on country performance in government effectiveness, regulatory quality and the rule of law.

Source: Worldwide Governance Indicators, http://info.worldbank.org/governance/wgi/index.aspx.

Empirical studies have suggested that having a high level of economic growth does not necessarily lead to improvements in governance, and so a strategy that assumes improvements are inevitable as a country becomes richer is likely to fall short (Kaufmann et al., 2003). This is particularly relevant to producer economies looking to stimulate economic growth in their non-hydrocarbon sectors. Almost across the board, they have a higher level of economic output than countries with comparable levels of governance. This suggests that the growth of oil and gas industries is less dependent on good governance than other industries. It also suggests that producer economies wishing to stimulate non-

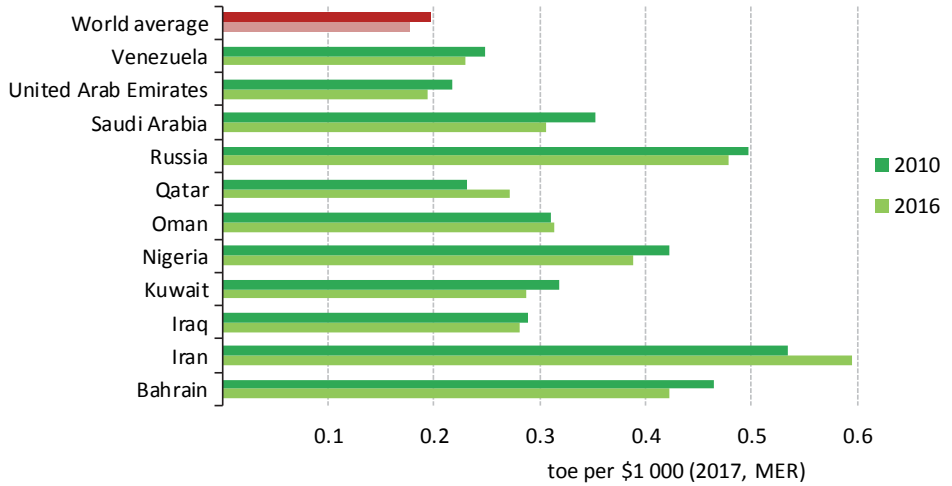
hydrocarbon economic growth are likely to see benefits from actions to strengthen government effectiveness, regulatory quality and the rule of law.

A number of producer economies have already taken steps in this direction. In 2012, Russia announced 23 separate reforms aimed at streamlining registration and permitting processes and at improving the tax system. In the UAE, federal and local government agencies were asked to develop a competitiveness strategy: the Crown Prince of Abu Dhabi approved a AED 50 billion ($13.6 billion) economic stimulus package in May 2018 for the capital city to accelerate growth, as well as for measures to improve permitting procedures and contract payments, and support to help improve the competitiveness of its small and medium enterprises (SMEs). Saudi Arabia is looking to take a similar approach and has worked with the World Bank to identify best practices: this has led it to develop a plan for some 400 reforms, of which about 40% have been enacted to date.

1.3 Energy pricing and efficiency

The producer economies covered in this report are some of the most energy intensive in the world (Figure 1.10). The UAE, while among the least energy intensive of these economies, requires 10% more energy to generate a dollar of economic output than the world average. In those producer economies that have seen energy intensity fall since 2010, the level was less than the average in the rest of the world: others, including Qatar, Oman and Iran, have seen an increase in energy intensity over the period.

Figure 1.10 ▷ Energy intensity of selected producer economies



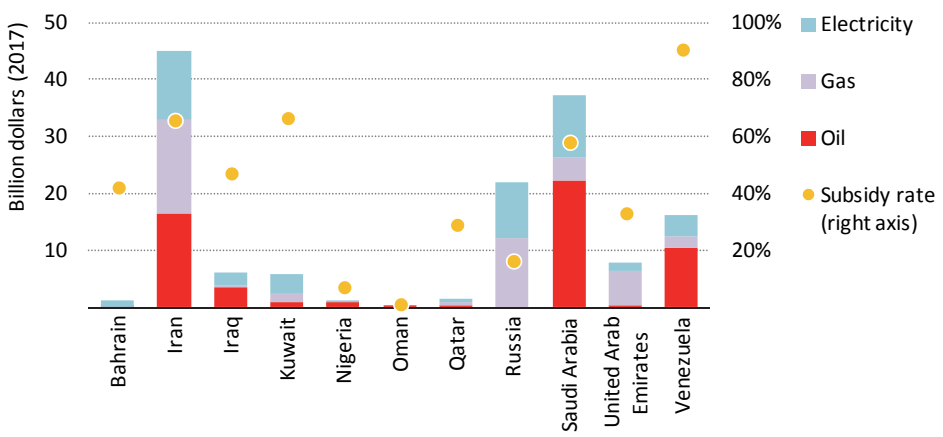
Producer economies are among the most energy intensive in the world

Note: toe = tonne of oil equivalent; MER = market exchange rate.

High energy intensity, in itself, is not necessarily a warning sign for resource-rich economies: it could simply be a reflection of comparative advantage in energy-intensive industrial activities. However, there is ample evidence to suggest that current pricing policies encourage wasteful energy consumption in ways that are damaging to the wider economy.

Prices for oil products and natural gas in most producer economies are well below the value that could be obtained for these commodities on the international market, even once transportation costs are taken into account. Eleven major producer economies in the world – Bahrain, Iran, Iraq, Kuwait, Nigeria, Oman, Qatar, Russia, Saudi Arabia, UAE and Venezuela – account for around half of the International Energy Agency estimate for worldwide fossil fuel consumption subsidies, which, in most cases, represent foregone revenue rather than actual budgetary payments. The total value of these subsidies was around $145 billion in 2017.[3] Iran's fossil fuel subsidies are the largest in the world, with an estimated value of $45 billion in 2017 (equivalent to 10% of the country's GDP). Saudi Arabia and Russia are in third and fourth place respectively in terms of the value of their fossil fuel subsidies (Figure 1.11).

Figure 1.11 ▷ Estimated value of fossil fuel subsidies in selected producer economies, 2017



Fossil fuel consumption subsidies are prevalent in many producer economies and account for more than half of global fossil fuel subsidies

Note: The subsidy rate refers to the ratio of the subsidy to the international reference price.

As in other areas, a number of producer economies have already taken steps to introduce reforms. The decline in international oil prices in 2014 gave a strong push for changes in oil and gas pricing. Since then, Kuwait, Oman, Qatar, Saudi Arabia and UAE have all increased domestic prices for gasoline, natural gas and electricity. Saudi Arabia plans to progressively

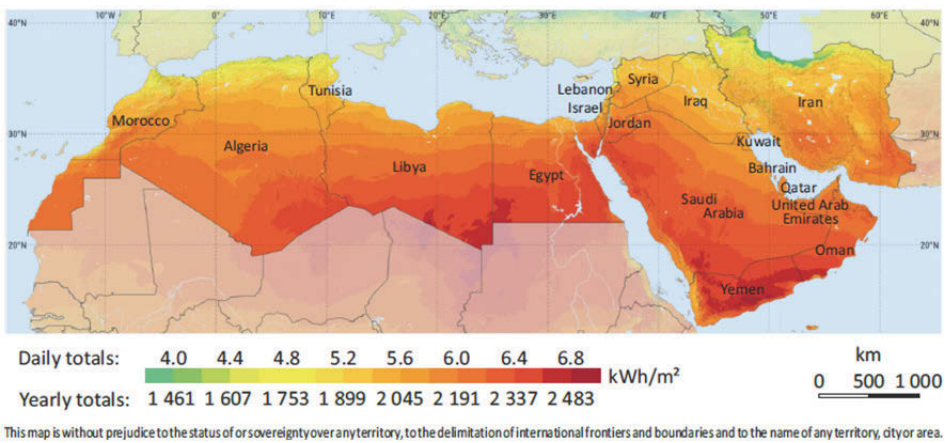
[3] The methodology for calculating fossil fuel consumption subsidies is available at: www.iea.org/media/weowebsite/energymodel/documentation/Methodology_FossilFuelSubsidies.pdf.

link prices for a range of energy products (including gasoline, diesel, natural gas, kerosene, liquefied petroleum gas and jet fuels) to international benchmarks. Iran started rationalising fossil fuel subsidies in 2010, and has more than doubled the price of regular gasoline since then. Nigeria, a net importer of oil products, lowered subsidised prices of gasoline in 2015, but in 2016 it increased them again to reflect market prices.

Another reason for the 2016 increase in gasoline prices in Nigeria was to try to cut opportunities for fuel smuggling, which is inevitably a potential problem when subsidised domestic products have a higher re-sale value over a border. Venezuela, which has the lowest consumer prices for gasoline in the world, recently announced a national census of the automotive fleet and the possible use of a "carné de la patria" (country card) to determine the distribution of subsidies for gasoline. This measure is intended to stop smuggling of gasoline, with customers that do not qualify for the subsidy being required to pay an "international price". Precise details about how the measure will work are not yet available.

Subsidised prices for energy matter because they encourage inefficient consumption within the country and limit the resources available for export. Primary energy demand in the Middle East has grown at 4.4% per year since 2000, a rate that is more than double the world average, and is out of line with what would be expected on the basis of population and economic growth. Over this period, almost one-out-of-every five barrels of growth in global oil use has come from the Middle East, meaning that 40% of the increase in production since 2000 went to serve the region's own demand. Subsidised prices can also affect upstream investment decisions—low natural gas prices, for example, have reduced the incentive for private companies to invest in exploration and production projects in parts of the Middle East.

Figure 1.12 ▷ Horizontal solar irradiation in the Middle East and North Africa

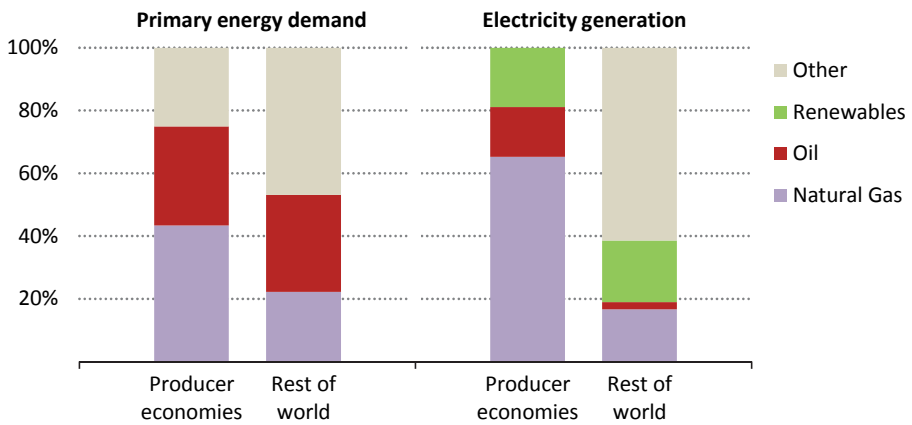


The MENA region has some of the highest solar irradiation rates in the world

Source: Global Solar Atlas

Subsidised prices also affect the demand and supply of electricity. Saudi Arabia's electricity consumption has now reached the same level as that of Italy, despite having a population half its size and per-capita income that is 35% lower. On the supply side, traditional oil and gas producers in the Middle East are endowed with some of the best solar irradiation rates in the world, reaching around 2 400 kilowatt-hours per square metre per year (kWh/m^2/year) in parts of southwest Saudi Arabia (Figure 1.12). As a result, Saudi Arabia and the UAE have both received some of the lowest bids so far seen for solar power projects, strengthening the case for accelerated deployment of solar technologies. Nonetheless, the availability of subsidised oil and gas for power generation has limited the development of renewables to a meagre 6% of generating capacity in the Middle East and 2% of electricity production (Figure 1.13).

Figure 1.13 ▷ Primary energy demand and electricity generation in six producer economies and the rest of the world, 2016



Fossil fuels play a significantly larger role in meeting the energy needs of producer economies than in the rest of the world

Changes in the energy mix in recent years in the Middle East have tended to be shifts among fossil fuels, notably from oil to natural gas in many parts of the region. While the region is home to two gas "giants" (Iran and Qatar), not all of its countries are gas rich. In other parts of the GCC (excluding Qatar), natural gas has become something of a premium fuel as demand outstripped the available associated gas (which, as a by-product of oil production, had essentially been available at zero cost). Liquefied natural gas imports to the region have become increasingly commonplace, including to hydrocarbon-rich Kuwait and the UAE (soon to be joined by Bahrain).

There is a persuasive case for renewables in other producer economies as well. Venezuela has a large hydropower sector (second only to Brazil in Latin America) that provides the bulk of the country's electricity. Russia and Nigeria also have significant hydropower

capacity, with shares of around 20% in generation in each case, but there is huge untapped potential. With average solar irradiation rates of 2 000 kWh/m^2/year in parts of Nigeria, solar energy could play a significant role in its power mix, not least as a cost-effective way to provide electricity to the 40% of the population (predominantly rural) currently without access. Russia has the world's largest wind power potential and has only exploited one-fifth of its economically feasible hydropower resource: however, it is important to note that a major portion of untapped hydro and wind potential is concentrated in sparsely populated areas of Russia with very little electricity demand, which poses an additional set of hurdles.

Economic performance and plans for reform

A person born in Saudi Arabia today can expect to live, on average, for 22 years longer than his or her compatriot born in 1970, as well as to benefit from a great deal of public infrastructure – schools, hospitals, transport and telecommunications networks – which has been built with the revenue from the oil and gas sector. Economies that are reliant on hydrocarbon exports, however, have performed less well in general than non-producers: across a wide range of economies, a ten percentage point increase in the share of oil in exports is associated with relative decline of 7% in long-run per-capita income (Kakanov et al., forthcoming).

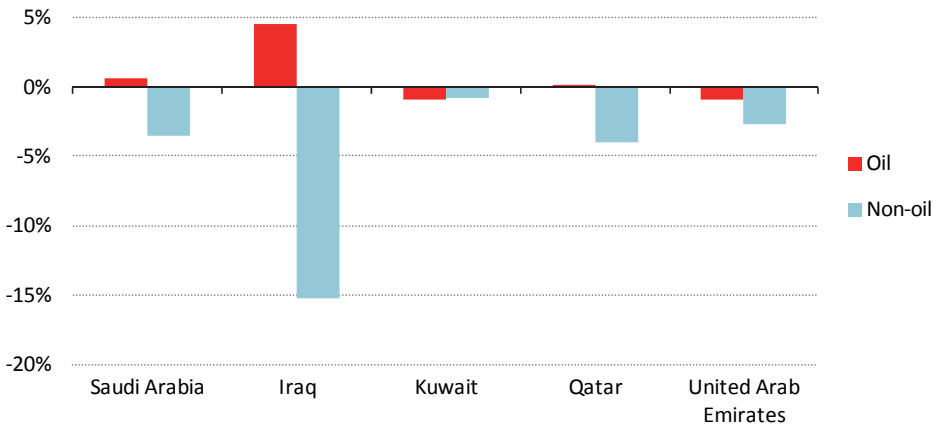
A number of factors explain the paradox that countries with tremendous natural resource wealth have historically performed less well than those with fewer endowments. They include volatility of revenue, low productivity and unproductive use of energy. In some countries, including Iran, Iraq, Libya, Nigeria and Venezuela, conflict and political tensions have also curtailed growth. Oil and gas revenues can pay for the infrastructure and capital stock of a modern society and economy, but they offer no guarantees of productive and sustainable growth. The appropriate conditions have to be in place to sustain such growth, include stabilisation mechanisms and funds that provide a buffer against market and commodity price volatility; strong institutions that can allow for the growth of non-hydrocarbon economic activity; and transparent management of hydrocarbon resources and revenues aimed at ensuring the productive use of energy. These conditions are not simple to put in place or to maintain.

Initiatives to reduce reliance on oil and gas and to diversify producer economies date back to the 1970s in many cases, but actual progress with diversification has been difficult and slow, with most economies remaining heavily reliant on consumption fuelled by hydrocarbon revenues. There has been little to no improvement since the 1970s in the complexity of exports from most major oil and gas exporting countries, a useful proxy for the level of diversification that has occurred over time. What this means in practice is that economies remain very vulnerable to any sustained deterioration in market conditions.

The impact of such a downturn might be expected to fall hardest on the oil and gas sectors themselves, but typically that is not the case. A fall in the oil price tends instead to impact the rest of the economy through lower revenues and reductions in public spending. The

case of Iraq is a striking example (Box 1.1), but the same is true of Saudi Arabia, where government spending contributes to around one-quarter of GDP. The construction sector, for example, has suffered in Saudi Arabia and in many other producer economies since 2014 as the flow of public contracts has dried up, and rates of growth in the non-oil economy in many countries in the Middle East have actually been worse since 2010 than in the oil sector (Figure 1.14).

Figure 1.14 ▷ Change in oil and non-oil sector GDP growth in selected producer economies, 2010-2017



In many countries in the Middle East, rates of growth in the non-oil economy have suffered more than those for the oil sector since 2010

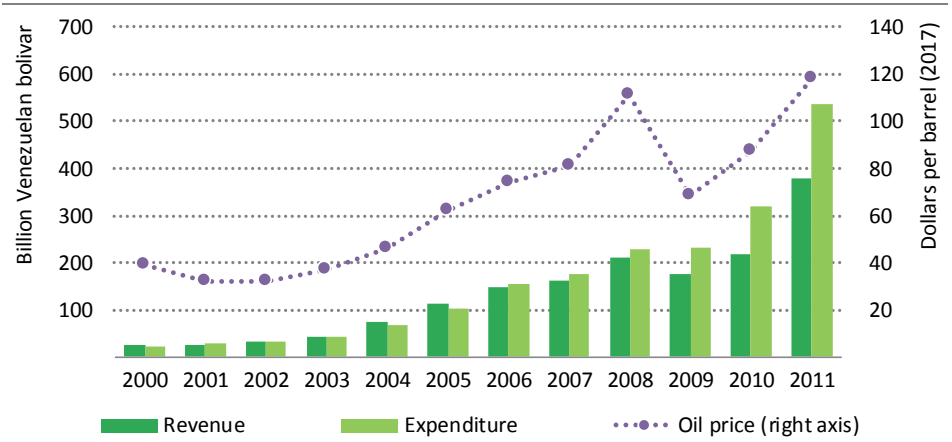
Diversification brings its own challenges. On one hand, producer economies need to diversify in order to reduce reliance on oil and gas revenues. On the other, the main means to diversify come from oil and gas, and so keeping up investment in the hydrocarbon sector is also a high priority. This conundrum is complicated by the fact that means and ends are typically out of sync: the pressure to diversify is highest when oil and gas revenues are low, and vice versa. Whichever pathway countries choose, a well-functioning oil and gas sector is an important point of departure. The ability to maintain oil and gas revenues at reasonable levels provides an important element of stability for the economy as a whole, especially when market conditions are tough.

The collapse of the oil and gas sector in **Venezuela** in recent years has been a pivotal element in the country's broader downward spiral. With some of the largest oil reserves in the world, Venezuela was producing around 3.5 million barrels per day (mb/d) in the late 1990s. The dismissal of nearly 20 000 employees in the early 2000s and the expropriation of assets owned by international operators severely impacted the ability of the national oil company, PDVSA, to operate its own assets, as well as the country's ability to attract

foreign investment. This loss of expertise led to the first phase of a prolonged fall in oil output, with production declining by over 400 thousand barrels per day (kb/d) between 1997 and 2011.

A 23-fold increase in government spending between 2000 and 2011 left Venezuela's public finances registering deficits even when oil prices averaged $118 per barrel (Figure 1.15). As a result, the government had very limited scope to protect the broader economy when prices began to fall in 2014. The oil sector has been starved of funds for investment: the number of oil wells completed in Venezuela in 2017 was less than 500, compared with over 1 500 in 2007, as international operators and service companies have curbed operations. Crude oil production decreased further from 2.3 mb/d in January 2016 to 1.3 mb/d in August 2018. The economy has shrunk by 12% per year since 2015, and inflation is estimated by the International Monetary Fund (IMF) to have reached one million percent in 2018.

Figure 1.15 ▷ Fiscal revenue and expenditure in Venezuela



Fiscal expenditure rose by more than the increase in oil price between 2000 and 2011, leading to an unsustainable situation even at record high oil prices

Sources: Ministry of Finance, Venezuela and Economist Intelligence Unit.

Other producer economies have also faced significant strains, although none of them bears comparison with what has happened in Venezuela, and have responded in part by developing reform plans. In **Iraq**, the oil and gas sector accounts for almost 60% of total GDP, 99% of export earnings and 90% of government revenues (World Bank, 2017), making the Iraqi economy one of the most hydrocarbon-dependent in the world. Like Saudi Arabia, Iraq is relatively populous: oil and gas income is recycled through the economy in part through salaries in a public sector that employs one-third of its labour force. The period of relatively low oil prices following 2014 led Iraq to cut back capital spending, and to delay investment in crucial infrastructure across the country, including in Mosul after it was taken

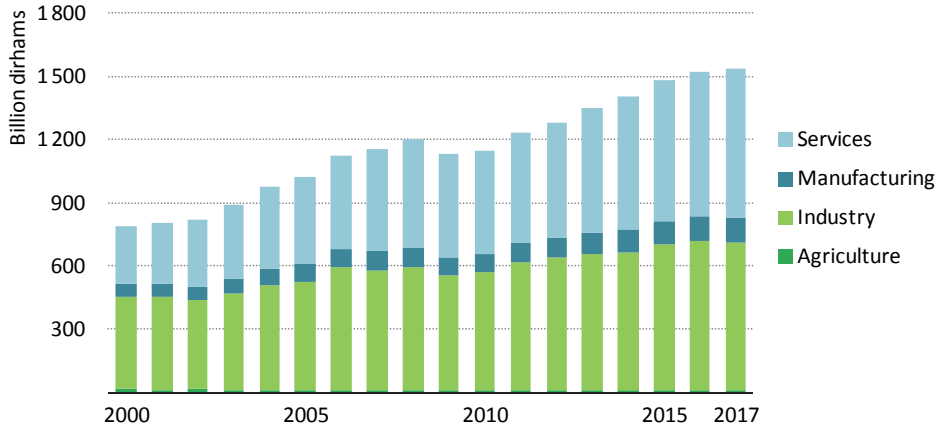
back from the Islamic State of Iraq and the Levant (ISIL). It also led Iraq to implement a hiring and salary freeze. Despite this fiscal consolidation, Iraq needed to draw down $20 billion in international reserves in 2015 and 2016, and has run significant fiscal deficits since 2014, turning to international financial institutions to help finance the gap.

Very little progress has been made in diversifying the Iraqi economy, with foreign investment in the non-oil sectors limited by a generally difficult business environment. Large-scale industrial growth is also impeded by the lack of reliable electricity supply. The agricultural sector, which employs around 20% of the workforce, has been in decline in recent years, and drought in summer 2018 resulted in water being diverted away from farming to satisfy basic demands. One notable reform initiative has been introduced in the power sector, where the government has started a pilot programme that allows private sector participation in electricity distribution. In areas where this has been implemented, there have been notable improvements in the quality of service and in payment rates.

In **Saudi Arabia**, gross national income per capita has increased more than 20-fold since 1970, and adult literacy is now almost universal, having risen 55 percentage points. Despite initially enunciating its desire to diversify its economy in its first National Development Plan in 1970, the Saudi economy remains heavily dependent on hydrocarbon revenues today. Following the fall in oil prices in 2014, Saudi Arabia announced a wide-ranging set of economic reforms as part of Vision 2030, aimed in part at moving the country away from its current high level of dependence on oil. Its component parts include tax increases and further cuts to energy subsidies (this includes an up to 80% gasoline price increase in 2018 and value-added tax at an initial rate of 5% - the latter being part of a GCC-wide initiative to broaden the tax base); efforts to stimulate private sector job creation to help reduce the 35% youth unemployment rate; plans to increase the private sector contribution to GDP from 40% to 65%; and the announced intention to hold an initial public offering of 5% of Saudi Aramco to help capitalise the Public Investment Fund.

The **United Arab Emirates** presents a significantly different set of circumstances, as a sizeable producer with a relatively small population (similar dynamics exist in Kuwait and Qatar). Because its population is relatively small by comparison with its hydrocarbon revenues, net oil and gas income per capita is 40% higher than in Saudi Arabia. The UAE has had relatively better success in diversifying its economy. One way in which it has done this is through the establishment of a world-class logistics hub, both for shipping and air travel, which has helped the services sector grow at a rate of 5.8% per year on average since 2000 (2.3 percentage points higher than the average rate of growth in industry, which includes the oil and gas sector). This has allowed the services sector to overtake the industrial sector to become the dominant pillar in the UAE economy (Figure 1.16). The government recently announced reforms to streamline processes for business, including those for worker visas and insurance, which aim to further increase competitiveness. It is also expected to soon announce new legislation to liberalise a range of sectors that it hopes will increase foreign investment by 15%.

Figure 1.16 ▷ Structure of the UAE economy



The strong growth of the services sector since 2000 has allowed it to overtake industry as the dominant sector in the economy

Russia's economy is larger and more diversified than that of any of the Middle East producers, with oil and gas accounting for around one-quarter of GDP. However, revenues from the oil and gas industry are a vital component of the state budget, accounting for around 40% of fiscal revenues.[4] After the fall in oil prices that began in 2014, Russia delayed its planned tax reforms, specifically a cut to export duties, to help address its budget shortfall. But it also had monetary policy levers not available to the Middle East's largest exporters: faced with a fall in oil prices, and with the added pressure of economic sanctions, Russia's Central Bank allowed the rouble to depreciate. This provided a revenue boost to its main energy exporters, which could earn revenue in dollars while covering upstream costs predominantly in roubles. Russia has also leaned heavily on its currency reserves and sovereign funds in the wake of the fall in the oil price. Currency reserves fell from a peak of $487 billion in 2012 to $318 billion in 2016, and the Reserve Fund has been run down almost entirely (Russia maintains a separate National Wealth Fund – see Box 1.2).

Flexible monetary policy has helped the Russian authorities to reduce budget dependence on oil and gas revenues in the short term. The government now plans to build on this by introducing a budget rule requiring the transfer of excess oil earnings into reserves. It has also declared its intention to enact new reforms to promote economic and technological advances and raise competitiveness, though this will require further development of specific policies to underpin these intentions.

[4] This number refers to the federal budget, which we have considered for the sake of consistency with other countries covered in this Special Report. Revenue from oil and gas account for around 20% of Russia's consolidated budget, which includes revenue and expenditure in the country's regions.

Table 1.1 ▷ Selected reform initiatives from producer economies

Programme	Major policies and targets
Bahrain Economic Vision 2030	• At least double the disposable income of every household in real terms by 2030. • Stimulate growth by enhancing productivity and skills. • Diversify and build the economy by focusing on existing high potential sectors. • Transform the economy in the longer term by capturing emerging opportunities.
Iran 6th National Development Plan (2016-2021)	• 8% economic growth rate. • Lower share of oil revenues in the budget to 22%. • Increase power generation capacity by 25 gigawatts. • Lower energy intensity by 15%. • Lower unemployment to 8.9% and inflation rate to 7%.
Kuwait National Development Plan 2035	• Develop a prosperous and diversified economy to reduce the country's dependence on oil export revenues. • Increase the number of small businesses by 3 500. • Realise the goal of producing 15% of electricity by renewable resources by 2030. • Increase investment by 11%.
Nigeria Economic Recovery and Growth Plan 2017-2020	• Real GDP growth rate of 4.62% projected. • Stabilise macroeconomic environment, ensuring energy sufficiency, driving industrialisation, focusing on SMEs. • Create more than 15 million jobs by 2020. • Increase oil production to 2.5 mb/d by 2020.
Oman The Ninth Five-Year Development Plan 2016-2020	• Maintain an annual real GDP growth rate of around 3%. • Non-oil sector growth rate of 4.3%. • Promote a diversified sustainable economy (share of oil sector in total GDP is expected to decrease from 44% to 30%). • Increase the share of non-oil exports in total exports.
Qatar National Vision 2030	• Reasonable and sustained rates of economic growth. • Stimulate business climate to attract foreign funds and technologies. • Optimise exploitation of hydrocarbon resources, establishing a balance between reserves and production. • A diversified economy that gradually reduces its dependence on hydrocarbon industries, enhances the role of the private sector and maintains its competitiveness. • Expansion of industries and services with competitive advantages derived from hydrocarbon industries.
Saudi Arabia Vision 2030	• Lower the rate of unemployment from 11.6% to 7%. • Generate 9.5 gigawatts from renewable energy sources. • Increase the private sector contribution from 40% to 65% of GDP. • Raise the share of non-oil exports in non-oil GDP from 16% to 50%. • Increase non-oil government revenue from SAR 163 billion to SAR 1 trillion. • Increase SME contribution to GDP from 20% to 35%.
United Arab Emirates Abu Dhabi Economic Vision 2030	• Reduce GDP volatility through diversification. • Enlarge enterprise base. • Equip the UAE youth to enter the workforce. • Diversify fiscal revenue sources.

Nigeria is slowly pulling out of the 2016 recession that was triggered by a combination of low oil prices and production outages associated with the conflict in the oil-rich southern part of the country. Oil and gas continue to play a significant role in the economy, accounting for over 50% of total government revenue. Foreign exchange reserves fell by $17 billion between 2013 and 2016, and the depreciation of the Naira (NGN) (and the widening of the black market exchange rate) led the government to enact foreign exchange controls. Since then, however, higher oil prices and tighter monetary policy have boosted reserves to four-year highs and helped contain inflation. Improvements so far, however, have offered little support for non-oil or non-agricultural activities or for reductions in unemployment levels.

Nigeria's Economic Recovery and Growth Plan 2017-2020 seeks to set a different course for the future (Table 1.1). It proposes to increase oil production by 2020 up to 2.5 mb/d, but balances this with proposals to privatise certain public enterprises, encourage businesses to deepen investments in non-oil sectors, improve environmental sustainability policies, invest oil revenues in developing and diversifying the economy, and take forward promising industrial and infrastructure initiatives. Since launching this plan, Nigeria has issued a NGN 10.69 billion green bond to fund renewable energy projects. This was its first green bond: the government is currently developing a green bond programme to raise funds for a range of projects that strengthen the country's environmental stewardship.

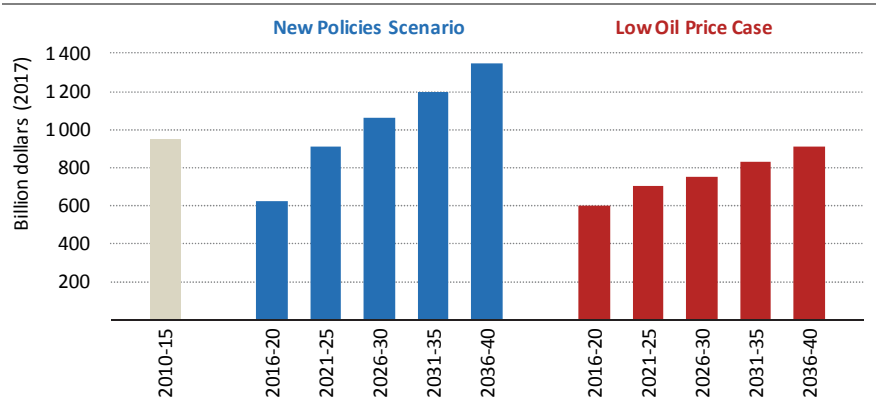
Outlook for producer economies

What prospects for change?

SUMMARY

- In the New Policies Scenario, oil and natural gas demand growth and gradually rising prices appear to present a relatively benign outcome for producer economies. Oil and gas revenues continue to rise, particularly after the mid-2020s when production from the United States is expected to plateau (Figure 2.1). Yet the imperative for reform remains strong in this scenario, especially given the risk of market volatility, continuing long-term policy uncertainty and the need to create new jobs, especially for large and youthful populations in Iraq, Nigeria and Saudi Arabia.

Figure 2.1 ▷ Average annual net income from oil and natural gas in selected producer economies* by scenario



Even in the New Policies Scenario, net income from oil and natural gas only regains its 2010-2015 levels in the mid-2020s

*Aggregated data for the six producer economies: Iraq, Nigeria, Russia, Saudi Arabia, United Arab Emirates and Venezuela.

- The risks are multiplied in a low oil price environment, where net income from oil and gas never recovers to its 2010-15 levels, leading to a cumulative $7 trillion reduction over the period to 2040 compared with the New Policies Scenario. Without far-reaching reform, this would translate into huge current account deficits, downward pressure on currencies and reduced government spending.
- The impact of the Sustainable Development Scenario on overall hydrocarbon revenue to 2040 is similar in magnitude to that of the Low Oil Price Case, but the challenge is fundamentally different as much stronger policies on fuel efficiency and fuel switching, including rapid growth in the electric vehicle fleet, bring an early peak

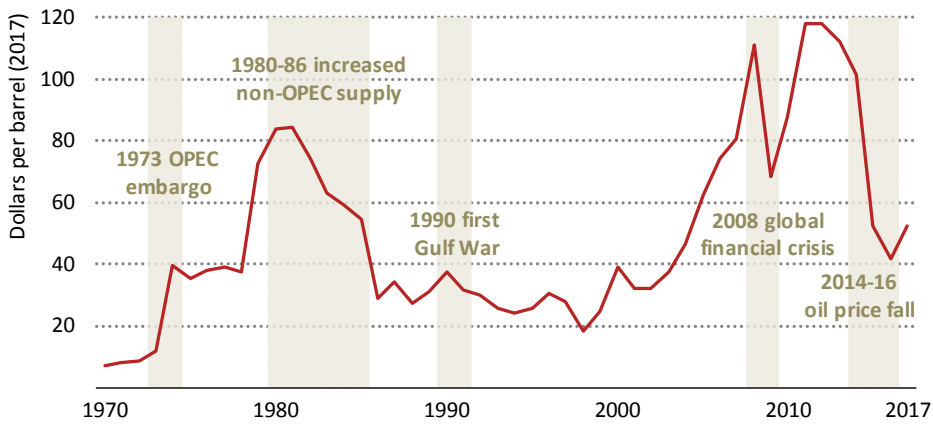
to global oil demand and lead to lower growth in gas use. In this scenario, producer economies would have little option but to ready themselves for a world in which hydrocarbons are no longer their main source of revenue.

- The reform agenda is much broader than just energy, but it relies on a well-functioning energy sector. Maintaining investment and the advantages of a low-cost resource base are vital. Some producer economies – notably Iraq, Nigeria and Venezuela – face major hurdles to bring sufficient investment to their upstream sectors. There are few signs on the horizon of the macroeconomic or policy changes that would arrest the decline in Venezuelan output.
- Pricing reform and energy efficiency offer major opportunities to rationalise consumption and encourage more diversified growth without foregoing economic opportunities to capitalise on the abundant resources of low-cost energy that producer economies possess. Energy efficiency and deployment of the region's huge solar potential also offer opportunities to help manage the rapid projected growth in electricity consumption, especially for cooling, in the Middle East. Natural gas does not present the same opportunities for revenue generation as oil, but offers more value as a fuel for industrial development.
- Moving further into the downstream oil value chain to refining and petrochemicals is a major focus for many producing economies. In the New Policies Scenario, the Middle East sees its share in global refinery output rise from 9% today to 13% in 2040. Its share in chemicals production increases by four percentage points, from 13% today to 17% in 2040. Investment in non-combustion uses of oil, such as petrochemicals, helps provide a hedge against possible contraction of oil demand as a result of a rapid uptake of electric vehicles or of efficiency improvements.
- More than at any other point in recent history, fundamental changes to the development model in resource-rich countries look unavoidable. The process of change will be complex and challenging. There is much at stake. Unsuccessful efforts to reduce reliance on hydrocarbon revenue would compound the risks facing producer economies and global markets in the future, especially in lower price or lower demand scenarios.
- Successful reform would have profound implications for prices and investment across the energy system as a whole. By increasing resilience at lower prices, it would open up a broader range of strategic options for producers.
- Today's hydrocarbon producers could also choose to play a leading role in energy technology development, particularly in areas such as carbon capture, utilisation and storage, hydrogen and finding new non-combustion uses for hydrocarbons. It should not be taken for granted that the comparative advantage in energy of major producers will disappear in the energy transitions.

Pressure to diversify

Reform initiatives in producer economies have been a feature of previous oil price cycles, appearing with regularity at the bottom of the curve and often losing impetus as the price recovered. In the 2000s, for example, a gathering sense of urgency among oil producers gradually dissipated as rising demand in China drove up global oil demand and helped to underpin a period of historically high prices (Figure 2.2). But these golden years for hydrocarbon producers contained the seeds of their own demise, in the shape of rallying supply and faltering demand growth. And so prices fell again.

Figure 2.2 ▷ Historical movements in the oil price



The fall in oil prices that began in 2014 was the steepest in the industry's recent history

The widely held view that oil prices would now stay "lower for longer" or indeed "lower forever" has retreated somewhat in the face of the rise in prices that started in 2017. A Low Oil Price Case was never the "base case" in the *World Energy Outlook (WEO)*, but it is much too soon to discard it as a possibility. Many producer economies are cognisant of the growing momentum behind energy transitions and the additional impetus that any spike in oil prices would give them. The market and policy context is changing, and there are reasons to believe that these changes will mean more sustained pressure for reform in producer economies than in the past:

- The United States is in the middle of an unparalleled expansion in oil and gas production that continues to shake up the established order. At least for the period in which it continues to exhibit dynamic growth, US tight oil and shale gas production limits the revenues available to other producers by balancing the market at a lower price.
- As examined in detail in the *WEO-2017*, China's energy system is moving in a new direction: stringent fuel-efficiency measures for cars and trucks, and a shift which sees

one-in-four cars being electric by 2040, mean that China is no longer the main driving force behind global oil demand (although it is becoming a major force in global natural gas markets).

- Alternatives to oil and gas may gain more rapid momentum. In the case of oil, other countries could follow China's example by adopting stronger efficiency measures and doing more to promote fuel switching away from oil for transport, for example through support for recharging infrastructure or through restrictions on sales of traditional gasoline or diesel vehicles. Continuing cost reductions for solar photovoltaic (PV) and wind power, as well as domestic coal resources, could also constrain market opportunities for natural gas in many parts of Asia.

The New Policies Scenario: a best case scenario?

The New Policies Scenario presents a future in which demand for oil grows by more than 10% to above 106 million barrels per day (mb/d) by 2040, and in which natural gas demand increases by over 40% to 5 400 billion cubic metres (bcm) by 2040. These relatively robust rates of growth, and the rising prices that are necessary to balance the market in this scenario, might appear to offer a relatively benign outlook for major producers. By the late 2020s, annual net income from oil and gas is higher for all major producer economies, with the exception of Venezuela, than it was in 2010-17 (Table 2.1). However, this scenario comes with a number of important caveats.

Table 2.1 ▷ Average annual net income from oil and natural gas for selected producer economies in the New Policies Scenario ($2017)

	Oil & gas (billion $)	Oil (billion $)		Natural gas (billion $)		On a per-capita basis ($)		
	2010-17	2018-25	2026-40	2018-25	2026-40	2010-17	2018-25	2026-40
Iran	69	88	148	7	12	888	1 121	1 785
Iraq	75	113	186	1	14	2 205	2 638	3 459
Kuwait	72	75	107	1	2	20 453	17 272	21 608
Nigeria	55	39	63	10	16	322	225	275
Oman	30	18	24	10	13	8 312	5 202	6 164
Russia	320	216	251	98	131	2 230	2 186	2 739
Saudi Arabia	239	247	358	2	3	8 047	6 995	8 892
United Arab Emirates	87	98	140	0	0	9 806	9 828	12 258
Venezuela	45	22	40	1	1	1 487	682	1 087

First, there is an important distinction between the period from now to 2025 and that from 2025 to 2040. In oil markets, the majority of the growth in production up to 2025 continues to come from non-OPEC (Organization of Petroleum Exporting Countries) countries, led by the United States. It is only after 2025, once US tight oil plateaus and then starts to fall back, that the world again becomes more reliant on the major conventional oil resource-holders to balance the market. This is why, in most cases, the pick-up in oil net income takes place only in the latter years of the New Policies Scenario (Figure 2.3). These latter

years are the ones where there is the most uncertainty about the outlook for demand. It is worth recalling that the New Policies Scenario is not a forecast, but an indication of where today's policy frameworks and ambitions might lead the energy sector. It is entirely possible that efforts to accelerate fuel switching away from oil, and to improve the efficiency of oil use, might accelerate beyond the policies and measures that have already been announced.

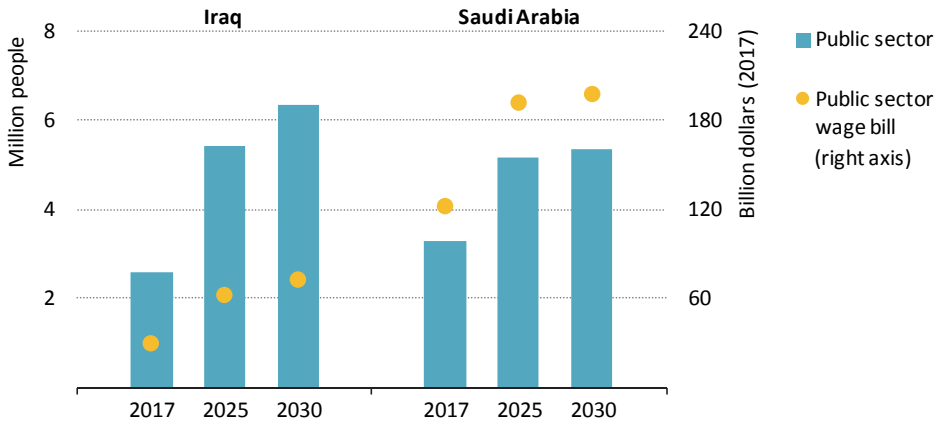
Figure 2.3 ▷ Average annual net income from oil and natural gas in selected producer economies in the New Policies Scenario

Net income from oil and natural gas grows to 2040, but rapid population growth in some countries means that it rises much more slowly on a per-capita basis

Note: In a number of the major producer countries, particularly in the Gulf Cooperation Council, population numbers are boosted by a large expatriate community. For the purpose of these calculations and given the scarcity of statistics from national sources, we use the projection data from *World Population Prospects*, which considers "de-facto population", including nationals and non-nationals present at a given period (UNPD, 2017).

A second caveat recognises that the nature of *WEO* modelling is that it always requires the system to be in equilibrium, and so the oil and gas price trajectories are smooth, with no attempt to capture the cycles that characterise commodity markets in practice. As discussed in Chapter 1, the volatility of earnings from oil and gas is one of the main pitfalls for producer economies. At least in the case of oil, there is no reason to believe that such cycles are a thing of the past. Indeed, there is a case to be made that oil markets may be on the cusp of a new boom-and-bust cycle. While the upswing would provide benefits for producer economies by way of increased revenues, it would also provide impetus for alternative fuels and technologies. The inevitable subsequent downswing could therefore be profoundly destabilising for revenues.

Figure 2.4 ▷ Public sector employment and wage bill in Iraq and Saudi Arabia



Unless things change, the rise in the public sector wage bill in Saudi Arabia would be more than the increase in net hydrocarbon income to 2030

Sources: International Monetary Fund; International Labour Organization; IEA analysis.

Third, there is the need to incorporate the impact of population growth. For sizeable producers with relatively small populations (for example the United Arab Emirates, Kuwait and Qatar), this is less of a concern. However, in Nigeria (+140 million increase in population anticipated by 2040), Iraq (+28 million) and Saudi Arabia (+10 million), population growth has significant implications for net income from oil and gas when calculated on a per-capita basis. This indicator declines in Saudi Arabia over the period to 2025 and increases only modestly overall to 2040, despite a large increase in total net income, and it falls in both Nigeria and Venezuela. Population growth also has implications for patterns of employment. If we assume that the public sector employs the same proportion of the labour force in 2030 as it does today, Iraq's public sector wage bill would increase by almost 150%, even without any real increase in average salaries, reaching $72 billion in 2030 (equivalent to 40% of its net income from oil and gas in 2030). The

public sector wage bill in Saudi Arabia would increase even more, reaching almost $200 billion (or 60% of its net income from oil and gas in 2030) (Figure 2.4). Pressure for reform in some key producer economies remains high, even in the New Policies Scenario.

Even if the overall outlook eventually resembles that of the New Policies Scenario, this level of net income from oil and gas cannot be taken for granted. It is contingent on maintaining a robust level of investment in new upstream activities (see section 2.1). This is not a straightforward task, given the practical difficulties that some producer economies face in bringing capital into their upstream sectors.

This all means that, even in the New Policies Scenario, the imperative for pursuing economic diversification remains strong. The upside for reform prospects in this scenario is that relatively buoyant income from oil and gas could play a prominent role in financing diversification programmes. However, as described in Chapter 1, the pressure to diversify is highest when revenues from oil and gas are low, and vice versa: the upside benefits depend on breaking this cycle.

Stress tests: low oil prices and accelerated transitions

As described in the introduction, a Low Oil Price Case is derived from the New Policies Scenario, but this case has the oil and gas market finding equilibrium at a lower price because of factors both on the supply side (higher US tight oil output and a faster pace of technological improvement in the upstream sector) and the demand side (more concerted policy support for fuel efficiency and fuel switching, notably electric mobility).

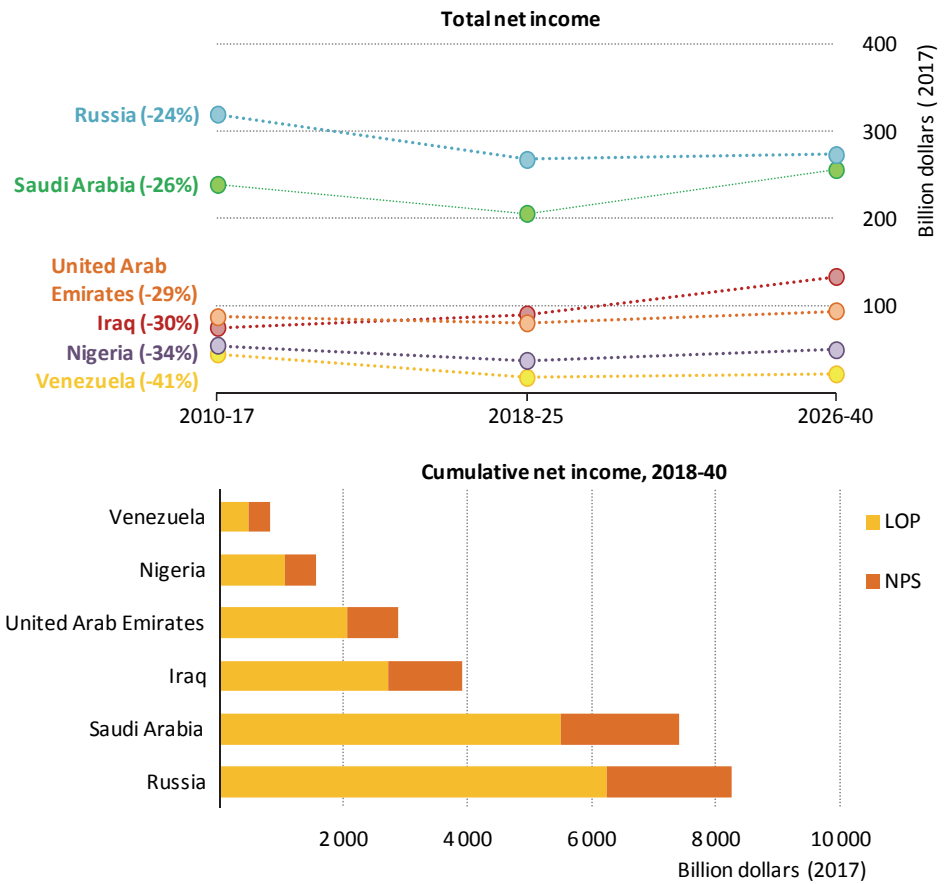
The impact of this case on the volume of oil and gas demand worldwide is relatively minor, not least because substitution effects are offset by the stimulating effect of a lower price on consumption. Global oil demand in 2040 in our Low Oil Price Case is 104.5 mb/d, compared with 106.3 mb/d in the New Policies Scenario; natural gas demand reaches 5 625 bcm over the same period, surpassing the 5 400 bcm projected in our main scenario. However, the lower price feeds through into a substantially lower net income from oil and gas for producer economies (Table 2.2).

Table 2.2 ▷ Average annual net income from oil and natural gas for selected producer economies in the Low Oil Price Case ($2017)

	Oil & gas (billion $)	Oil (billion $)		Natural gas (billion $)		On a per-capita basis ($)		
	2010-17	2018-25	2026-40	2018-25	2026-40	2010-17	2018-25	2026-40
Iran	69	68	94	8	16	888	893	1 221
Iraq	75	89	124	1	10	2 205	2 105	2 315
Kuwait	72	60	70	1	2	20 453	13 953	14 202
Nigeria	55	28	35	10	14	322	175	173
Oman	30	14	13	10	12	8 312	4 464	4 135
Russia	320	164	137	104	137	2 230	1 864	1 962
Saudi Arabia	239	204	255	2	1	8 047	5 816	6 318
United Arab Emirates	87	80	94	0	0	9 806	8 057	8 255
Venezuela	45	17	21	1	1	1 487	530	579

What this means in practice is that, in the vast majority of cases, the net income from oil and gas never gets close to the "golden years" of 2010-14. Only in countries that have a major projected increase in production in order to balance the market – Iraq is the main example – does total rent actually increase over time. However, all the caveats from the New Policies Scenario continue to apply, and it would be even more challenging in this revenue-constrained environment to mobilise the necessary upstream investment. On a per-capita basis, all producer economies – with the exception of Iraq and Iran – would see a decline in net income over the period.

Figure 2.5 ▷ Average annual net income from oil and natural gas in selected producer economies in the Low Oil Price Case



Cumulative net income from oil and natural gas is $7 trillion lower over the period to 2040 in the Low Oil Price Case than in the New Policies Scenario

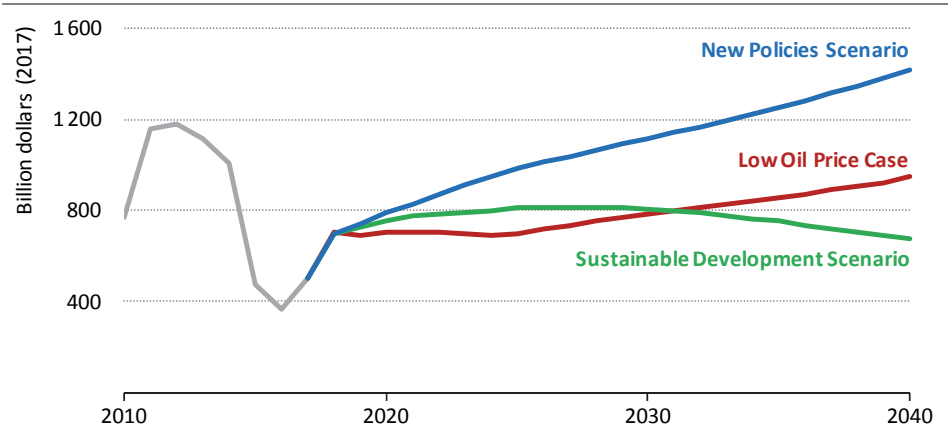
Notes: LOP = Low Oil Price Case; NPS = New Policies Scenario. The change in average annual net income to 2040 relative to the New Policies Scenario is shown in brackets.

Overall, the total cumulative difference in oil and gas rents between the Low Oil Price Case and the New Policies Scenario is huge. For Iraq, Nigeria, Russia, Saudi Arabia, UAE and Venezuela, the six producers that are at the centre of this analysis, it translates to a $7 trillion cumulative difference between today and 2040. For comparison, this is more than two-and-a-half times the combined gross domestic product (GDP) of the Middle East and Nigeria today. All producer economies would see a fall in total rent of between 25% and 40% to 2040 compared with the New Policies Scenario (Figure 2.5).

The Sustainable Development Scenario is the third scenario considered in this analysis. It is fully consistent with the objective of the Paris Agreement to reach net-zero emissions in the second-half of this century and provides a window into a world where dependence on fossil fuels (or, at the very least, on their unabated combustion) has to decline. Net income from hydrocarbons in the Sustainable Development Scenario is quite similar in the period to 2040 as the net income level in the Low Oil Price Case, but it offers a quite different set of strategic perspectives for hydrocarbon producers.

In the Sustainable Development Scenario, producer economies face not only lower prices for oil and gas than in the New Policies Scenario, but also lower demand as a result of more rigorous policies on fuel switching and efficiency. By 2040, oil demand is 70 mb/d and on a steadily declining trajectory. Natural gas demand is higher in 2040 in the Sustainable Development Scenario than today, as gas helps to displace more polluting fuels in some countries and sectors, but it is nonetheless 30% lower than in the New Policies Scenario. Although net income is somewhat higher in the period to 2025 than in the Low Oil Price Case, by 2040 it is considerably lower and on a downward curve (Figure 2.6).

Figure 2.6 ▷ Average annual net income from oil and natural gas for selected producer economies* by scenario



Subdued prices and falling demand result in significantly lower hydrocarbon revenues in both the Sustainable Development Scenario and the Low Oil Price Case

*Aggregated data for the six producer economies: Iraq, Nigeria, Russia, Saudi Arabia, United Arab Emirates and Venezuela.

In both the Low Oil Case and the Sustainable Development Scenario, and particularly in the latter, the pressures that are already visible in the New Policies Scenario are multiplied. Squeezed government revenues make it harder to manage immediate budgetary requirements while simultaneously complicating the task of making changes to diversify the economy. Of course, there are also numerous hybrid possibilities, in which, for example, the world might follow a pathway similar to the New Policies Scenario for a period before a more rapid transition to a trajectory approximating the Sustainable Development Scenario. Or a peak in oil demand might not be followed by a decline (as in the Sustainable Development Scenario), but by oscillations around this peak caused by price volatility. As we often underscore, there is no single story to portray the future of global energy.

However the coming decades play out, the world's energy economy will be affected in many different ways by the response from the producer economies themselves as active participants. So the success or failure of their reform programmes will have major implications for the global outlook as well as for their own prosperity. Similarly, the strategies that the producer economies choose to pursue for upstream investment and production (which may in turn be closely linked to the success or failure of broader reform efforts) and their engagement in initiatives to produce lower emissions fuels have significant implications for the global energy outlook.

Downside risks for economic growth

The New Policies Scenario describes the outlook for producer economies in an oil market that is characterised by robust demand growth and relatively high prices, compared with those seen since 2014. As we have seen, even this scenario sees growing pressures for key producers. But beyond the decrease in net income, what could a Low Oil Price Case mean for the economic outlook in producer economies?

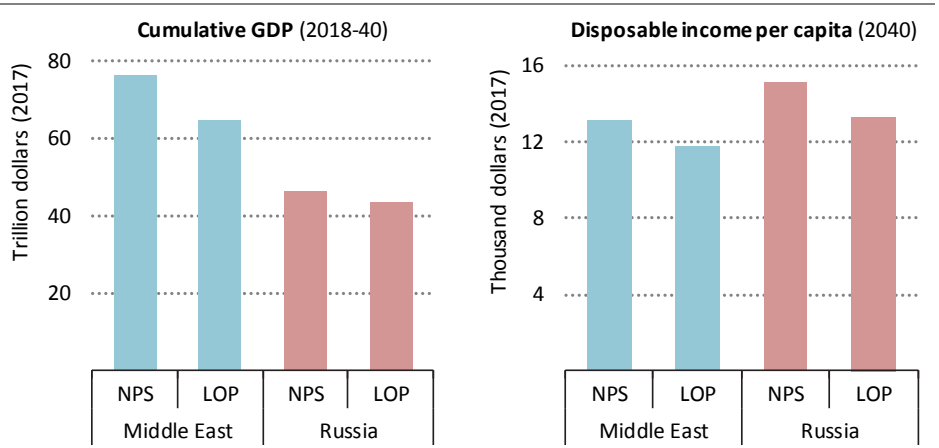
To help answer this question, we have coupled the results of the International Energy Agency's World Energy Model with the Organisation of Economic Co-operation and Development's (OECD) computable general equilibrium model, ENV-LINKAGES, to generate results for the Middle East as a whole, Russia, North Africa and the Caspian countries. In the New Policies Scenario, we have not assumed that major structural economic changes take place among the world's major hydrocarbon producers. This scenario assumes a degree of continuity with the past, in which diversification efforts have made steady rather than transformative progress. But if this gradual approach to reform implementation were to characterise a Low Oil Price Case, it would come at a significant economic cost.

The results of this economic modelling in the Low Oil Price Case show that as export revenues decline in the period to 2025, the trade balance falls into deficit for the Middle East as a whole and stays in deficit through to 2040. For countries that have a floating exchange rate, the resulting currency depreciation makes imports ever more expensive. For countries that have pegged regimes, such as the Gulf producers and Iraq, maintaining the

link becomes an increasingly difficult and expensive proposition. Furthermore, reduced revenues impinge on the ability of countries to pursue expansionary fiscal policies to stimulate growth. This hits all sectors of the economy, with the business services and public sector output each around 20% smaller in 2040 than in the New Policies Scenario, and construction output reduced by more than 15%. This has implications for jobs in the Middle East: there are 8 million fewer jobs in 2040 than in the New Policies Scenario.

The net impact of these effects is that wider economic output is severely curtailed compared with the New Policies Scenario. In the Middle East alone, the cumulative economic losses between 2018 and 2040 amount to $11 trillion, five-times the current GDP of the region, and the economy is one-fifth smaller by 2040 than in the New Policies Scenario. This has a clear impact even at the household level where the average person in the Middle East has $1 500 less disposable income per year than they would in the New Policies Scenario to 2040 (Figure 2.7).

Figure 2.7 ▷ Cumulative real GDP and disposable income per capita in the Middle East and Russia by scenario



Notes: GDP based on market exchange rates (MER) terms. NPS = New Policies Scenario; LOP = Low Oil Price Case.

In Russia, lower oil and natural gas prices feed into the economy in much the same way as they do in the Middle East. The sectors most affected are those that in one way or another rely on state-backed spending, including construction (down 10% compared to the New Policies Scenario in 2040) and business services (down 13%). Ancillary sectors, including iron and steel, and the automotive industries, are similarly affected. The net losses to the economy amount to almost $3 trillion between 2018 and 2040, with declining terms of trade and more expensive imports reducing per-capita disposable income by $1 250 per year to 2040.

Strategic responses: energy sector

The reform agenda for producer economies is much wider than energy: indeed, the whole thrust of the diversification effort is to make hydrocarbons less important to overall economic activity, and to provide productive and rewarding opportunities in other industrial sectors. That said, overall reform efforts stand to benefit significantly from a well-functioning energy sector, which can help provide an effective platform – both in terms of revenue and comparative advantage – for achieving broader social and economic objectives.

This section focuses on the ways that producer economies can best position their energy sectors to provide long-term advantage and to increase their resilience to a range of future market and policy outcomes. As emphasised in Chapter 1, producer economies are far from homogeneous. The strategic issues covered in this section do not apply equally to each producer economy, but together they are of concern for all producer economies.

- **A dynamic upstream:** What can countries do to ensure they keep costs down and investment flowing to their upstream industry?
- **Energy pricing and energy efficiency:** How to reduce wasteful consumption while retaining an economic advantage from energy?
- **Strategic priorities for natural gas:** How can gas best be used to stimulate economic growth and diversification?
- **Capturing more value from hydrocarbons:** What role for refining and petrochemicals in producer's economic reform strategies?
- **Cost-effective deployment of low-carbon energy:** Where do renewables and nuclear power (in some countries) fit into the picture?
- **Reducing the emissions intensity of oil and gas supply:** What can producer economies do to make their output more compatible with energy transitions?

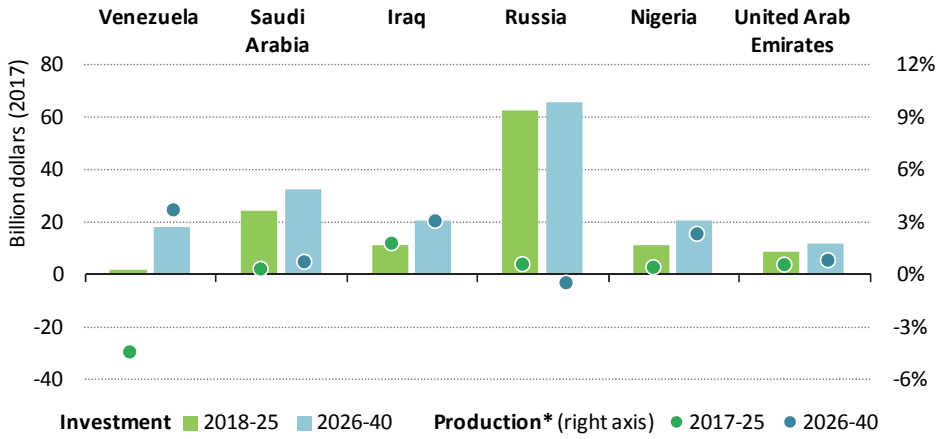
2.1 A dynamic upstream

Given the centrality of the energy sector in many producer economies and the likelihood that countries looking to reform their economies will need to rely on oil and gas revenues to finance broader economic change, it remains crucial for producers to attract investment and maintain or improve the productivity of their upstream sectors. In the New Policies Scenario, each of the six producer economies that we focus on need to increase investment over the next decade just to maintain production levels close to those in 2017 (Figure 2.8).

The need to step up investment comes at a time when there are many competing priorities for domestic spending, potentially limiting the amounts available to national oil or gas companies, and when there are other impediments that could stand in the way of new upstream projects. There is also likely to be strong competition for international investment capital. The situation is not uniform across countries, but we focus in this

section on four producers that are facing or could face problems: Venezuela, Iraq, Nigeria and Russia. This is by no means an exhaustive list: for example, the re-imposition of US sanctions on Iran in 2018 severely constrains its ability to raise its own production capacity.

Figure 2.8 ▷ Average annual upstream oil and natural gas investment and production in selected producer economies in the New Policies Scenario



Large volumes of investment are needed just to compensate for declines at existing fields

* Compound average annual growth rate.

The country that faces the most immediate difficulty (and for which the outlook is most uncertain) is **Venezuela**, where the upstream industry is caught in a vicious cycle of dwindling revenue, mounting debt, and falling investment and output. Its national oil company, PDVSA, is desperately short of funds, an issue that is exacerbated by it having to supply almost one-quarter of its total production to the domestic market at such a subsidised price that it barely recovers any revenue. Problems in project execution have become chronic: PDVSA has run up large debts both with joint-venture partners and with service companies, and many of these are hesitant to work further on uncertain credit. Venezuela produces heavy crudes that sell, at the best of times, at around a $10 per barrel discount to the Brent crude benchmark price. But much of its output does not even generate this discounted international price. This is because it is either marketed under a variety of politically driven deals for subsidised supply, barter or swap, or it is supplied to China as repayment for loans (and, when prices fall, the number of barrels needed for repayment increases). Repayments to China could account for as much as 375 thousand barrels per day (kb/d). Against this backdrop, turning the production trajectory around will not be quick (Box 2.1).

Box 2.1 ▷ What would it take to turn Venezuela's production around?

A range of political and economic factors would need to be addressed in order to generate adequate investment in Venezuela's large hydrocarbon resources. A degree of macroeconomic stabilisation and some restructuring of Venezuela's crippling debt levels would be essential. The practical problems of working in an extreme inflationary environment are huge: oil earnings and money paid to contractors loses value before it can be spent, causing a constant cycle of renegotiations and workarounds.

In the upstream, the possibility of slowing and then reversing current declines in production depends on boosting capital spending on infrastructure and maintenance of existing facilities. In theory, with appropriate levels of investment, this would not be too complex a task. The hydrocarbon resources in Venezuela are known and very large. Operations such as well repairs could take place to restore production in wells that are currently shut-in due to lack of parts or equipment; so could work on upgrading and repairing water injection facilities to sustain and boost production; drilling campaigns to add horizontal wells which have not been drilled for several years (due to the absence of rigs in the country); and the development of deeper horizons in existing reservoirs. All of these could yield additional volumes relatively quickly.

History offers some guidance on what might be possible: after re-opening the country to foreign investments in 1990 and signing operating agreements with international oil companies (primarily to develop the Orinoco Belt), Venezuela managed relatively quickly to increase the activity in the sector. Between 1993 and 1998, production increased from 2.5 mb/d to 3.4 mb/d (with an almost fivefold increase in the number of wells completed during that period).

However, there are a number of important caveats. One is the possibility that recent neglect has caused long-term damage to Venezuela's production potential. In fields on the eastern shore of Maracaibo, an important recovery mechanism has been compaction. Without appropriate field management practices and continuous monitoring, this can cause damage not just to existing wells and facilities, but to the wider reservoir. Cumulative subsidence in parts of this area has already reached five metres, and it is not clear how far the "Drainage Masterplan" formulated in the 1980s has been able to mitigate the risks.

Above ground, the main caveat is that it would take a sea-change in the commercial environment to bring back the capital and expertise that has deserted Venezuela in recent years. This is not just a question of a more stable political and macroeconomic situation, but also of wholesale changes to the institutional arrangements in the hydrocarbons sector in order to rebuild the trust of service companies and operators. There are few signs of such a profound reform on the horizon. This underpins a downbeat outlook for Venezuela in our projections: in the New Policies Scenario, production in Venezuela bottoms out in the mid-2020s before beginning a gradual recovery back up to 2.5 mb/d by 2040.

Iraq brought in a number of international oil companies to develop existing fields during its first and second bid rounds starting in 2009, and has raised output by 2.1 mb/d since then. The size and quality of Iraq's fields, and the capital and expertise that Iraq attracted to its upstream, meant that the country accounted for one-in-every-five incremental barrels produced worldwide between 2009 and 2017. However, momentum has slowed considerably in recent years. A number of prominent companies have withdrawn, citing unfavourable contract terms, and Iraq has repeatedly reduced its plateau target, most recently to 6.5 mb/d by 2022 (compared with an initial vision of 12 mb/d by 2018).

Generating sufficient investment to meet this revised target is complicated by the constrained fiscal situation, which limits the funds that Iraq's Ministry of Oil can dedicate to cost recovery payments. In response, the authorities have sought to reform the terms on offer. The technical service agreements awarded in the initial bidding rounds for the south of Iraq reimbursed upstream costs and then paid a fixed fee per barrel for companies operating there; this arrangement meant that companies saw little of the upside of any rise in the oil price and also limited the incentives to pursue cost efficiencies, a consideration that became a major issue for the authorities following the downturn in prices. In 2018, the Ministry of Oil unveiled a new contract structure for a fifth bidding round, aimed at better aligning its needs with those of the international oil companies by linking revenue and cost recovery to the oil price, rather than fixed remuneration and recovery rates. The impact on investors is not yet clear.

One of the biggest uncertainties for oil development in Iraq in the medium term is the lack of progress on projects to supply water for injection in upstream operations. The Common Seawater Supply Project that was initially planned to be in operation by 2013 has yet to make any real progress. Without additional water injection, Iraq could reach a ceiling in production well below the 7 mb/d mark, and the intense pressure on freshwater resources means that the seawater supply project looks essential to the provision of the additional water needed.

Overall, the improving security situation in Iraq provides an opportunity for significant improvements in the upstream sector, although 200 kb/d of oil output in and around the northern province of Kirkuk remains shut-in due to a disagreement between the central government and the Kurdistan Regional Government. A political resolution of this dispute would significantly improve the immediate prospects for the upstream, and free up much needed revenue for reconstruction and investment.

A number of changes have been proposed to improve governance and to attract further private investment. Perhaps the most important development in this context is that the Iraqi parliament voted in early 2018 to re-establish the Iraq National Oil Company to manage upstream operations, in effect separating the regulatory and operational tasks currently which are undertaken in the Ministry of Oil. This could help professionalise the operation of the sector, improve transparency and bring in investment (Table 2.3). In our projections, Iraq's production increases steadily over the period, rising from 4.6 mb/d today to 5.3 mb/d in 2025 and reaching 7 mb/d by 2040.

Table 2.3 ▷ Average annual upstream oil and natural gas investment in selected producer economies by scenario ($2017 billion)

		New Policies		Low Oil Price Case		Sustainable Development	
	2010-17	2018-25	2026-40	2018-25	2026-40	2018-25	2026-40
Iraq	14	11	21	10	17	9	7
Nigeria	7	11	20	7	14	7	8
Russia	61	63	66	57	44	53	32
Saudi Arabia	29	24	33	26	30	22	17
United Arab Emirates	10	9	12	9	10	8	6
Venezuela	10	2	18	2	11	2	7

Nigeria has, by a distance, the largest oil resource base in sub-Saharan Africa. Yet it has faced a number of challenges in recent years. Violence and smuggling in the Niger Delta led oil companies operating there to reduce activity, and then the drop in the oil price in 2014 hit the broader economy, leading in 2016 to the first annual fall in GDP in 25 years. There has been a significant dip in investment, which fell by almost 50% between 2010 and 2017, and also in production, which fell from 2.5 mb/d in 2012 to around 2 mb/d in 2017.

In 2018, the government of Nigeria announced its intention to seek $40 billion in new investment, with the aim of raising production to 3 mb/d over the next five years. Attempts have been ongoing for over a decade to reform its 40 year old oil and gas production legislation in an effort to improve the investment climate, and the government's plans have added new urgency to this. After making apparent progress with the passage of the Petroleum Industry Governance Bill (intended to be the first of five tranches of the broader Petroleum Industry Bill) by the legislature, as of October 2018 it remains uncertain whether, and in what form, it will enter into force. The legislation had outlined the creation of a new regulatory agency for the sector and intended to split the existing upstream role of the Nigerian National Petroleum Corporation between two new entities, one of which, the National Petroleum Company, was to operate as a fully commercial entity in joint ventures. Many large-scale investment decisions, especially for capital-intensive deepwater projects, are awaiting clarity on a number of elements of the Petroleum Industry Bill, including those dealing with taxes and royalties: their final shape will be a critical determinant of Nigeria's production outlook.

The fall in new project approvals in recent years dampens our projections for Nigerian oil output into the 2020s, but the expectation of gradual consolidation and improvement in sector regulation underpins an upturn later in the 2020s, with production rising to 2.6 mb/d in 2040, underpinned largely by new deepwater developments.

As a result of its consistent upstream spending through the recent downturn, **Russia** is well placed to maintain production levels above 10 mb/d for the next decade, despite sanctions limiting its access to technology and capital. Russia aims to arrest decline and improve recovery at the huge "brownfield" plays in western Siberia and the Volga-Urals basin; the

longer term trajectory depends increasingly on identifying and developing new production from "greenfield" assets in eastern Siberia, the Arctic and the Caspian Sea, and potentially also in tight oil. In all of these areas, the tax system (or exemptions from it) will play a critical role in determining the direction and volume of upstream investment.

If maintained, current sanctions could affect the longer term competitiveness of the Russian upstream by slowing its move into new, more complex resource areas such as tight oil, the Arctic and deep offshore. Accordingly, Russia is seeking alternative, non-western sources of financing and equipment, as well as encouraging domestic companies to invest more heavily in research and development at home through an import substitution programme. In our outlook, Russian production remains above 10 mb/d into the 2030s before a very gradual decline to 9.4 mb/d in 2040.

2.2 Energy pricing and energy efficiency

Energy pricing reform is the key to a more efficient allocation of resources across producer economies. Artificially cheap energy not only encourages wasteful consumption, but also distorts broader investment incentives across the economy. But reform is far from simple: low-cost energy is deeply embedded in the social contract in many producer economies, and rapid change can have social ramifications as well as implications for industrial competitiveness. Pricing reform, on its own, is a fairly blunt tool, so there is a strong case for efforts in this area need to be part of a broader strategy that includes efficiency policies, a social safety net for vulnerable groups and a coherent industrial strategy (Box 2.2).

For some energy-intensive industries such as metals, the cost of energy is a key consideration in deciding the location of a manufacturing base, and a number of producers have targeted these types of investment. United Arab Emirates, for example, is now the fifth-largest aluminium producer in the world. In 2014, Saudi Arabia formed a joint venture with a major Japanese titanium company to produce sponge titanium, offering an average electricity price that is around 70% lower than that in Japan in 2016. Given the importance of energy-intensive industrial sectors in producer economies, it is not surprising that reducing their subsidies is particularly sensitive.

However, even without subsidies, most oil and gas producers would still have a comparative advantage in energy, since a low production cost base can provide a stable low domestic price. This is of particular value in the case of natural gas and electricity, where a global commodity market is constrained by infrastructure bottlenecks and high transport costs, or does not exist at all. This comparative advantage can be significant in a sector such as petrochemicals, which also benefits from the skills built up in the oil and gas industries. The key disadvantage of a narrow focus on energy-intensive sectors is their low labour intensity: they may be economically important, but they tend not to create a large number of jobs.

Reducing subsidies on transport fuels has been a focus for policy makers in many producer economies, but very low tariffs for end-use electricity consumption are also a significant

issue. In the Middle East, electricity use in the residential sector is projected to grow faster than any other major source of energy to 2040. Per-capita residential electricity demand is projected to increase by around 50% by 2040 to more than 2 400 kilowatt-hours per capita (kWh/capita) in 2040, a level twice as high as the global average. This is largely driven by demand for appliances and cooling (see section 2.5 for the implications for electricity supply).

Box 2.2 ▻ A call for integrated policy making

The way in which major producers form and implement their energy policies reflects a wide variety of circumstances and institutional arrangements, but a common denominator is a policy focus on energy supply. Major producers differ in their approach to dealing with hydrocarbons and electricity. Saudi Arabia[1], the United Arab Emirates and Russia all have a single entity responsible for all aspects of energy policy making. Each of these countries has also developed long-term energy plans: these feature in Vision 2030 in Saudi Arabia, as well as in the Russian Energy Strategy to 2030 (an updated strategy to 2035 currently is in draft form) and the UAE Energy Strategy 2050. Each of these strategy documents establishes a broad set of objectives for energy development.

In contrast, Venezuela, Iraq and Nigeria have separate ministries for hydrocarbons and for power. This configuration has its merits, but can increase the risk (which is present in all institutional arrangements) of misaligned policies. In Iraq, for example, the Ministry of Electricity built a significant amount of generation capacity with combined-cycle gas turbines without having a firm guarantee from the Ministry of Oil that sufficient gas would be available; a gas shortage in Iraq meant that these highly efficient turbines were switched to use oil.

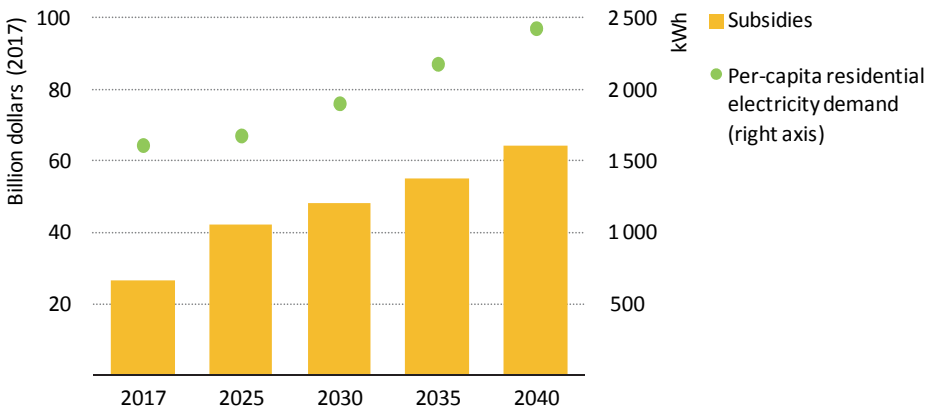
Strong co-ordination across different areas of energy policy making is particularly important to integrate energy efficiency and the deployment of clean energy technologies. In addition, issues of pricing and subsidy reform, which are often considered through the prism of fiscal policy and therefore handled by finance ministries, add to the complexity of policy integration. Effective handling of these issues depends on taking full account of the linkages with other policy areas, underlining the importance of strong and effective co-ordination within governments.

Some progress has been made in raising residential electricity prices in several producer economies, including in Saudi Arabia. But prices are still relatively low, with the average price for residential consumers in Saudi Arabia around 80% lower than the global average

[1] In 2016, Saudi Arabia dissolved its Ministry of Power, folding its functions into a broader Ministry of Energy, Industry and Mineral Resources (formerly the Ministry of Petroleum and Mineral Resources). The country also announced that it will form a "Higher Committee for Hydrocarbons Affairs" consisting of the energy, economy, trade and finance ministers, to be headed by the Crown Prince.

in 2016, and in Russia around 50% lower. When Kuwait took steps to raise electricity prices significantly, including increases for the public sector by 500%, it excluded residential electricity prices, which have been fixed at the same rate for more than 50 years (unlike the price for gasoline, electricity prices are regulated by law in Kuwait and require parliamentary approval to modify). In many producer economies, electricity prices for residential consumers do not cover the cost of supply. If subsidies to electricity were to remain at their current levels, rising electricity demand in the residential sector would increase the subsidy bill to around $65 billion by 2040 in the Middle East (Figure 2.9).

Figure 2.9 ▷ Estimated subsidy bill for residential electricity in the Middle East in the absence of pricing reforms in the New Policies Scenario



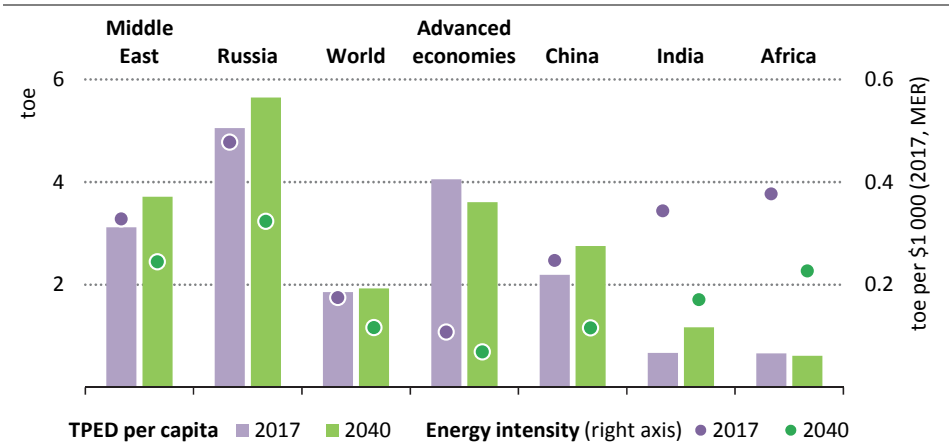
Without pricing reforms, electricity consumption will expand the subsidy bill to around $65 billion by 2040

The implications of pricing reform for energy consumers can be mitigated substantially if reform is paired with enhanced energy efficiency measures. Raising fuel and electricity prices reduces the payback period for products with higher efficiency, and helps raise public awareness of the links between efficiency and the cost of the energy they consume, but a push is typically required on the supply side to ensure that more efficient products are available on the market. A number of producer countries are introducing efficiency policies. For example, the UAE has introduced an efficiency labelling programme for refrigerators and air conditioners, and Saudi Arabia has introduced minimum efficiency performance standards (MEPS) for the same appliances. Yet much more can be done. In Saudi Arabia, for example, the average efficiency of air conditioners on the market is at the lower range of what is available in the global market (IEA, 2018), indicating scope to strengthen efficiency efforts to incentivise the uptake of more efficient equipment. Expanding the coverage of efficiency policies and ensuring adequate MEPS could help to maximise the benefit and minimise the pain of reforming subsidies.

The imperative to improve efficiency is by no means limited to the Middle East. Russia is the world's largest user of district heating, which accounts for more than 70% of all heat distributed in the country. Much of the heating network was developed in the 1960-70s and is characterised by leaks and losses that now amount, in some cases, to 40-50% of total heating energy. Investments have been made in recent years to begin to improve the networks, and some 30% of district heating networks have now been upgraded. However, inadequate consumption data, overcapacity in the system, lack of a clear national policy, and unequal distribution of resources among municipalities are all complicating the process of improving district heating systems in some regions. Furthermore, the heat is generated by power plants that are themselves often 50-60 years old and in need of upgrading.

Despite progress in some producer economies, energy intensity in the Middle East (at 0.24 tonne of oil equivalent [toe]/$1 000) and Russia (at 0.32 toe/$1 000) remains high in 2040 in the New Policies Scenario, compared with other regions (Figure 2.10). While these levels represent a decline of some 30% by 2040, as economies orientate further towards services, and as policy and technology developments deliver efficiency gains, these energy intensity levels are still around twice as high as the global average in 2040. This highlights that there are opportunities for further efficiency improvement, for example by completing the removal of fossil fuel subsidies, expanding the scope of MEPS and raising the level of current efficiency standards. In the Sustainable Development Scenario, enhanced efficiency policies mean that total final consumption in the Middle East is around 15% lower in 2040 than in the New Policies Scenario, with around 70% of these energy savings coming from improved energy efficiency in end-use sectors.

Figure 2.10 ▷ Per-capita energy demand and energy intensity in selected regions in the New Policies Scenario



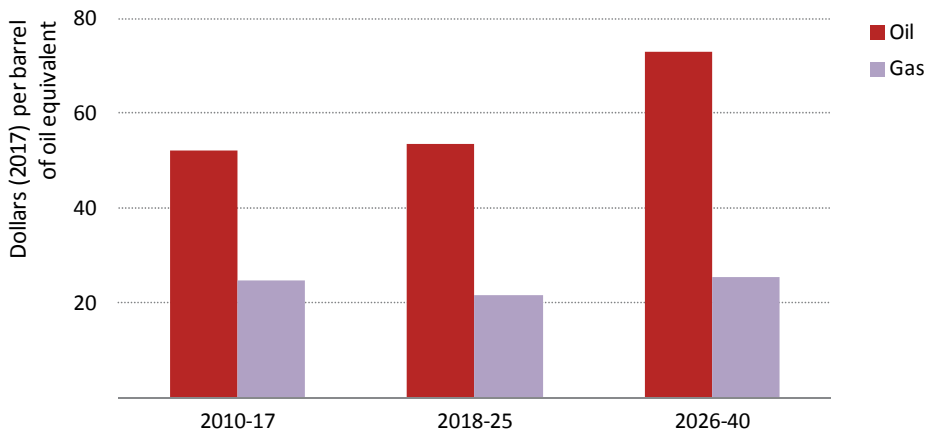
Energy intensity remains relatively high in Middle East and Russia, while declining by around 30% to 2040

Note: toe = tonne of oil equivalent; MER = market exchange rate.

2.3 Strategic priorities for natural gas

Discussions about the outlook for producer economies tend to focus heavily on the earnings and distribution of oil wealth, rather than natural gas. This is not surprising given that gas prices do not allow for the same revenue as oil per unit of production (Figure 2.11). Nonetheless, natural gas deserves a prominent place in this debate, both for producer economies that have it in abundance and those for whom it is a scarcer commodity. For major producers and exporters, such as Russia, Qatar and Turkmenistan, revenue from gas can provide a useful hedge against changes elsewhere in the energy mix. These producers face a range of dilemmas arising from a rapidly changing global gas market, but overall gas consumption is higher in 2040 than today in each scenario that we examine, including the Sustainable Development Scenario. There is a different set of strategic choices facing some other producer economies, notably in the Gulf Cooperation Council[2] (GCC), where domestic natural gas production is barely keeping pace with demand growth.

Figure 2.11 ▷ Global average annual net income from oil and natural gas per barrel of oil equivalent in the New Policies Scenario



Natural gas does not present the same opportunities for generating revenue as oil, meaning that reliance on gas presents a very different balance of opportunities and risks

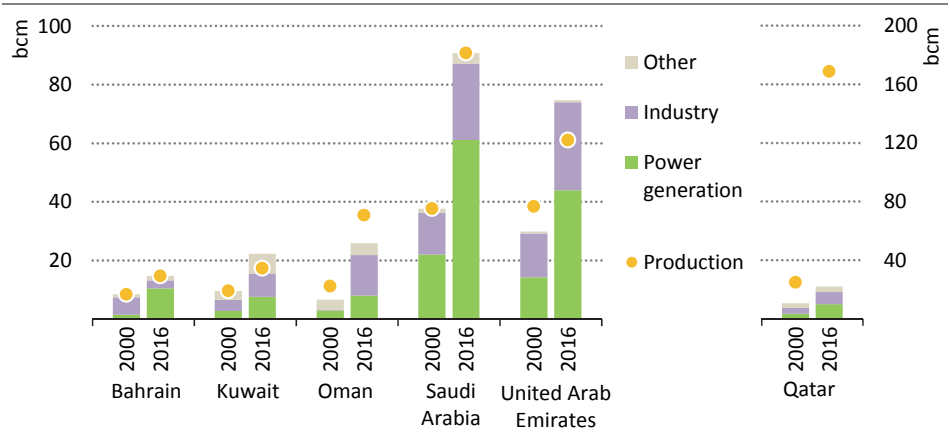
In the GCC, gas consumption has been fuelled in the past by associated gas, available essentially at zero cost as a by-product of oil production. Rising consumption and the limited availability of associated gas (with the exception of Qatar) now require that gas be sought and produced as a commodity in its own right, and often imported (Figure 2.12). This requires a re-assessment of pricing policies to incentivise upstream activity, as well as a review of the priority sectors for gas consumption. In many cases, gas can bring value by displacing oil in domestic energy use, especially where oil is combusted to generate

[2] The GCC countries include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

electricity. But the potential significance of natural gas is broader than the direct incomes that it can bring; it can underpin an industrial strategy in a way that oil cannot, and in this sense can be an important conduit to economic diversification.

Gas demand across the GCC countries has increased two-and-a-half times since 2000, with around half of this growth coming from power generation. There is a strong economic case across the Middle East for faster deployment of solar PV to displace gas as well as oil in power generation, which would augment gas availability for use in value-added industries (see section 2.4). This underlines the case for strategic thinking about where gas is likely to bring the best value within the energy system, especially in countries where there are strains on the gas balance.

Figure 2.12 ▷ Natural gas demand and production in the Gulf Cooperation Council countries, 2016



Gas demand across the GCC has more than doubled since 2000, with most of the growth coming from power generation

At present, most industrial applications of gas are capital but not labour intensive. For example, the Qatar Petrochemical Company generates more than $1 billion in annual revenues, but employs just 1 000 people. These large industrial complexes, however, can act as anchor consumers to help underwrite large infrastructure investments that bring benefits to smaller industrial consumers, supporting the emergence of lighter manufacturing and small and medium enterprises (SMEs), which thereby contributes to economic diversification and job creation. In our projections, gas demand for industry in the Middle East increases by 65 bcm to 2040, reaching 170 bcm by the end of the projection period.

Currently, more than two-thirds of **Saudi Arabia's** associated and non-associated sales of gas come from the Ghawar field, though it has invested in further exploration and development. Assisted by increases in the price of domestic natural gas, which rose from

$0.75/million British thermal units (MBtu) in 2015 to $1.25/MBtu in 2016, Saudi Arabia plans to double its natural gas output in the next ten years, mostly from conventional, non-associated plays, with processing at three new gas complexes at Wasit, Fadhili and Midyan. In our projections, gas production in Saudi Arabia continues to rise strongly from today's 94 bcm, reaching 106 bcm by 2025 and almost 160 bcm in 2040.

The **United Arab Emirates** has managed to cut its liquefied natural gas (LNG) import requirement over the past year by promoting a combination of alternative energy projects and the development of local gas reserves. The gas price was around $1.10/MBtu for some 15 years, but is now close to $3/MBtu. With electricity demand growing strongly, the UAE is now planning for local gas prices that are close to $5/MBtu. The Abu Dhabi National Oil Corporation (ADNOC) is looking to develop its giant ultra-sour gas project in the northwest, (consisting of the Hail, Ghasa and Dalma fields) and anticipates this project could meet some 20% of UAE gas demand by the late 2020s. Against a backdrop of strong electricity demand growth (rising at around 7% annually in recent years), the future role of gas in the UAE is set to be shaped by the success of this project, and by the pace at which nuclear and solar energy expand, with LNG playing a balancing role as necessary to ensure supply security.

Iraq is currently one of the countries where there is significant gas-flaring, along with Russia, Iran and Nigeria. Iraq plans to eliminate flaring by 2021 and is investing in gas capture and processing in order to augment domestic supply. The long-awaited start of operations of the Basrah Gas Company in early 2018 was an important step in this direction. The volumes that are currently flared could fuel around 4.5 GW of gas-fired power generation, which is enough to power 3 million homes. Given the persistent electricity shortages across the country, limited policy support for solar PV and the fact that some 300 kb/d of crude and heavy fuel oil is used for power generation, it is not surprising that power generation is a very high priority for gas use in the future. However, Iraq has also signalled its intention to develop its domestic gas value chain, and has signed an agreement with Shell to develop a large petrochemicals complex, Nebras. In our projections, Iraq's gas production rises rapidly from 8 bcm today to 115 bcm in 2040.

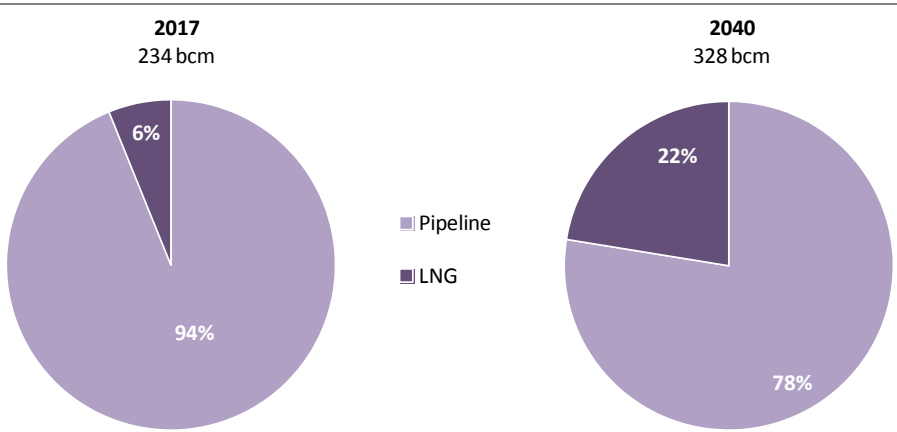
Countries across Eurasia generally face a different set of strategic dilemmas and choices from those facing countries in the Middle East. **Russia** has abundant available gas, but its domestic demand is stagnant and opportunities to expand exports are currently limited: it sent record volumes to Europe in 2017, but access to other markets is constrained pending the completion of the "Power of Siberia" pipeline to China (anticipated in 2020) and planned expansion of LNG capacity. The relatively high levels of gas use in industry and a falling population make for a subdued gas demand outlook, increasing by just 3% to 2040 in the New Policies Scenario. Power and heat generation are the Russia's largest consumers of natural gas (nearly 25% and 30% respectively), and they have huge opportunities for efficiency improvements.

For Russia, as for Turkmenistan and Qatar, the key question is what export strategies to adopt in an increasingly interconnected and competitive global gas market in which

demand is shifting towards the emerging economies in Asia, and in which international trade is moving towards LNG. Each of these producers faces different constraints and opportunities. Qatar looks best placed to respond. It already occupies a leading position in LNG markets and the recent lifting of the moratorium on the North Field was accompanied by the announcement of a plan to increase liquefaction capacity by around 45 bcm per year. Qatar has a variety of strategic options open to it in order to retain a leading role as a major gas supplier to global markets.

Russia faces a more difficult task in seeking to diversify its export opportunities (Figure 2.13). Pipeline connections are by their nature inflexible, and its pipeline links to Europe tie it to markets where gas consumption is moving into gradual decline, and where it faces regulatory pressures. In the New Policies Scenario, gas demand in the European Union in 2040 is more than 100 bcm lower than its 2010 peak, even if the effect on import levels is mitigated by continued falls in the EU's own output. Pipeline exports to China are projected to expand beyond the Power of Siberia link, but in our outlook Russia is also increasingly drawn to the flexibility and optionality available from LNG. How this LNG, exported by different companies, coexists with Gazprom's continued monopoly on pipeline exports is another strategic question that may ultimately serve to catalyse changes in the organisation of Russia's gas market.

Figure 2.13 ▷ Natural gas exports from Russia by type in the New Policies Scenario



Pipelines remain Russia's main avenue to reach export markets, but the optionality of LNG helps it to gain a firmer foothold in Russia's export strategy to 2040

Turkmenistan's perennial strategic dilemma, located as it is in the middle of the Eurasian landmass, is access to markets. It is entirely dependent on long-distance pipelines and energy transit arrangements to reach the world's large gas-consuming markets. If the infrastructure is not in place, or the transit or offtake arrangements are unreliable, its gas

risks being stranded. Two of Turkmenistan's neighbours, Russia and Iran, are themselves large gas producers: this inevitably limits their potential as export markets and their interest in acting as transit countries.

In our projections, Turkmenistan remains highly reliant on China as a market for its gas exports. Alternative pipeline routes to South Asia face numerous political and security hurdles that dull the commercial case for trade. Furthermore, while the recent agreement on the legal status of the Caspian Sea could eventually help it to ship gas westward, there are still difficult issues to be resolved and no clear way forward. A high-level strategic partnership, coupled to upstream opportunities, was the key to unlocking the pipeline investments linking Turkmenistan with China, and would in all probability be required again to underpin any further diversification of exports.

2.4 Capturing more value from hydrocarbons

In recent years, many of the producer economies, notably those in the Middle East, have embarked on expansion into the oil downstream value chain. Middle East countries currently account for around 10% of global refinery runs, and that percentage is set to increase. Saudi Arabia has several large-scale refineries such as Jubail, Yanbu and the Jizan complex due to come online soon (400 kb/d each). The United Arab Emirates' ADNOC has announced a $45 billion downstream investment plan with the aim of creating the world's largest refining and petrochemical facility by 2025. And the Kuwait Petroleum Corporation (KPC) has unveiled a plan to invest $25 billion to double its refining capacity by 2035, with expansion at Mina Abduallah and a new 615 kb/d Al-Zour plant. Iran is building a series of condensate splitters, and Iraq also has several projects in the pipeline.

The recent expansion drive goes beyond national boundaries as producer economies increasingly seek opportunities in growing markets, notably in Asia. Saudi Aramco has recently reached a series of agreements to invest in refineries in China, India, Indonesia, Malaysia and the United States. The company already holds stakes in overseas refineries equivalent to around a third of its domestic capacity, and its new projects will add significantly to this. Kuwait's KPC is assessing investment in India's Bina refinery in addition to its two existing investments in Oman and Viet Nam, and the UAE's ADNOC is also exploring downstream opportunities in India and other growing Asian markets.

There are several motivations behind this downstream drive, including a wish to extract more value from the oil the region produces, to promote economic diversification and to secure outlets for crude exports. The expansion increases revenues for each barrel produced, and thereby also risks increasing dependency on oil revenue. However, downstream earnings typically move in a different direction from upstream earnings – they tend to be higher when crude oil prices are low, and vice versa – so they also provides a hedge against lower oil prices.

Many producer economies in the Middle East are looking at downstream investments in petrochemicals as well as in refining. Earlier investments in the 2000s relied largely on low-

priced gas-based feedstock, such as ethane, although tightening gas supply in the 2010s has meant a shift in some countries towards liquid feedstocks. Saudi Aramco plans to build a major new petrochemical complex next to the SATORP refinery in order to capture operational synergies, and new Kuwaiti and UAE refinery projects also include substantial petrochemical elements. Qatar, which does not share the same ethane supply constraints as other producer economies, aims to build one of the world's largest ethane crackers at Ras Laffan by 2025. Outside the Middle East, Russia is advancing its own petrochemical programme with the aim of reducing reliance on direct oil revenue.

Several factors explain this renewed enthusiasm for petrochemicals. Expansion into petrochemicals offers companies the potential prospect of higher and more resilient margins. The demand outlook for petrochemical products remains robust: while there is growing attention on reducing single-use plastics and increasing plastic recycling, especially in advanced economies, the impact of these trends is more than offset by surging demand in developing economies and the increasing use of plastics in place of other materials such as wood and metal. Chemical products are already a major part of Saudi Arabia's non-oil export, representing some 60% of non-oil exports revenue in 2017, and the additions of new capacity in various other producer economies has the potential to raise their non-oil revenue considerably.

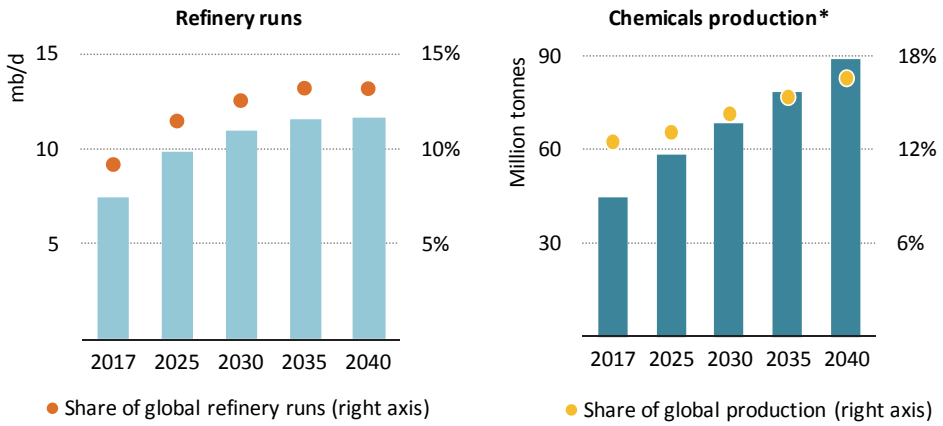
Petrochemicals also provide a hedge against the possibility of a contraction of oil demand as a result of a rapid uptake of electric vehicles or higher levels of efficiency improvements. Although global oil use continues to grow to 2040 in our New Policies Scenario, the Sustainable Development Scenario sees oil demand for passenger vehicles drop significantly, as well as pressure on oil consumption for other modes of transport such as trucks, shipping and aviation. However, oil demand for petrochemicals remains relatively resilient in this scenario, despite increased recycling and use of alternative feedstocks.

Many of the recently announced petrochemical projects are being planned as integrated facilities, with refineries either co-located in the same industrial complex or more closely integrated. This is because integration allows companies to maximise yields of chemical products instead of traditional refined products, thereby offering an ability to better cater to changing demand patterns as well as a range of operational synergies.

An even more integrated approach, being explored by Saudi Aramco and SABIC, is to convert crude oil directly into chemical products, with traditional refinery outputs becoming by-products of this process, a dramatic change compared with current practices. The first planned complex is being designed to convert 40-45% of crude to chemical products, while a second project aims for a higher yield, and is being developed based on new thermal cracking technology. These schemes could challenge traditional upstream, refining and petrochemical businesses, especially in the event that demand for transport fuels wanes while petrochemical uses remain strong (as in the Sustainable Development Scenario).

The strategic reorientation of producer economies towards refined and chemical products bears fruit in the New Policies Scenario, and has wider ramifications for the global energy market. The Middle East's refinery output grows by nearly 60% over the period to 2040, and the region's share in global refinery runs rises from 9% today to 13% by 2040. The Middle East emerges as a major oil product exporter in addition to its existing role as the world's largest crude oil exporter. This is likely to have implications for refineries in other regions, especially those which rely on crude imports from the Middle East. Mounting consumption from its own refineries could limit the growth of crude oil volumes available for export – taking into account refineries where Middle Eastern companies have stakes, the amount of Middle Eastern crude oil freely available on the market could actually shrink over time (IEA, 2017). The production of chemical products in the Middle East also grows strongly in this scenario – doubling between today and 2040 – and the share of the Middle East in global chemicals production increases from 13% today to 17% by 2040 on the back of feedstock cost advantage and the high level of efficiency of newly built facilities (Figure 2.14).

Figure 2.14 ▷ Refinery runs and chemicals production in the Middle East in the New Policies Scenario



Producer economies in the Middle East make significant inroads into global refining and petrochemical markets with their downstream expansion drive

* Includes ethylene, propylene and aromatics (benzene, toluene and xylene).

Although the downstream expansion of producer economies has the potential to bring them benefits in terms of margins, economic diversification and an increased presence in global downstream markets, there are also challenges ahead. Downstream capacity additions can help to extract more value from the region's indigenous production, but high capital costs or cost overruns could easily wipe out this additional value, especially in the case of refining where margins are generally thin. And companies will need to find or develop the necessary skilled labour to ensure operational excellence.

It will also be challenging to develop related industries so as to maximise the impact of investment on economic growth and job creation. Large-scale commodity chemicals are capital intensive and tend to be dominated by large companies, so the impact of job creation per invested dollar is smaller than in more labour-intensive industries. Fostering businesses producing downstream chemical products, or manufacturing end-use products based on those, would help to create more employment opportunities, to nurture SMEs and to amplify the impact of investment on economic growth.

2.5 Cost-effective deployment of low-carbon energy

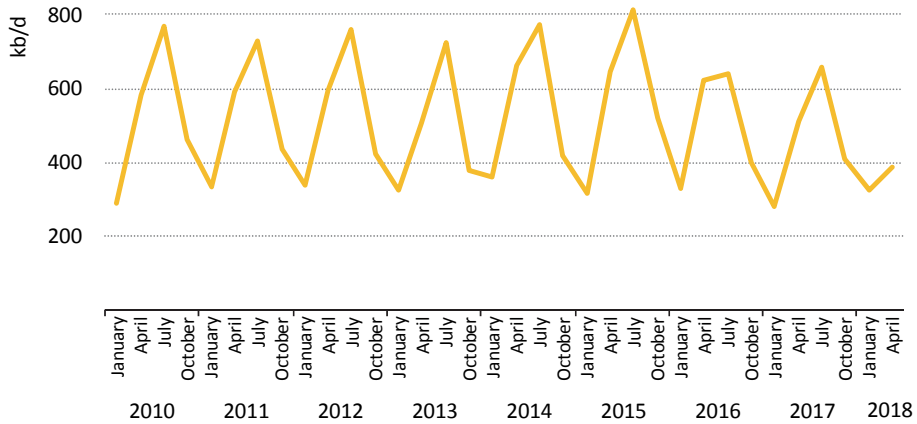
A number of producer economies are endowed with world-class solar and wind resources, and are increasingly looking to tap this potential as a way to improve the operation of their energy sector and to free up hydrocarbons for other uses (see Chapter 1). For Middle East producer economies, the main opportunity is clear: their electricity demand has increased at a rate of 5.7% per year since 2000, almost twice the global average, and oil-fired generators play a prominent role in the generation mix. Since 2000 there has been a 900 kb/d increase in the region's oil consumption for power generation to around 1.8 mb/d in 2017. This diverts oil away from exports towards inefficient domestic consumption and incurs a significant opportunity cost – especially significant at a moment when global spare production capacity is starting to look thin.

On the demand side, electricity use for buildings is by far the largest component of consumption in the Middle East, with appliances in general and air conditioners in particular playing a prominent role. Energy consumption for space cooling has almost tripled since 2000 and there is very large potential for further growth. Without a significant improvement in efficiency over time, and considering the large anticipated increase in the use of air conditioners, demand for space cooling alone could skyrocket from 135 terawatt-hours (TWh) today to over 300 TWh in 2040.

There are much better solutions, both on the demand and supply sides. On the demand side (as discussed in section 2.2 above), there is significant potential to improve the efficiency of the air conditioners (and other appliances) marketed in the region: in recent years, both the UAE and Saudi Arabia have introduced efficiency labelling programmes. On the supply side, there is a huge opportunity to tap into the region's ample solar potential to relieve pressure on the power system.

For the moment, peaking capacity in many parts of the Middle East is provided by oil-fired plants, often burning crude oil directly. In Saudi Arabia, for example, the daily load curve in summer reaches almost twice its peak in winter months because of air conditioning use. This means that 20-25 gigawatts (GW) out of a total of 88 GW of capacity are used only for around half the year. These are mostly oil-fired plants, and they increase daily crude burn by as much as 500 kb/d in peak summer periods relative to winter months (Figure 2.15).

Figure 2.15 ▷ Crude oil use in power generation in Saudi Arabia

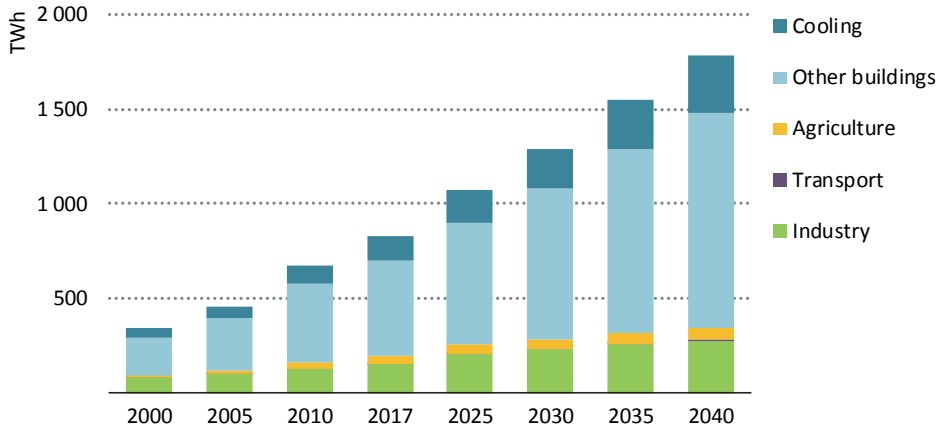


Crude oil use in power generation peaks every summer, as air conditioning propels electricity demand

Solar PV is ideally placed to meet these peaks: daily demand for cooling peaks between 13:00 and 16:00 and corresponds with peak solar PV output. At present, this potential is almost entirely untapped, with the 1.2 GW of solar capacity making up less than 0.5% of total generation capacity in the Middle East. However, there has been a significant recent increase of interest in the potential of solar PV, and a number of auctions in Saudi Arabia and the UAE have broken records for the lowest bids for solar PV generation globally. A number of producers have now incorporated renewables in their diversification strategies, including Saudi Arabia, which has significantly raised its aspirations for solar PV, and the UAE, which plans to have a 25% share of renewables in power generation by 2030.

In the New Policies Scenario, electricity demand is projected to continue to grow robustly in the Middle East, at around 3% per year to 2040, by which time total demand reaches 1 800 TWh (Figure 2.16). Demand for cooling alone accounts for almost one-fifth of the total increase: although this takes into account some announced efficiency initiatives, it remains well above what could be achieved with a more concerted policy effort. For example, cooling demand could be limited to around 170 TWh in 2040 if all models sold were at the higher end of the efficiencies available today – a saving of nearly 135 TWh relative to the New Policies Scenario. More stringent energy performance standards for buildings and a modal shift towards district cooling could bring even larger gains.

Figure 2.16 ▷ Electricity demand by sector in the Middle East in the New Policies Scenario

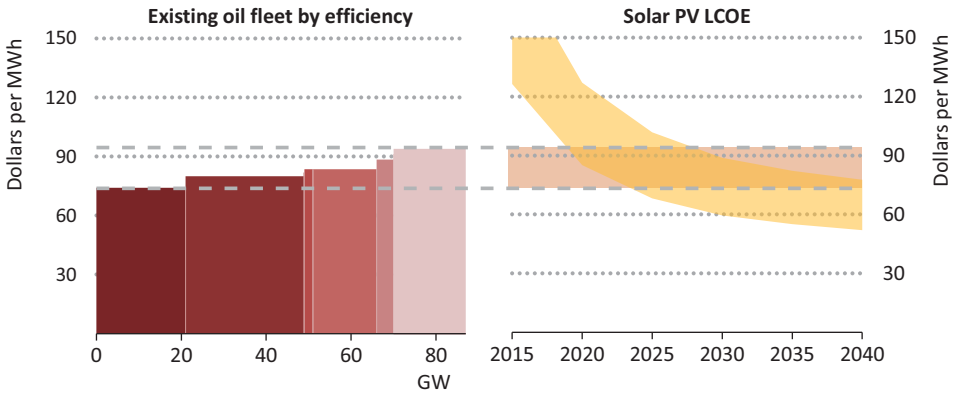


Appliances and cooling account for almost all of the increase in electricity demand in the Middle East

On the supply side, the share of low-carbon generation does rise in our projections, but the level of deployment leaves plenty of untapped cost-effective potential. In the New Policies Scenario, solar PV capacity reaches 90 GW in 2040, with a further 15 GW of concentrating solar power capacity. Low-carbon generation deployment in the Middle East is not limited to renewables, with more than 14 GW of nuclear capacity also expected in that time, reflecting developments in the UAE, but also policies announced in Kuwait and Saudi Arabia. In any system where the costs of generation are properly accounted for, solar PV could compete with any thermal (oil) generator currently deployed at a price per barrel above $40 by the mid-2030s (Figure 2.17).

At current levels of deployment, concerns about the impact of variable renewables on grid stability in the Middle East are misplaced, although care will be needed to ensure that network planning matches plans for new utility-scale renewable projects. Most GCC countries in particular have generation fleets that are flexible enough already to enable a much higher penetration of renewables, and the rise in electricity demand for desalination could provide a further synergy for renewables (Spotlight). In the UAE, for example, 85% of generation capacity consists of combined-cycle gas turbines with the operational flexibility and ramping capability to help operators deal with variability in renewable energy generation. Similarly in Saudi Arabia, over 80% of capacity is provided by oil-fired steam turbines and simple cycle gas generators. These offer a high degree of flexibility and would thus allow for large-scale penetration of variable renewables at little risk to system stability, particularly when considering the relatively predictable nature of the load curve in summer months.

Figure 2.17 ▷ **Levelised cost for solar PV, 2017-2040, compared with existing oil-fired generation at $40 per barrel oil price**



Solar PV can compete on a cost basis with oil-fired generation, even at an oil price of $40 per barrel

Note: MWh = megawatt-hour; LCOE = levelised cost of electricity.

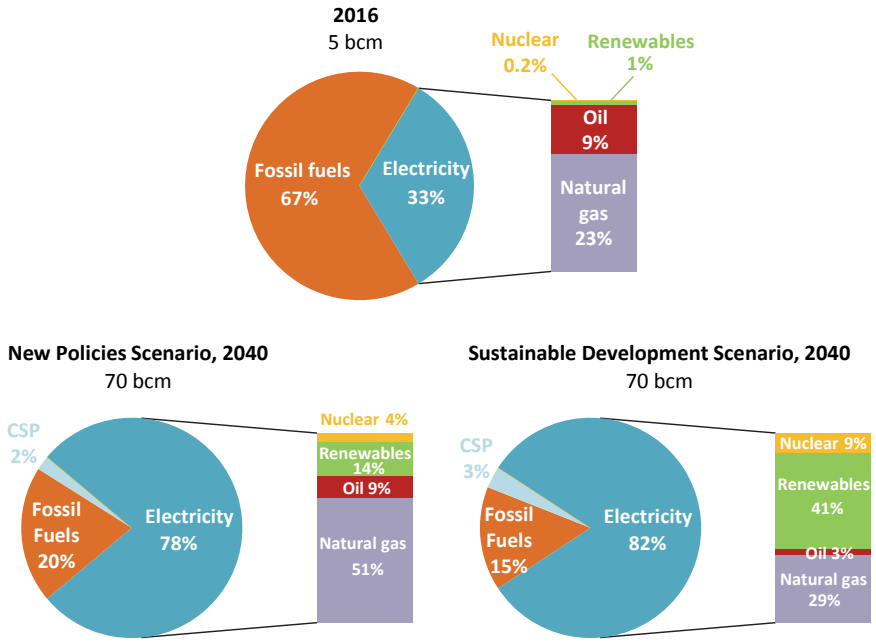
S P O T L I G H T

Desalination: significant energy cost for the Middle East but part of the solution for renewables integration?

Countries in the Middle East have among the lowest water availability levels on a per-capita basis in the world. Moreover, the consistent underpricing of both water and energy has encouraged the inefficient use of water and contributed to unsustainable levels of water withdrawals from non-renewable groundwater resources. To compensate, the region has increasingly turned to desalination, which has a significant energy cost: in 2016 desalination accounted for 5% of total energy consumption in the Middle East.

Membrane technologies that use electricity, such as reverse osmosis (RO), are the most common desalination technology installed worldwide. However, the low cost of oil and gas and the prevalence of co-generation facilities for power and water in the Middle East has meant that it currently relies heavily on fossil fuel-based thermal desalination (multi-stage flash or multiple-effect desalination). Two-thirds of the water produced from seawater desalination in the region today is from fossil fuel-based thermal desalination, while the rest is from membrane-based desalination that relies heavily on natural gas-based power generation (Figure 2.18). The Middle East accounts for roughly 90% of the thermal energy used for desalination worldwide, with the United Arab Emirates and Saudi Arabia the two largest players.

Figure 2.18 ▷ **Water production from seawater desalination in the Middle East by input fuel and scenario**



The share of water produced from membrane-based desalination rises in each scenario, but the power mix of the NPS means desalination remains reliant on fossil fuels

Notes: NPS= New Policies Scenario; SDS= Sustainable Development Scenario; CSP= concentrating solar power; bcm= billion cubic metres. Excludes desalination for offshore oil and gas facilities and most industry. The electricity mix assumes the same split as the overall generation mix of the Middle East region.

The use of membrane technologies however is growing in the region. RO accounts for 60% of capacity in Oman and roughly half of the capacity in Saudi Arabia. All of the contracted plants currently under construction in Saudi Arabia and a majority of planned capacity are RO desalination plants, including the Rabigh 3 project being developed by Saudi Arabia Water & Electricity, which is expected to come online in 2021 and has the potential to become one of the largest membrane-based seawater desalination plants in the world (GWI, 2018; Freyberg, 2018).

The production of desalinated seawater in the Middle East is projected to increase almost fourteen-fold to 2040, and there is a concerted shift towards membrane-based desalination in both the New Policies and the Sustainable Development scenarios. This occurs for several reasons. First, the cost of RO technologies continues to decline. Second, the use of domestic oil and gas resources for thermal desalination cuts into

potential export revenues. Third, many countries in the Middle East are looking to diversify their energy mix and increase the share of renewables in power generation. Pairing more co-generation plants with RO technologies instead of thermal technologies would allow for greater operational flexibility and for the system to be used as a demand response facility: it could help ensure an outlet during periods of excess electricity production, with water storage tanks also serving as energy storage.

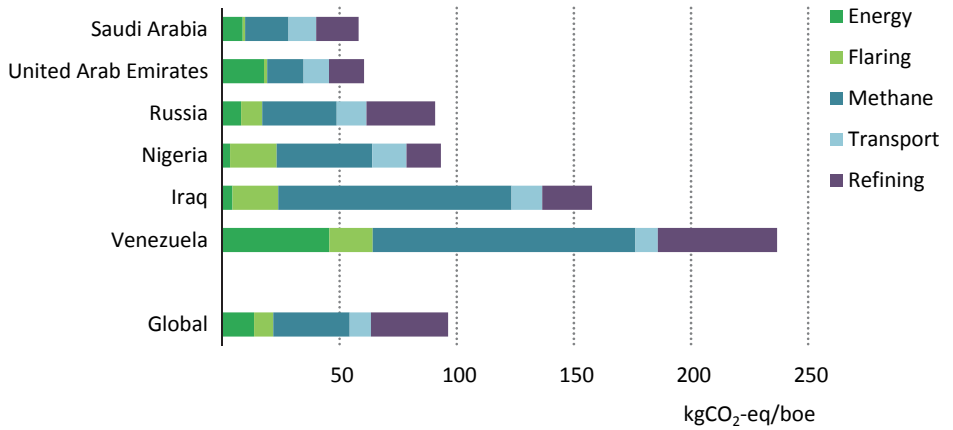
By 2040, over three-quarters of the water produced in the Middle East in the New Policies Scenario is from membrane-based desalination. However, because the power sector remains heavily reliant on natural gas and oil for power generation in 2040, most desalination still depends on fossil fuel-based electricity, impeding efforts to generate more revenue by exporting hydrocarbons. The phase-out of subsidies for fossil fuels and electricity in the Sustainable Development Scenario results in a slightly higher share of water production from membrane-based and CSP desalination in 2040 than in the New Policies Scenario. The policy choices taken in the Sustainable Development Scenario also lead to the deployment of more renewables, which account for over half of power generation by 2040. This shift not only frees up resources for export, but also reduces carbon dioxide (CO_2) emissions and local air pollutants.

Low-carbon energy accounts for around one-third of Russia's electricity generation, with the majority of this accounted for by nuclear and hydropower, and variable renewables playing only a marginal role. Here too there is considerable room for growth, given that Russia has the world's largest wind potential, estimated at nearly 260 TWh per year (IRENA, 2017). In the New Policies Scenario, this leads to a rise in wind power generation across Russia, which grows from a minimal level today to 23 GW in 2040 (around 8% of total capacity). A bigger push towards decarbonising the electricity sector, as outlined in the Sustainable Development Scenario, sees an even larger increase to 38 GW. In this scenario, Russia also takes even greater advantage of its significant hydro resources, with installed capacity increasing from 51 GW to 86 GW, meaning that renewables account for over half of installed generation capacity in 2040.

2.6 Reducing the GHG emissions intensity of oil and gas supply

Extracting oil and gas, processing it and getting it to consumers can consume large amounts of energy and, given the importance of oil and gas extraction to producer economies, this energy can represent a larger portion of overall energy demand than in other countries. Keeping this element of demand in check can provide substantial cost savings, as well as helping with the environmental credentials of their oil and gas output. For the moment, there are substantial differences in the estimated greenhouse gas (GHG) emissions intensity of oil production among the various producer economies (Figure 2.19).

Figure 2.19 ▷ Average greenhouse gas emissions intensity of oil from selected producer economies, 2017



Several producer economies already provide some of the lowest GHG emitting sources of oil today; but flaring and methane emissions mean others are relatively emissions intensive

Notes: kg CO_2-eq/boe = kilogrammes of carbon-dioxide equivalent per barrel of oil equivalent; CO_2 emissions from oil combustion is around 405 kg CO_2/boe.

Most of the producer economies discussed here have huge subsurface reservoirs with high levels of natural drive pressure. This means that the energy required to extract the oil from the ground is relatively small, especially compared with many mature oil provinces in other parts of the world. The main exception to this is Venezuela, whose extra-heavy oil from the Orinoco Belt requires large quantities of heat and energy to extract. There is also some variation in the quality of crude oil between the producer economies both in terms of sulfur content and density. For example, Nigeria produces a light crude oil (average 35°API)[3] with a low sulfur content (less than 0.2% sulfur by weight); crude oil from Saudi Arabia is slightly heavier (around 33 °API) and generally has a much higher sulfur content (2% sulfur); while crude oil from Venezuela is even heavier still (19 °API) and is also quite sour (2% sulfur).

During the refining process, heavy crude oil produces large volumes of low-value oil products, such as heavy fuel oil. Heavy crude oil must therefore undergo a more complex refining process to increase the share of higher value products (known as “upgrading”). Similarly, sulfur and other undesirable contaminants usually need to be removed from refined products to ensure regulations are met (known as “hydrotreating”). The extent of upgrading and hydrotreating depends on the crude oil produced: refining heavy, sour crude oil requires more energy than refining light, sweet crude oil to produce a given array of oil products.

[3] API gravity is a measure of density.

These differences help to explain some of the variation seen between the different producer economies in terms of the overall GHG emissions intensity of their oil operations. But two of the largest factors differentiating the producer economies on this score are the levels of CO_2 emissions from flaring and the extent of fugitive or vented methane emissions.

- Natural gas is produced in association with crude oil: if there are limited ways to bring this gas to market, operators often choose to flare it or vent it to the atmosphere. For example, Iraq and Nigeria flared around 18 bcm and 8 bcm of natural gas in 2017, respectively. This added substantially to the overall GHG emissions intensity of oil from these countries.
- Methane is a more potent greenhouse gas than CO_2 and so vented methane emissions have an even larger impact than flaring on the relative emissions intensity of different crude oils.[4] Given the relative weakness of regulation and oversight of methane emissions in Venezuela and Iraq, oil production there is estimated to cause large levels of fugitive and vented methane emissions.[5] In these two countries, methane emissions add around 100 kg CO_2-eq to the well-to-tank emissions intensity of oil production.

Saudi Arabia and the UAE have made significant efforts to capture produced natural gas either for domestic use or export and so they flare and vent only very small volumes. This is also the case in Qatar and Kuwait. Despite the fact that the crude oil they produce is relatively sour, oil from these countries has among the lowest emissions intensity of any source globally. Saudi Arabia and the UAE therefore point the way for other producer economies to step up their endeavours to eliminate flaring and venting.

There are a number of other options to reduce the GHG emissions intensity of oil and gas extraction.

- One possibility is to use solar energy rather than oil and gas to provide the energy needed to extract oil from the subsurface. This is particularly attractive in many Middle East countries, as they have high capacity factors for solar PV and solar thermal plants (Box 2.3). Although Saudi Arabia already has some of the least emissions intensive oil in the world, it is continuing to explore options to reduce this further.
- Another possibility is to enhance oil recovery (EOR) using CO_2. CO_2-EOR is one of the few options available today to monetise carbon capture, utilisation and storage (CCUS), since it can lead to higher levels of oil extraction while permanently keeping injected CO_2 in the ground. There are important issues to be resolved – most notably ensuring that CO_2-EOR leads to an overall reduction in the level of CO_2 in the atmosphere – but this represents an important opportunity for the producer economies to make a substantive contribution to the energy transitions. Not only

[4] Here we use the 100-year global warming potential of methane and assume that one tonne of methane is equal to 30 tonnes of CO_2-equivalent.

[5] For more information on methane emissions related to natural gas, see *World Energy Outlook-2017* (IEA, 2017).

could this help to reduce CO_2 emissions directly but as more capture, transport and CO_2 storage facilities are deployed, it could help reduce the cost for future facilities, improving the economics of CCUS more generally. Saudi Arabia has expressed interest in these technologies and has a demonstration project that takes CO_2 from a gas processing plant for injection into the Uthmaniyah area of the super-giant Ghawar field.

Some producer economies are also considering possible alternative uses for oil and gas in the future which would minimise overall GHG emissions. One option is to increase the levels of hydrocarbons in non-combustion uses such as petrochemicals (discussed in the previous section). Another is to convert the hydrocarbons to a zero-carbon-vector such as hydrogen. This can be produced from methane using steam. If the CO_2 from this process is stored underground, this zero-carbon hydrogen could help decarbonise a number of end-user sectors across the global energy system while still providing a mechanism to monetise the producer economies' hydrocarbon resources.

Box 2.3 ▷ Enhanced oil recovery fuelled by solar: heating up in Oman

Oman's oil production peaked around 2000 and fell by more than 20% over the subsequent seven years. Given the importance of the oil sector to the Omani economy, the national oil company, Petroleum Development of Oman (PDO), started to invest heavily in enhanced oil recovery (EOR) techniques in order to extract larger oil volumes from its mature resource base. PDO launched some 16 EOR projects and trials (a further six are currently under consideration) and managed to reverse the decline in production, which today stands at just under 1 mb/d.

PDO experimented with a number of different EOR technologies, including miscible gas injection and surfactant, and polymer floods. However, since a large portion of Oman's remaining oil resources are heavy, it took a particular interest in thermal EOR. In thermal EOR, steam is injected into the subsurface to heat the oil in the reservoir so that it can be extracted more easily. This is an energy-intensive process and typically gas generators are used. These consume large quantities of natural gas and mean that the oil produced tends to have a high GHG emissions intensity. An alternative to the use of gas is concentrating solar power technology, where large mirrors are used to concentrate the sun's energy to generate the steam for injection. In 2015, Oman announced one of the world's largest solar installations, the 1 GW (thermal) Miraah project. Not only will this free up around 170 million cubic metres of gas each year, but it also means that the GHG emissions intensity of oil produced using thermal EOR will be substantially lower.

Strategic responses: the broader reform agenda

The objective to diversify hydrocarbon-dependent economies and reduce their reliance on oil and gas is not new, and the reform discussions unfolding in many producer economies today have many parallels with previous efforts. The longstanding nature of these efforts underscores that diversifying away from commodity dependency is genuinely challenging and raises a complex set of policy questions that do not have a straightforward solution. Even a country like the Netherlands, a pioneer in the development of modern market institutions, was susceptible to the "Dutch disease", a phenomenon first documented in the context of Dutch gas exports in the 1960s. There are also relatively few historical examples that identify a clear reform path for producer economies to follow, although the experience of countries like Mexico and Indonesia provides some useful context (Box 2.4).

Box 2.4 ▻ Lessons from economic diversification and non-oil development in Indonesia and Mexico

With the exception of countries that were already advanced market economies before the arrival of oil, like the United Kingdom, the most important conventional oil producers that have witnessed respectable growth in non-hydrocarbon sectors in recent decades are Indonesia and Mexico. In both cases, non-oil growth has not been achieved by the state directly recycling oil revenues. There has been some indirect support, as hydrocarbon revenues allowed the government to maintain a certain level of funding for education, health care and other social objectives with a lower level of general taxation than would otherwise have been possible. However, even with oil revenues, both countries have maintained a moderate ratio of government expenditure to GDP.

Instead, in both Indonesia and Mexico, the engine of non-oil growth has been export-oriented manufacturing, often based on outsourcing by major international enterprises that, in turn, has created a hub for networks of domestically owned medium-sized suppliers. The most important source of finance has been foreign direct investment, including the reinvested earnings of the local subsidiaries of multinationals, equity of family-owned enterprises and bank lending for the domestic suppliers. The industries range from labour intensive (textiles) to moderately capital and technology intensive (cars, household appliances). In addition, labour-intensive services like tourism have played a significant role.

The key contribution from government policy was not state investment in production facilities. Nevertheless, government policy did play an important role. Both countries maintained an openness to foreign investment and had trade policies aiming at market integration. Transport infrastructure witnessed major government investment, although bottlenecks persist in both countries. Both experienced a financial crisis in the 1990s, but since then their prudent macro policies have maintained financial stability. Last, but not least, both achieved a step change in the past three decades in skills and human capital development.

Prolonging the status quo for producer economies looks difficult even in the relatively benign market and policy environment of the New Policies Scenario. The challenges facing producer economies in the Low Oil Price Case and the Sustainable Development Scenario are more profound; they are also quite distinct. The Low Oil Price Case is driven to a considerable degree by the entry of a new supply source into the market – US tight oil – at a much larger scale than in the New Policies Scenario. This allows the market to balance at a lower price, but the role of oil in the global energy mix is not fundamentally questioned, even with the higher assumed penetration of electric vehicles. As such, some producers with large sovereign savings and creditworthiness in international bond markets might try to ride out the storm, knowing that US tight oil is a large but ultimately finite resource that will eventually deplete. The challenge in the Sustainable Development Scenario is different. There is still a major need for investment in new field development, as the decline in oil demand in this scenario is considerably less than the natural depletion of conventional production. But the strong policy push for reductions in emissions, accompanied by rapid technological change, would imply persistent pressure on oil markets and consequently on the producers as well (even if natural gas markets would offer some relief). In this scenario, there is an inescapable imperative to prepare for a world in which hydrocarbons are no longer the main source of revenue, even if, as discussed, there may be alternative ways to monetise hydrocarbon resources that do not contribute to global emissions.

A full discussion of the development policies that would aid the broader economic transformation of producer economies is beyond the scope of the *WEO*. It is also impossible to do justice to the range of economic circumstances and specificities of the various countries involved. Nevertheless, there are some broad principles that might usefully underpin reform programmes.

- **Strengthen the microeconomic and institutional foundations of growth.** Although the indicators vary widely by country, many producer economies have scope to strengthen the legal and institutional foundations necessary for a modern market economy, and to improve the ease of doing business in their country.
- **Maintain macroeconomic stability.** Fiscal policy in many major hydrocarbon producer economies is effectively pro-cyclical as government spending typically expands in high oil price periods and has to be cut when prices decline. Stabilisation funds can effectively be used for smoothing the cycle and to provide a stimulus in a period of falling oil prices. However, if the underlying structural fiscal position is not sustainable in a particular producer economy, it risks a repeat of the experience after 2014, when budget cuts reinforced the negative macroeconomic impact of the declining oil price.
- **Financial sector reform.** Domestic banks are poorly capitalised in a number of producer economies, since the revenues from oil and gas flow directly from national oil companies to the government, bypassing the domestic banking system. As a result, the economy can be capital-rich and a net international saver in the hydrocarbons sector, but capital-poor and reliant on either foreign lending or family savings in the rest of the economy. This duality is especially visible in Russia, although recent efforts by the Russia's Central Bank to stabilise the banking system have improved the

situation somewhat. A well-regulated and adequately capitalised banking system integrated into global financial markets could play an important role in driving growth.

- **Develop labour markets and human capital.** With the exception of Russia, major oil producers often have limited formal employment in the non-hydrocarbon private sector of the economy. In the GCC countries, the private sector typically relies on foreign workers, whereas in Nigeria, Venezuela and Iran informal employment is widespread. This is detrimental to growth in the long term as it hinders the accumulation of skills and human capital. Good educational systems are also critical to develop the skills needed for future employment.

These broad principles are of course applicable in non-oil producing countries as well: improving the business environment or the quality of education is desirable regardless of whether a country produces hydrocarbons or not. However, there are some specific considerations in the major producing economies. One is the role of energy as a source of comparative advantage. Lower energy prices are a corollary of resource-ownership and low production costs, meaning that investment in energy-intensive industries need not be an outcome of subsidised energy inputs or particular state interventions. Even without any state investment, strong concentrations of energy-intensive industries have emerged in market-based producing regions such as the US Gulf Coast.

A second is the possibility of using hydrocarbon income to underpin state-financed infrastructure investment. Whether it is desirable to redirect hydrocarbon revenues from sovereign wealth accumulation to domestic infrastructure depends on the current state of the capital stock as well as the institutional capability of the state. In countries where much modern infrastructure is yet to be built, as in Nigeria, or which have suffered extensive war damage, as in Iraq, the social returns from infrastructure investment (and general reconstruction in Iraq) are likely to be high. The GCC countries tend to have an extensive and modern infrastructure capital stock, so further large-scale investments in these countries might face a diminishing return.

Implications for energy security and energy transitions

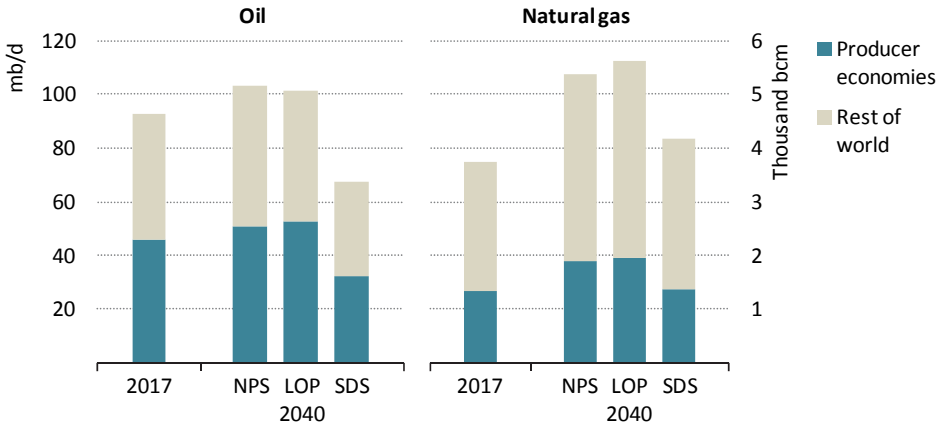
The most recent cycle of oil price volatility highlighted that the long-recognised risk of dependence on energy exports is as damaging as ever for producer economies. Fundamental changes to the development models of resource-rich countries look to be inevitable, but the transformation process will be complex and challenging. The way it unfolds will not only have profound implications for the producer economies but also for the global energy system and energy security more widely.

The starting conditions among producer economies are very different, and risks are not evenly distributed. Collectively, however, the producer economies constitute a pivotal element of any global supply scenario, both in terms of how they can influence the future trajectory of the energy system and how they will be affected by it (Figure 2.20). The share

of these predominantly low-cost suppliers remains high in the Low Oil Price Case and the Sustainable Development Scenario.

The prospects for stability in commodity markets, in particular for oil, are increasingly interwoven over time with the reform agendas in producer economies. Venezuela provides a cautionary tale of how a decline in one producer economy can have significant implications for the global balance. It is also evident that the risks for producer economies and markets do not disappear in scenarios where equilibrium prices are lower, or in which the world uses less oil and gas. Indeed, if reform efforts are not successful, the risks increase.

Figure 2.20 ▷ Share of selected producer economies* in global oil and natural gas production by scenario



The key producer economies maintain a significant market share in all scenarios

*Aggregated data for: Iran, Iraq, Kuwait, Nigeria, Oman, Qatar, Russia, Saudi Arabia, United Arab Emirates and Venezuela. Note: NPS = New Policies Scenario; LOP = Low Oil Price Case; SDS = Sustainable Development Scenario.

Periods of higher prices due to under-investment offer the possibility of temporary relief for producer economies, but they also present a clear downside. They risk easing the pressures for change at just the time when, higher prices accelerate the policy momentum behind alternatives to oil and gas, especially in some of the emerging global energy demand giants in Asia that are particularly sensitive to price swings. Recent history suggests that higher prices would encourage new, higher cost production in other parts of the world, setting the stage for prices to fall again.

The sum of these risks and challenges means that there is considerable and widespread interest in supporting successful transformations in producer economies (a realisation that underpins international collaboration efforts [Box 2.5]). As a safety net, it is equally as important in the carbon-constrained world of the Sustainable Development Scenario as in the New Policies Scenario to maintain a well-functioning oil security mechanism.

Box 2.5 ▻ How can international collaboration support reforms in producer economies?

Increasing the resilience of major producer economies, particularly as energy transitions gather pace, is a matter of great importance beyond the producers themselves. It is integral to ensuring secure energy flows that provide producers with sufficient capital to finance the large-scale changes required by their economies, while ensuring consumers a stable supply of energy as they make the shift to a low-carbon future.

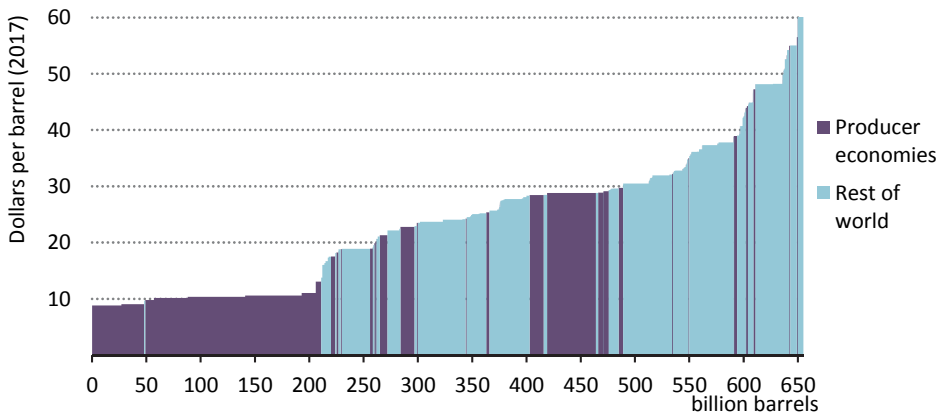
The shared interests of producers and consumers can be greatly enhanced by increased co-operation between exporters and their traditional markets. The recent agreements made by Saudi Arabia and Japan illustrate the potential here. The "Saudi Japan Vision 2030" covers nine broad areas: trade; investment and finance; energy and industry; SMEs and capacity building; and culture, sports and education. The aim is to help diversify the Saudi economy and enhance its resilience. The two countries have pledged to collaborate to develop low-carbon energy technologies including hydrogen fuel technologies and CCUS. This collaboration has two purposes: it helps Saudi Arabia secure the long-term competitiveness of its upstream industry by minimising the carbon intensity of its production, while at the same time ensuring that the country remains an important player in the future energy market. This dovetails with Japan's aims, enunciated in the 5th Strategic Energy Plan, to move towards the decarbonisation of its energy sector, and its intention to enhance its relations with oil producers in the energy and non-energy sectors.

A successful transformation of producer economies would have profound implications for the energy outlook. By reducing the "social costs" of production, i.e. by diminishing the dependence on hydrocarbon revenues to finance areas such as education, health care and public sector employment, it would also lower the oil price at which these countries can manage without persistent fiscal deficits (Dale and Fattouh, 2018). In such a case, oil markets could find an equilibrium at a lower price, with major low-cost producers taking a larger share of the market based on their position at the lower end of the global supply cost curve (Figure 2.21).

Major natural gas producers will be faced with their own strategic choices, most notably about how to respond to an increasingly competitive and liquid global gas market. Qatar and Russia are among the world's lowest cost suppliers, and how they respond to these competitive pressures will likewise have an important bearing on where the global gas market finds its equilibrium, as well as the market shares of different producers. To the extent that this produces lower prices for consumers, it could also have an important impact on the prospects for gas to displace coal in key Asian markets, therefore contributing to a reduction both in air pollutant and GHG emissions.

The implications of lower oil prices for energy transitions are more ambiguous. On one hand, low prices could facilitate some policy shifts, such as easing the removal of fossil fuel consumption subsidies or introducing an effective or actual price on CO_2 emissions. On the other hand, experience since 2014 has underlined that lower prices can provide a boost to global hydrocarbon consumption. Payback periods for many efficiency measures increase and the growth of renewable technologies, outside the power sector, becomes much more challenging. The case for electric vehicle technologies would be particularly disadvantaged. To achieve the same outcomes, policies would need to be strengthened to counteract the effect of lower oil prices on transport and industrial demand.

Figure 2.21 ▷ Cost curve of all new oil resources developed in the New Policies Scenario



Producer economies dominate the lower end of the cost curve. Successful reform could allow this to be reflected in higher market share.

This raises the question of the strategy that producer economies might follow in a lower demand scenario, and whether the prospect of accelerated energy transitions might invite producers to accelerate extraction of hydrocarbons (the so-called "green paradox"). The answer again is contingent upon the pace and extent of their broader economic transformation. If investments were to be mobilised to maximise production in such a case, this would bring down prices. Yet oil prices that cause producer economies to run into significant fiscal difficulties are unlikely to be maintained for long.[6]

One potential way out of the green paradox is to accelerate research efforts targeting new models of resource development that are compatible with deeper decarbonisation, whether focused on CCUS, trade in hydrogen or enhanced strategies to find and develop

[6] With this in mind, we continue to assume, even in the Sustainable Development Scenario, that major resource-dependent economies maintain a strategy of market management that keeps the price higher than the cost of extracting the marginal barrel of oil.

non-combustion uses for hydrocarbons. Both the Middle East and Russia have extremely cost efficient carbon storage options, which would be a location advantage as heavy industry moves to low-carbon production processes.

Significant parts of a decarbonising energy system will need a fuel other than electricity. Our analysis suggests that the production route via steam reforming of hydrocarbons (even with CCUS) represents a significantly cheaper option than electrolysis for production of hydrogen. Even in a world which is progressively more reliant upon electricity, the future for many hydrocarbon-producing regions is far from bleak. Electricity is very unlikely to develop an oil-style global commodity market due to infrastructure limitations, and so electricity-intensive industries may look instead to areas that can best provide low-cost carbon-free generation. The abundant solar, and in some cases wind, resources among major oil producing economies could also prove to be an enduring source of long-term advantage. Ultimately, in a world where demand for energy services is only going to increase, resource-rich countries will always seek value from their endowments, hydrocarbon or otherwise. The task ahead is to make this quest compatible with the gathering pace of change in global energy.

Methodology

The *Outlook for Producer Economies*, part of the *World Energy Outlook 2018* (*WEO-2018*) series, presents for the first time a calculation of net income for selected oil and natural gas producers (expressed in year-2017 dollars). This definition of net income is also referred to in the literature as oil and natural gas "rents"; it coincides with the definition used in the World Bank's "World Development Indicators". In general the calculation is defined as the difference between the costs of various types of oil and natural gas production, and the value realised from their sale on either domestic or international markets. This net income changes over time and between various scenario projections, depending on the cost and volume of production by type of oil and natural gas, as well as both the international and domestic price, including any applicable energy subsidies. The principal quantitative tool used to generate the underlying scenario projections is the *World Energy Model (WEM)*, a large-scale simulation model developed at the International Energy Agency (IEA) over many years to capture the evolving nature of energy markets and technologies[1].To calculate net income for producers:

Net income ($): net income from export sales + net income from domestic sales

Net income from export sales ($): net export revenue - net export cost

- Net export revenue ($): net exports × international price
- Net export cost ($): net exports × (average finding and development unit cost + average lifting unit cost)
- Net exports (mb/d, bcm): production - (domestic demand + international bunker fuels demand)

Net income from domestic sales ($): domestic revenue - domestic cost

- Domestic revenue ($):
  - For a net importer: production revenue × (1 - subsidy rate)
  - For a net exporter: demand × international price × (1 - subsidy rate)
- Domestic cost ($):
  - For a net importer: finding and development cost + lifting cost
  - For a net exporter: demand × (average finding and development unit cost + average lifting unit cost)
- Production revenue ($): production × international price
- Finding and development cost ($): production × finding and development unit cost
- Lifting cost ($): production × lifting unit cost
- Subsidy rate: Refers to the ratio of the subsidy to the international reference price[2]

[1] Details related to the *WEM* are available at www.iea.org/weo/weomodel.

[2] The methodology for calculating fossil fuel consumption subsidies is available at www.iea.org/media/weowebsite/energymodel/documentation/Methodology_FossilFuelSubsidies.pdf.

Definitions

This annex provides general information on terminology used throughout *The Outlook for Producer Economies* including: units and general conversion factors; definitions of fuels, processes and sectors and abbreviations and acronyms.

Units

Emissions		
	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
	g CO_2/km	grammes of carbon dioxide per kilometre
	g CO_2/kWh	grammes of carbon dioxide per kilowatt-hour
Energy	boe	barrel of oil equivalent
	toe	tonne of oil equivalent
	ktoe	thousand tonnes of oil equivalent
	Mtoe	million tonnes of oil equivalent
	MBtu	million British thermal units
	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	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
	mboe/d	million barrels of oil equivalent 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})

Water	bcm	billion cubic metres
	m^3	cubic metre

General conversion factors for energy

Convert to:	**TJ**	**Gcal**	**Mtoe**	**MBtu**	**GWh**
From:	multiply by:				
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	10^{7}	1	3.968×10^{7}	11 630
MBtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3 412	1

Note: There is no generally accepted definition of boe; typically the conversion factors used vary from 7.15 to 7.40 boe per toe.

Definitions

Agriculture: Includes all energy used on farms, in forestry and for fishing.

Buildings: The buildings sector includes energy used in residential, commercial and institutional buildings, and non-specified other. Building energy use includes space heating and cooling, water heating, lighting, appliances and cooking equipment.

Bunkers: Includes both international marine bunkers and international aviation bunkers.

Electricity generation: Defined as the total amount of electricity generated by power only or combined heat and power plants including generation required for own-use. This is also referred to as gross generation.

Energy services: Energy that is available to end-users to satisfy their needs. This is also sometimes referred to as "useful energy". Due to transformation losses the amount of useful energy is lower than the corresponding final energy. Forms of energy services include transportation, machine drive, lighting or heat for space heating.

Gas (also referred to as natural gas): comprises gases occurring in deposits, whether liquefied or gaseous, consisting mainly of methane. It includes both "non-associated" gas originating from fields producing hydrocarbons only in gaseous form, and "associated" gas produced in association with crude oil as well as methane recovered from coal mines (colliery gas). Natural gas liquids (NGLs), manufactured gas (produced from municipal or industrial waste, or sewage) and quantities vented or flared are not included. Gas data in cubic metres are expressed on a "gross" calorific value basis and are measured at 15 °C and at 760 mm Hg ("Standard Conditions"). Gas data expressed in tonnes of oil equivalent, mainly for comparison reasons with other fuels, are on a "net" calorific basis. The difference between the "net" and the "gross" calorific value is the latent heat of vaporisation of the water vapour produced during combustion of the fuel (for gas the net calorific value is 10% lower than the gross calorific value)

Gas-to-liquids (GTL)**:** Process featuring reaction of methane with oxygen or steam to produce syngas (a mixture of hydrogen and carbon monoxide) followed by synthesis of liquid products (such as diesel and naphtha) from the syngas using Fischer-Tropsch catalytic synthesis. The process is similar to those used in coal-to-liquids.

Heat (end-use): Can be obtained from the combustion of fossil or renewable fuels, direct geothermal or solar heat systems, exothermic chemical processes and electricity (through resistance heating or heat pumps which can extract it from ambient air and liquids). This category refers to the wide range of end-uses, including space and water heating, and cooking in buildings, desalination and process applications in industry. It does not include cooling applications.

Heat (supply): Obtained from the combustion of fuels, nuclear reactors, geothermal resources and the capture of sunlight. It may be used for heating or cooling, or converted into mechanical energy for transport or electricity generation. Commercial heat sold is reported under total final consumption with the fuel inputs allocated under power generation.

Industry: Includes fuel used within the manufacturing and construction industries. Key industry branches include iron and steel, chemical and petrochemical, cement, and pulp and paper. Use by industries for the transformation of energy into another form or for the production of fuels is excluded and reported separately under other energy sector. Consumption of fuels for the transport of goods is reported as part of the transport sector, while consumption by off-road vehicles is reported under industry.

International aviation bunkers: Includes the deliveries of aviation fuels to aircraft for international aviation. Fuels used by airlines for their road vehicles are excluded. The domestic/international split is determined on the basis of departure and landing locations and not by the nationality of the airline. For many countries this incorrectly excludes fuels used by domestically owned carriers for their international departures.

International marine bunkers: Covers those quantities delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and in coastal waters. Consumption by ships engaged in domestic navigation is excluded. The domestic/international split is determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship. Consumption by fishing vessels and by military forces is also excluded and included in residential, services and agriculture.

Investment: All investment data and projections reflect “overnight investment”, i.e. the capital spent is generally assigned to the year production (or trade) is started, rather than the year when it actually incurs. Investments for oil, gas and coal include production, transformation and transportation; those for the power sector include refurbishments, uprates, new builds and replacements for all fuels and technologies for on-grid, mini-grid and off-grid generation, as well as investment in transmission and distribution. Investment data are presented in real terms in year-2016 US dollars.

Liquid fuels: Natural gas liquids accompanying tight oil or shale gas production are accounted together with other NGLs under conventional oil.

Middle distillates: Include jet fuel, diesel and heating oil.

Modern energy access: Includes household access to a minimum level of electricity; household access to safer and more sustainable cooking and heating fuels and stoves; access that enables productive economic activity; and access for public services.

Modern renewables: Includes all uses of renewable energy with the exception of traditional use of solid biomass.

Natural gas liquids (NGLs)**:** Liquid or liquefied hydrocarbons produced in the manufacture, purification and stabilisation of natural gas. These are those portions of natural gas which are recovered as liquids in separators, field facilities or gas processing plants. NGLs include but are not limited to ethane (when it is removed from the natural gas stream), propane, butane, pentane, natural gasoline and condensates.

Net income (rent)**:** The difference between the costs of oil and gas production, including a normal return on capital, and the value realised from its sale on either domestic or international markets. Net income is separated by exports and domestic sales.

Non-energy use: Fuels used for chemical feedstocks and non-energy products. Examples of non-energy products include lubricants, paraffin waxes, asphalt, bitumen, coal tars and oils as timber preservatives.

Nuclear: Refers to the primary energy equivalent of the electricity produced by a nuclear plant, assuming an average conversion efficiency of 33%.

Oil: Oil production includes both conventional and unconventional oil. Petroleum products include refinery gas, ethane, liquid petroleum gas, aviation gasoline, motor gasoline, jet fuels, kerosene, gas/diesel oil, heavy fuel oil, naphtha, white spirit, lubricants, bitumen, paraffin, waxes and petroleum coke.

Other energy sector: Covers the use of energy by transformation industries and the energy losses in converting primary energy into a form that can be used in the final consuming sectors. It includes losses by gas works, petroleum refineries, blast furnaces, coke ovens, coal and gas transformation and liquefaction. It also includes energy used in coal mines, in oil and gas extraction and in electricity and heat production. Transfers and statistical differences are also included in this category.

Power generation: Refers to fuel use in electricity plants, heat plants and combined heat and power (CHP) plants. Both main activity producer plants and small plants that produce fuel for their own use (auto-producers) are included.

Pre-salt oil and gas: These resources are referred to as such because they predate the formation of a thick salt layer, which overlays the hydrocarbons and traps them in place.

Productive uses: Energy used towards an economic purpose: agriculture, industry, services, and non-energy use. Some energy demand from the transport sector (e.g. freight-related) could also be considered as productive, but is treated separately.

Renewables: Includes bioenergy, geothermal, hydropower, solar photovoltaics (PV), concentrating solar power (CSP), wind and marine (tide and wave) energy for electricity and heat generation.

Residential: Energy used by households including space heating and cooling, water heating, lighting, appliances, electronic devices and cooking equipment.

Self-sufficiency: Corresponds to indigenous production divided by total primary energy demand.

Services: Energy used in commercial (e.g. hotels, offices, catering, shops) and institutional buildings (e.g. schools, hospitals, offices). Services energy use includes space heating and cooling, water heating, lighting, equipment, appliances and cooking equipment.

Shale gas: Natural gas contained within a commonly occurring rock classified as shale. Shale formations are characterised by low permeability, with more limited ability of gas to flow through the rock than is the case with a conventional reservoir. Shale gas is generally produced using hydraulic fracturing.

Tight oil: Oil produced from shales or other very low permeability formations, using hydraulic fracturing. This is also sometimes referred to as light tight oil.

Total final consumption (TFC)**:** Is the sum of consumption by the different end-use sectors. TFC is broken down into energy demand in the following sectors: industry (including manufacturing and mining), transport, buildings (including residential and services) and other (including agriculture and non-energy use). It excludes international marine and aviation bunkers, except at world level where it is included in the transport sector.

Total primary energy demand (TPED)**:** Represents domestic demand only and is broken down into power generation, other energy sector and total final consumption.

Transport: Fuels and electricity used in the transport of goods or persons within the national territory irrespective of the economic sector within which the activity occurs. This includes fuel and electricity delivered to vehicles using public roads or for use in rail vehicles; fuel delivered to vessels for domestic navigation; fuel delivered to aircraft for domestic aviation; and energy consumed in the delivery of fuels through pipelines. Fuel delivered to international marine and aviation bunkers is presented only at the world level and is excluded from the transport sector at the domestic level.

Variable renewable energy (VRE)**:** Refers to technologies whose maximum output at any time depends on the availability of fluctuating renewable energy resources. VRE includes a broad array of technologies such as wind power, solar PV, run-of-river hydro, concentrating solar power (where no thermal storage is included) and marine (tidal and wave).

Water consumption: The volume withdrawn that is not returned to the source (i.e. it is evaporated or transported to another location) and by definition is no longer available for other uses.

Water sector: Includes all processes whose main purpose is to treat/process or move water to or from the end-use: groundwater and surface water extraction, long-distance water transport, water treatment, desalination, water distribution, wastewater collection, wastewater treatment and water re-use.

Water withdrawal: The volume of water removed from a source; by definition withdrawals are always greater than or equal to consumption.

Abbreviations and Acronyms

CAAGR	compound average annual growth rate
CCGT	combined-cycle gas turbine
CCUS	carbon capture, utilisation and storage
CH_4	methane
CHP	combined heat and power; the term co-generation is sometimes used
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-eq	carbon-dioxide equivalent
CPS	Current Policies Scenario
CSP	concentrating solar power
CTG	coal-to-gas
CTL	coal-to-liquids
EOR	enhanced oil recovery
EU	European Union
EV	electric vehicle
FDI	foreign direct investment
FOB	free on board
GDP	gross domestic product
GHG	greenhouse gases
GTL	gas-to-liquids
HFO	heavy fuel oil
IEA	International Energy Agency
IGCC	integrated gasification combined-cycle
IMF	International Monetary Fund
IOC	international oil company
LCV	light-commercial vehicle
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MER	market exchange rate

MEPS	minimum energy performance standards
NDCs	Nationally Determined Contributions
NGLs	natural gas liquids
NGV	natural gas vehicle
NPS	New Policies Scenario
NOC	national oil company
NO_X	nitrogen oxides
NPS	New Policies Scenario
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
PHEV	plug-in hybrid electric vehicles
PLDV	passenger light-duty vehicle
PPA	power purchase agreement
PPP	purchasing power parity
PV	photovoltaic
SDS	Sustainable Development Scenario
SME	small and medium enterprises
SO_2	sulfur dioxide
TES	thermal energy storage
TFC	total final consumption
TPED	total primary energy demand
UAE	United Arab Emirates
US	United States
WEO	World Energy Outlook
WEM	World Energy Model

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Outlook for Producer Economies 2018

What do changing energy dynamics mean for major oil and gas exporters?

For resource rich-economies, the high reliance on hydrocarbon revenues, coupled with the risk of fluctuations in prices, creates well-known pitfalls. The current market and policy environment is adding to these uncertainties, with questions surrounding the impact of the shale revolution in the short term, along with longer-term structural questions about the outlook for demand. In response to these changing conditions, many major producers are displaying a renewed commitment to reform and economic diversification.

This analysis provides a comprehensive assessment of how the prospects for major oil and gas producer economies evolve in various scenarios to 2040. The report:

- Assesses the impact of different price and demand trajectories on revenues from oil and gas in several key producer economies.
- Explores the ways in which the energy sector can help mitigate vulnerabilities and support economic diversification.
- Examines the potential implications of different pathways for energy markets, global environmental goals, and energy security.

for more information visit www.iea.org/weo/ProducerEconomies