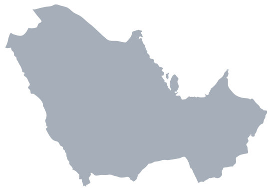
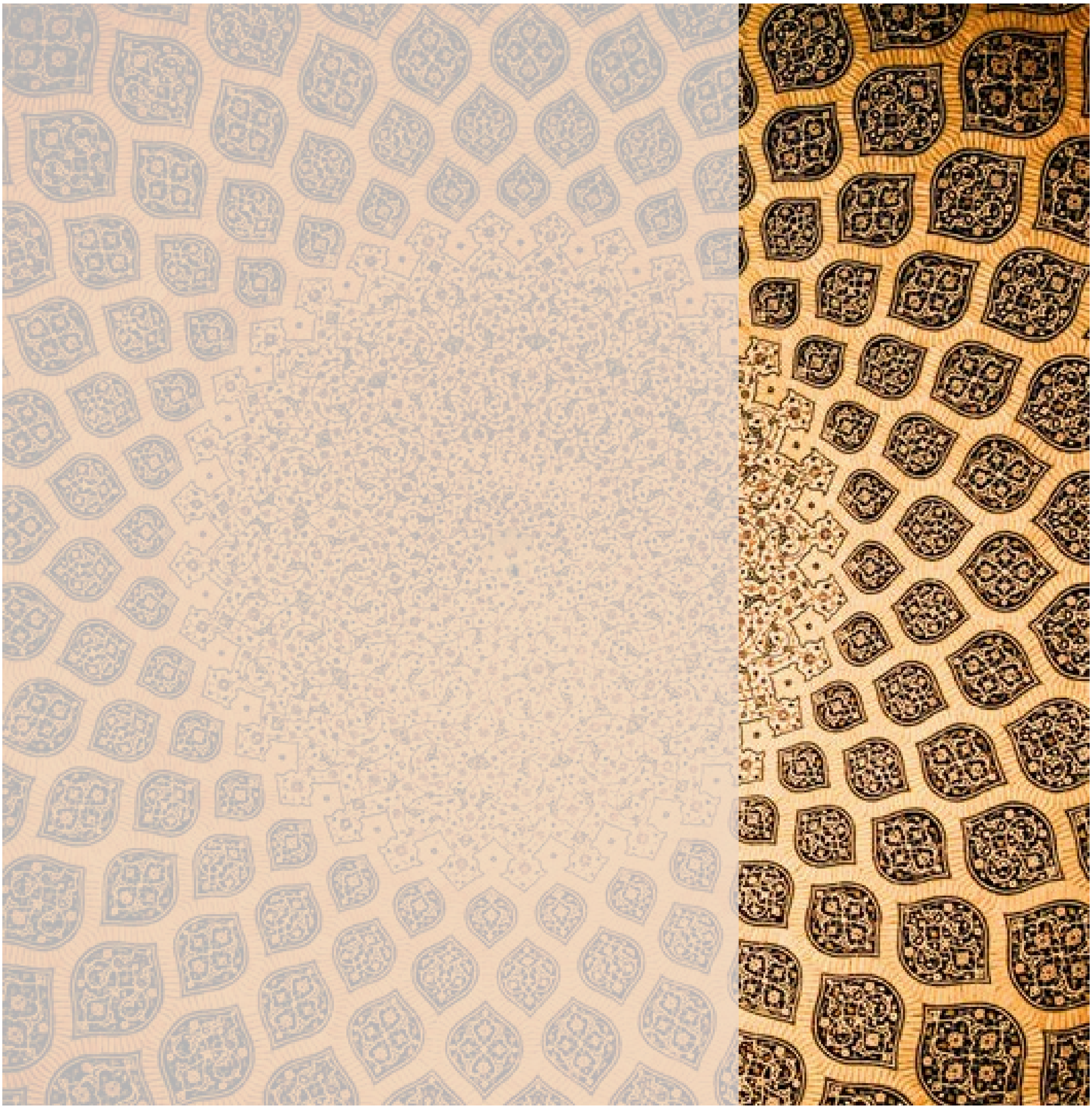
International Renewable Energy Agency

RENEWABLE ENERGY MARKET ANALYSIS:



GCC 2019



IRENA
International Renewable Energy Agency

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ABOUT IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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FOREWORD

Adnan Z. Amin
Director-General
IRENA

The world of energy is witnessing rapid and far-reaching changes. Cost reductions, innovation and policy frameworks are driving an unprecedented growth of renewable energy across the globe. The imperative to tackle climate change and to advance sustainable development are further strengthening the momentum of this energy transition. As a result, many countries are raising their level of ambition to accelerate renewables deployment.

The oil- and gas-exporting countries of the Gulf Cooperation Council (GCC) are increasingly part of this momentum When the International Renewable Energy Agency (IRENA) released its 2016 edition of the Renewable Energy Market Analysis for the GCC region, renewables were starting to be developed as a serious value proposition for the region.

Two years later, renewables have become a central element of energy planning. Consecutive auction rounds in 2016 and 2017 have pushed down prices for solar photovoltaic and concentrated solar power in GCC countries to world-record lows. This remarkable result showcases the combination of abundant resources and an attractive investment climate.

This second edition of IRENA's regional market analysis analyses the GCC's rapid progress on renewable energy deployment. It captures market conditions at a time when conversations have moved from "should we have renewables" to "how much can we integrate" and "how do we go further". The growing adoption of renewables in the region sends a signal to the whole world about the enormous opportunities at hand.

Gulf countries are set to capitalise on their promising resources for renewable power generation, along with applications for buildings, transport, direct heat and cooling. Renewable energy targets at the national and sub-national levels are key. By 2030, the region could save 354 million barrels of oil equivalent (a 23% reduction), create more than 220 500 jobs, reduce the power sector's carbon dioxide emissions by 22%, and cut water withdrawal in the power sector by 17% based on the renewables targets already in place.

The current targets are entirely within reach for the GCC countries. The economic and social rationale for the energy transition in the GCC has never been stronger. By maintaining their leadership in the energy sector and embracing their region's abundance of renewable energy resources, GCC countries can ensure their own long-term economic and social prosperity.

RENEWABLE ENERGY
MARKET ANALYSIS

THE GCC REGION

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ABBREVIATIONS

ADFD Abu Dhabi Fund for Development
ADNOC Abu Dhabi National Oil Company
ADWEA Abu Dhabi Water and Electricity Authority
ADWEC Abu Dhabi Water and Electricity Company
AER Authority for Electricity Regulation (Oman)
APICORP Arab Petroleum Investments Corporation
BAPCO Bahrain Petroleum Company
bbl Barrels of oil
bcm Billion cubic metres
b/d Barrel per day
Btu British thermal unit
CCS Carbon Capture and Storage
CCUS Carbon Capture, Utilization, and Storage
CORSIA Carbon Offsetting and Reduction Scheme for International Aviation
CO_2 Carbon Dioxide
CSP Concentrated Solar Power
DEWA Dubai Electricity and Water Authority
DNI Direct Normal Irradiation
DSCE Dubai Supreme Council of Energy
ECRA Electricity and Cogeneration Authority (Saudi Arabia)
EDF Electricité de France
EIA US Energy Information Agency
EOR Enhanced Oil Recovery
EPC Engineering Procurement and Construction
EU European Union
EVA Ethylene-vinyl acetate
EWA Electricity and Water Authority (Bahrain)
FAB First Abu Dhabi Bank
GCC Gulf Cooperation Council
GCCIA Gulf Cooperation Council Interconnection Authority
GCPA Gulf Coast Power Association
GDP Gross Domestic Product
GHI Global Horizontal Irradiance
GJ Gigajoule
GW Gigawatt
ICAO International Civil Aviation Organization
IEA International Energy Agency
IMF International Monetary Fund
IPP Independent Power Projects
IRENA International Renewable Energy Agency
IWPP Independent Water and Power Project
K.A.CARE King Abdullah City for Atomic and Renewable Energy (Saudi Arabia)
KACST King Abdul Aziz City for Science and Technology (Saudi Arabia)
KAHRAMAA Qatar General Electricity and Water Corporation
KAPSARC King Abdullah Petroleum Studies and Research Center (Saudi Arabia)
KISR Kuwait Institute for Scientific Research
kgoe kilograms of oil equivalent
kV Kilovolt
kWh Kilowatt-hour
$kWh/m^2/yr$ Kilowatt-hour per square meter per year
LCOE Levelised Cost of Electricity
LNG Liquefied Natural Gas
LPG Liquefied Petroleum gas
Mb/d Million barrels per day
mcm Million cubic metres
MEES Middle East Economic Survey
MEIM Ministry for Energy, Industry and Mineral Resources (Saudi Arabia)
MENA Middle East and North Africa
MESIA Middle East Solar Industry Association
MOCAF Ministry of Climate Change and Environment (UAE)
MOCCAE Ministry of Energy and Industry (UAE)
MOEI Ministry of Cabinet Affairs and the Future (UAE)
MOO Ministry of Oil (Kuwait)
Mtoe Million tonnes of oil equivalent
MW Megawatt
NDC Nationally Determined Contributions
NRM Natural Resource Management
OPEC Organization of the Petroleum Exporting Countries
PAEW Public Authority for Electricity and Water (Oman)
PIF Public Investment Fund (Saudi Arabia)
PPA Power Purchase Agreement
PV Photovoltaic
QSTec Qatar Solar Technologies'
RAECO Rural Areas Electricity Company (Oman)
R&D Research and development
RE Renewable Energy
REPDO Renewable Energy Project Development Office (Saudi Arabia)
RO Reverse Osmosis
RSB Abu Dhabi Regulation and Supervision Bureau
SAR Saudi Riyal
SBRC Sustainable Bioenergy Research Consortium
SEAS Seawater Energy and Agriculture System
SPC Supreme Petroleum Council (Kuwait)
Takreer Abu Dhabi Oil Refining Company
tcf Trillion cubic feet
tcm Trillion cubic metre
TW Terawatt
UAE United Arab Emirates
UN United Nations
UNFCCC United Nations Framework Convention on Climate Change
UN ESCWA United Nations Economic and Social Commission for West Asia
US United States
USD United States Dollar
VAT Value Added Tax
VRP Vision Realization Program
WDI World Development Indicators

EXECUTIVE SUMMARY

ES

Renewable energy has made striking gains in the Gulf Cooperation Council (GCC) countries over the past five years. From niche technologies with little application beyond small-scale pilot projects, the project pipeline has grown to almost 7 gigawatts (GW) of new power generation capacity. Record-breaking bids in renewable energy auctions in the United Arab Emirates (UAE) and Saudi Arabia in 2016-2018 have, in fact, made solar power cost-competitive with conventional energy technologies.

Renewables continue growing fast and can help greatly to boost the region's power supply in the years ahead.

The economies and populations of the GCC countries have been grown steadily for several decades, with much of the region's wealth and socio-economic development tied closely to its substantial oil and gas resources. Renewable energy, although a relatively recent entrant to the GCC energy landscape, holds vast potential to cut fuel costs, reduce carbon emissions, conserve water and create jobs. This comes as the GCC states seek to diversify their economies, against the backdrop of fast-growing domestic energy demand and a desire to safeguard hydrocarbon export revenues for the future.

GCC decision makers aim to reduce the risks of dependence on oil and gas revenues, including fluctuating oil prices and changes in global market dynamics. In parallel, they recognise the need to plan for the post-oil era, when demand for fossil fuels might subside regardless of supply outlooks.

This report explores the status of renewable energy development in the region, as well as the prospects for renewables to diversify both national economies and the combined GCC energy mix, while also contributing to the region's commitments towards the global climate and 2030 Agenda for Sustainable Development.

ES

Abundant renewable energy resources

The GCC region has considerable renewable energy potential, particularly for solar photovoltaic (PV) generation (Figure ES.1). The United Arab Emirates (UAE) hosts close to 79% of the installed solar PV capacity in the GCC and has managed to attract some low-cost solar PV projects without offering subsidies. While the resource base for concentrated solar power (CSP) is less optimal in the arid region, some sites rival other CSP-deploying regions.

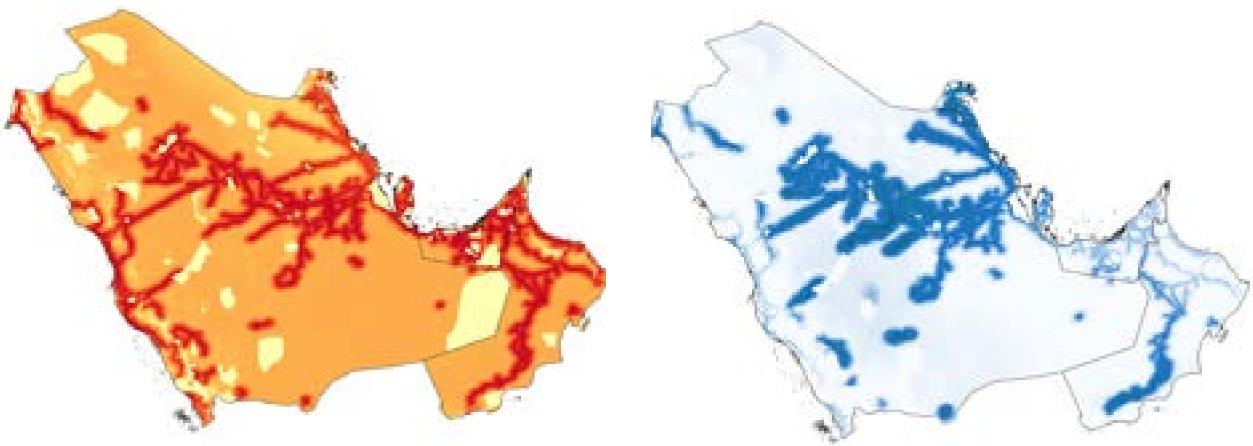
Contrary to common perceptions, some GCC countries – particularly Kuwait, Oman, and Saudi Arabia, – also have good wind resources. Technological improvements, including higher turbine towers and longer blades, continue making wind farms economically viable in regions with lower wind speeds.

Renewable energy plans moving forward

Renewable energy plans and the status of deployment have come a long way in the GCC economies, with recent developments being especially significant. Ambition differs between countries, as does market size and readiness. Yet the overall picture is one of a dynamic region. While deployment in the UAE and, more recently, Saudi Arabia, stands out, interesting projects are also seen in Kuwait, Oman and Qatar.

Figure ES.2 summarises the renewable energy targets of the GCC states. Lower oil prices since 2014 have had little effect on the region's renewable energy plans, in large part because subsequent auctions (discussed in Chapter 3) have pushed the costs for solar PV down to levels that are competitive with conventional fossil fuels.

Figure ES.1 Suitability analysis results for on-grid solar PV (left) and on-grid wind (right)



Suitability scores for on-grid solar PV (35 km)

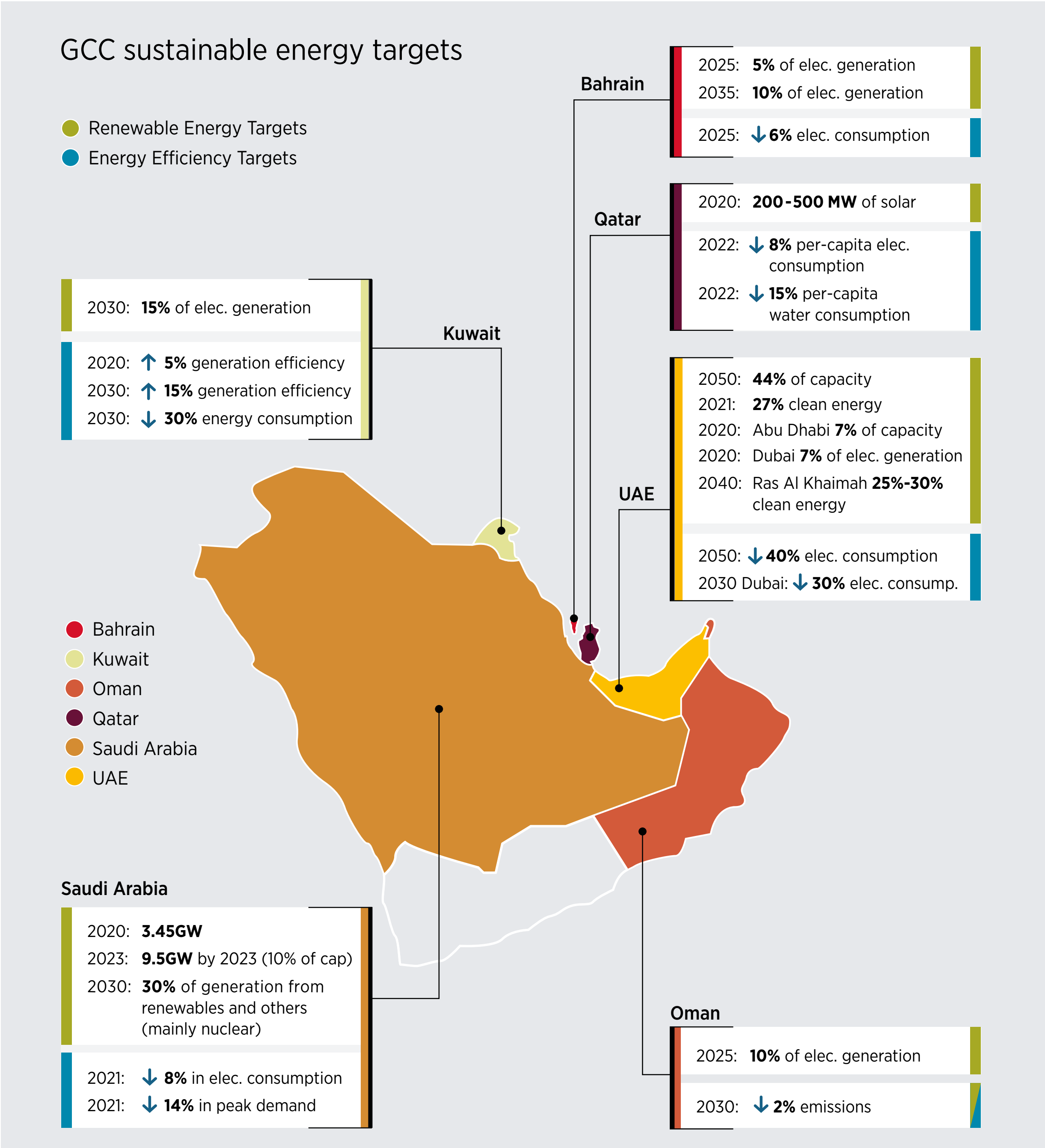
- 50% to 60% suitable
- 60% to 70% suitable
- 70% to 80% suitable
- 80% to 90% suitable
- 90% to 100% suitable

Suitability scores for on-grid wind (50 km)

- 50% to 60% suitable
- 60% to 70% suitable
- 70% to 80% suitable
- 80% to 90% suitable
- 90% to 100% suitable

Source: IRENA (2019d), Global Atlas Suitability Map, Solar PV Map Data: World Bank Group, 2018, Global Horizontal Irradiation kWh/m² World 1km, Wind Map Data: Technical University of Denmark Global Wind Atlas, Average Wind Speed 1km at 100m height

Figure ES. 2 Sustainable energy targets



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Plans and targets for the development of renewable energy are gradually being translated into concrete policies and projects, and the short- and medium-term outlook is promising, particularly in the GCC's biggest energy markets, Saudi Arabia and the UAE. Deployment in other GCC countries has progressed more slowly. Still, as cost-competitive projects keep coming online, the prospects for accelerated renewable energy uptake are positive.

At the end of 2017, the region had some 146 GW of installed power capacity, of which renewable energy accounted for less than 1% (867 megawatts, MW). The UAE accounted for 68% of the total installed capacity in 2018, followed by Saudi Arabia (16%) and Kuwait (9%). Although this is far from the capacity planned, it does represent roughly a four-fold increase from 2014 (Table ES.1).

Table ES.1 Installed renewable energy capacity as of the end of 2018

	2017 – 2018						2016	2015	2014
Country	**PV**	**CSP**	**Wind**	**Biomass and waste**	**Total RE (in MW)**	**Share of RE in total electricity capacity**	**Total RE**	**Total RE**	**Total RE**
Bahrain	5	0	1	0	6	0.1%	6	6	6
Kuwait	19	50	10	0	79	0.4%	20	1	0
Oman	8	0	0	0	8	0.1%	2	2	1
Qatar	5	0	0	38	43	0.4%	43	42	42
Saudi Arabia	89	50	3	0	142	0.2%	74	74	24
United Arab Emirates	487	100	1	1	589	2.0%	144	137	137
Total	**613**	**200**	**14**	**39**	**867**	**0.6%**	**289**	**262**	**210**

Source: IRENA, 2018a; IRENA estimates.

Note: 2018 data are available only for Kuwait and the UAE. Oman's 7 MW_{th} solar enhanced oil recovery plant and the newly finished first phase of 1 GW_{th} Miraah Solar EOR is not included because this table addresses only electricity. PV = photovoltaic; CSP = concentrated solar power; RE = renewable energy. Totals may not add up due to rounding.

Installed capacity is dominated by a handful of utility-scale solar projects. Solar PV and CSP, together, provide 94% of installed capacity presently and almost 91% of the project pipeline. The CSP capacity is currently located in the UAE, Kuwait and Saudi Arabia. Qatar hosts virtually all of the region's commercial-range waste-to-energy power generation capacity, while most of the limited deployment of wind power is located in Kuwait. Plans for the expansion of wind power, in particular in Saudi Arabia and Oman, should raise wind capacity in the GCC over the coming decade.

A positive outlook for renewables

Looking forward, the GCC is set to see a major acceleration in renewable energy deployment. Led by the UAE, Oman and Kuwait, a total of nearly 7 GW in renewable power generation capacity is planned to come online by the early 2020s. Solar PV remains the dominant technology in the region's project pipeline, with a share of over three-fourths, followed by CSP (around 10%, all of which accounted for by a single project in the UAE) and a 9% share for wind projects, primarily in Saudi Arabia and Oman. Solar-assisted enhanced oil recovery in Oman is also expected to contribute about 1 gigawatt-thermal (GW_{th}) in 2019.

A large portion of the region's demand for renewable energy can be expected to come from its largest energy markets – in particular the UAE, where the market for renewables is most mature, and Saudi Arabia, where a changing policy focus is assigning greater priority to renewables. Among the other GCC markets, Oman, in particular, has demonstrated interest in solar and wind energy as alternatives to domestic gas supply. Oman and Saudi Arabia also demonstrate that wind resources, both onshore and offshore, could complement the load profile of solar power.

Rising investment in renewables as costs drop to record lows

In recent years, major advancements – well-designed auctions, favourable financing conditions and declining technology costs – have brought renewables into the mainstream. A considerable share of investment in the region is driven by large stand-alone projects. In addition to the projects themselves, the GCC countries are also investing in the value chain including project developers, manufacturing companies, and research and development initiatives. Although the bulk of investments to date are concentrated in the UAE, as deployment picks up, investment flows will likely be distributed more evenly among the countries in the region.

Globally, the increasing cost-competitiveness of renewable energy technologies has been most apparent in the large-scale grid-connected market. Improving technologies, access to low cost finance, greater rates of deployment, increased familiarity with technologies and better understanding among the stakeholders have all combined to lower costs for utility scale projects. Cost trends in the GCC have been consistent with international trends. Well-designed auctions have been essential for lowering costs. Since 2015, they have been used to award more than 3 500 MW of renewable energy projects in the region. Other helpful factors include investor confidence, the strategic benefits of entering a promising market, low taxes, and minimal land and grid-connection costs.

Large-scale solar PV projects in Dubai have featured record-low bids in 2014 (5.98 US cents per kilowatt-hour (kWh) for a 200 MW project) and again a few years later (2.99 US cents/kWh for an 800 MW venture). And yet, these bids now look high compared to the winning 2.34 US cents bid by ACWA Power for the 300 MW Sakaka project in Saudi Arabia, and 2.4 US cents for another, 250 MW, solar park in Dubai in late 2018.

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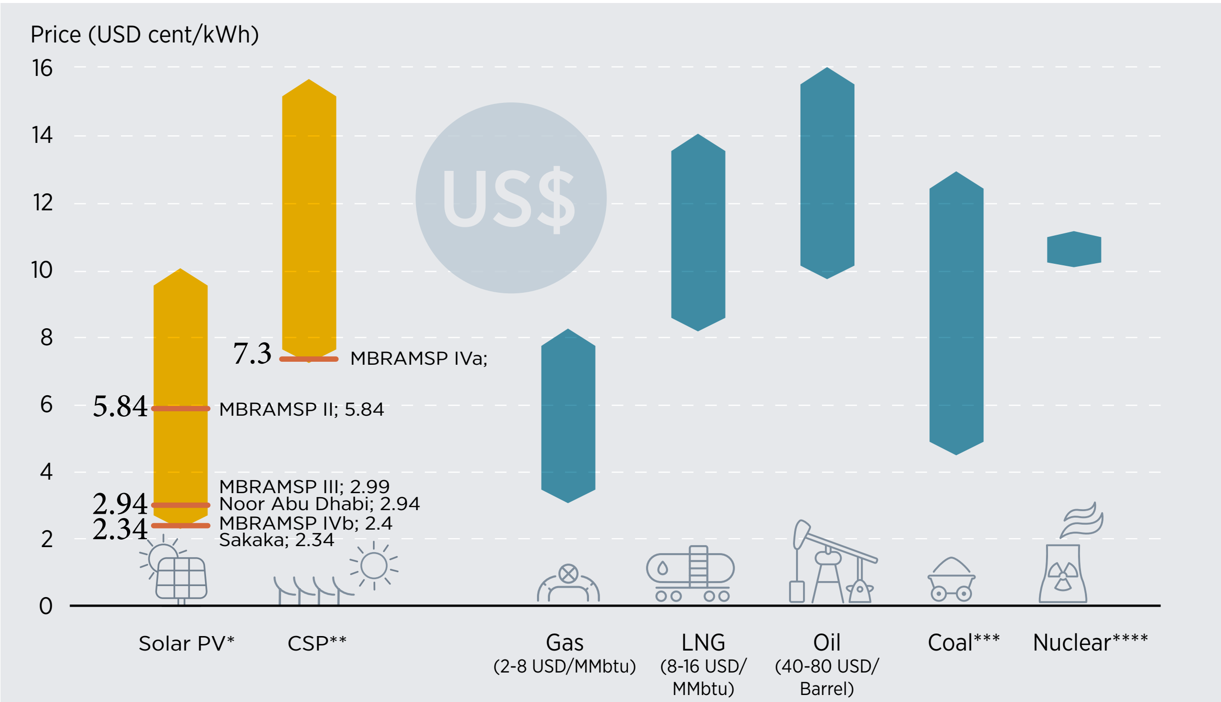
Costs of CSP projects are also coming down, as shown by the record-low of 7.3 US cents/kWh for the 700 MW Phase IV of Dubai's solar park. Because Oman or Saudi Arabia have even better solar irradiation (see Chapter 1), similar projects there should permit even lower prices.

As Figure ES.3 shows, solar PV is emerging as the cheapest source of electricity generation for new projects in the GCC, beating natural gas, liquefied natural gas, oil, coal and nuclear. Meanwhile, CSP costs less than what some utilities such as the Dubai Electricity and Water Authority pay for gas-based options. With 15 hours of storage, CSP is a dispatchable alternative to natural gas, including for peak evening demand. In Oman and Saudi Arabia, as noted, wind is also an option. The four bids submitted for the 400 MW Dumat Al Jandal wind project in Saudi Arabia were reported to be between 2.13 US cents/kWh and 3.39 US cents/kWh, but the project has yet to be awarded.

Figure ES.3 Price of utility-scale electricity generation technologies in the GCC



Sources: Derived from Mills, 2018; Channell et al., 2015; Manaar, 2014; Scribbler, 2015.

* *Low = price for 300 MW Sakaka solar PV; and High = a conservative assumption based on project data and expert opinion*
** *Low = price for 700 MW MBRAMSP IVb in Dubai; and High = price for Morocco's Noor II*
*** *Low = price for the Hassyan Clean Coal Power Plant; and High = estimate for coal with CCS*
**** *Estimated range for nuclear power based on (Mills, 2012) and (Scribbler, 2015)*

Notes: LCOE and auction/PPA prices represent one way to examine cost-competitiveness in a static analysis. These estimates are not a substitute for detailed nodal modelling, system cost tracking or analysis of factors such as backup generation requirements or demand side management. Moreover, care should be taken in comparing LCOE, auction/PPA prices and Feed in Tariff levels, as they can be very different cost metrics (see IRENA, 2018c for details). Prices for gas, LNG and oil and based on inputs from regional experts (Mills, 2018). MBRAMSP = Mohammed bin Rashid Al Maktoum Solar Park; USD cent/kWh = US Dollar cent per kilowatt-hour; PV = photovoltaic; CSP = concentrated solar power; LNG = liquefied natural gas; MMbtu = million British thermal units.

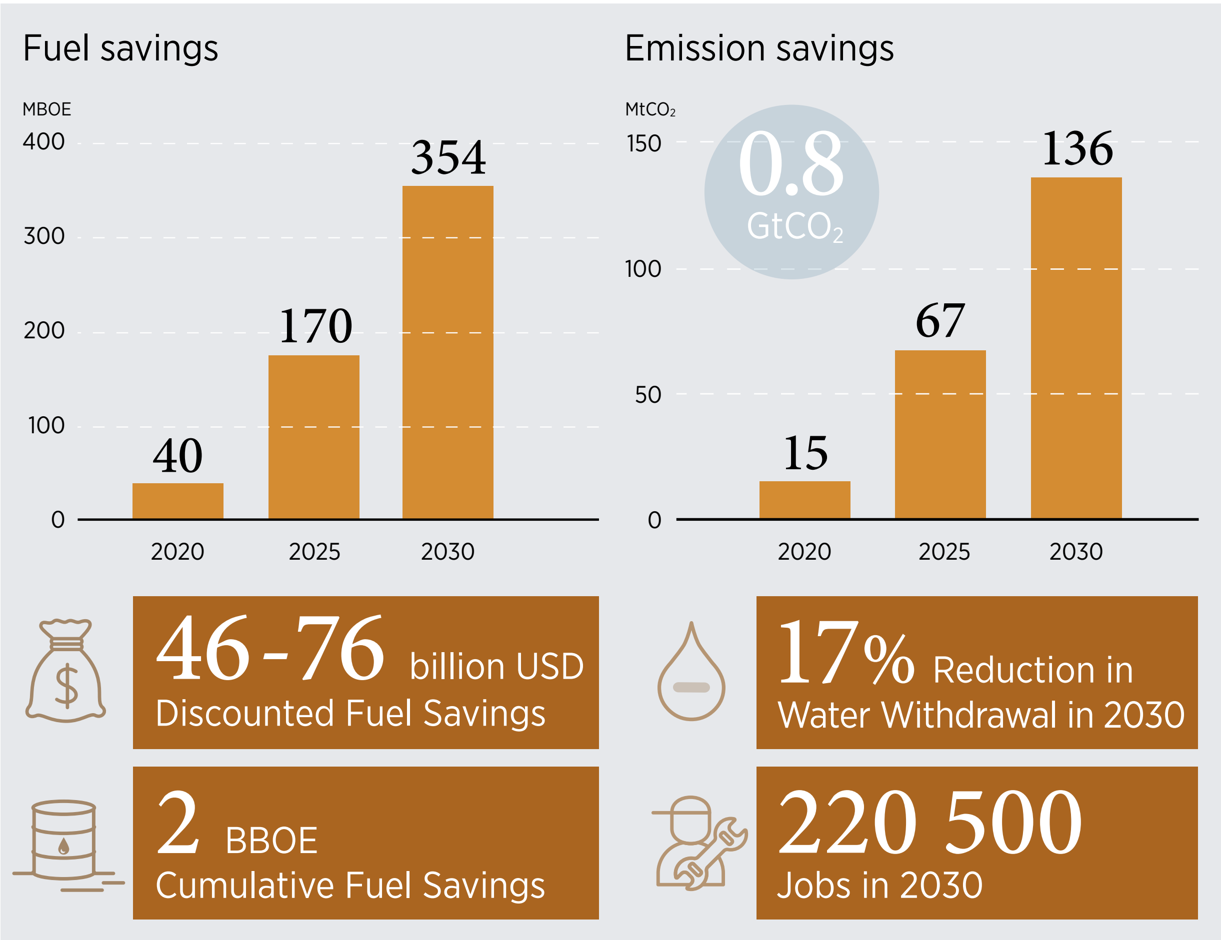
Wider socio-economic benefits of renewables

Renewables can bring socio-economic benefits to all GCC countries. A deeper look at the region's power systems reveals that countries stand to gain significantly from renewable energy installations through fossil-fuel savings, emission reductions and job creation.

IRENA's analysis suggests that achieving renewable energy deployment targets and plans by 2030 can save 354 million barrels of oil equivalent in fossil fuel consumption in the power sector (a 23% decrease over the baseline); reduce its emissions by 136 million tonnes of carbon dioxide ($MtCO_2$); create more than 220 500 direct jobs; and reduce water withdrawal for power production and associated fuel extraction by 11.5 trillion litres (a 17% decrease)[1] (Figure ES.4).

Saudi Arabia, the largest consumer of fossil fuels for power production in the region, could under these projections account for about 40% of the GCC wide fuel savings in that year, followed by the UAE with 39%.

Figure ES.4 Benefits of renewable energy deployment in the GCC



Note: MBOE = million barrels of oil equivalent; BBOE = billion barrels of oil equivalent; $MtCO_2$ = million tonnes of carbon dioxide.

1 *Seawater is the predominant source of water withdrawal for cooling in thermal power plants in the UAE. Discharge of cooling water back into the sea creates thermal pollution leading to algal bloom and other effects on marine life. Treated water is used during fuel extraction.*

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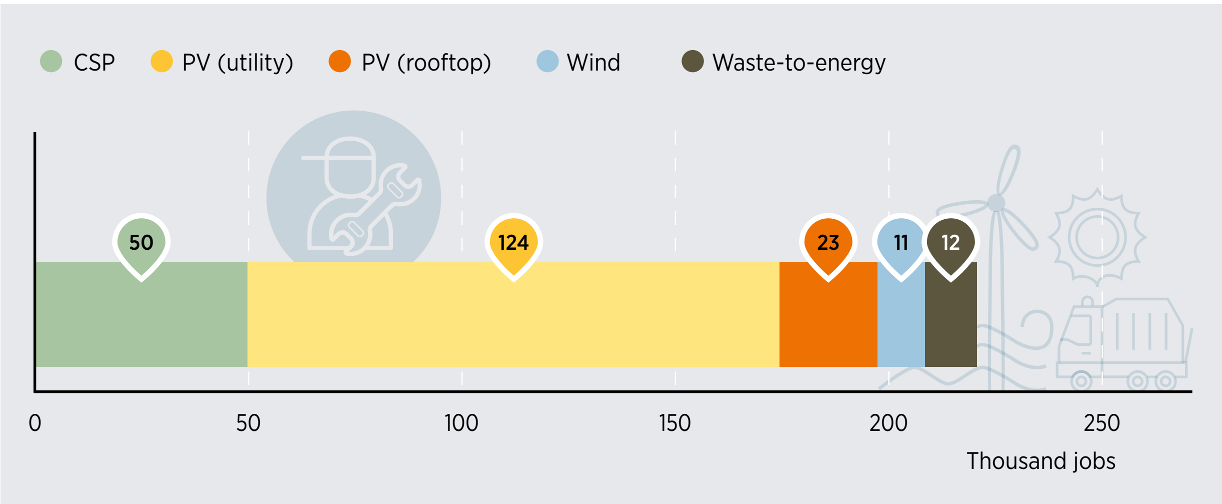
Solar technologies could under IRENA projections account for 89% of renewable energy jobs in the region by 2030. The deployment of around 40 GW of utility-scale solar PV across the GCC could account for about 124 000 jobs (Figure ES.5). Small-scale rooftop solar, which tends to be more job-intensive per unit of installation, could employ about 23 000 people, mostly in the UAE and Oman. Construction, operation and maintenance, and manufacturing inputs for CSP projects could account for 50 000 jobs. Wind energy can also be a key employer, especially in Saudi Arabia, Oman and Kuwait. Waste-to-energy may represent 6% of jobs according to conservative estimates.

Figure ES.5 Renewable energy jobs in 2030, by technology



Source: IRENA calculations.

Renewable energy and energy efficiency

GCC governments have shown increasing attention to improving energy efficiency, adopting targets for the reduction of energy or water consumption and the reduction of greenhouse gas (GHG) emissions. Measures to reach these targets include green building codes, incentives for electric and public transport, fuel efficiency standards, actions toward energy-intensive industries and reforms of the energy and water sectors. By establishing cohesive regulatory frameworks to mandate the implementation of targets, GCC countries could achieve their targets by 2030.

Energy efficiency is also a prime driver of integration of variable renewable energy. In fact, energy efficiency measures like time-dependent tariffs, vehicle to grid solutions, thermal and electric storage and smart appliances and grids can accelerate the adoption of demand side management, which in turn can accommodate the electric load to the generation profile of variable renewable energy.

A promising future for the region

The market for distributed generation will likely grow. Up to now most renewable energy projects in the GCC have been of utility scale, mainly devised through central planning and implemented by independent power producers. But distributed (or decentralised) generation of electricity is expected to play a growing role in the future. Distributed generation is no longer suitable only for remote areas such as islands, mountainous regions, deserts and off-grid oil and gas developments. It may gain prominence in the on-grid environment as well, through self-generation by industries as well as commercial and residential buildings. Its growth will be linked to further reform of utility tariffs and incentive schemes for self-generators, as well as long-term policies to liberalise regional electricity market structures.

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Rooftop solutions can proliferate. Available rooftop or land space limits the economies of solar panels relative to electricity demand. Country-specific regulations will be needed to encourage the uptake of rooftop solar. The UAE has already made some inroads through Shams Dubai and more recently through Abu Dhabi's net-metering regulation. Better business models can also help speed up deployment in the region.

Electricity systems will accommodate more variable energy. Both solar and wind are intermittent sources of power, and electricity systems will have to be modified to accommodate them, particularly in those GCC countries planning significant additions of renewables relative to the size of their national electricity systems, such as Oman, the UAE, and Saudi Arabia. A range of technology solutions is available to support the necessary changes, including electricity storage, demand-side management, efficiency measures and electricity trading.

Electrification of transport can offer an opportunity. Renewable energy is also likely to contribute to the diversification of the transport-fuel base in the GCC, through the electrification of private, public and industrial vehicle fleets using clean power sources. The availability of several mass-market electric vehicle models, along with recent advances in prolonging battery range, could be game-changers. Policies to help materialise the many potential benefits of electrifying transport include infrastructure development (charging stations), financial incentives, and the expansion of electrified trains and subway systems to transport growing numbers of daily commuters as an alternative to private cars.

Energy efficiency measures and technologies can boost renewable energy – and vice versa. GCC governments have shown increasing attention to improving energy efficiency, driven by the recognition that this is a vital component of policies for economic resilience and environmental sustainability. Renewable energy and energy efficiency have a synergistic and reciprocal relationship. The channels through which they reinforce each other include technology synergies; the use of more efficient technologies; and lower water consumption for power systems that include a higher share of renewables.

Specific policies to advance renewables through the deployment of energy efficiency include setting targets for improvements in efficiency or reductions in energy intensity; raising energy prices; reducing and reforming energy subsidies; introducing or tightening standards for the efficiency of buildings, vehicles and appliances; raising consumers' awareness of energy-efficient practices; boosting efficiency in government assets; and introducing technologies such as smart meters, light-emitting diode lighting, reverse osmosis desalination and district cooling. By establishing cohesive regulatory frameworks to mandate the implementation of targets, GCC countries could achieve a major share of their targets by 2030.

The overarching role of policy

Proactive policy management is central to accelerating renewable energy deployment. Lessons can be drawn from the GCC, where substantial inroads have been made in recent years thanks to a combination of factors, including firm government commitment to renewable energy (accompanied by credible, time-bound targets) and clear focus on a supportive business environment for investments (through financing, technology, infrastructure, land and non-obtrusive bureaucracy).

The deployment of renewable energy clearly benefits from the integration of targets with wider policies for sustainable, long-term management of the energy sector encompassing energy efficiency and technology development. Policies to manage demand through smart grids and metering technologies are key parts of the puzzle, as are cost-reflective utility tariffs. The acceleration of renewable energy deployment in the GCC has also benefited from the creation of dedicated institutions with clear mandates and transparent processes (*i.e.*, auctions) for introducing new projects.

Policy objectives for the longer term include encouraging private enterprise, education, training, and investment in human resources to localise many of the jobs created by renewable energy deployment, with cross-sectoral benefits through high-quality job creation and a contribution to local knowledge industries.

The creation of institutions to take the lead on energy research is an essential component of sustainable energy strategies, in part because it creates local centres of expertise to inform and advise policy-making and foster industrial diversification. Region specific research and development, combined with workforce training, can strengthen all segments of the value chain.

Regional aspirations for energy diversification are realistic. If today's plans are backed up with the establishment of enabling frameworks, the successful implementation of projects and, in some cases, the development of local industries, then the medium-term future promises a significant increase in the deployment of renewable energy in the GCC. The extent to which the region can seize the opportunity presented by renewable energy should become much clearer in the next few years.

BACKGROUND AND ENERGY SECTOR OVERVIEW

01

The economies of the countries of the Gulf Cooperation Council (GCC) have grown substantially in the past few decades. With large hydrocarbon resources and comparably small populations, some of the smaller GCC economies, notably Kuwait, Qatar and the United Arab Emirates (UAE), are among the wealthiest countries in the world on a per capita basis. Oil and natural gas are key drivers of the region's rapid development. Among other things, hydrocarbon exports generate government revenue in a region that does not yet know income tax. Oil and gas are also fuels and feedstocks for domestic energy-intensive industries. Fossil fuels account for virtually all of the GCC economies' domestic energy supply.

The GCC's two largest economies, Saudi Arabia and the UAE, together account for about two-thirds of regional gross domestic product (GDP); in 2018, Saudi Arabia, accounted for 47% of the region's GDP, followed by the UAE at 26%, and Qatar and Kuwait at about 11% and 9%, respectively (FAB, 2018a). Saudi Arabia is the world's second-largest oil producer after the United States; the UAE and Kuwait come in as the eighth- and tenth-largest. Qatar is the world's fourth-largest producer of gas (BP, 2018). Government spending is a key driver of economic growth, including in non-hydrocarbon sectors, through state companies and public investment funds, while the public sector also employs a large share of the population (IMF, 2017a).

1.1 DIVERSIFICATION OF THE GCC ECONOMIES

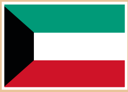
While the oil and gas sectors remain major contributors to the region's GDP, economic policy in the GCC places increasing emphasis on diversification. This is driven by several factors. The first is to reduce risks associated with dependence on oil revenues (*e.g.*, fluctuating oil prices and changes in global oil-market dynamics). The second is to create jobs – particularly high-value jobs for nationals – by establishing a more varied range of business sectors and industries, and opening up more opportunities for the private sector. Third, and in tandem with the aforementioned points, diversification is being undertaken to plan for the post-oil era, when demand for fossil fuels is expected to subside. Another critical consideration in economic diversification efforts has been the private sector, which is meant to drive further economic expansion and job creation.

In pursuit of diversification, GCC governments have formulated strategies to develop sectors such as services (finance, health care, transport, etc.), aviation, construction and manufacturing (Devaux, 2013), as summarised in Box 1.1. Of these, the services sector is the most dynamic, accounting for 50-60% of regional GDP (World Bank, 2018). Underpinning industrial activity are energy-intensive industries such as chemicals, petrochemicals, steel and aluminium (Devaux, 2013).

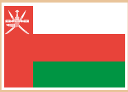
01

Box 1.1 National economic strategies

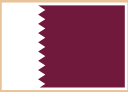
Bahrain's *Economic Vision* 2030 calls for a "shift from an economy built on oil wealth to a productive, globally competitive economy, shaped by the government and driven by a pioneering private sector." Much emphasis is placed on attracting foreign direct investment to create jobs. By 2030, the financial services sector is to be the main pillar of the economy, together with oil and gas, complemented by tourism, business services, manufacturing and logistics.



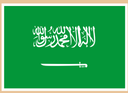
Kuwait's *New Kuwait National Development Plan* and current *Five-Year Development Plan* aim to position the country as a regional trade and financial hub, and focus on economic diversification. The plans focus on infrastructure investment, including transportation, a new port and the planned development of the "Silk City" business hub in Subiyah.



Oman's *Vision 2020* and the subsequent Five-Year Development Plan (2016–2020) call for economic diversification, and aim to set objectives, policies and mechanisms to raise non-oil revenue through increased private activity and human resource development. Industries targeted for expansion include fertiliser, petrochemicals, aluminium, power generation and water desalination, but also tourism, with its high relevance for local job creation.



Qatar's *National Vision 2030* aims to strike a balance between an oil-based and a diversified, knowledge-based economy. The plan includes economic, social and environmental components, with emphasis on responsible exploitation of the country's oil and gas resources, and on the creation of a diverse set of economic subsectors capable of promoting innovation, technical specialisation and education. Qatar's *Second National Development Strategy 2018–2022* further sets out a plan for natural resource management that includes a call for an increase in the use of renewable energy.



The **Saudi** government's *Vision 2030*, launched in early 2016, is a comprehensive strategy for systematically restructuring the Saudi economy away from its reliance on oil. Under the three themes of "A vibrant society", "A thriving economy" and "An ambitious nation", the plan targets the development of new industries and business sectors, in part through a boost for private enterprise. Among the national strategy's key vehicles are so-called vision realisation programmes, one of which, the newly empowered Public Investment Fund programme, is tasked with investing in sectors that aspire to diversify the Saudi economy. Saudi Arabia and the UAE were the first countries in the GCC to introduce Value Added Tax (VAT) in January 2018.

The **United Arab Emirates'** *Vision 2021, UAE Energy Strategy 2050, UAE Green Growth Strategy, UAE Future Strategy and UAE Centennial Plan (2071),* all highlight economic diversification and technological innovation as pivotal to future development. Besides a focus on tourism, aviation, advanced manufacturing and services, the UAE's plans place great emphasis on knowledge creation and technology in green energy, among other areas. The country is positioning itself as a regional hub for research, innovation and sustainable energy, with the latter recognised as a new growth sector with vast potential. Expo 2020 in Dubai is expected to attract more than 25 million visitors and have a positive impact on tourism, travel and real estate.

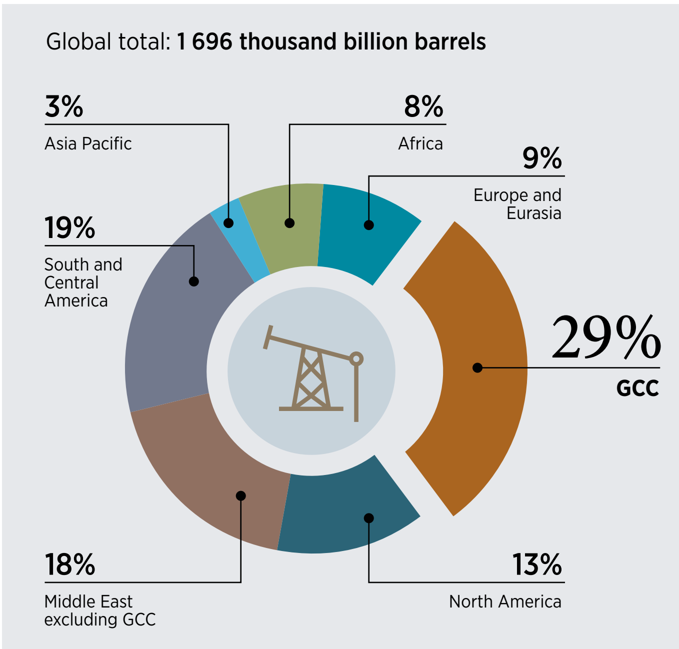
The impact of falling oil prices in 2014-2015 and a generally lower oil-price environment since then have been felt across the GCC economies. Most countries have undergone substantial fiscal consolidation since 2014, primarily by cutting spending. GCC members, in particular Saudi Arabia and the UAE, have also begun to reduce subsidies on fuel and electricity and to set tariffs closer to market prices (IMF, 2017b). While necessary from a fiscal perspective, the spending reductions have further weakened non-oil growth (IMF, 2017a).

1.2 ENERGY RESOURCES

1.2.1. Production of oil and petroleum products

The GCC is the world's most important oil-producing region, holding about 30% of proven crude oil reserves (Figure 1.1) and about 22% of global gas reserves (Figure 1.2). Saudi Arabia, with current reserves of some 266 billion barrels, ranks second in the world after Venezuela (Bolivarian Republic of) and could produce at current rates for at least another 60 years. Saudi Arabia also holds the world's sixth-largest natural gas reserves, the second-largest in the region behind Qatar, whose estimated proven gas reserves of about 24.9 billion cubic metres (bcm) make it the world's third largest holder of reserves after the Russian Federation and Iran (Islamic Republic of).

Figure 1.1 Crude oil reserves by region in 2017 as a share of world total



Source: BP, 2018.

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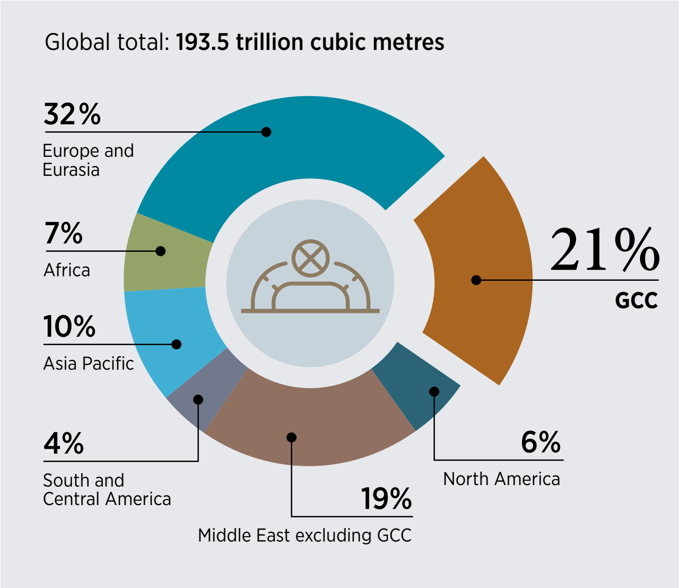
Figure 1.2 Natural gas reserves by region in 2017 as a share of world total



Source: BP, 2018.

The GCC accounts for about a quarter of global crude oil production, mostly from Saudi Arabia, the UAE and Kuwait, and the three countries are among the world's ten-largest crude oil producers in 2017 (Figure 1.3). In addition to the scale of reserves and production, the GCC's importance to global crude markets lies in the fact that the region is home to most of the world's spare production capacity[1], most of it in Saudi Arabia.

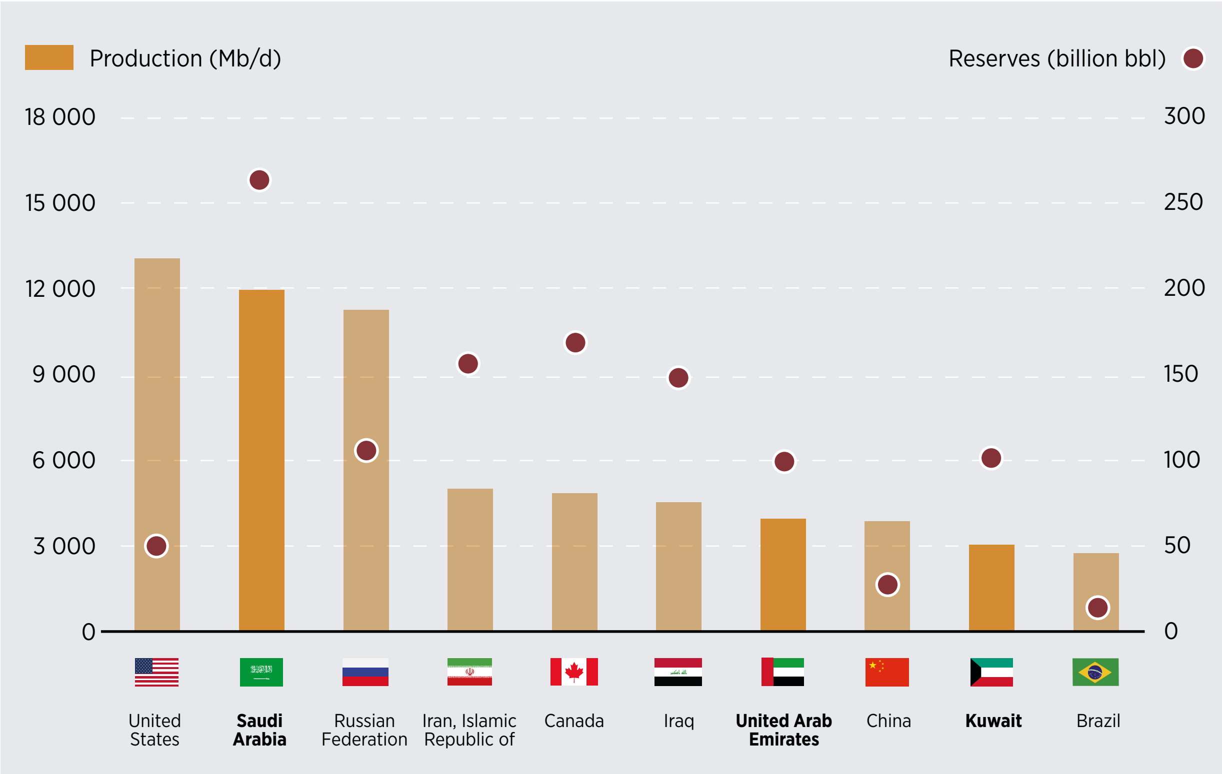
Historically, most of the GCC states' oil production has been exported, owing to high reserves and comparably small domestic consumption. Although the region's domestic energy demand has risen tremendously over the past decades, the GCC is the source of just under a third of the crude oil supplied to the international market (Figure 1.4) and accounts for more than two-thirds of the Middle East region's exports of crude oil. More than half of the GCC exports come from Saudi Arabia, although the country, together with Kuwait, still use crude oil and oil products for power generation, as natural gas supplies have lagged behind growth in peak demand (S&P Global Platts, 2018; Kuwait Times, 2018).

More than two-thirds of the crude oil exports of Saudi Arabia and Kuwait, and more than 90% of the UAE's is sent to Asian markets, particularly China, India, Japan and the Republic of Korea (EIA, 2017a; EIA, 2017b; EIA, 2016a), and their importance as customers has been growing over the past decade.

The GCC is a large and rapidly growing producer of petroleum products other than crude oil – among them gasoline, liquid petroleum gas (LPG), propylene, naphtha (a key source of feedstock in petrochemical production), diesel and fuel oil, kerosene, and jet fuel.

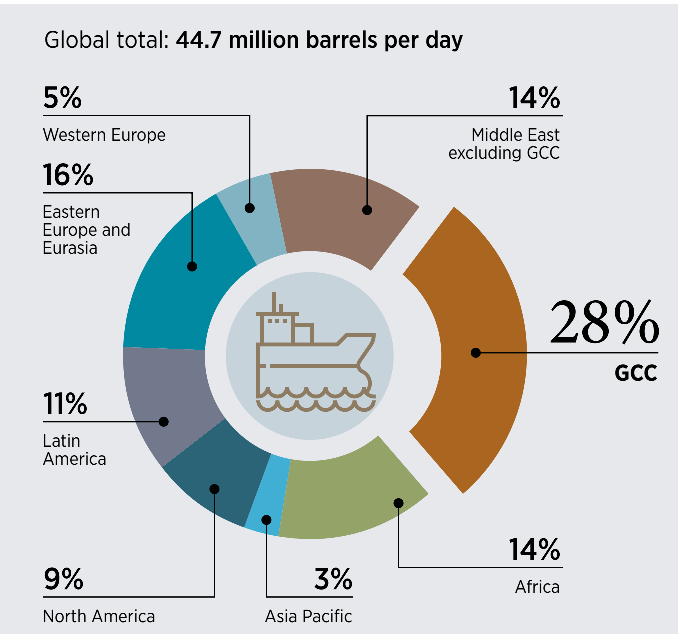
1 *The technical capacity to raise production at short notice for a sustained period of time.*

Figure 1.3 The world's ten-largest crude oil producers in 2017



Source: BP, 2018.
Note: Mb/d = million barrels per day; bbl = barrels of oil.

Figure 1.4 Crude oil exports by region in 2017 as a share of world total



Source: Based on OPEC (2018).

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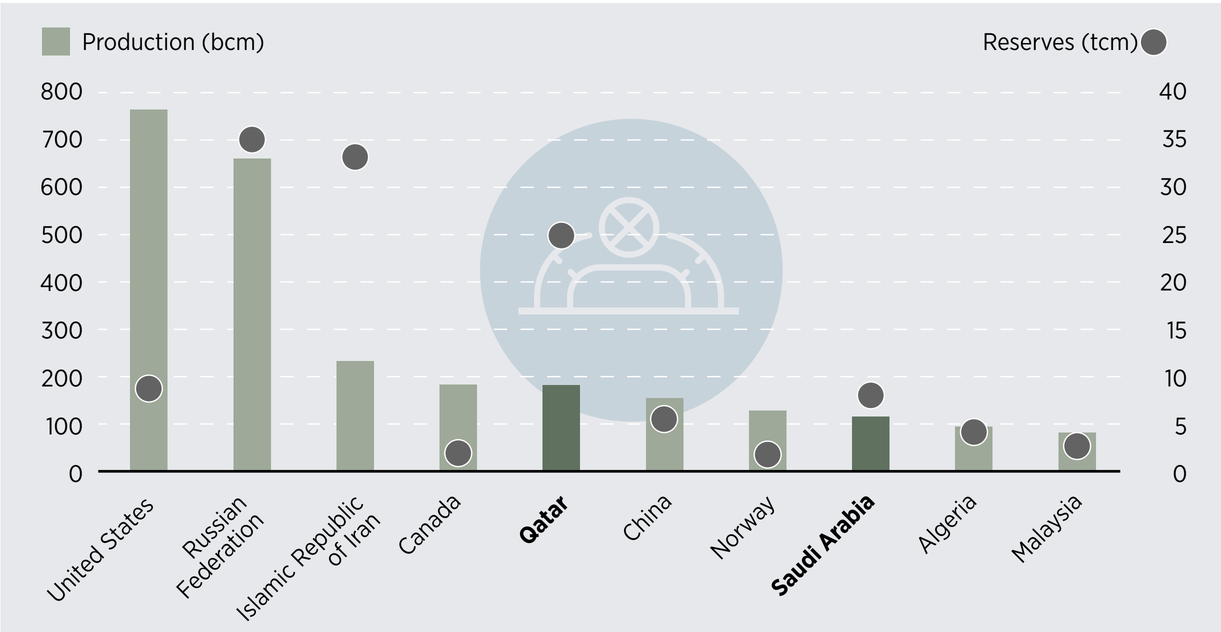
Overall, the region boasts a refining capacity of some 5.7 million barrels per day (Mb/d), about half of which is in Saudi Arabia. The region plans a boost of 1.5 Mb/d in refining capacity between 2017 and 2021, with the largest additions slated in Kuwait (APICORP, 2017a). The large project pipeline for new refining capacity in several GCC countries means the region will no longer be seen as simply a production centre, but a refining centre as well (Krane, 2015).

Saudi Arabia, with a total of 1.4 Mb/d, is by far the largest exporter of refined products in the GCC, followed by the UAE (654 000 b/d) and Qatar (640 000 b/d) (OPEC, 2018). Total net exports of refined products amounted to 3.4 Mb/d in 2017, more than a third of which were from Saudi Arabia. Similar to crude oil, the most important markets for the GCC's refined products are in Asia. All of Qatar's refined products exports go to Asian markets (EIA, 2015).

1.2.2. Natural gas

Natural gas is the GCC region's second most important energy resource. Production has increased substantially since the 1980s, following the rise of natural gas as a fuel for domestic power generation, for inputs in intermediate industries such as petrochemicals, and for export. Qatar is by far the region's largest producer and exporter of liquefied natural gas (LNG) (over 70% of exports go to Asian markets) as well as the world's fifth-largest producer of dry gas (Figure 1.5). It is also home to the world's largest conventional natural gas reservoir, the North Field, Qatar's section of the joint field known in Iran (Islamic Republic of) as South Pars. Saudi Arabia holds the GCC's second-largest natural gas reserves, while Kuwait and the UAE boast their own significant reserves.

Figure 1.5 The world's ten-largest natural gas producers in 2017



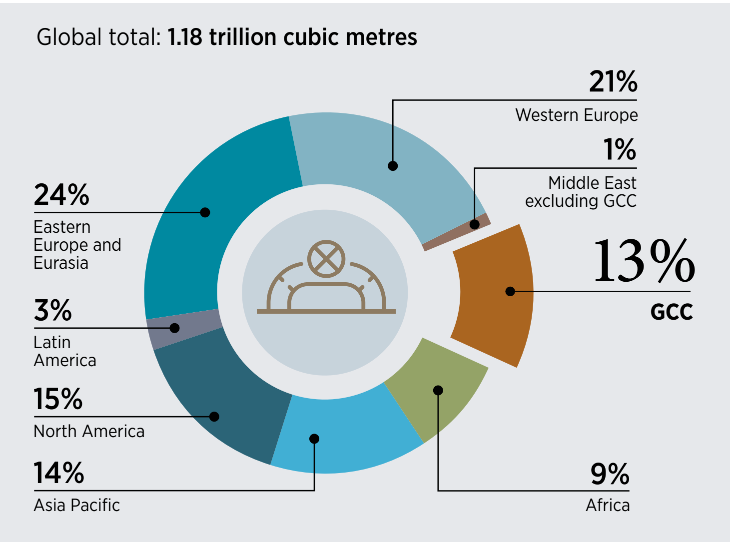
Source: BP, 2018.
Note: bcm = billion cubic metres; tcm = trillion cubic metres.

With the notable exception of gas giant Qatar, natural gas from the GCC plays a much smaller role in international markets than does oil, with only 13% of global exports (Figure 1.6), despite the GCC accounting for a fifth of global reserves (BP, 2018). At the same time, natural gas has become a highly valuable domestic source of energy, in particular for power generation, where it has become the preferred substitute for oil in meeting the surge since the 1980s in the region's demand for power and desalinated water. This substitution explains why Saudi Arabia, the world's eighth-largest producer of natural gas (Figure 1.5), exports no gas but has instead been considering imports to satisfy rapidly growing domestic demand, particularly for power generation (Butt, 2017). The country has also announced plans to double its natural gas production by 2030, increasing the share of gas in its energy mix (Saudi Gazette, 2018).

Qatar is thus the only GCC country with a substantial natural gas export capacity, exporting about 85% of its total gas production. It exports some 77 million tonnes per year of LNG. In addition, 18.5 bcm of dry gas are exported regionally through the Dolphin pipeline project (BP, 2018).

Oman and the UAE are also small-scale LNG exporters, selling to Asian markets, primarily Japan, although the UAE became a net importer of gas in 2008 owing to a domestic gas shortage (Figure 1.7). In 2017, Oman exported some 11.4 bcm and the UAE some 7.7 bcm of LNG, with the latter importing gas in quantities of more than three times its export volumes, mostly from Qatar through Dolphin (BP, 2018). In November 2018, the UAE announced major new gas discoveries that are expected to help the country return to self-sufficiency in natural gas supplies (Rahman, 2018). The lagging pace of development of new gas resources across the GCC, much of which is "sour" (thus costly to develop), suggests that a supply gap will remain for the foreseeable future, except in Qatar, with substantial portions of any new production capacity destined for domestic consumption. Kuwait has been importing LNG since the early 2010s, Bahrain is expected to start shortly, and Saudi Arabia has mulled LNG imports as well (APICORP, 2017b).

Figure 1.6 Natural gas exports by region in 2017 as a share of world total



Source: Based on OPEC (2018).

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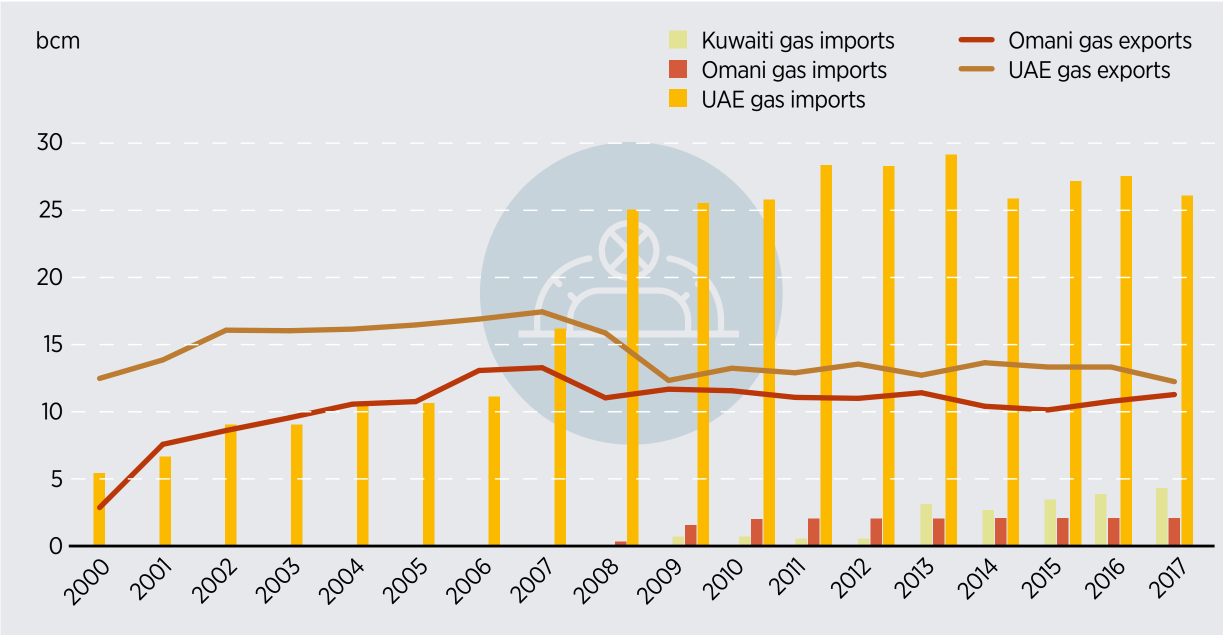
Figure 1.7 Natural gas import and export trends for Kuwait, Oman and the UAE, since 2000



Source: OPEC, 2018.
Note: bcm = billion cubic metres.

1.2.3. Renewable energy

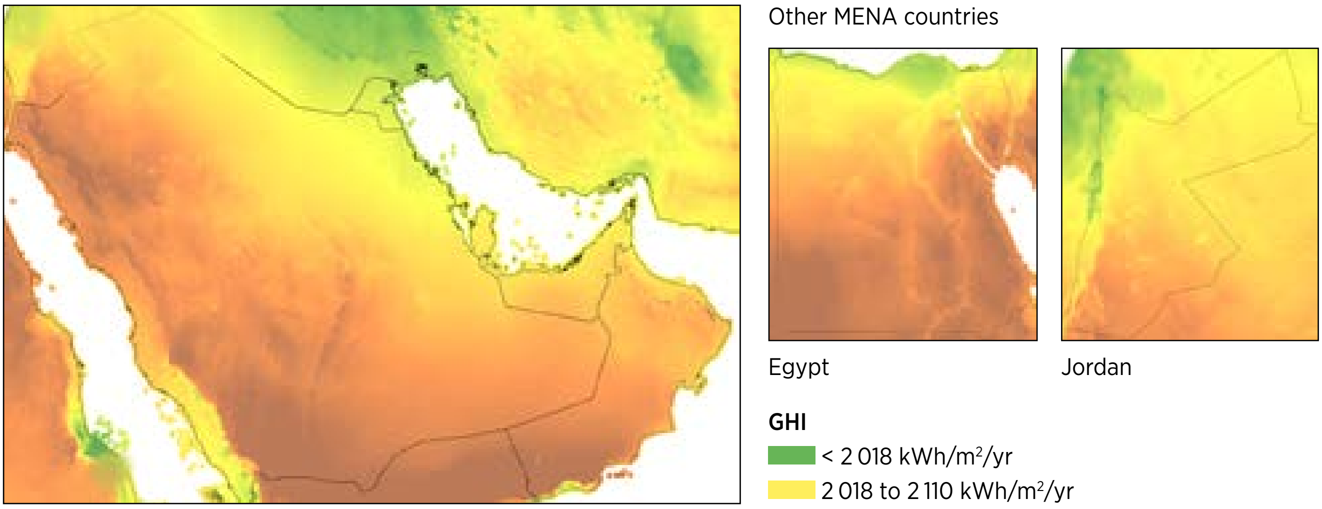
The GCC region is endowed with considerable renewable energy potential – and not just solar. Areas in Kuwait, Oman and Saudi Arabia also boast good wind resources. Technologies such as biomass and geothermal power may hold additional potential but remain underexplored. This section analyses the region's solar and wind potential.

Solar resources

The GCC region is home to excellent solar resources, in particular for photovoltaic (PV) generation. The global horizontal irradiance (GHI) map for the GCC extracted from the Global Atlas tool[2] and presented in Figure 1.8, reveals good solar PV resources, particularly in the north-western and central regions of Saudi Arabia and the southwestern region of Oman. Bahrain, Kuwait, Qatar and the UAE also have very good annual average GHI. Overall, the GHI resources in the GCC are at least as good as those of the other countries of the Middle East and North Africa

2 *IRENA's web-based Global Atlas software (https://irena.masdar.ac.ae/) can be used to map and assess solar, wind and geothermal energy resources around the world. It includes over 2 000 maps providing national and global coverage.*

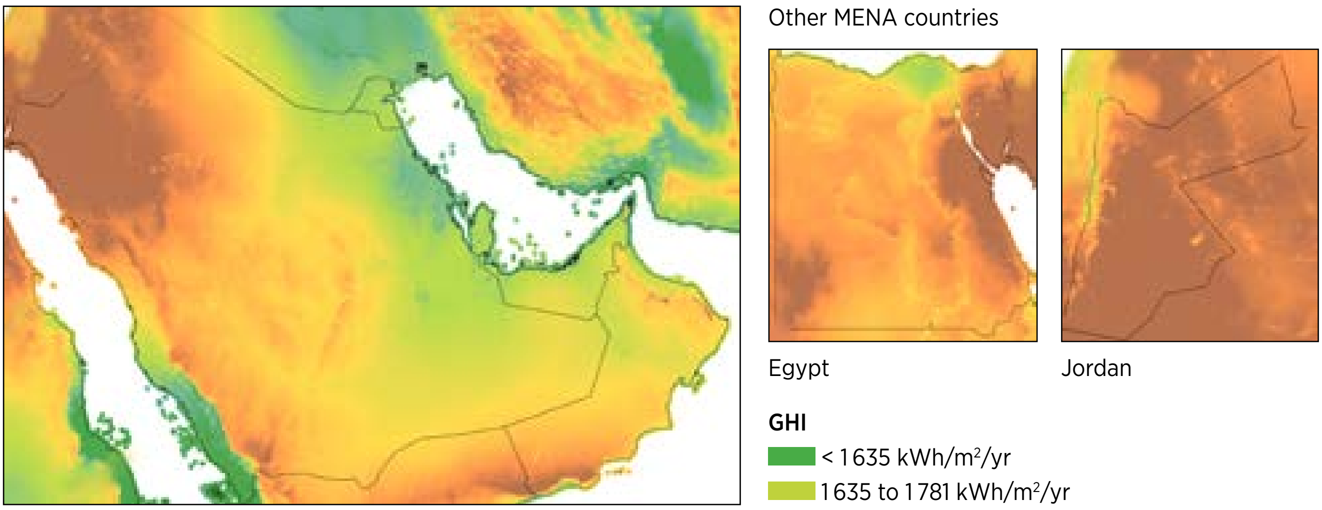
Figure 1.8 Global horizontal irradiation (kWh/m²/yr)



Source: IRENA (2019a), Global Atlas, Map Data: World Bank, 2018, Global Horizontal Irradiation kWh/m² World 1km 1994/1999/2007-2015 WBG, World country borders using Global Administrative Boundaries (GADM) database

region, such as Egypt and Jordan (Beták *et al.*, 2012). Currently, the UAE, with a GHI of close to 2 200 kilowatt-hours per square meter per year (kWh/m²/yr) is home to about 65% of the total installed solar PV capacity in the GCC, and has managed to attract some of the lowest-cost solar PV projects without subsidies (Apostoleris *et al.*, 2018). This should be a positive sign for solar PV deployment in Saudi Arabia and Oman, where large areas boast GHI values above 2 200 kWh/m²/yr.

Figure 1.9 Direct normal irradiation (kWh/m²/yr)



Source: IRENA (2019b): Global Atlas, Map Data: World Bank, 2018, Direct Normal Irradiation kWh/m² World 1km 1994/1999/2007-2015 WBG, World country borders using Global Administrative Boundaries (GADM) database.

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While the region has areas with excellent resources for CSP, notably in parts of Oman and Saudi Arabia, the CSP resource base is less ideal in other GCC countries. Figure 1.9 traces levels of direct normal irradiation (DNI), the relevant resource for CSP, revealing significant intra-regional variation. The northwestern region of Saudi Arabia and the southwestern Dhofar region of Oman have some of the best DNI readings in the GCC, comparable to those of Egypt and Jordan. Saudi Arabia may have the best DNI locations in the region, at least as good as the best in Jordan, Spain and Morocco (Beták *et al.*, 2012). Oman, too, with the second-best DNI readings in the GCC, compares with the best locations in Spain but lags those in Jordan and Morocco. DNI readings in the best locations in Bahrain, Kuwait, Qatar and the UAE trail those in Jordan, Spain and Morocco.

The combination of dust and high levels of humidity along the region's Gulf coast affect DNI rates and can influence the choice of CSP technology best suited for these locations. Climatic differences in the Arabian Peninsula also cause the quality of the GHI resource to differ significantly across the region (Box 1.2).

Box 1.2 Direct normal irradiation, global horizontal irradiance and weather conditions

Direct sunlight, measured as direct normal irradiation (DNI), is solar radiation traveling from the sun in a straight line, without any scattering from particles in the earth's atmosphere, to a surface perpendicular to the sun's rays. Concentrated solar power (CSP) technologies (parabolic troughs, solar towers, etc.) rely on DNI because they cannot concentrate scattered sunlight.

Solar photovoltaic (PV) plants, by contrast, depend on a combination of direct and diffused sunlight. That combination, known as global horizontal irradiance (GHI), is the total solar radiation falling on a horizontal surface; it includes both DNI and the sunlight scattered by the particles in the sky (*i.e.* diffused horizontal irradiance).

Sunny days with clear skies lead to high DNI and GHI, resulting in high outputs for both CSP and PV. Bad weather conditions – including dust particles, fog, clouds and humidity – tend to diffuse and attenuate the intensity of solar irradiance, exerting a more severe impact on DNI.

In most of the GCC countries, dust and humidity are a bigger cause of attenuation in solar irradiation than clouds (Ghedira, 2018). During extreme dust events in North Africa, GHI can decline by 40-50% compared with a much stronger attenuation of 80-90% for DNI (Kosmopoulos, 2017). The dust and humidity are also responsible for soiling, which decreases the absorptivity of solar PV panels and the reflectivity of mirrors (Alobaidli *et al.*, 2017).

Although the DNI resources in some GCC countries are lower than those in some other countries around the world, this has not stopped CSP projects from being developed in the UAE. One such is the 700 megawatt (MW) Fourth Phase of the Shaikh Mohammed bin Rashid Al Maktoum Solar Park. This development shows that the declining costs of CSP technologies and high energy demand can justify projects even in regions without optimal DNI resources.

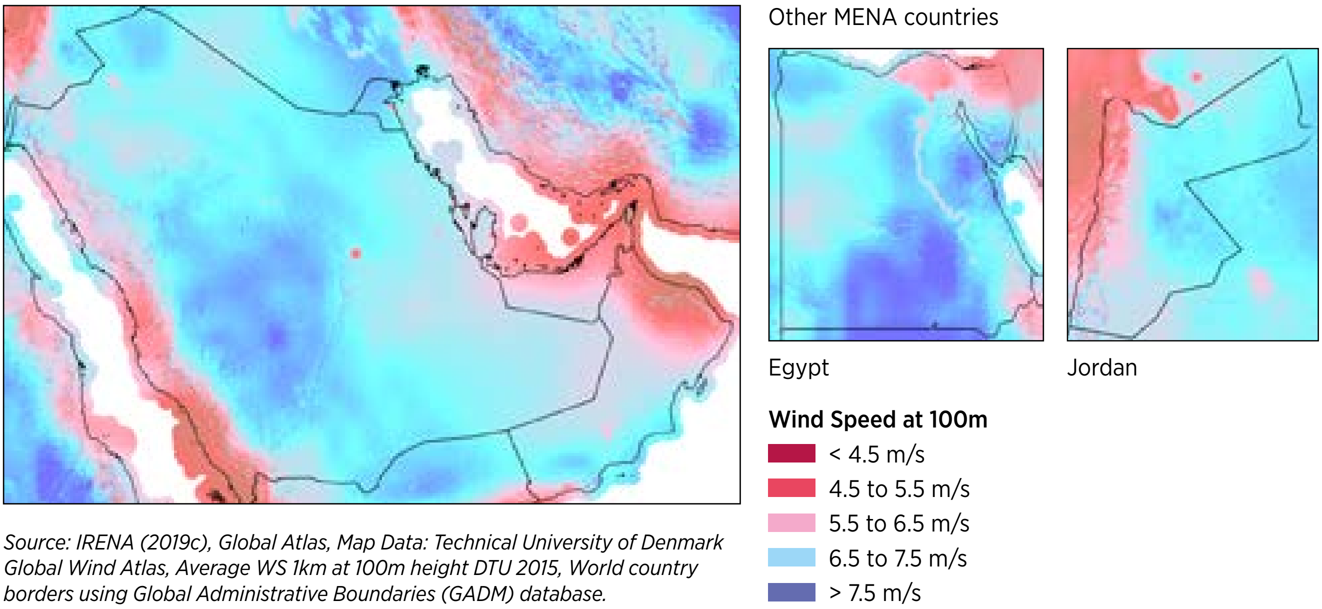
Wind resources

Contrary to common perceptions, some countries in the GCC, such as Kuwait, Oman, and Saudi Arabia, have very good wind resources. The following discussion explores those resources, based on wind speed data.

The average annual wind speed in the GCC at a hub height of 100 metres is mapped in Figure 1.10 with data from IRENA's Global Atlas tool. It reveals that large areas in the centre and north of Saudi Arabia, southern region of Oman and the western region of Kuwait have good wind resources (above 7.5 m/s).

Kuwait, Oman and Saudi Arabia have areas with wind speeds comparable to those in neighbouring Jordan, but behind the excellent resources of Egypt's Gulf of Suez and Central regions. In Kuwait, the Shagaya wind project (10 MW) is being built in the western region; the site, like most of the country's windiest areas, is distant from the capital. Oman's southwestern region of Dhofar has promising sites boasting wind speeds exceeding 7.5 m/s. A 50 MW wind farm is under construction in the region. In Saudi Arabia, the upcoming 400 MW Dumat-al-Jandal wind project is sited in the northern province of Al Jouf.

Figure 1.10 Annual average wind speeds



Source: IRENA (2019c), Global Atlas, Map Data: Technical University of Denmark Global Wind Atlas, Average WS 1km at 100m height DTU 2015, World country borders using Global Administrative Boundaries (GADM) database.

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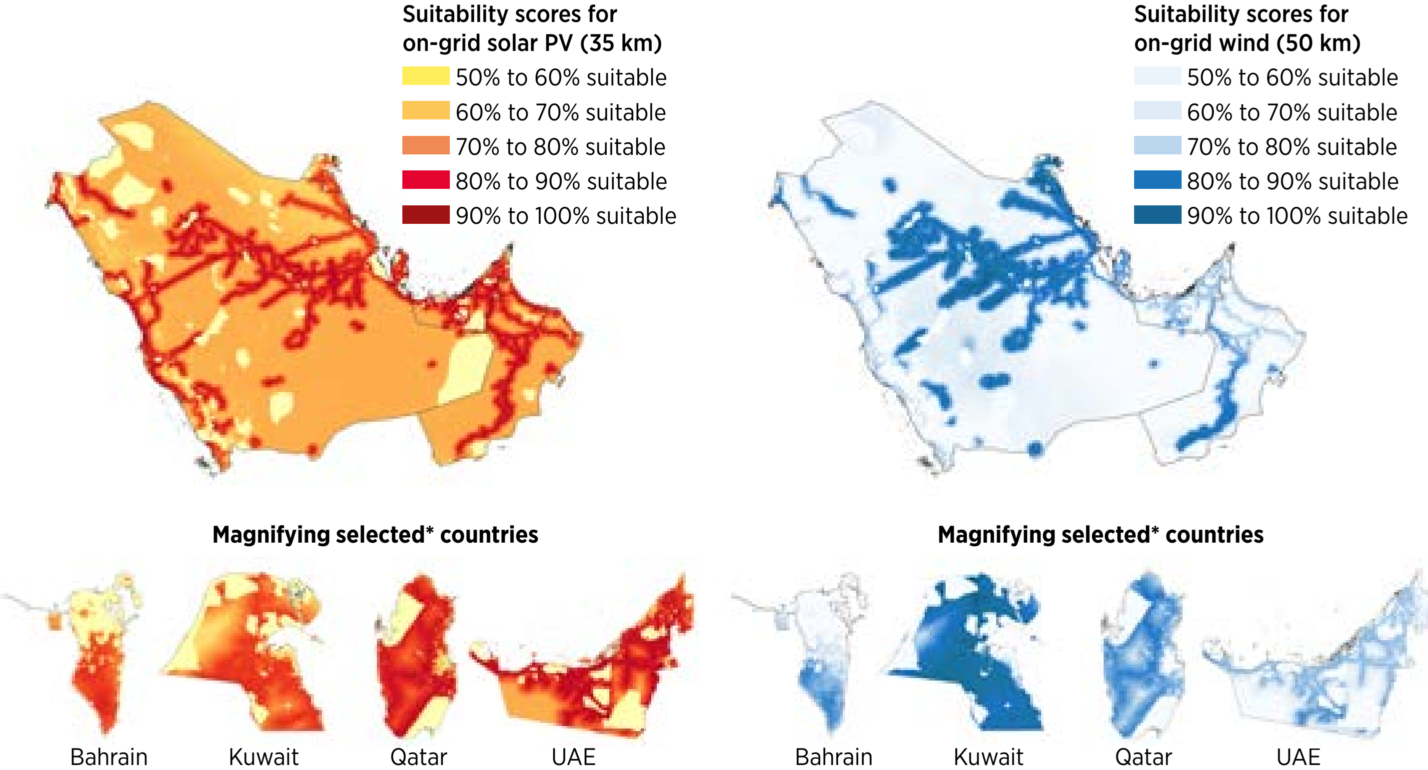
Suitability analysis of wind and solar PV

Suitability analysis combines renewable energy resources with factors such as distance from the grid, population density, topography, land cover and protected areas to identify regions for project development.

The suitability analysis for solar PV technology in the GCC reveals strong potential for deployment in all GCC countries, with Oman, Saudi Arabia, and UAE as leaders. Developing just 1% of the suitable area could result in 608 gigawatts (GW) of solar PV capacity (Figure 1.11).[3]

The wind analysis shows significant opportunities for deployment in Kuwait, Oman and Saudi Arabia (Figure 1.11). Covering just 1% of the suitable area could translate into the equivalent of 26 GW of capacity.

Figure 1.11 Suitability analysis results for on-grid solar PV (left) and on-grid wind (right)



Source: IRENA (2019d), Global Atlas Suitability Map, Solar PV Map Data: World Bank Group, 2018, Global Horizontal Irradiation kWh/m² World 1km, Wind Map Data: Technical University of Denmark Global Wind Atlas, Average Wind Speed 1km at 100m height

*Note: *The four countries with the lowest areas have been selected for magnification; Higher scores represent increased suitability.*

3 The conversions in equivalent capacity are provided for illustrative purposes. These figures provide helpful orders of magnitude, but depend heavily on the underlying assumptions.

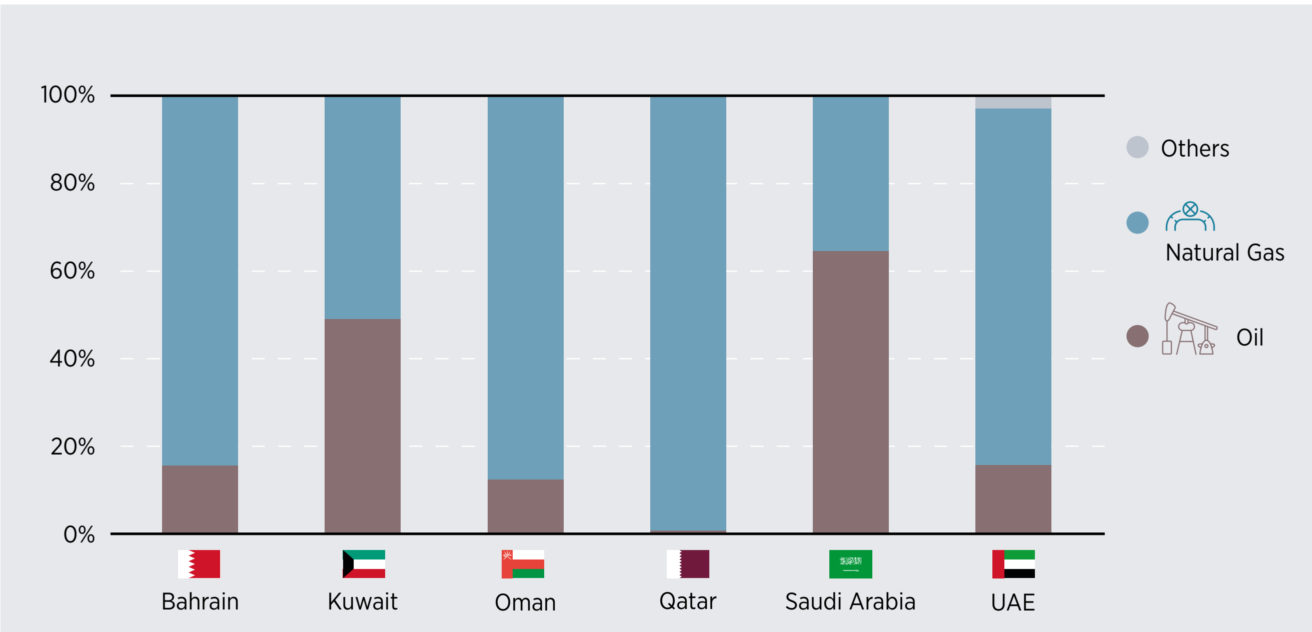
1.3 ENERGY SUPPLY AND CONSUMPTION

1.3.1 Total primary energy supply

Fossil fuels are virtually the only source of primary energy in the GCC. Bahrain, Oman, Qatar and the UAE use gas for about 90% of their needs (Figure 1.12), including in industry. In Kuwait and Saudi Arabia, where supplies of natural gas are insufficient and production lags behind growth in domestic demand, oil remains the predominant source.

The rising domestic demand for energy and the continued dominance of fossil fuels in the regional energy mix pose significant challenges for the GCC. In Saudi Arabia, former Saudi Aramco CEO Khalid Al-Falih warned in 2010 that without changes to the fuel mix and improvements in energy efficiency, domestic demand would shrink the availability of crude oil for export by the 2020s (Financial Times, 2010). Other countries such as Kuwait, Oman and the UAE, face the prospect of rising, and costly, natural gas imports. In 2018, Saudi Arabia mulled natural gas imports to fill the gap in domestic energy supply, following similar announcements by Bahrain (Butt, 2017) (APICORP, 2017b).

Figure 1.12 Total primary energy supply by fuel in 2016



Source: IEA, 2018a.

Notes: Small volumes of coal are used by cement industries in Kuwait and the UAE. Coal is not part of the electricity mix of the GCC, but figures in total primary energy supply.

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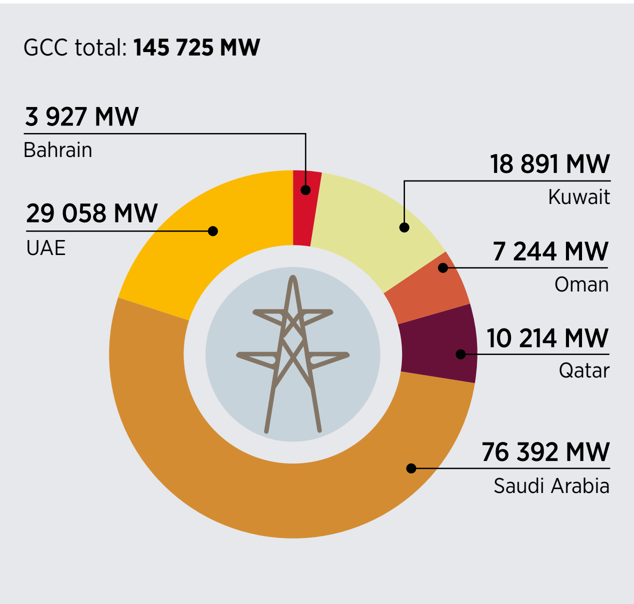
1.3.2. Electricity sector

The GCC economies' capacity to generate electricity has expanded quickly in recent decades in response to burgeoning domestic demand. The largest market is Saudi Arabia, with some 76 GW of installed power generation capacity, followed by the UAE and Kuwait (Figure 1.13). Virtually all of this capacity is powered by fossil fuels, primarily natural gas, but also oil products – and even, at peak times, crude oil – in Saudi Arabia and Kuwait (Figure 1.14). Less than 1% of current installed capacity is based on renewable energy.

The GCC countries took a step toward interconnecting their electricity sectors by establishing a GCC regional grid in 2009. The interconnection currently maintains a relatively small capacity of 2.4 GW, primarily because it was designed in the 1990s, when demand was lower. For now, the capacity appears to be sufficient, as the interconnection's primary function is to act as an emergency backup system that allows ad hoc transfers between GCC members (El-Katiri, 2011; GCCIA, 2017; see also Box 1.3).

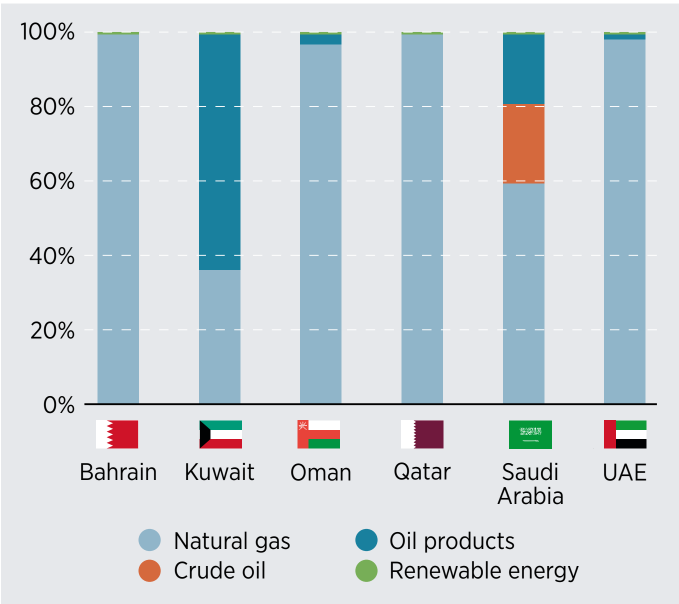
A larger-scale application of the grid, extending its capacity and creating a wholesale market similar to those of several European systems and Latin America, is technically possible and may be of great benefit as the GCC economies diversify their energy mix through accelerated deployment of renewable energy and other means (see discussion in Chapter 2).

Figure 1.13 Installed capacity by country in 2017



Source: IRENA, 2018a.
Note: MW = megawatt.

Figure 1.14 Electricity generation capacity by fuel source as a percentage of the total in 2016



Source: IEA, 2018a; IRENA, 2018a.

Box 1.3 The GCC interconnection grid

The Gulf Cooperation Council (GCC) interconnection grid connects the national grids of the six GCC member states. It began operations in 2009, when initially four, later all six members linked their national grids. The grid, conceived in the 1980s, has a total capacity of 2 400 MW; a double-circuit 400 kilovolts (kV), 50 hertz (Hz) AV line connects the six countries along the Gulf's western shore. The northern and southern members are brought into the interconnection via 400 kV lines, and a 220 kV line links Oman through the UAE. Saudi Arabia is linked to the grid via a separate back-to-back high-voltage direct current interconnection using a 380 kV line. Bahrain is linked via a 400 kV subsea cable (GCCIA, 2017).

The grid was originally expected to facilitate intra-regional electricity trade within the GCC, but today it primarily serves the purpose of sharing spinning reserves and at times of exchanging small volumes of scheduled or unscheduled power transfers in emergencies. The GCC Interconnection Authority (GCCIA) estimates that between 2011 and 2017 member countries saved some USD 2.2 billion by sharing spinning power and through occasional electricity exchanges (GCCIA, 2017). The amount of electricity actually exchanged between GCC countries has been limited by the absence of a commercial trading market (El-Katiri, 2011).

There has been considerable interest in expanding the use of the grid, including for commercial purposes. The GCCIA has positioned itself as one of the most important advocates of regional power trading (Al-Asaad and Ebrahim, 2008; Al-Shahrani, 2009). When the UAE's link to the grid opened in April 2011, energy ministers and other regional leaders described the grid as both an emergency tool and a backbone for future trade (Kumar, 2011). In November 2017, a six-month trial of spot trading was initiated, with the aim of developing a commercial platform from this experience (GCCIA, 2017).

A complex but technologically feasible task, a regional power market based on the existing interconnection would need to overcome several hurdles, including, initially, an upgrade of the grid's capacity to accommodate larger volumes of traded electricity to justify investment in large-scale projects such as Saudi Arabia's Solar Power Project 2030. A regional market would also necessitate a new legal framework, which, in turn, would depend on overcoming intra-regional political hurdles between neighbouring countries. Tariffing questions would have to be agreed on, and national utility markets would probably have to be reformed to allow utilities to buy electricity from abroad under a commercial mechanism (GCCIA, 2017; El-Katiri, 2011).

The successful use of the GCC interconnection grid for commercial electricity trading could also provide incentives for expanding the grid beyond the GCC. Egypt has been in talks with Saudi Arabia for many years over the possibility of linking both countries' national power grids to take advantage of different demand peaks between Egypt and the Gulf countries via Saudi Arabia. This, in turn, could incentivise further GCC investment in clean energy projects in Egypt. Yemen provides another grid expansion option; it could benefit tremendously from the added generation capacity and power system stability that access to a GCC electricity pool could provide. An interconnection could be an important form of postconflict economic restructuring in Yemen.

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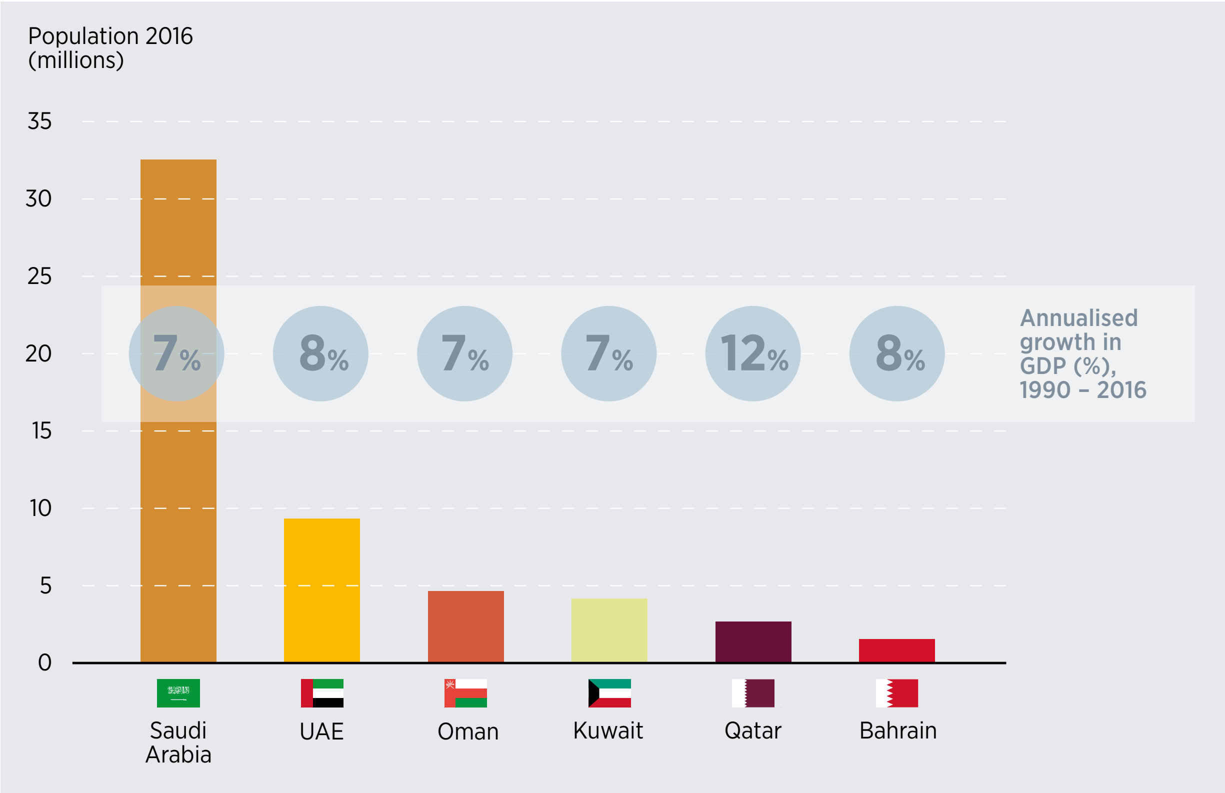
1.3.3 Energy consumption

The GCC economies have historically been small energy consumers compared with Asia, Europe, and North America, which enabled them to export a large share of their hydrocarbon production. However, rapid economic growth, energy-intensive industrial expansion, growing populations (Figure 1.15), high incomes and high living standards have gradually altered the perception of a natural abundance of hydrocarbon resources relative to the region's needs.

The surge in domestic energy consumption, including in the power sector, has challenged policy makers to meet demand economically, without compromising current and future hydrocarbon export revenues, while also managing their countries' carbon footprint. This section explores the basic dynamics of the GCC's energy consumption over the last decade. Renewable energy, alongside energy efficiency (discussed in more detail in Chapter 5) has gained significantly in appeal in the region, in particular in response to the dramatic, parallel fall in renewable energy technology costs relative to fossil fuels (Chapter 3).

Figure 1.15 Population and annualised growth in GDP

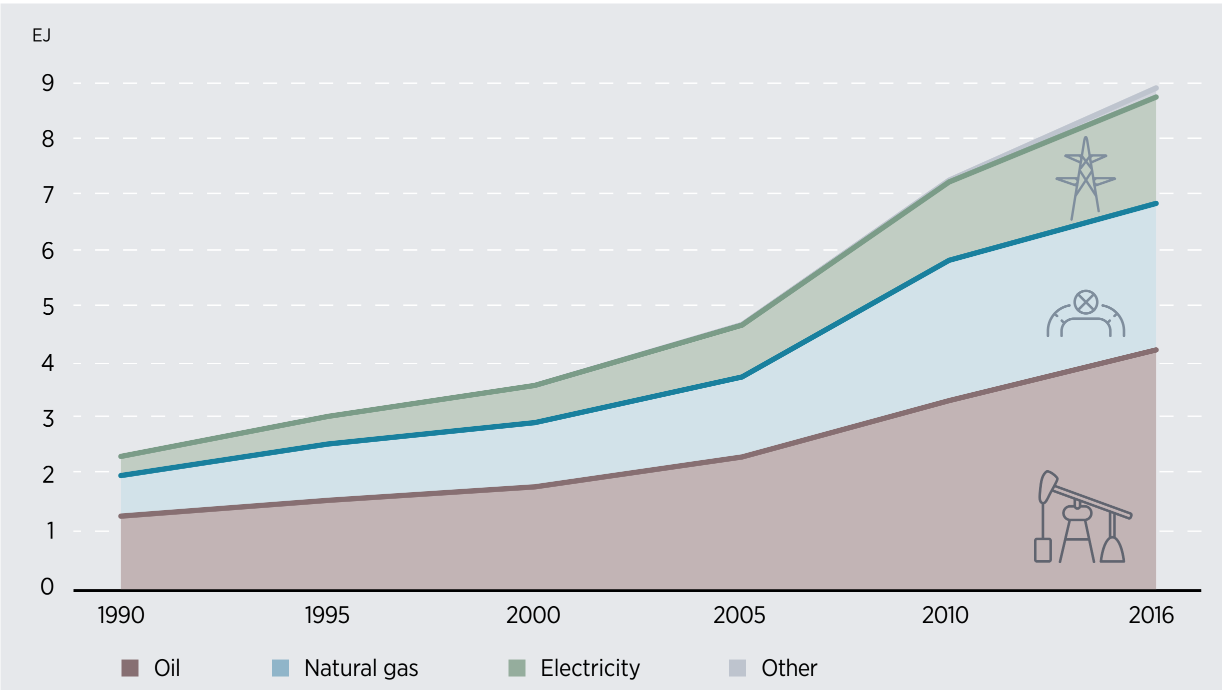


Source: Based on World Bank, 2018; IEA, 2018b.

Overall trends in energy consumption

Total final energy consumption in the GCC has doubled since 2000 and almost quadrupled since 1990 (Figure 1.16). This extraordinary surge makes the GCC the fastest-growing energy market in the world, outpacing emerging economies in Asia. The region is no longer a marginal consumer. Saudi Arabia, which accounts for over half of GCC final energy demand (Figure 1.17), is the world's sixth-largest consumer of oil (BP, 2018), at 3 Mb/d, about a quarter of its production in 2017. Energy demand has also expanded on a per-capita basis: Bahrain, Kuwait, Oman and the UAE show levels far above those of most other industrialised countries, including China, India, Japan, the Russian Federation and the United States, while Qatar has the world's highest rate of energy demand on a per capita basis (Figure 1.18)

Figure 1.16 Total final energy consumption by source in the GCC, 1990–2016



Source: IEA, 2018a.

Note: EJ = exajoule.

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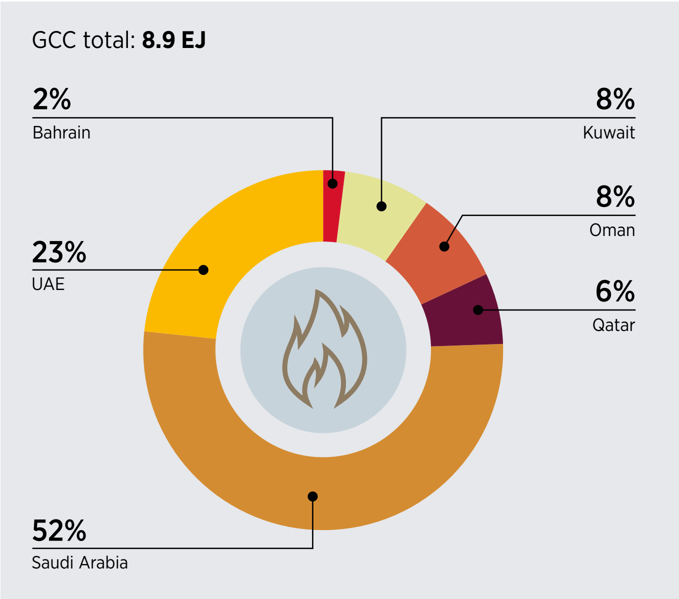
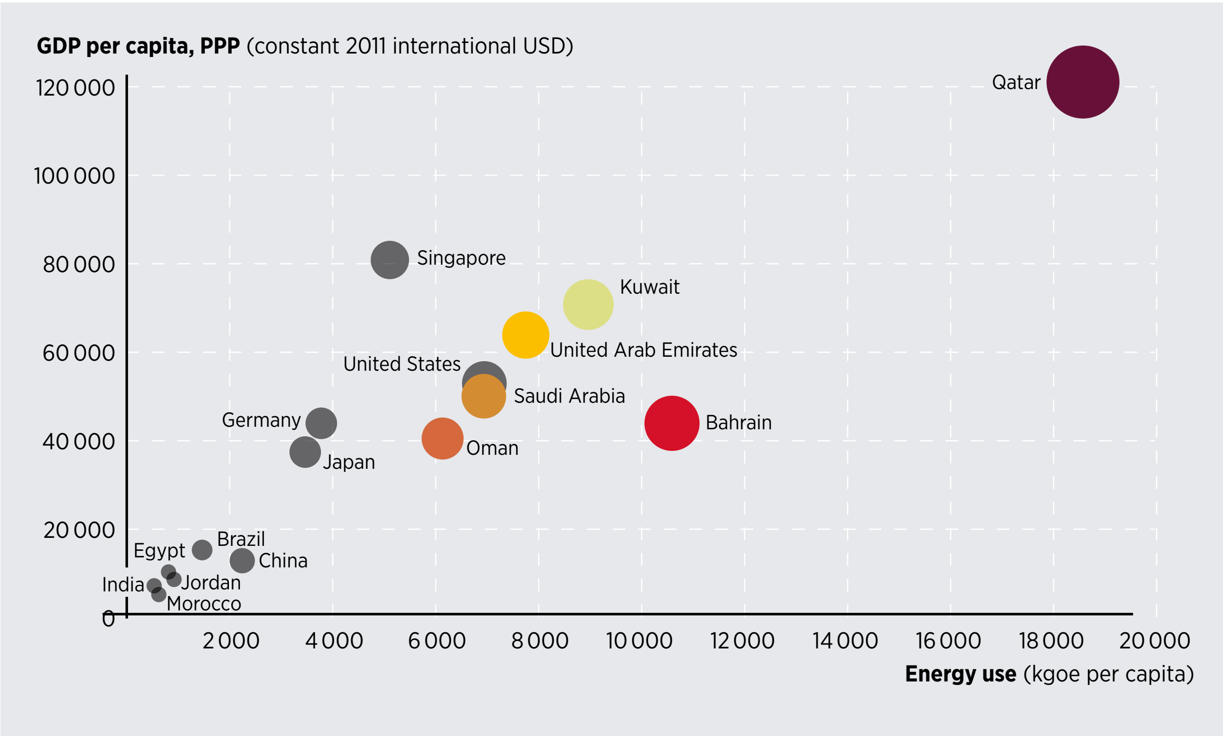
Figure 1.17 Total final energy consumption by country as a share of the total in 2016



Source: IRENA, 2018a.

Note: Totals may not add up due to rounding; EJ = exajoule.

Figure 1.18 Total primary energy use per capita in 2014 (kg of oil equivalent per capita)



Source: IRENA based on World Bank (2018).

Note: PPP = Purchasing power parity; USD = United States Dollar; kgoe = kilograms of oil equivalent

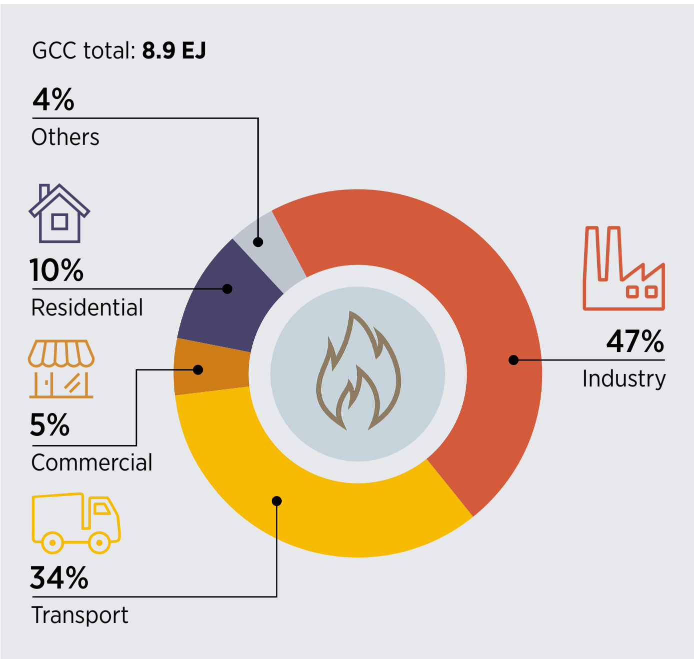
Matching the overall trend, GCC countries are experiencing significant growth in demand for electricity. Peak electricity load in Saudi Arabia in 2015, for instance, was 10% higher than in 2014; the 2020 level is expected be nearly a third greater than that of 2014. By 2032, it will have doubled (MEES,2016; MEES, 2015). As demand rises, the need for new power sector infrastructure grows apace. In Qatar, for instance, rising demand for power in remote settings requires significant upgrades and extensions in the grid (Zarzour, 2018). Saudi Arabia was projected to require additional investment in the power sector of at least 500 billion Saudi Riyals (SAR) (USD 133.3 billion) until the mid-2020s in order to safeguard supply (MEES, 2016). Slower economic growth recently may reduce this number.

There are multiple reasons for the rising demand in electricity. Strong economic and demographic growth, driven in part by the GCC economies' energy-intensive industrialisation programmes and by high rates of labour migration. Energy- and water-intensive service sectors such as tourism have added more demand, particularly over the past three decades. Gains in living standards, the need for year-round air conditioning, and water desalination are additional drivers. Finally, enduring energy market structures – in particular, limited energy efficiency regulation and a legacy of controls on energy prices that has produced some of the lowest costs of fuel, electricity and water in the world – have provided little incentive to use resources efficiently or sparingly (UN ESCWA, 2017; Lahn *et al.*, 2013).

Energy consumption by sector

Industry is the dominant user of energy in the GCC, accounting for close to half of the total demand. Transport presently accounts for a third, with its share growing. Residential and commercial uses represent smaller shares of overall final energy consumption, chiefly in the form of electricity (Figure 1.19).

Figure 1.19 Total final energy consumption by sector as a share of the total in 2016



Source: IEA, 2018a.
Note: EJ = exajoule.

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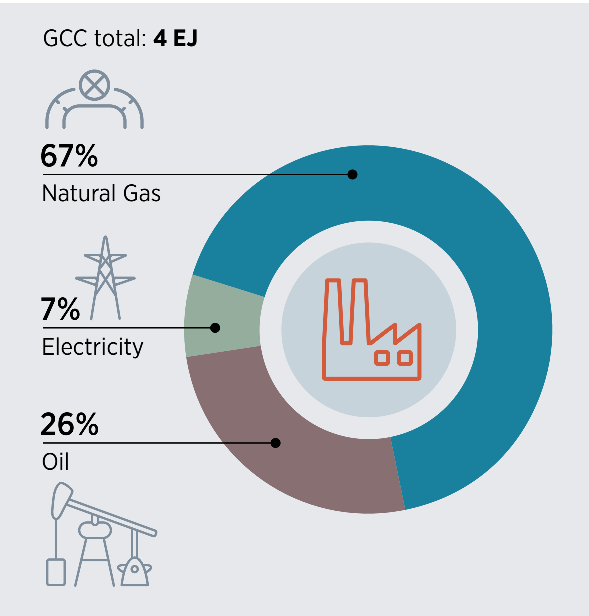
Industrial sector

Oil and gas are used by industries as fuel and feedstock, the main consumers being energy-intensive industries such as petrochemicals, aluminium, steel and fertilisers. Saudi Arabia, for example, has placed several petrochemical facilities close to existing oil fields to benefit from low-cost associated gas. Industrial demand for natural gas, in particular, is growing rapidly, with gas now accounting for 67% of energy inputs for the sector (Figure 1.20).

Captive industrial power generation constitutes a major component in the sector's energy use, with many industries generating their electricity themselves as part of parallel production processes, rather than buying it from the grid. The increasing use of gas in the sector has reduced the consumption of crude oil, other petroleum products and grid-based electricity by these industries, leaving the transport sector and residential consumers to account for a large proportion of recent growth in the consumption of fuel and grid-based electricity.

Figure 1.20 Final energy consumption in the industrial sector as a share of the total in 2016



Source: IEA, 2018a.
Note: EJ = exajoule.

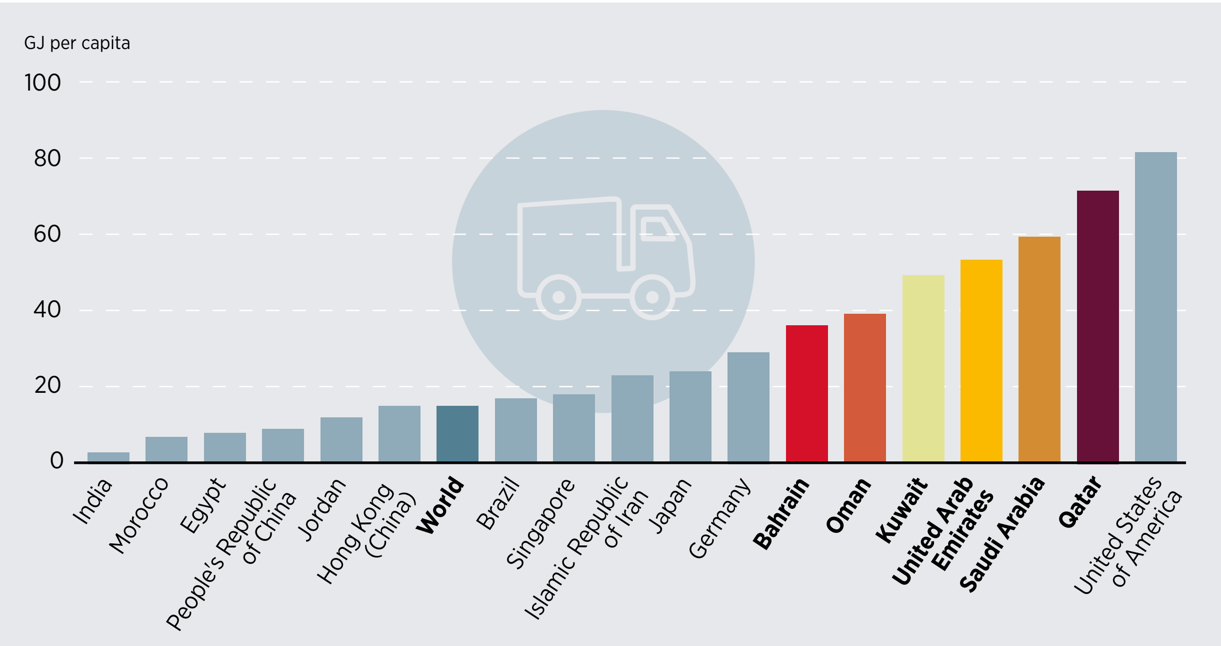
Transport sector

The transport sector is a critical driver of GCC demand for liquid fuel. The sector's final energy consumption more than doubled since the early 2000s,[4] the result of fast-growing economies and populations, combined with high income levels, subsidised prices for transport fuels, extensive expansions of road infrastructure and a lack of public transport. The consumption of gasoline, for example, more than doubled in Kuwait, Saudi Arabia and the UAE over the period of 2006–2016, while Oman's demand over the same period almost tripled (UN, 2018). The GCC economies' per capita consumption of fuel for transport now surpasses that of most developed economies, with Qatar approaching levels matched only in the United States (Figure 1.21).

Rising domestic demand for transport fuels has required imports to fill the growing gap between domestic production and demand, contributing to the rationale for investments in large refineries. For example, the UAE's imports of gasoline more than doubled over the last decade, while Saudi Arabia's almost tripled (UN, 2018). Bahrain and Qatar have remained self-reliant but have curtailed gasoline exports as a result of increased domestic consumption.

Surging fuel consumption in the transport sector has led several GCC countries to start fuel-switching toward natural gas in public transport and government vehicles (Ahmad, 2017). More recently, electrified transport has begun to make inroads in the Middle East, with growth likely over the coming years (see Chapter 6 for further discussion).

Figure 1.21 Final energy consumption in the transport sector in the GCC and selected countries in 2016



Source: Based on IEA, 2018a.

Note: GJ = gigajoule

4 *Calculated based on IEA, 2018a.*

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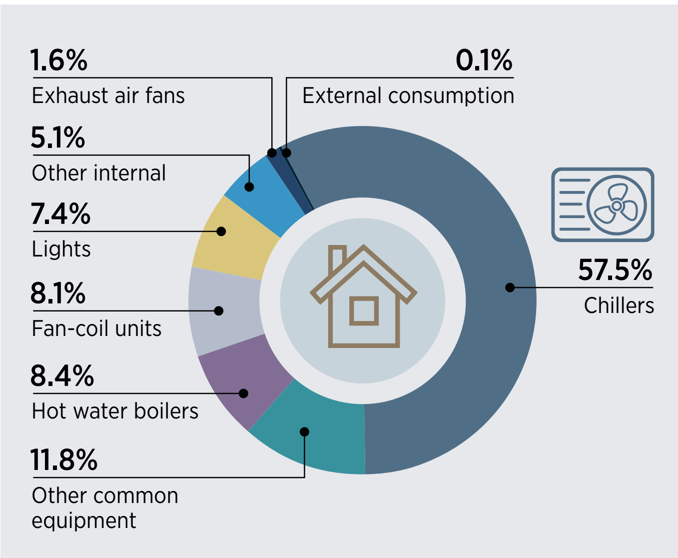
Residential and commercial sector

Residential and commercial energy demand in the GCC has grown rapidly in recent years, particularly for electricity. Nearly 50% of all electricity consumed in the GCC now goes to the residential sector; the share is even greater in Kuwait and Saudi Arabia (IEA, 2018a). Air conditioning accounts for a considerable portion of residential and commercial electricity demand, as illustrated by Abu Dhabi's end-user profile in Figure 1.22. The high share of air conditioning (chillers and fan-coil units) in the profile explains why electricity demand peaks in the summer, when temperatures are at their highest, and particularly at midday and in the evening.

Figure 1.22 Electricity end-user profile for a typical building in Abu Dhabi as a share of total electricity consumed in 2010



Sources: Municipality of Abu Dhabi City; Masdar and Schneider Electric, 2011.
Note: In this figure, the term "chillers" means air conditioning.

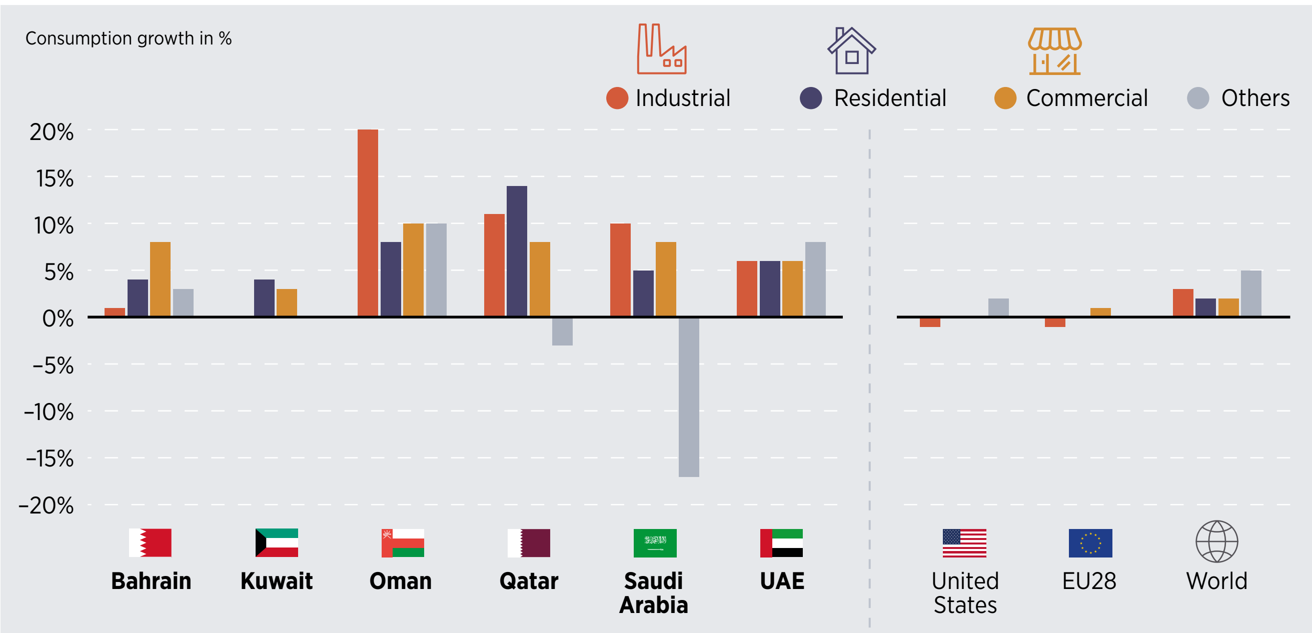
With plenty of new housing and commercial projects across the GCC over the past decade, and significant industrial expansion – particularly in energy-intensive industry segments – it is not surprising that regional electricity consumption grew at an average rate of 7% per annum between 2006 and 2016, faster than anywhere else in the world. Oman and Qatar saw the steepest overall rise in electricity consumption, with annualised growth of 11% and 10% and respectively, while industrial consumption in both countries, and residential consumption in Qatar, increased by more than 10% per year (Figure 1.23).

Other factors have amplified the demand expansion, among them the combination of a hot climate and high average incomes and living standards. The climate requires almost year-round air conditioning, and energy efficiency measures for buildings, electrical appliances and industries are very limited. Utility price incentives for end users have also been historically weak (see Chapter 5 for further discussion).

1.4 CONCLUSION

The region's heavy reliance on fossil fuels may imply two choices for a long-term strategy: continued reliance on fossil fuels, requiring considerable additional oil and gas allocations to the domestic market; or a systematic diversification of the region's energy mix that would incorporate renewables and other alternatives. Aspirations for diversification of the energy sector are realistic. Governments have turned their eyes toward alternative energy sources, in particular renewable energy. As Chapter 2 explores in more detail, governments are also devising strategies to exploit promising sources of renewable energy. These strategies are backed by the establishment of enabling frameworks, the implementation of projects and the development of local industries. The next few years will reveal the extent to which the region is able to seize these opportunities.

Figure 1.23 Annualised growth in electricity consumption by sector in the GCC and selected countries, 2006–2016



Source: Based on IEA, 2018c.

Note: No data are available for industrial and other consumption in Kuwait.

RENEWABLE ENERGY LANDSCAPE

02

Recent years have seen a pick-up in national plans, targets and strategies to promote renewable energy in the GCC. Alongside energy efficiency, renewables play an important role in regional efforts to conserve natural resources and diversify the energy mix, which remains heavily dominated by fossil fuels. Renewables also have the potential to generate valuable jobs in research and development (R&D) and along the value chain, in line with the shared goal of creating more diversified, innovative and knowledge-based economies. The relatively low oil prices that have prevailed since 2014 have had little effect on regional renewable energy plans, as auctions (discussed in Chapter 3) have pushed down prices for solar PV and other renewable technologies to levels that are competitive with oil and natural gas. This chapter reviews the status, trends and evolving policy frameworks for renewable energy in the GCC states.

2.1 RENEWABLE ENERGY TARGETS, STATUS AND TRENDS

Renewable energy plans and developments have come a long way in the GCC in recent years. Ambitions differ across countries, as do market size and readiness, but the overall picture is one of a dynamic region. Figure 2.1 summarises current targets. Regarding deployment, the UAE has taken the lead, joined recently by Saudi Arabia. Interesting projects can also be found in Kuwait, Oman and Qatar.

Because the region has only recently become a market for renewable energy, most declared targets are not yet enshrined in legislation. The UAE and several other GCC countries have incorporated their renewable energy targets into their Nationally Determined Contributions (NDCs) under the United Nations Framework Convention on Climate Change (UNFCCC) (Box 2.1). Targets also figure in official state visions and announcements from high-ranking members of government.

Those visions for renewable energy development are gradually translating into concrete policies and projects, and the short- and medium-term outlook looks promising, particularly in the UAE and Saudi Arabia, the region's biggest energy markets. Deployment in other GCC members remains limited to pilot and demonstration projects. Nevertheless, as more projects come online and confirm the cost-effectiveness of renewable energy, prospects for an accelerated take-up are positive.

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Box 2.1 GCC members' Nationally Determined Contributions (NDCs)

Bahrain's NDC focuses on adaptation, given the country's status as an archipelago of low-laying islands and its small area, population and economy. The country thus emphasises that "a delicate balance must be struck in order for Bahrain to be able to develop sustainably" (UNFCCC, 2015a). Most mitigation focuses on energy efficiency in building, industry, transport and the energy sector, but small-scale utility-based renewable energy projects are also found, including a 5 MW grid-connected solar PV plant operated by BAPCO.

Kuwait has committed to reducing its greenhouse gas emissions through a variety of policies, including producing a greater share of its energy from renewable sources and from municipal waste by 2030; the gradual reform of price subsidies for petroleum products, electricity and water; and investment in cleaner, less-fuel-intensive transport systems, including a metro and a railway project. Kuwait also adopted a new Environment Protection Law (No. 42, 2014, amended by Law No. 99, 2015) to protect human health, control pollution, enhance natural resources, and promote energy efficiency and clean energy (UNFCCC, 2015b).

Oman's NDC calls for policy responses to climate change, including measures such as reducing gas flaring from oil industries, boosting energy efficiency and raising the share of renewable energy. Specific areas of intervention include sustainable buildings and low-carbon transport technologies (UNFCCC, 2015c).

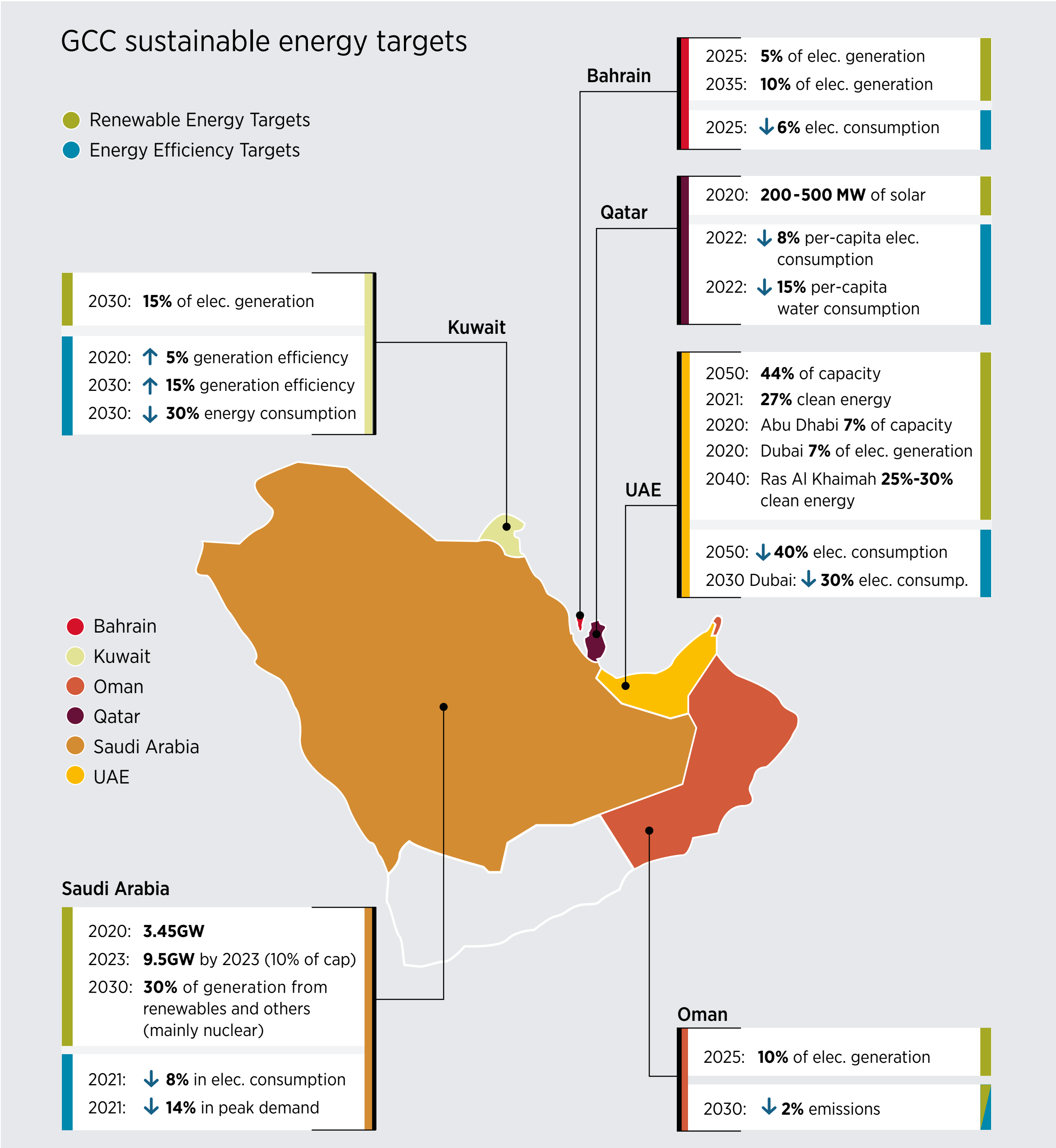
In Pillar 4 of its *National Vision 2030*, **Qatar** seeks to mitigate climate change and strike a balance between development needs and environmental protection. Therefore, Qatar has committed to promote energy efficiency, clean and renewable energy, education, and research and development. As part of its adaptation strategy, the country seeks to strengthen the management of water and waste and to develop infrastructure and transport (UNFCCC, 2015d).

In its NDC, **Saudi Arabia** declares its ambition to avoid by 2030 up to 130 million tons of CO_2 equivalent. Diversifying the Saudi economy and investing in adaptation programmes is to be the primary route to achieve this target. Among the chief mechanisms to be employed are investments in energy efficiency and renewable energy, promotion of carbon capture and utilisation/storage, greater use of natural gas, and further reductions in gas flaring. Adaptation measures include improved water and waste water management, urban planning, marine protection, and actions to reduce desertification (UNFCCC, 2015e).

When it signed and ratified the Paris Agreement in 2016, the **United Arab Emirates** pledged to pursue "a strategy of economic diversification that will yield mitigation and adaptation co-benefits". A part of these efforts is to increase the share of clean energy (renewable and nuclear) in the total energy mix to 24% by 2021.[1] In addition, the country has put forward other measures, including a reduction in gas flaring; carbon capture and utilisation/storage; tariff reform and deregulation of fossil fuel prices; efficiency standards for buildings and household appliances; and investments in Dubai's light rail and metro system and the rail network connecting the emirates. A Ministry of Climate Change and Environment was also created to make the climate one of the country's top priorities. In 2017, the ministry produced the *National Climate Change Plan of the United Arab Emirates*, which serves as a road map for nationwide actions for climate mitigation and adaptation through 2050.

1 *It is not clear whether the target refers to total primary energy, electricity generation or electricity capacity. The National Climate Change Plan says the UAE has increased its clean energy target for 2021 from 24% to 27% (MOCCAE, 2017). This update is not reflected in the official documents submitted to the UNFCCC.*

Figure 2.1 Sustainable energy targets



At the end of 2018, the region had 146 GW of installed power capacity, of which renewable energy accounted for less than 1% (867 MW) (Table 2.1). Of that, the UAE accounted for 68%, followed by Saudi Arabia (16%) and Kuwait (9%) (Figure 2.2). The present level of renewably-sourced capacity is a long way from the levels planned by the GCC countries, but it does represent a four-fold increase from 2014 (Figure 2.3). The trend is likely to accelerate in the future, as 7 GW of projects are reported to be in the pipeline.

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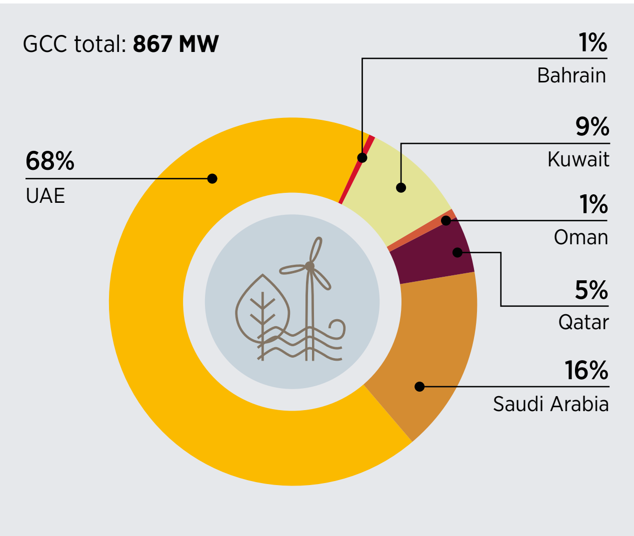
Table 2.1 Installed renewable energy capacity as of the end of 2018

	2017 – 2018						2016	2015	2014
Country	**PV**	**CSP**	**Wind**	**Biomass and waste**	**Total RE**	**Share of RE in total electricity capacity**	**Total RE**	**Total RE**	**Total RE**
Bahrain	5	0	1	0	6	0.1%	6	6	6
Kuwait	19	50	10	0	79	0.4%	20	1	0
Oman	8	0	0	0	8	0.1%	2	2	1
Qatar	5	0	0	38	43	0.4%	43	42	42
Saudi Arabia	89	50	3	0	142	0.2%	74	74	24
United Arab Emirates	487	100	1	1	589	2.0%	144	137	137
Total	**613**	**200**	**14**	**39**	**867**	**0.6%**	**289**	**262**	**210**

Source: IRENA, 2018a; IRENA estimates.

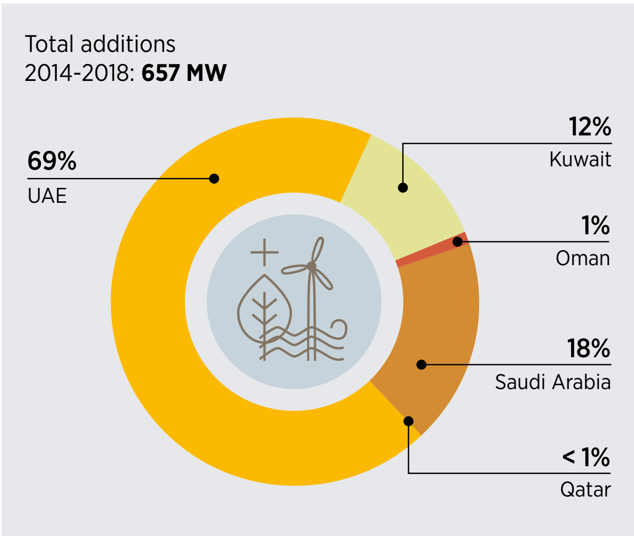
Note: 2018 data are available only for Kuwait, Saudi Arabia and the UAE. Oman's 7 MW_{th} solar enhanced oil recovery plant and the newly finished first phase of 1 GW_{th} Miraah Solar EOR is not included because this table addresses only electricity. PV = photovoltaic; CSP = concentrated solar power; RE = renewable energy. Totals may not add up due to rounding.

Figure 2.2 Installed renewable energy capacity in GCC countries as a share of the total by 2018



Source: IRENA, 2018a.

Figure 2.3 Growth in renewable energy capacity in the GCC by country, 2014-2018



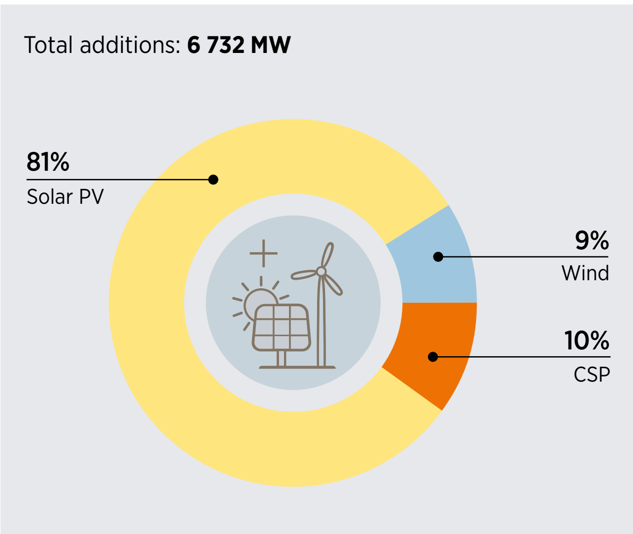
Source: IRENA, 2018a.

Installed renewable electricity capacity in the GCC is dominated by a handful of utility-scale solar projects. Solar PV and concentrated solar power (CSP) provide 94% of the total, as well as almost 91% of the project pipeline (Figure 2.4). The currently existing CSP capacity is located in Abu Dhabi's Shams Solar Power Station, Kuwait's Shagaya project and Saudi Arabia's Waad Al-Shamal. Almost all of the GCC's commercial waste-to-energy generation capacity is in Qatar, while most of the limited wind capacity is found in Kuwait. Plans to expand wind power, in particular in Saudi Arabia and Oman, should raise wind's share over the coming decade, although solar power will remain the dominant source of renewable energy.

Renewables are also gathering traction in heating applications, including the production of steam, hot water and desalinated water. Solar-assisted steam generation is used in enhanced oil recovery (EOR) in Oman, which plans more such activity, as does Kuwait. Thanks to supportive green-building regulations, solar water heaters are increasingly used in Dubai. Solar technologies are also being used in desalination.

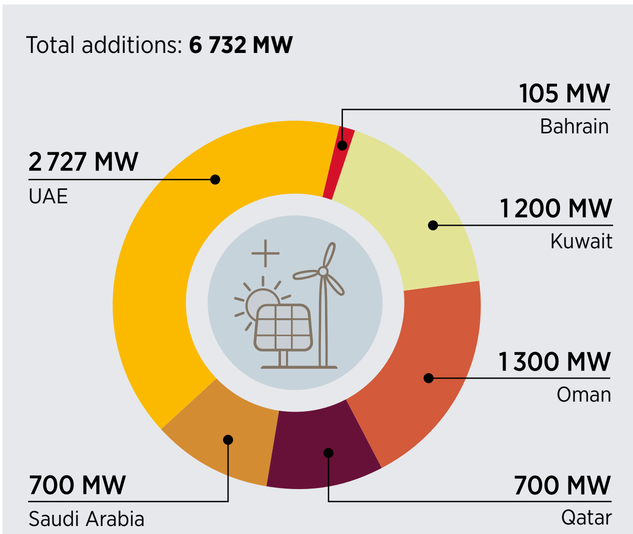
Looking forward, the region is set to see a major acceleration in renewable energy deployment. Led by the UAE, Oman and Kuwait, nearly 7 GW of new renewable power generation capacity is expected to come online by the early 2020s (Figures 2.5 and 2.6; Table 2.2). Solar PV is the dominant technology, used in three-fourths of currently planned renewable projects, followed by CSP (about 10%, all in a single project in the UAE) and wind (9%), primarily in Saudi Arabia and Oman (Figure 2.4). Solar-assisted EOR in Oman is also expected to contribute approximately 1 GW_{th} by 2019.

Figure 2.4 Renewable power planned additions by technology



Source: IRENA, 2018a.

Figure 2.5 Renewable power planned additions by country



Source: IRENA, 2018a.

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Table 2.2 Utility-scale renewable energy projects in the GCC as of January 2019

Country	Project/site	Technology	Size (MW)	Price (US cents/kWh)
United Arab Emirates (Dubai)	Mohammed bin Rashid Al Maktoum Solar Park, Phase IV	CSP	700	7.3
		Solar PV	250	2.4
	Mohammed bin Rashid Al Maktoum Solar Park, Phase III	Solar PV	600 (of 800)	2.99
			200 (of 800)	
	Mohammed bin Rashid Al Maktoum Solar Park, Phase II	Solar PV	200	5.85
	Mohammed bin Rashid Al Maktoum Solar Park, Phase I	Solar PV	13	
United Arab Emirates (Abu Dhabi)	Noor Abu Dhabi, Sweihan	Solar PV	1 177	2.42 (non-weighted price of 2.94)
	Shams 1	CSP	100	
Oman	Dhofar, Phase I	Wind	50	
	Dhofar, Phase II	Wind	150	
	Miraah Solar Thermal	Solar thermal	1 000 (GW_{th})	
	Ibri PV Plant	Solar PV	500	
	PDO Amin PV Plant	Solar PV	100	
Saudi Arabia	Sakaka	Solar PV	300	2.34
	Dumat Al Jandal	Wind	400	
Qatar	Al-Kharsaag	Solar PV	700	
	Mesaieed Waste to Energy	Waste to energy	38	
Kuwait	Shagaya	CSP	50	
		Solar PV	10	
		Wind	10	
	Al Dibdibah/ Shagaya Phase II	Solar PV	1 200 – 1 500	
Bahrain	Askar Landfill	Solar PV	100	
	Al Dur	Solar-wind hybrid	5	

	Status	Expected start of operation	Comments
	Contracts awarded	To come online in stages starting in 2020	The project has been hailed as the world's largest CSP plant, expected to cost USD 3.87 billion (AED 14.2 billion) to build.
		Assumed 2020 onwards	Added as additional scope to the CSP plant in November 2018.
	Construction has begun in 2017	2020	The project was developed by Shuaa Energy 2, a joint venture established between DEWA (with a 60% stake) and a Masdar-led consortium which also includes Electricité de France's subsidiary, EDF Energies Nouvelles.
	First stage of 200 MW completed in May 2018		
	Completed in March 2017	2017	The project has been developed by ACWA Power and TSK and is delivering power to DEWA since March 2017.
	Completed	2013	The first phase of the Solar Park was a 13 MW PV plant completed by First Solar in late 2013.
	Under construction	2019	The 2.42 US cents/kWh is the rate for winter season, when generation is less valuable for the off-taker. The average price is about 2.94 US cents/kWh.
	Completed	2013	
	EPC contract awarded	2020	
	Planned	2023	
	Under construction	100 MW complete, delivering 660 tonnes of steam/day as of February 2018	Miraah is a 1 GW solar thermal plant that creates steam for enhanced oil recovery. Once completed, Miraah will provide a significant portion of the steam required at Amal. The first four blocks (100 MW) were completed in February 2018.
	Companies shortlisted	Early 2021	The Oman Power and Water Procurement company (OPWP) has shortlisted the three bidders in November 2018 for the USD 500 million project.
	Contract awarded		A joint Japanese-Omani consortium has been selected in Nov, 2019. This includes a 23-year PPA to sell all generated electricity to PDO.
	Under construction	To begin commercial operation in 2019	The USD 302 million facility will be developed on the basis of an independent power producer model and is backed by a 25-year PPA with the Saudi Power Procurement Company.
	Bids received; expected to be awarded start of 2019		The planned USD 500 million project is expected to be awarded in January 2019 under a 20-year PPA with the Saudi Power Procurement Company.
	Bids received	2020 (first 350 MW)	The project is structured as a 25 year build, own, operate, and transfer (BOOT) public-private partnership with Kahramaa.
	Completed		
	Completed		
	Completed		
	Completed		
	Bids invited	2022	The USD 1.2 billion project is owned by Kuwait National Petroleum Company (KNPC). Bidders expected to construct the project and perform O&M for 25 year.
	Request for concept	December 2019	

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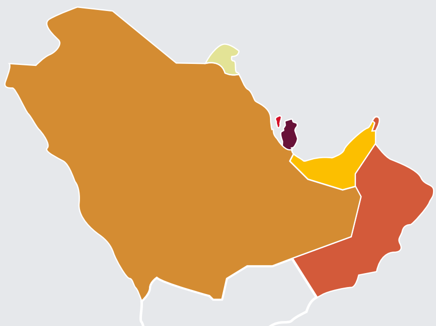
Figure 2.6 Renewable energy projects in the GCC at the end of 2018



Wind
Solar Thermal
Solar PV
Waste to Energy

Bahrain

Solar PV Plant, 100 MW	Request for concept
Al Dur Solar Wind Hybrid, 5 MW	Planned

Qatar

Al-Kharsaag Solar PV, 700 MW	Bids received
Mesaieed W2E, 38 MW	Completed

United Arab Emirates

Mohammed bin Rashid Al Maktoum Solar Park, Phase IVa, 700 MW	Contract awarded
Mohammed bin Rashid Al Maktoum Solar Park, Phase IVb, 250 MW	Contract awarded
Mohammed bin Rashid Al Maktoum Solar Park, Phase III, 800 MW, 200 MW	Completed
Mohammed bin Rashid Al Maktoum Solar Park, Phase II, 200 MW	Completed
Mohammed bin Rashid Al Maktoum Solar Park, Phase I, 13 MW	Completed
Noor Abu Dhabi Solar PV, 1177 MW	Under construction
Shams 1 CSP, 100 MW	Completed

Oman

Dhofar, Phase I, 50 MW	Contract awarded
Dhofar, Phase II, 150 MW	Planned
Miraah Solar EOR, 1000 MW-th	Under construction
Ibri PV Plant, 500 MW	Companies shortlisted
PEO Amin PV Plant, 100 MW	Expression of Interest issued

Saudi Arabia

Sakaka Solar PV, 300 MW	Under construction
Dumat Al Jandal Wind plant, 400 MW	Bids received
Waad Al-Shamal CSP, 50 MW	Completed

Kuwait

Shagaya CSP, 50 MW	Completed
Shagaya Solar PV, 10 MW	Completed
Shagaya Wind, 10 MW	Completed
Al Dibdibah/Shagaya Phase II, 1200 MW	Planned

2.2 RENEWABLE ENERGY POLICIES

2.2.1 United Arab Emirates

Being the GCC's second-largest energy market after Saudi Arabia, the UAE is the region's front runner in adopting renewables into its energy mix and the largest market for renewables. Burgeoning domestic demand for electricity has so far been largely met by natural gas, an increasing proportion of which must be imported. Like other GCC countries, the UAE and the governments of individual emirates have emphasised the need to reduce reliance on oil and gas by adopting new energy technologies that can also help generate jobs and contribute to the long-term goal of making the UAE a regional knowledge and technology hub.

The UAE is also the largest and fastest growing solar market in the GCC. The country boasts an attractive investment landscape, and Dubai and Abu Dhabi have conducted auctions that awarded more than 2 GW of solar projects in the last couple of years. Solar PV has been the leading technology, accounting for 83% of the 589 MW of installed renewable energy capacity and most of the project pipeline. CSP is the second-largest technology by installed capacity.

Renewable energy plans and strategies

Energy is largely an emirate-level matter in the UAE and, until recently, long-term energy plans and targets were issued at the emirate level. Nonetheless, the UAE has launched several large-scale economic plans and strategies which attest to the country's broader commitments to the Sustainable Development Goals and are directly relevant to renewable energy. These include UAE Vision 2021, UAE Green Growth Strategy, UAE Future Strategy and the UAE Centennial Plan (2071) (MOCAF, n.d.; MOEI, 2017; Vision 2021, n.d.). Besides the conventional focus on economic diversification, all of these place great emphasis on knowledge creation and technology innovation, including in green energy. In 2018, the Global Councils on SDGs were launched at the World Government Summit in Dubai, UAE, followed by the launch of the Sustainable Development Goals Center for the Arab Region.

In 2017, the UAE launched "Energy Strategy 2050" (also known as UAE Energy Plan 2050), the first unified energy strategy in the country to become a law. The strategy aims to increase the share of clean energy in the country's electricity generation capacity to 50% by 2050 (44% renewable and 6% nuclear) and to expand renewable energy capacity to reach 44 GW (UAE Government, 2018). The country also has short- to medium-term targets. In line with Vision 2021, the UAE plans to generate 27% of its energy requirements from clean sources, including nuclear power (Figure 2.1).

Dubai significantly revised its targets upward after recent auctions revealed the declining prices of solar. The emirate announced in January 2015 that it would increase its 2030 renewables target to 15% of power

Quick fact box: United Arab Emirates

Installed renewables-based capacity (2018):	589 MW
Share of renewables in total installed power generation capacity (2018):	2%
Project pipeline as of November 2018:	3.14 GW solar power (PV and CSP) by 2020

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generation, up from 5%. Later the same year, this was raised to 25%, all of which is expected to be solar, under the emirate's Clean Energy Strategy 2050.

Recently, a Memorandum of Understanding (MoU) was signed between Expo 2020 and DEWA aiming to have 50% of power needs for the Expo supplied through various renewable energy sources. An MoU has also been signed to set-up a pilot project for the region's first solar-driven hydrogen electrolysis facility.

Utility-scale projects

Abu Dhabi's 100 MW Shams 1 became the first CSP plant in the GCC when it was commissioned in 2013. The project was completed with an investment of USD 765 million by Masdar, in collaboration with Total, Teyma and Abengoa Solar. The project provided an opportunity for key stakeholders including the utility - the Abu Dhabi Water and Electricity Authority (ADWEA), project developer – Masdar – and the regulator – Regulation and Supervision Bureau (RSB) – to gain experience in building, connecting, regulating and operating a large-scale renewable energy project.

Solar PV deployment was soon taken up by the **Dubai** Electricity and Water Authority (DEWA), starting with the Mohammed bin Rashid Al Maktoum Solar Park. Its first phase was a 13 MW PV plant completed by First Solar in late 2013. The satisfactory performance of this pilot phase triggered a series of projects that over time have positioned the Solar Park as a hub of solar deployment in the GCC.

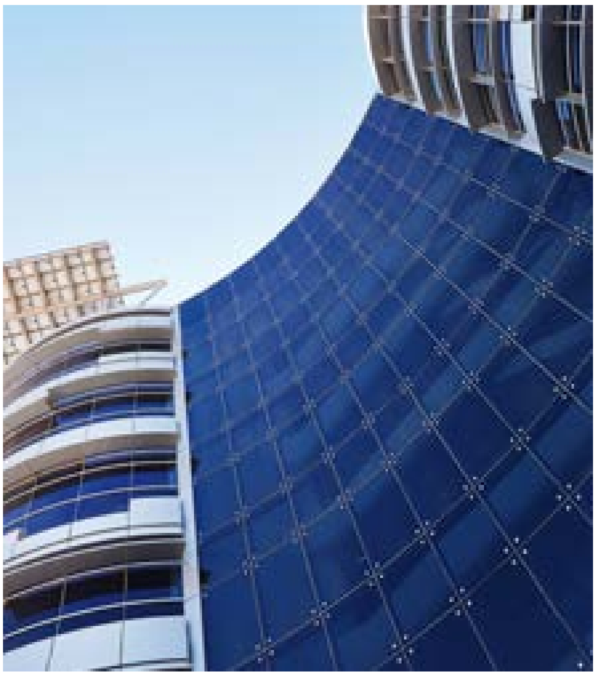
The second phase of the Mohammed bin Rashid Al Maktoum Solar Park was initially auctioned as a 100 MW solar PV project following the independent power producer (IPP) model. However, the capacity was increased to 200 MW to lower costs through economies of scale. The project was built and commissioned in 2017 by the Saudi Arabian group ACWA Power and TSK, a Spanish engineering firm, whose winning bid of 5.85 US cents/kWh set a record in 2015 (ACWA POWER, 2017).

The third phase started with the auctioning of 800 MW of solar PV capacity in 2016. The project was awarded in 2017 at a then record-low price of 2.99 US cents/kWh to Masdar and Electricité de France (EDF). The project is being developed by Shuaa Energy 2 – a joint venture established between DEWA (with a 60% stake) and a Masdar-led consortium which also includes EDF's subsidiary EDF Energies Nouvelles.

Construction began in 2017; the first stage of 200 MW was completed in May 2018, with the full 800 MW expected to be online by 2020.

The fourth phase commenced in 2017 with the auctioning of 700 MW of CSP capacity. The project was conceived to supply electricity outside operating hours of lower-price PV, taking advantage of storage to supply electricity at night. Saudi Arabia-based ACWA Power and Shanghai Electric won the tender with a bid of 7.3 US cents/kWh, at the time the lowest price for CSP anywhere in the world. It will have the world's tallest solar tower (260 metres), 100 MW of capacity, a 600 MW solar trough and molten salt energy storage technology. In November 2018, an additional 250 MW of solar PV was added. The low price of the fourth phase can be attributed to low technology costs, a 35-year power purchase agreement (PPA), favourable financing and production guarantee (Lilliestam and Pitz-Paal, 2018) (see Chapter 3 for details). When completed, the Dubai CSP project will single-handedly increase the 2017 global installed CSP capacity of 4 950 MW by 14%. As such, it is expected to drive a significant reduction in costs of CSP technology.

Abu Dhabi has also adopted auctions to support its quest for solar PV projects. The Abu Dhabi Water and Electricity Company (ADWEC) launched an auction for 350 MW of solar PV in the Sweihan region of Abu Dhabi in 2016, Noor Abu Dhabi. A consortium of Japan's Marubeni Corp and China's JinkoSolar Holding were selected to build and operate the facility at a non-weighted bid price of around 2.94 US cents/kWh and a revised capacity of 1 177 MW. Construction is expected to end in 2019. National media have announced further, albeit less-specific plans for new joint projects between ADWEC and partners from the private sector (WAM, 2018).



In September 2018, the emirate of **Sharjah** obtained a concessionary loan from the Abu Dhabi Fund for Development for the development of a waste-to-energy facility. The facility is part of Sharjah's zero-waste-to-landfill target and the UAE's objective of diverting 75% of its municipal solid waste from the landfill by 2021.

Rooftop and small-scale installations

Rooftop solar programmes remain a niche market in the GCC, with the UAE taking the lead through small-scale schemes to encourage rooftop applications. So far their scope has been limited, however.

Dubai in 2015 launched its Shams Dubai programme, which allows customers to use solar power to generate electricity for their own use, with any excess fed back into the grid. Slow to take off, the scheme has gathered steam recently through applications to government and commercial buildings. As of October 2018, 49.9 MW of solar PV rooftop projects had been installed under net metering in Dubai, and connection requests for another 323 MW of projects had been received (Bellini, 2018a). This is up from just 17.7 MW in 450 buildings in October 2017 (Bellini, 2017).

Abu Dhabi had been experimenting with rooftop solar even before Dubai started its net metering programme in 2015. Abu Dhabi's Masdar, for instance, had installed rooftop solar on 11 government buildings. In late 2017, Abu Dhabi started its own net metering policy, which is structured like the policy in Dubai (Graves, 2017a).

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2.2.2 Saudi Arabia

As in the UAE, the country's energy demand has been rising rapidly, with total final energy consumption increasing by more than 60% over the past ten years. The pace is expected to continue. Accounting for about half of the GCC's total final energy consumption, Saudi Arabia is the region's largest energy market. Although deployment of renewable energy has been limited, its potential far exceeds that of its neighbours owing to its market size. A steady, credible policy focus on renewables could turn Saudi Arabia into a major growth market for renewable energy.

Renewable energy plans and strategies

Saudi Arabia's renewable energy plans date back to the 2000s, when several institutions were founded to support the development of renewables. The initial target of 54 GW of renewable energy by 2030, later delayed to 2040, was eventually abandoned (IRENA, 2016a). The country's renewable capacity in 2017 was about 92 MW, mostly from solar PV projects (with some 2 MW of onshore wind), based on small-scale demonstrational projects, such as solar-powered buildings and parking lot installations.

Renewable energy resurfaced in the Kingdom's 2015/2016 economic reform drive, with new plans, targets and institutional reforms that have made renewables an integral part of a larger effort to prepare the Kingdom for a future beyond oil. The new National Renewable Energy Programme, launched in 2016, falls under the Kingdom's National Transformation Programme,[2] which is part of Saudi Arabia's broader economic development plan, Vision 2030. Launched in 2016, Vision 2030 aims to diversify the economy, making it less dependent on oil. It positions Saudi Arabia among the first Arab countries to give prominence to renewable energy. Renewable technologies are valued not only as a new fuel source for a rapidly growing power sector, but also as a new industry with the potential to create jobs and move the country into more service- and knowledge-based industries (Government of Saudi Arabia, 2018a).

The government indicated in 2016 that it seeks to attract between USD 30-50 billion of new investment in renewables in the period up to 2023, including from the private sector (Kerr, 2017). As part of Vision 2030, the National Renewable Energy Programme aims for 3.45 GW of installed renewable capacity by 2020 and 9.5 GW by 2023 (10% of power generation capacity). Overall, Saudi Arabia plans to produce 70% of its

Quick fact box: Saudi Arabia

Installed renewables-based capacity (2018):	142 MW
Share of renewables in total installed power generation capacity (2018):	0.2 %
Project pipeline as of November 2018:	700 MW wind and solar PV power by 2019/2020

2 *In September 2017, the government announced that the National Transformation Programme (NTP), which originally contained a set of several hundred specific goals, would be streamlined to focus on 36 most strategic targets and reissued at an unspecified date as NTP2.*

power from natural gas and 30% from renewables and other sources (mainly nuclear power) by 2030 (REPDO, 2018).

In March 2018, Saudi Arabia announced the construction of up to 200 GW of solar power generation capacity by 2030 together with the Japanese multinational conglomerate SoftBank (Cunningham and Nereim, 2018). In late 2018, reports surfaced indicating that the project was being shelved, though the Public Investment Fund (PIF), which had been involved in the initial (non-binding) agreement, has not confirmed this. The same year, a new city powered entirely by renewable energy was announced (Box 2.2) (Government of Saudi Arabia, 2018b).

The 2023 target of 9.5 GW is more modest than the earlier goal of 54 GW of zero-carbon technologies by 2040, but recent announcements, as well as the SoftBank deal reached in March 2018, suggest that Saudi Arabia's renewable energy capacity may well exceed the target by the early 2020s.

Regulatory framework and policy instruments

How to achieve the country's ambitious goals remains a challenge, as regulation dedicated to attracting investment in renewables remains in its infancy and the private sector presently plays only a small role in the energy sector. With the right policies, this could be reversed in the coming years, given the considerable capacity for policy development that exists within local institutions such as the King Abdullah Petroleum Studies and Research Centre (KAPSARC) among others.

From an institutional standpoint, Vision 2030's launch in 2016 was accompanied by intra-governmental restructuring, the closure of some subcommissions, streamlining of decision-making and personnel changes up to the ministerial level in several key ministries. Among the most important changes has been the combination of the previously separate ministries for oil and electricity under one Ministry for Energy, Industry and Mineral Resources that formally oversees the National Renewable Energy Programme. These changes raise hopes for a more dynamic

pursuit of the country's alternative energy plans over the period to 2020.

As for policy instruments to support deployment, the government has pushed ahead with ambitious plans for several rounds of auctions under the National Renewable Energy Programme, with a major role for solar power. The first round was launched in October 2017, with the issuance of tenders for two renewable energy projects, one solar and one wind. Both are located in the northern Al Jouf area, which boasts high resource potential for both types of technologies.

The 300 MW solar PV plant at Sakaka, which will be the country's first utility-size renewable energy plant, was awarded in February 2018 to ACWA Power. The project set a new world record with a bid of 2.34 cents/kWh (8.781 halalas/kWh). The USD 302 million facility, to be developed on the IPP model, is backed by a 25-year PPA with the Saudi Power Procurement Company, a subsidiary of the Saudi Electricity Company.

The new wind project will be the largest in the GCC. The 400 MW Dumat Al Jandal wind park is expected to be awarded and to reach financial close by the end of 2018.

Regarding small-scale decentralised renewables-based power generation, the Electricity and Cogeneration Regulatory Authority approved a net metering scheme for residential PV in 2017 under "Small-Scale Solar PV Systems Regulations" (Bellini, 2018b).

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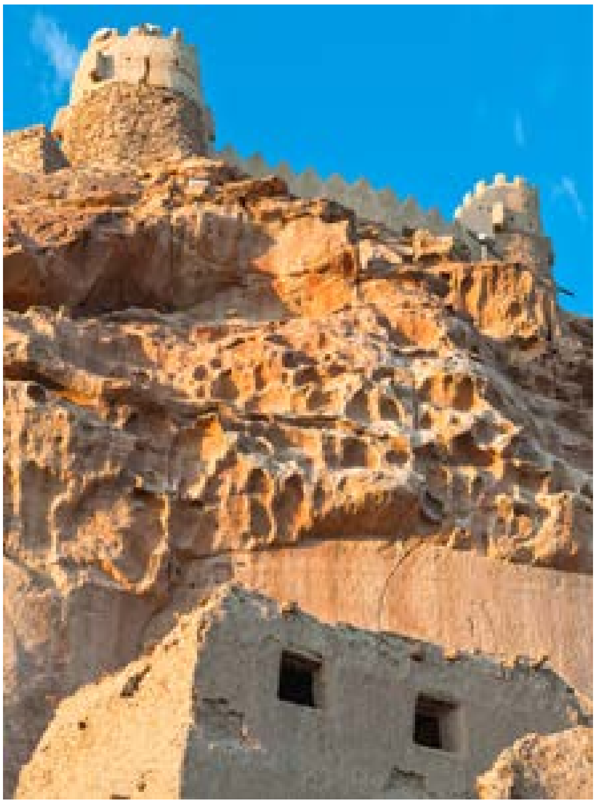
Box 2.2 Neom – Vision 2030's clean city project

Saudi Arabia's ambitious Vision 2030 calls for the development of a large new business zone near the Red Sea and the Gulf of Aqaba, in proximity to Egypt and Jordan. Plans for the new city, to be known as Neom, were announced by Saudi Crown Prince Mohammed bin Salman in October 2018 at the Future Investment Initiative conference in Riyadh.

Neom's designation as "the world's most ambitious project" (26 500 square kilometres) marks the city as a location for new businesses and industries and as a way to create jobs for young Saudis in energy and water, biotechnology, food, advanced manufacturing, and tourism. The zone is intended to be pollution free and to run entirely on renewable energy (Government of Saudi Arabia, 2018c). Neom's first section is to be completed as early as 2025. Its costs of about USD 500 billion will be financed both by public and private investors (Kalin *et al.*, 2017).



2.2.3 Kuwait

Kuwait is the GCC's third-largest market for electricity and boasts good solar resources. As in neighbouring countries, demand for primary energy and electricity has risen sharply, and domestic production of natural gas has not kept pace. From 2016 to 2017, the population grew by 2%, while energy demand increased by 3% (AUE, 2017).

Renewable energy plans and strategies

Kuwait's government intends to encourage the use of renewable energy to diversify the national energy mix, free up more oil and oil products for export, lower greenhouse gas emissions, and create new jobs and businesses. The use of renewable energy technologies could generate savings of up to USD 750 million through 2030 (Xinhua Net, 2018). Kuwait's *Vision 2035* and current *Five-Year Development Plan* focus on economic diversification and aim to position the country as a regional centre for trade and finance. The plan focuses on infrastructure investment, including transportation, a new port and the development of the "Silk City" business hub in Subiyah (IRENA, 2016a).

To this end, the government set a target of having renewable energy contribute 15% of the total energy mix by 2030 and 10% by 2020, from an installed capacity of 5.7 GW CSP, 4.6 GW solar PV, and 0.7 GW wind. Based on current plans, renewable sources will cover no more than 3% of total energy demand by 2020 (KUNA, 2018). The capacity operating presently consists of a handful of small but ultimately important demonstration projects, while several large-scale projects are under development or in the planning stages.

Kuwait has had several small- to mid-scale demonstration solar projects in recent years, with steady increases in size. One of the most important showcases has been Shagaya, developed by the Kuwait Institute for Scientific Research (KISR). Shagaya consists of 10 MW of solar PV capacity, 10 MW of wind, and 50 MW of CSP. All three components are now online and feed electricity into the grid. An engineering, procurement and construction contract in the amount of USD 385 million was signed in 2015 for the CSP component, which has ten hours of storage capacity and is managed by a consortium of the Spanish engineering company TSK and Kharafi National of Kuwait (HELIOSCSP, 2017a). Equipment is provided by Solar Frontier KK and Jinko Solar Co Ltd. According to information from KISR, prices for the solar tower technology have still not reached the competitive level of 10 US cents/kWh. However, world record-low bids for DEWA's 200 MW solar tower project in Dubai hint at further price reductions in the region over the coming years.

The largest solar project in Kuwait is the 1.5 GW Al Dibdibah Solar PV plant/Shagaya Phase II, owned by the Kuwait National Petroleum Company. With a construction cost of USD 1.2 billion, it is expected to begin operation by 2022 and to generate 15% of the oil sector's electricity needs.

Kuwait has started chemical EOR and is considering a 100 MW_{th} CSP installation at the Ratqa oilfield. The oilfield's owner, the Kuwait Oil Company, plans to use the CSP steam for EOR to reduce natural gas consumption (HELIOSCSP, 2017b).

Quick fact box: Kuwait

Installed renewables-based capacity (2018):	79 MW
Share of renewables in total installed power generation capacity (2018):	0.4 %
Project pipeline as of November 2018:	1 200 MW solar PV power (2022)

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2.2.4 Oman

Like its neighbours, Oman has experienced fast-rising demand for energy in recent decades. With smaller oil and gas reserves than other GCC members, the country's economy nonetheless remains dependent on the hydrocarbon sector, both for domestic energy supply and as a source of export revenue. Oman's geography and socio-economic context – including remote mountain settlements that only recently gained access to electricity and dwindling oil and gas reserves that may last only a few more decades (BP, 2018) – have enabled renewable energy to take hold in areas that have not yet been much explored in neighbouring countries. These include solar-powered EOR and small-scale, roof-mounted solar generation.

Renewable energy plans and strategies

The drive to adopt renewables originated in 2008, when a study commissioned by the Authority for Electricity Regulation (AER) concluded that Oman had one of the world's highest solar energy densities and excellent potential for renewable energy (AER, 2008). The Public Authority for Electricity and Water followed up with a feasibility study to prepare the ground for the country's first large-scale solar power project (Oman Power and Water Procurement Co., 2016).

Oman's National Energy Strategy to 2040 was released in 2015, supported by IRENA's Renewables Readiness Assessment (IRENA, 2014a). The strategy envisions that 10% of the national generation mix, or 2.6 GW, will be supplied from renewable energy sources by 2025, primarily from onshore wind and solar. Similar targets appear in Oman's Vision 2020 and the subsequent 5-Year Development Plan (2016–2020), released by the Supreme Council for Planning. Both call for increasing non-oil revenue through economic diversification, and a larger role for private business and human resource development. Industries targeted for expansion include fertiliser, petrochemicals, aluminium, power generation, water desalination and tourism, the latter having high relevance for job creation (EIA, 2017c).

Announced in December 2017, the 500 MW Ibri Solar Project will be the first utility-scale solar project, encouraged by the region's record-setting low bids

Quick fact box: Oman

Installed renewables-based capacity (2017):	8 MW
Share of renewables in total installed power generation capacity (2017):	0.1%
Project pipeline as of November 2018:	2.3-2.8 GW solar PV and wind power by 2023

for solar projects. To be funded on the IPP model, it had 12 bidders shortlisted at the time of writing (Bellini, 2018c). Petroleum Development Oman's 100 MW Al Amin solar PV plant was awarded in November 2018 to a consortium led by Marubini.

A 50 MW wind park at Harweel is set to be commissioned in 2020 (REVE, 2017). An extension, the 50 MW Dhofar I Wind Power Project, is expected to become the first large-scale wind farm in Oman, powering 16 000 homes in the Governorate of Dhofar and reducing CO_2 emissions by 110 000 tonnes yearly (Masdar, 2017). In an effort to further explore the potential for wind power, the Oman Power and Water Procurement Company (OPWP) is currently seeking support for a wind resources atlas (PAEW, 2018).

Policy instruments for small-scale installations

The Rural Areas Electricity Company (RAECO) is planning for renewable capacity of 90 MW by 2020 (Bellini, 2018d). Oman's 2 MW of installed capacity in 2016 were expanded to 8 MW a year later (IRENA, 2017a). The country's first commercial solar power project in Dhofar, with a 303 kilowatt (kW) capacity, has been in operation since 2015 (Times of Oman, 2015). RAECO signed a 20-year PPA for the plant, which is run by Bahwan Astonfield Solar Energy Company (Ventures Onsite, 2015). The 8 MW Muscat PV plant and the 60 kW Jacobs Qaboos rooftop PV plant began generating in early 2018.

In June 2017, the AER launched the Sahim initiative, the GCC's most sophisticated and ambitious solar rooftop programme. When Sahim was first conceived in 2008, promoting a solar rooftop programme in Oman was difficult in view of high technology prices and subsidised electricity tariffs. But PV installation costs have dropped sharply since then, while power subsidy costs have risen, from OMR 113 million (about USD 290 million) in 2006 to OMR 510 million (USD 1.32 billion) in 2016 (Al Ghaithi, 2017). In view of rising costs and consumption pressures, AER introduced a tariff reform in 2017, with cost-recovery tariffs applying to large consumers. The higher electricity tariff, coupled with the streamlining of approval and permitting processes for installation of solar rooftop PV, was expected to induce industrial and commercial customers to participate in Sahim (Al Ghaithi, 2018).

Uptake has been slow, however, with a total of 12 MW installed as of 2018 both on industrial and residential premises (Al Ghaithi, 2017). Sahim has yet to attract small-scale and residential customers, as they continue to enjoy subsidised tariffs. Eventually, AER plans that Sahim will supply 10% to 15% of residential customers' demand for electricity. If this plan is realised, it would further reduce the government's annual subsidy bill. A new small-scale, grid-connected system framework has helped Sahim gain momentum. The framework allows self-supply for PV installations on customers' premises, with a time-based bulk supply tariff and a feed-in of excess electricity at slightly elevated tariffs (Al Ghaithi, 2018).

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To bridge the cost difference between the subsidised grid tariff and the cost of solar PV, Sahim II, which took effect in 2018, allows distribution companies to aggregate residential rooftops and to auction their surface for solar PV development under an IPP model. First, AER identifies qualified residential buildings and invites qualified customers to join the pool, followed by a tender for private investors to install the agreed solar system on each building. In contrast to Sahim I, customers will no longer bear the costs of procuring, installing, operating and maintaining the systems (Al Ghaithi, 2018; Bellini, 2018d). Distribution companies, acting on behalf of the OPWP as the previous single buyer of electricity, purchase electricity generated from residential consumers' rooftop PV plants. A regulatory framework developed by AER sets minimum technical standards and a feed-in tariff for rooftop PV-generated power (Al Ghaithi, 2017).

With the planned residential PV programme in place, the regulator expects the following benefits:

- Prospective gas savings over 25 years of an estimated 2 billion standard cubic metres[3] or a financial value of between OMR 161.2 million and OMR 505 million (AER, 2017);
- CO_2 emission reductions of about 3.2 million tonnes over 25 years;
- Average reductions in yearly customer electricity bills of about 42%;
- A decrease in investment needs for electricity networks and generation capacity (Al Ghaithi, 2017).

Oman has also been promoting renewable energy to provide access to electricity in remote areas such as the Hajjar mountains in the North (REEGLE, 2012). The Omani government has also been examining the option of promoting rooftop schemes to electrify off-grid areas. Despite the existing solar rooftop initiative and a first feed-in tariff for consumers with existing grid access, processes are slowed down by administrative and policy barriers, particularly by high subsidies for gas-based electricity, and by a lack of monetary incentives for installation by private consumers (REEGLE, 2012). Further reform of utility prices, financial incentives and financing products dedicated to this small but important market, and targeted investor campaigns for the young but promising renewables sector, could boost the current level of activity.

In summer 2018, RAECO announced a new initiative that envisions the hybridisation of 11 existing small-scale diesel-powered plants in rural areas. The projects are to be developed and operated by the private sector as IPPs, to turn either to 100% renewables-based small-scale capacity or a combination of solar PV and conventional diesel power hybrids (Oman Daily Observer, 2018). These will be financed through a tendering process allowing for PPAs with independent power producers (RAECO, 2016).

Renewables in non-power applications

Solar EOR is one of the niche applications of solar power that may gain ground in coming decades as more reservoirs in the GCC mature and technology costs continue to decrease (Box 2.3). Having pioneered EOR in the Middle East, Oman is widely recognised as a global leader. Since 2007, the country has increased its oil production through steam injection and other advanced EOR solutions (AER, 2018). Some 107 MW_{th} of solar EOR are in operation at the Amal-West oil field as part of the Miraah solar thermal plant, owned by Petroleum Development Oman and being developed by GlassPoint Solar (GlassPoint, n.d.; Bigdeli, 2014). When complete, the plant will have a capacity of 1 GW peak thermal power in the form of 6 000 tonnes of solar steam each day. No electricity will be produced (EIA, 2017c). After the successful completion of the first four blocks (100 MW_{th}) of the solar EOR project, Petroleum Development Oman plans to add another four blocks by the beginning of 2019. It also intends to produce domestically the aluminium needed for the remaining 28 blocks, instead of importing it from China.

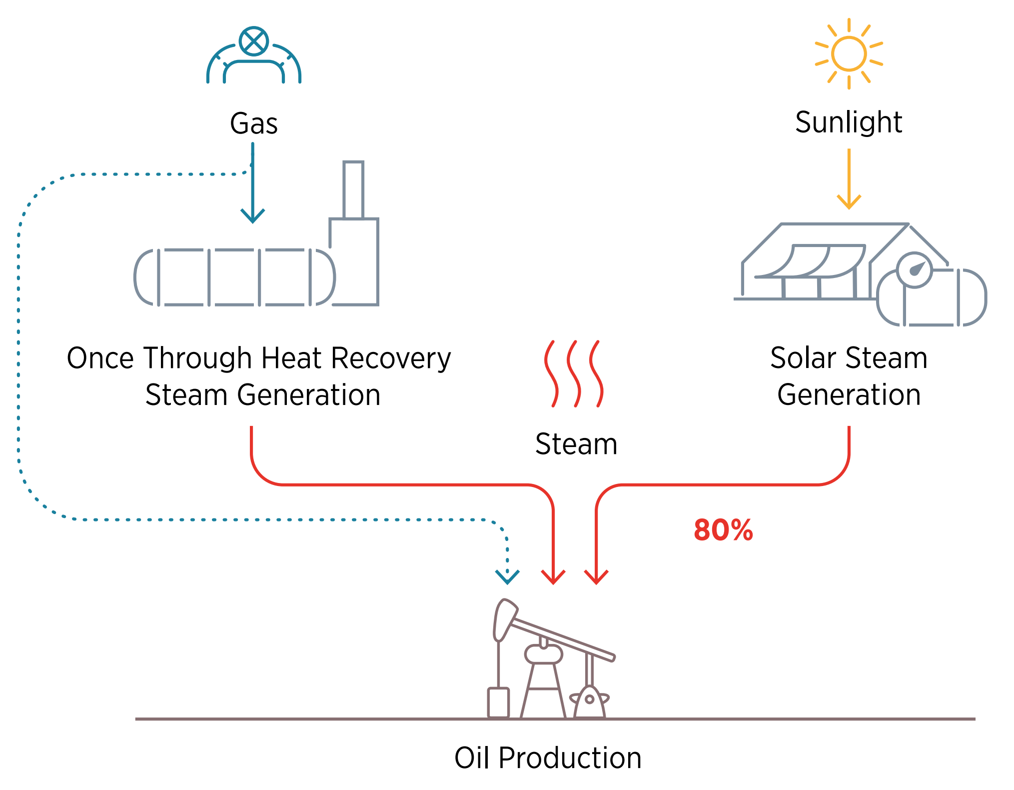
3 The volume of gases changes with temperature and pressure, a Standard cubic metre (Sm^3) is most commonly referred to as: Temperature: 20 °C, Pressure: 1.01325 barA, (for Sm^3 definition) (Oxywise, 2009).

Box 2.3 Solar enhanced oil recovery

Enhanced oil recovery (EOR) or "tertiary oil recovery" is the last stage in extracting crude oil from a reservoir. Primary oil recovery is limited to hydrocarbons that rise naturally to the surface, or those that use artificial lift devices, such as pump jacks. Secondary recovery employs water and gas injection, displacing oil and driving it to the surface. EOR entails changing the properties of the hydrocarbons to facilitate extraction (Rigzone, n.d.). The three major EOR techniques are thermal recovery (used chiefly for heavy oil), gas injection and chemical injection.

Solar energy can be used to generate steam for injection into oil wells as part of thermal EOR. Several solar-powered technologies can be used to do this, but as yet only "central tower" and "enclosed trough" technologies have been used.

Both of the renewables-based EOR projects in the GCC (7 MW_{th} pilot and 1 GW_{th} project) are being carried out in Oman by GlassPoint and Petroleum Development Oman. They use troughs enclosed in glass houses to keep out wind and sand. Steam produced by the solar field is mixed with steam produced from natural gas and injected into the oil well to enhance production.



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2.2.5 Qatar

Qatar has frequently acknowledged the need to use energy and other natural resources in a more sustainable way. The country's energy policy has long focused on natural gas as a replacement for oil in power generation and industry. This was for sound reasons of economics, as the country's dwindling oil reserves were seen early on to be most valuable when exported abroad.

Renewable energy plans and strategies

Qatar's National Vision 2030 strives to create a balance between an oil-based and a knowledge-based economy, with the ultimate aim of diversifying the economy (MDPS, 2008). Qatar's Second National Development Strategy 2018–2022 sets out a plan of natural resource management that calls for an increase in renewable energy use. Specifically, the strategy aims for 200–500 MW of solar-powered generating capacity by 2020 (MDPS, 2018). This target presumably replaces the previous target of 1 800 MW by the same year, as reported in 2012 (Ayre, 2012). In 2017, the Ministry of Energy and Industry announced a long-term target of 10 GW of solar power by 2030 (The Peninsula, 2017), but this has not been translated into legislation.

Qatar had also previously announced plans to use solar power to cool the 2022 FIFA World Cup stadiums. The project, announced by Kahramaa (Qatar General Electricity and Water Corporation) was estimated to have a capacity of 3 500 MW (Kelly, 2015). In November 2018, it was announced that the World Cup would be taking place in the winter months of November and December of 2022, significantly reducing the tournament's cooling needs (Skysports, 2018).

Regulatory framework and policy instruments

To date, Qatar has made slow progress in deploying renewable energy with the notable exception of municipal waste. Qatar's first, commercial PV project is run by the Qatar Foundation, which uses 3 MW of PV capacity to power its campus (Qatar Foundation, 2014). Biogas and municipal waste account for about 38 MW of power generation capacity in 2017. Qatar is home to the largest waste-to-energy facility in the GCC region, the 30 MW Mesaieed plant, which also generates 8 MW of biogas-based power.

On multiple occasions, Qatar has expressed its intention to hold auctions for solar power projects (Ayre, 2015). At the end of 2018, Kahramaa initiated the prequalification of bidders for a 500 MW solar tender (Tsanova, 2018). The project is set to be built near Al Kharasaa, with an expected commercial operation date of December 2020. Pre-qualified bidders have already been confirmed. The project could potentially

Quick fact box: Qatar

Installed renewables-based capacity (2017):	43 MW
Share of renewables in total installed power generation capacity (2017):	0.4%
Project pipeline as of November 2018:	350 MW solar PV power by 2020, with a total of 700 MW by the early 2020s

be linked to Siraj Power, a USD 500 million joint venture of Kahramaa and Qatar Petroleum. The joint venture company may be involved in overseeing development, but details are not yet known.

The 10 MW Al Duhail Solar PV Park was reported in 2016 to have the potential to expand from its pilot stage to 210 MW (Industrial Info Resources, 2016). No recent activity has been reported for the project, however. Among various isolated applications of roof-mounted PV solar panels, a 0.7 MW solar PV array was installed at the Qatar National Convention Centre (Alhaj, 2017).

2.2.6 Bahrain

Bahrain is the smallest oil producer in the GCC (EIA, 2016b). The country is a minor producer of crude oil, refined oil products and natural gas. The energy sector is almost completely dependent on fossil fuel. Against this background, the government sees the need to diversify energy supply and reduce demand for cooling (University of Bahrain, 2018).

Bahrain has an installed generating capacity of nearly 4 GW, of which just 6 MW stems from renewable sources (5 MW of solar PV and 1 MW of wind). Rapid population growth and industrial development are the main drivers of the increase in power demand, and Bahrain has addressed these needs by expanding existing conventional power plants to supply residential and industrial end users, such as Aluminium Bahrain (Alba). To meet rising gas demand in excess of its domestic output, Bahrain plans import LNG, starting from early 2019 (The Maritime Standard, 2018).

Renewable energy plans and strategies

To diversify the Kingdom's energy supply, the cabinet adopted the National Renewable Energy Action Plan (NREAP) and the National Energy Efficiency Action Plan (NEEAP) in early 2017. The NREAP highlights feasible renewable energy options for the country, and proposes targets, policies and initiatives for implementation. It sets a national renewable energy target of 5% by 2025 and 10% by 2035. The envisioned renewable energy mix comprises solar, wind and waste-to-energy technologies. The NEEAP sets a national energy efficiency target of 6% by 2025. It aims for efficiency improvements in both energy supply and demand through 22 initiatives across all economic sectors (SEU, 2017).

Both reflect Bahrain's ambition to achieve the sustainable energy transition presented in its Economic Vision 2030 and to meet the country's commitments under the Paris Agreement, the Sustainable Development Goals, and the Renewable Energy Framework of the League of Arab States (SEU, 2017).

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Quick fact box: Bahrain

Installed renewables-based capacity (2017):	6 MW
Share of renewables in total installed power generation capacity (2017):	0.1%
Project pipeline as of November 2018:	100 MW solar PV power by 2019

Regulatory framework and policy instruments

The Bahrain Petroleum Company (BAPCO) is developing the 100 MW Bahrain PV Park, expected to be commissioned in 2019 (BNEF, 2018a). The USD 360 million project, part of NREAP and NEEAP, will be a public-private partnership formed through competitive bidding. The larger Bahrain PV Park 1 (200 MW) was announced by the Bahrain Electricity and Water Authority (EWA) in 2017 (BNEF, 2018a). Its cost is USD 720 million.

In early 2018, EWA announced a USD 17.18 million (BHD 6.5 million) investment to construct and develop the Al Dur PV Plant and the Al Dur Wind Farm, with installed capacities of 3 MW and 2 MW, respectively (BNEF, 2018a; Global Data, 2018a). BAPCO will further provide USD 25 million in funding toward a 5 MW distributed power plant to supply electricity to the BAPCO township of Awali, the University of Bahrain, and other locations (Solar GCC Alliance, n.d.). Announced in 2014, construction was still pending in 2018.

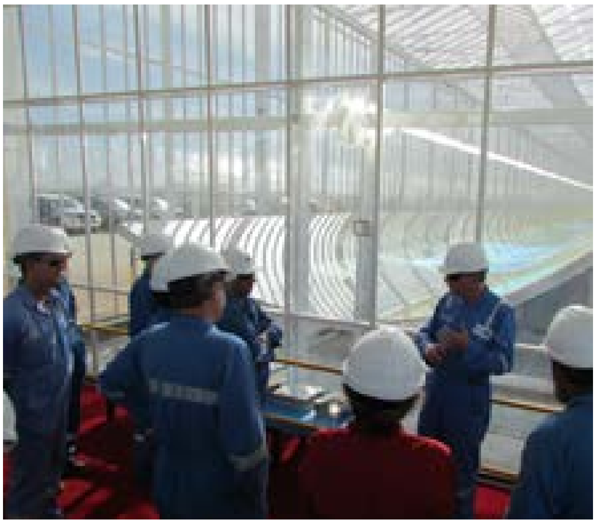
Beyond solar and wind, the Bahrain Waste-to-Energy Project (54 MW) started construction in 2018 as an integrated solid waste management and desalination plant. A 24 MW share is planned for self-consumption, with the remaining 30 MW to be fed into the grid. An additional 30 MW waste-to-energy project at Askar was announced in 2018 (Global Data, 2018b).

Despite the existing measures, the country does not yet have an overall energy strategy in place, nor does it provide incentives geared to attract private sector investments in renewables and energy efficiency (Oxford Business Group, n.d.).

2.3 THE INSTITUTIONAL LANDSCAPE

The institutional landscape for renewable energy deployment in the GCC is in flux. Ongoing changes to institutional mandates reflect the historical focus of the region's energy sector on fossil fuels, with planning capacity in the area of domestic energy divided between ministries (and planning authorities) responsible for oil, energy, and, in some cases, electricity. In the UAE, planning responsibility is further divided between the national and the emirate levels.

The accelerated deployment of renewable energy could benefit from institutional reform, clear mandates and dedicated planning capacity for the entire energy sector, as well as from incentives to attract private investment. This section reviews some of the most important elements of the institutional landscape in the GCC with relevance for renewable energy.



2.3.1 United Arab Emirates

Renewable energy deployment has been taken up by both existing and new energy sector institutions in the UAE (Figure 2.7). Overarching (and cross-emirate) guidance on renewable energy is provided by the Ministry of Energy and Industry (MOEI) and the Ministry of Climate Change and Environment (MOCCAE). Research institutions have contributed to advances in regulation and policy-making, innovation, and regional and international cooperation.

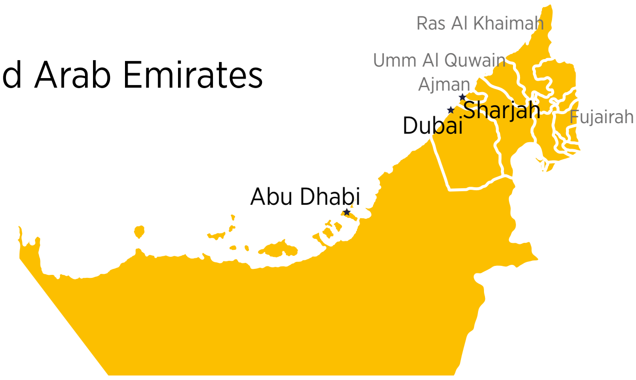
The MOEI is tasked with developing policy and draft legislation for the sector, including energy, water and mineral resources (hydrocarbons). It is also contributing to the development and implementation of regulations related to energy and water conservation and renewable energy deployment, including the UAE National Energy Strategy 2050. The MOCCAE is primarily responsible for international and domestic climate change affairs, environment, green development, air quality management, waste management, agriculture, fisheries, livestock and biodiversity. It is tasked with implementing the UAE Green Agenda 2030 (green growth strategy) and the UAE National Climate Change Plan.

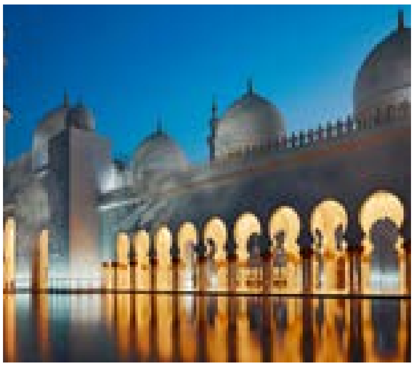
The development of specific regulations and policy mechanisms are generally handled by the governments of each emirate. Details for Abu Dhabi and Dubai follow. The other five emirates (Sharjah, Ajman, Ras Al Khaimah, Fujairah, and Umm Al Quwain) have not announced targets for renewable energy development. Their electricity and water authorities are responsible for the entire energy sector; none of the five emirates has a separate energy regulator.

02

Figure 2.7 Institutional structure of decision-making in energy and electricity in the United Arab Emirates

United Arab Emirates





Federal-level institutions

The **Ministry of Energy and Industry (MOEI)** develops and implements general policies and legislation for the energy sector, including energy and water conservation and renewable energy deployment.

The Ministry stands behind the *UAE National Energy Plan 2050*, the UAE's first federal energy sector strategy.

The **Ministry of Climate Change and Environment (MOCCAE)** is primarily responsible for international and domestic climate change affairs, environment, green development, air quality management, waste management, agriculture, fisheries, livestock and biodiversity.

The Ministry is charged with the implementation of the UAE Green Agenda 2030 (green growth strategy) and the *UAE National Climate Change Plan*.

Emirate-level institutions

Abu Dhabi

The **Department of Energy (DoE-AD)** develops and implements policies and legislation for the energy sector, including energy and water conservation and renewables deployment. It acts as a regulator for the power sector through its Regulation & Supervision Bureau.

The **Abu Dhabi Power Corporation** oversees the financial and operational performance of various entities involved in distribution, transmission and generation.

The **Emirates Water and Electricity Company (EWEC)** is responsible for water production and power generation in Abu Dhabi and the Northern Emirates. As a single buyer of power and water, it conducts auctions and buys renewable energy power from IPPs.

Dubai

The **Dubai Electricity and Water Authority (DEWA)** develops strategies, devises policies, conducts auctions, buys renewable energy power from IPPs and implements net-metering

The **Dubai Supreme Council of Energy (DSCE)** provides overall guidance and is charged with the development of overarching strategies for renewable energy and energy efficiency

Sharjah

The **Sharjah Electricity and Water Authority** (SEWA) is responsible for electricity, water and gas in Sharjah.

Northern Emirates

Federal Electricity and Water Authority (FEWA) is responsible for electricity and water in the Emirates of Ajman, Ras Al Khaimah, Fujairah and Umm Al Quwain. It is set to join the newly-formed EWEC (as of Dec 2018).

Abu Dhabi. Abu Dhabi's newly formed Department of Energy (DOE) is broadly responsible for the emirate's energy sector, consolidating roles and functions previously held by ADWEA and its subsidiaries. The DOE also oversees the development of renewable energy policy mechanisms such as auctions and net-metering. After the consolidation of ADWEA into the newly formed DOE, some subsidiaries of ADWEA such as the Regulation and Supervision Bureau (RSB) are now part of DOE (Reuters, 2018).

The Abu Dhabi Power Corporation was formed in 2018 to guide the development of the power and water sector in the Emirate by overseeing the financial and operational performance of its various subsidiaries including the Emirates Water and Electricity Company (EWEC), the Abu Dhabi Transmission and Dispatch Company (TRANSCO), and the distribution companies for Al-Ain and Abu Dhabi (Eye of Riyadh, 2018).

The newly formed EWEC is responsible for water production and power generation in Abu Dhabi and the northern emirates (Ras al Khaimah, Fujairah, Umm al Quwain and Ajman), thus combining the functionalities previously held by Abu Dhabi Water and Electricity Company (ADWEC) and Federal Electricity & Water Authority (FEWA) (Gulf News, 2018).

Previously, ADWEC managed auctions and held a 60% share in the resulting projects, under which IPPs entered into agreements of 20-25 years' duration with ADWEC, the sole buyer of their products.

The RSB, which is now a part of the DOE, regulates the power sector, as well as independent water and power projects (IWPPs). The RSB has facilitated the grid integration of landmark projects such as the 100 MW Shams 1 CSP plant and the 10 MW Masdar City Solar PV plant.

Small-scale solar implicates a slightly different set of public institutions. The RSB is charged with the development of standards and regulations for small-scale grid-connected solar. In this role, it issued the regulation for net metering in Abu Dhabi (Graves, 2017a). The Abu Dhabi Distribution Company is implementing the regulation (ADDC, n.d.).

Dubai. Although the Dubai Supreme Council of Energy holds ultimate responsibility for renewable energy in the Emirate, DEWA is in charge of implementation of policies. It plays multiple roles in the deployment of renewable energy. Among those roles are developing strategies, devising policies, conducting auctions, buying renewable energy power from IPPs and implementing net metering. Large-scale projects in Dubai follow an IPP approach in which DEWA holds a 51% share, with the project developer holding 49%.

DEWA was central to the successful implementation of the Mohammed bin Rashid Al Maktoum Solar Park. It is also responsible for managing the integration of small-scale grid-connected solar under the net metering plan. The rules and regulations for net metering are set by Dubai RSB.

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Education and research. Within the GCC, the UAE has been a locus of clean energy R&D. Masdar was established in 2006 as a subsidiary of the Mubadala Development Company, a state-owned investment firm. Its mission is to promote the clean energy industry and sustainable technologies through education, R&D, investment and commercialisation. Over the years, Masdar has gradually become more prominent as a project developer in the UAE and around the world, of solar PV, CSP and wind energy projects in its portfolio. In addition, Masdar has contributed to research. The Masdar Institute of Science and Technology, now under the Khalifa University umbrella, is a graduate level, research-oriented institute focused on alternative energy and sustainability. The Masdar City Free Zone offers business opportunities and investments in the UAE and is focused on clean energy solutions. Masdar City, founded in 2008, combines traditional Arabic architectural techniques with modern technology to capture prevailing winds and remain cool and comfortable in high summer temperatures. Renewable energy R&D is also being carried out in other universities in the UAE.

By 2020, DEWA plans to establish an R&D centre focusing on four key areas (DEWA, 2018): producing electricity from solar power, integrated smart grids, energy efficiency and water. An innovation centre equipped with the latest clean and renewable energy technologies will serve as a museum and exhibition for solar energy. The Ras Al Khaimah Research and Innovation Centre (RAK-RIC) is also conducting tests and studies of solar power, renewable desalination and efficient air conditioning.

Finally, the Sheikh Mohammed bin Rashid Al Maktoum Solar Park features two solar-testing facilities: the first specialises in testing solar PV panels; the second focuses on CSP. The facility is currently testing 30 PV panel types from global specialist manufacturers (DEWA, 2018).

2.3.2 Saudi Arabia

The governance of Saudi Arabia's energy sector and pursuit of the renewable energy targets are the charges of the Ministry for Energy, Industry and Mineral Resources (MEIM), created in 2016 to combine decision-making in energy, utility and industry development. The Ministry works with organisations involved in projects in the field of renewables and energy efficiency. These include the King Abdullah City for Atomic and Renewable Energy (K.A.CARE), King Abdullah City for Science and Technology, Saudi Aramco, the Saudi Electricity Company (SEC), and the Electricity and Cogeneration Regulatory Authority (ECRA). The roles of these institutions are summarised in Figure 2.8.

MEIM created the Renewable Energy Project Development Office (REPDO) in early 2017 as a one-stop shop for the government and project developers. The office reports to a committee chaired by the Minister which brings together stakeholders involved in energy research, measurement, data acquisition, regulation and predevelopment. Those stakeholders include KACARE, ECRA, Saudi Aramco and SEC.

SEC holds the national monopoly on generation, transmission and distribution of electricity except on the premises of Saudi Aramco and Saudi Basic Industrial Corporation (SABIC). The company was formed in 2000, merging three existing regional electricity companies in the central, eastern, western and southern regions into a single joint stock company.

Figure 2.8 Institutional structure of decision-making in energy and electricity in Saudi Arabia

Research

King Abdullah City for Science and Technology (KACST)
Established in the 1970s as a scientific government institution that supports and enhances scientific applied research

King Fahd University of Petroleum and Minerals (KFUPM)

King Abdullah University of Science and Technology (KAUST)

King Saud University (KSU)

King Abdulaziz University (KAU)

King Abdullah Petroleum Studies and Research Center (KAPSARC)

Energy Sector Governance

The Ministry of Energy, Industry and Mineral Resources (MEIM)
Created in 2016 to combine the previously separate portfolios of the Ministries of Oil, Electricity, and Industry, with the overarching mandate of energy sector governance

Renewable Energy Project Development Office (REPDO)
Created in 2017 as a one-stop shop for the government and project developers and to oversee the country's renewable energy programme.

King Abdullah City for Atomic and Renewable Energy (KACARE)
Created 2010 with the mandate to help develop substantial alternative energy capacity to support local industries

Saudi Energy Efficiency Center (SEEC)
Established 2010 in order to contribute to the government's efforts to rationalise national energy demand

Electricity

Electricity and Cogeneration Regulatory Authority (ECRA)
Established in 2001 to regulate and monitor the electricity and water desalination industry in Saudi Arabia, and to develop laws for the utility sector.

Saudi Electricity Co. (SEC)
Since 2000 the national monopoly holder on generation, transmission and distribution of electrical power in Saudi Arabia outside Saudi Aramco and SABIC-owned premises

Energy Industry

Saudi Aramco
The national oil company, in the past tasked also with the development of renewable energy.

The private sector

ECRA had announced plans to break up SEC by the end of 2016, but this was not done; current plans are to privatise SEC in the near future (MEES, 2017).

ECRA was established in 2001 to regulate the Kingdom's electricity and water desalination industries. It monitors utilities, prepares legislation, and has been involved in planning sectoral reform, including the likely opening of the Saudi utility market to private enterprise.

02

Education and research. Saudi Arabia has dedicated research institutions to support the country's diversified energy future. In addition to the King Abdullah Petroleum Studies and Research Center (KAPSARC), created in 2010, players include the King Abdullah University of Science and Technology (KAUST), King Fahd University of Petroleum and Minerals (KFUPM), King Faisal University (KFU) and King Abdulaziz University (KAU) (Figure 2.8).

KACARE was established in 2010 with the aim of developing a substantial alternative energy capacity supported by local industries. The organisation has been engaged in research and policy advice both in the areas of renewable energy and nuclear power, and is associated with previous Saudi targets for renewable energy that were subsumed under current plans in 2016.

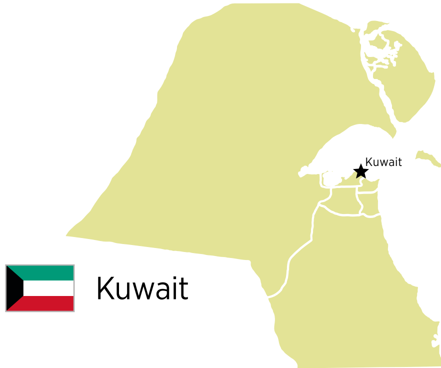
KAPSARC, like KACARE, was established in 2010, with the aim of becoming a world-class dedicated research institution focusing on energy. KAPSARC is funded by a state endowment, which is meant to make the organisation independent. Its international research team works on energy markets and economics, energy efficiency and productivity, energy and environmental technologies, and carbon management.

The King Abdulaziz City for Science and Technology (KACST) is a public scientific institution that supports and enhances applied research. Established in the 1970s, it has research capacity in the areas of energy, water, building, transport and logistics. Other focal points are renewable-energy-based power generation, storage and optimal utilisation; energy solutions for remote areas; power conversion and control systems; and smart electrical networks and automotive technology.

2.3.3 Kuwait

Kuwait's energy sector is governed by three core government institutions. The Supreme Petroleum Council (SPC) oversees Kuwait's hydrocarbon sector policy. It is supported in this mission by the Ministry of Oil (MOO). The electricity sector is governed by the Ministry for Electricity and Water, which also owns and operates Kuwait's electric power system. The ministry not only acts as the regulator of the electricity market, but is also in charge of generation, grid operation, transmission, distribution and, broadly, retailing. A notable exception is the Az-Zour North power plant, which is operated by an IPP. The ministry sets up new tenders and explores new energy sources and generation technologies.

Recent years have seen some disruption of vertical market integration and the creation of more opportunities for IPPs and IWPPs operating under public-private partnerships. The Kuwait Authority for Partnership Projects and the ministry have invited local and international companies to invest in power generation and water production in the country (The Az-Zour Power plant is an outcome of a PPP). Kuwait first integrated the private sector into the development of its power market in 2011, later than other GCC countries (BNEF, 2018b).



Education and research. Kuwait is a pioneer in researching the use of renewables in the GCC (El-Katiri and Hussain, 2014). Founded in 1967, KISR is an independent national institute that conducts scientific research and provides consulting services within Kuwait, the region and internationally. Its focus areas are environmental conservation and sustainable resource management, including innovative agricultural methods, water and energy (KISR, 2018). Today, KISR is developing several renewable energy projects, including Kuwait's flagship solar PV, CSP and wind power project, Shagaya Phase I.

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2.3.4 Oman

Oman's energy policy is driven by a number of different institutions. Two ministries hold portfolios for the energy sector: the Ministry of Oil and Gas, as the governing body of the country's fossil fuel sector; and the Ministry of Environment and Climate Affairs. The electricity sector is governed by the Public Authority for Electricity and Water (PAEW), the planning body for power supplies in the country; and the Authority for Electricity Regulation (AER). AER is in charge of regulating electricity and associated water functions, overseeing the implementation of state policies, licensing and compliance, while also coordinating sectoral stakeholders, including ministries. The Council of Ministers has highest-level authority over decision-making, including key issues such as utility tariffing.

The Omani power system is composed of three domestic grids that are not yet fully integrated:

- the Main Interconnected System (MIS) for the northern part of Oman;
- the Rural System of the Rural Areas Electricity Company (RAEC); and
- the Dhofar Power System (DPS).

RAECO, created in 2005, supplies electricity to customers across the Sultanate, predominantly in rural areas. Under license from the AER, the company is responsible for electricity generation, transmission, distribution and supply, as well as desalination.

Oman's electricity sector is unique within the GCC context in its comparably extensive unbundling that reaches back to the 2000s. More than a dozen power companies produce electricity in Oman, in addition to an increasing number of IPPs and IWPs. The Oman Power and Water Procurement Company is the single buyer of electricity and water for all IPP and IWPP projects in Oman. It also undertakes long-term generation planning for the sector. Every seven years, it announces new projects to be tendered and constructed by private IPPs. Electricity transmission has been separated from generation and distribution, and is currently managed by Oman Electricity Transmission Company. End-users are served by a number of distribution companies (Oman Electricity Transmission Company, 2018).

2.3.5 Qatar

Qatar has yet to establish a dedicated agency to pursue its renewable energy targets. Key institutions that have so far played a role in Qatar's renewable energy environment include the Ministry of Energy and Industry, Kahramaa, and the Qatar National Research Fund. The latter is a member of the Qatar Foundation, and provides funds for research on a variety of subjects including renewable energy. In 2013 Kahramaa announced a USD 125 billion investment programme for alternative and renewable energy, USD 22 billion of which is set aside for electricity and water infrastructure.

Education and research. The Qatar Environment and Energy Research Institute conducts multidisciplinary research, developing new knowledge-based solutions to enhance sustainable development, capacity building and networking. It has a solar energy research program as well as a water desalination program. The Qatar National Food Security Program (QNFSP) aims to improve food security, also through the use of renewable energy and carbon reduction schemes, as

well as the use of renewables for water desalination. It coordinates activities on energy and water security, as well as food security, across sectors.

Through the Qatar Science and Technology Park (QSTP), the QNFSP aims to become a leading exporter of solar technology and knowledge in the region and internationally by establishing a solar technology industry. The QSTP has been working closely with Qatar Solar Technologies, a joint venture with SolarWorld AG, one of the largest solar companies. It is also developing a testing facility for solar technologies. An important goal is to test the suitability of technologies under local conditions (*e.g.*, dust and wind).

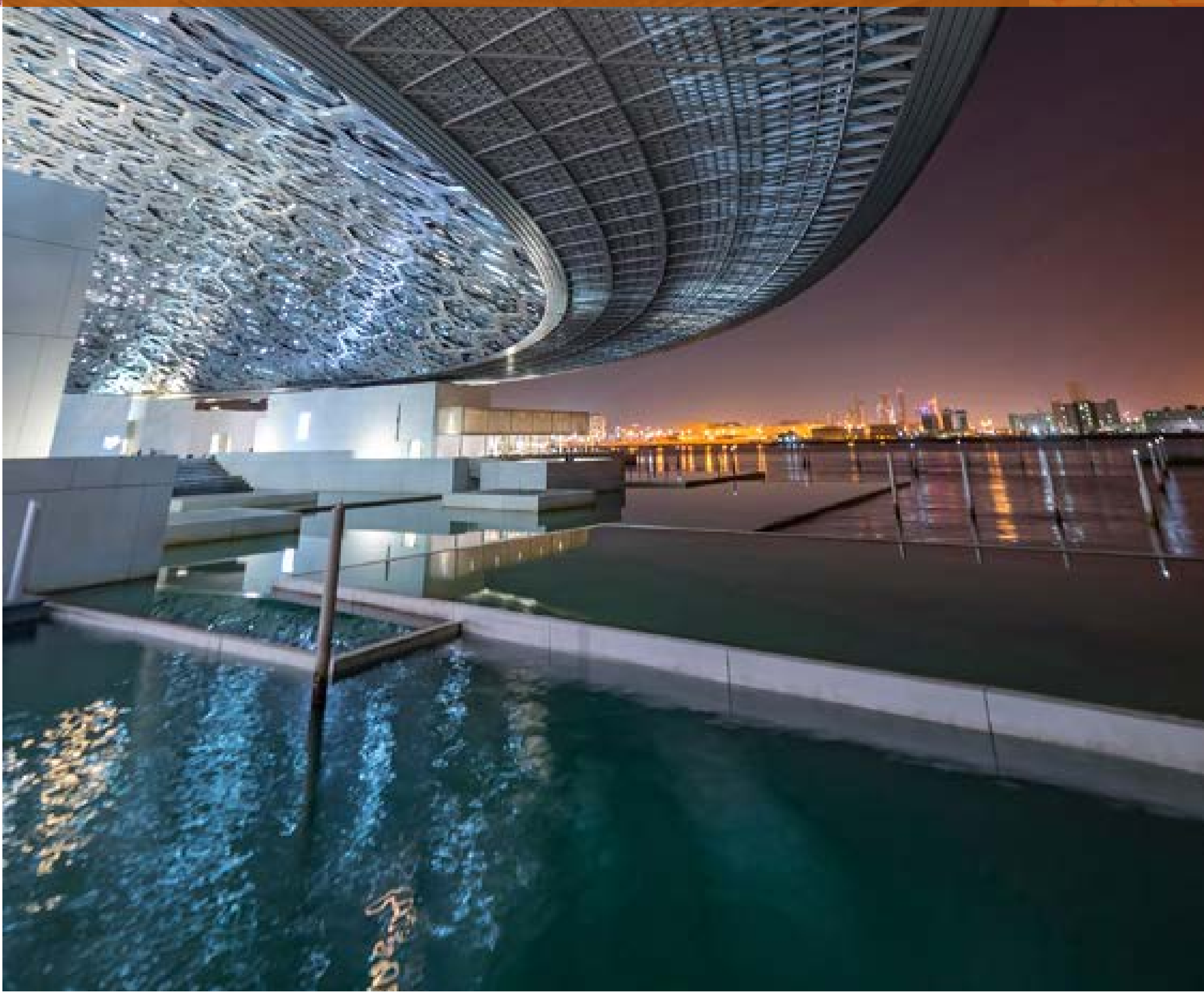
Plans have been laid to keep up with developments in the sector by establishing new institutes of higher education and R&D centres. The QNFSP intends to develop projects under the Clean Development Mechanism in the areas of solar power generation, solar desalination, wind power generation, waste heat recovery and CO_2 usage in farming and food production. Other activities are being developed at the QSTP, including the construction of a testing facility of about 35,000 m^2 for all types of solar technology.

2.3.6 Bahrain

Bahrain's energy sector features several key players with relevance to renewable energy. The Electricity and Water Authority (EWA) governs the utility sector and owns infrastructure for electricity generation and transmission, water transmission, distribution, electric services, and customer services. Customers include residential, industrial and commercial end-users. EWA runs power generation facilities across Hidd, Sitra, Rifa'a, Aluminium Bahrain (Alba) and Al Ezzel. Its water production plants are Hidd Station, Sitra Station, Ras Abu Jarjur Station, Ad Dur Station and Alba Station (Global Data, 2018c).

At inter-ministerial level, the Supreme Committee for Natural Resources and Economic Security advises additional sector-relevant policy-decisions. Some of Bahrain's energy policy initiatives were initiated elsewhere; for instance, national action plans for renewable energy (NREAP) and energy efficiency (NEEAP) were prepared by the Sustainable Energy Unit, a joint initiative between the Office of the Minister of Electricity and Water Affairs and the United Nations Development Program (UNDP) (SEU, 2018). The Bahrain Solar Industry Association, planned since 2015 as an affiliate of the Solar GCC Alliance, will be tasked with developing solar energy opportunities across Bahrain and with facilitating collaboration across the GCC region.

RENEWABLE ENERGY INVESTMENT AND COSTS



03

The potential of renewable energy in the GCC has long been recognised. The early investments of both public and private stakeholders attest to this. Thanks to a number of recent advancements – including well-designed auctions, favourable financing conditions and declining technology costs – investments are set to increase. This chapter provides an overview of renewable energy investments in the GCC. It discusses the decreasing costs of renewable energy in the region, highlighting the key determinants.

3.1 RENEWABLE ENERGY INVESTMENT

The rapidly growing investments in renewable energy in the GCC may be divided into two broad categories: investments in (1) renewable energy projects, and (2) the renewable energy value chain.

3.1.1 Investment in renewable energy projects

The investment pattern observed in the GCC countries reflects their status as relatively new markets for renewable energy. A considerable share of investment is driven by individual, large projects, implying considerable year-on-year fluctuations in investment volumes. So far, investments are concentrated in the UAE. As deployment picks up, annual investment flows will likely become more consistent, and increase across all countries.

Investment trends in renewable energy projects in the GCC between 2006 and 2018 are shown in Figure 3.1. Investments spiked in 2011 with USD 765 million invested in the UAE's 100 MW Shams 1 CSP plant, which became operational in 2013. Investment activity dropped in 2012. As a result of increasing government interest and falling technology costs, investment in new projects rose in 2015, and included USD 326 million in the UAE's 200 MW Mohammed bin Rashid Al Maktoum Solar Park Phase II, USD 400 million in the Shagaya project in Kuwait and USD 600 million in Oman's 1 GW_{th} Miraah Solar EOR project.

After a lean year in 2016, investments again picked up in 2017, mainly in three large-scale solar projects in the UAE. In Dubai's Mohammed Bin Rashid Al Maktoum solar Park, the 800 MW solar PV Phase III and the 700 MW CSP Phase IV received investments of USD 940 million and USD 3 870 million, respectively.[1] In Abu Dhabi, about USD 870 million was invested in the 1 177 MW Noor Abu Dhabi solar PV plant in Sweihan.

1 *Sources such as ACWA Power (2018a) indicate that financing of USD 1 500 million (out of a total of USD 3 870 million) for the Phase IV was secured in 2018.*

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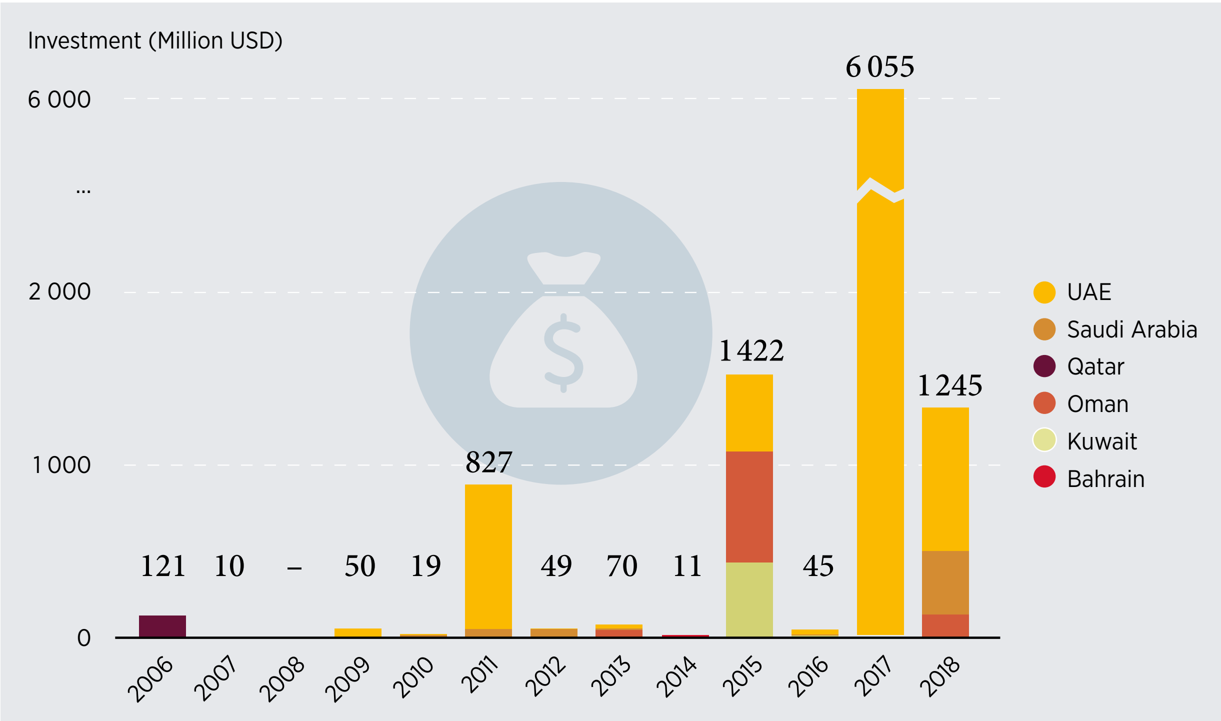
While data on investment in small-scale solar projects in 2017 are not available, IRENA's conservative estimates are USD 40 million in the UAE, USD 30 million in Saudi Arabia and USD 12 million in Oman.

The investment data available for 2018 (Figure 3.1) include an additional USD 490 million for Phase IV of the Mohammed Bin Rashid Al Maktoum Solar Park, as the 700 MW CSP project was amended to add 250 MW solar PV, thus raising the project's total cost to USD 4 360 million. They also include an estimated USD 320 million for a 300 MW Sakaka solar PV project in Saudi Arabia, USD 125 million in the 50 MW Harweel wind project in Oman and USD 225 million in a 27 MW waste-to-energy plant in Sharjah, UAE (Masdar, 2018a).

So far, the UAE has received the lion's share of investment in the region and the country is expected to retain its leadership through the expected deployment of 44 GW of renewable capacity by 2050 (WAM, 2018). Investments are likely to step up in Saudi Arabia, as REPDO's renewable energy auctions get underway. Investments in Bahrain, Kuwait, Oman and Qatar are also set to pick up as these countries embark on their renewable energy plans. Further details on investments in large-scale renewable energy projects and their financing can be found in section 3.4.

Investment in regional projects is set to be the key component of renewable-energy related investments by entities based in GCC. That said, during the last decade these entities have focussed on other opportunities such as investments in projects outside the region (Box 3.1) and investments in segments of the renewable energy value chain.

Figure 3.1 Investment in renewable energy projects in the GCC, 2006-2018



Source: Based on BNEF, 2018a.

Notes: Investments are recorded in the year when financial closure is reached, though actual investment may occur over several years. The figure includes direct investments in GCC renewable energy projects (both equity and debt). It does not include the following indirect forms of investments: 1) by GCC-based public and private entities in non-GCC renewable energy projects, 2) in R&D initiatives, 3) in manufacturing companies, 4) in project development companies or 5) in other renewable energy assets.

Box 3.1 Investment by GCC entities in renewable energy projects outside the region

Wind and solar photovoltaic (PV) projects have been profitable investment opportunities in many markets around the world for the past decade. The long-term and stable cash flows provided by renewable energy projects match the long-term return horizons of some investors such as institutional investors – sovereign wealth funds, pension plans and insurance companies (IRENA, draft report-a). Investors based in the GCC region have been keen to invest in industries that show prospects for long-term development.

These direct investments in projects outside the region (Table 3.1) have primarily been initiated by public-sector-backed entities, which are often sovereign wealth funds. Masdar, a UAE-based developer, which holds stakes in many renewable energy projects around the world, is wholly owned by UAE's Mubadala Investment Company, a sovereign wealth fund. ACWA Power, a Saudi developer of power and desalination plants, is partially owned by the Saudi Public Investment Fund, the sovereign wealth fund of Saudi Arabia, and Nebras Power, a Qatar power company, is a joint venture between the Qatar Electricity and Water Company and Qatar Holding, the latter being founded by the Qatar Investment Authority, a sovereign wealth fund of Qatar.

These investments have helped GCC public entities to diversify their investment portfolios. They have also helped establish Masdar and ACWA Power as key renewable energy project developers.

In some cases, investments are driven by the desire to advance sustainable development, increase energy access and improve livelihoods. The UAE's Abu Dhabi Fund for Development has committed USD 350 million in concessionary loans over seven funding cycles to renewable energy projects recommended by the International Renewable Energy Agency (IRENA). About USD 214 million of co-financing for 21 renewable energy projects has been allocated during the first five funding cycles, helping leverage additional USD 420 million of financing from other funding sources (IRENA, 2018b).

Investment funds from several GCC countries, including Abu Dhabi, Kuwait, Qatar and Saudi Arabia, are taking part in the Sovereign Wealth Funds Initiative of the One Planet Summit and committed to invest in companies that factor climate risks into their strategies.

Table 3.1 Investment by GCC entities in renewable energy projects outside the region

Country (year)	**Fund**	**Investments**	**Host**
Qatar (2016, 2018)	Nebras (QWEC and QH)	Multiple solar PV projects (Nebras Power, 2018): • 24% stake, 40 MW AM Solar Jordan • 35% stake, 52 MW Shams Ma'an Jordan	Jordan
Saudi Arabia (2014)	ACWA Power (Saudi PIF)	Stakes in operational wind projects (ACWA Power, 2018b): • 75% stake, Khalladi, Morocco, 120 MW • Small wind projects in Jordan, ~1.5 MW	Morocco, Jordan
Saudi Arabia	ACWA Power (Saudi PIF)	Stakes in operational solar projects (ACWA Power, 2018b): • 42% stake, Karadzhalovo Bulgaria, 50 MW PV • 73% stake, NOORo I Morocco, 160 MW CSP • 40% stake, Bokpoort South Africa, 50 MW CSP, 9 hour storage	Bulgaria, Morocco, South Africa
United Arab Emirates (2013, 2014)	Masdar (Mubadala)	Minority stakes in offshore wind plants (Masdar, 2018b): • 20% stake, 630 MW London Array • 35% stake, 402 MW Dudgeon • 25% stake, 30 MW Hywind	United Kingdom
United Arab Emirates (2015, 2019)	Masdar (Mubadala)	Development of wind farms around the world (Masdar, 2018b): • 158 MW Čibuk 1, Serbia • 117 MW Tafila wind farm, Jordan • 49% stake, 72 MW Krnovo wind farm, Montenegro	Serbia, Jordan, Montenegro
United Arab Emirates	Masdar (Mubadala)	Several utility-scale solar projects (Masdar, 2018b): • 200 MW, Baynouna PV, Jordan • 120 MW in 3 CSP projects, Torresol, Spain	Jordan, Spain

03

3.1.2 Investment in the value chain

Beyond direct investments in renewable energy projects, both public and private entities have invested in the development of various segments of the region's renewable energy value chain. In most cases these entities have previous experience investing in energy, and seek to extend their footprint in a dynamic and promising sector and to diversify their investment portfolio beyond conventional energy. Their initiatives have involved project development, manufacturing, R&D and specially designed funds, among others.

Public (and in some cases private) entities have used acquisitions and equity investments as a tool for establishing domestic **project development** companies that are now spearheading renewable energy deployment in the MENA region and beyond (Table 3.2). Saudi Arabia's Public Investment Fund (PIF) and Saudi Public Pension Agency (PPA) hold significant stakes in ACWA Power (25% and 5.7% respectively), which has enabled the company to develop and operate a significant portfolio of conventional and renewable energy projects in the region over the last decade. Abdul Latif Jameel Energy acquired Spanish developer Fotowatio Renewable Ventures (FRV), including its global 3.8 GW pipeline of PV projects in 2014, to establish itself as a significant developer. In the UAE, Mubadala has established Masdar, whose project development division, Masdar Clean Energy, is now a leading force in renewable energy project development in the region and beyond.

Table 3.2 highlights a number of investments outside the GCC by regional sovereign wealth funds and public investment entities such as UAE's Abu Dhabi Investment Authority (ADIA), Qatar's Nebras Power, Oman's State General Reserve Fund (SGRF) and the Kuwait Investment Authority (KIA).

Public sector investments in solar PV **manufacturing** initiatives have had mixed results. Masdar opened a thin-film solar PV module manufacturing facility in Germany in 2009, but closed it down in 2014 amid international competition. Qatar Foundation held a sizeable stake in German SolarWorld, which stopped production in 2018 (Enkhardt, 2018).

Many GCC countries have invested in **R&D** to further sustainable energy technologies and their adaptation to local market and climate conditions. Examples include Masdar Institute (now part of Khalifa University), and Qatar Environment and Energy Research Institute.

Several institutions have set up **funds** to invest in sustainable energy. Masdar established the first green revolving credit facility in the GCC in collaboration with four local and international banks. The facility will provide funding for sustainable technologies and real estate projects (TradeArabia, 2018). In Dubai, DEWA is setting up the AED 100 billion (USD 27 billion) Dubai Green Fund, by raising AED 2.4 billion. The fund will be used to finance local and global renewable energy and energy efficiency projects and companies (Clowes, 2017). Saudi Arabia has invested more than USD 45 billion in Japan's SoftBank, and is considering a 200 GW solar programme (see Chapter 2).

Several sovereign wealth funds in the region are also investing in other avenues of sustainable development. For example, Saudi PIF acquired a 5% stake in the electric vehicles manufacturer Tesla and recently invested USD 1 billion in Lucid motors, an electric vehicle start-up (Lambert, 2018).

Investments have increased across all segments of the value chain in the region, including in renewable energy projects, development companies, manufacturing companies and R&D ventures. Going declining costs of renewables, in particular for solar PV and CSP, are likely to ensure that investments in renewable energy will continue to rise across the region.

Table 3.2 Investment in the renewable energy value chain inside and outside the region

Country (year)	Fund	Deal	Value chain	Host	Value (USD)
Kuwait	KIA (SWF)	25% stake in Global Power Generation (75% is Naturgy), which owns 3 GW of projects including wind and solar projects.	Project developer, operator	Spain	NA
Oman (2014)	SGRF (SWF)	Joint equity investment in Glasspoint Solar (including Royal Dutch Shell), which develops solar EOR projects.	Project developer, operator	Oman, United States	USD 53 million
Qatar (2018)	Nebras Power Investment	75% stake in Zon Exploitatie Nederland, a developer with 96 MW of capacity.	Project developer, operator	Netherlands	USD 20 million
Saudi Arabia (2015)	PIF (SWF), PPA	Saudi PIF and PPA own 25% and 5.7% stakes (respectively) in ACWA Power (portfolio of 29 GW).	Project developer, operator	Saudi Arabia	NA
Saudi Arabia (2015)	Abdul Latif Jameel Energy	Acquired Fotowatio Renewable Ventures (FRV), including its global 3.8 GW pipeline of PV projects.	Project developer, operator	Spain	NA
UAE (2015)	ADIA (SWF)	Investment in ReNew Power Ventures for a significant minority share. ReNew Power has 5.8 GW of solar and wind portfolio.	Project developer, operator	India	USD 200 million
UAE (2016–2018)	ADIA (SWF)	Joint investment with Singapore's GIC (majority owner) in Greenko, with more than 3.2 GW renewable energy capacity.	Project developer, operator	India	USD 1.5 billion (including GIC)
UAE (since 2007)	Mubadala (SWF)	Masdar Energy (project development), Masdar Institute (R&D) and Masdar City have been established by Mubadala.	R&D, project developer, operator	UAE	NA

Sources: Gifford, 2015; GPG, 2018; Mubasher, 2018; UNEP, 2017.

NOTE: SWF = Sovereign wealth funds.

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3.2 DECLINING COSTS

Globally, the increasing cost-competitiveness of renewable energy technologies has been most apparent in the large-scale grid-connected market segment. Improved technologies, access to low cost finance, competitive procurement, greater rates of deployment, as well as increased familiarity with relevant technologies and better understanding among stakeholders have all helped lower the costs of utility-scale projects. The global weighted average levelised cost of electricity (LCOE)[2] for solar PV projects around the world decreased by 73% between 2010 and 2017, with projects regularly being commissioned around 6 to 10 US cents/kWh. During the same time period the global-weighted average cost of electricity from onshore wind declined by 22%; nowadays projects are routinely commissioned at 4 US cents/kWh in areas with strong winds (IRENA, 2018c). Information on upcoming projects suggests that these cost reductions are set to continue (Box 3.2).

Prices[3] in the GCC countries are consistent with international trends. Large-scale solar PV started with a record-breaking 5.98 US cents/kWh bid (later reduced to 5.84 US cents/kWh) in late 2014 in Dubai for the 200 MW Phase II of the Mohammed bin Rashid Al Maktoum Solar Park, which was completed in 2017. A couple of years later, again in Dubai, records were broken with an astonishing 2.99 US cents/kWh bid for the 800 MW Phase III of the Mohammed bin Rashid Al Maktoum Solar Park, of which 200 MW was completed in May 2018 (Ponce de Leon, 2018). These bids now look high compared with the 2.34 US cents/kWh bid that won ACWA Power the 300 MW Sakaka project in Saudi Arabia. A similarly low price of 2.4 US cents/kWh was also seen for the 250 MW of solar PV added to Phase IV of Dubai's Mohammed bin Rashid Al Maktoum Solar Park in late 2018.

Crucial for the longer-term growth of renewables in the region, CSP joined in with a record 7.3 US cents/kWh for the 700 MW Phase IV of the Mohammed bin Rashid Al Maktoum Solar Park in Dubai. It should be noted that locations in the UAE do not have the best DNI resources in the region (see Chapter 1); a similar project in Oman or Saudi Arabia might allow for even lower price points.

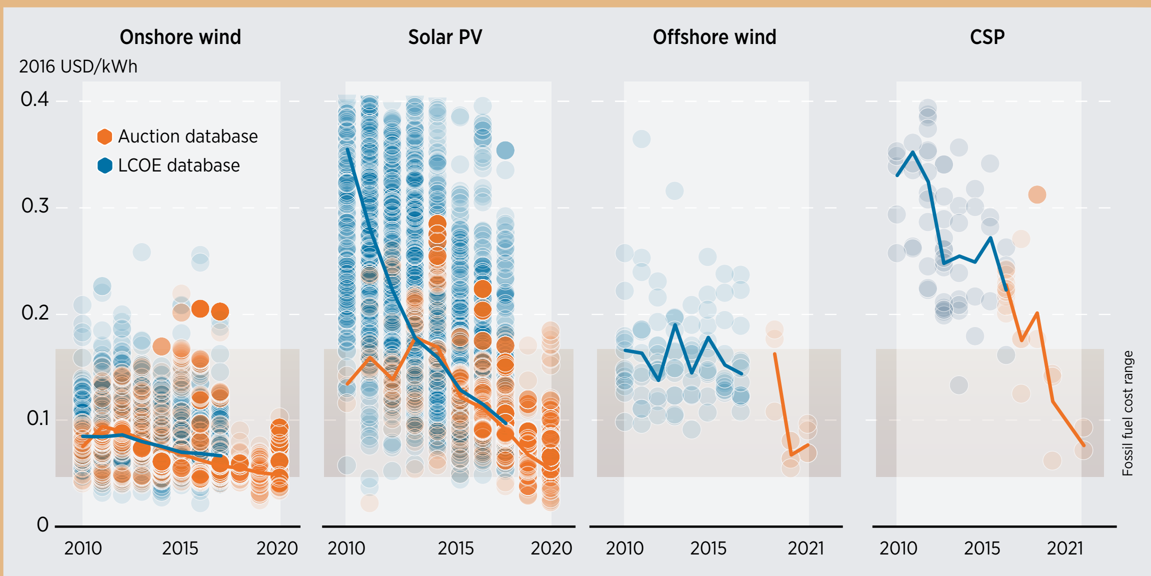
2 *Assuming a weighted average cost of capital of 7.5% in the OECD and China and 10% elsewhere. See (IRENA, 2018c) for further details of the assumptions behind the LCOE calculations and of the IRENA Renewable Cost Database.*

3 *The section uses a combination of LCOE and auction/PPA prices to discuss the cost competitiveness of renewable energy technologies. As explained in detail in IRENA (2018c), care is needed in comparisons between LCOE, auction/PPA prices and Feed in Tariff levels, as they can be very different cost metrics and may not be directly comparable.*

Box 3.2 The increasing cost-competitiveness of renewables globally

Globally, the increasing competitiveness of renewables has been evident in recent years. The outlook for solar and wind technologies in particular is promising. Figure 3.2 combines data points from IRENA's LCOE Database and IRENA's Auctions Database to project a forward-looking curve of global weighted average LCOE estimates. The figure shows that onshore wind in good wind locations was already competitive with fossil fuel cost range, but increasingly a growing number of solar PV, offshore wind and CSP projects are also undercutting the fossil fuel cost range. Auction data seems to suggest that these reductions are expected to continue for the projects to be commissioned in the coming years.

Figure 3.2 The levelised cost of electricity for projects and global weighted average values for CSP, solar PV, onshore and offshore wind, 2010–2022



Source: IRENA, 2018c.

Notes: Each circle represents an individual project or an auction result. The thick lines are the global weighted average LCOE, or auction values, by year. For the LCOE data, the real WACC is 7.5% for OECD countries and China, and 10% for the rest of the world. The band represents the fossil fuel-fired power generation cost range.

CSP = Concentrated solar power.

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3.3 COMPETITIVENESS WITH FOSSIL FUELS

The declining renewable energy costs in GCC means that they are increasingly the cheapest sources of electricity generation for new projects. As Figure 3.3 shows, solar PV, at less than 3 US cents/kWh, is the most cost effective source of electricity generation in the GCC, leaving behind natural gas, LNG, oil, coal and nuclear. CSP, at 7.3 US cents/kWh, costs less then what DEWA must pay for gas-based options (Padmanathan, 2018). With 15 hours of storage, CSP is a dispatchable alternative for natural gas that DEWA intends to use for evening generation. In Saudi Arabia and Oman, wind is another cost-effective option. The four bids submitted for the 400 MW Dumat Al Jandal wind project were reported to be between 2.13 US cents/kWh and 3.39 US cents/kWh (as of this writing, the project was yet to be awarded).

The principal factors deciding the costs of renewable energy (*e.g.* energy resources, scale, installation costs and costs of capital) vary substantially by country, project and technology, which makes comparisons difficult (Ritchie 2018). It should be noted that lower LCOE does not necessarily entail lower system costs, if structural changes to increase system flexibility are not adopted.

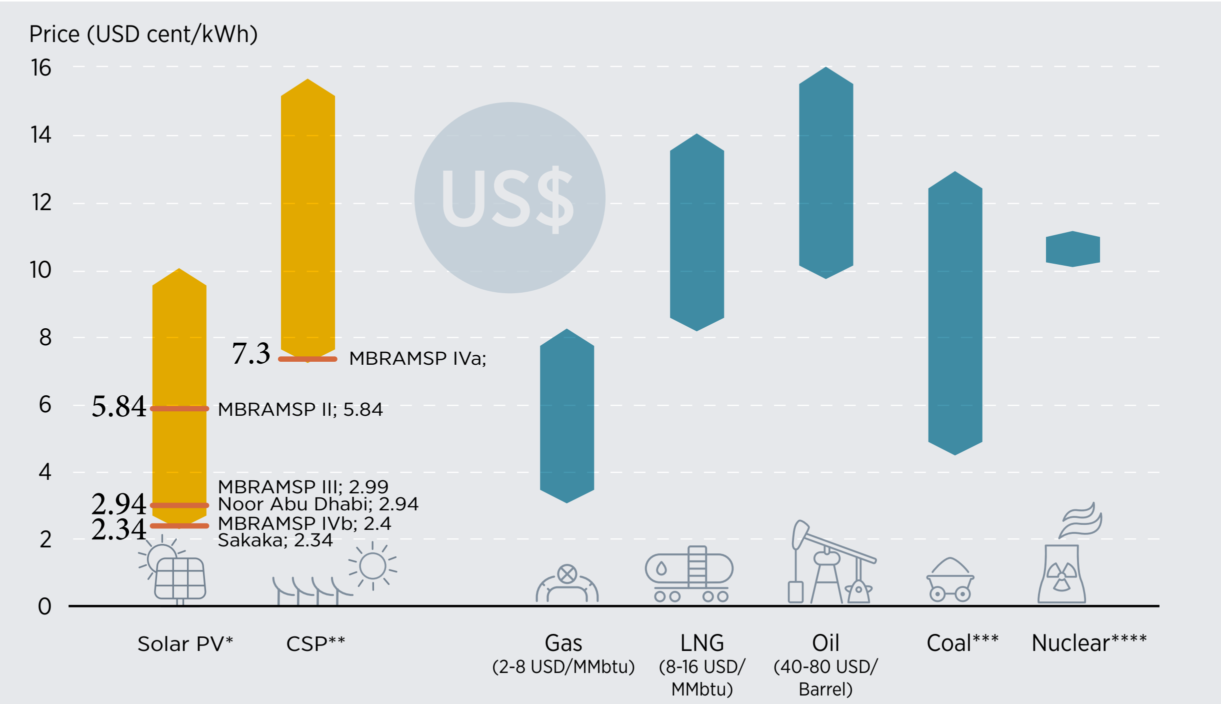
3.3.2 Competitiveness with gas

Electricity produced from large-scale solar PV is now cheaper than the electricity produced from natural gas sourced locally or imported as LNG, as measured by bid prices in US cents/kWh (Figure 3.3). The 2.34 US cents/kWh bid for Sakaka is lower than the lowest gas-based generation costs, estimated at 3 US cents/kWh assuming a gas price of USD 2 per million British thermal units (MMbtu) (Graves, 2017b). Dispatchable CSP with storage is also competitive with gas-fired electricity generation. CSP, at 7.3 US cents/kWh, is equivalent to a gas-fired power station buying gas at USD 5–6/MMBtu, which is lower than the opportunity cost of gas in most GCC countries (Mills, 2017; Sgouridis *et al.*, 2016).

Since the costs of non-associated gas in the region are likely higher than USD 6/MMBtu, there is a strong case for solar PV and CSP. Historically, gas prices in the GCC countries have been lower than USD 3/MMBtu. However, newer developments have higher extraction costs, often because gas is sour or in tight reserves. The marginal production cost for some new gas fields is estimated at more than USD 6/MMBtu. Imported gas via the Dolphin pipeline used to be relatively inexpensive for Oman and the UAE, at about USD 1.5/MMBtu for the initially contracted volumes in 2008 (later increased for additional volumes). This price is unlikely to be available for any incremental regional gas needs. For instance, "interruptible supply" was sold to Sharjah via the spare capacity in the Dolphin Pipeline at a reported price of USD 5/MMBtu. In 2011, Dolphin Energy resold Qatari gas in the UAE for USD 7 to 10/MMBtu Darwish *et al.*, 2015; Krane and Wright, 2014). For LNG imports, prices rose higher than USD 9/MMBtu in 2018 (Financial Times, 2018). Solar PV and CSP can be competitive with electricity generation from practically all of these gas sources.

3 The section uses a combination of LCOE and auction/PPA prices to discuss the cost competitiveness of renewable energy technologies. As explained in detail in IRENA (2018c), care is needed in comparisons between LCOE, auction/PPA prices and Feed in Tariff levels, as they can be very different cost metrics and may not be directly comparable.

Figure 3.3 Price of utility-scale electricity generation technologies in the GCC



Sources: Derived from Mills, 2018; Channell et al., 2015; Manaar, 2014; Scribbler, 2015.

* *Low = price for 300 MW Sakaka solar PV; and High = a conservative assumption based on project data and expert opinion*

** *Low = price for 700 MW MBRAMSP IVb in Dubai; and High = price for Morocco's Noor II*

*** *Low = price for the Hassyan Clean Coal Power Plant; and High = estimate for coal with CCS*

**** *Estimated range for nuclear power based on (Mills, 2012) and (Scribbler, 2015)*

Notes: LCOE and auction/PPA prices represent one way to examine cost-competitiveness in a static analysis. These estimates are not a substitute for detailed nodal modelling, system cost tracking or analysis of factors such as backup generation requirements or demand side management. Moreover, care should be taken in comparing LCOE, auction/PPA prices and Feed in Tariff levels, as they can be very different cost metrics (see IRENA, 2018c for details). Prices for gas, LNG and oil and based on inputs from regional experts (Mills, 2018). MBRAMSP = Mohammed bin Rashid Al Maktoum Solar Park; USD cent/kWh = US Dollar cent per kilowatt-hour; PV = photovoltaic; CSP = concentrated solar power; LNG = liquefied natural gas; MMbtu = million British thermal units.

While solar PV projects provide an opportunity to save natural gas and oil, they may not provide firm capacity during evening peak demand, and are non-dispatchable. CSP with storage, however, can provide a dispatchable source of renewable generation that may be considered firm capacity by utilities. CSP blended with solar PV (such as the amended Phase IV of the Mohammed bin Rashid Al Maktoum Solar Park) features the low price of solar PV and the storage of CSP to provide a comprehensive alternative to gas-based generation (Padmanathan, 2018).

3.3.3 Cost-competitiveness with oil

Renewable energy technologies such as solar PV and CSP are very competitive with oil-based electricity generation, even when oil is priced as low as USD 40 per barrel (Figure 3.3). The electricity generation price of the 200 MW Phase II of Dubai's Mohammed bin Rashid Al Maktoum Solar Park at 5.84 US cents/kWh, for instance, is comparable to the price of electricity generation from oil priced at USD 20 per barrel. With crude oil priced at about USD 60 per barrel (Bloomberg, 2018), the case for the greater integration of solar PV and CSP in the oil-based power sectors of Kuwait and Saudi Arabia is very strong. Experts such as Luciani (2014)

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have suggested that the marginal cost of crude production, instead of international crude prices, could be a useful metric for determining the opportunity cost of oil. Even if this definition is used, with oil production costs reported at above USD 20 per barrel across the region (Conca, 2015), large-scale solar PV, priced at about 2.99 US cents/kWh, is much cheaper than oil-based electricity production.

3.3.4 Competitiveness with nuclear and coal

Solar PV in the region is cost-competitive with nuclear energy and coal. The estimated price of nuclear power in the UAE is about 11 US cents/kWh (Mills, 2012; Scribbler, 2015), which is much higher than that of both CSP and solar PV. Dubai's planned Hassyan coal project is expected to generate electricity at 4.5 US cents/kWh once operational in 2020 (DEWA, 2016). This is higher than the price for recent solar PV projects in the region, but lower than the price for dispatchable power from Dubai Solar Park's 700 MW CSP. However, it should be noted that the price of coal-based electricity is contingent on coal prices, which are prone to significant fluctuations and have been on the rise in the past couple of years (BP, n.d.).

Renewable options are also emerging for industrial applications that require direct heat or steam input. Solar thermal enhanced oil recovery (solar EOR) is one such application, where steam produced by solar thermal troughs or towers can be used in oil fields to enable oil production. Oman has been pioneering the field of solar EOR with a unique design of enclosed troughs that reduce investment and operational costs (Box 3.3).

3.4 KEY FACTORS FOR PRICE REDUCTIONS

As discussed earlier, auctions for large-scale projects in the GCC countries have yielded some of the lowest prices for solar PV and CSP in the world. The decrease can be attributed to a number of key factors including: (1) the availability of vast land with good solar resources; (2) auction designs successful at achieving low prices; (3) access to finance and (4) technological improvements. The first factor has already been discussed in Chapter 1 and the remaining three are explored in this section. This list of factors is not meant to be comprehensive; other factors that influence prices in the region may include investor confidence, the strategic benefits of entering a promising market, low taxes, low land costs, low grid connection costs and low soft costs (IRENA, 2017b).

3.4.1 Auctions achieve deployment and development

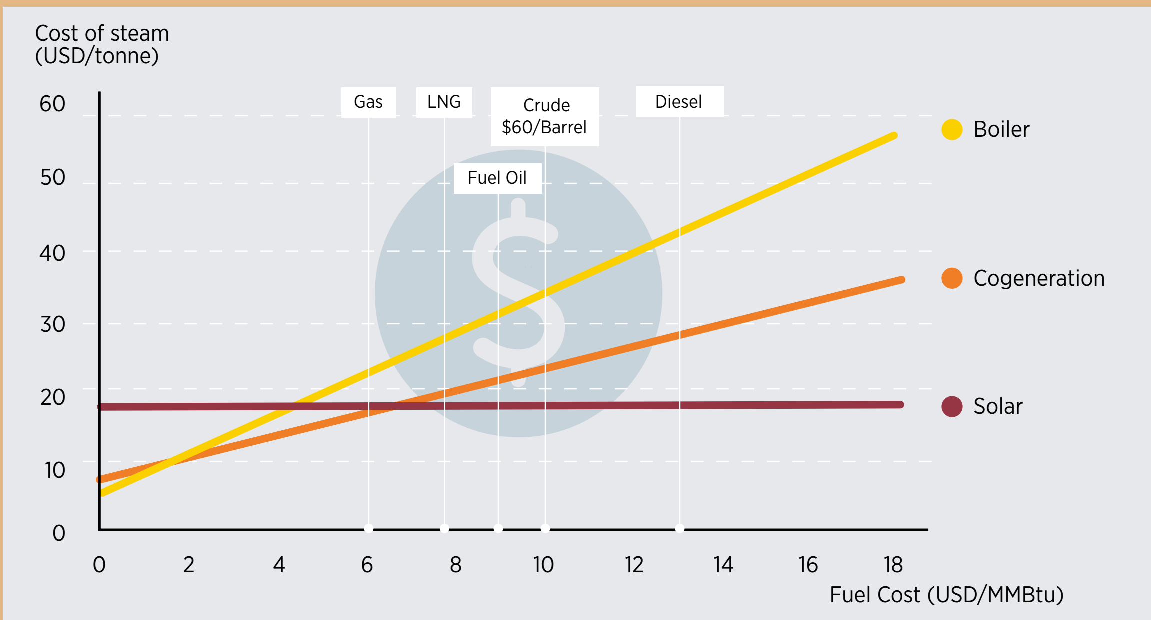
Renewable energy auctions have been central to large-scale renewable energy deployment in members of the GCC. Since 2015, auctions have been used to award more than 3 500 MW of renewable energy projects in the region. Close to 80% of the awarded capacity is for solar PV and about 88% of the awarded projects are in the UAE. Auctions in Oman, Qatar and Saudi Arabia have also picked up in 2018, and more activity is expected in all GCC countries in 2019. Out of the total awarded capacity of 3 500 MW, at least 400 MW had already been completed and connected to the grid as of November 2018. The GCC countries are using auctions to achieve renewable energy deployment at competitive prices (see Table 3.3), while also achieving broader development objectives such as job creation and industrial development.

Auctions create competition, which allows falling technology costs to be more fully reflected in bid prices (IRENA, 2017b). Requests for expressions of interest in renewable energy projects in the GCC countries have regularly attracted large numbers of local and international companies. In the auction for Sakaka 300 MW solar PV, REPDO received statements

Box 3.3 Costs of solar enhanced oil recovery

Several petroleum-extraction projects in GCC countries, mainly in Oman, Kuwait and the Saudi-Kuwait Neutral Zone, require steam injection (a dominant method for EOR) to lower the viscosity of heavy oil to enable production. Steam can be produced using natural gas, but the product is also in demand for other industrial applications and electricity production. In Oman, GlassPoint Solar has been pioneering the field of solar EOR with a unique design that has substantially reduced investment and operational costs. Research and pilot projects in Oman have shown that solar troughs can deliver steam at a lower cost than fossil-fuel-based steam boilers if gas prices are higher than USD 4.5/MMBtu (Figure 3.4).

Figure 3.4 Cost of steam for different generation technologies for enhanced oil recovery



Source: Chaar et al., 2014.

Note: MMBtu = million British thermal units.

of qualifications from 128 companies. Similarly, the 800 MW Phase III of DEWA's Mohammed bin Rashid Al Maktoum Solar Park received expressions of interest from 95 companies (Whitlock, 2016). The long track record of these companies with renewable energy projects and the scale of their purchasing power have been important drivers of low bids.

The administrative requirements that bidders must meet to qualify for an auction can impact project costs. Such requirements include environmental licenses, resource assessments and grid-access permits. In auctions in Saudi Arabia and UAE, governments assumed responsibility for some of these activities, such as resource assessments, site selection and grid connection, which is an effective way to reduce barriers to entry and bidders' costs (IRENA, 2017b). For 300 MW solar PV and 400 MW wind projects in Saudi Arabia, for example, REPDO took responsibility for conducting resource assessments, site preparation, soil testing, environmental and social impact assessment, permitting and licensing. This reduced costs for all bidders and helped standardise some of the assumptions used by project developers.

Although aggressive competition can lower prices, it may also result in underbidding, leading to projects' delay or abandonment. Auctions in the GCC countries tend to minimise the probability of underbidding through strict financial and technical requirements

Table 3.3 Results of selected auctions in GCC countries

Country	Project/Site name	Tech.	Size (MW)	Year (bids received)	Year (awarded)
Kuwait	KNPC, Dibdibah	Solar PV	1 500	-	-
Oman	PDO Amin IPP	Solar PV	100	January 2018	November 2018
	Ibri PV Plant	Solar PV	500	November 2018	-
Qatar	Kahramaa	Solar PV	500	-	-
Saudi Arabia	Sakaka	Solar PV	300	October 2017	February 2018
	Dumat Al Jandal	Wind	400	April 2017	-
United Arab Emirates	MBRAMSP Phase II	Solar PV	200		January 2015
	MBRAMSP Phase III	Solar PV	800	May 2016	November 2017
	MBRAMSP Phase IV	CSP	700	September 2017	September 2017
		Solar PV	250	Added in November 2018	
	Noor Abu Dhabi, Sweihan	Solar PV	1 177	September 2016	September 2016

Note: MBRAMSP = Mohammed bin Rashid Al Maktoum Solar Park.

during the prequalification and evaluation stages. The DEWA auction for Phase III of the Sheikh Mohammed Bin Rashid Al Maktoum Solar Park was reported to have very stringent technical and financial requirements during the prequalification stage. That, combined with the large project size (800 MW), meant that only 20 companies entered the prequalification stage, less than half of the number (49) applying for the 200 MW Phase II (Clover, 2015). In Saudi Arabia's solar PV Sakaka project, REPDO's stringent prequalification requirements ensured that only companies with financial and technical credibility could qualify. REPDO received statements of qualifications from 128 companies and shortlisted 27, out of which 8 eventually submitted final bids (Nada, 2017; REPDO, 2017a).

As the GCC countries gain experience with large-scale renewable energy projects, auctions are becoming more sophisticated. Utilities are designing auctions to incentivise power production that complements existing generation capabilities. In Abu Dhabi, ADWEC designed an auction for the 1 177 MW Noor Abu Dhabi solar PV project to incentivise maximum generation during the summer months. The energy delivered during the peak summer season (June to September) is remunerated at 1.6 times as much as the energy delivered during the remaining year. The design led to a winning bid of 2.42 US cents/kWh, which is the price

	Year of completion	Price US cents/kWh	Status
	-	-	Bids invited
	May 2020 (expected)	-	Awarded
	2021 (expected)	-	Bids received
	End of 2020 (expected)		Prequalification stage completed
	End of 2019 (expected)	2.34	Awarded
	-	2.13 to 3.39	Four bids received
	March 2017	5.84	Awarded, completed
	200 MW in May 2018 and 600 MW by 2020 (expected)	2.99	Awarded, partial completion
	In stages, starting in 2020 (expected)	7.3	Awarded (250 MW solar PV added without separate auction)
		2.4	
	April 2019 (expected)	2.94 (2.42 off peak)	Awarded

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for non-peak months (2.94 US cents/kWh is average price)(IRENA, 2017b). In Dubai, DEWA used an auction for the 700 MW CSP Phase IV of the Sheikh Mohammed Bin Rashid Al Maktoum Solar Park for electricity generation from 4 pm to 10 am – thus complementing production from solar PV (Padmanathan, 2018).

Auctions are being used to create jobs and localise skills in Kuwait and Saudi Arabia. Kuwait's ongoing auction for 1 500 MW solar PV has a 30% local content requirement for both equipment and services (Petrova, 2018). The technical criteria for the 300 MW solar PV and 400 MW wind tenders in Saudi Arabia include a 30% local content requirement. This requirement is likely to gradually increase in future rounds to encourage the growth of a sustainable renewable energy supply chain (REPDO, 2017b).

3.4.2 Favourable financing conditions enable low prices for large-scale projects

Very attractive conditions for financing – such as low interest rates, long loan duration and high debt to-equity ratios – have supported the record PV and CSP prices of large renewable energy projects in the region. Unfortunately, it is comparatively difficult to finance small-scale projects.

Financing large-scale renewable energy projects

Obtaining financing for large-scale renewable energy projects (all based on solar PV or CSP) in the GCC countries has not been a barrier. Commercial banks are willing to offer loans with long tenors and reasonable interest rates in the presence of well-designed enabling frameworks.

As the market matures and regional commercial banks gain experience with renewable energy projects, debt conditions are becoming more attractive. Large-scale renewable energy projects that secure long-term PPAs with public sector off-takers (utilities or other special purpose entities) have no trouble in attracting renewable energy finance in the UAE and Saudi Arabia at favourable conditions. As Table 3.4 shows, renewable energy projects in the region are generally receiving loans with long loan tenors (over 20 years), high debt-to-equity ratios (ranging between 70% and 86%), and low interest rates (ranging between 120 and 200 basis points [bps] over the benchmark London Interbank Offered Rate, or Libor), which are very competitive with utility-scale PV projects being developed around the world (Apostoleris *et al.*, 2018). The global average debt-to-equity ratio for solar PV projects, for instance, was in the 60–70% range in 2015-2016 (IRENA and CPI, 2018). Well-structured projects in the region have attracted this kind of financing for a number of reasons:

- The GCC economies have reliable off-takers. Once a project developer wins a PPA, timely payments are guaranteed by public off-takers, and therefore the risk and cost of financing go down. In UAE, the off-taker owns a large stake of the project. Furthermore, almost all GCC currencies are pegged

Table 3.4 Financing details of large-scale solar projects

Project	Developer	Off-taker	Financiers	Investment (million)	Conditions
Shams 1, 100 MW CSP UAE	Masdar (UAE), Total (France) and Abengoa (Spain)	ADWEC, 25 year PPA	UNB, NBAD (UAE); Natixis, Société Générale (France); Mizuho, Bank of Tokyo, Mitsubishi, Sumitomo (Japan); WestLB, KfW (Germany)	USD 153 million equity (USD 612 million loan)	22 year, 80% debt-equity ratio
MBRAMSP II, 200 MW PV UAE	ACWA (Saudi Arabia) and TSK (Spain)	DEWA, 25-year PPA	First Gulf Bank (UAE), National Commercial Bank and Samba Financial Group (Saudi Arabia)	USD 326 million	27 year, 86% debt fraction, Avg. 180 bps over Libor
MBRAMSP III, 800 MW PV UAE	Masdar (UAE), ALJ (Saudi Arabia) and EDF (France)	DEWA	UNB (UAE), IDB, APICORP (Middle East); Natixis (France), Siemens Financial (Germany), Korea Development Bank and EDC (Canada)	USD 940 million (USD 650 million loan)	70% debt-equity ratio, soft mini-perm, starting 175 bps over Libor
MBRAMSP IV, 700 MW CSP + 250 MW PV UAE	ACWA (Saudi Arabia) and Shanghai Electric (China)	DEWA, 35-year PPA for CSP	ICBC, Bank of China, Agricultural Bank of China, China Minsheng Bank and the Silk Road Fund (China)	USD 4 360 million (USD 1 500 million debt secured)	70% debt-equity ratio
Noor Abu Dhabi 1 177 MW PV UAE	Marubeni (Japan) and Jinko Solar (China)	ADWEC, 25-year PPA	Natixis, CA-CIB, BNPP (France); MUFG, MUTB, the Norinchukin Bank, SMBC (Japan); First Abu Dhabi Bank	USD 870 million (USD 648 million loan)	26 year, 75% debt equity ratio, soft mini-perm, Start 120 bps over Libor
Sakaka 300 MW PV Saudi Arabia	ACWA (Saudi Arabia)	SPPC, 25-year PPA	Natixis (France)	USD 320 million	NA

Sources: Shams 1 (Carvalho, 2011; Ratcliffe, 2013); MBRAMSP II (ACWA Power, 2017; Reuters, 2015; Apostoleris et al., 2018); MBRAMSP III (Dipaola, 2018; IPP Journal, 2017; Apostoleris et al., 2018); MBRAMSP IV (Santamarta, 2018; Lilliestam and Pitz-Paal, 2018); Noor Abu Dhabi (Natixis, 2017; Power Technology, 2018; Apostoleris et al., 2018); Sakaka (APICORP, 2018; Kenning, 2018).

Notes: MBRAMSP = Mohammed bin Rashid Al Maktoum Solar Park; SPPC = Saudi Power Procurement Company; ADWEC has been replaced by Emirates Water and Electricity Company (EWEC).

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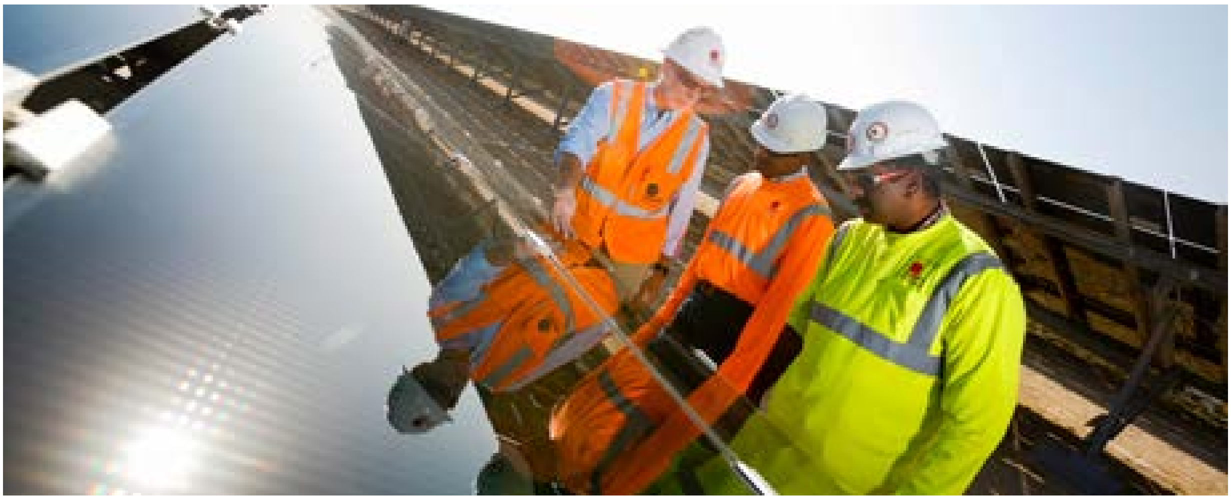
to the US dollar, lowering the currency risks for foreign lenders.

- Projects using the IPP approach have proven successful in the region. Oman started with the first IPP in 1996, followed by the first IPP in 2002 in Abu Dhabi. From a financier's standpoint, the new IPPs focused on renewables are little different from their proven fossil-fuel-based counterparts.
- Selected bidders have a proven track record. The design of renewable energy auctions, especially at the prequalification stage, allows only a relatively small number of well-established developers with sound technical capabilities and creditworthiness to make it to the final bidding rounds. Given their experience and track record, they do not have a problem in attracting low-cost finance from their local banks as well as the global financial markets.

Large-scale renewable energy deployment in the region has also benefitted from low interest rates around the globe. These may not last. The US Federal Reserve, for example, raised interest rates three times in 2018 alone, and eight times since late 2015 (Condon and Torres, 2018). Project developers fear that the lending rates available for projects in the region are likely to increase. Meanwhile, declining technology costs and the financial sector's growing familiarity with renewables promise to offset this effect and help avoid any uptick in bid prices (Padmanathan, 2018).

Local banks have played a leading role in financing renewable energy projects in the region, but as the market grows, foreign financiers are also participating, especially in multi-billion-dollar projects. Phase II of the Mohammed bin Rashid Al Maktoum Solar PV required financing of about USD 300 million, which was delivered by a consortium of local banks (Table 3.4). The subsequent Phase III of 800 MW PV and Phase IV of 950 MW CSP and PV, and 1 177 MW Noor Abu Dhabi PV are much larger projects (USD 940 million, USD 4 360 million and USD 870 million, respectively) requiring syndicates consisting of local and foreign banks, often with the significant contributions of lenders from developers' home countries (Apostoleris *et al.*, 2018).

The increasing funding demands of renewable energy projects in the region mean that lenders need to employ innovative mechanisms that encourage project developers to look for additional sources of funding. Soft mini-perms[4] are one such mechanism. These are long-term loans in which interest rate increases after a stipulated time, thus encouraging developers to refinance the project. This reduces the risks for lenders, helps reduce the initial interest rate and potentially decreases the bid price. Developers however run the



4 A soft mini-perm structure typically involves a long tenor. However, the sponsors have an incentive to refinance the loan by an earlier date. If the sponsors fail to refinance the loan by a specified time, the margins increase, making the cost of borrowing more expensive, and the lenders are entitled to a cash sweep.

risk of refinancing (Keenan, 2012). As Table 3.4 shows, three large projects (MBRAMSP Phase III, MBRAMSP Phase IV and Noor Abu Dhabi PV) are all reported to employ soft mini-perm structures. In the specific case of Noor Abu Dhabi PV, the interest rate is reported to increase from 120 bps over Libor to 190 bps over Libor five years past the financial closure (eventually rising to 250 bps) (Natixis, 2017; MESIA, 2018a; IJGlobal, 2017).

Another innovative financing mechanism that could be used for large-scale project financing, as well as for the refinancing stage, is green bonds, which for example have been used to finance renewable energy projects by MASEN of Morocco and the City of Johannesburg in South Africa (GIZ, 2017). Green bonds are an increasingly attractive vehicle for large investors, such as institutional investors, to invest in renewable energy projects via capital markets securities. They provide issuers with large-scale long-term non-bank capital, possibly at lower cost of capital (IRENA, 2016b). Global issuance of green bonds reached a record of USD 155.5 billion in 2017, with investment in renewable energy as the most common use of proceeds (accounting for 33% of proceeds in 2017, followed by energy efficiency and low carbon buildings at 29%) (Climate Bonds Initiative, 2017). In the GCC region, the green bonds market is in the beginning stages, but has already seen a large green bond issuance. The National Bank of Abu Dhabi (now First Abu Dhabi Bank, following a merger with the First Gulf Bank in 2017), has issued the first green bond in the Middle East valued at USD 587 million in 2017 (FAB, 2018b). Green Sukuk bonds, the Sharia-compliant green bonds, have also been used in two renewable energy projects in Malaysia. Indonesia has launched the world's first sovereign green Sukuk bonds (for USD 1.25 billion) whose proceeds will partially finance renewable energy projects (Climate Bonds Initiative, 2018).

Some large-scale investors (*e.g.* institutional investors) may not have the internal capacity or desire to invest directly in renewable energy projects. Attracting such investors may require investment vehicles and securities which are listed and managed by reputable asset managers and ideally also rated. Such vehicles include green bonds, green equity listings, green indices and listed renewable energy funds, such as yieldco-like structures (listed companies holding operating renewable energy assets), among others (IRENA, draft report-a).

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Financing small-scale renewable energy projects

Financing the small-scale solar PV market poses a daunting challenge: banks are not willing to lend amid the higher per unit costs of small projects, long payback periods and the lack of off-taker guarantees. Developers and customers must resort to costly financing arrangements that raise project costs, thus hindering rapid uptake (Zywietz, 2018).

Leasing plans are starting to emerge under the Shams Dubai net-metering programme. Yellow Door Energy offers leasing arrangements for rooftop installations by which building owners pay monthly bills depending on the solar energy consumed. The arrangements include a clause allowing the ownership of the installations to be transferred to the building owner. Developers such as Sirajpower and Enviromena are also providing turnkey leasing solutions that include project financing, development, construction and operation. These developers rely on a number of sources for financing. Sirajpower, for instance, draws financial backing from Corys Environment, which is the environmental investment arm of Green Coast Enterprises. Enviromena has the financial backing of Arjun Infrastructure Partners (AIP), an infrastructure asset management company based in the United Kingdom.

Standardisation and aggregation are also viable options to make small-scale projects worth the investment of time and capital, especially for larger investors. Standardised project documents for example, can significantly reduce transaction costs and the time required for project development, while improving the bankability of projects. It is with these goals in mind that IRENA and Terrawatt Initiative (TWI) have jointly launched the *Open Solar Contracts Initiative* to make standardised legal documents for solar PV publicly-available, including the PPA, implementation agreement, supply and installation agreement, among others. Greater standardisation allows smaller projects to be ‘aggregated’, opening the doors to securitisation via listed or unlisted vehicles. An example of a successful aggregation is Jordan’s Seven Sisters project where International Finance Corporation (IFC) acted as the lead arranger and lender of record for seven solar projects in Jordan, engaging a common team of legal, technical, financial and insurance advisors to serve all projects. This led to a USD 247 million investment in 102 MW installed capacity (IRENA, 2016b). Smaller to medium scale projects can also benefit from platforms that connect project developers with providers of capital and services. IRENA’s *Sustainable Energy*

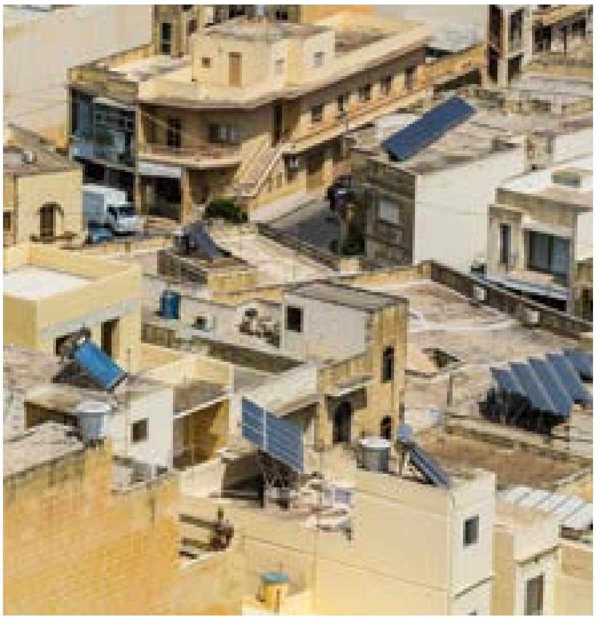
Marketplace for example, provides such 'matchmaking' services, free of charge and on a global basis, and at the time of this writing hosts about 200 projects, 158 financing instruments and 205 service providers.

Another growing and potentially significant way to raise capital for renewable energy projects is via crowd-funding platforms which by-pass traditional intermediaries such as commercial banks and allow for faster collection of relatively small amounts of capital from a large number of individuals or legal entities (IRENA, draft report-b). While relatively new, the global crowdfunding industry has grown dramatically in recent years, with investments reaching USD 100 billion in 2015, from only USD 1.5 billion in 2011 (Jenik *et al.*, 2017; Massolution, 2015). In the GCC region, Enerwhere, a solar PV developer in the UAE, has raised USD 2 million from crowd-funding platforms in the form of equity (on eureeca.com) and debt (on beehive). However, transaction costs tend to be high and projects sizes remain small, as online crowd-funding platforms have built-in limits on funding volumes (Zywietz, 2018).

Mechanisms that allow for direct PPAs between utilities and developers might provide necessary off-taker guarantees, thus unlocking cheap bank finance for developers of small-scale solar PV. One potential solution is the so-called solar partners model (Kuldeep *et al.*, 2018) in which utilities aggregate rooftop owners in a selected area, auction the combined capacity and sign PPAs directly with the successful bidders. This lowers the financing risk by signing direct PPAs with developers and has the added benefit of bringing costs down through auctions. The recently announced second phase of the Sahim Residential Solar programme in Oman (see Chapter 2) allows distribution companies to combine both aggregation and auctioning of residential rooftop solar. A small-scale grid-connected system framework supports the programme by allowing self-supply from PV rooftop installations, including a time-based bulk supply tariff (BST) and feed-in of excess electricity at slightly elevated tariffs (Al Ghaithi, 2017). This approach might benefit rooftop solar deployment in other GCC countries as well.

3.4.3 Improving technology ensures price reductions

Renewable energy technologies have significant potential for improvement, depending on their level of maturity. Costs of renewable power generation technologies decline significantly as deployment grows, technologies improve, economies of scale are unlocked, learning accumulates, manufacturing processes improve and competition increases along the supply chain. Technological improvements impact renewable energy cost in several ways. First, improved production processes, innovative designs and economies of scale in manufacturing facilities mean that the costs of manufacturing equipment (*e.g.* solar modules, wind blades) is falling. Second, improvements in project development, construction and civil engineering mean that the costs of installation are falling. Third, improved technological efficiency means that the energy harvested from the same resource increases thus decreasing the cost per unit of generation (*e.g.*, as solar PV module efficiencies increase, less area and materials are required for the same power capacity) (IRENA, 2018c; IRENA, 2014b).



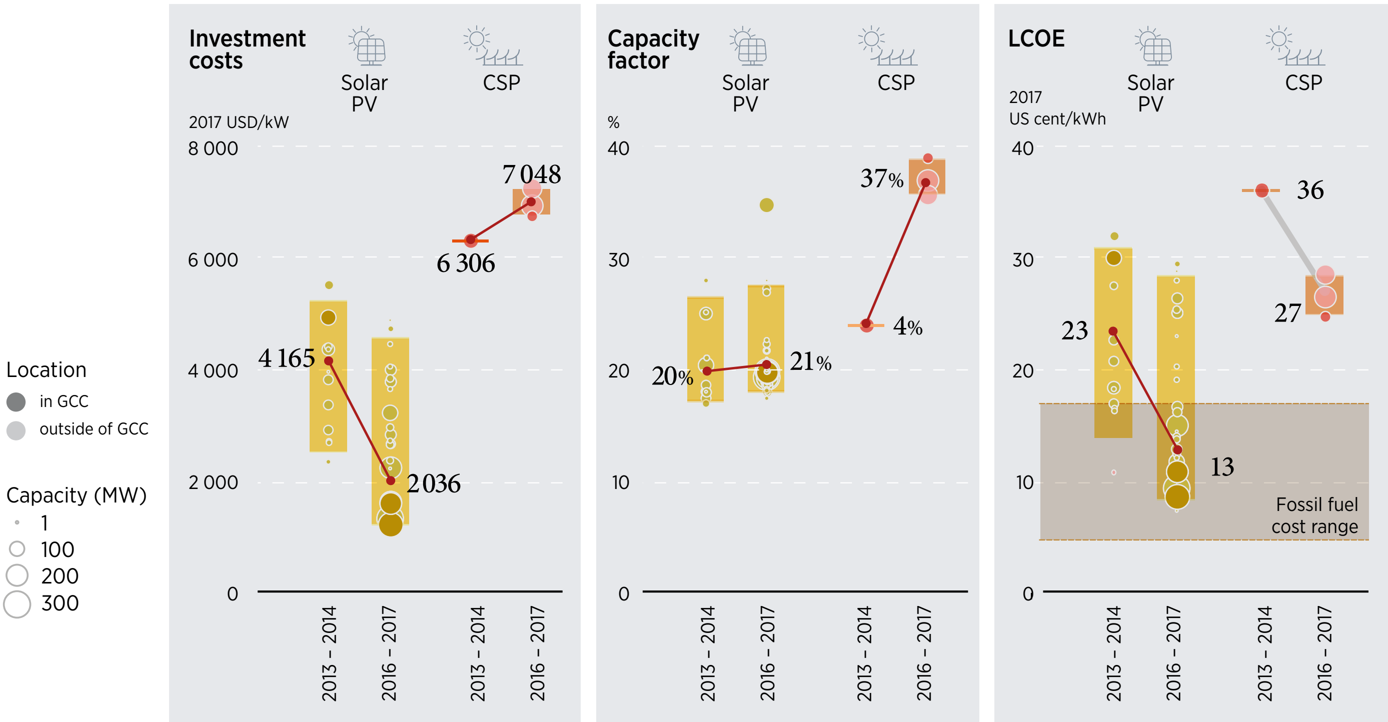
03

Solar PV

The effects of technological improvements are especially evident in solar PV. Module costs are declining due to improvements in the production processes, efficiency gains associated with increased adoption of newer cell designs, intense market competition and overcapacity. Globally, the weighted average total installed cost for utility-scale solar PV decreased from USD 4 394/kW in 2010 to USD 1 388/kW in 2017. At the same time, solar PV capacity factors increased from 14% on average in 2010 to 18% in 2017. Conversion efficiencies increased by about 3% to 4.5% per year over the past decade. Combined, these factors are ensured that the LCOE of solar PV fell by 73% between 2010 and 2017 and continues to decline (IRENA, 2014b; IRENA, 2018c).

While data on solar PV projects in the GCC countries are limited, a look at the larger MENA region reveals that costs are declining amid continued technological improvement. Investment in solar PV in the MENA region averaged about USD 4 165/kW in 2013-2014, a figure that more than halved to USD 2 036/kW in 2016-2017. In tandem, solar PV capacity factors in the MENA region increased slightly. Thus, the estimated LCOE (capacity weighted average) of solar dropped by 43% to reach 13 US cents/kWh for projects commissioned in 2016-2017 (Figure 3.5). In the GCC countries, the 200 MW Phase II of Mohammed bin Rashid Al Maktoum Solar Park, which was awarded in 2015, had an investment cost of USD 1 254/kW[5] and a bid price of 5.84 US cents/kWh. Just two years later, the 1 177 MW Noor Abu Dhabi solar PV project in Sweihan had a much lower investment cost of about USD 740/kW and a bid price

Figure 3.5 Costs and performance indicators in MENA countries for solar PV and CSP technologies, 2013–2014 and 2016–2017



Source: IRENA Renewable Cost Database.

Note: Grey range shows 5th and 95th percentile range. Grey line shows the capacity weighted average.
MENA - Middle East and North Africa; PV = photovoltaic; CSP = concentrated solar power; LCOE = levelised cost of electricity.

5 *Calculated using a DC capacity of 260 megawatt peak (MWp) and investment of USD 326 million.*

less than 3 US cents/kWh. Small-scale solar PV projects could achieve costs that are comparable or lower than large-scale projects. In the UAE, for instance, rooftop PV projects with aggregated capacity of 10 MW in 2018 are being implemented as low as USD 700/kW. These are very competitive installed cost structures. They demonstrate how quickly efficient cost structures can be achieved under the right regulatory framework.

CSP

The installed costs of CSP projects in the MENA region seem to have increased by 12% to reach USD 7 048/kW in 2016-2017. This increase is primarily due to the increasing thermal storage and larger solar field[6] – the 100 MW Shams CSP in Abu Dhabi has no storage but the 750 MW Phase IV of the Mohammed bin Rashid Al Maktoum Solar Park has 15 hours of molten salt-based thermal storage, allowing it to generate during night hours. In parallel, the performance of CSP in the region has improved, with the weighted average capacity factor rising from 24% in 2013-2014 to 37% in 2016-2017. One key reason for this is the addition of storage (IRENA, 2012a). The capacity weighted average of the LCOE estimate of CSP projects in MENA, for which IRENA has data, declined by 25%, from 36 US cents/kWh during 2013-2014 to 27 US cents/kWh during 2016-2017 (Figure 3.5).

Onshore wind

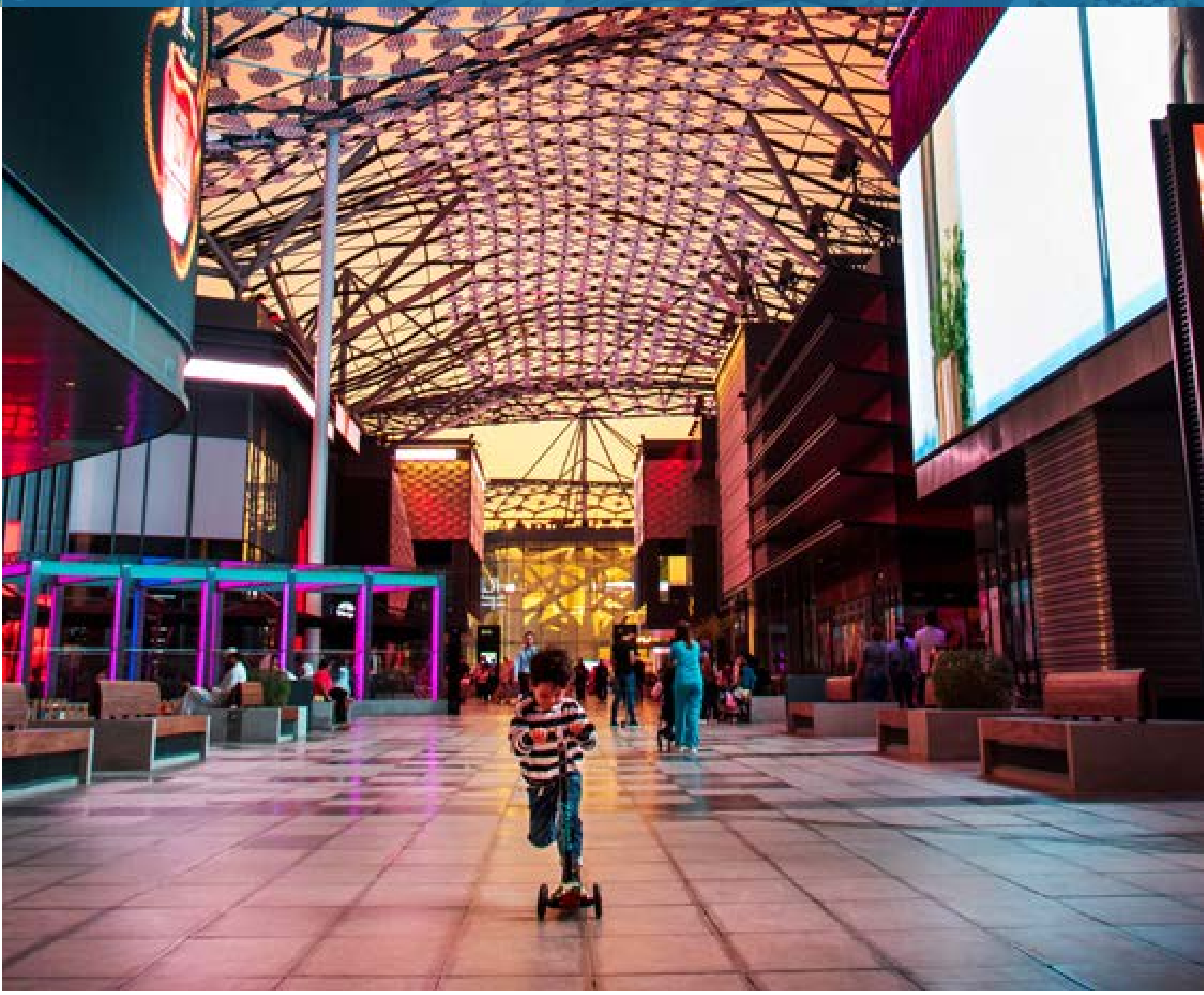
Governments in the broader MENA region are capitalising on the availability of strong wind resources, thus increasing the competitiveness of onshore wind in the region. The total installed costs of wind projects in 2016-2017 stayed relatively flat in the MENA region, in contrast to a 3% drop during 2013 2014. Performance improvements saw the capacity factors improve from 32% to 42% during the same period. This caused the capacity weighted average LCOE estimate to decrease by 12.5% to reach 7 US cents/kWh during that timeframe.

The recent market developments have put the region on the global map with some of the lowest prices for electricity for renewable energy technologies, in-particular solar PV. This rising cost competitiveness, coupled with country-specific policy frameworks, can pave the way for greater investments in the sector.

Stakeholders in GCC have been investing in the renewable energy value chain and renewable energy projects. As deployment grows, the investments in renewable energy project can help address the rising energy demand in a sustainable manner, while creating opportunities for economic growth and job creation. The investments in the renewable energy value chain can further support efforts for economic diversification and industrial development, while positioning the countries as important players in a new and growing sector.

6 The solar field (parabolic troughs or mirrors) can be oversized compared with the rated output of the power block (steam turbine). The excess energy from the oversized solar field can be thermally stored and delivered to the power block when sunshine declines – thus raising the capacity factor of the plant.

RENEWABLE ENERGY BENEFITS



04

Several governments in the Gulf Cooperation Council (GCC) have set targets for the deployment of renewable energy, typically as part of broader initiatives aimed at achieving greater economic and energy sustainability (see Chapter 1). A deeper look at the power systems in the region indicates that countries stand to gain significant benefits from renewable energy installations – benefits that include fossil-fuel savings, emissions reductions and new jobs.

A preliminary analysis was conducted in 2016 to analyse the potential benefits of achieving GCC renewable energy targets (IRENA, 2016a). In the present report, the analysis is updated on the basis of recent changes to some of the declared targets, which, if met, could result in about 72 GW of renewable energy capacity in GCC by 2030 (Table 4.1). It should be noted that this is an estimate based on assumptions and does not intend to limit the range of possibilities in the region (Box 4.1).

Achieving the region's renewable energy deployment targets, as estimated in Table 4.1, could save 354 million barrels of oil equivalent (MBOE) (a 23% reduction in power sector's fossil-fuel consumption); create more than 220 500 jobs; reduce the power sector's CO_2 emissions by 136 million tonnes ($MtCO_2$); and reduce water withdrawal for the power sector (for production and fuel extraction) by 11.5 trillion litres (an 17% decrease)[1] in 2030. These potential benefits are explored in greater detail in this chapter.

1 The ocean is the predominant source of water used for cooling thermal power plants in the UAE. Discharge of cooling water back into the sea creates thermal pollution, with effects on marine life, including greater algae blooming. Treated water is used during fuel extraction.

04

Box 4.1 Estimated renewable energy capacity in the GCC, 2030

For the purposes of this report, a forecast of renewable energy capacity in the GCC was prepared using official deployment targets. An end year of 2030 was used. National targets stated for other years were extrapolated.

Where targets did not specify the technology breakdown of planned deployment, it was assumed that solar technologies (concentrated solar power and photovoltaic) would dominate. For countries without declared targets (*e.g.* Bahrain and Qatar), a future capacity based on assumptions was estimated.

Table 4.1 Estimated renewable energy capacity by 2030

	CSP	PV (utility scale)	PV (roof-top)	Wind	Waste-to-energy	Total	Source
	Capacity in 2030 (MW)						
Bahrain	70	520	70	20	20	700	IRENA assumption
Kuwait	1 000	5 800	1 000	200	-	8 000	Based on inputs from country expert
Oman	770	2 420	990	1 210	110	5 500	Target of 2.6 GW by 2025, followed by 600 MW added every year to 2030
Qatar	600	2 250	150	-	100	3 100	IRENA assumption
Saudi Arabia	9 500	10 500	750	3 500	750	25 000	Target of 9.5 GW by 2023, followed by 2 GW added every year to 2030
United Arab Emirates	6 000	18 900	4 200	300	600	30 000	Based on Masdar Institute/IRENA (2015)
GCC Total	17 940	40 390	7 160	5 230	1 580	72 300	

Source: As noted in table.

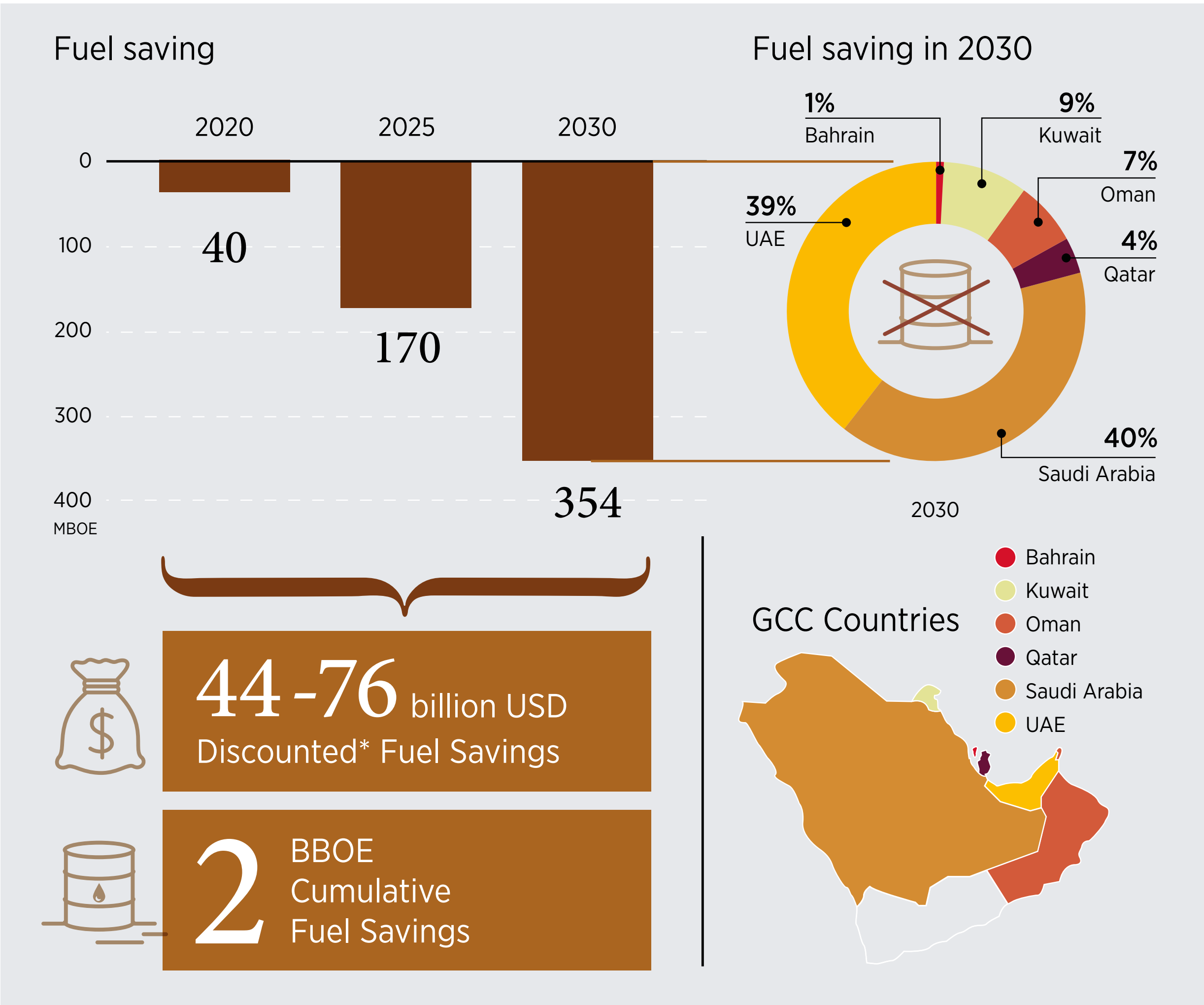
Note: CSP = concentrated solar power; PV = photovoltaic; GCC = Gulf Cooperation Council.

4.1 FUEL AND EMISSIONS SAVINGS

If the region's renewable energy plans are realised, this could result in cumulative savings of 2 billion barrels of oil equivalent (2016–2030) in fossil-fuel consumption. This translates into savings of USD 44 billion to USD 76 billion, depending on oil and gas prices.[2] As more renewable power plants are brought online every year, fossil-fuel savings (gas and oil) in the power and water sectors would peak in 2030 at around 354 MBOE, representing a 23% decrease from the baseline.[3] To put this figure in context, it is roughly equivalent to 970 000 barrels per day, which is comparable to Oman's daily oil production and a quarter of UAE's daily oil production in 2017.

Saudi Arabia, the region's largest consumer of fossil fuels for power production, would save around 141 MBOE of oil and gas resources in 2030, or 40% of the GCC wide savings in that year. The UAE would account for around 139 MBOE of fossil-fuel savings, followed by Kuwait, Oman, Qatar and Bahrain (Figure 4.1). Although the UAE's renewable capacity in 2030 is estimated to be higher than Saudi Arabia,

Figure 4.1 Fossil fuel savings by achieving renewable energy targets, by country in 2030



*Note *Discount rate 5%; low-price scenario (oil: USD 40/barrel; gas: USD 8/MMBtu); high price scenario (oil: USD 90/barrel; gas: USD 12/MMBtu). MBOE = million barrels of oil equivalent.*

2 Assumptions: discount rate 5%; low price scenario (oil: USD 40/barrel; gas: USD 8/MMBtu); high price scenario (oil: USD 90/barrel; gas: USD 12/MMBtu).

3 The baseline scenario includes nuclear plans for the UAE (5.6 GW by 2030) and Saudi Arabia (16 GW by 2030).

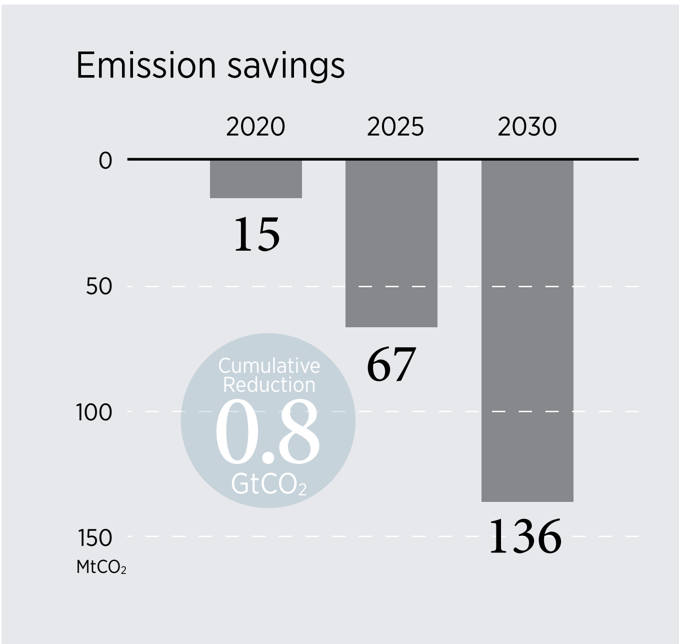
its the expected fuel savings are strikingly similar (Table 4.1). This is because of Saudi Arabia's higher share of CSP, which tends to have much higher capacity factors than solar PV, due to thermal storage (IRENA, 2018c).

Several studies estimate that if Saudi Arabia continues to rely on oil, domestic demand may consume all of production, leaving nothing to export, as early as the mid-2020s and as late as the 2030s (Lahn and Stevens, 2011; Daya and El Baltaji, 2012). IRENA estimates that the fulfilment of renewable energy targets for 2030 could cut the power sector's fossil-fuel consumption by 19% (a reduction of 141 MBOE). Renewable energy therefore offers the country, as well as the region, an important opportunity to optimise the use of fossil fuels, either for exports or as industrial feedstock.

Similarly, renewable energy could also help mitigate the natural gas shortages the GCC economies may experience over the coming decades. In Kuwait, Oman, Saudi Arabia, and the UAE, local production has already been outstripped by domestic market consumption. Gas consumption in the UAE's power sector, for example, could be reduced by 59% compared to the baseline,[4] resulting in a savings of 139 MBOE in 2030, and a significant reduction in costly natural gas imports. Similarly, the power sectors of Kuwait and Oman could save 12% and 16% of their fossil-fuel consumption.

Beyond its role in addressing resource constraints, renewable energy promises to be instrumental in reducing the region's carbon footprint. Achieving renewable energy targets by 2030 could reduce emissions by 0.8 gigatonnes of carbon dioxide ($GtCO_2$), with 136 $MtCo_2$ in year 2030 alone (Figure 4.2).

Figure 4.2 Emissions saved by realising renewable energy deployment plans



4 *The baseline includes 5.6 GW of nuclear energy.*

4.2 EMPLOYMENT AND VALUE CREATION

As global economies continue to struggle with economic boom-bust cycles, unemployment and its associated social and economic impacts remain key concerns and instrumental drivers of public policy. The GCC economies have been relatively resilient in the aftermath of the 2008–2009 financial crisis (Jaber, 2012; El-Katiri, 2016), but the relatively low oil prices of 2014–2017 reinforced a long-standing consensus that the GCC's future growth is tied to its successful economic diversification. In the face of on-going population growth, creating jobs is a key priority for the GCC governments; high-level occupations in scientific research and technological innovation hold particular promise.

Renewable energy, too, offers considerable promise for job creation in the GCC economies, across a range of skillsets. According to IRENA estimates, the renewable energy sector supported about 10.3 million jobs worldwide in 2017 (IRENA, 2018d). Project-level data indicate that, on average, renewable energy create more jobs than fossil-fuels. For instance, solar PV projects create at least twice the number of jobs per unit of electricity generated than do coal or natural gas projects (UKERC, 2014). As countries in the GCC progress toward their targets, they can expect to create significant numbers of new jobs along the way.

Box 4.2 Labour markets in the GCC

The populations of the GCC countries are unique for their very high ratio of expatriates, who constitute around 30% of the total population in Saudi Arabia, 70% in Kuwait and 90% in the United Arab Emirates and Qatar. Expatriate workers make up the vast majority of employees in the private sector. Most are in low-skilled jobs in construction and manufacturing, and a significant number are in skilled and semi-skilled jobs in service sectors.

National populations are generally young (more than 50% of the populations in Saudi Arabia and Kuwait, for example, are under 24), representing a job-creation challenge for the future. In addition to unemployment, the under-employment of young nationals, a growing proportion of whom are well educated, implies a need for more skilled jobs.

Policy responses have included settings quotas for nationals' employment at the company and sector levels. Other efforts have focused on building local knowledge economies. Renewable energy, and the wider category of green energy, holds promise as a source of high-skilled jobs for GCC countries' growing population of youth.

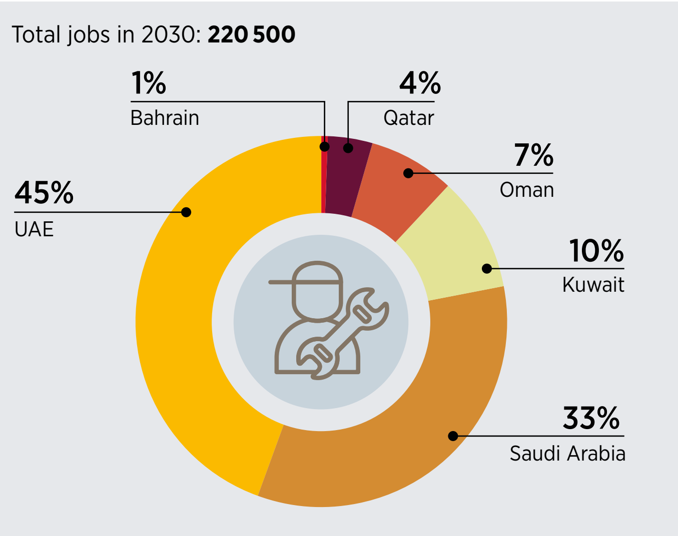
04

4.2.1 Employment

Employment by country

If the region were to progress toward its renewable energy targets, this could create an average of 135 000 direct jobs every year. In 2030, jobs could reach 220 500. Most of these jobs would be concentrated in the UAE and Saudi Arabia, given their significant deployment plans (Figure 4.3).

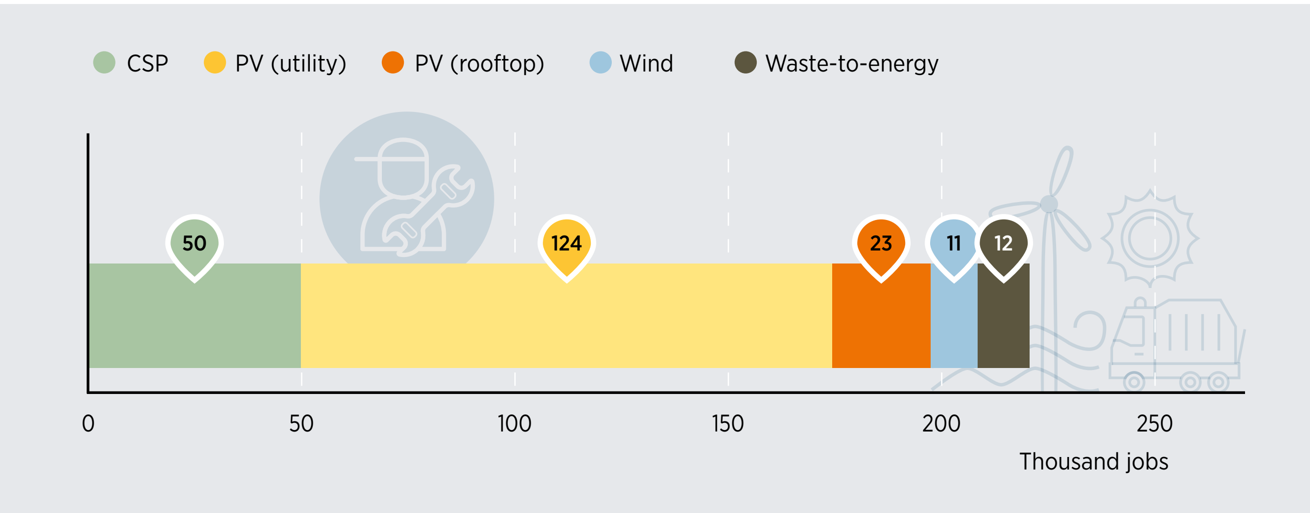
Figure 4.3 Renewable energy jobs in 2030, by country



Employment by technology

Together, solar technologies – including CSP and solar PV (small and large) – would account for 89% of the renewable energy jobs expected in 2030. The deployment of around 40 GW of utility-scale solar PV across the region could result in around 124 000 jobs – more than any other renewable technology. Small-scale rooftop solar projects, which tend to be particularly human-resource intensive, could create 23 000 jobs. Most rooftop solar jobs would be in the UAE and Oman, given their focus on rooftop generation. The construction, operation and maintenance (O&M) and manufacturing of CSP projects could account for 50 000 jobs. Wind energy would also create a significant number of jobs, especially in Saudi Arabia, Oman and Kuwait. Waste-to-energy would create around 6% of the jobs – according to conservative estimates that do not account for operational jobs in waste collection and processing (Figure 4.4).

Figure 4.4 Renewable energy jobs in 2030, by technology



Employment by segment of the value chain

Looking at the segments of the value chain, the largest share of jobs (67% in 2030) would be in construction and installation. As markets mature and local manufacturing increases, the share of jobs in the manufacturing segment is likely to rise. Initially, expatriate workers will represent a significant share of the renewable energy workforce across all segments of the value chain. In the medium to longer term, education and training could help GCC nationals develop the skill levels needed to play a more central role.

4.2.2 Value creation

Developing a local value chain

A lack of local demand is one key reason for the dearth of solar PV or CSP manufacturers in the region. This is of course a two-way problem, because the large-scale application and deployment of these technologies would benefit from the presence of a local supply chain. The identification of the labour, materials and equipment needed for each segment is an essential first step towards maximising local value creation (IRENA, 2017c; IRENA, 2017d). The development of a local market for renewable energy, and of a domestic value chain, will thus go likely hand in hand. As demand picks up and a sizeable market for equipment is created locally and regionally, manufacturers would benefit in a number of ways. First, the GCC is located right in the middle of three major centres of demand for renewable energy equipment: Europe, Africa and Asia. Second, the well-developed infrastructure (seaports, airports) in many GCC cities allows for the quick and efficient shipping of domestic products. Third, the tax and ownership structures in free zones render investment attractive. Fourth, energy prices are still relatively low in most GCC countries, which reduces the costs of production. All of these factors have encouraged companies to set up solar PV component manufacturing plants of various types in the region.

Timely dispatch from local manufacturers, until a few years ago, was a key reason to procure equipment locally. In 2013, companies such as First Solar used

60% local components for the 13 MW solar PV Phase I of Mohammed bin Rashid Al Maktoum Solar Park, mainly transformers and cables, as these were faster to deliver locally than waiting for international deliveries (Bkayrat, 2018). Although they may vary by component, the costs and dispatch times for key components such as modules and inverters from international producers could be lower than local ones. Overall, these considerations need to be balanced against the long-term socio-economic benefits of establishing a local supply chain.

Local content requirements

Since 2016, several GCC markets, such as Kuwait, Oman and Saudi Arabia, introduced local content requirements, similar to those applied for services, O&M and engineering jobs, among others around the world (IRENA, 2017c). The 300 MW solar PV plant at Sakaka in Saudi Arabia, for instance, requires a minimum local content of 30%. Local content requirements could apply to the entire value chains, and do not necessarily need to focus on domestic manufacturing of solar PV modules. In a solar PV project today, for example, modules represent around 35% or less of the project value, down from 60% to 70% in past years (Bkayrat, 2018).

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Equipment providers and manufacturers

A large share of the equipment for most of the renewable energy projects in the GCC is, for now, manufactured by foreign companies. But local suppliers are trying to position themselves at various segments of the value chain.

Both Qatar and Saudi Arabia have announced plans for the establishment of world-class polysilicon production facilities (Figure 4.5). In 2012, IDEA Polysilicon announced plans to set up a facility in Yanbu Industrial City (Saudi Arabia), expected to produce 5 000 tonnes of polysilicon a year and create 1 000 local jobs. Of this, 1 500 tonnes would be turned into 55 million solar wafers with a capacity of 180 MW. Additionally, high purity (11N) silicon would be produced for use in electronics and semi-conductors (ProTenders, 2018). The status of the project remains unknown. Meanwhile, in March 2017, Qatar's Solar Technologies (QSTec) completed a polysilicon production plant in Ras Laffan Industrial City. At current full capacity, it would produce 8 000 tonnes of high-grade polysilicon a year, with the potential to expand up to 45 000 tonnes annually. QStec is a joint venture of the Qatar Foundation (70%), SolarWorld AG (29%) and the Qatar Development Bank (1%). The launch of production at the facility is seen as a key step towards the establishment of a solar manufacturing base in the region.

Solar modules are being produced by several companies in the GCC, including Qatar Solar Energy (QSE) (300 MW), Solon (200 MW), Almaden (150 MW) and Dusol (50 MW) and since 2018, by Noor Solar Technology (300 MW) (Figure 4.5). In the UAE, some manufacturers, such as First Solar, the solar PV panel provider for Phase I of the Mohammed bin Rashid Al Maktoum Solar Park, have established themselves as developers and equipment suppliers of foreign-manufactured panels in the region (First Solar, n.d.). Substantial localisation of manufacturing may happen only with a substantial increase in annual installed capacities. Some companies seek to become system solution providers, such as the Dubai-based manufacturer Noor Solar Technology. As part of its business plan, the company aims to expand its product range beyond solar panels to include of modules and inverters with integrated battery storage. In cooperation with Emirates Glass, Noor Solar integrates solar panels with building surfaces (building-applied solar PV, BAPV) and envisions partnering with a local aluminium producer (Kuqi, 2018). Al Maden Solar has been manufacturing in the UAE since 2017; its applications range from 180 kW systems on farmhouse roofs and shaded car parks to a 10 MW installation at a carport in Dubai (Almaden, 2018a). Microsol, a company based in Fujairah, UAE, acquired a German PV manufacturing

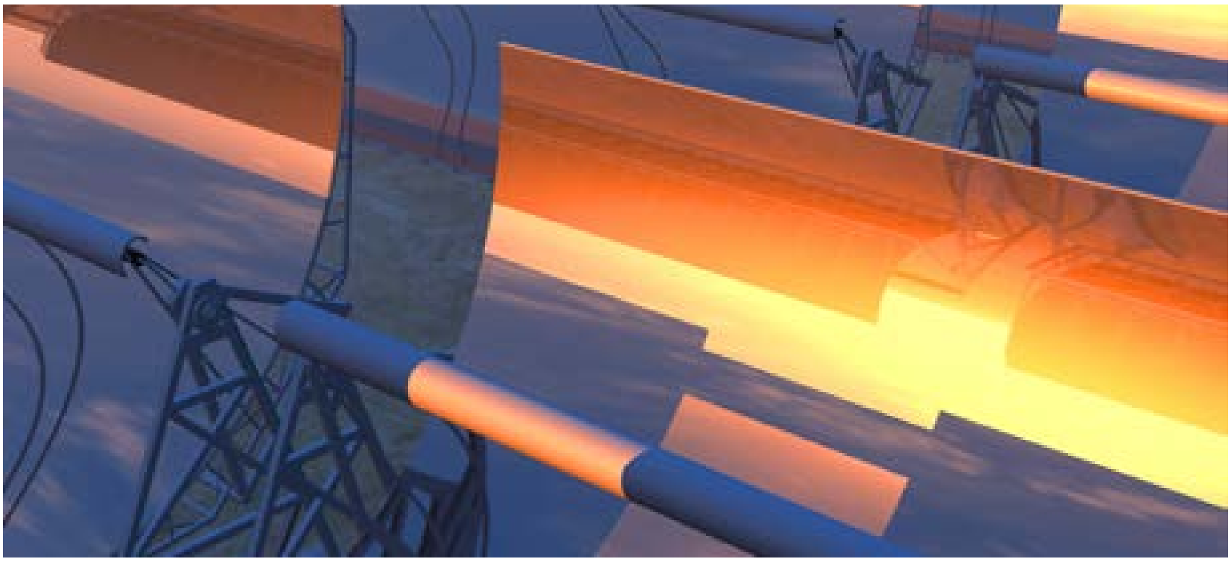

Figure 4.5 Selected local manufacturers of solar PV components

Polysilicon	Inverters	Mounting Structures	Modules
• IDEA Polysilicon • QStec • REC Silicon	• AEC • New Energy • Noor Solar	• Al Jazira • Tiger Profiles	• Almaden • DUSOL • Noor Solar • Qatar Solar Energy • SOLON

company, Solon Group, in 2012, thus enabling Solon/Microsol to strengthen its outreach to the European Union, United States, Africa, Middle East and India. Almaden has built a 150 MW double glass PV module factory in the UAE (Almaden, 2018b).

In Qatar, QSE has established a 300 MW PV module manufacturing facility in Doha, with an eventual goal of producing 2.5 GW (Al Jazeera, 2014; Bellini, 2018e). It has provided the panels for all of Qatar Foundation's solar projects including the Qatar National Convention Centre, Qatar Foundation Student Housing, Solar Car Parking and the retrofitting of several of the university buildings at Education City. In addition to this, QSTec has supplied turnkey solar systems for a number of clients including Kahramaa and Barwa (QSTec, n.d.).

The production of modules and polysilicon represents a non-traditional industry in the regional context. Renewable energy deployment, meanwhile, could also create value in more traditional industries such as the manufacturing of electrical equipment and metallic structures. Japan's KACO and Saudi AEC, for instance, have started producing a series of solar inverters for Shams in Saudi Arabia. The plant is capable of producing 1 GW of inverters every year (AEC, 2015). Similarly, well-established providers for foundries and building material could easily produce mounting structures for solar PV panels; examples in the UAE include Al Jazira and Tiger Profiles.

The enabling regulatory framework for deployment, as well as the competitive advantages of the region, such as its reliable solar resources and availability of large-scale finance, have also attracted foreign investors. SunEdison, for example, is conducting feasibility studies with the National Industrial Clusters Development Programme, the Public Investment Fund and the Saudi Arabian Investment Company, to develop a vertically integrated solar PV manufacturing facility with 3 GW of production capacity and polysilicon production. The polysilicon would be used to supply in-house module manufacturing as well as to cater to the needs of both regional and global markets (SunEdison Inc., 2014).

Separately, Qatar Airways, together with Airbus, Qatar Petroleum, Qatar Science and Technology Park, and Rolls-Royce, have formed the Qatar Advanced Biofuel Platform, a consortium that aims to develop the first large-scale algae bio-jet fuel value chain in the world (IRENA, REN21 and UAE MOFA, 2013). Similarly, in the UAE, the Sustainable Bioenergy Research Consortium (SBRC) has conducted research since 2011 to develop alternative fuel supply (Box 4.3) (SBRC, 2018).

04

Box 4.3 The value chain of aviation biofuels in the UAE

The Sustainable Bioenergy Research Consortium (SBRC) was founded by the Masdar Institute of Science and Technology, Etihad Airways, the Boeing Company and Honeywell-UOP. The consortium was later joined by Safran, GE and the Abu Dhabi Oil Refining Company (Takreer) (SBRC, 2018).

The Seawater Energy and Agriculture System (SEAS) is the flagship project of the consortium. It integrates a system of aquaculture, halophyte agriculture and agroforestry. The consortium has a 2-hectare solar-powered SEAS pilot facility operating in Masdar City, Abu Dhabi. The facility aims to evaluate the process of growing Salicornia bigelovii using marine aquaculture wastewater for the purpose of generating food products and aviation biofuels, and to determine the technical parameters of an efficient scale-up to commercial levels. A 200 hectare demonstration-scale plant was planned for 2018, while commercial-scale operations at 100 000 hectares and above were being considered. The process is showing a comparatively low carbon footprint for the produced aviation fuel (Warshay *et al.*, 2016).

Conceptually, the SEAS platform is expected to enable the development of a local value chain through secondary industrial activities. SBRC partners are assessing the downstream potential of the SEAS platform to provide enough biomass, at scale, that would justify investment from its member, ADNOC Refining, into deploying infrastructure to process Salicornia oil locally into sustainable aviation fuels. Further down the value chain, the alternative fuel would enable another member of the SBRC, Etihad Airways, to comply with the mandates established by the International Civil Aviation Organization (ICAO) through its Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), and to help meet the aviation industry's targets for lowering its carbon footprint.

Leveraging on existing industries

Developing a local value chain for solar PV offers the chance to leverage existing industries to provide required materials including glass, steel, aluminium, concrete, as well as silicon, copper and plastic (IRENA, 2017c), for the manufacturing of components such as panels, inverters, mounting structures and cables. The further development of local supply chains depends on the progress and size of relevant local economic segments. The manufacturing industry plays a role across all national markets in the GCC (Dubai Free Zone, n.d.-a; Oxford Business Group, 2018a). Oman's manufacturing sector grew 17% between 2017 and 2018 (Oxford Business Group, 2018b). Several GCC countries are among the leading aluminium producers globally. The UAE can rely on a domestic industry for steel, aluminium and building materials (Dubai Free Zone, n.d.-b), while Oman's Sohar Aluminium plant, for instance, produced nearly 400 000 tonnes in 2016 (Sohar Aluminium, 2017). Aluminium Bahrain has expanded through a USD 3 billion investment, which expects to see production grow to 1.5 million tonnes annually – an increase of 50% (Oxford Business Group, 2018a). The aluminium industry can be leveraged for the production of solar PV support structures.

The cabling industry is spread across the region. Saudi Arabia's structured cabling market is expected to expand at a compound annual growth rate of 10.7% during 2018–2024, partly due to the growth of energy investments, along with investments in hotels, hospitals and commercial establishments that would require cabling (PR Newswire, 2018). Revenues of the UAE's power cabling industry are expected to increase at a compound annual growth rate of 2.5% over the coming five years (Utilities Middle East, 2018). To cater to a smaller economy, Kuwait keeps its cabling industry focused on exports, with a potential to supply neighbouring markets (Oxford Business Group, 2017). Cabling in renewable energy projects is often locally sourced, although specialised cables may be procured from abroad (Mkalalati, 2018).

Mounting structures and electrical equipment are largely sourced locally. In Saudi Arabia, international suppliers often collaborate with local producers, both to fulfil local content quotas and to minimise the costs of transport and import duties (Mkalalati, 2018). The Kingdom's well-developed steel industry caters to neighbouring countries in the region, and could be in a position to produce up to 75% of required mounting structures domestically (Mkalalati, 2018). Procuring steel from abroad and processing it locally is economically viable in several GCC countries, despite import taxes such as a 5% tariff in the UAE and Oman (Zywietz, 2018).

By contrast, transformers, inverters and other high-end technology components may be more difficult to localise fully. Instead, parts could be imported and assembled domestically, which has been successfully done in Saudi Arabia, the UAE and Oman. Solar transformers and inverters cost less to assemble locally. Also, they are stationary, comprise fewer moving parts and are thus more straightforward than, for example, the highly technical specifications prevalent in oil and gas installations (Mkalalati, 2018).

Expanding local value chains

Despite positive developments in the PV manufacturing industry of several GCC markets, localising value chains remains a challenge. So far, local suppliers of solar PV modules and inverters are more expensive than international ones and struggle to offer long-term competitive costs at the right quality level. This is usually the case for most infant industries. The development of the renewable energy value chain in the region requires a range of policies and dedicated efforts to ensure coherence among these policy areas and the relevant stakeholders. The main policy areas concern deployment measures in support of renewable energy, industrial policies to enhance capacities along the supply chain, education and training policies to ensure a well-trained and capable workforce.

From the deployment standpoint, targets should be accompanied by suitable policy instruments that provide a stable and predictable environment for attracting investments. Larger markets such as Saudi Arabia and the United Arab Emirates, in

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particular, could create an enabling environment for local industries by making reliable plans and setting up predictable policy frameworks to boost investors' confidence.

The uptake of renewable energy could lead to the establishment of a regional market of equipment and services, offering promising opportunities to countries with well-developed relevant industries and service sectors. Countries with relatively nascent industries can also contribute to this market by adopting industrial policies to help build or strengthen their domestic capabilities. Potential measures may include preferential access to credit, and formation of economic incubators and industry clusters. Strengthening the industrial capability and competitiveness of domestic firms, may also benefit from measures such as promotion of joint ventures, industrial upgrading programmes, supplier development programmes and investment promotion schemes.

To ensure the development of the nascent renewable energy industry in the region, policy support should be timebound and include broader aspects beyond deployment, human resources and industrial development.

Education is an essential way to create local value. So far, the skills and knowledge required for renewable energy and related industries have yet to be integrated into educational programmes in the region (Zywietz, 2018).

Solar PV manufacturers often rely on skilled expatriate labour to run their assembly lines. Some of the manufacturers keep their assembly lines partially manual to ensure adaptability of their production to changing technical specifications, and to account for the variable skill levels of the workforce (Bkayrat, 2018) (Kuqi, 2018). Technical education and training offered by dedicated institutions or as part of university curricula can help equip the workforce with adequate skills required in the local value chains (IRENA, 2017c).

Renewable energy projects and initiatives in the GCC have been accompanied by tangible developments in segments of the domestic renewable energy industry. As the renewable energy sector in the region grows, it could become a new engine of growth that supports national plans for economic diversification and socio-economic development by creating local industries as well as employment.

It is clear that renewable energy can provide remarkable benefits in terms of fossil-fuel savings, emission reductions and job creation, and that all of this can be achieved with increasingly cost-effective technologies. However, achieving renewable energy targets and maximising their socio-economic impacts requires the appropriate institutional and policy frameworks to encourage deployment, and strengthen local industries through technology transfer, investment promotion mechanisms and education and training. A look across the region shows that, while frameworks are in their early stages of development, some very promising initiatives have been implemented that can serve as examples for the region. Renewable-energy-based desalination, for instance, presents a promising avenue for addressing the strains on regional water resources in a sustainable way.

4.3 WATER SAVINGS

The water and energy sectors are intrinsically linked in the GCC, as well as globally. Water is a critical input for fuel extraction and processing as well as for power generation. Energy, in turn, is a key requirement to access, process, clean, desalinate and transport water to its users.

With one of the fastest-growing populations in the world, the region's demand for water is expected to increase fivefold by 2050. Meanwhile, its renewable water resources count among the smallest of all world regions.

The following section examines the potential role of renewable energy in alleviating the water intensity of the regional power sectors and the provision of water through sustainable desalination.

4.3.1 Water savings in the power sector

Water intensity holds special importance in the GCC, which is among the most water-stressed regions in the world, where domestic demand for water is growing amid very limited replenishable water resources. This amplifies the importance of the potential of renewable energy technologies to generate water savings in the power sector. According to IRENA calculations (IRENA, 2015), overall, renewable energy requires less water than fossil or nuclear sources per generated kilowatt hour. The exact level of intensity varies by type of resource and technology. While the operational water needs of solar PV and wind are consistently low (118 and 0 litres per MWh (l/MWh)), for CSP, water intensity depends on the applied technology. During CSP operations, the water consumption levels needed for wet cooling (up to 3 000 l/MWh) are comparable to those of conventional thermoelectric power plants (Burkhardt *et al.*, 2011; Padmanathan, 2018). By contrast, IRENA calculations show that CSP, geothermal and biogas achieve very low water consumption intensities when dry cooling is used, such as for CSP power tower or trough (118 l/MWh and 123 l/MWh), biogas (159 l/MWh) and geothermal flash (0 l/MWh). However, given its potentially higher energy demand, dry cooling cannot, per se, be taken as the cooling technology of choice. The optimum choice will depend on the local power and water supply markets, prices as well as commitments to energy efficiency and demand management.

If the GCC countries were to realise their renewable energy targets (Box 4.1), this would lead to an estimated overall reduction of 17% and 12% in water withdrawal and consumption, respectively, in the power sectors of the region[5] (Figure 4.6). This is equivalent to an annual reduction of 11.5 trillion litres of water withdrawn and 170 billion litres of water consumed. Much of this reduction would be in Saudi Arabia and UAE, due to their plans to add significant shares of renewable energy in the power sector.

As mentioned before, most power plants in the region rely on seawater cooling, whereas crude-oil extraction uses treated water. Depending on the technology and other factors, such as plant location, renewables may require substantially less water. It should be noted, however, that the water may be procured from other water sources than those used for conventional generation. Therefore, a shift towards renewable energy needs to be guided by a careful examination of the opportunities and risks for the sustainability of water sources in specific contexts.

5 *The analysis considers water consumption for power generation in all GCC countries and includes water use during fuel extraction only for those countries using high shares of domestic oil resources for generation (Kuwait, Oman and Saudi Arabia). Water consumption factors for different technologies are derived primarily from NREL (2011) using median values. Total water use does not consider the sources of water due to lack of available data.*

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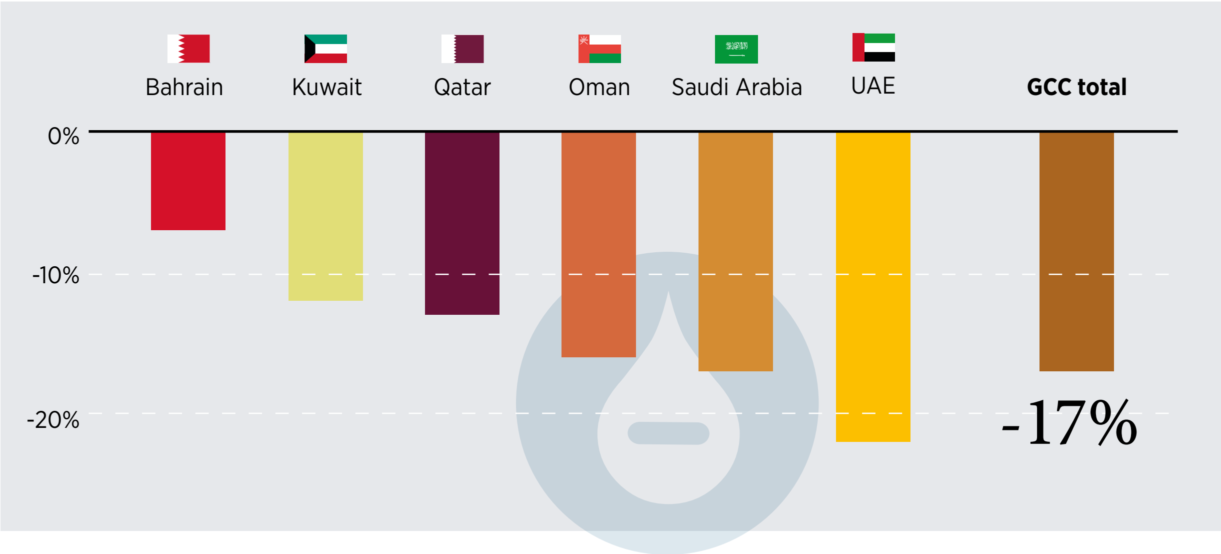
Figure 4.6 Reduction in water withdrawal by realising renewable energy deployment plans



4.3.2 Renewable desalination

Energy is needed in several segments of the water supply chain, including withdrawal, distribution, wastewater collection, treatment and the installation and O&M of water supply facilities (IRENA, 2015). In each case, renewables could substantially reduce energy intensity, depending on the selected technology. Solar-powered desalination offers one example.

Generally, desalination technologies fall into two main categories – thermal and membrane-based. Thermal desalination technologies (in particular Multi-Stage Flash (MSF)) have traditionally been preferred in the GCC region. Membrane-based desalination, such as reverse osmosis, mainly requires electricity inputs and is generally less energy intensive than thermal desalination.

The power and water sectors of the GCC countries are very closely inter-linked. Power plants in the region are equipped with thermal desalination units and co-generate power and water. Seawater desalination options now provide anywhere from 27% of total water demand in Oman to 87% in Qatar. However, desalination is an expensive and energy-intensive process, which contributes to concerns about the consumption of fossil fuels, energy security and environmental degradation. Desalination accounts for a significant share of the total input fuel consumed in the power and water sector (IRENA, 2016a). In Qatar and the UAE, for instance, almost 30% of fuel consumed during power and water generation is due to desalination (Lahn *et al.*, 2013).

These factors have compelled governments and the private sector to explore more affordable and sustainable ways to power desalination such as reverse osmosis and renewable energy.

The past decade has seen a clear shift towards new investments in membrane-based desalination in the region. Its higher energy efficiency, compared to MSF technology, makes a strong business case for reverse osmosis, even where natural gas is very cost-competitive (Reinisch, 2018). There are several regional project examples for reverse osmosis installations.

In Abu Dhabi, ADWEA is spearheading the trend and constructing the world's largest facility of this type in Taweela, with a generation capacity of 900 000 m^3 per day (Abdul Kader, 2018). Oman has put in place reverse osmosis in both the Salalah Integrated Water and Power Plant and the Barka II Power and Desalination Plant (Oman Power and Water Procurement Co., n.d.; Sembcorp Salalah, n.d.). Kuwait added a reverse osmosis facility to the Az-Zour South MSF plant, while the UAE opened a MED-

RO co-generation plant in Fujairah in 2015 and Saudi Arabia runs a hybrid Ras Al-Khair Power and Water Plant with a 1:3 share of reverse osmosis and MSF capacities (GWI, 2016; IRENA, 2016a). The increase in reverse osmosis can serve as an opportunity for greater integration of renewables, such as solar PV and wind, as they become cost-effective alternatives to fossil-fuel-based electricity generation.

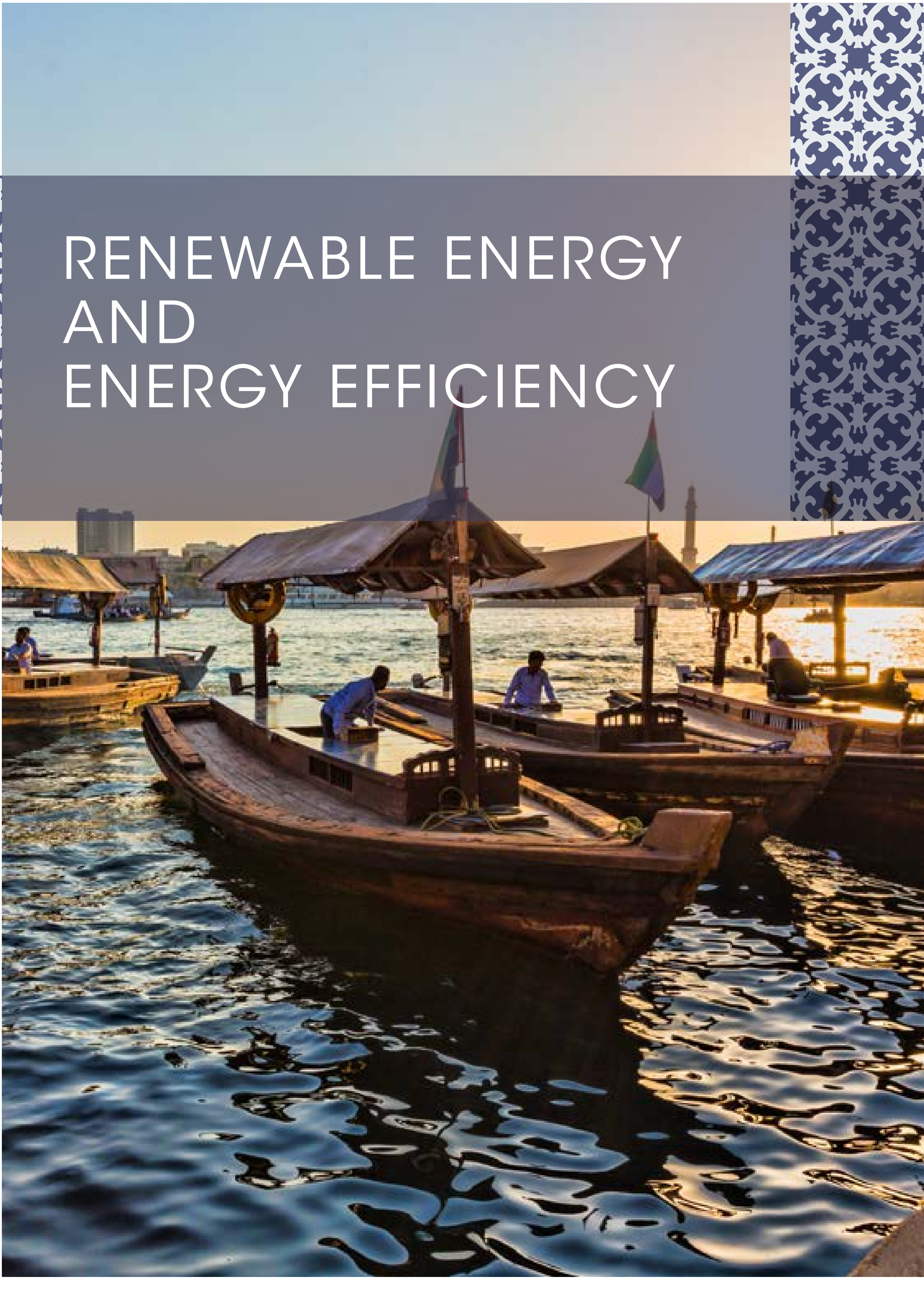
There are two main approaches to integrating renewables into the desalination process: (1) *gradually electrifying* desalination along with gradually integrating higher shares of renewables into the overall electricity mix, or (2) *co-locating* desalination and renewable installations. The second option may be particularly attractive in specific cases, for example, remote off-grid settings or if a utility decides to build a co-located system with low emissions.

With the advent of cost-effective solar PV in the region, several renewable desalination projects are being established. The UAE's Masdar is evaluating five pilot plants with different seawater desalination technologies and configurations. Four years of tests indicate that solar PV–powered reverse osmosis is commercially viable. Levelised costs of below USD 0.9/m^3 (AED 3.3/m^3) can be realised in renewable desalination if applied at a scale of 100 000 m^3/day or higher, compared to a current average water production cost of USD 1.41/m^3 (AED 5.15/m^3) in the UAE (Masdar, 2018c). Oman's PAEW is conducting technical and financial feasibility studies of, for example, the Sharqiyah 80 000 m^3/day reverse osmosis desalination plant, which will be partially powered by a dedicated solar PV facility of undisclosed capacity (Construction Week, 2018a). In Saudi Arabia, the King Abdullah Economic City (KAEC) has selected Metito to construct a desalination plant of 30 000 m^3 capacity, which will be powered by a solar PV array and grid (Construction Week, 2018b).

Stand-alone physically integrated renewable desalination systems can face several challenges. One, there is lower solar irradiation in coastal areas, compared to in-land areas, because of both fog and smog (Ghedira, 2018). Two, coastal areas are often densely populated, with little available land. Three, humidity-related corrosion of solar technology infrastructure is a concern and is likely lower in-land (Reinisch, 2018). Four, the intermittency of on-site solar PV or wind can interrupt the desalination process and lead to the clogging of membrane filters or membrane fouling (Ghedira, 2018).

However, most of these problems can be addressed through, firstly, the national grid that provides solar power to desalination plants without immediate need for co-location of reverse osmosis and solar plants. Secondly, hybrid systems that integrate on-site renewables and grid-connected power supply. Thirdly, batteries that balance out temporary fluctuations. In Saudi Arabia, Advanced Water Technology (AWT), a subsidiary of TAQNIA, the commercial arm of King Abdulaziz City for Science & Technology (KACST), developed a 60 000 m^3/day reverse osmosis desalination plant powered by a 15 MW solar PV plant in 2018. The project is equipped with a smart control system that aligns the power demand of the reverse osmosis processes to the variable available solar power (TAQNIA, n.d.).

RENEWABLE ENERGY AND ENERGY EFFICIENCY



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Energy efficiency is a vital component of policies promoting environmental, climatic and economic resilience and sustainability. Reducing greenhouse gas emissions requires both deploying low-carbon energy and improving the efficiency of energy consumption. As such, improved energy efficiency is a vital component of an integrated national energy strategy, and supports the advancement of renewable energy.

The GCC countries have some of the highest per capita energy intensities in the world due to several factors which include harsh climatic conditions, energy intensive heavy industries and oil and gas sectors, behaviour patterns, and inefficient infrastructure in the power, water, transport and industrial sectors.

Governments in the region have begun to advance energy efficiency as a component of broader sustainable programmes promoting renewables and other low-carbon energy sources. Specific efforts have included setting targets for improvements in efficiency; reforming energy pricing structures; introducing standards for the efficiency of buildings, vehicles and appliances; raising consumers' awareness of energy-efficient practices; boosting efficiency in government assets by direct action; and introducing technologies such as smart meters, light-emitting diode (LED) lighting, reverse osmosis desalination and district cooling.

Improving energy efficiency and energy productivity offers a number of benefits including reduced spending on power generation and transmission, improved competitiveness of industrial firms, reduced costs for residents and businesses, the possibility of increased hydrocarbon exports, and reduced stress on government budgets. Environmental benefits include reductions in air pollution and lower emissions of greenhouse gases.

Initiatives that help increase energy efficiency can also support the advancement of renewable energy through a number of channels. First, reducing energy demand makes it easier to achieve a given target for a share of renewables. Second, shaping the energy demand using measures such as peak shaving, demand response and real-time pricing can support the integration of variable renewable energy technologies into the electricity grid. Third, reforms in energy pricing can level the playing field for renewable energy technologies, thus incentivising their uptake in both on-grid and off-grid settings. Fourth, the introduction of electric vehicles can help pave the way for integration of renewable electricity in the transport sector. Finally, in the specific context of GCC, the ongoing shift towards energy-efficient reverse osmosis creates an opportunity for powering the desalination sector through renewable electricity.

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5.1 ENERGY SECTOR STATUS AND TRENDS

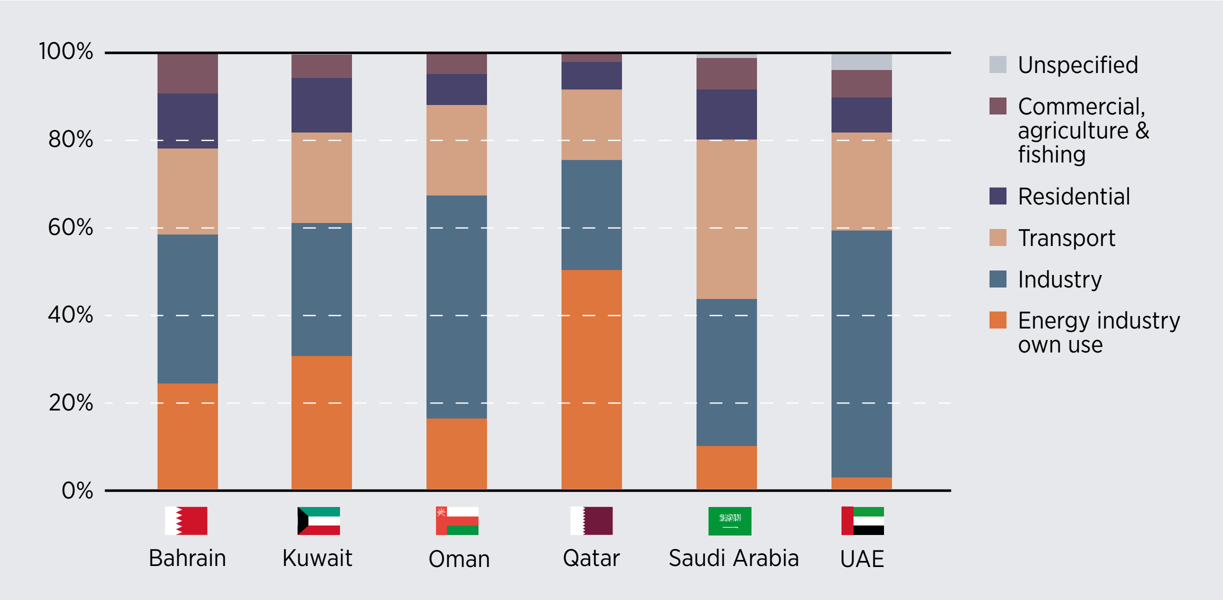
Energy efficiency is related to energy intensity (the quantity of energy or electricity used per capita or per unit of GDP) and energy productivity (the value or quantity of output produced for a given energy input). While primary energy intensity in most parts of the world is decreasing, an upward trend is observed in the countries of the MENA region, as energy consumption increases amid high economic growth and policies that provide fuel and power subsidies. The GCC countries in particular have some of the highest per capita energy intensities in the world, led by Qatar and Bahrain. This is partly due to harsh climatic conditions in the region, and partly the structure of the economies, in particular to the important role of oil and gas production and heavy industry. It is also driven by behavioral patterns and relatively inefficient buildings and infrastructure in the power, water, transport and industrial sectors.

Figure 5.1 depicts the GCC members' patterns of energy consumption. The large oil and gas sector attracts a major share of consumption in Qatar, Bahrain and Kuwait.

Final energy consumption (Figure 5.2) is mostly in the form of oil and gas, with electricity contributing up to 20% (higher share in Bahrain due to the Alba aluminium plant). The main final uses of gas are for industrial heat, oil industry own use, petrochemical feedstock, iron ore reduction and aluminium smelting (for which an intermediate step of self-generated electricity is apparently not reflected in data on final use). Biofuels are used only minimally.[2] The energy-intensive industries, notably steel, aluminium and cement, feature high levels of efficiency; most companies in these GCC industries come close to the world's top performers.

To significantly impact consumption and CO_2 emissions, therefore, efficiency measures would have to be applied across all final energy carriers, as well

Figure 5.1 Total final energy consumption by sector and country in 2016



Source: IEA, 2016.

Note: This chart excludes international marine bunkers and international aviation; these are extremely large consumers in the UAE in particular, but the host country has relatively little influence over efficiency. It also excludes non-energy use, e.g. petrochemical feedstocks.

2 *Biofuels have limited competitive advantage and are therefore used minimally. Converting waste cooking oil is one example, alternative fuels another (The Neutral Group, 2018); see also Chapter 4.*

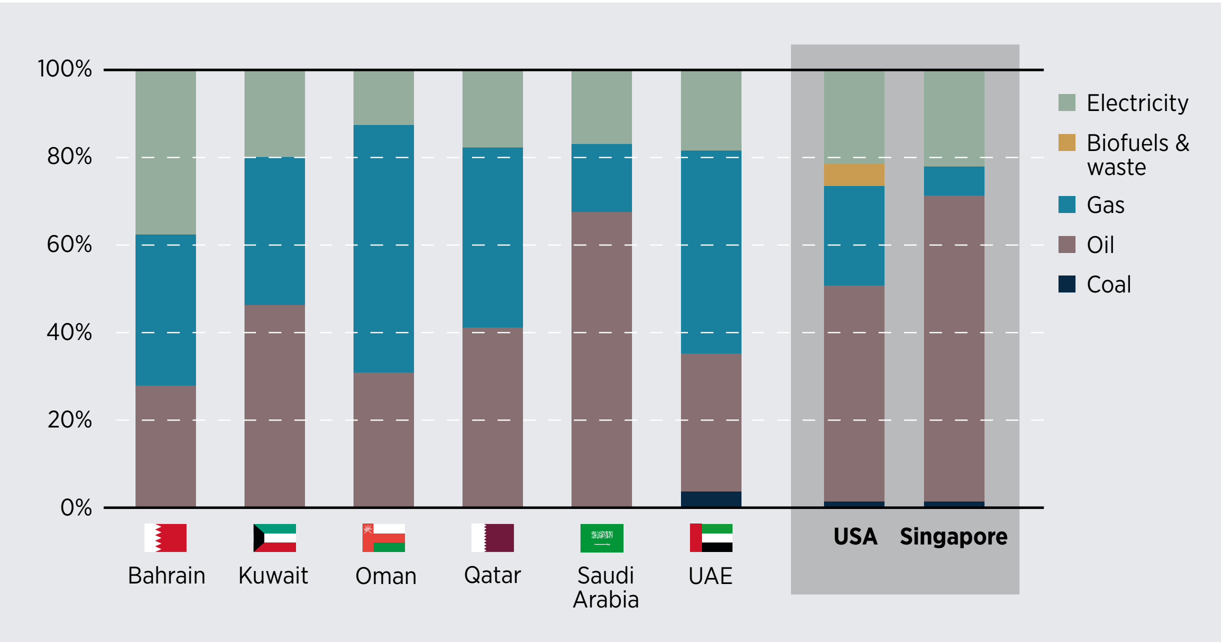
as generation and transmission. Greater electrification of transport and industry would increase the ultimate scope of renewables in electricity generation, boosting energy efficiency measures.

The per capita electricity consumption has been gradually increasing in most GCC countries amid improving living standards and continued industrialisation (Figure 5.3). In tandem, the electricity intensity of GDP – the amount of electricity required to produce a unit of economic output – has been rising, with the exception of Qatar, where the rapid growth of GDP has outpaced required generation (Figure 5.4).

Energy or electricity intensity (per capita or per unit of GDP) is a simplistic metric for efficiency that does not account for other key factors, such as climate and economic structure (the share of services, light and heavy industries). However, it is still instructive for comparisons across time and countries (Howarth and Phil, 2016). Some other countries with high electricity intensity, such as the Russian Federation and the United States, have managed to reduce it through efficiency improvements and structural economic shifts (some of these due to natural demographic changes).

Energy flows and use within an economy can be represented by a Sankey diagram and used to calculate the amount of waste energy, as done for Saudi Arabia in Figure 5.5. In this case, excluding non-energy use (feedstocks) and imports and exports, an estimated 5 596 petajoule (PJ) was rejected (waste) while 2 571 PJ ended up as useful energy services. A large part of thermal losses is unavoidable, of course, for thermodynamic and practical reasons. However, the high level of rejected energy in Saudi Arabia indicates a substantially low level of efficiency, with major losses occurring particularly in power generation and transport.

Figure 5.2 Final energy consumption by source and country in 2016, and compared with the United States and Singapore



Source: IEA, 2016.

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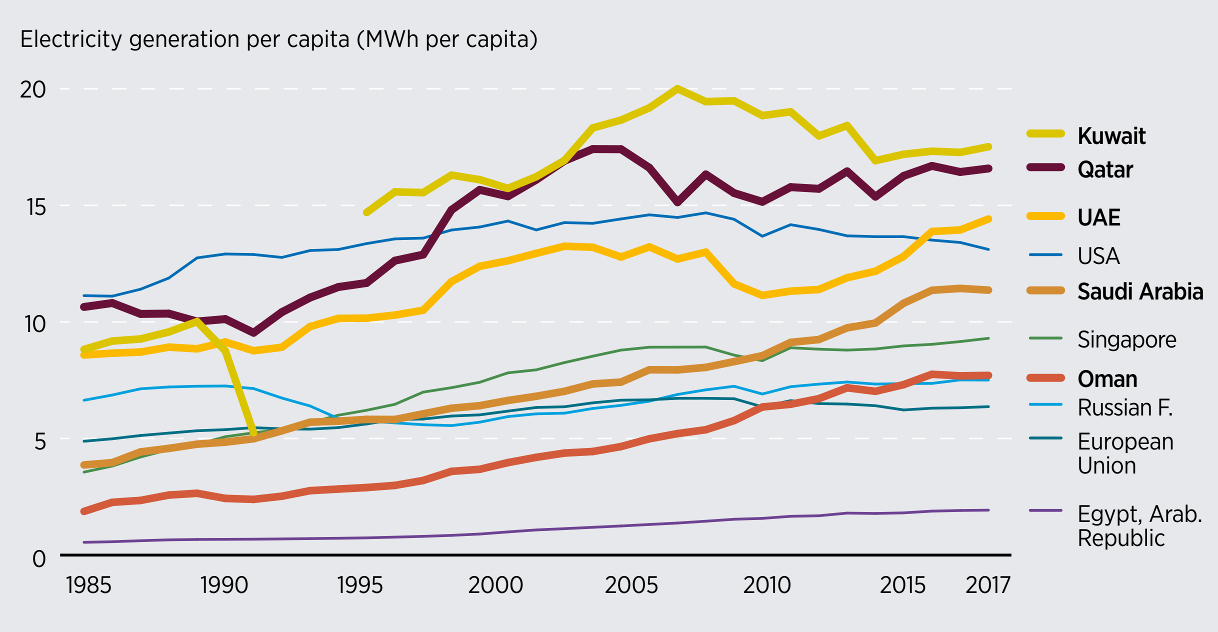
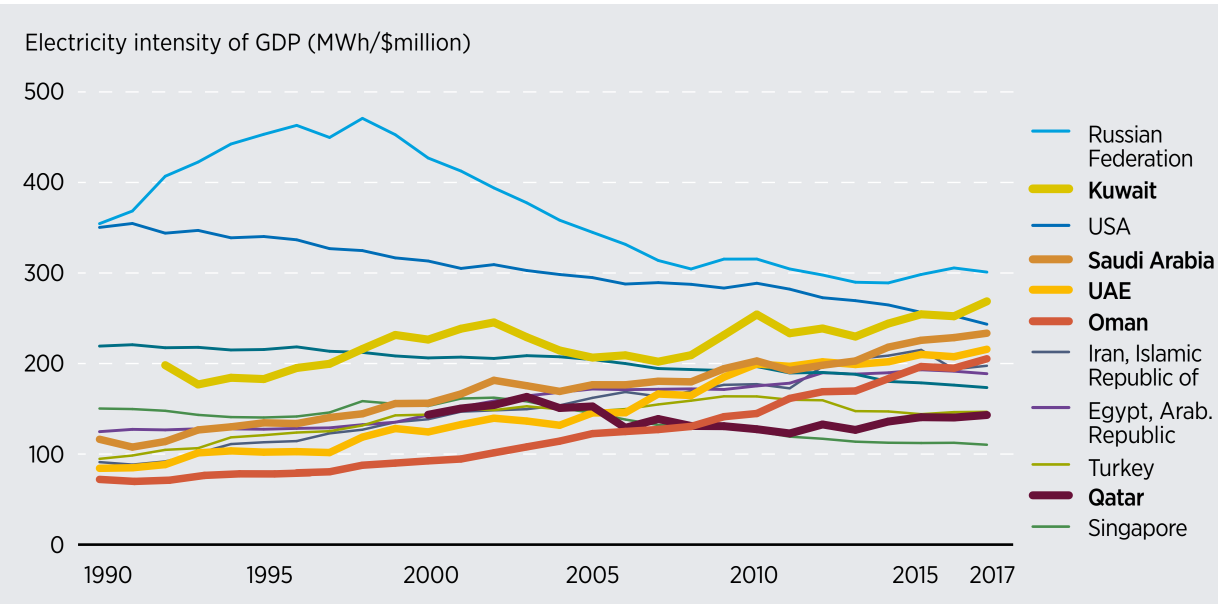
Figure 5.3 Per capita electricity generation in the GCC and selected comparators, 1985-2015



Source: BP, 2018; World Bank, 2017a

Note: Comparators include a regional peer (Egypt), one small high-income state with a hot climate (Singapore) and other high-income economies (United States, European Union).

Figure 5.4 Electricity intensity of GDP, PPP (constant USD 2011) in GCC and selected comparators, 1985-2015



Source: BP, 2018; World Bank, 2017b.

Note: Comparators include several regional peers (Turkey, Egypt, Iran), one small industrialised state with a hot climate (Singapore) and other leading economies (United States, European Union, the Russian Federation).

5.2 CURRENT POLICY AND OUTLOOK

GCC governments' increased focus on improving energy efficiency is driven by a number of factors. The most important of these is the growth of (1) the fiscal burden of subsidies and (2) the share of oil and gas production devoted to domestic consumption. Low oil prices in 2014-2016 spurred regional governments to seek additional revenue sources and/or minimise outlays. However, energy efficiency has been a mandate in all GCC countries since the early 2000s, when oil prices were at their highest. As of today, all GCC countries have some form of energy efficiency targets (Table 5.1). Bahrain is targeting a 6% reduction in final energy consumption by 2025 and Kuwait is aiming to improve its power generation efficiency by 5% by 2020. Qatar initially announced an aggressive target of reducing per capita electricity consumption by 20% by 2017. This was later adjusted under the Qatar National Development Strategy and the National Program for Conservation and Energy Efficiency (Tarsheed), which set targets for per capita consumption of electricity and water to be reduced by 8% and 15%, respectively, during the period 2018-2022. Saudi Arabia is aiming to cut peak electricity demand by 14% and overall electricity consumption by 8% by 2021. UAE plans to reduce carbon footprint of power generation by 70% by 2050 as part of its Energy Strategy 2050. Some of these targets have been included along with other

Table 5.1 Energy efficiency targets of the GCC countries and key global actors

Energy efficiency targets of the GCC economies		
Country	**Target**	**Year**
Bahrain	Reduce electricity consumption by **6%**	2025
Kuwait	Improve generation efficiency by **5%**	2020
	Improve generation efficiency by **15%** and reduce energy consumption by **30%**	2030
Oman	Reduce greenhouse gas emissions by **2%**	2030
Qatar	Reduce per capita electricity and water consumption by **8%** and **15%**, respectively	2022
Saudi Arabia	Reduce electricity consumption and peak demand by **8%** and **14%**, respectively	2021
United Arab Emirates	Reduce power consumption by **30%** (in Dubai) below business as usual	2030
	Reduce carbon footprint of power generation by **70%**	2050
	Increase energy consumption efficiency for corporates and individuals by **40%**	2050

Energy efficiency targets of key global economies and economic groupings		
Country	**Target**	**Year**
Brazil	Reduce final energy consumption by **10%**	2030
China	Reduce energy intensity by **15%**	2020
	Reduce carbon dioxide intensity by **45%**	2020
India	Reduce carbon dioxide intensity by **35%**	2030
ASEAN* countries	Reduce energy intensity by **20%**	2020
Norway	Improve energy intensity by **30%**	2030
United Kingdom	Reduce final energy consumption by **18%**	2020
European Union	Increase overall energy efficiency by **32.5%**	2030

Source: KAPSARC, 2017; REN21, 2017; UAE Government, 2018; European Parliament, 2018
*Note: *The Association of Southeast Asian Nations includes Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam.*

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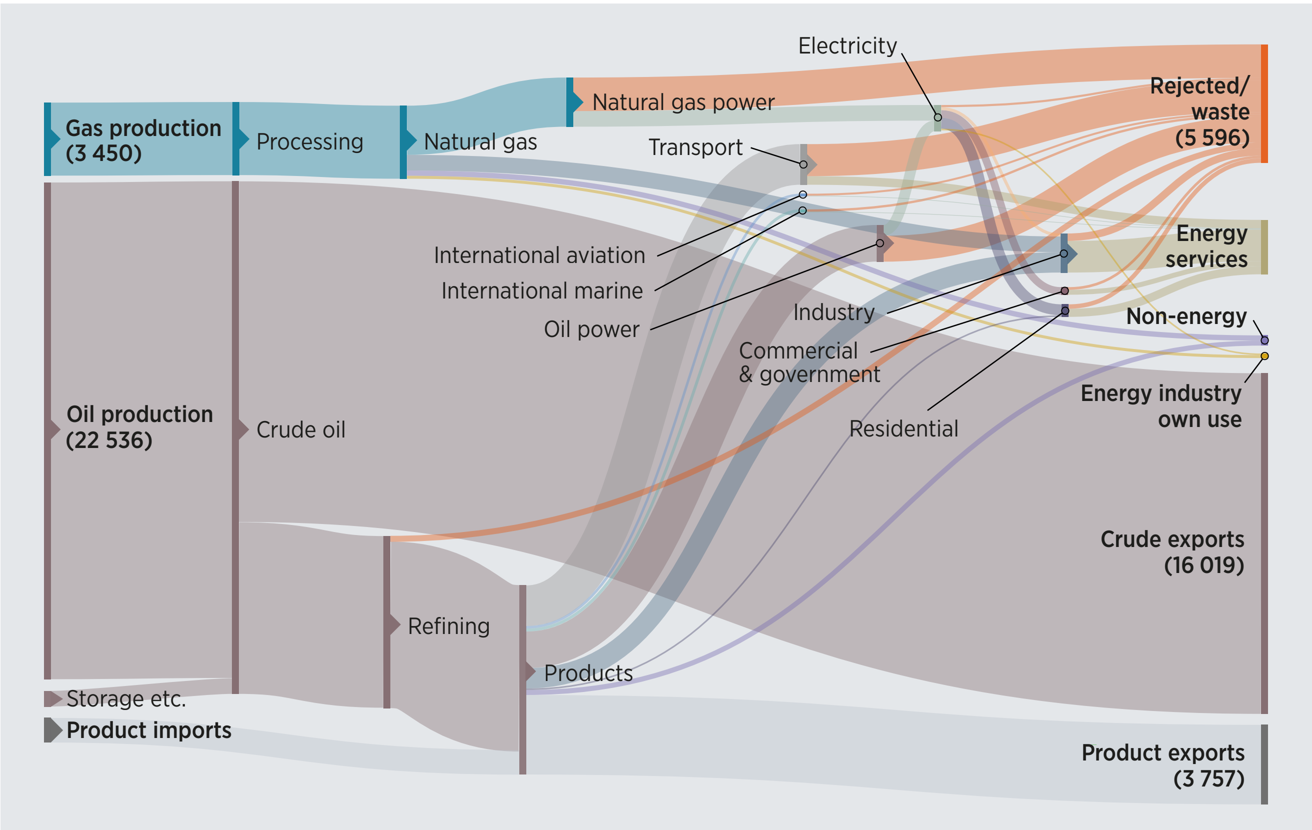
wider goals are established more cohesively under the Nationally Determined Contributions (NDCs) to the Paris Climate Accord (see Chapter 2).

Measuring progress towards these energy efficiency targets has its challenges. It can be hard to estimate business-as-usual trends, much less distinguish these from actual reductions in usage. Extraneous factors such as changes in economic growth rates come into play. Meanwhile, good estimates are needed to compare regional energy efficiency with best-in-class global benchmarks, whether at a macro-level or at the level of an individual sector (*e.g.* the cement or aluminium industry).

Accelerating progress toward the set targets, in the face of current patterns of energy use, demands a cohesive set of regulatory frameworks and initiatives, some of which are discussed in this section.

Figure 5.5 Saudi Arabia's energy flows in 2016 (PJ)



Source: IEA, 2016.

5.2.1 Green building codes

Green building codes have been adopted by governments across the region. Bahrain has implemented these codes for government buildings. Oman has committed to adopting technologies that would further the development of sustainable, green buildings. Saudi Arabia mandated that all new buildings install thermal insulation in order to receive a connection with the Saudi Electric Company, and has one of the most comprehensive building energy efficiency codes in the region. Kuwait updated its Energy Conservation Code of Practice in 2010, and then again in 2014, to specify the minimum energy-efficient practices required for new buildings. In the UAE, Abu Dhabi established the Pearl Rating System under the Estidama Scheme of the Abu Dhabi Urban Planning Council to evaluate resource depletion, energy and water consumption, waste management and natural systems protection in buildings. All new buildings must achieve at least a 1 Pearl rating, and all government-funded buildings, schools, hotels and mosques must achieve a 2 Pearl rating. In Dubai, the Dubai Green Building Regulations (DGBR) were made compulsory for all buildings across the emirate in 2014. In 2016, Al Sa'fat, Dubai's version of the Pearl Rating System, was introduced as a voluntary green rating scheme for all new buildings in the emirate.

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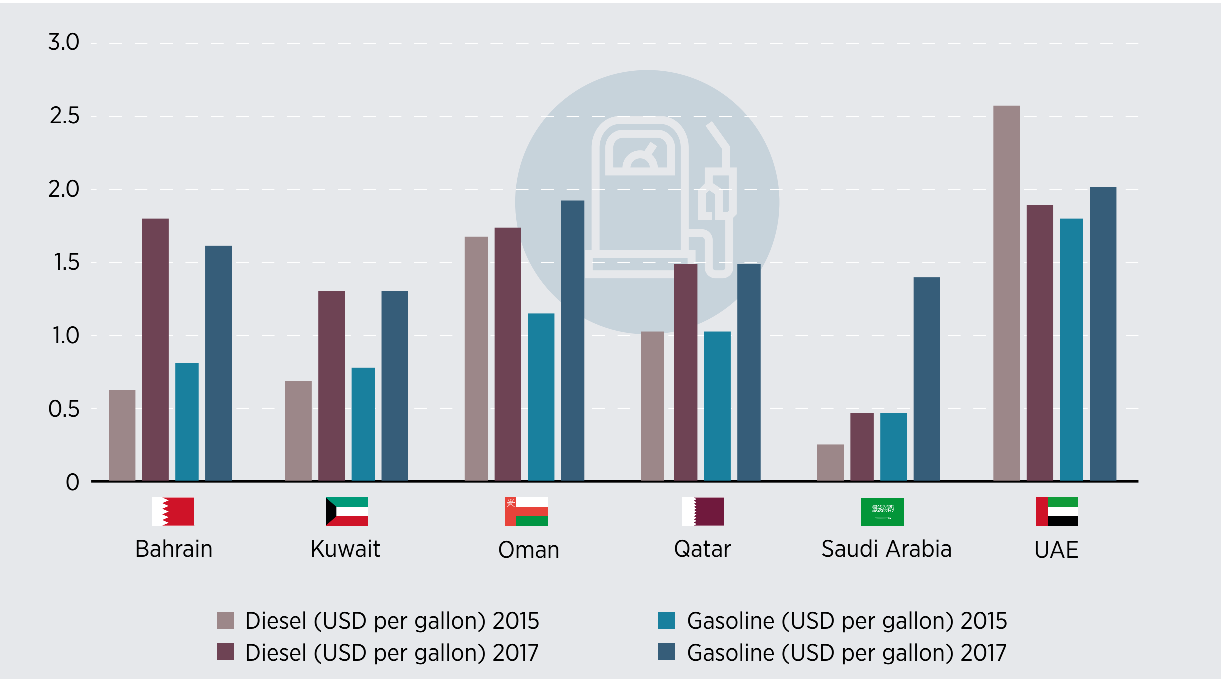
5.2.2. Electric and public transport

The UAE is making strides with its Smart Dubai Initiative, under which DEWA has installed 200 electric vehicle charging stations as part of its implemented the Green Charger[3] programme. As of 2016, there were 200 registered electric vehicles in the UAE, and the number is targeted to reach 40 000 by 2030. The Dubai Autonomous Transportation Strategy, developed by the Dubai Future Foundation (Dubai Future Foundation, 2017), estimates that 25% of all transport in Dubai will be smart and driverless by 2030. This would result in USD 6 billion in savings annually, thanks to increased efficiency, and reduced carbon emissions (Sadaqat, 2018). Much higher penetration values are possible, based on projected adoption trends with positive reductions in emissions (Sgouridis, *et al.*, 2017). In Saudi Arabia, the Saudi Energy Efficiency Centre is working to promote electric vehicle adoption, while Qatar has launched the Electric Car Charging Stations Project – Phase 1, under which nine charging stations will be set up. The country currently has three. Bahrain is working to introduce electric vehicles to combat CO_2 emissions through its motor vehicle standards, and has proposed a light railway project to improve the efficiency of public transport. Qatar's Doha Metro was intended to open at the end of 2018. Similarly, in Kuwait, a mass transit metro system and a railway project linking key ports has been suggested. Saudi Arabia is currently constructing the Riyadh Metro, similar to the UAE's Dubai Metro, and is planning additional metro systems at Dammam and Jeddah. More than 4 200 solar PV panels will be installed on the roof of the Riyadh Metro Depot Line 4/6 to power carriages (Railway Pro, 2018).

Figure 5.6 Transport fuel price increases, 2015–2017



Source: Nature Energy, 2017.

3 Green Charger is DEWA's initiative to promote electric vehicle charging stations.

5.2.3 Fuel tariffs and fuel efficiency standards

Fuel prices have increased in almost all GCC countries in recent years (Figure 5.6). In Oman and the UAE, they have been set to follow international (untaxed) prices as part of a wider strategy to promote energy-efficient practices. The sharpest percentage increases have been seen in Saudi Arabia, though prices there remain the lowest overall. Saudi Arabia's vehicle fuel efficiency standards are mandated by the Gulf Standards Organisation (GSO), and in 2016 the UAE stated an intention to introduce standards. In Saudi Arabia, fuel economy labelling is now a must for all light-duty vehicles. Cars in the UAE consumed 8.3 litres/100 km on average in 2013, a rate the country aims to reduce to 4.8 litres/100 km by 2028 (Wasmi, 2016). Fuel prices in Qatar were pegged to the international market starting in 2016 and have continuously increased, with gasoline prices rising to USD 0.6/litre. In Bahrain, a structured subsidy removal plan has been introduced to bring fuel prices closer to global prices.

5.2.4 Energy-intensive industry

In GCC member states, industry (including the energy industry) uses over half the total final energy consumption (except in Saudi Arabia where it is a little less than half). The most energy used in the industrial sector is consumed by the upstream oil and gas sector, oil refining, petrochemicals, aluminium, steel and cement. These are usually run by state-controlled companies, and therefore the government is able to mandate efficiency improvements directly.

Bahrain has mandated retrofit programmes for gas turbines to replace high nitrogen-oxide-emitting gas liners with energy-efficient ones in its gas and aluminium industries, and manifold flare and oil electrification projects in its oil and petrochemical industries. In 2012, it increased industrial tariffs by 50% for gas, despite concerns that this would render the aluminium industry unprofitable. Kuwait is aiming to improve its petroleum products industry by supplying clean fuel to its refineries. Oman has developed a CSP-EOR project as a form of energy-

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efficient technology for its Amal oilfield to diversify away from gas reinjection and steam generation using gas fuel. Similarly, Qatar is utilising a solar PV complex to power its Dukhan oilfield to offset consumers' dependence on diesel generators in remote or hard-to-access areas. Saudi Arabia is planning to convert all single-cycle power plants to combined-cycle power plants, and its national phosphate and mining company, Ma'aden, was recently awarded the ISO 50001 energy management systems accreditation for its ammonia plant. In the UAE, the Abu Dhabi National Oil Company is aiming to increase its energy efficiency by 10% by 2020. The Emirates National Oil Company in Dubai has adopted energy and resource management (E&RM) strategies to drive operational and energy-saving improvements over the last five years. Emirates Global Aluminium has achieved thermal efficiency of 46–48% through co-generation and combined-cycle configuration (MOCCAE, 2017).

5.2.5 Electricity pricing reform

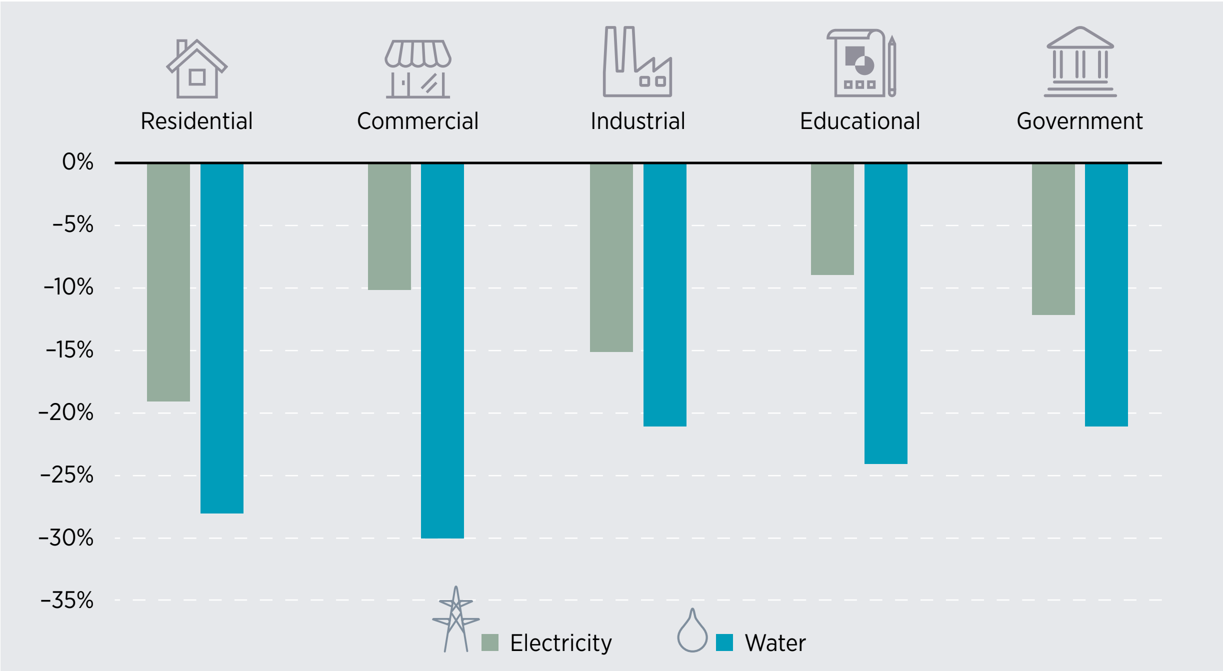
Policies aimed at promoting energy efficiency in the electricity sector are inter-linked with pricing reform measures. For example, the UAE was the first among the GCC countries to remove electricity subsidies for expatriates, who are now a subject to a fuel surcharge and since 2018, a 5% value added tax (VAT). In Abu Dhabi, electricity rates have increased by 34% for UAE nationals and 28% for expatriates from 2017. Along with the UAE, Saudi Arabia introduced VAT in early 2018. Saudi Arabia increased its electricity prices in January 2016, and again in January 2018, to reflect real-system costs, albeit still including low-input fuel costs. Qatar increased electricity rates in 2015 after 13 years of no change, and now reflect a slab system, while in Oman, a cost-reflective tariff (CRT) system was introduced in January 2017 for about 10 000 customers consuming more than 150 MWh per year, and accounting for more than 35% of electricity supply. Bahrain will be increasing its electricity tariffs to 7.7 US cents/kWh by March 2019 for industrial, commercial and most residential customers; this tariff is the highest yet seen in the country.

5.2.6 Water pricing reform

Water efficiency is closely related to energy efficiency in the GCC countries, where most water production involves desalination, an energy-intensive process. Additional energy is required for pumping and waste-water treatment.

Water tariffs have increased in some countries to increase water efficiency and promote conservation. Water tariffs increased in January 2016 in Saudi Arabia, and again in January 2018, while in Dubai they have been unsubsidised for expatriates since 2011. DEWA has reported significant savings as a result of removing subsidies (Figure 5.7). Qatar introduced a slab system for water pricing in 2015, and Kuwait increased its water rates in 2017 for expatriate and commercial consumers.

Figure 5.7 Efficiency savings in Dubai's electricity and water sectors, 2009–2016



Source: DEWA, 2017.

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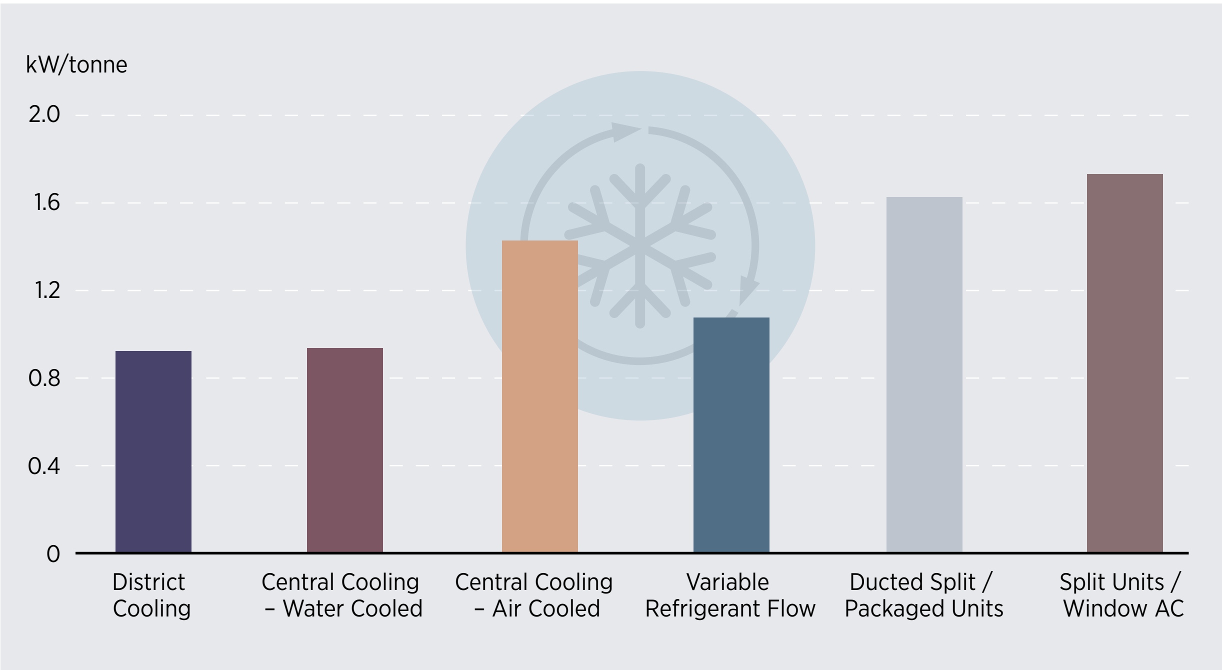
5.2.7 Space cooling

As the major consumer of electricity in the residential and commercial sectors (50–70%), and the driver of peak loads, space cooling is the end-use with the largest potential for savings. The MENA region as a whole is projected to witness the third-highest rise in energy demand from cooling due to climate change by 2050, second to China and the United States (IEA, 2013). Also, under the Kigali Amendment to the Montreal Protocol (MOP 28), the GCC is to freeze the growth of hydrofluorocarbons in 2028 (EDA, 2018), which would encourage a transition to more energy-efficient and less polluting cooling technologies. For example, district cooling is being increasingly adopted in high-density areas, especially in Dubai. District cooling and more advanced cooling technologies, such as solar and absorption technologies to produce chilled water, have been proposed in Doha. Saudi Arabia has invested in a turbine inlet air chilling (TIAC) system to increase power output during off-peak consumption times and store the energy to be used during the daily six-hour peak consumption period in a thermal energy storage tank. Thermal storage via chilled water or ice can help to balance renewable energy input. Significant efficiency improvements in chillers can be achieved by mandating stricter, region-specific standards and operational procedures – without a substantial increase in up-front costs (Tabreed, 2018).

Dubai is working to increase the penetration of district cooling to reduce overall energy consumption. Steps taken under Dubai's demand side management (DSM) strategy include higher insulation standards and minimum cooling equipment ratings for new buildings; retrofit programmes for existing buildings; and district cooling systems for multiple buildings in dense urban areas. According to Dubai's RSB, district cooling is more energy efficient than air-cooled alternatives (Figure 5.8).

Figure 5.8 Average efficiency of cooling technologies used in Dubai



Source: RSB, n.d.
Note: Lower kW/tonne values imply higher cooling efficiencies

5.2.8 Lighting and appliances

Energy efficiency standards for indoor appliances in the GCC countries are set by the Gulf Standards Organisation (GSO) as well as the appropriate authority in each member state. In UAE, the Energy Efficiency Standardisation and Labelling Programme (EESL) under Emirates Authority for Standardisation and Metrology (ESMA) involves minimum energy performance standards and mandatory comparative labels for indoor and household appliances. The typical rating system involves five stars: five stars is the most efficient, and one the least. The Saudi Arabia Standards Organisation (SASO) has a similar programme, the Saudi Labels Standard (SLS), to rationalise energy consumption for indoor appliances such as air conditioners, refrigerators and washing machines in a bid to improve energy efficiency and reduce demand loads.

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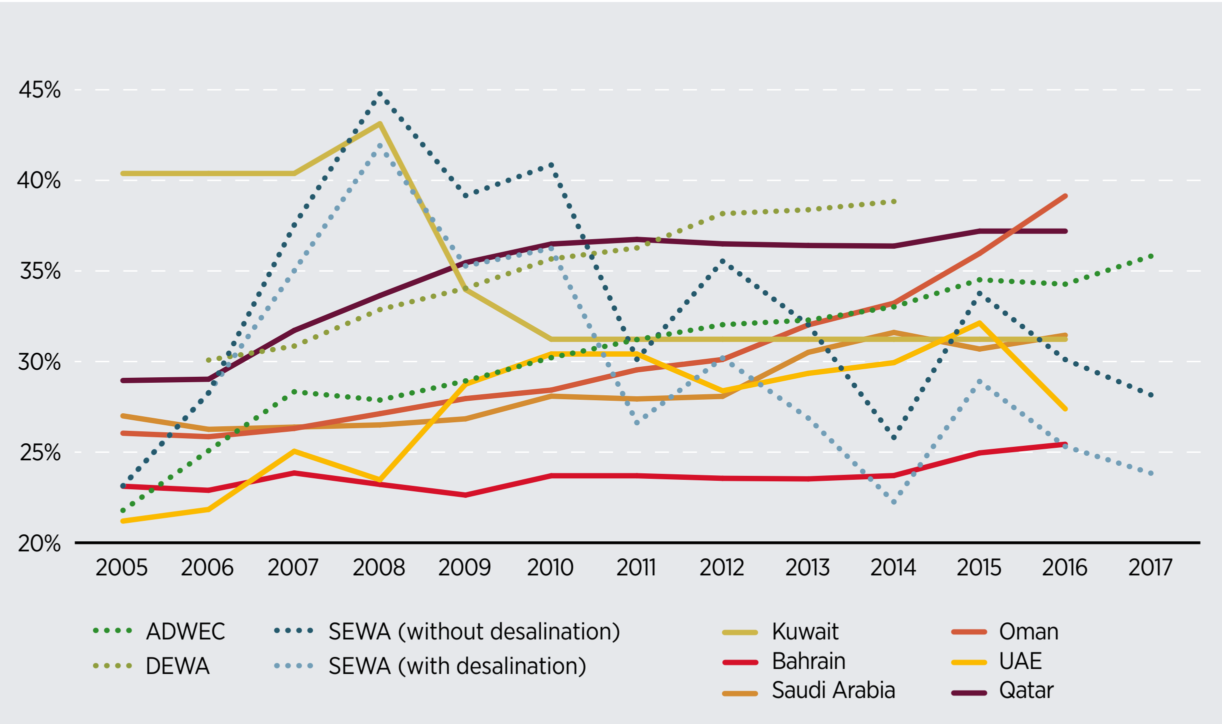
5.3 INTEGRATING RENEWABLE ENERGY THROUGH ENERGY EFFICIENCY MEASURES

Synergies between renewable energy and energy efficiency exist at multiple levels. When pursued together, they can result in higher shares of renewable energy, a faster reduction in energy intensity, and lower energy system costs (IRENA, 2017e).

The introduction of renewable energy technologies, coupled with appropriate grid flexibility measures (e.g. storage, real time pricing) in the region can help improve the thermal efficiencies of the regional power and water sectors. The thermal efficiency of power generation in the region is low. Even in the region's hot and humid ambient conditions, modern combined-cycle turbines can reach an efficiency of 50% but nowhere in the GCC countries does the efficiency of gas-powered generation plant currently exceed 40% (Figure 5.9). Fuel savings would be significant if thermal efficiency were raised throughout the region to the level seen in Oman in 2016.

An increase in the share of renewable electricity in the grid would reduce the load factor on thermal power, and allow for the preferential running of the most efficient units, hence increasing overall fleet efficiency. However, rapid ramp rates to meet shortfalls in renewable generation, particularly the sharp evening peak when solar output ceases, could result in thermal plants running in less than ideal conditions, reducing their efficiency. This can be mitigated by battery storage or by the introduction of CSP with thermal storage. More distributed (solar) generation would also reduce the load on the transmission system at peak times, and so potentially cut losses.

Figure 5.9 Thermal efficiency of gas power generation, 2005–2016



Source: Based on Mills, forthcoming

Note: Figures are shown for the United Arab Emirates as a whole and separately for its three main utility companies (ADWEC, SEWA and DEWA).

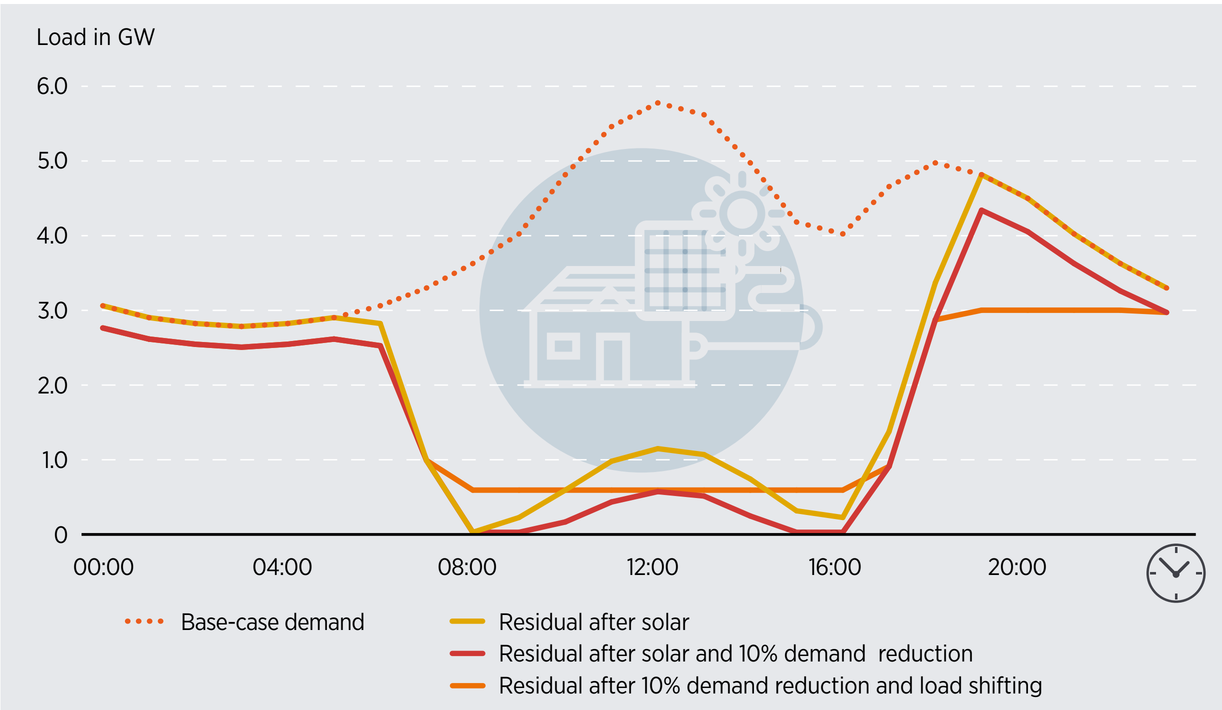
Part of the reason for low efficiency in the power sector is the co-generation of water via multi-stage flash desalination. In winter, generating plants may be run solely to produce water. As discussed below, the expansion of reverse osmosis desalination and the reduction of water demand would improve efficiency by decoupling power and water production. Reverse osmosis can be powered by renewable electricity.

Energy efficiency measures could help support the integration of renewable energy in multiple ways highlighted in the following discussion.

Managing energy demand through the introduction of key technologies in generation and distribution would advance the integration of renewable energy in the power sector. Such technologies include smart grids and smart meters. Four smart grid projects were identified for this study, all in Saudi Arabia, between 2011 and 2015. In Dubai, DEWA is to invest USD 1.9 billion between 2014 and 2035 under its smart grid strategy. When rolled out to end-use sectors, smart meters – a subsystem of smart grids – offer direct benefits, such as economic returns to both governments and consumers, and indirect benefits, such as load shifting during peak demand hours.

Typically, peak demand occurs in summer in the region, particularly during daylight hours till early evening. Solar power is ideally suited to meeting the daytime peak but not the early evening. Battery or thermal (*e.g.* CSP with molten salt) storage can be used for that time period. Energy efficiency measures to reduce the overall load level, and in particular to shrink the peak and shift it partly into periods when solar generation is abundant, would reduce the required size of storage systems (Figure 5.10).

Figure 5.10 Impact of energy efficiency and demand shifting on solar PV



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The inclusion of solar PV eliminates most of the daytime residual load but leaves a significant evening peak. Reducing overall demand by 10% through efficiency measures slightly lowers this evening residual, but leads to excess solar generation during daytime hours. Shifting the peak greatly reduces the evening residual (thus shrinking the size of the required flexible generation or storage), and increases the daytime load which would also allow for more solar penetration.

On-peak thermal generation is usually met by the least-efficient plants, burning high-cost gas or oil, and possibly relying on a congested grid, and therefore reducing this peak has a positive impact on the efficiency and cost of generation and transmission. Renewable energy, particularly solar at peak daytime periods, is one part of the solution. The most effective efficiency measures will be those that reduce the air-conditioning load overall; shift cooling loads (for instance, using buildings' thermal inertia, creating chilled water or ice in off-peak periods, and employing district cooling); reduce the evening lighting load (*e.g.* through sensors and LEDs); and shift on-peak appliance use. These approaches can be encouraged via pricing reform, particularly time-of-use pricing at the retail level; interruptible contracts for large users; and critical peak pricing and day-ahead markets for the wholesale market. Current GCC electricity models feature vertically integrated utilities or a single buyer, but the Oman Power and Water Procurement Company is developing a spot market, intended to be fully in operation by the end of 2020 (Oman Power and Water Procurement Co., 2018).

Battery deployment is part of improving efficiency by demand shifting (as above), as well as easing renewable integration. In Abu Dhabi, ADWEA has deployed approximately 120 MW of sodium-sulphur (NaS) high-temperature batteries in 4 MW or 8 MW systems at various 33 kV/11 kV substations across its distribution network to strengthen the grid, and to provide investment deferral through peak shaving.

Smart meters offer numerous ways to facilitate efficiency improvements and renewable integration, such as immediately informing customers of unusually high consumption; raising awareness of consumption levels; and enabling time-of-day pricing to facilitate demand shifting. They can also facilitate more distributed and self-generation that can be combined with the "Internet of Things" and "smart homes" to permit automated and remote monitoring and control. This includes turning on air conditioning shortly

before a resident returns home, or running a washing machine in a low-demand period. A greater share of solar power is thus employed to ultimately contain peak demand from both the utility and consumer while promoting efficiency.

Thirteen smart metering programmes have been identified in the GCC, in Kuwait (one), Qatar (three), Saudi Arabia (three), and the UAE (six, of which three are in Dubai, two in Abu Dhabi and one in Sharjah). Most of them date back to 2010–2015; two were set up in 2017. Costs have generally not been reported, but Kuwait's, the most expensive, was priced at USD 72.5 million for 880 000 installations. DEWA intends to replace all existing meters by 2020.

Smart city concepts could be a unifying theme to tie together efficient electrified transport, smart homes with energy demand response and renewable energy balancing via real-time adjustments in battery storage, cooling and desalination.

The Smart Dubai Initiative (Dubai Smart City) was launched in 2013. While not mainly about efficiency or renewables, it does include autonomous transport; paperless government services; the "Oasis Eco-Resort" with solar roofs and many efficient techniques; and the Mohammed bin Rashid Al Maktoum Solar Park. Dubai Sustainable City, a residential community, features solar power, electric vehicles, urban farming, LED lighting, high-efficiency air conditioning, high levels of insulation and sustainable social and community initiatives. Masdar City in Abu Dhabi, aims to be the world's first carbon-neutral city, using solar power and energy-efficient architecture, partly inspired by traditional Arab cities. Finally, the planned city of Neom, in northwest Saudi Arabia, is also intended to be served entirely by renewable energy and to include driverless vehicles and vertical farms (Mairs, 2017).

Reforming energy pricing to level the playing field opens up opportunities for the rooftop solar PV market. Energy pricing reform for electricity and water tariffs was introduced by the UAE in 2011. This prompted several other GCC member states to adopt similar policies (see Section 5.2). Subsidy reform is expected to continue, closing the gap between subsidised levels and full costs. In turn, investing in a rooftop solar market would allow end users to reduce the cost of their bill, and utilities to achieve the multiple benefits of peak shaving, firming and frequency regulation through grid connection.

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The **Shams Dubai** net metering programme, for instance, benefits from the unsubsidised electricity rates in Dubai. Launched in 2015 the programme has resulted in around 50 MW of rooftop solar PV deployment.

For smaller-scale solar PV systems, Saudi Arabia has prepared the Small Photovoltaic Solar System Regulation which sets out the framework for connecting rooftop solar to the nation's distribution system. In Oman, the Sahim scheme is based on a scheme, which means all future small-scale grid-connected solar PV systems will be channelled through relevant distribution companies.

Another area of energy pricing reform is fuel tariffs. Reforming diesel prices encourages the adoption of a distributed renewables market, especially for remote or off-grid applications. For instance, solar, combined with battery or thermal storage, can provide a 100% solution for hard-to-access areas reliant on diesel generators. These include remote settlements, farms, military bases, oilfield camps, installations and pipelines, offshore sites, construction sites and labour camps.

Solar-hybrid generators for off-grid locations and mini-grids are being deployed in the UAE. Efficiency in these applications is important to keep overall consumption at a level that can be easily met on-site, and to shift the demand peak to minimise the requirement for storage. For instance, in Dubai, the site office for Multiplex uses power generated from 40 kWp of solar panels installed on the roof during daylight hours and switches to the site's 100 kW/200 kWh battery system at night, with a diesel generator functioning as backup in case of intermittent solar power, or battery outage.

Raising diesel and other fuel tariffs also encourages the uptake of renewables in the transport sector. **Electric vehicle** charging stations can be installed at a customer's residence, powered by renewable energy through the national grid, or through a distributed renewables system in more remote locations.

An increase in electric vehicles usually coincides with the reduction of subsidies for fuel tariffs. Where a larger number of electric vehicles are on the road, this adds to the demand on the national electricity grid. To alleviate the impact, renewable energy sources may be integrated into electric vehicle charging infrastructures. For instance, charging electric vehicles in the presence of a smart grid system overcomes the intermittent nature of renewable energy, while promoting a cleaner, more efficient charging process.

A concept that could be applied to the GCC market is the vehicle-to-grid (V2G), essentially an extension of the smart grid system. An electric vehicle can communicate to the power grid to sell demand response services, by delivering electricity into the grid. The vehicle can facilitate energy storage during its recharge time, allowing for better integration of renewable energy. When the vehicle is not in use, the restoration of the stored energy from the vehicle into the grid can provide significant economic benefits to the power system. It can also mitigate grid-demand variations in load balancing by valley filling (*i.e.* charging at night, when demand is low), peak smoothing, regulating voltage and frequency, and providing a spinning reserve to meet sudden power demand changes.

For the owner, benefits include little to no fuel and maintenance costs, reduced emissions and the absence of the transmission or timing belt damage common in internal combustion engines. Even though Saudi Arabia's fuel tariffs are the lowest in the world, using an all-electric vehicle could cost about USD 140 less per year than a gasoline-powered vehicle, based only on fuel costs. The savings jump to USD 817 annually once operating costs are included (Deloitte, 2015).

Synergies between renewable energy integration and energy efficiency also exist in the **water sector**.

Thermal desalination uses 3.5 times the energy of a modern reverse osmosis plant, and reduces the flexibility and efficiency of traditional power generation. Reverse osmosis, or membrane desalination, on the other hand, utilises high pressure from electrically powered pumps to desalinate, which opens up potential for the deployment of solar PV to power the pumps. Other solar technologies, based on solar heat concentration, such as CSP, can produce large amounts of heat more suited to thermal desalination processes.

The falling costs of renewable energy, including wind and geothermal, could lower the costs of renewable-powered desalination. Across the GCC countries, the costs of renewable technology, mainly solar PV, are quickly decreasing, and renewable desalination based on reverse osmosis could soon compete with conventional systems. This is ideal for remote regions, where the cost of energy transmission and distribution is higher than the cost of distributed generation. Because renewable desalination is mostly based on the reverse osmosis process (62%) (IRENA, 2012b), the right combination of a renewable energy source with the process could help match both power and water demand economically, efficiently and in an environmentally friendly way.

Reducing water demand through the introduction of reverse osmosis technologies and conservation practices would decouple power and water production, reducing the requirement of co-generation water power plants, and thus minimising loss of efficiency. Typical water conservation practices being mandated in the GCC countries include higher water tariffs (see Section 3), and improved monitoring of water consumption through smart water meters. Other approaches include waterless car-cleaning systems, use of grey-water recycling, climate-appropriate vegetation in landscaping, advanced irrigation, sustainable land management and the processing of wastewater to a high enough standard for use in industry and agriculture.

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Another avenue for integrating renewable energy into water efficiency is the **production of chilled water via renewable energy**. Producing chilled water through solar, low-grade geothermal, or waste heat processes offers higher efficiency; solar-powered chilled water production also allows for reducing peak loads through thermal storage. Absorption chillers based on renewable energy are being researched to establish wider applicability in the region.

Cooling represents 70% of the GCC region's peak demand (PWC, 2015). This has led to more efficient air-conditioning systems being mandated, such as variable refrigerant flow (VRF), and district cooling for high-density developments. In the UAE, district cooling is a key efficiency driver, as it produces chilled water during off-peak hours and stores the excess for use during high-demand periods. Dubai has issued a decree to replace desalinated water with treated sewage effluent (TSE) for district cooling, and is also utilising thermal energy storage for district cooling in large-scale real estate developments.

5.4 BARRIERS, POTENTIAL MEASURES AND LONG-TERM OUTLOOK

Delivering on efficiency targets depends on access to appropriate policies, finance and technology. Residents and businesses in GCC countries have historically tended to overlook efficiency due to low energy prices and a limited regulation and enforcement environment. Other barriers include lack of awareness, up-front costs, high costs of retrofits, low organisational priority, mismatched incentives (*e.g.* short-term tenant pay the bills), fragmented ownership (*e.g.* many offices/ apartments in one building), and a lack of appropriate finance and technologies for the situation.

Mismatched incentives have been a barrier in the region. For instance, the predominance of an expatriate resident population limits the incentive for efficiency improvements, or the installation of renewable energy, with a pay-out period longer than a year or two. Conversely, landlords may not see the benefit of higher efficiency in an increased rental value.

Energy service companies, or ESCOs, are a potential solution. ESCOs implement and monitor energy efficiency projects, typically for buildings, and may arrange or provide funding, which is then paid back over time from a share of the savings. If an ESCO is contracted for an entire building or neighbourhood, this can alleviate the problem of fragmentation and allow common, repeatable solutions to be applied. If legal entitlement to such improvements can be passed on from one tenant to another, it helps overcome the tenant-owner problem mentioned above.

Dubai's Etihad ESCO, a government firm, was established in 2013, and is supporting the rapid uptake of energy performance contracting (EPC) in Dubai. EPC is projected to have a compound annual growth rate (CAGR) of 15% to 17% in the UAE by 2022, with incremental growth in other GCC states. Saudi Arabia's National ESCO (Tarshid) was founded in October 2017 by the Public Investment Fund and other government partners, with the exclusive mandate to improve the efficiency of government bodies (Graves, 2017c). Private ESCOs have increasingly been established in Oman (Prabhu, 2018).

ESCOs, certification bodies and energy-intensive industries need appropriately trained staff. Universities and training bodies can be encouraged to develop a well-qualified class of energy efficiency professionals.

To further incentivise energy efficiency and develop access to appropriate technologies, GCC governments could establish a specialised financial vehicle, such as an Energy Efficiency Investment Bank. This would be analogous to the green investment banks in many countries that finance renewable energy investment. This would give energy efficiency greater visibility, sending a signal to potential developers, and could attract new investors through green bonds or green Sukuk, which is well suited to efficiency projects as it provides a social benefit. Dubai has established the Dubai Green Fund to raise AED 100 billion (USD 27 billion), ultimately for projects in renewables, electric vehicles and building retrofits (see Chapter 3).

Increasing awareness is inter-linked with rising energy prices. Subsidy reform is likely to continue, closing the gap between subsidised levels and full costs. To encourage citizens to make full use of energy efficiency opportunities (and to install distributed renewables where feasible), these subsidies could be replaced by a blanket payment not linked to consumption. Saudi Arabia has pursued such an approach by granting a cash payment, the "citizen's account", to low- and middle-income families, to compensate for the withdrawal of various subsidies (Obaid, 2017).

Another mode of increasing awareness is developing science-based energy-efficiency standards, labels and codes which can drive demand and stimulate the supply market, providing consumers with increased product availability. The availability of more energy-efficient equipment would improve economies of scale and lower technology costs, also improving the productivity of ESCOs. Harmonising efforts for labelling and standards across the GCC would reduce inconsistencies, costs and limited product availability.

A traditional approach of information provision, regulation and standards has been adopted in the GCC, and can be expected to be progressively tightened. Enforcement remains important, given a continuing fast pace of construction in some areas, and a lack of awareness and expertise to implement standards properly. Companies and government bodies are also independently seeking certification, such as the ISO 50001 standard (ISO, n.d.). Prizes, pilot projects and "model homes" are being implemented by utilities, and government bodies are ordered to procure efficient installations directly.

Development of regionally appropriate technologies to combine energy efficiency and renewable energy targets could become the basis of several export-oriented industries in the GCC countries, helping in the diversification of their economies. The region's needs are quite specific given its hot, arid climate and high humidity, and its high income level, yet it can still learn from areas with similar conditions. Improved energy efficiency will offer an economic boost to households and corporations. It can create a valuable new industry, covering skilled manual jobs in retrofitting and construction, a range of employment in manufacturing energy-efficient equipment, and high-skilled non-manual work in energy efficiency projects (policy making, regulation, design, engineering, legal, financing). Energy audits and retrofits often reveal opportunities for simultaneous renewable and efficiency deployment. Such developments facilitate the emergence of a broader clean-energy ecosystem.

In the long term, higher energy prices, a shift toward low-carbon growth, holistic integrated resource planning and the accumulation of years of efficiency-focused policies can lead to changes in the urban fabric. These might include densification and layouts that create natural shade and breeze and minimise the urban heat island effect – effectively a passive use of renewables, that could be supplemented with building-integrated or canopy-based solar. Road networks, public transport, cycle ways and cooled walkways can be adapted to reduce congestion and driving requirements and improve walkability and bikeability. Technological improvements such as autonomous vehicles, ride-sharing, the internet of things affect the demand and timing for energy services and can ease the integration of renewables.

THE WAY FORWARD

Renewable energy has made striking gains in the GCC countries over the past five years. From niche technologies with little application beyond small-scale pilot projects, the project pipeline has grown to almost 7 GW of new power generation capacity. Record-breaking bids in renewable energy auctions in Saudi Arabia and the UAE in 2016-2018 have, in fact, made solar power cost-competitive with conventional energy technologies. This is expected to further boost renewables in the region – and the world – in the coming years.

A large portion of the region's demand for renewables can be expected to come from its largest energy markets – particularly the UAE, where the market is most mature, and Saudi Arabia, where a changing policy focus has made renewables a higher priority. But other GCC markets could account for an increasing share in the region's renewable energy use by the early 2020s. Oman, for example, has significant solar and wind potential and has shown interest in developing these resources as an economic alternative to domestic gas supply.

As Oman and Saudi Arabia demonstrate, renewable energy in the GCC is not exclusively about solar power; both countries' wind resources could complement solar power, particularly by tapping their off-shore wind potential. While wind power will likely remain a distant second to solar in the GCC in the near-term, its potential in Saudi Arabia and Oman exceeds earlier expectations. For now, however, solar is emerging as the pre-eminent renewable energy technology in the GCC.

Proactive policy support plays a pivotal role as countries set out to scale up renewable energy technologies. Several key developments, which are outlined in this chapter, could help accelerate the deployment in the GCC in the coming years. Dedicated policies and targets, adopted at both national and sub-national levels, drive incentives, remove market barriers and helping markets to harvest the multiple benefits associated with renewable energy.

THE WAY FORWARD

6.1. ESTABLISHING A MARKET FOR DISTRIBUTED GENERATION

Up to now, most renewable energy projects in the GCC have been in the utility-size power-generation segment, mainly centrally planned and then implemented by IPPs. The future of renewables in the GCC may also lie partly with distributed generation. Distributed, or decentralised, electricity generation often provides remote access, such as through power generation on islands, in mountain areas and in desert areas off the grid, as well as for off-grid oil and gas developments both on- and offshore. In addition, particularly in the GCC on-grid segment, it can involve self-generation by industries, commercial and residential buildings.

Utility tariffs and incentive schemes for self-generators are needed to accelerate decentralised renewable energy growth. This could allow smaller, local private companies to enter the market. Self-generation targets for renewables, in combination with sustainable building codes in the residential and commercial sector, such as the UAE's Estidama scheme, could provide such incentives. The introduction of true two-way smart meters and dynamic pricing in the tariff market, ideally at the retail level, would also provide useful signals for consumers to adjust their demand and storage systems in response to competitively priced renewable power.

6.2. READYING ELECTRICITY SYSTEMS FOR MORE VARIABLE ENERGY

Both solar and wind are intermittent sources of power, and electricity systems will have to be modified to accommodate them, particularly in GCC countries planning significant additions of renewables relative to the size of their national electricity systems.

As more VRE is added, greater fluctuations in net load (*i.e.* demand minus VRE generation) have implications on electricity grids, system operations, the institutional architecture and market design. GCC countries (*e.g.* Saudi Arabia, the UAE and Oman) planning significant additions of solar and wind capacity in the coming decades, relative to the size of their national electricity systems, would do well to plan for load variations.

Improving operations and using existing system resources more efficiently would go far toward supporting the system integration of renewables (IRENA, 2017f). Next is to carefully increase power systems' flexibility (IRENA, IEA and REN21, 2018). Combining technologies appropriately is important as their share in the power system gradually increases. CSP, for instance, is a dispatchable technology with short-term storage capacity that contributes inertia to the system similar to conventional thermal power. Some enabling technologies include:

- **Electricity storage**, which can be provided both through batteries or thermal technologies – some of which are being considered by utilities in the region. Pumped hydropower storage in desalination plants is also an option, though not on a large scale. CSP with 15 hours of molten salt thermal storage is already being implemented in the UAE to provide power in the evening (4 pm to 10 am). DEWA is also considering pumped hydro storage in Hatta, Dubai.
- **Demand-side management** and **energy efficiency measures** can help shape or reduce the load curve, allowing higher levels of VRE penetration while lowering the need for storage. Policy makers can support these through economic incentives, *e.g.* by widely adopting smart grid and metering technologies, cost-reflective utility tariffs and real-time pricing.

- **Electricity trading** has been seen to successfully integrate power dispatching with high shares of VRE through short-term markets (IRENA, 2017f). Making use of their existing interconnection grid, the GCC economies have the chance to build a regional power market that allows the trading of larger power capacities (El-Katiri, 2018; Mollet *et al.*, 2018).

Regarding the integration of power systems, governments and public utilities will play a pivotal role in increasing power systems' flexibility in the medium and long term.

Rooftop solutions

Rooftop solar PV panels are popular in many countries, but in the GCC their outlook is constrained by several factors. Large apartment blocks, for instance, would not be well served, but stand-alone villas, government and commercial buildings, and some industrial applications are viable options.

Tariffs are generally too low to encourage users to self-generate electricity. Further tariff reform, coupled with other economic incentives, might boost rooftop solar generation even while reducing overall electricity bills. National regulations that encourage small solar systems, and self-generation in general.

The UAE has started to offer signs of encouragement, through Shams Dubai and more recently through Abu Dhabi's net-metering regulation. In Saudi Arabia, ECRA has developed a draft regulation for small solar PV systems. Similarly, Oman's Sahim scheme encourages the installation of PV panels in homes, as well as public and private facilities.

Financing rooftop solar projects is a challenge and therefore, better business models could help speed deployment in the region. Most systems in Dubai are funded by building owners through equity or debt financing. Leasing models could help mitigate up-front costs, allowing building owners to rent systems from a third party that finances and owns them. Some projects already use this model, including a 1.1 MW project set up by Siraj Power on the premises of an RSA Global building.

The success of national rooftop schemes depends on the existence of a well-established domestic value chain. Qualified installers and after-sales service providers are crucial to deployment. This is why the listing of approved consultants and installers by DEWA and the ADDC is very useful.

Finally, even where regulatory, financial and economic conditions are conducive, it might be necessary to raise consumers' awareness on the viability of rooftop technology. Governments interested in promoting rooftop solar solutions will need to be far more proactive. In fact, because of their high visibility, rooftop schemes may serve as an important policy tool to raise the profile of renewable energy more generally.

Electrification of transport

Renewable energy is often linked to the power sector, but technological developments in recent years suggest that renewables are also likely to contribute to the diversification of the transport-fuel base in the region. The electrification of private, public and industrial vehicle fleets using clean power sources, offers tremendous opportunities to harvest low-cost energy from renewable sources and integrate clean-energy solutions into broader policies. The availability of several mass-market electric vehicle models for private use, and the rapid development of battery storage, hold great promise (MESIA, 2018b). More could be done, meanwhile, to prolong battery life under the climatic conditions prevalent in the GCC states.

Economically, the high average income ranges in GCC countries suggests that a switch to electric vehicles, which involves a high up-front cost but lower fuel costs in the long run, is economically feasible for at least a portion of the market. The abundant resources could be harnessed via solar-powered charging stations in homes and work places. Because travel distances are comparably short, electric vehicles are a practical solution in cities. Finally, the electrification of transport fits within existing strategies promoting technology innovation and R&D.

Government incentive schemes will play a critical role in accelerating the electrification of transport. Financial incentives for switching from gas-powered to electric vehicles, and free use of solar-powered charging stations, are viable options. Dubai has launched a set of incentives that include free charging, free parking, free registration fees and free Salik (road toll) tags (MESIA, 2018b). Trains that run on electricity could transport increasing shares of daily commuters as an alternative to private cars. Making public transport self-reliant through renewable energy has tremendous potential to help reduce congestion, and manage energy demand sustainably in the long term.

6.3. RENEWABLE ENERGY AND ENERGY EFFICIENCY

Improvements in energy efficiency are a vital part of boosting renewable energy use. Lower energy demand helps in meeting quantitative targets for the share of renewables in the total energy mix, as well as in powering specific sites exclusively with distributed renewables. Load shifting permits higher levels of renewable integration with a lower need for storage. Certain technologies, particularly for passive or solar heating and cooling, combine aspects of efficiency and renewable energy.

Currently, the GCC is characterised by relatively inefficient energy use and high per-capita consumption. Yet customised energy efficiency policies are being developed, suited to the region's unique economic, demographic and geographic profile.

Energy prices are being reformed in all states to reflect global prices, and other reforms are being introduced, with specific regulations and programmes, to ease the financial and environmental burden on GCC governments. Energy efficiency has been integrated with renewable targets mandated under national energy strategies, which also include the increasing use of other low-carbon energy and optimising water usage. This mitigates the negative social impacts, while maximising the boost to employment and exports.

For instance, the UAE, Bahrain, and Oman, have moved the most on reducing energy subsidies. The UAE and Saudi Arabia have made the most progress on introducing specific efficiency-focussed policies. State-owned oil, utility and industrial companies, that account for a large share of energy consumption, have introduced their own programmes. Though it is still early in most cases to judge the impact of such approaches, the availability of timely and granular public data shall assist in more accurately judging their results.

Efficiency targets and measures so far concentrated particularly on electricity, and on the residential and commercial sectors. Industrial efficiency has been addressed primarily by large state-owned, energy-intensive companies. Major efficiency gains are being targeted in these areas, while also exploring the requirements to improve efficiency in thermal power generation, the desalination and water sector, the oil and gas industry, other related industries, and transport.

Overall, GCC countries can be expected to continue improving their energy efficiency policies, as a cost-effective way of meeting energy, economic and environmental goals. Such policies must be properly enforced, integrated with other relevant initiatives, and adapted for specific GCC conditions.

6.4. THE OVERARCHING ROLE OF POLICY

Renewable energy deployment in the GCC has grown rapidly in most of the years between 2013 and 2018. Proactive policy management has proven central to accelerating renewable energy deployment. The substantial inroads in recent years are due to a combination of factors, including firm government commitments to renewable energy, as reflected in credible, time-bound targets, and a clear focus on providing a supportive business environment, through the availability of financing, technology, infrastructure and land, with streamlined procedures.

Renewable energy deployment clearly benefits from the integration of renewable energy targets with wider policies for sustainable long-term energy sector management, energy efficiency and technology development. This is seen in policies designed to manage demand, for instance through wider adoption of smart-grid and metering technologies, and cost-reflective utility tariffs.

The creation of dedicated institutions with clear mandates and a transparent process to devise new projects, for instance through public auctions, has also helped to spur renewable energy deployment in the GCC. In the longer term, parallel policies to foster private enterprise, education, training and investment in local skills and human resources should help GCC countries to localise many of the jobs associated with increased renewable energy deployment. High-quality job creation and to the development of local knowledge industries can be expected to provide further benefits across many sectors.

The creation of leading energy research institutes has been a common centrepiece the overall sustainable energy strategies of GCC countries. Such institutes provide local centres of expertise to inform policy-making and advise on industrial diversification. Region-specific R&D and workforce training can strengthen all segments of the value chain, further facilitating renewable energy deployment.

Regional aspirations for energy diversification are realistic. If today's plans are backed up with the establishment of enabling frameworks, the successful implementation of projects and, in some cases, the development of local industries, then the medium-term future promises a significant increase in the deployment of renewable energy in the GCC. The extent to which the region can seize the opportunity presented by renewable energy should become much clearer in the next few years.

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IRENA conducted regional stakeholder interviews with various senior representatives from industry, government and academia. Interviewees were selected to ensure that they collectively provide a comprehensive overview of renewable energy issues in the region. They included (by alphabetical order of institutions names): Andrea Lovato and Paddy Padmanathan (ACWA Power), Bruce Smith (ADWEC), Hilal Al Ghaithi (AER Oman), Daniel Zywietz (Enerwhere), Ayham Mkalalati (Enviromena), Amro Elshurafa (KAPSARC), Salem Alhajraf (KISR), Hosni Ghedeira (Khalifa University), Kanav Duggal (MESIA), Luan Kuqi (Noor Solar Technology), Khalil Al-Zidi (PAEW Oman), Hannes Alexander Reinisch (PWC), Robin Mills (Qamar Energy), Othman Zarzour and Shashi Prakash (Qatar Supreme Committee for Delivery & Legacy), Daria Revina (QSTec) and Raed Bkayrat (Sun Energy Advisory).

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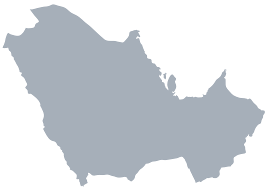

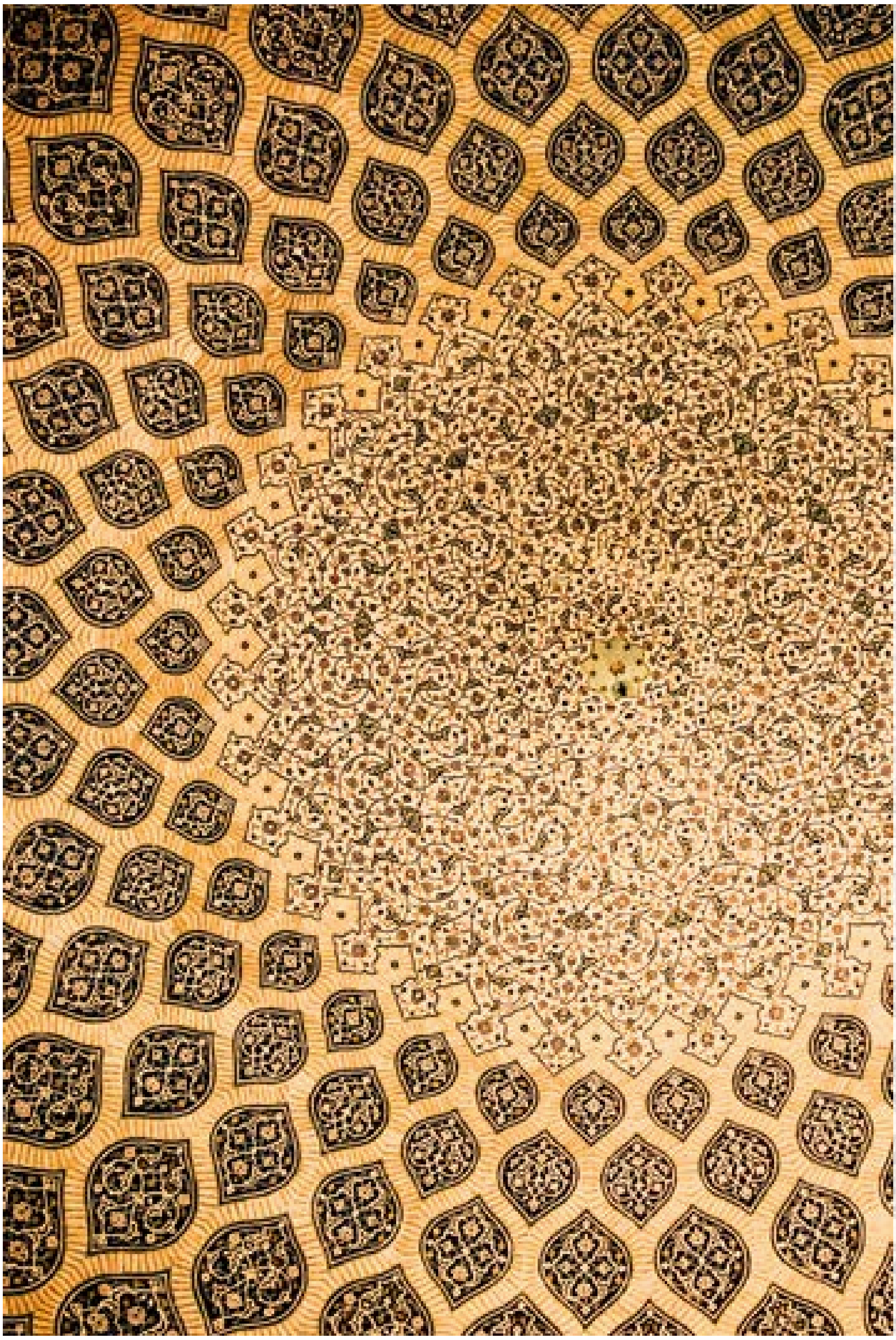

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