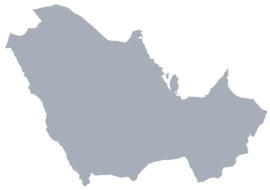
IRENA
International Renewable Energy Agency

RENEWABLE ENERGY MARKET ANALYSIS

THE GCC REGION



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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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DISCLAIMER

The transition towards renewable energy is creating a fundamental, long-term shift in the global economy. This shift can be expected to have a significant impact on fossil-fuel producers, including the oil- and gas-exporting countries of the Gulf Cooperation Council (GCC).

The landmark December 2015 Paris Agreement, backed up with detailed plans by countries around the world to overhaul their energy sectors, could imply the eventual softening of global demand for oil and gas, the main drivers of local economies. But it also presents an exciting opportunity for economic diversification and entry to new markets.

For the last several years already, GCC countries have been fashioning a critical role for themselves in the global shift to renewable energy. They have done so as investors in major solar and wind projects worldwide and also by adopting innovative and increasingly cost-competitive technologies in their own domestic markets.

With the advent of lowest solar prices in the world, Gulf countries are set to capitalise on their promising solar resources for power generation and water desalination. As the present market analysis finds, the GCC region can cut its annual water use by 16 per cent, save 400 million barrels of oil, create close to 210,000 jobs and reduce its per capita carbon footprint by 8% in 2030 – all by achieving the renewable energy targets that national and sub-national governments have already put in place.

These current targets are entirely within reach. A solar photovoltaic tender in Dubai last year resulted in the record-low electricity price of USD 0.06 per kilowatt hour – cheaper than domestically produced power from gas-fired generation. Indeed, for countries that use a substantial share of their hydrocarbon production for power generation, solar power has emerged as one of the quickest, least-risk investments to meet rapid demand growth for electricity and even boost export capacity and revenues.

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 through a clean energy future.

Adnan Z. Amin
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RENEWABLE ENERGY
MARKET ANALYSIS

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ABBREVIATIONS

AER	Authority for Electricity Regulation
BAPCO	Bahrain Petroleum Company
bbl/d	Barrels of oil per day
Btu	British thermal unit
CCS	Carbon capture and storage
CEBC	Clean Energy Business Council
CO_2	Carbon Dioxide
CSP	Concentrated Solar Power
DECC	Directorate of Energy and climate Change
DEWA	Dubai Electricity and Water Authority
DSCE	Dubai Supreme Council of Energy
ECRA	Electricity and Cogeneration Authority
EIA	US Energy Information Agency
EIB	European Investment Bank
EOR	Enhanced Oil Recovery
EPC	Engineering Procurement and Construction
EU	European Union
EWA	Electricity and Water Authority
GCC	Gulf Cooperation Council
GCPA	Gulf Coast Power Association
GDP	Gross Domestic Product
GW	Gigawatt
IEA	International Energy Agency
IFC	International Finance Corporation
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
KACST	King Abdul Aziz City for Science and Technology
KAHRAMAA	Qatar General Electricity and Water Corporation
KAPSARC	King Abdullah Petroleum Studies and Research Center
KISR	Kuwait Institute for Scientific Research
kWh	Kilowatt hour
LCOE	Levelised Cost of Electricity
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum gas
MED	Multiple-effect distillation
MEI	Ministry of Energy and Industry
MENA	Middle East and North Africa
MESIA	Middle East Solar Industry Association
MOFA	Ministry of Foreign Affairs
MOG	Ministry of Oil and Gas
MOPM	Ministry of Petroleum and Mineral Resources
Mtoe	million tonnes of oil equivalent
MW	Megawatt
NGL	Natural Gas Liquids
NOC	National Oil company
NOGA	National Oil and Gas Authority
OECD	Organisation for Economic Cooperation and Development
OPEC	Organization of the Petroleum Exporting Countries
PPA	Power Purchase Agreement
PV	Photovoltaic
RO	Reverse Osmosis
RSB	Abu Dhabi Regulation and Supervision Bureau
SPC	Supreme Petroleum Council
tcm	Trillion cubic metres
UAE	United Arab Emirates
UNEP	United Nations Environmental Programme
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USD	United States Dollar

EXECUTIVE SUMMARY

ES

The Gulf Cooperation Council (GCC) region comprises some of the world's largest hydrocarbon producing countries. The six member countries, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE), hold almost a third of proven crude-oil reserves, and approximately a fifth of global gas reserves. The development of fossil fuel reserves and exports has underpinned impressive economic growth, which has brought widespread prosperity and development. Hydrocarbon exports have been an engine of growth, but fossil fuels are increasingly used to meet the rising domestic energy demand.

Rapid industrialisation, population growth and increasing water desalination are resulting in high energy demand growth, impacting the ability of some countries to maintain export levels over the long-term. These dynamics have compelled governments to embark on a diversification strategy to meet growing energy demand and support continued economic growth.

A systematic diversification of the region's energy mix towards alternative sources, including renewables, presents ample opportunities, as it would free up domestic energy production for export. Additionally, a transition towards a more sustainable energy future would reduce carbon-dioxide (CO_2) emissions and bring a wide array of other socio-economic benefits. These include job creation along with increased local economic diversification, an aspiration deeply embedded in all countries' visions and development strategies.

This report examines the energy economies of the GCC countries. It discusses the opportunities and barriers for renewable energy deployment, formulating recommendations for the greater integration of renewables into the regional energy mix. The report provides insights on best practices in policy-making, project development and financing that are paving the way towards more sustainable energy systems. It also analyses the broader socio-economic benefits that can result from such a transition. Finally, the report discusses the potential for renewables-based desalination.

AN INTRINSIC LINK BETWEEN ENERGY EXPORTS AND ECONOMIC GROWTH

The economies of the GCC have experienced tremendous socio-economic development in recent decades, driven both by oil-and-gas revenues and by growth-oriented policies that have led to some of the world's highest urbanisation rates and living standards.

Hydrocarbon exports, in the form of crude oil, petroleum products and other liquids and natural gas, have been the main source of government budget revenues in the GCC, constituting almost 80% of total revenue for the region's governments in 2013. In that year, GCC

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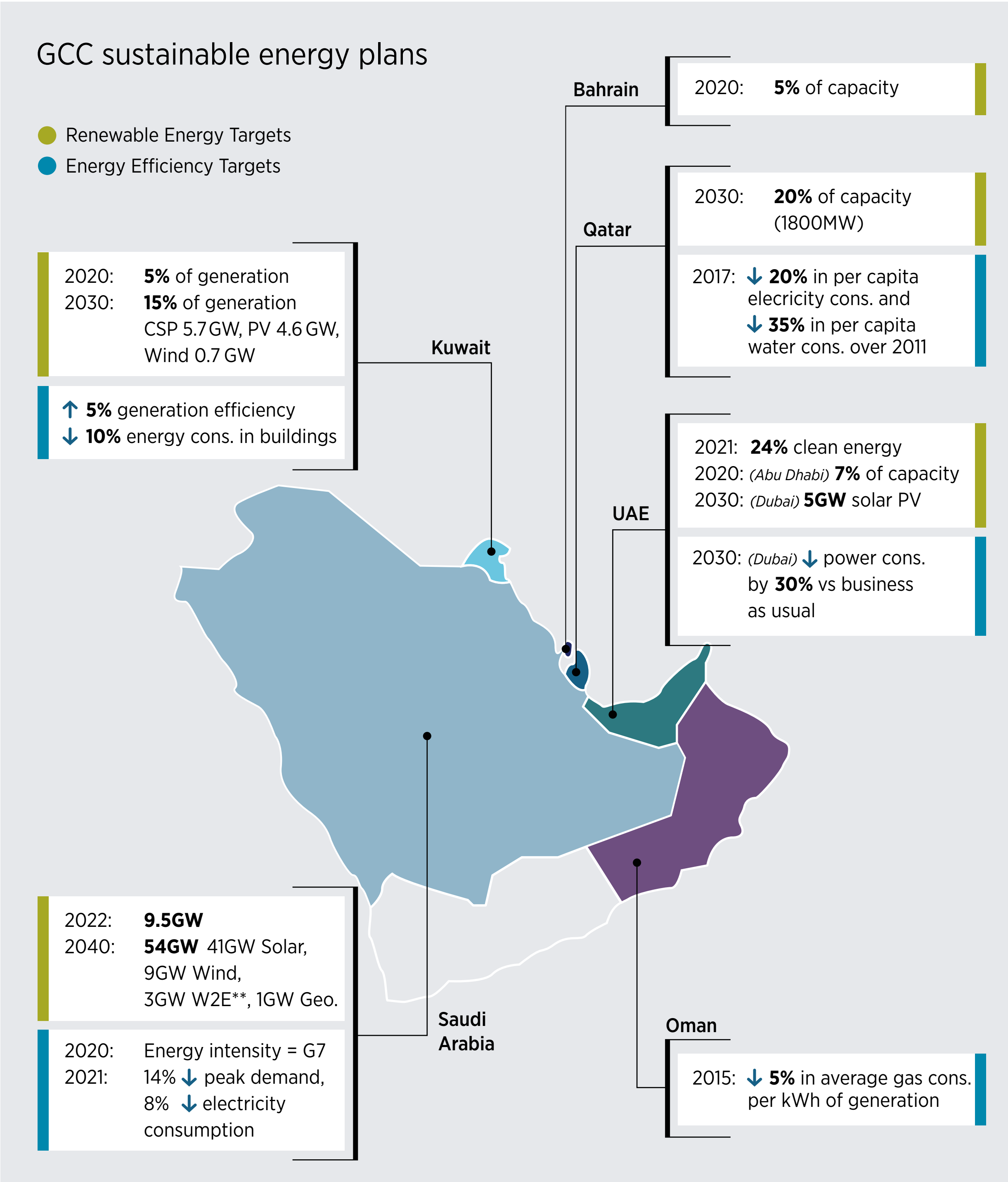
Figure ES.1 Sustainable energy plans and targets in the Gulf Cooperation Council



** The Saudi Arabian renewable energy plan from the King Abdullah City for Atomic and Renewable Energy (K.A.CARE) was intended as a scenario rather than an official target. It has been reported that the plan has been pushed back by eight years (BNEF, 2014).*
Source: Based on (Lahn, Stevens and Preston, 2013); (RCREEE, 2015a) and others

countries exported roughly 13 million barrels per day (b/d) of crude oil.[1] Saudi Arabia is the region's largest exporter of crude, with almost 19% of global exports in 2013. Qatar is the largest exporter of natural gas, with almost 12% of global exports in 2013.

With the recent fall in global oil prices, the contribution of hydrocarbon exports to the GCC economies is expected to fall. Also, GCC countries might not be able to sustain the same level of exports at the current rate of growth in energy consumption.

A SURGE IN ENERGY CONSUMPTION

GCC economies' position in global energy markets over the past 40 years has been shaped by their role as oil and gas producers. Rapid socio-economic growth over the past decade is positioning them as one of the world's highest growth markets. During the 2000s, regional energy consumption grew at an average of 5% per annum, faster than India, China and Brazil. Saudi Arabia is now the world's seventh largest consumer of oil. In 2014, domestic consumption amounted to about 28% of production, compared with 17% in 2000. Notably, with rising domestic demand, some countries are turning to imports. The UAE, for instance, is turning to gas imports due to the surge in demand, lag times for domestic production, and export obligations through established long-term contracts.

These trends have inspired countries in the region to devise strategies for conserving natural resources, improving energy efficiency, and diversifying the energy mix towards alternative sources, including renewables. In fact, countries in the GCC have already started planning their transition towards a more sustainable energy future.

1. *Based on IEA data.*

2. *A geographical region consisting of countries that are situated between 35°N and 35°S and generally characterized by high solar irradiation (EPIA and ERA, 2010).*

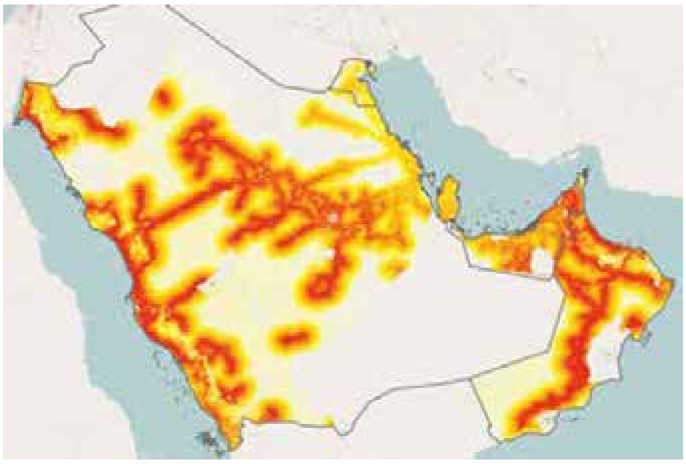
ASPIRATIONS FOR A MORE SUSTAINABLE ENERGY FUTURE

In recent years, several GCC countries have announced plans and targets for conserving natural resources, improving energy efficiency, and deploying renewable technologies (Figure ES 1). Solar energy has received particular attention, reflecting its high suitability in terms of resource availability, cost-competitiveness and matching regional demand patterns.

THE ATTRACTIVENESS OF SOLAR ENERGY IN THE GCC

The abundance of solar resource potential and the falling cost of associated technologies, mainly photovoltaic (PV) modules are major factors influencing the attractiveness of solar energy in the region. The GCC countries lie in the so-called Global Sunbelt[2] and boast some of the highest solar irradiances in the world. Close to 60% of the GCC's surface area is found to have excellent suitability for solar PV deployment (Figure ES 2), and developing just 1% of this area could create almost 470 gigawatts (GW) of additional power-generation capacity.

Figure ES.2 Suitability of grid connected solar PV



Source: (IRENA, 2016) (http://irena.masdar.ac.ae/?map=2146)

Note: The potential for solar energy in the region has been analysed using suitability factors such as solar irradiation, distance from the grid, population density, topography, land cover and protected areas (IRENA, 2016a). The analysis indicates vast areas suitable for solar PV deployment throughout the region. The map shows suitability scores between 70% and 100% (from light yellow to dark red).

The resource abundance and its suitability coupled with the falling technology costs, strengthen the business case for renewables in the GCC. Solar PV modules, for instance, cost three quarters less today than in 2009 and will continue to decrease. Falling technology costs are translating into record low generation costs. The recent auction for the Mohammed Bin Rashid Al Maktoum Solar Park 2 in Dubai yielded prices as low as 5.85 US cents per kilowatt-hour (kWh). This price is one of the lowest in the world and even competitive with oil and gas in the region.

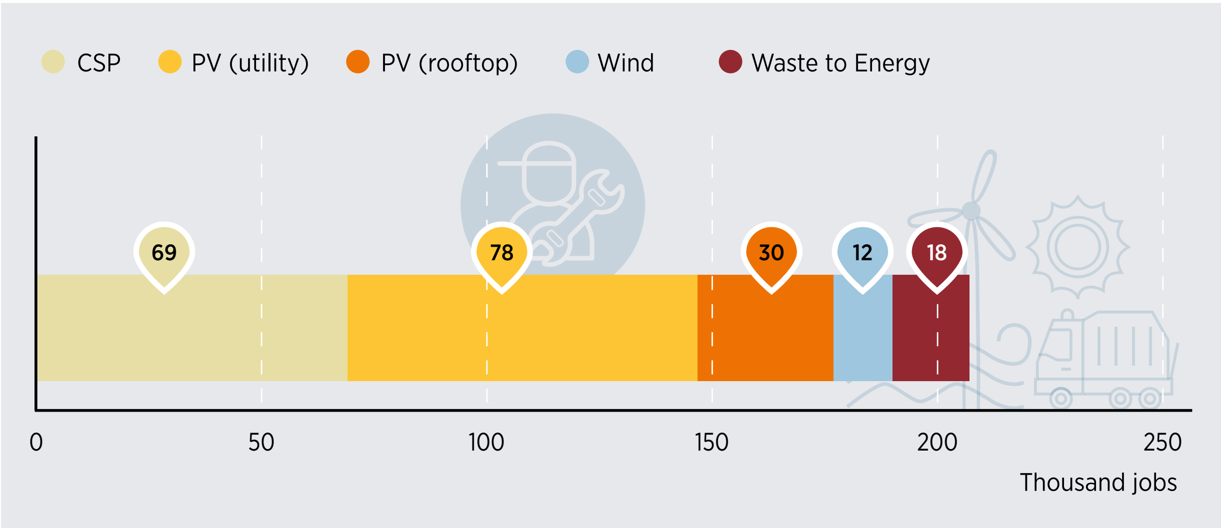
THE ENABLING ENVIRONMENT FOR THE DEVELOPMENT OF THE SOLAR INDUSTRY

The design of the Dubai auction succeeded in bringing the price down mainly due to the creditworthiness of the off-taker, the Dubai Electricity and Water Authority (DEWA), and the long-term vision for solar deployment in the region. DEWA, the majority owner of the solar plant, is a reliable off-taker, which reduces the risk of non-payment and lowers financing costs. A long loan tenor of 27 years, low interest rate of 4% and high debt-to-equity ratio of 86% were instrumental in achieving the record-low electricity price. In addition, the long-term vision of Dubai to deploy 5 GW of solar energy by 2030 encouraged low bidding, as developers sought to establish themselves in a promising market.

Developments in the market attracted players from other segments of the value chain, such as manufacturing. Incentives for the establishment of local industries in the GCC typically include free zones, well-developed infrastructure, and the potential for synergies with established industries such as glass, aluminium and steel. The region also has the potential to spread expertise. For example, local project developers, such as ACWA Power and Masdar, are also developing projects in other countries in the Middle East and North Africa (MENA) region through partnerships and joint ventures.

Local companies have also benefited from partnering with (or acquiring) well-established technology providers and engineering, procurement and construction (EPC) companies. They have enhanced local capabilities, gained experience and strengthened the GCC firms' renewable energy portfolio. Examples include Masdar's partnership with Abengoa and Sener, and Abdul Latif Jameel's acquisition of leading solar developer Fotowatio Renewable Ventures (Spain).

Figure ES.3 The breakdown of direct jobs in renewable energy in 2030 by technology (thousand jobs)

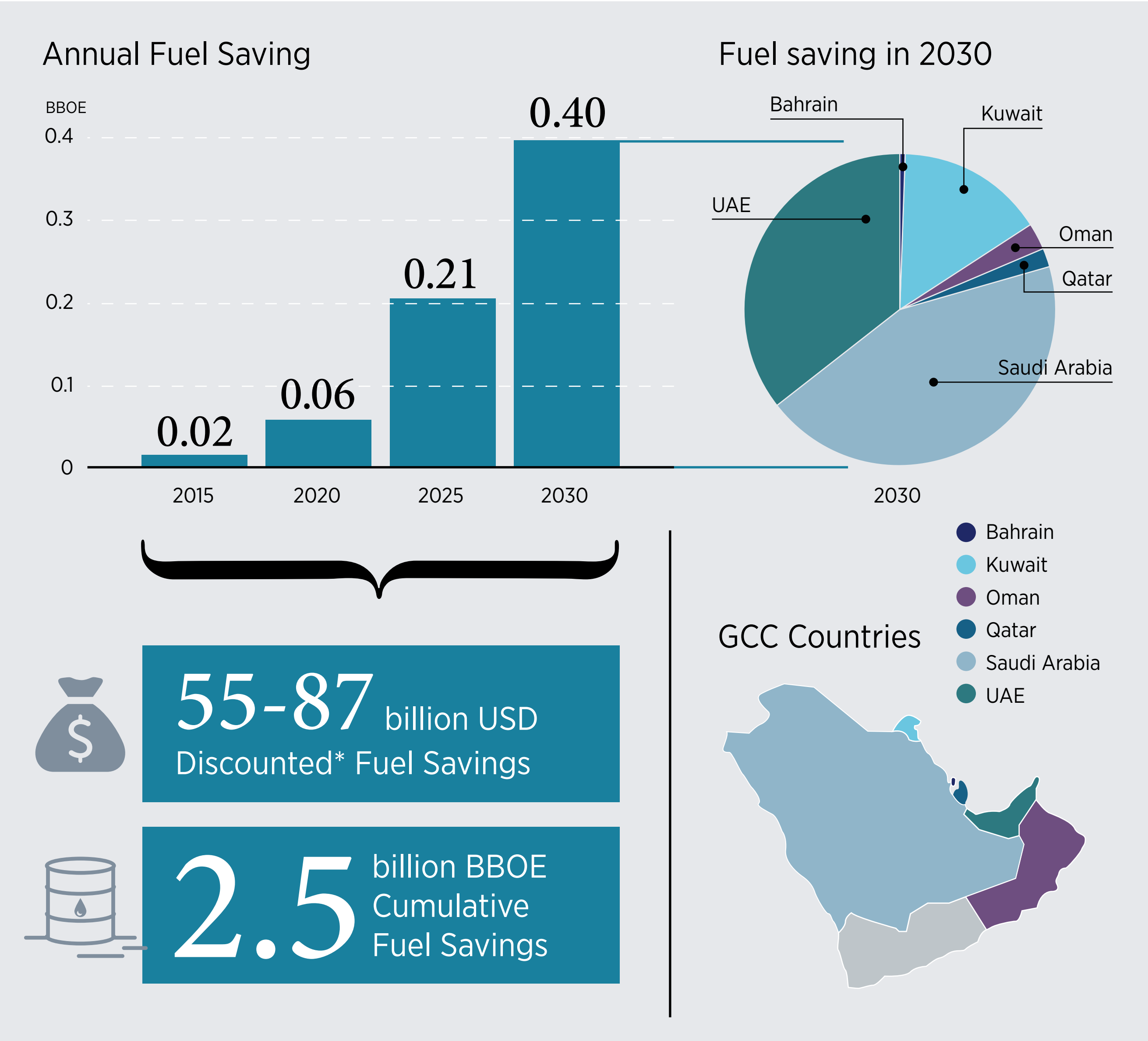


These factors have all contributed to creating an enabling environment for the development of a local renewable energy industry. If the GCC countries' renewables objectives are met by 2030, the projected 80GW renewable energy capacity could bring far-reaching socio-economic benefits, including job creation and savings in fuel consumption, CO_2 emissions and water withdrawal.

POTENTIAL FOR JOB CREATION

IRENA estimates that achieving the GCC renewable energy targets and plans could create an average of 140,000 direct jobs every year. In 2030 alone, close to 210,000 people could be employed in renewables. It is assumed that solar PV (small and large) and concentrating solar power (CSP) would account for 85% of the region's renewable energy jobs in 2030. Massive

Figure ES.4 Fossil fuel savings from GCC renewable energy targets by year and by country



** Discount rate 5%; Low price scenario (Oil: USD 40/barrel; Gas: USD 8/MMBtu); High price scenario (Oil: USD 80/barrel; Gas: USD 11/MMBtu)*

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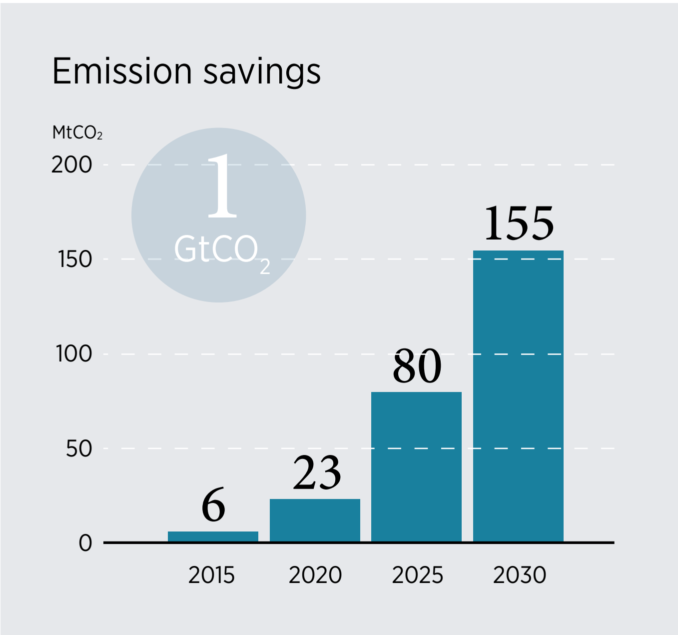
deployment of PV could create more than 100,000 jobs, making it the largest employing technology, followed by CSP with 31% of the jobs. Waste-to-energy can be an important employer, with around 14% of the jobs, according to conservative estimates that do not account for operational jobs in waste collection and processing (Figure ES 3). Wind energy could also contribute, especially in Saudi Arabia, Kuwait and Oman.

Figure ES.5 Emission savings due to renewable energy deployment plans ($MtCO_2$)



SAVINGS IN FUEL CONSUMPTION, CO_2 EMISSIONS AND WATER WITHDRAWAL

Achieving renewable energy plans could result in cumulative savings for the region of 2.5 billion barrels of oil equivalent (2015-2030), leading to overall savings of USD 55 billion to USD 87 billion, depending on oil and gas prices.

Decreasing fuel consumption can also reduce regional carbon footprints, in line with the countries' Intended Nationally Determined Contributions (INDC) submissions to the Paris climate conference (COP21). Carbon emissions can be reduced by a cumulative total of around 1 gigatonne (Gt) by 2030, resulting in an 8% reduction in the region's per capita carbon footprint (Figure ES 5).

In addition to saving CO_2 emissions, realising renewable energy plans could result in an overall reduction of 16% in water withdrawal in the power sector[3], equivalent to 11 trillion litres of water per year This would have ecological benefits and reduce energy consumption for water desalination.

WATER DESALINATION: THE OTHER RENEWABLES APPLICATION

Desalination provides a large share of the region's fresh water needs, ranging from 27% in Oman to 87% in Qatar. It also accounts for a substantial share of total energy consumption in most GCC countries; as much as 30% for Qatar and the UAE, for example. In Saudi Arabia, thermal desalination accounts for around 10% of domestic oil consumption. Desalination also draws considerable volumes of natural gas, where available (e.g. in Oman and Qatar).

A transition towards a greater use of renewables for desalination, especially solar power, can reduce fossil fuel consumption for exports or more economic uses. Both grid connected and off-grid desalination can be cost-competitive. Ongoing research and deployment can enhance the business case. Large-scale renewable energy-based desalination projects could further reduce costs through economies of scale.

3. 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.

THE WAY FORWARD

The development of fossil fuel reserves and exports in the GCC has underpinned impressive economic growth, bringing widespread prosperity and development. Fossil fuel production is increasingly used to meet the fast-growing domestic energy demand. Rapid industrialisation, high demography and rising water desalination are the leading reasons for this growth and can have important implications for GCC countries' ability to maintain export levels over the long-term. In fact, as discussed in this report, some countries, have recently become, or are on the verge of becoming, net importers of natural gas. Governments are, therefore, compelled to embark on energy diversification strategies to meet growing energy demand with energy supply options that are domestically available, secure, cost-effective and environmentally-sustainable. Renewable energy is a key part of the solution.

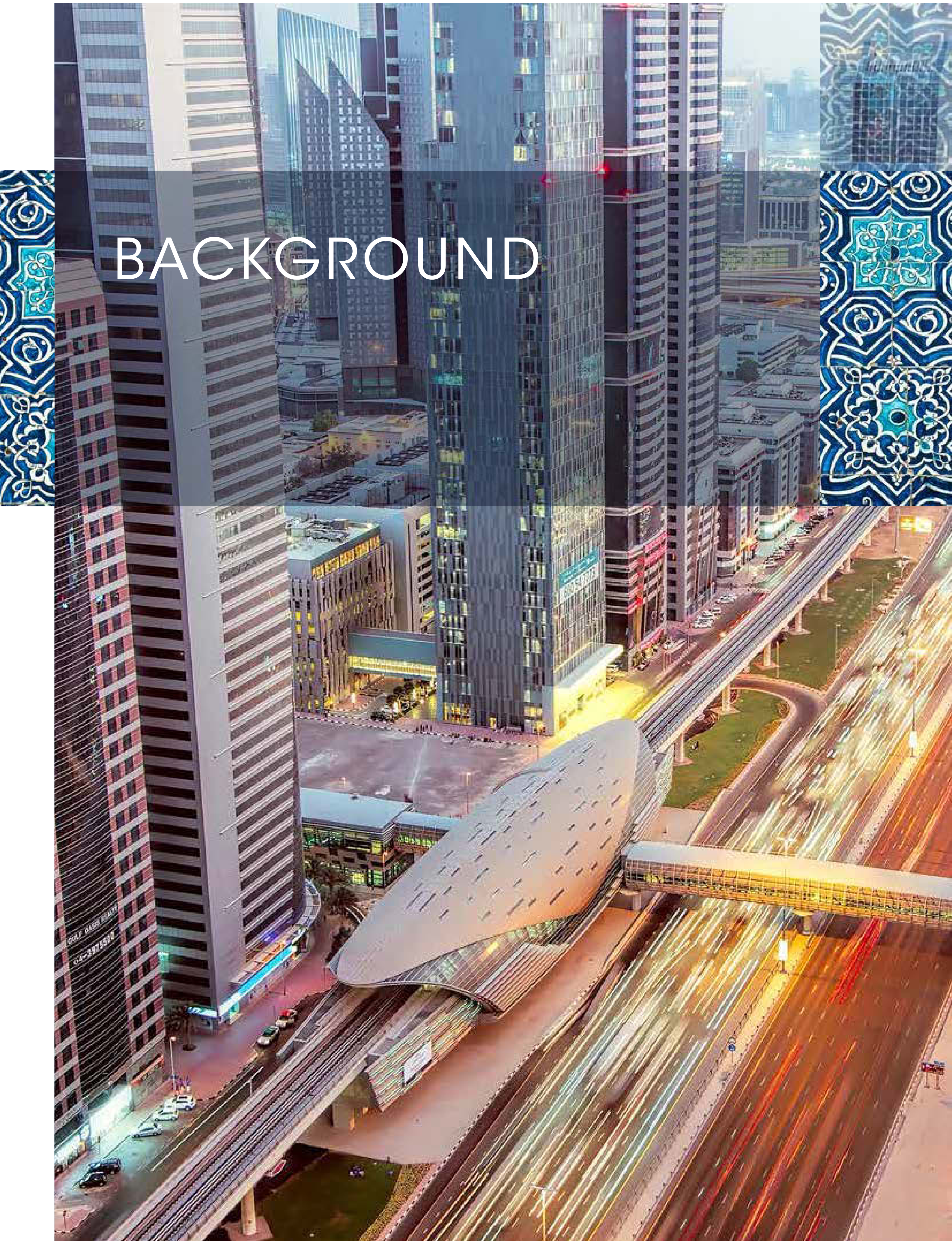
Despite potential benefits, the pace of renewables deployment has, to date, fallen short of its potential in the region. This can be attributed to a range of factors, including institutional inertia faced with new markets, clarity in institutional roles and responsibilities, and lack of dedicated policies and regulations. In the recent past, efforts were made to overcome existing barriers by setting up specialised institutions, building adequate capacities and providing a vision for the sector's development through renewable energy plans and targets. Government commitments can take the form of credible, time-bound renewable energy targets, which serve to anchor investor confidence and set out the trajectory for the development of the sector. To be effective, targets must be backed by dedicated policies and regulatory frameworks.

Renewable energy deployment policies are essential market-creating measures, as they trigger investments in the sector. They are most effective when they foster stable and long-term development for renewable energy in the different market segments, while being continually adapted to dynamic technological and market changes. For this purpose, auctions have been identified as an effective policy for large-scale deployment. The design of auctions is integral to their success in achieving deployment in a well-planned and cost-efficient manner while also fulfilling development objectives. Auctions can be implemented along with other instruments, especially for small-scale projects, such as feed-in tariffs and net-metering. The success of net metering relies on conducive financing conditions to lower the upfront costs of installing the systems and on electricity tariffs that are comparable to the current levelised cost of solar photovoltaic. While deployment policies in the region to date focus on the power sector, they could also support other renewable energy applications, such as heating/cooling and renewables-based desalination.

In general, deployment policies need to be part of a broad range of cross-cutting policy instruments – the "policy mix" – that supports the energy transition. Tailored to specific country conditions and the level of maturity of the sector, the policy mix should focus on building institutional and human capacity, promoting research and development, strengthening domestic industry and creating an investment-friendly environment.

The GCC countries are endowed with hydrocarbon resources that have fuelled development over the past decades. Blessed with abundant solar resources, the region can fuel economic growth and provide employment for future generations in a sustainable manner.

BACKGROUND



01

The Gulf Cooperation Council (GCC) is comprised of six countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE). These countries have experienced high economic growth in recent decades, due largely to the wealth generated from abundant hydrocarbon reserves. This growth has also been accompanied by a globally unparalleled rise in urbanisation, infrastructure development and overall socio-economic conditions. The region's population has grown by six-fold since 1970, with migrant workers from Asian and other Middle East and North African countries as key contributors (World Bank, 2015).

As some of the world's largest producers of oil, and to a lesser extent natural gas, the GCC countries form a core group of global oil producers whose energy policy actions have far-reaching consequences for global energy market dynamics. Four of its member states are members of the Organization of the Petroleum Exporting Countries (OPEC): Saudi Arabia, the UAE, Kuwait and Qatar.

Despite the intrinsic link between fossil fuels and the socio-economic development of the GCC states, the region is highly vulnerable to the impacts of climate change. If global temperatures continue to rise, the region will experience an above average increase in temperatures and decrease in precipitation. This would mean a rise in demand for air conditioning and desalination, in a region that is one of the most water-stressed in the world (Dziuban, 2011). In addition, climate change can lead to rising sea levels that pose threats to the highly populated coastal communities (Donat, 2014; Pachauri, 2014).

1.1 OVERVIEW OF GCC ECONOMIES

The economies in the GCC have grown substantially in the last decade, with the countries boasting some of the highest per capita gross domestic products (GDP) in the world. This growth has been mostly fueled by the hydrocarbon sector. In 2014, Saudi Arabia, represented 53% of the region's GDP, followed by the UAE at 20% and Kuwait and Qatar at around 10% each (World Bank, 2015). This breakdown reflects the respective position of the GCC countries as hydrocarbon producers and exporters. Saudi Arabia, the UAE and Kuwait, are the second, sixth and ninth-largest oil producers globally, while Qatar is the fifth largest producer of gas worldwide.

The economic growth in the region is primarily driven by government spending and large state-owned enterprises (IMF, 2015). The high economic growth witnessed in the region has been accompanied by a high annual population growth rate of almost 7%. With a growing population entering the labour force, there is a risk of unemployment and underemployment among young nationals which raises concerns (Box 1.1). This, among other factors, provides further justification for diversification into economic sectors, other than oil and gas.

01

Box 1.1 Labour markets in the GCC

The labour markets and 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 UAE and Qatar. Expatriate workers mostly fill blue collar jobs such as construction and manufacturing, and many skilled and semi-skilled jobs in other sectors such as services. Expatriates generally comprise the vast majority of employees in the private sector.

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

Policy responses by GCC governments have included encouraging national participation in the labour force by establishing quotas at the company and sector levels. Other efforts have focused on building local knowledge-economies and promoting jobs in new economic areas that attract educated nationals without regulatory incentives. Renewable energy, and the wider category of sustainable energy is considered as an area that fits those criteria, and will be discussed later in this report.

1.2 DIVERSIFICATION OF GCC ECONOMIES

While the oil and gas sectors remain major contributors to the regional GDP, the national economic policies and the articulated visions have increasingly aimed towards economic diversification. The push for diversification in the region is driven by a number of factors. First, to reduce risk associated with dependence on oil revenues (e.g. fluctuating oil prices and changes in global oil market dynamics). Second, to create jobs through the establishment of labour intensive industries. Third, to plan for the post-oil era. As a result, GCC governments have developed strategies to promote specific sectors as summarized in the national strategies in Box 1.2.

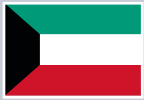
"In 50 years, when we might have the last barrel of oil, the question is: when it is shipped abroad, will we be sad? ... If we are investing today in the right sectors, I can tell you we will celebrate at that moment."

Sheikh Mohammed bin Zayed,
Crown Prince Abu Dhabi
(The National, 2015)

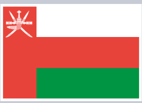
While the share of the non-oil sector in total real GDP has increased from 58% in 2000 to 70% in 2013, the strategies adopted by governments have had modest results. The rise in oil prices and resulting increase in domestic spending for infrastructure and wages led to the strong growth in sectors such as construction, transport and retail (IMF, 2014). In Dubai, for instance, the development of modern infrastructure, along with a business-friendly environment have paved the way for significant development in finance, transportation, trade, tourism and manufacturing.

Box 1.2 National economic strategies of the GCC countries

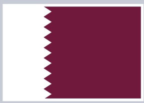
Bahrain's *Economic Vision* 2030 calls for a 'shift from an economy built on oil wealth to a productive, globally competitive economy, shaped by the government and driven by a pioneering private sector'. Much emphasis is on attracting foreign direct investment to create jobs. By 2030, the strategy envisions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



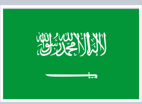
Kuwait's *Vision Plan* 2035 and current *5-Year Development Plan* focus on economic diversification and aim to position the country as a regional trade and financial hub. The plan focuses on infrastructure investment, including transportation, a new port, and the development of the business hub 'Silk City' in Subiyah.



Oman's *Vision 2020* and successive *5 Year Development Plans* aim for further diversification from the oil sector and development of human resources and infrastructure. Its *In-country* Value Strategy increases spending to benefit business growth and human-resource development. Tourism is seen as a key economic sector for growth and employment creation for nationals. More than half the budget of the past development plan went toward improved airports and roads.



Qatar's *National Vision 2030* and *National Development Strategy (2011 – 2016)* foresee a dominant role for hydrocarbons in the future economy but also provide a gradual and managed diversification strategy with greater involvement of the private sector. National institutions are developing strategies for investments in transport infrastructure, housing, and industrial activities to prepare for the FIFA World Cup in 2022.



The **Saudi Arabian** *Long Term Strategy 2025*, emphasises the challenges of the growing youth unemployment among nationals and of boosting income in the country. Goals include reducing government reliance on oil revenues from 72% of total exports to 37% between 2004 and 2024 and doubling national income in this time period. The associated *Ninth Development Plan* aims for increased participation by the private sector in the economy.

In the **UAE's** *Vision 2021 document* and in individual development plans for Abu Dhabi and Dubai, continued economic diversification is emphasised with a focus on growing sectors of tourism, aviation, and financial services. The country is positioning itself as regional hub of research and innovation and sustainable energy. The Dubai Expo 2020 is expected to attract more than 25 million visits and have a positive impact on tourism, travel and real estate.

Source: (Hvidt, 2013)

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1.3 IMPACT OF OIL-PRICE FLUCTUATIONS ON GCC ECONOMIES

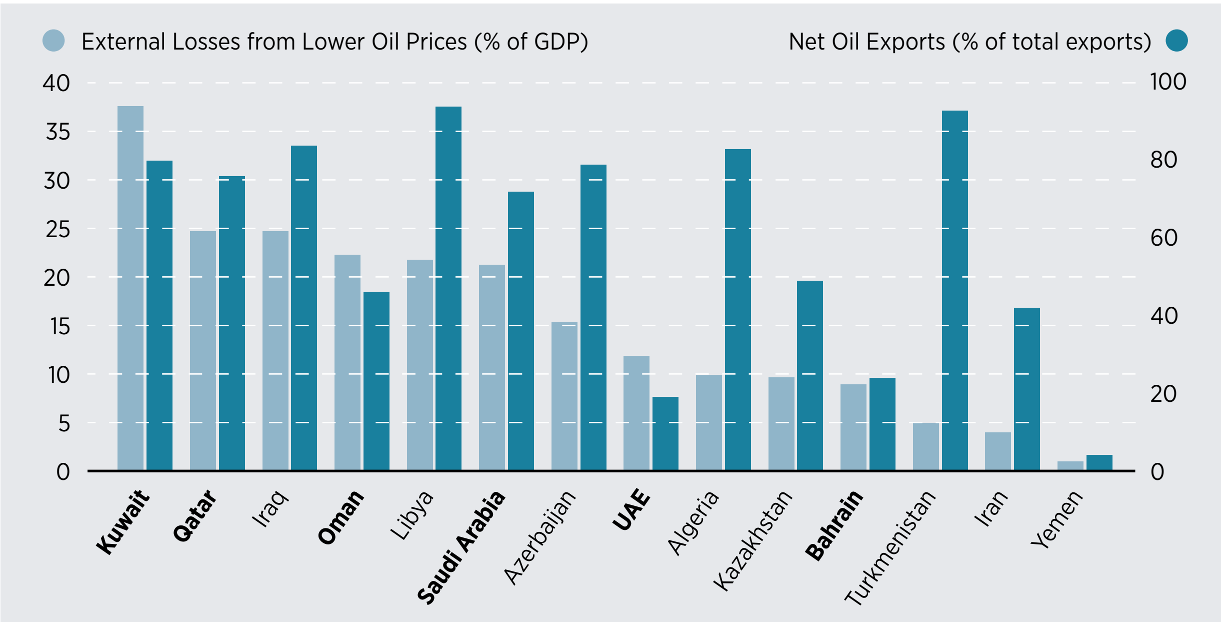
The collapse in oil prices since mid-2014 from over USD 100 per barrel in the first half of 2014 to around USD 35 by January 2016 has meant lower exports and government revenue in the GCC. Export losses are estimated to be around USD 287 billion for 2015 (21% of GDP in the region) (IMF, 2015). Figure 1.1 shows that losses in Kuwait, Qatar, Oman and Saudi Arabia, are estimated at more than 20% of GDP.

As a result, a number of GCC countries have pledged fiscal consolidation and economic reform programmes for 2016, including changes to the region's long-established subsidy systems (Gulf News, 2015). As their development plans hinge on the assumption of strong economic growth, governments are likely to further consider spending on non-asset creating expenditures, diversifying government revenues (e.g. through income tax or value added tax), and pursuing further economic diversification strategies in the medium to long term (IMF, 2015).

The duration of the current low-oil price environment is still uncertain, as are the implications of falling oil prices on government investment in alternative energy plans. Nevertheless, the long-term economics of renewables in the GCC remain positive, given that solar PV power in the region is comparable to the Levelised Cost of Electricity (LCOE) from oil priced at USD 20 per barrel (see Chapter 3). In a "low-price" environment of around USD 35 per barrel in January 2016, this cost advantage still offers plenty of economic opportunity for renewable energy deployment. Whether the GCC states will exploit this potential depends to a large extent on long-term policy planning and the creation of a stable and transparent regulatory and investment climate to support early deployment.

The ongoing reform in the energy pricing structures and the inclusion of renewables in the energy mix can present an opportunity of further reducing the reliance of the region's economy and energy sector on oil and gas. Chapter 2 provides more detailed insight on the role of hydrocarbons in the regional energy sector landscape.

Figure 1.1 External losses from lower oil prices in 2015 (% of GDP) and net oil exports (% of total exports)



Sources: (IMF, 2014)

Notes: External losses are calculated as the projected difference in the US dollar value of net oil exports in 2015, using the 2015 oil price assumptions in the May 2015 and October 2014 World Economic Outlooks of the IMF, and the volume of net oil exports in the latter, with adjustments for country-specific factors.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GCC ENERGY MARKETS

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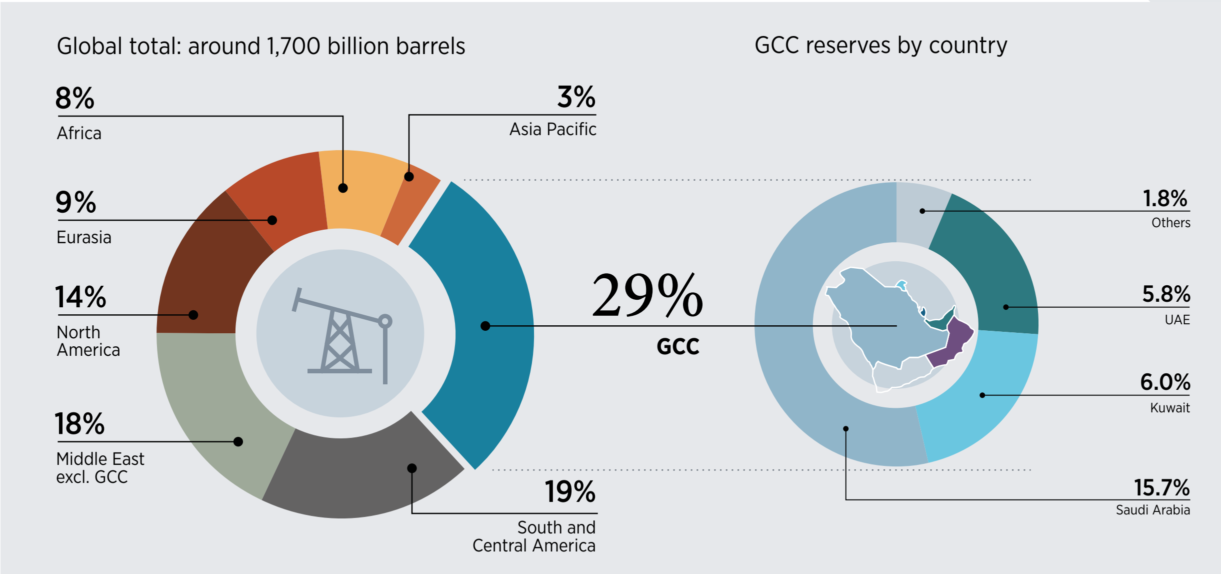
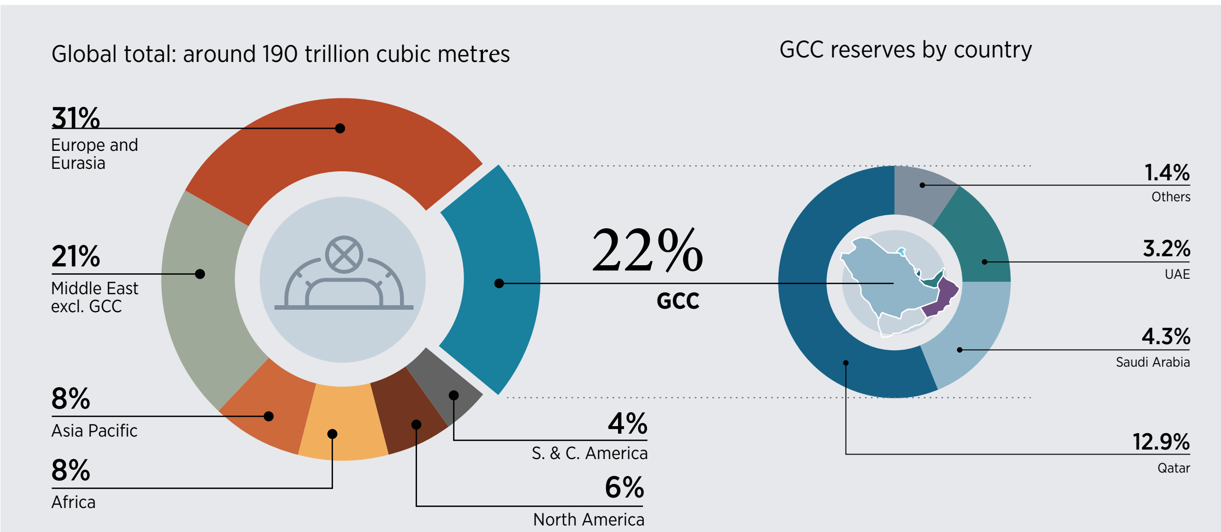
The GCC countries comprise the world's largest hydrocarbon producing region, with around 30% of proven crude oil reserves (Figure 2.1), and around 22% of global gas reserves (Figure 2.2). Saudi Arabia, with currently around 270 billion barrels, has the world's second largest oil reserves after Venezuela and is able to produce for at least another 75 years at current rates. Saudi Arabia also holds the world's sixth largest natural gas reserves, largest in the region save for those of Qatar, whose estimated proven gas reserves of around 25 trillion cubic meters (tcm) make it the world's third-largest holder.

Figure 2.1 The world's crude oil reserves by region, 2014 (%)



Source: (BP, 2015)

Figure 2.2 The world's natural gas reserves by region, 2014 (%)



Source: (BP, 2015)

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2.1 ENERGY SUPPLY

The abundance of hydrocarbon resources in the GCC makes it a premier producer and exporter of crude oil, petroleum products and natural gas.

Oil and petroleum products production and trade

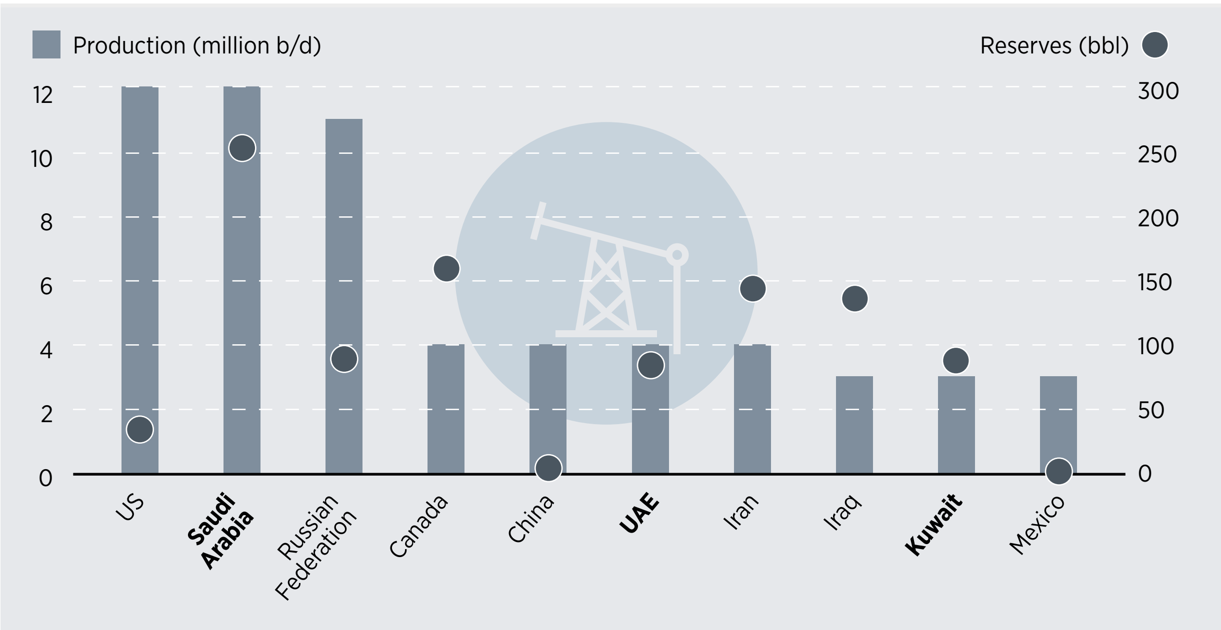
Production of crude oil

The GCC accounts for around a quarter of global crude oil production and stands out for having the second, sixth and ninth-largest global producers: Saudi Arabia, the UAE and Kuwait, respectively (Figure 2.3). The majority of GCC oil production is exported to international markets given the relatively small domestic market (Table 6 in Annex 2). In addition to the scale of reserves and production, the GCC's importance to global crude markets also lies in the fact that it has virtually all of the world's spare production capacity.[1] It is estimated that the effective spare capacity held in the region in 2014 amounted to around 3.52 million b/d (IEA, 2014).[2] More than 90% of spare capacity is held by Saudi Arabia, with the remainder by Kuwait and the UAE. This means Saudi Arabia has considerable influence over global oil-market dynamics.

Production of petroleum products

In addition to crude oil, the GCC is also a large producer of petroleum products[3]. Saudi Arabia is the region's largest product refiner with eight operating refineries and a capacity of well over 2.2 million b/d, followed by Kuwait and the UAE (EIA, 2015). The region's refineries produce a range of products for both the domestic and the international market. A large project pipeline for new refining capacity in several GCC countries means the region will no longer be seen as just a production centre, but as one for

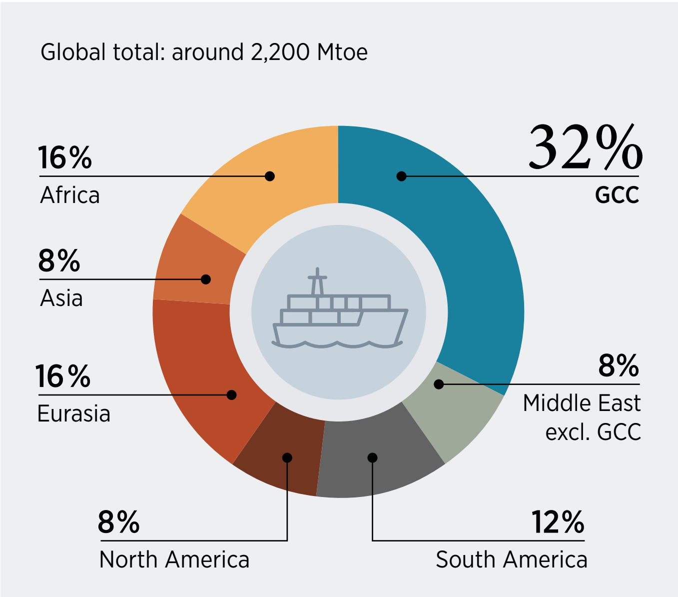
Figure 2.3 The world's 10 largest oil producers in 2014 (production in million barrel/day; reserves in billion barrels)



Source: BP (2015)

1. *The technical capacity to raise production at short notice for a sustained period of time.*
2. *By the IEA's definition, effective spare capacity captures the difference between nominal capacity and the fraction of that capacity actually available to markets.*
3. *This includes gasoline and diesel, kerosene, jet fuel, liquefied petroleum gas (LPG), propylene and naphtha, among several other products.*

Figure 2.4 Global liquids exports by exporting region in 2013 (% in energy terms)



Note: Liquids includes crude oil, NGL and feedstocks as per IEA definition.
Source: Based on IEA data

refining as well. Saudi Arabia is currently finalising plans to increase the country's refinery capacity by nearly 60% to reach 3.4 million b/d by 2017/18. This is part of its long-term strategy of diversifying energy outputs (Krane, 2015).

Trade of crude oil and petroleum products

The GCC accounts for more than 80% of the Middle East's total liquids exports (crude oil and petroleum products) of roughly 19 million b/d (2,200 Mtoe) (Figure 2.4). In addition to exporting crude oil, GCC countries also export a range of petroleum products, particularly liquid petroleum gas (LPG), naphtha (a key source of feedstock fuel in petrochemicals production), diesel and fuel oil. Saudi Arabia, with a total of 62 million tonnes of oil equivalent (Mtoe), is by far the largest exporter of refined products in the GCC, followed by Kuwait (32 Mtoe) and Qatar (22 Mtoe) (IEA, 2015). Total net exports of refined products amounted to 2.57 million b/d in 2012, nearly half of which were from Saudi Arabia.

GCC crude oil exports to Asian countries have been growing over the past decade. More than two-thirds of Saudi Arabia's and Kuwait's crude oil exports, and over 95% of that of Qatar, Oman and the UAE are sent to Asian markets, particularly, China, India, Japan and Korea. The trend is similar for refined products. More than 60% of Qatar's refined-product exports, for instance, go to Japan (EIA, 2014c).

Natural gas production and trade

Production of natural gas

Natural gas production has increased substantially since the 1980s in the GCC following its rise as a coveted fuel for domestic power generation, for inputs in intermediate industries such as petrochemicals, as well as for exports. Qatar is by far the region's largest producer and exporter of liquefied natural gas (LNG) as well as the world's third largest producer of dry gas (Figure 2.5).

The region's overall share in global gas production stands at 10%, despite accounting for around a fifth of global reserves. With the notable exception of Qatar, production of natural gas has lagged in all other GCC countries. This is due to a variety of factors, including comparably late development of non-associated gas resources and the historic focus on oil as the region's primary revenue source. Slower domestic gas development, coupled with the predominance of sour

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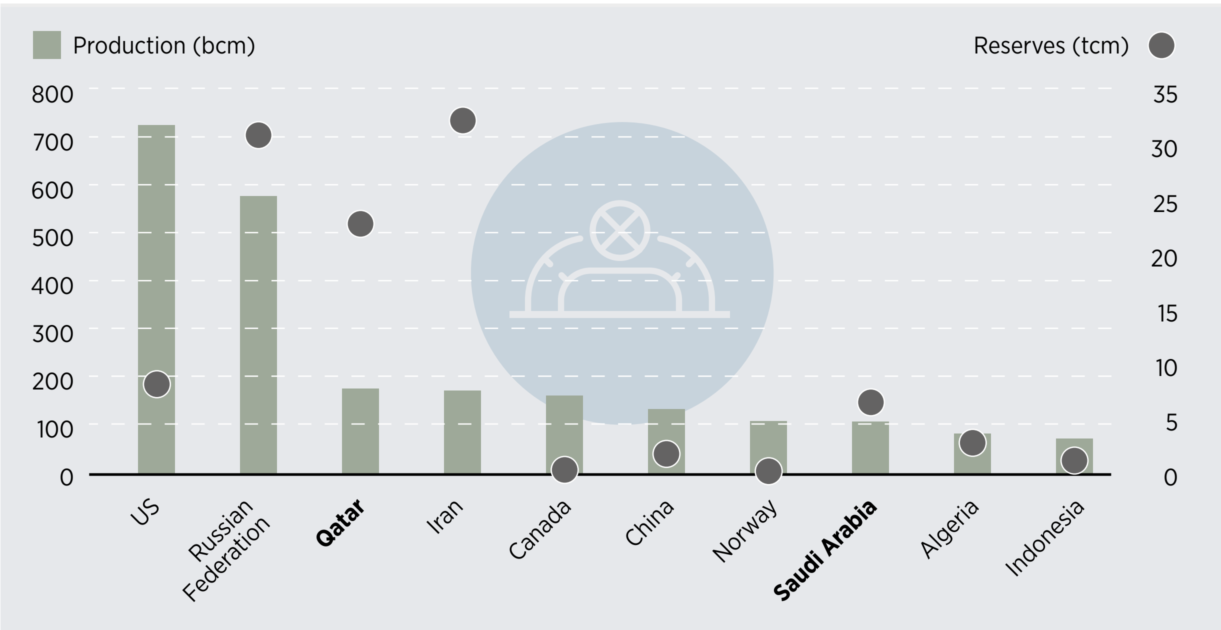
gas reserves among the region's non-associated gas resources and rapidly increasingly domestic demand have further contributed to a situation where several GCC members have recently turned to gas imports, including via regional supplies from Qatar.

Trade of natural gas

Although the GCC countries have significant natural gas reserves, the role of gas as a tradable commodity overall does not match the role played by crude oil in the region (Figure 2.6). Qatar, as the exception, exports around 85% of its natural gas production, with an export capacity of some 77 million tonnes per year (around 104 bcm) of LNG. In addition, around 60 million cubic metres (MMcm) per day of dry gas is mar-keted regionally through the Dolphin pipeline project (EIA, 2014c).

The region's other two exporters, the UAE and Oman, are small-scale LNG exporters, selling to Asian markets, primarily Japan. In 2013, the UAE exported some 8 bcm (EIA, 2014). Oman has export capacity for around 14 bcm of LNG per year (EIA, 2014c). The lagging pace of development of new gas resources across the GCC, and the likelihood that any finds would be consumed domestically, means the region, as a whole, is not expected to be a major gas exporter in the future. In fact, several GCC members are turning to natural gas imports due to the surge in demand for electricity production, lag times for new non-associated gas production, and established long-term contracts for LNG exports. The UAE and Oman, both with existing LNG export commitments in place well into this decade, are now importing – the UAE regularly and Oman occasionally – to avoid shortfalls during the peak summer months for electricity consumption. Since 2008, both countries have imported from Qatar through the Dolphin pipeline. The UAE and Kuwait are also importers of LNG (El-Katiri, 2013).

Figure 2.5 The world's ten largest natural gas producers in 2014 (production in bcm, reserves in tcm)



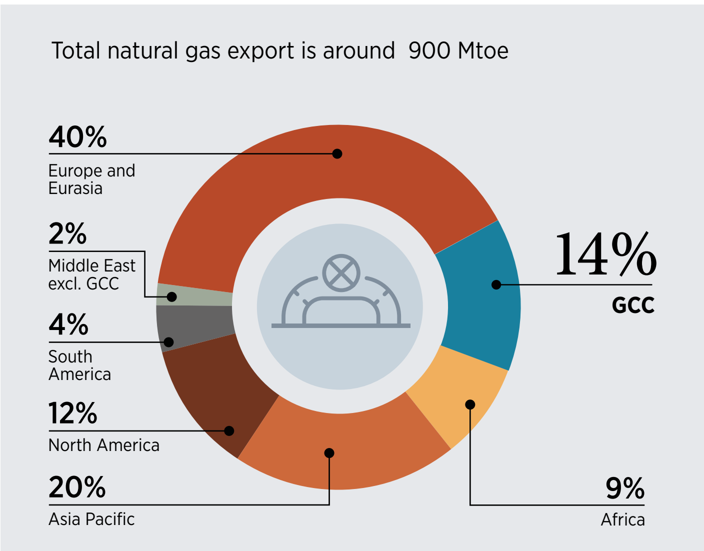
Source: (BP, 2015)

The GCC regional grid

The GCC countries have moved a step closer towards more electricity trade by interconnecting their electricity sectors through the GCC region grid in 2011. The interconnection currently maintains a relatively small capacity of 2.4 gigawatts (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. Usage has so far been reportedly minimal given the purpose (El-Katiri, 2011; MEES, 2014).

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 but unlikely given the absence of competitive markets for electricity, price controls in each of the GCC countries and similarities in demand profiles across each electricity system. Technical caveats, such as Saudi Arabia operating on a different frequency than the others, also adds to the challenges in scaling up electricity trade between Saudi Arabia and the rest of the GCC (El-Katiri, 2011).

Figure 2.6 Global natural gas exports by region in 2013 (% in Mtoe)



Source: Based on IEA data

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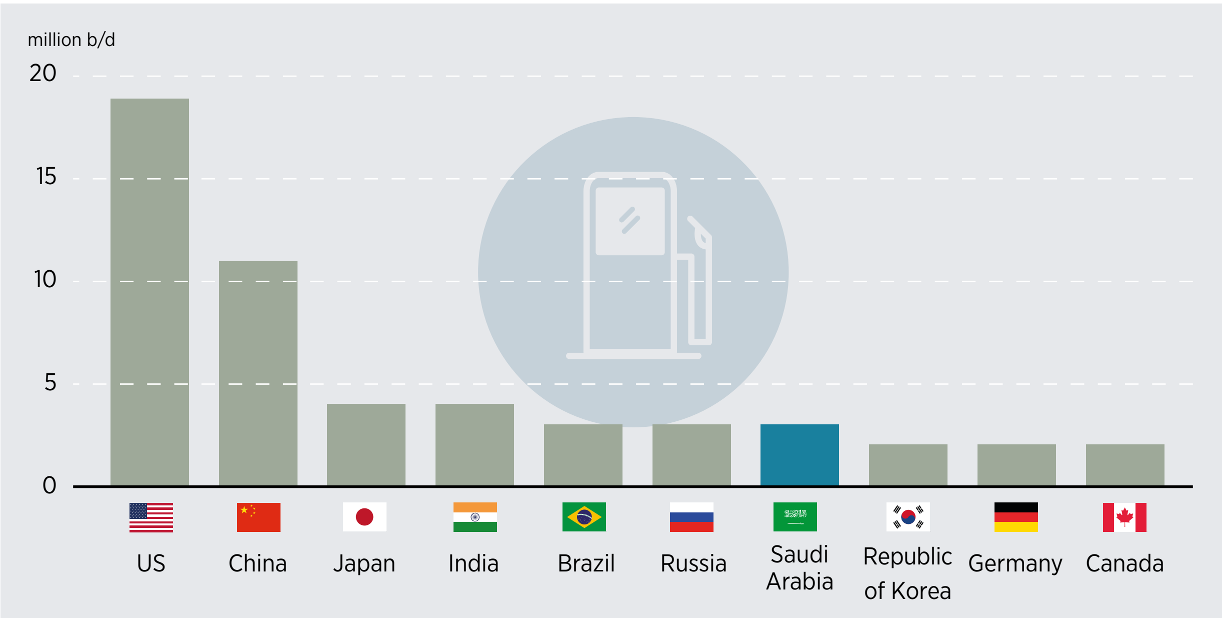
2.2 ENERGY DEMAND

GCC economies have traditionally not been major consumers of energy, and their position in global energy markets over the past forty years has been shaped by their role as producers, exporting the majority of domestically produced oil and gas. Against this background, hydrocarbons have formed an integral part of the region's energy focus, with the perception of a natural abundance of these resources relative to the region's own energy needs. However, rising domestic energy demand, driven by rapid industrialisation, growing population and increasing water desalination, has stressed the region's resources. This section explores the basic dynamics in energy consumption over the last decade.

Overall trends in energy consumption

The GCC is experiencing an extraordinary surge in energy consumption, rising on average some 5% per annum during the 2000s[4]. In the last few years, together the GCC countries have overtaken major consumers such as China, India and Brazil in terms of consumption growth, thereby reducing the share of production that can be exported. Saudi Arabia, for instance, domestically consumed nearly a third of its oil production in 2014 making it the seventh largest consumer of oil (Figure 2.7).

Figure 2.7 The world's ten largest oil consumers in 2014 (million barrels per day)



Source: (BP, 2015)

4. *According to EIA statistics, the six GCC economies consumed a total of 4.57 million b/d in 2014. IRENA calculations of 10-year CAGR (2000 – 2009) based on EIA data.*

"Renewable energy solutions are an excellent response to meeting energy needs in remote areas, and can help alleviate pressure on GCC countries to expand and upgrade their transmission and distribution grids."

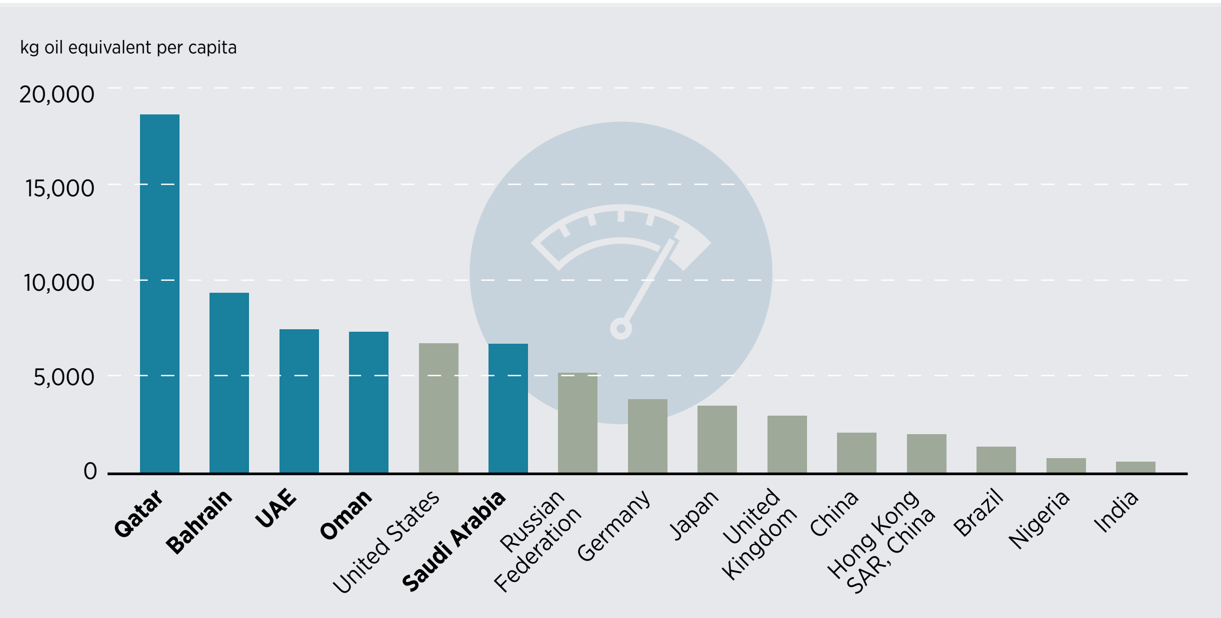
Othman Zarzour
Energy Analyst

GCC energy consumption is substantial on a per-capita basis. Kuwait, Bahrain, the UAE and Oman face levels far above those of most other industrialised countries including the US, India, Russia China and Japan, and Qatar's is the world's highest. (Figure 2.8)

With the overall energy demand rising, GCC countries are also experiencing significant growth in electricity demand. Peak electricity load in Saudi Arabia, for instance, has been rising by 7% every year. It is projected to increase by 32% from 2014 to 2020 and more than double by 2032 (MEES, 2015). As the demand increases, GCC countries are also experiencing significant requirements for power sector infrastructure development. In Qatar, for instance, rising demand for power in remote settings requires significant upgrades and extensions of the grid. (Zarzour, 2015).

There are multiple reasons for the rising demand in electricity as well as the broader energy sector. Strong economic and demographic growth, driven in part by the GCC economies' highly energy-intensive industrialisation programmes, has led to a dramatic surge in consumption. Energy-intensive industries and energy- and water-intensive service sectors, such as tourism, have added to the demand, particularly over the past decades. Gains in living standards, the arid climate-induced need for year-round air conditioning, and water desalination are additional demand drivers. Finally, existing pricing structures have provided little incentive to use these resources efficiently or sparingly (Lahn, Stevens and Preston, 2013).

Figure 2.8 Total primary energy use per capita in 2012 (kg of oil equivalent per capita)



Source: (World Bank, 2015)

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Consumers of energy

With highly energy-intensive industries, including the power and water sectors, refining, petrochemicals, and fertiliser industries, the industrial sector is the dominant user of energy in the GCC, accounting for half of demand. Transport accounts for a third, and residential and commercial consumption (mainly electricity) represent a relatively smaller share of overall final energy consumption (Figure 2.9).

Industrial Sector

Industrial demand for natural gas is growing and accounts for 65% of energy inputs for the sector (Figure 2.10). There are two main uses: the first is as a feedstock for petrochemicals production. Saudi Arabia, for example, has placed several petrochemical production factories close to existing oil fields to benefit from low-cost associated gas (Figure 2.11). The second use is for captive industrial power generation in energy-intensive industries such as aluminium. The increasing use of gas in the sector is reducing the consumption of crude oil, other petroleum products and grid based electricity.

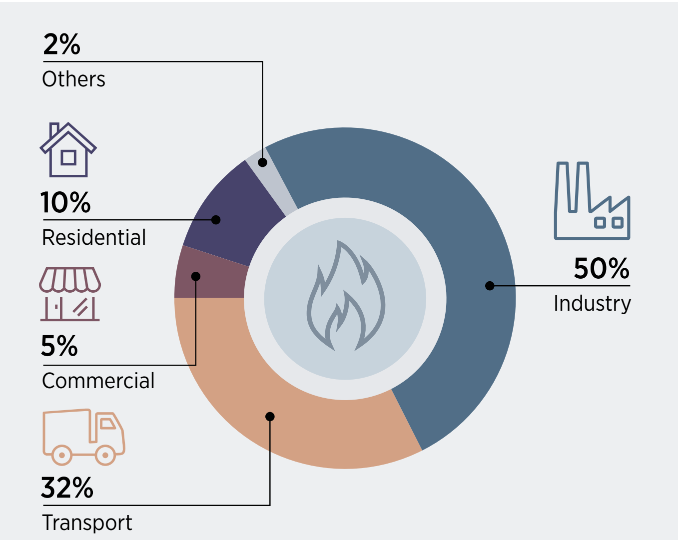
Transport Sector

The GCC economies' per-capita consumption of fuel in transport now rivals that of most developed economies, with Qatar approaching that of the US, the world's largest transport-fuels consumer (Figure 2.12).

The surging consumption for motor gasoline and diesel is attributed to the high reliance on road transport in the region – given historically low fuel prices and limited public transport – coupled with high population growth. The consumption of gasoline, for example, has doubled in Kuwait, Saudi Arabia and the UAE over the period of 2002 – 2013, while Oman's demand in 2013 almost tripled since 2003.

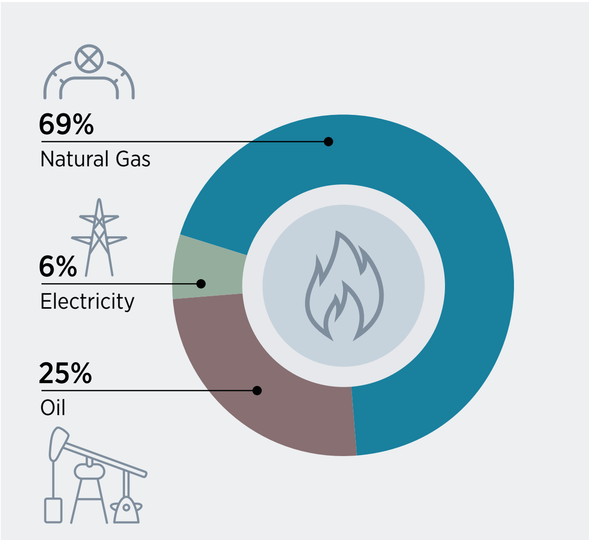
Rising domestic demand for transport fuels has even resulted in regional imports to fill the growing gap between domestic production and demand, contributing to the rationale for investments in large refineries. For example, Saudi Arabia's imports of gasoline have more than quadrupled over the last decade, and its diesel imports have grown over the period between 2003 and 2013, by over 500% (EIA, 2015). In the UAE, gasoline imports have risen as well, doubling in

Figure 2.9 Total final energy consumption in the GCC by sector in 2013 (%)



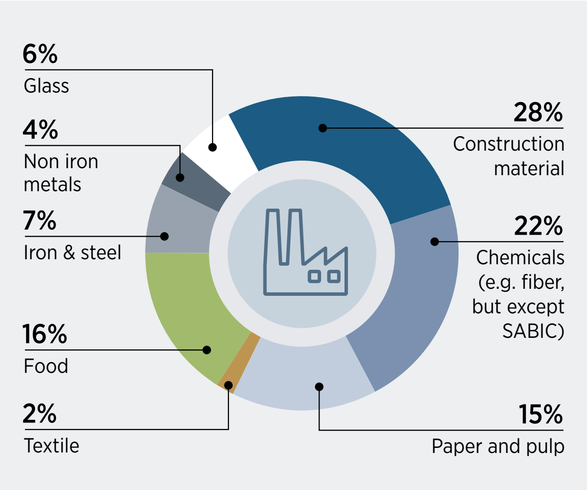
Source: (IEA, 2015)

Figure 2.10 Breakdown of energy consumption within GCC industries in 2013 (%)



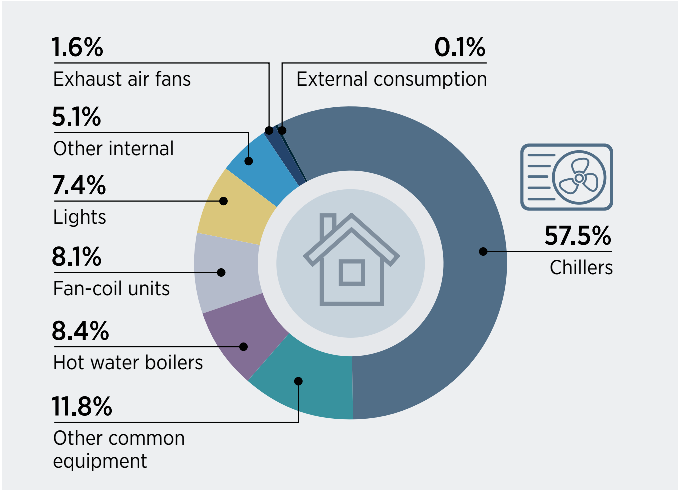
Source: (IEA, 2015)

Figure 2.11 Energy consumption in Saudi Arabia by industry in 2012 (%)



Note: SABIC is Saudi Arabia Basic Industries Corporation
Source: (KICP, 2014)

Figure 2.13 Electricity end-user profile for a typical building in Abu Dhabi in 2010 (% of total electricity consumed)



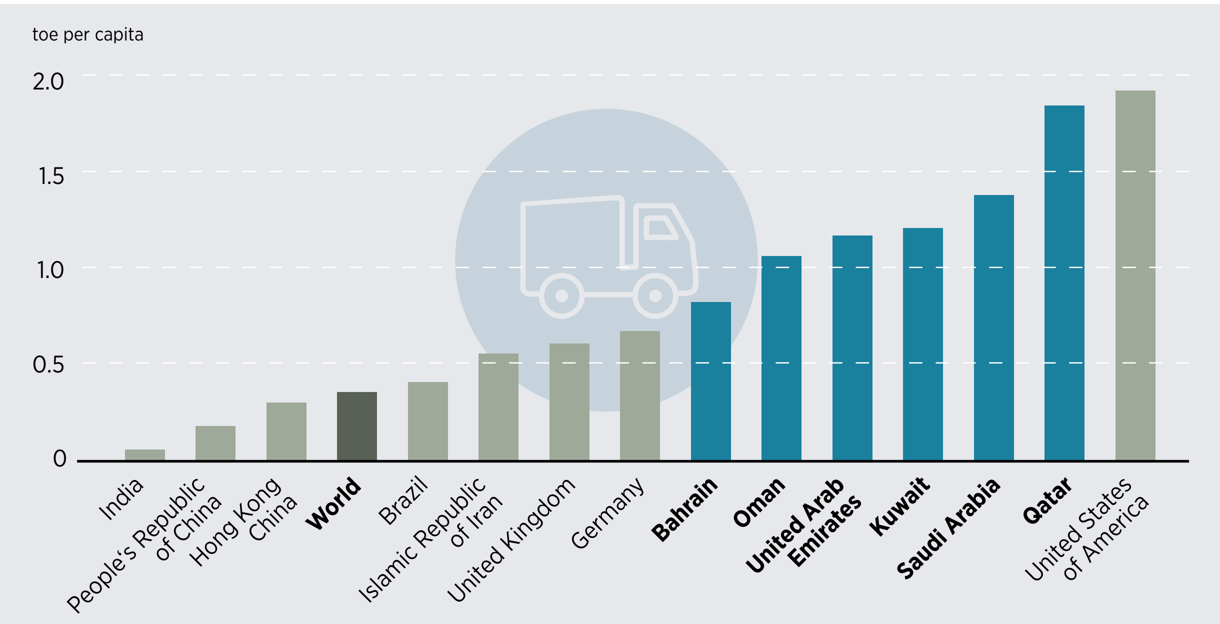
Note: In this figure, the term "chillers" means air conditioning
Source: (Municipality of Abu Dhabi, Masdar and Schneider Electric, 2011)

the same period. Bahrain and Qatar have remained self-reliant but, have curtailed gasoline exports as a result of increased domestic consumption.

Residential and commercial sector

Residential and commercial energy demand in the GCC has grown rapidly, particularly for electricity. Nearly 50% of all electricity produced in the GCC now goes to the residential sector, a share that is even greater

Figure 2.12 Energy consumption in the transport sector of the GCC and selected countries in 2013 (toe per capita)



Source: (IEA, 2015)

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in Saudi Arabia, Kuwait and Oman. Air conditioning accounts for a considerable portion of residential and commercial electricity demand, as illustrated by Abu Dhabi's end-user profile in Figure 2.13. 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 in particular at midday and in the evening.

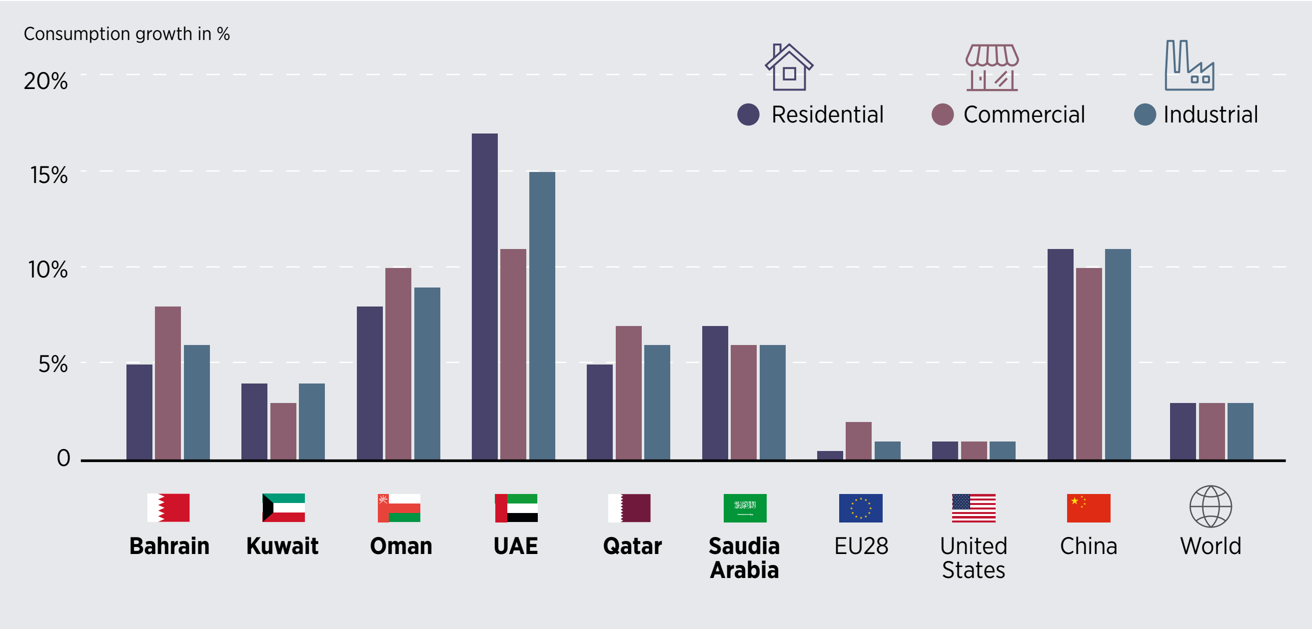
With plenty of new housing and commercial projects across the GCC over the past decade, it is not surprising that regional electricity consumption has grown at an average rate of 6% to 7% per annum between 2003 and 2013 – faster than anywhere else in the world. Qatar and Oman have seen the steepest rise in both industrial and residential electricity consumption, with Qatar's residential electricity demand having grown an average 17% per year over the 2000s and early 2010s (Figure 2.14).

The regional energy mix

Fossil fuels are essentially the only source of primary energy in the GCC (Figure 2.15). Oman and the UAE use gas for about 60% of their needs, having made a strategic decision to maximise oil exports and exploit gas reserves for domestic use. In Bahrain, Kuwait and Saudi Arabia, where gas is not available or extraction infrastructure is less developed, oil remains the primary source. Kuwait and Saudi Arabia also continue to burn considerable amounts of oil in power generation.

The rising domestic demand for energy, and the continued dominance of fossil fuels in the regional energy mix, poses significant challenges. In Saudi Arabia, former Saudi Aramco CEO Khalid Al-Falih warned in 2010 that if there were no changes to the fuel mix and no improvements in energy efficiency, domestic demand could reduce the availability of crude oil for exports. Other countries such as the UAE and Oman run the risk of increasing their imports of costly natural gas amid rising domestic demand.

Figure 2.14 Annual electricity consumption growth by user group in the GCC and selected countries, 2003 – 2013 (%)



Source: Based on IEA data

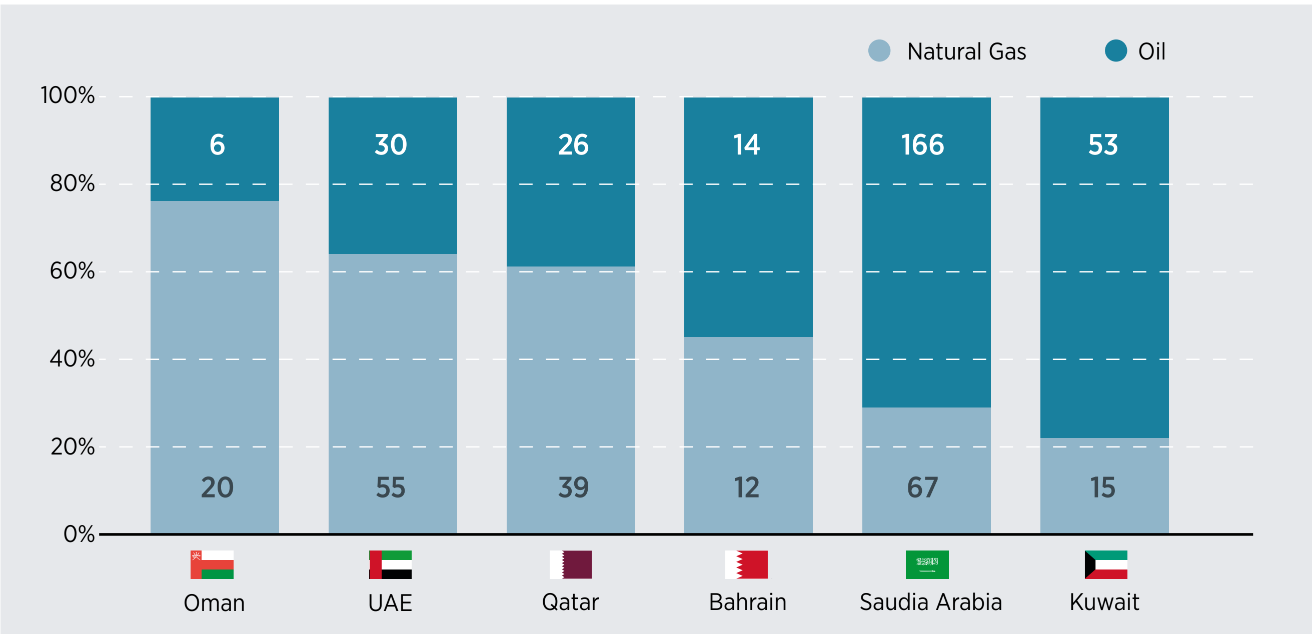
The region's high reliance on fossil fuels implies two choices for a long-term energy sector strategy: continued reliance on fossil fuels, requiring considerable additional oil and gas allocations to the domestic market; or a systematic diversification of the region's energy mix that would incorporate renewables and other alternatives.

"If no efficiency improvements are achieved, and the business is as usual, the oil availability for exports is likely to decline to less than 7 million barrels per day by 2028."

Khalid Al Falih, (Financial Times, 28 April 2010).

More recently, energy policy in many GCC countries has started articulating a forward-looking vision towards sustainable development. Policy and regulatory interventions to increase energy efficiency, rationalise consumption and encourage the diversification of the energy mix are being considered or implemented across the GCC. Initiatives giving a greater role to renewable energy, nuclear power, energy efficiency and carbon capture and sequestration are underway, and in some countries, such as Saudi Arabia and the UAE, specialised bodies for renewables and energy efficiency have been created to support the transition. Indeed, a key determinant of how much and how quickly the region's energy mix can diversify will be the adaptability of the institutional framework and the current mechanisms driving energy infrastructure development.

Figure 2.15 Total primary energy supply in the GCC by source in 2013 (share in % and absolute values in Mtoe)



Source: (IEA, 2015)

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2.3 ENERGY SECTOR GOVERNANCE

The dominance of fossil fuels has strongly influenced the institutional framework of the energy sector in the GCC. Though domestic energy supply remains heavily in the hand of the states, opportunities for private sector participation are increasing, primarily in the utility sector. The growth in private sector participation is directly linked to efforts to increase operational efficiency on both the supply and demand side, but also to create overtime a more conductive investment climate for energy (and other infrastructure) projects. This section describes the institutional framework and recent dynamics which will strongly influence the trajectory of the energy sector's development in the decades to come, including a transition towards renewable energy.

Energy sector institutional framework

The GCC energy sectors are traditionally dominated by the state and its central institutions, such as the various ministries for oil, energy and electricity on the one hand; and by state energy companies such as national oil companies (NOCs), utilities and, where present, utility regulators (Box 2.1 and Table 2.1). Due to the strategic and multi-disciplinary nature of energy sector planning, a variety of additional stakeholders from government are often involved such as those related to economic planning, transport and infrastructure, finance and social affairs.

In the oil and gas sector, regulatory and policy-making mandates often do overlap due to the historical formation process of these institutions, implying that in some cases separate ministries and government end up being policy makers and regulators at the same time. The role these institutions have played in the development of the GCC upstream oil and gas sectors has meant that energy affairs remain centred on upstream production, exploration, and export. The domestic portfolio of managing supply sources of energy beyond domestically produced oil and gas, and of demand management, is hence a new area of responsibility.

Box 2.1 Ministries involved in energy-related planning and decision-making in the GCC

- **The Ministry of Oil and/or Energy**, whose primary historical role has been to oversee the exploration, development and export of national hydrocarbon resources by the national oil company (NOC). More recently, Energy Ministries in the region have become more critical players in the formulation of domestic energy goals.
- **The Ministry of Electricity and Water**, which has historically dealt with domestic utility sector planning, often overseeing various subsidiary bodies such as national utility sector companies, and regulatory bodies.

More recently, other ministries such as those of environmental affairs and foreign affairs have been increasingly involved in energy-related issues:

- **The Ministry of Environmental Affairs**, typically tasked with environmental matters, which extend frequently into the energy sphere, including in areas such as industrial waste management, environmental standards, transport fuel efficiency regulation and air quality control.
- **The Ministry of Foreign Affairs**, which also represents the country in international energy forums. Some GCC members have actively involved their Foreign Affairs Ministry in forums focused on sustainable development and climate change, such as the UAE. Others, such as Saudi Arabia, do not link their climate policy negotiation teams to any ministry, sending instead special missions consisting of members of various ministries and internal advisors.

Due to the strategic and multi-disciplinary nature of energy sector planning, a variety of additional ministries are often involved, such as those dealing with economic planning, finance, education, transport and infrastructure, etc.

Table 2.1 Institutions involved in policymaking and planning in the GCC Energy Sectors

Country	Oil & Gas	Electricity and Water
Bahrain	National Oil and Gas Authority (NOGA)	Electricity and Water Authority (EWA)
Kuwait	Supreme Petroleum Council (SPC), Ministry of Petroleum	Ministry of Electricity and Water
Oman	Ministry of Oil and Gas (MOG)	Ministry of Electricity and Water
Qatar	Ministry of Energy and Industry (MEI)	Qatar General Electricity and Water Corporation (Kahramaa)
Saudi Arabia	Ministry of Petroleum and Mineral resources (MOPM)	Ministry of Water and Electricity
UAE	Ministry of Energy	Ministry of Energy
UAE, Abu Dhabi	Supreme Petroleum Council, Executive Affairs Authority	Abu Dhabi Water and Electricity Authority (ADWEA)
UAE, Dubai	Dubai Supreme Council of Energy	Dubai Electricity and Water Authority (DEWA), Dubai Supreme Council of Energy

Regulatory bodies in the energy sector

Regulatory authorities are variously distributed in the GCC across a number of different bodies, including ministries, ministerial committees, and specialised regulatory agencies. Oil and natural gas typically work under a separate institutional framework from the utility sector. In most GCC countries, the ultimate regulator of oil and gas remains the national ministry of oil and mineral resources. In Abu Dhabi, there is a separate Supreme Petroleum Council, which acts independently of the more generic Ministry of Energy, with a parallel but separate institution in Dubai called the Dubai Supreme Council of Energy. In Kuwait, the Supreme Petroleum Council shares regulatory duties with the ultimate source of legislative guidance, the Ministry of Petroleum.

The structure of utility markets notably differs from oil and gas. Policy formation in the utility sector traditionally falls onto Ministry of Electricity and Water. By contrast, regulation of the utility sector tends to fall into specific bodies that are clearly separated from the ministerial level; for instance, in Saudi Arabia regulation falls within the realm of the specially created Electricity and Cogeneration Authority (ECRA); in Oman the Authority for Electricity Generation; and in Qatar, the country's General Electricity and Water Corporation (Kahramaa) is both utility supplier and regulator in one (Table 2.2).

It is noticeable from the institutional framework of the energy sector that the traditional focus of the different entities has been on oil and gas. Mandating institutions with the development of strategies for domestic energy consumption, including the transformation towards a more sustainable energy mix, is still in progress. However, the region has been witnessing some dynamics in the energy sector that can facilitate the transformation.

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Table 2.2 Regulatory bodies in the GCC energy sectors

Country	Oil & Gas	Electricity and Water
Bahrain	National Oil and Gas Authority (NOGA)	Electricity and Water Authority (EWA)
Kuwait	Supreme Petroleum Council (SPC), Ministry of Petroleum	Ministry of Electricity and Water (MoEW)
Oman	Ministry of Oil and Gas (MOG)	Authority for Electricity Regulation (AER)
Qatar	Ministry of Energy and Industry (MEI)	Qatar General Electricity & Water Corporation (Kahramaa)
Saudi Arabia	Ministry of Petroleum & Mineral Reserves (MOPM)	Electricity and Cogeneration Regulatory Authority
UAE	Ministry of Energy	Electricity is regulated by Emirate-level institutions in Abu Dhabi, Dubai and Sharjah. The remaining are covered by Federal Electricity and Water Authority (FEWA)
UAE, Abu Dhabi	Supreme Petroleum Council	Abu Dhabi Regulation & Supervision Bureau (RSB); Abu Dhabi Water and Electricity Authority (ADWEA)
UAE, Dubai	Dubai Supreme Council of Energy	Dubai Regulation & Supervision Bureau (RSB); Dubai Electricity and Water Authority (DEWA)

Recent dynamics in the energy sector

As the energy plans of GCC countries evolve overtime, strategies are being adopted that involve a greater participation of the private sector and, more recently, that include reforms in the energy pricing structures. While these trends have significant impacts on the overall economic efficiency of the energy systems, they can also pave the way for greater deployment of renewable energy in the region.

Participation of the private sector

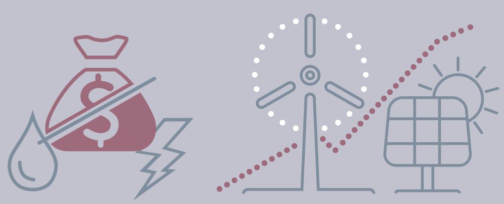
Recently, several GCC countries have been introducing policies that allow the participation of power producers from the private sector, mainly in the construction and operation of utility plants. The Saudi Arabian power sector has recently enabled the involvement of private companies in the power sector, within the framework of Independent Power Producers (IPPs) and Independent Water and Power Producers (IWPPs), such as Shuaibah, Qurayyah and Rabigh. Recent royal decrees also indicate that the Saudi Electric Company will move towards greater private sector participation (Padmanathan, 2015). Kuwait has also launched its first IWPP in 2010 for the Az-Zour North development, taking an unusual turn in the country that otherwise prohibits private investment in the energy sector. Bahrain, Oman and Qatar also have more recent histories of involving private developers in new utility sector projects. In the UAE, much of Abu Dhabi's existing electricity and water production capacity was installed by private developers. In all of these projects, ADWEA retains a 60% ownership and remains the single buyer of power and water (Arab Oil and Gas Directory, 2015). This trend towards increased participation of the private sector in the region's energy sector, among other benefits, lays the foundation for the development of alternative energy sources, including renewable energy. Positive signs are already emerging – the 200 MW Mohammed Bin Rashid Al Maktoum Solar Park is one of the first projects contracted under an IPP framework by DEWA which holds a monopoly over all electricity supply.

Reforms in energy pricing

Energy prices remain regulated throughout the GCC, with some prices for electricity and fuel not having changed since they were originally put in place in the 1960s. With ample hydrocarbon resources, GCC countries have historically used low energy prices to pursue social and economic development goals. However, with growing energy consumption, in some cases outpacing domestic supply, the rising cost of maintaining prices at their historical low levels has become a challenge. The overall cost of subsidising energy in the GCC has been estimated by the IMF to amount to as much as USD 105 billion in 2011 (IEA, 2015).[5] In Saudi Arabia and Kuwait, subsidies reached almost 8% and 4% of GDP respectively in 2014. It is estimated that of the total sums, some USD 51 billion went to subsidising gasoline and diesel – nearly two-thirds of which was used in transport sector, the remainder used by diesel in electricity sector. Since 2015, falling state revenues due to declining oil prices have triggered a series of energy price reform processes in the region (Gulf News, 2015). A key figure of the region's discourse on energy pricing has been the need to price domestically supplied fuels at updated marginal cost of production, and to consider the opportunity cost of consuming energy that can otherwise be sold to the international market.

Survey Box 2.1: Subsidies

85% of respondents believe that reducing water and electricity tariff subsidies would significantly help the development of renewable energy in the region.



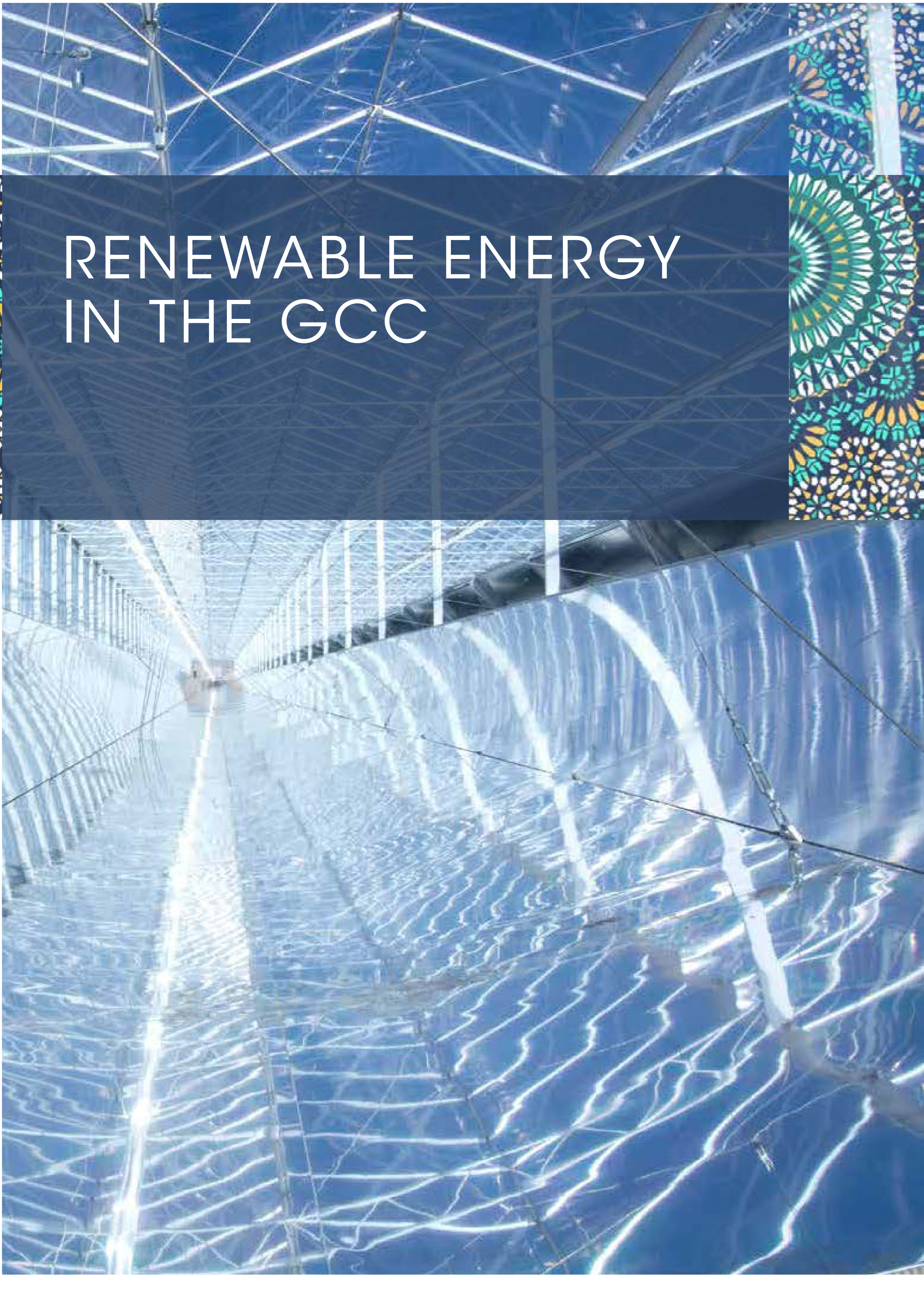
Historically, low energy prices have offered limited economic incentives for the uptake of alternative energy technologies such as renewables, which currently compete with low-cost oil and natural gas on an unequal cost footing (Survey Box 2.1). Renewable energy technologies generally struggle to compete in the GCC, due to factors including the low prices of fuels for electricity generation.

Bahrain, Kuwait and Saudi Arabia (as of December 2015), have some of the lowest utility tariffs in the world, charging less than 2 cents/kWh. The UAE so far displays slightly higher prices for fuel and electricity, which provides some incentives for the development of renewable energy. Reducing fossil-fuel subsidies can significantly level the playing field for renewables and ensure government finance is on hand for other initiatives. Indeed, when considered, energy pricing reforms may need to account for the impacts on low-income groups and growing economic sectors.

The energy challenge for the region is to meet the demand growth which underpins economic development. In doing so, the GCC countries have two options: continued reliance on traditional fuels; or a systematic diversification of the region's energy mix that would incorporate renewables. Recent developments in the region have showcased the opportunity that renewables present for meeting growing demand in a cost-effective, secure and environmentally-sustainable manner. The next chapter will delve deeper into the opportunity, the current state of development and the benefits for achieving the diversification through renewables.

5. Whether or not pricing practices associated with different fuels and with electricity in the GCC qualify as "subsidies" in the legal sense or not is heavily debated. The IEA uses the term "subsidies" for this concept.

RENEWABLE ENERGY IN THE GCC



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Interest in renewable energy in the GCC has been on the rise in recent years. With the region's consumption expected to continue growing at a fast pace over the next two decades, renewables have become an important consideration in government strategies to diversify the domestic energy mix. This was demonstrated by the INDC submissions of GCC countries to the Paris climate conference, COP 21, which culminated in the Paris Agreement in December 2015. Also, the steadily improving cost competitiveness of renewable energy technologies has become an important driver of deployment in the GCC, in particular for solar PV (Box 3.1). Finally, fostering a regional renewable energy industry – with companies such as ACWA Power (Saudi Arabia), Abdul Latif Jameel (Saudi Arabia) and Masdar (UAE) emerging as leaders – offers an opportunity to diversify economies that have traditionally relied on oil and gas exports.

In recent years, several GCC countries have announced plans and devised strategies for conserving natural resources, improving energy efficiency, and deploying renewable technologies (Figure 3.1). Targets are generally set at the national level. The UAE is a partial exception, with the national government announcing an overarching clean-energy target and the two largest emirates each setting their own targets for renewables. Most of the declared targets in the GCC are yet to be enshrined in official legislation, though they are part of official state visions and have been announced by high-ranking government officials. Examples include Kuwait, Qatar and the Emirate of Abu Dhabi.

"The Stone Age did not end for the lack of stone, and the Oil Age will end long before the world runs out of Oil."

Sheikh Zaki Yamani
Former Oil Minister, KSA

Box 3.1 Solar technology is not new to the region

Ample solar resources inspired several early efforts to understand and apply solar energy technologies Research institutions such as King Abdul Aziz City for Science and Technology (KACST) in Saudi Arabia and the Kuwait Institute for Scientific Research (KISR) explored the economic potential of solar power through research programmes and pilot projects as early as the 1970s and 1980s. At the time however, costs for technologies compared to domestically sourced fossil fuels made renewables unattractive.

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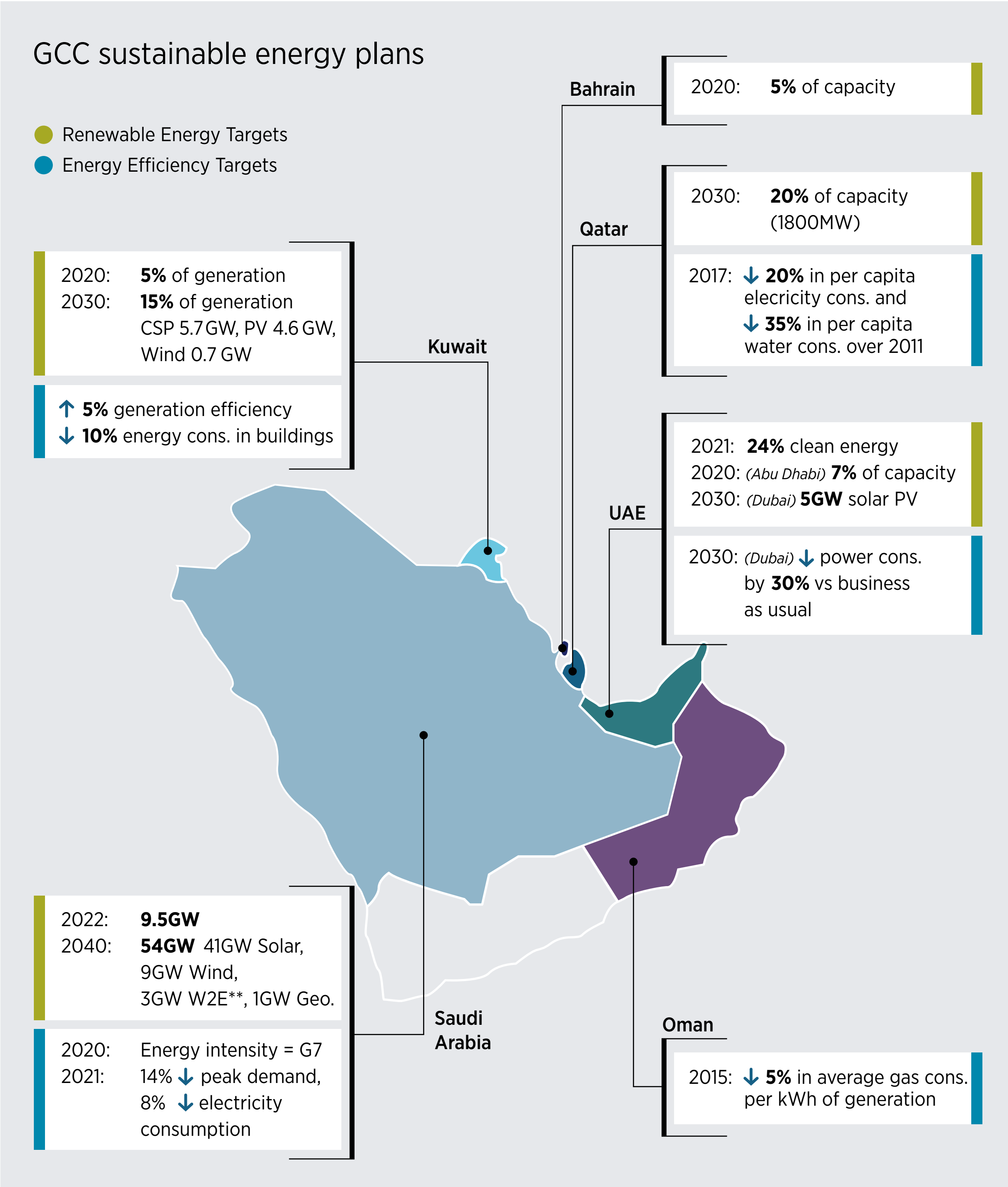
Figure 3.1 Sustainable energy plans and targets in the Gulf Cooperation Council



** Sources from K.A.CARE have indicated that the renewable energy plan for Saudi Arabia was intended as a scenario rather than an official target.*

*** Waste-to-energy*

Source: (Lahn, Stevens and Preston, 2013); (RCREEE, 2015a); (REN21, MOFA and IRENA, 2013) and (RCREEE, 2015b) and others.

Some of these plans specify a percentage of overall power capacity or generation, others are technology-specific, such as those in Kuwait, Saudi Arabia and the Emirate of Dubai. Solar power, either as solar PV and CSP, forms the largest share of these technology-specific plans which is consistent with the availability of the promising solar resources in the region.

3.1 ABUNDANT RENEWABLE ENERGY RESOURCES AND POTENTIAL

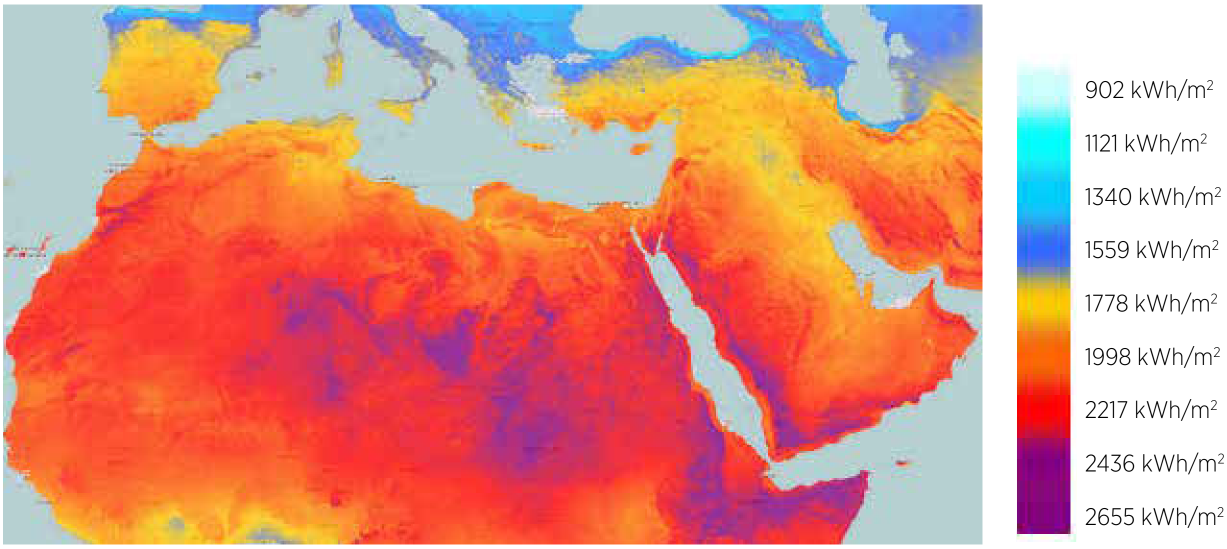
Resources

The region is well endowed with renewable energy resources with an abundance of solar irradiation in particular. Areas in Kuwait, Oman and Saudi Arabia also have wind resources. Technologies such as biomass and geothermal power may hold additional potential but are relatively underexplored.

The GCC countries lie in the Global Sunbelt[1] and are endowed with solar resources that parallel those of nearby North African countries (Figure 3.2). In fact, the region boast some of the highest solar irradiances in the world (EPIA, 2010; Al-Shalabi, Cottret and Menichetti, 2013). The GCC also holds significant wind resources, albeit less significant than solar. Parts of Kuwait, Oman and Saudi Arabia's Red Sea coast have relatively high wind speeds (between 5 and 7.5 m/s) (MASDAR, 2015c; Said, El-Amin and Al-Shehri, 2004).

Waste-to-energy is another interesting renewable energy option and would also address waste-management challenges. The estimated per-capita

Figure 3.2 Solar resources in the MENA (kWh/m²) (Annual Average)



Source: MINES ParisTech / ARMINES / Transvalor - HC3V5 - Dec 2015

1 *A geographical region consisting of countries that are situated between 35°N and 35°S and generally characterised by high solar irradiation (EPIA and ERA, 2010).*

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generation of waste in the UAE, for example, is about 1.86 kilogrammes (kg) per person per day of solid waste, which is relatively high and comparable to that of the United States (2.02 kg per person per day) (NBAD, University of Cambridge and PwC, 2015). Potential for other renewables, such as geothermal and bioenergy technologies, are relatively under-explored.

Suitability

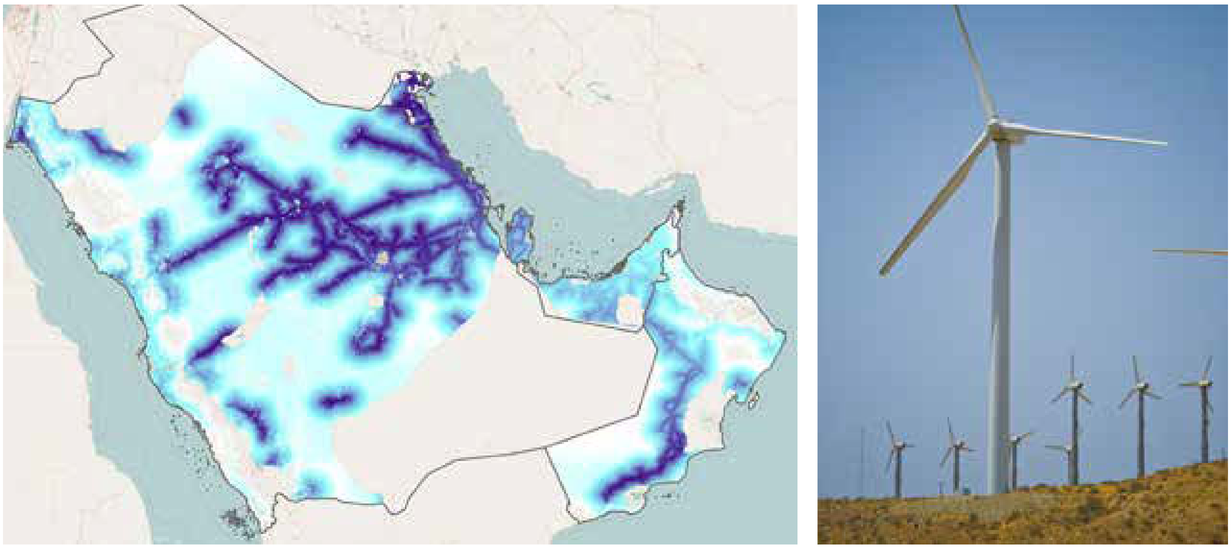
Tapping into abundant resources depends on factors such as distance from the grid, population density, topography, land cover and protected areas. IRENA has recently analysed the potential for both technologies in the GCC according to these suitability factors, revealing strong potential for both technologies (IRENA, 2016).

The analysis of the wind energy resource shows promising potential in Kuwait, Oman and Saudi Arabia, where there are significant opportunities for deployment not only in coastal areas but also in the central regions (Figure 3.3). In fact, more than 56% of the GCC's surface area has significant potential for wind deployment. Covering just 1% of this area could translate into an equivalent 60 GW of capacity[2].

Importantly, the analysis reveals that more than 59% of the GCC's surface area has significant potential for solar PV deployment. Developing just 1% of this area can potentially result in 470 GW of solar PV capacity[3] (Figure 3.4) (see IRENA, 2016 for more details).

In addition, the solar resource in the region is a good match for the electricity demand. While solar PV can cater to the midday demand peak, CSP with storage[4] can be an increasingly viable technology to address the evening peak, in tandem with demand-side management (Figure 3.5).

Figure 3.3 Suitability scores for grid-connected wind up to 75 km from the grid



Note: The map shows the scores above 70% (light blue) and up to 100% suitability (dark blue). Higher scores represent increased suitability.
Source: (IRENA, 2016) (http://irena.masdar.ac.ae/?map=2146)

2, 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.

4 Local adaptations to challenging atmospheric conditions will be necessary, as dust can reduce direct normal irradiation (DNI) required for CSP applications.

Despite region-specific challenges, such as performance degradation due to dust accumulation and high temperature, the majority of surveyed experts indicated that solar resources are promising for deployment (Survey Box 3.1). Going forward, a better understanding of these regional challenges can ensure the optimal utilisation of solar resources.

Strong solar and wind resources, declining technology costs and the presence of an enabling policy environment are increasing the cost competitiveness of renewables, in particular for solar PV.

Survey Box 3.1:
Renewable energy deployment in harsh weather

Regional experts sureyed still believe that despite the GCC region's harsh climate (high temperatures, dust and humidity) renewable energy deployment is still lucrative.

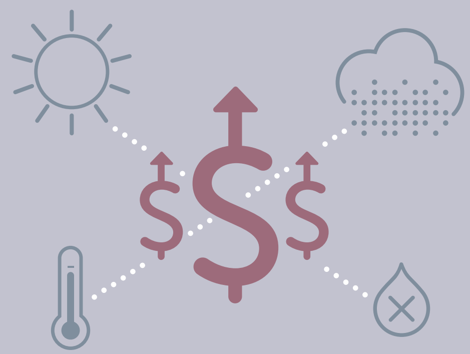
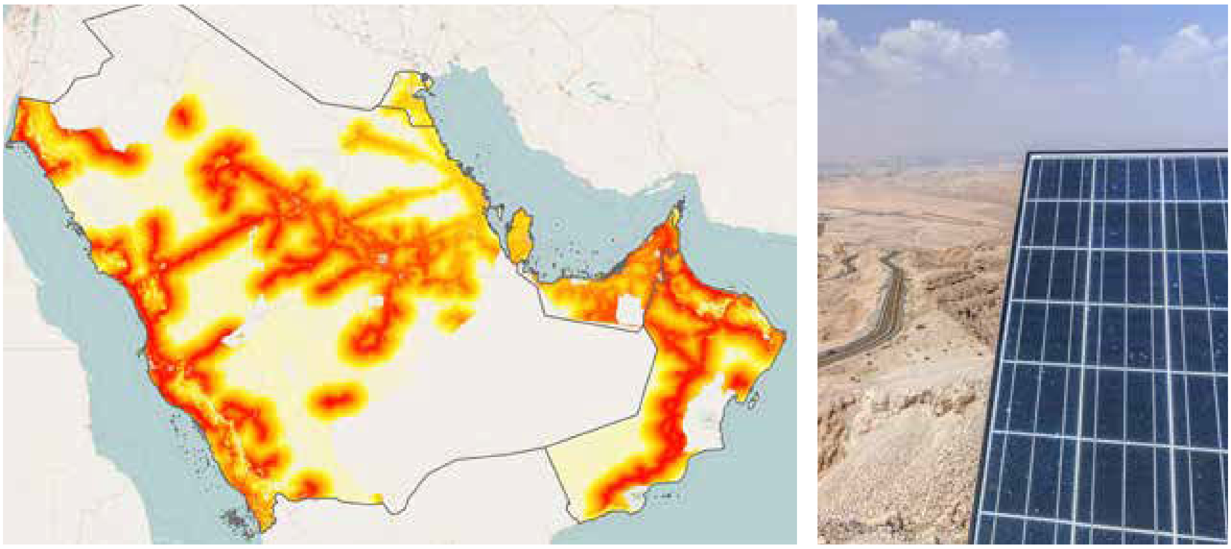


Figure 3.4 Suitability scores for grid connected solar PV up to 75 km from the grid



Note: The map shows the scores above 70% (light yellow) and up to 100% (dark red). Higher scores represent increased suitability.
Source: (IRENA, 2016) (http://irena.masdar.ac.ae/?map=2146)

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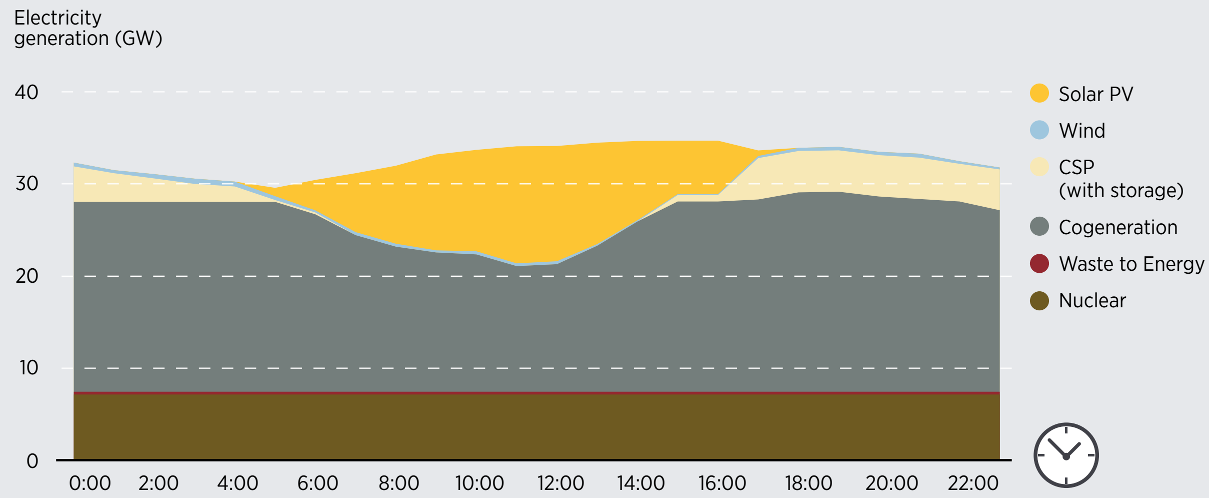
Figure 3.5 Projected daily power generation for the UAE in 2030 by technology



Source: Sgouridis et al. 2013

3.2 FAVOURABLE ECONOMICS FOR RENEWABLES

Recent market developments have put the region on the global map with some of the lowest levelised costs for electricity from solar PV. This rising cost competitiveness, coupled with country-specific policy frameworks, can pave the way for greater deployment (Survey Box 3.2).

Utility-scale applications

Globally, the increasing cost competitiveness of renewable energy technologies has been most apparent in the large-scale grid connected market segment. Improving technologies, access to low-cost finance, greater rates of deployment as well as increased familiarity with the technologies and better understanding among the stakeholders have all combined to lower costs for utility-scale projects.

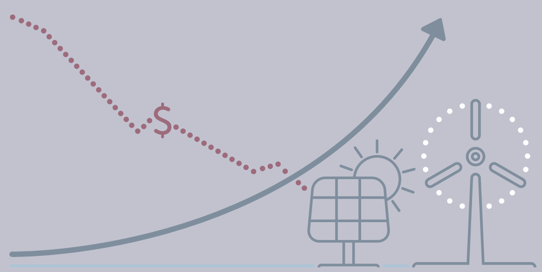
Globally, onshore wind costs have been declining, making it one of the most competitive sources of electricity available in wind-rich countries. The best wind projects around the world are consistently delivering electricity at 5 US cents/kWh without financial support. The prices of solar PV modules

"I believe solar will be even more economic than fossil fuels."

Ali Al-Naimi,
Oil Minister of Saudi Arabia
Business and Climate Summit, Paris, May 2015

Survey Box 3.2:
Cost as the key driver

The cost of renewable energy remains the primary factor that ultimately influences deployment according to most experts surveyed in the region.



have declined by around 75% in 2014 compared to the prices at the end of 2009 (IRENA, 2014a). During that period, the LCOE of utility-scale installations has halved, with competitive projects regularly being contracted at around 8 US cents/kWh.

Costs in the GCC have been consistent with international trends. In fact, developers in the region have been leading the cost race in solar PV with auction of the second phase of Mohammed bin Rashid Al Maktoum Solar Park for a price of 5.85 US cents/kWh. This announcement has been followed by even lower ones elsewhere, including, the 5.71 US cents/kWh bid for a project owned by the city of Austin in Texas, a 5.53 US cents/kWh solar PPA signed by NV Energy in Nevada in the US, and a 4.9 US cents/kWh 50 MW solar PV plant being considered by Taqnia for Saudi Electric Company in Saudi Arabia (Ayre, 2015).

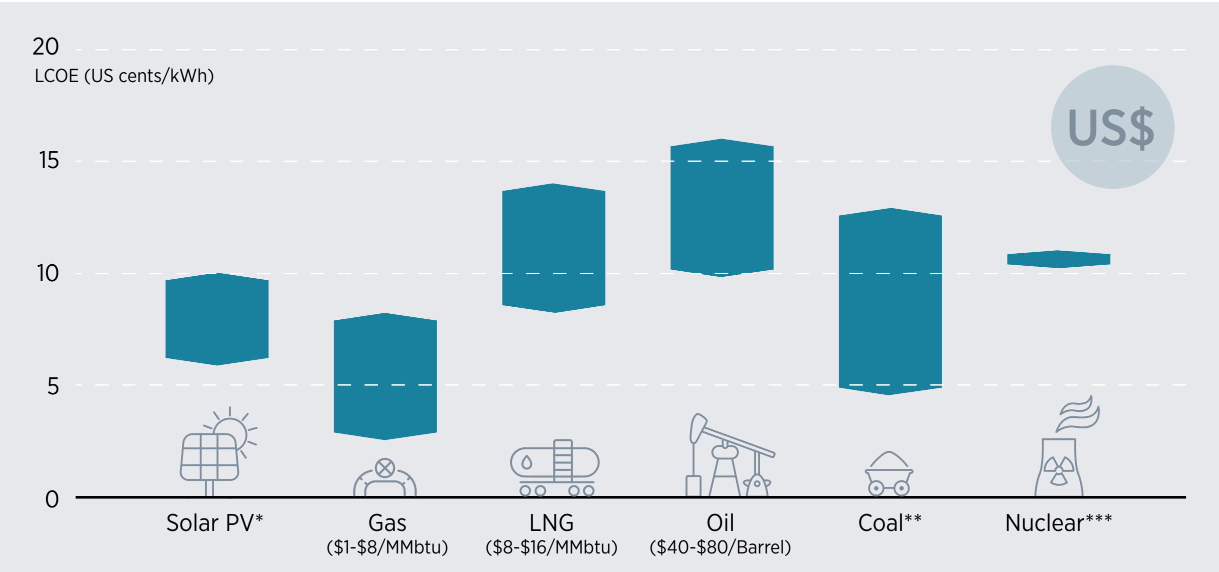
"Without fuel price reforms, the utility in Saudi Arabia is unlikely to go for solar."

Raed Bkayrat
VP of Business Development for
Saudi Arabia and the Middle East, First Solar

Cost-competitiveness with oil

Renewable energy technologies are still competitive even with the recent fall in the prices of fossil fuels, as can be seen in Figure 3.6. The LCOEs of the solar PV projects at utility scale in the region are comparable to the LCOE of electricity generation from oil priced at USD 20 per barrel. With crude oil priced at around USD 35 per barrel[5], the case for greater integration of solar PV in the oil-based power sectors of Kuwait and Saudi

Figure 3.6 LCOE of utility-scale electricity generation technologies in the GCC (US cents/kWh)



** Low = price for second phase of the Mohammed Bin Rashid Al Maktoum Solar Park and High = a conservative (high) assumption based on project level data and opinion of regional experts*

*** Low = price for Hassyan Clean Coal Power Plant (at May 2015 coal prices) and High = estimate for coal with CCS*

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

Note: LCOE is one way to examine the cost-competitiveness in a static analysis. LCOE estimates are not a substitute for detailed nodal modelling and analysis of factors such as backup generation requirements or demand-side management.

Sources: Includes information applicable to the period (2014-2015), derived from (Mills, 2015), (Channell et al., 2015), (MANAAR, 2014), (Scribbler, 2015), (Utilities ME Staff, 2015)

5 At the time of writing

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Arabia is strong. In the past, it has been suggested that the marginal cost of crude production, instead of international crude prices, can also be considered as a useful metric for determining the opportunity cost of oil (Luciani, 2014). With production costs reported at above USD 20 per barrel across the region (Conca, 2015), large-scale solar PV is a cost effective technology compared to new oil-based electricity production. However, utilities such as the Saudi Electric Company buy oil at USD 4 to 5 per barrel, which does not provide an economic incentive even at solar PV prices of around 5.85 US cents/kWh (Bkayrat, 2015).

"Renewable energy is cost-competitive in the country [UAE] for the first time – and possibly even the cheapest source of new power supply."

Thani Al Zeyoudi
Director of Energy and Climate Change, UAE Ministry of Foreign Affairs (Masdar Institute, MOFA and IRENA, 2015)

Cost-competitiveness with gas

Electricity produced from solar PV is also cost competitive with the electricity produced from natural gas sourced domestically or imported. Regional experts have indicated that large-scale solar in the region is competitive with gas priced from USD 3.5 to 6/MMBtu (Mills, 2015; Smith, 2015; NBAD, University of Cambridge, and PwC, 2015). Gas production has historically cost between USD 1 to 3/MMBtu, but newer developments have higher extraction costs, often because gas is sour or in tight reserves. The marginal production cost for some of these fields has been estimated at more than USD 6/MMBtu, and more in the case of unconventional gas resources in Saudi Arabia.

Imported gas via the Dolphin pipeline used to be relatively inexpensive for Oman and the UAE, at around USD 1.5/MMBtu for the initially contracted volumes in 2008. But 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, Abdulrahim and Hassan, 2015; Krane and Wright, 2014). For LNG imports, prices have been fluctuating recently within a range of USD 7 to 19/MMBtu (Verda, 2015). Solar can therefore be cost-competitive with many of these gas sources (see Figure 3.6).

Cost-competitiveness with nuclear and coal

Solar PV in the region could also be cost-competitive with nuclear energy and coal, although nuclear and renewables are not direct competitors given that nuclear power is best suited for producing baseload electricity. Estimates for the cost of nuclear power in the UAE have been around US 11 cents/kWh (Mills 2012 and Scribbler 2015), compared with the US 5.85 cents/kWh budgeted for the second phase of DEWA's solar PV park.

Dubai's planned Hassayan coal project is expected to generate electricity at US 4.5 cents/kWh once operational in 2020 (DEWA, 2015). This is lower than the price for the Mohammed Bin Rashid Al Maktoum 2 solar park, but prospects for a further fall in costs for solar PV by 2020 implies the two technologies could eventually be equal on a cost basis. These estimates however do not account for other factors such as the environmental externalities associated with coal technologies.

> *"We're a lot more competitive with today's cost of solar than the delivered cost of electricity from oil power plants and diesel, which is what we're displacing a lot of the time."*
>
> Sami Khoreibi
> CEO, Enviromena

Small scale projects

Although small-scale developments in other regions such as Europe and North America have become cost competitive, they remain in early stages of development in the GCC.

In the UAE, the uptake of off-grid diesel-generator replacement applications has been possible to some extent due to the costs of diesel (ranging from USD 0.51 to 0.79/litre in 2015) which roughly translates to an electricity generation cost of 12 to 16 US cents/kWh when other costs such as transportation are accounted for. Solar-diesel hybrid solutions can produce power at lower rates (Zywietz, 2015). Oman represents another promising case, where the production costs of diesel-based electricity can reach US 23 cents/kWh and the LCOE of power from off-

Table 3.1 Electricity consumption tariffs, 2014

(US cents/kWh)	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE	
						Abu Dhabi	Dubai
Residential Tariffs	0.8	0.7	2.6	2.2 - 6.0	1.3	5.6 – 8.7	7.8 - 12.1
Commercial Tariffs	0.8	0.7	5.2	2.5 - 4.9	3.2	4.2	7.8 - 12.1
Industrial Tariffs	3.8	0.4	4.2	2.2	4.1	4.2 – 8.0	7.8 - 12.1

Note: The tariff changes effective from January 2016 in Saudi Arabia and Abu Dhabi are included.
Sources: (RSB, 2015), (DEWA, 2015), (RCREEE, 2015a)

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"Enhanced Oil Recovery is the most cost effective application for solar heat because it does not require any external storage."

Daniel Palmer
Vice President of Sales, GlassPoint Solar

Box 3.2 Regulations for net metering in Dubai

Shams Dubai, DEWA's net-metering programme, creates a regulatory environment for solar PV plants to be connected to the electricity network and to be compensated for the surplus electricity fed to the grid. In order to avoid faulty installations and to ensure smooth operation of the grid DEWA has mandated that the installations can only be performed by registered contractors and consultants. Registration comes only after a sufficient number of employees of the company have been trained and certified by DEWA. In addition, installers are only allowed to use components from DEWA's eligible-equipment list. The utility also approves design plans and inspects facilities before they can connect to the grid.

There is a strong business case for rooftop solar installations for medium to large scale industries (above 50kW). So far, DEWA has received many applications for installation, with several government and private entities showing interest. The Dubai Ports authority, for instance, recently announced that they will be adding 30 to 40 MW of capacity on their premises under the programme.

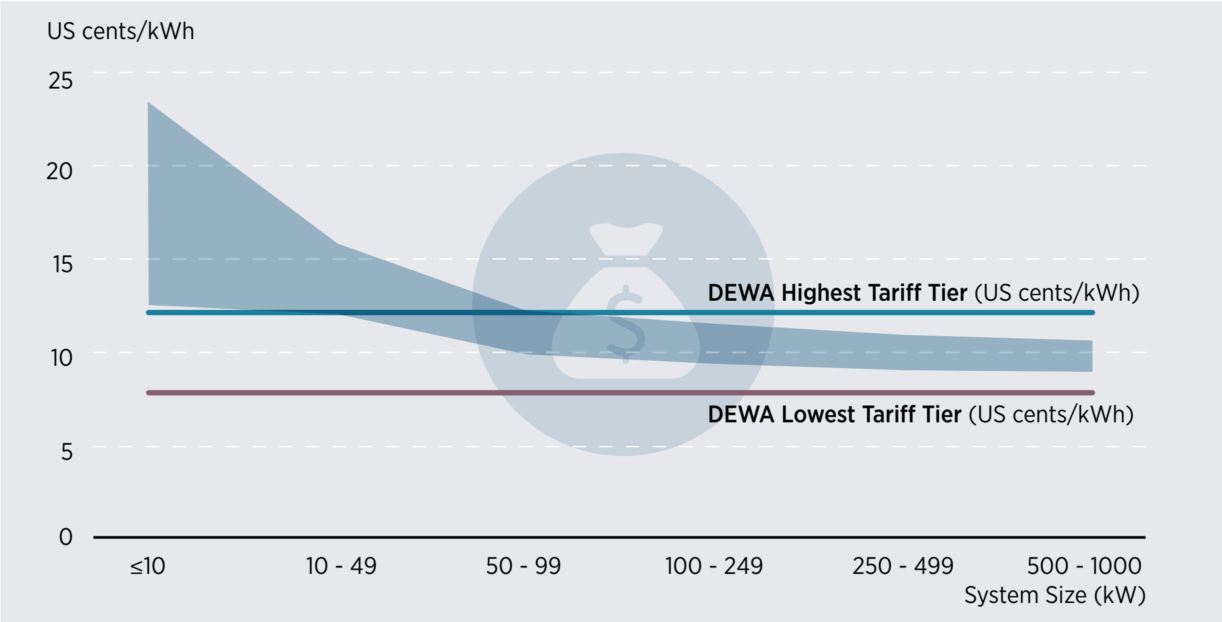
Source: (DEWA, 2015)

grid PV is estimated at around 13 US cents/kWh (Alagos, 2015).

Another opportunity for small-scale deployment is the solar roof-top market segment. It offers a promising sector for solar generation, cutting down the need for investments in transmission and distribution infrastructure while utilising unused rooftop space. Shams Dubai, the net metering scheme in the emirate (Box 3.2), is especially attractive for medium-sized (roughly more than 50 kW range) commercial and industrial solar-electricity prosumers (i.e. consumers who produce power) for at least two reasons:

- A significant part of their consumption lies in the highest tier in the tariff structure – more than US 12 cents for every kWh consumed (Table 3.1). Solar PV replaces power purchased at these higher rates (Table 3.1 and Figure 3.7).
- Many potential prosumers have large unused rooftop areas (e.g. warehouses, industrial units) ideal for a large solar PV system. As the size of solar PV installation increases, economies of scale result in lower LCOEs that are competitive with applicable tariffs. As Figure 3.7 shows, a system with a capacity above 50 kW has a lower LCOE than the highest DEWA tariff tier, so net-metering makes economic sense.

Figure 3.7 Estimated LCOEs of distributed solar PV in Dubai in 2015 (US cents/kWh)



Source: Inputs from project developers including (Bkayrat, 2015), (Zywietz, 2015) and others

The programme has attracted considerable attention from the commercial and industrial community, with more than 40 MW of capacity installation in initial stages of development (Todorova, 2015). Residential take-up may be slower, as current tariffs (see Table 3.1) do not yet make rooftop programmes economically attractive for households. Their consumption levels are usually low and the size of the solar PV system is limited. A success in Shams Dubai can set the scene for further development of rooftop solar PV across the region. Low electricity tariffs, however, may be a challenge requiring the introduction of policies, such as feed-in tariffs, as well as reforms of electricity pricing structures.

While small-scale solutions can provide cost-competitive electricity in both on- and off-grid settings, renewable options are also emerging for industrial applications that require direct heat or steam input (Box 3.3). Desalination represents another area where renewable energy technologies, in particular solar PV and to some extent CSP and wind, can offer cost-effective solutions (see In-Focus).

The cost competitiveness of solar PV in the region is increasing as technology costs continue to decline in the presence of an enabling environment that contributes to reducing risk perception of potential investors.

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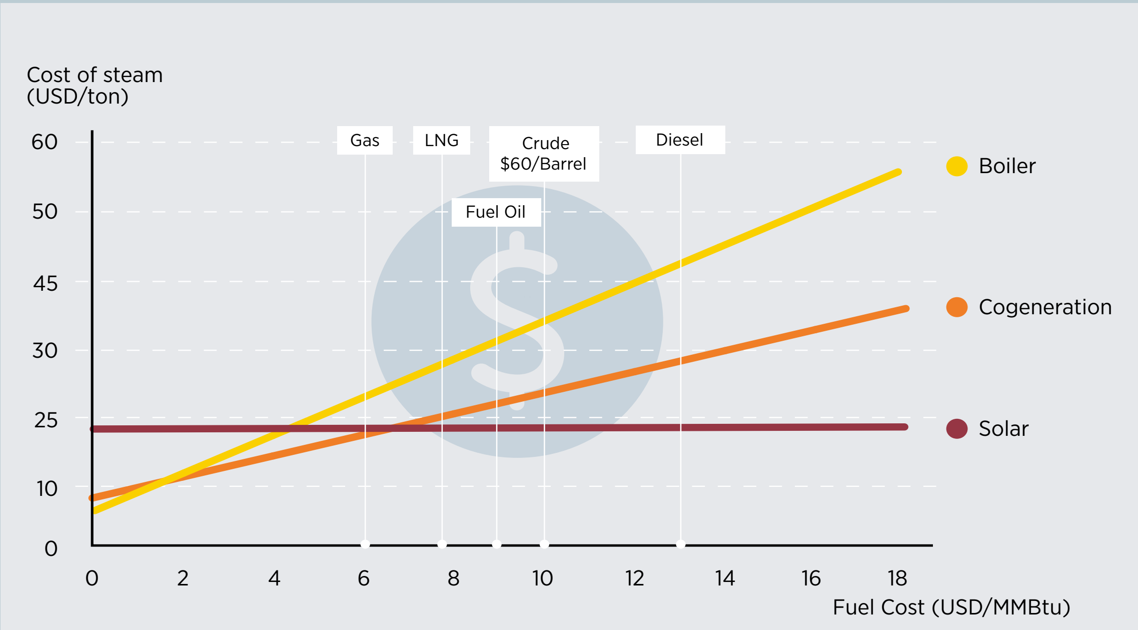
Box 3.3 Cost competitiveness of CSP in steam production for enhanced oil recovery

Several petroleum-extraction projects in the GCC require steam injection (a dominant method for EOR) to maintain the pressure in the oil field to enable production. Steam can be produced using natural gas, but the product is also in demand for other industrial applications and electricity production. Countries must decide how to allocate their scare gas resources and how solar-assisted EOR can help with that choice. In Oman, GlassPoint Solar has been pioneering the field of solar EOR with a unique design that has substantially reduced investment and operational costs. In the future, solar technologies could spread to other EOR projects in the region, freeing up gas for other uses.

Research and pilot projects in local settings such as in Oman have shown that solar technology can deliver steam at a lower cost than boilers, assuming a gas price higher than USD 4.5/MMBtu, and at a lower cost than cogeneration when the gas price is USD 7.5/MMBtu or higher (Figure 3.8).

Figure 3.8 Cost of steam for different generation technologies for enhanced oil recovery (USD/tonne)



Source: (Chaar, Venetos, and Dargin 2014) and (Harrington 2015)

3.3 EVOLVING RENEWABLE ENERGY POLICY FRAMEWORKS

Government plans and targets must be backed by dedicated policies and regulatory frameworks. The effective design, implementation and operation of such frameworks requires mature and well-coordinated institutions.

Policy frameworks for renewable energy deployment

In recent years, a number of GCC countries have set plans for the deployment of renewable energy, which have often been translated into targets at both the national and the local level. To be effective, these targets need to be backed by policies and measures that ensure predictable revenue streams for projects, create a stable investment environment and can help to overcome non-economic barriers for large and small-scale applications.

■ Large scale deployment

Some GCC countries have started implementing auction mechanism to support the deployment of large-scale renewable energy projects. Auctions typically refer to competitive procurement processes for electricity from renewables where the auctioned product can be either capacity (MW) or energy (MWh). The UAE has so far been pioneering the adoption of auctions in the region, followed by Kuwait and Saudi Arabia. The auctions that have taken place in the GCC vary considerably in their designs. In the past, auctions were implemented under the Engineering Procurement and Construction (EPC) model, while the most recent auction followed the Independent Power Producer (IPP) model that resulted in a Power Purchase Agreement (PPA) with the selected project developer.

The EPC model was the preferred option in the early developments. In Dubai, Mohammed bin Rashid Al Maktoum solar park 1 (13 MW), for example, was contracted under the EPC model. In Kuwait, the first phase of the Shagaya Renewable Energy Park has been tendered based on EPC contracts coupled with a 6-year O&M requirement. The next phases of the project are likely to be contracted under the IPP model.

> *"The first phase of the Shagaya Initiative is being funded by the government, providing a firm bases for the development of following phases, to be led by the private sector."*
>
> Dr. Salem Alhajraf,
> Executive Director, Energy and Building Research Center, KISR

Insights from interactions with regional experts reveal that public entities tend to rely on EPC model in initial projects to get a better understanding of the economic and operational viability of renewables. Once sufficient institutional experience in procurement, financing, development and operation is accrued, greater involvement of commercial developers and financers is usually encouraged through IPP procurement models (Alhajraf, 2015). For example, the phases 2 and 3 (200 MW and 800 MW) of the Mohammed bin Rashid Al Maktoum solar park in Dubai are set under the IPP model.

The second phase of the auction succeeded in substantially reducing bid prices through a mix of conditions including Dubai's long-term vision, DEWA's majority project ownership and guaranteed off-take, along with other factors, attracted accomplished developers and enabled low cost financing (Box 3.4).

In addition to reducing deployment costs, auctions can also include design elements that aim to achieve broader development objectives such as supporting job creation or the development of a nascent domestic renewable energy industry through local content requirements. To date, such requirements have not been implemented in the GCC. However, the proposed Saudi competitive procurement plans strongly favour local involvement in projects, as the levels of local content and employment proposed by bidders are expected to play an important role in the winner selection process (K.A.CARE, 2013).

The implementation of auctions is likely to continue in the region to support large-scale deployment,

Box 3.4 Best practices from renewable energy auctions in Dubai

Auctions for the second phase of the 200 MW Mohammed bin Rashid Al Maktoum solar park resulted in the lowest awarded price of US 5.85 cent/kWh. The auction featured numerous bidders below US 10 cent/kWh, which indicates that the overall design of the auction facilitated low bids. Some important factors to consider are:

- **DEWA is a reliable off-taker and a majority owner:** This reduces the risks associated with non-payment, resulting in lower financing costs. The financing conditions (a 27 year loan tenor, a 4% interest rate and a debt-to-equity ratio of 86%) were better than industry norms (Shams 1 in Abu Dhabi received 80% debt to equity ratio and 22 year loan tenor). These financing conditions represented the trust the financers (National Commercial Bank, First Gulf Bank and Samba) placed in the developer (ACWA Power/TSK) and the off-taker.
- **A long-term vision:** Dubai has a long term vision for deployment that aimed for 1 GW by 2030 and has now been increased to 5 GW. The strategic goal of entering a promising market intensified the competition and encouraged low bidding.
- **Flexibility of the auction:** The original capacity tendered was 100 MW. However, ACWA power, the successful bidder, proposed alternative bids with higher capacities and lower prices. After consultation between DEWA and ACWA power 200 MW at US 5.85 cent/kWh was finalized.
- **Other factors** such as availability of land and transmission infrastructure were helpful.

Though, aggressive competition can lower costs, it may also result in underbidding, leading to delays or abandonment of the project. This issue is addressed in the DEWA auction through an aggressive qualification process that short-listed 49 applicants to 10 based on qualification documents and through the requirement of a USD 2-3 million bid bond. Rigorous prequalification helps ensure that capable companies with solid track records are allowed to compete and win.

Source: (IRENA, 2015c), (Solar GCC Alliance, 2015), (Graves, 2015a), (Nassif, 2011)

as shown by the upcoming tenders for the 800 MW Phase 3 of the solar park in Dubai, 350 MW Noor 1 in Abu Dhabi, as well as the plans by K.A.CARE for competitive procurement of the 54 GW of renewable energy. As the GCC countries go forward with renewable energy auctions for the large-scale market segment, other policy measures are being put in place to support small-scale deployment.

Small-scale deployment

Small-scale development in the GCC presents opportunities for both on and off-grid applications, which can be unlocked through supportive policy mechanisms. Feed-in tariffs and net-metering are considered for wider adoption of grid connected small-scale applications. Such considerations have resulted in concrete actions in the UAE.

Dubai's net metering programme Shams Dubai allows consumers to feed their excess solar PV generation to the grid, which can be later offset against future bills (offset window is indefinite). By allowing PV producers to credit their excess generation to the grid, Shams Dubai is stimulating the small and medium scale solar market in the Emirate. The programme is in early stages of implementation and is expected to result in more than 50 MW of deployment in the near term (Box 3.2). Unleashing the estimated 2.5 GW roof-top solar potential of the Emirate of Dubai is going to require improved and innovative financing mechanisms (Box 3.5).

The replication of Shams Dubai elsewhere in the region will be difficult with the current electricity pricing regime (Table 3.1). In fact, regulations in the Emirate of Abu Dhabi do allow for net-metering where consumers can feed-in to the grid to offset their monthly consumption (offset window = 1 month). However, given the less conducive tariff structures and smaller offset window, deployment has not been possible (RSB, 2014). Going forward, more cost reflective tariffs coupled with net-metering programmes could trigger development in the small scale grid-connected market in other GCC countries.

Box 3.5 Future prospects for Shams Dubai

The announcement of "solar panels on every roof by 2030" indicates that the Emirate of Dubai has strong aspirations for greater development in the rooftop sector. In parallel, the government has also announced the Dubai Green Fund of around USD 27 billion, which will extend concessional loans to developers of clean energy projects (The National, 2015). Government funding at favourable conditions can help unlock the rooftop solar market.

In fact, feedback from project developers suggests that deployment under the Shams Dubai programme can be significantly increased if financing issues are sorted out. Currently, agreements under the programme are signed between DEWA and consumers. High up-front costs and long payback period remain barriers to investments. Third party providers of PV systems that offer PPA contracts or leasing options can address the high upfront costs. However, they face an uphill task in attracting finance since DEWA does not provide any guarantees for power offtake over the life time of the installed PV systems.

Going forward, DEWA may want to accommodate changes in Shams Dubai that allow for greater third party participation. Direct agreements between DEWA and the third party providers, for instance, can provide bankable guarantees for offtake and bring down financing costs. DEWA can also support developers in running advertising campaigns for the overall programme thus allowing them to concentrate on implementation. In addition, DEWA can provide clear signals to the market by outlining the targeted deployment levels under the programme.

While grid-connected applications have been supported through auctions and net-metering, off-grid applications have generally been driven by commercial forces. However, given the energy pricing structures in most of the GCC countries, commercial incentives are often not sufficient to spur significant deployment.

Saudi Arabia is a very interesting example where low-priced diesel is being used for power generation in remote locations and presents a burden on the budget. This has prompted Saudi Aramco, the supplier of diesel, to consider around 300 MW of solar and wind projects at 10 remote locations, replacing around 1 million barrels of liquid fossil fuels per day (ARAMCO, 2014). Which policy mechanisms will be used to support these projects remains to be seen. RAECO in Oman, which is planning to develop seven small scale solar and wind projects for rural areas, is considering auctions to attract developers for these projects (Abdel-Razzaq, 2015).

In the future, large scale off-grid projects can benefit from auctions. For small scale projects, load centres in a region can be aggregated and auctioned to a renewable energy service company that enters into a PPA with the relevant entity (e.g. ARAMCO or Saudi Electric Company in the case of Saudi Arabia). Increasing the efficiency standards for diesel based electricity generators can also offer incentives for solar deployment, by encouraging inefficient generators to either become more efficient or rely on renewable energy.

The effectiveness of the policy frameworks for small and large scale renewable energy deployment has benefited from a parallel development of the institutional capacities in the region.

"Most off-grid small scale solar projects are driven by commercial motives, and are carried out through direct agreements often without any tenders."

Daniel Zywietz,
CEO, Enerwhere

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Institutional framework for renewable energy deployment

Since the mid-2000s, some countries in the GCC have established specialised institutions to streamline policy-making in areas beyond oil and gas, such as renewable energy and energy efficiency. In other countries, this task is assumed by existing entities. In both cases, renewable energy benefits from research institutions in areas of innovation and policy-making; and from regional and international cooperation.

Institutions for planning and policy-making

The UAE has been among the most active countries within the GCC in mandating specialised institutions to promote renewable energy. In addition to entities in charge of energy planning and policy-making within the Ministry of Energy, the UAE established a separate unit within the Ministry of Foreign Affairs (MOFA), the Directorate of Energy and Climate Change (DECC), in 2010. In its domestic role, the DECC actively contributes to the development of sustainable energy, including renewable energy (MOFA, 2015). On the Emirate level, Dubai has established the Dubai Supreme Council of Energy (DSCE) that assumes both roles of policy-maker and regulator (DSCE, 2015).

"We need an organisation that will champion the cause of renewable energy."

Dr Abdul-Hussain Mirza
Bahrain's energy minister
IRENA's Workshop on
GCC market analysis WFES 2016

In Saudi Arabia, K.A.CARE was established with the mandate of developing the renewable energy (and nuclear energy) sector of the country. The announcement of the initial targets by K.A.CARE was followed by uncertainty regarding the implementation programme. Recent developments in policy and institutional framework seem to suggest that renewable energy project deployment under a competitive procurement procedure may start in the near future (Padmanathan, 2015). Saudi Aramco has been taking the lead on the development of renewable energy projects in remote areas.

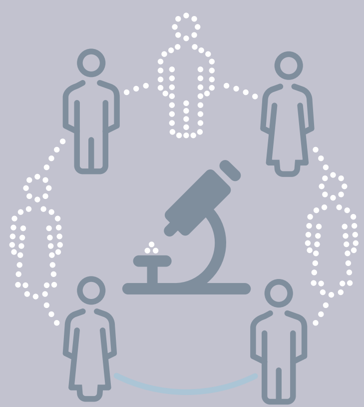
Institutions to regulate renewables

Regulators have a fundamental role in the development of renewable energy. Typically, they ensure the efficiency of the electricity and water sector and the effectiveness of policy; they issue licenses and in principle function as an intermediator between the government and the private developers and investors.

The regulatory authorities in the UAE have made significant strides in integrating renewables in the power system by working with developers to ensure that projects can be fed to the system. Regulation and Supervision Bureau (RSB) Abu Dhabi, for instance, 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. The electricity regulators in Saudi Arabia (Electricity & Cogeneration Regulatory Authority - ECRA) and Oman (Authority for Electricity Regulation - AER) have initiated the development of a regulatory framework that encourages the use of renewable energy.

Survey Box 3.3: Human Capital and R&D

The majority of respondents believe that the renewable energy deployment in the region can be accelerated through R&D and skill development.



Institutions for research and innovation

The creation of institutions that can take the lead on energy research has been a centre piece of the overall sustainable energy strategy. These contribute to the development of local centres of expertise to inform and advise policymaking and industrial diversification. Region specific R&D and training of workforce can strengthen all segments of the value chain, thus facilitating project deployment (Survey Box 3.3). Key examples include Kuwait Institute for Scientific and Research (KISR), Sultan Qaboos University in Oman, Qatar Foundation, K.A.CARE and King Abdullah Petroleum Studies and Research Center in Saudi Arabia.

Most of these institutions combine research on supply and demand-side solutions including fossil fuel-based energy, energy efficiency and alternative energies. The UAE's Masdar project, which includes Masdar City, represents a systematic approach towards creating a special knowledge cluster focusing on the development of sustainable energy solutions.

These research institutions have been providing valuable insights in areas such as pilot studies and continue to inform policy and decision-making.

International cooperation

International cooperation has been supporting private and public sector leaders from the region in several renewable energy aspects. IRENA, for instance, collaborated with UAE's DECC and Masdar Institute to highlight the striking cost effectiveness of solar PV in UAE (Masdar Institute, MOFA and IRENA, 2015). The EU-GCC Clean Energy Network is another example of successful international collaboration.

The renewable energy industry is also benefiting from regional cooperation, especially, at the commercial scale. Despite differences in regulatory frameworks and business environments in the GCC countries, renewable energy stakeholders often face similar challenges in scaling up deployment. Industry associations such as Middle East Solar Industry Association (MESIA) and Clean Energy Business Council (CEBC) act as platforms for networking and best practice sharing and are also providing advice and feedback to the governments on how to best implement renewable energy policies and regulations.

The past few years have seen a gradual evolution in the institutional and policy frameworks in the

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region. Specialized institutions have been developed and existing ones have enhanced their capabilities. Institutional capacity building and decision making have benefitted from regional cooperation as well as research and development. Finally, renewable energy policy mechanisms are also being developed in some countries to up-scale deployment.

Survey Box 3.4: Aspirations vs. Deployment

The survey respondents believe that of renewable energy project deployment in the region has been laaging, while the perception of government aspirations is marked higher.

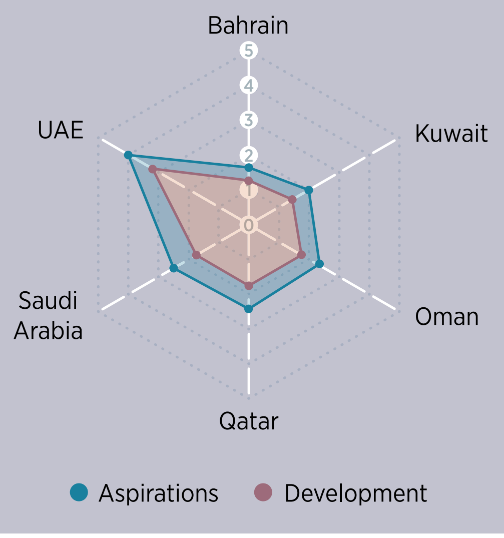


Table 3.2 Installed Renewable Energy Capacity in the GCC Countries, as of 2014

Countries/ Capacity (MW)	2011	2012	2013	2014				
	Total RE*	Total RE*	Total RE*	**Total RE***	Wind	PV	CSP	Biomass and Waste
Bahrain	0.6	0.6	0.6	**0.6**	0.5	0.1	0	0
Kuwait	0.1	0.1	0.2	**0.2**	0	1	0	0
Oman**	0	0	0	**0.7**	0	0.7	0	0
Qatar	25	28.2	28.2	**28.2**	0	3.2	0	25
Saudi Arabia	0	19	25	**25**	0	25	0	0
UAE, Abu Dhabi	19.5	20	134.9	**134.9**	0.9	33	100	1
Total	45.2	67.9	188.9	**190.4**	1.4	63	100	26

*RE = renewable energy
**Oman's 7 MW_{th} enhanced oil recovery plant is not included because this table addresses only electricity.
Source: IRENA Renewable Energy Statistics; (REN21, MOFA and IRENA, 2013); (RCREEE, 2015b)

3.4 STATUS AND TRENDS IN DEPLOYMENT

The GCC's renewable energy sector is still at an early stage and deployment has lagged behind aspirations (Survey Box 3.4). However, the plans and targets for renewable energy in many countries are gradually translating into projects, and the short- and medium-term outlook looks promising.

■ Installed renewables capacity

At the end of 2014, the region had more than 120 GW of installed power capacity, of which renewable energy were less than 1%. The UAE accounted for 70% of the installed renewables capacity in 2014, followed by Qatar (15%) and Saudi Arabia (13%) (Table 3.2). Deployment is likely to accelerate in the future, as more than 250 MW of projects are currently in the pipeline[6] and around 2 GW have been planned or announced (BNEF, 2015).

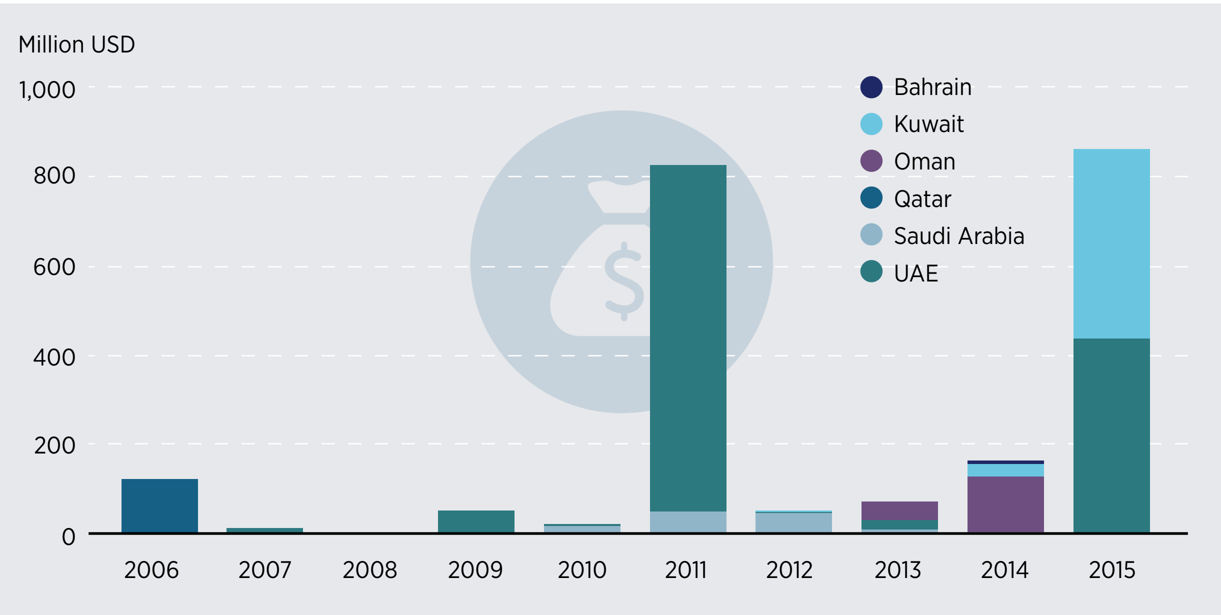
The installed renewable electricity capacity in the GCC is dominated by a handful of centralised solar projects. Solar PV and CSP provide more than 85% of existing capacity and more than 80% of the project pipeline (Table 3.2). Some wind and waste-to-energy projects are also in development.

While the electricity sector accounts for the bulk of renewable energy activity, renewables are also gathering some traction in heating applications, including the production of steam, hot water or desalinated water (see In Focus). Solar-assisted steam generation is used in Oman for enhanced oil recovery (EOR), and there are plans for more of this activity in Oman and Kuwait. Small-scale solar desalination plants have been set up across the region to supply remote areas and assess the technical and economic viability of these technologies (see In Focus).

■ Investments in renewables

Investments in renewable energy in the GCC spiked in 2011 with USD 800 million invested in the UAE's 100 MW Shams 1 CSP plant, which became operational in 2013 (Figure 3.9). Investment activity dropped in

Figure 3.9 GCC renewable energy investments from 2006 to 2015 (Million USD)



Source: BNEF data with additions from IRENA based on interaction with GCC experts including (Alhajraf, 2015)

6 *Projects that are under construction or are fully financed.*

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2012. However, with improved cost effectiveness, investment in new projects is on the rise, as illustrated by the recent investment of USD 400 million in the UAE's 200 MW Mohammed bin Rashid al-Maktoum solar park and the USD 400 million for the Shagaya project.

Renewable energy projects

Investment in renewable energy has varied across the region, and was initially characterised by both small- and large-scale prototype projects, geared at developing a better understanding of available technologies. The 13 MW first phase of Dubai's Muhammad bin Rashid Al Maktoum solar park, for instance, was instrumental in developing institutional capacity and in proving the technical and economic viability of solar PV at the utility scale. Other examples include the pilot 7 MW_{th} solar thermal EOR plant in Oman and the 100 MW Shams 1 CSP plant in Abu Dhabi. Given the relatively nascent state of GCC renewable energy markets, several countries are still undertaking pilot projects. The ongoing 70 MW Shagaya project, for instance, allows Kuwait to evaluate the performance of different technologies while building institutional capacity. Figure 3.10 provides a detailed illustration of all the projects in the region and their stages of development.

"Dubai's success has captured headlines and spurred greater interest across the region."

Robin Mills
Manaar Co.

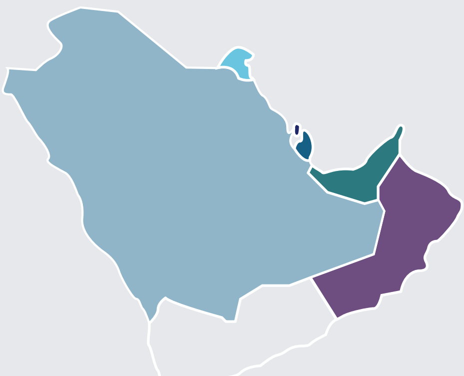
Growing stakeholder experience, the development of enabling frameworks and increasing cost competitiveness of solar PV are encouraging the implementation of larger projects. This is best illustrated by the financial closure for Dubai's 200 MW second phase of Mohammed bin Rashid Al Maktoum solar PV park, which set a new global benchmark for solar PV prices. Several projects have followed, building hopes that the aspirations for renewable energy can be met. These include the announcement of the 800 MW third phase of the Mohammed bin Rashid Al Maktoum solar park, the 350 MW solar PV plant Noor 1 in Abu Dhabi, the Al-Aflaj 50 MW solar PV plant in Saudi Arabia by Taqnia as well as a 1 GW_{th} solar thermal EOR project in Oman (Figure 3.10).

Although the outlook for large-scale development looks positive, the adoption of small scale distributed applications are still held back by less-favourable economics, and the lack of supportive policy and regulatory frameworks in most GCC countries. These applications include rooftop solar PV installations and the replacement of diesel generators in off-grid settings. Dubai, where the rooftop solar potential is estimated between 1.5 GW to 2.5 GW, is beginning to tap into the market. The generator-replacement market in off-grid settings[7] represents a potential of more than 500 MW across the UAE, and above 3 GW in Saudi Arabia. However, only around 5 MW of capacity has been deployed in the UAE (Zywietz, 2015).

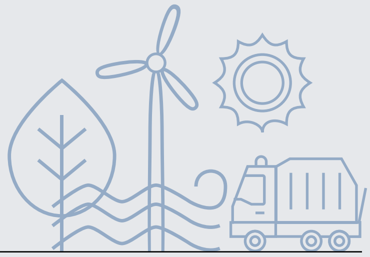
7 *Off-grid settings in GCC primarily includes: 1) Electricity generation in remote areas (farms, camps, small commercial/industrial setups) and 2) Electricity generation in temporary settings, often at construction sites.*

Figure 3.10 Renewable energy projects in the GCC

Renewable energy projects in the GCC



- Wind
- Solar Thermal
- Photo Voltaic
- Waste to Energy
- Mix



Kuwait

Wind	MEW/KISR–Shagaya Wind turbine 10MW	bidder selected
Solar Thermal	MEW/KISR–Shagaya Solar Thermal 50 MW	bidder selected
Photo Voltaic	MEW/KISR–Shagaya PV 10 MW	bidder selected
Solar Thermal	Al-Abdaliyah ISCC project 60 MW	planned

Saudi Arabia

Photo Voltaic	KAUST rooftop PV panels 2MW	Completed
Photo Voltaic	KAPSARC PV Phase 1 - 3.5 MW	Completed
Photo Voltaic	KAPSARC PV Phase 2 - 1.8 MW	Completed
Solar Thermal	Princess Nora University solar water heating 17MW	Completed
Mix	ARAMCO, 300 MW capacity off-grid	Planned
Photo Voltaic	Saudi Aramco North Park PV Project 10.5 MW	Completed
Solar Thermal	SEC – Duba ISCC Power plant phase 1 CSP 50 MW	Planned
Solar Thermal	Waad Al-Shamal ISCC Project 50 MW	Planned
Photo Voltaic	Al-Aflaj Solar PV Park 50 MW	Planned
Photo Voltaic	KACST Al Khafji PV desal Plant 10 MW	Planned
Photo Voltaic	K.A.CARE, Royal Commission for Jubail and Yanbu 50 MW PV	Planned
Photo Voltaic	K.A.CARE, 500 MW PV plants around the kingdom	Planned
Mix	K.A.CARE, King Salman Green Initiative, Madinah	Planned
Mix	K.A.CARE/SWCC, Solar & Wind Desalination in north and south	Planned

Bahrain

Waste to Energy	Waste to Energy Plant 25MW	Planned
Photo Voltaic	BAPCO Bahrain PV Plant 5 MW	Completed
Photo Voltaic	Petra Solar-Manama Solar PV Park 5 MW	Completed

Qatar

Photo Voltaic	KAHRAMAA–Solar Power Plant 230 MW	Announced
Waste to Energy	Mesaieed waste to energy plant 40MW	Completed
Photo Voltaic	Al Duhail Solar PV Park 10 MW	Announced

United Arab Emirates

Wind	Sir Bani Yas Wind Energy plant 30 MW	Planned
Photo Voltaic	Solar power plant, Utico, RAK 40MW	Planned
Waste to Energy	Waste to Energy, TAQA 100MW	Bids invited
Photo Voltaic	Masdar City solar PV park ADFEC 10MW	Completed
Solar Thermal	Shams 1 CSP plant 100MW	Completed
Photo Voltaic	Mohammed bin Rashid Al Maktoum 1 - 13 MW	Completed
Photo Voltaic	Mohammed bin Rashid Al Maktoum 2 - 200 MW	Financial Closure
Photo Voltaic	Mohammed bin Rashid Al Maktoum 3 - 800 MW	Bids invited
Waste to Energy	Waste to energy, Bee'ah 83 MW	Planned
Photo Voltaic	Noor 1 Solar PV plant 350MW	Bids invited

Oman

Solar Thermal	Solar thermal EOR plant 1 GW	Planned
Solar Thermal	Solar thermal EOR plant 7MW	Completed
Wind	Dhofar Wind farm 50 MW	Planned

Source: (Ferroukhi et al., 2013a) with updates

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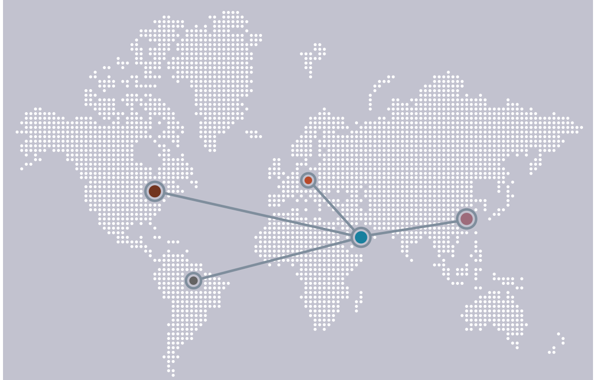
3.5 DEVELOPMENTS ALONG THE VALUE CHAIN

Renewable energy project implementation in the GCC has benefited from the parallel development of the industrial value chain in the region. Figure 3.11 highlights the roles of some of the key stakeholders in selected projects. Developers, EPC companies, equipment providers, financiers and utilities are increasingly filling roles across the different segments of the value chain, ranging from project planning to operation and maintenance (O&M) as well as supporting functions.

In support services, regional utilities and regulatory entities are gaining experience in performing roles such as system planning and decision-making (e.g. auctioning) and banks are gaining experience in financing renewable energy projects. Project developers in the region are collaborating with foreign and domestic partners to plan, construct and maintain projects. Many of these projects rely on equipment manufactured outside the region, but the sales and distribution are carried out by local providers.

Survey Box 3.5:
Local-International Partnerships

91% of respondents believe that the partnership between local and international companies is a key success factor for the development of renewable energy projects.



Domestic manufacturing is picking up in polysilicon, modules, mounting structures, inverters and other components.

- **Developers and EPC companies**

Project development in the region has been supported by a large number of developers and EPC companies. Although established foreign developers and EPC companies (e.g., First Solar, Abengoa and SENER) have been playing an important role, local ones (e.g., ACWA Power, Masdar and Abdul Latif Jameel) have also been successful.

Larger projects are often carried out by consortia of local and foreign developers and EPC companies (Figure 3.11). This arrangement capitalises on the complementarity between the project-development abilities of the domestic company and the EPC expertise of the foreign one, and is an important factor in the success of project development in the region (Survey Box 3.5). Shams 1, Ouarzazate 1 and the phase two of Mohammad bin Rashid Al Maktoum are prime examples (Figure 3.11).

The roles of the stakeholders involved in the collaboration usually depend on their specific capabilities. Masdar, for instance, has worked in the past with companies such as Abengoa and SENER as they are established technology providers and EPC companies. However, in 2013, after gaining sufficient experience with CSP projects, Masdar assumed the role of technology partner and bid for Ouarzazate 2 and 3 with GDF Suez.

In addition, developers such as Masdar and ACWA Power have invested in projects outside the GCC, such as the 630 MW off-shore wind plant London Array in the U.K. and the 50 MW CSP plant in South Africa, respectively. Not only did they gain know-how, but also experience to add to their track record of projects, an essential requirement in business development.

Other developers have acquired established companies to enhance their capabilities. Abdul Latif Jameel, for example, recently acquired leading solar developer Fotowatio Renewable Ventures of Spain. The acquisition gives the Saudi company ownership of Fotowatio's solar PV pipeline of 3.8 GW as well as their

Figure 3.11 The value chain and involved stakeholders of selected projects

Stakeholders	Role in the value chain	DEWA 13MW	DEWA 200MW	SHAMS I 100MW	OURZAZATE I**
		Renewable Energy Projects across the region			
Equipment Provider(s)	• Manufacturing • Assembly • Distribution	• First Solar • ABB	• First Solar	• Abengoa Solar • First Solar • Schott Solar • Flabeg	• Flabeg • SENER
Developer and/or EPC*	• Project planning • Construction • Operation and maintenance	• First Solar	• ACWA Power • TSK	• Total • Masdar • Teyma • Abengoa Solar	• ACWA Power • SENER • Acciona • TSK • Aries
Utility(ies)	Support functions: • Decision making • System planning • Grid connection	• DEWA • DSCE	• DSCE	• Masdar • ADWEC	• MASEN
Financier(s)	Support function: • Financial services	• DEWA	• First Gulf Bank • Samba • NCB	• NBAD • KfW • BNP Paribas • Societe Generale • SMBC • MUFG	• KfW • EIB • Afdb • World Bank • AFD

**EPC = Engineering, Procurement and Construction*
*** The Ouarzazate 1 project has been included since it is developed by a company based in the GCC.*

proven expertise in solar plant development, project financing and engineering (Abdul Latif Jameel, n.d.)

Several small scale developers have been successfully operating in the region. UAE-based Enviromena has been a prolific developer, with a portfolio including almost 30 projects in GCC and beyond. Examples include a 10 MW solar PV plant in Masdar City, a 15 MW solar PV plant in Mauritania and more recently a 100 MW solar PV plant to be developed in Jordan (Enviromena, n.d.).

Developers of solar PV-based diesel replacement applications (e.g. Enerwhere and Qmega) have been moderately successful. This is because of the relatively low diesel prices in the region and the absence of favourable financing, two important factors hindering growth in the small-scale market segment.

> ***"Acquiring the leading solar developer, FRV, enhances our existing project portfolio… and our capability to implement with a world class team, thus markedly improving our chances to win projects in the region."***
>
> Roberto de Diego
> CEO, Abdul Latif Jameel Energy

Supported by the "Shams Dubai" net-metering programme, small-scale developers in Dubai are well positioned to play an important role in rooftop solar PV deployment (see Section 3.3 for details). Many are already registered with DEWA and are implementing projects.

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Financiers

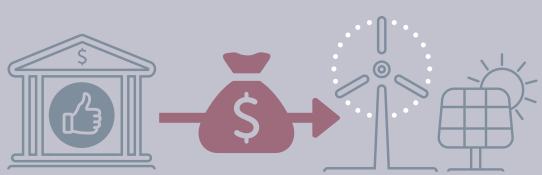
Financing has not been a barrier for large-scale renewable energy projects in the GCC. Commercial banks have been willing to offer loans with long tenors and reasonable interest rates in the presence of enabling frameworks (see Survey Box 3.6 and Section 3.3). As the market matures and regional commercial banks gain experience with renewable energy projects, debt conditions are becoming more attractive. The lending terms offered for the second phase of the Mohammed bin Rashid Al-Maktoum solar park, for instance, were better than those offered for the 100 MW Shams 1 in Abu Dhabi just two years before (Box 3.4).

Despite favourable terms to large scale projects, banks in the region have been recently facing regulatory pressures to decrease long-term lending. Bond markets and institutional investors, however, may emerge as another source of financing in the future (NBAD, University of Cambridge and PwC, 2015).

A more daunting financing challenge is seen in the small-scale solar PV market as banks are not willing to lend due to small project sizes, long payback periods and the lack of off-taker guarantees. However, leasing plans are starting to emerge under the Shams Dubai net-metering programme. Yellow Door Energy offers leasing arrangements in which owners of rooftop installations pay monthly bills depending on the solar energy consumed. It includes a clause allowing for transfer of ownership to the rooftop owner (Graves, 2015c).

Survey Box 3.6: Bank financing

The banking sector is willing to invest in renewable energy, particularly in Saudi Arabia and the UAE.



Similar financing solutions are also being developed for diesel generator-replacement applications in the temporary power market. Developers, such as Enerwhere, are teaming up with financers, such as Adenium Capital, to provide mobile solar-diesel hybrid units under flexible leasing agreements. Adenium Capital is investing USD 10 million in this venture and aims to tap into an estimated USD 4 billion diesel generator market in the UAE (Graves, 2015b).

Equipment providers and manufacturers

The equipment in almost all renewable energy projects in the GCC is manufactured by foreign companies. However, suppliers are increasingly positioning themselves in different segments of the local value chain. For instance, First Solar, the panel provider for both phases of the Mohammed bin Rashid Al Maktoum solar park, has established itself not only as an equipment supplier but also as an EPC company and a developer in the region. The localisation of its manufacturing segment, however, may only happen with a substantial increase in the annual installed capacities in the GCC and MENA (Bkayrat, 2015).

The weak local demand is often described as one of the leading reasons for the relative absence of solar PV or CSP manufacturers in the region. As demand picks up and a sizeable market for equipment is created, manufacturers can benefit from several advantages. First, the GCC is located in the middle of renewable energy equipment demand centres: Europe, Africa and Asia. Second, strong logistic infrastructure (e.g. seaports, airports etc.) in many GCC cities means that modules can be dispatched immediately. Third, the tax and ownership structures in the free-zones makes investment attractive. Fourth, the energy prices are still relatively low in some GCC countries, which reduces the cost of production. All of these factors have encouraged some solar PV manufacturing companies to set shop in the region (Figure 3.12).

Both Qatar and Saudi Arabia have announced plans for the establishment of world-class polysilicon production facilities. The planned facility for IDEA Polysilicon in Yanbu Industrial City (Saudi Arabia) is expected to produce 10,000 tons per annum of polysilicon and create 1,000 new local jobs (Ferroukhi et al., 2013).

Solar module production has also been taken up by several companies including Qatar Solar Energy (QSE) (300 MW), Solon (200 MW), Almaden (100 MW) and Dusol (50 MW) (Figure 3.12). In Qatar, QSE has established a 300 MW PV module manufacturing facility in Doha, with an eventual goal of producing 2.5 GW in the long run (Kennedy 2014). Microsol, a company based in Fujairah, UAE, acquired a German PV manufacturing company Solon Group in 2012. This enabled Solon/Microsol to strengthen its outreach to the markets in the European Union, United States, Africa, Middle East and India. Almaden is currently building its 100 MW factory with operations set to start beginning of 2016.

The competitive advantages of the region and the potential for a large market in the GCC have also attracted foreign investors. SunEdison, for instance, is conducting feasibility studies to develop a vertically integrated solar PV manufacturing facility with 3 GW of production capacity and polysilicon production. The polysilicon will be used to provide feedstock for in-house module manufacturing and to cater to the needs of the regional and global markets (SunEdison Inc., 2014).

Production of modules and polysilicon are clear examples of non-traditional industries in the regional context. Renewable energy deployment can also create value in the more traditional industries such as manufacturing of electrical equipment and metallic structures. In Saudi Arabia, Japan's KACO and Saudi AEC, for instance, have started producing a series of solar inverters that qualify for the Shams Dubai programme. The plant is capable of producing 1 GW of inverters every year (AEC, 2015). Similarly, the well-established foundries and building material providers

"Dubai's central location, close proximity to ports, state of the art infrastructure and absence of taxes were the deciding factors in placing our [100 MW] factory here."

Manfred Fussi
Sales and Marketing Director,
Almaden MENA FZE

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Figure 3.12 Solar PV manufacturers in the GCC

Poly Silicon	Inverters	Mounting Structures
QStec REC Silicon IDEA Polysilicon	AEC New Energy	Al Jazira Tiger Profiles

Modules			
SOLON	Almaden	DUSOL	Qatar Solar Energy

in GCC are up to the challenge of producing mounting structures for solar PV panels. Examples include Al Jazira and Tiger Profiles in the UAE.

Renewable energy projects and initiatives in the GCC have grown together with tangible developments in the local value chain. Further expansion can position the sector as a new engine of growth that supports the national plans for economic diversification and socio-economic development.

3.6 THE SOCIO-ECONOMIC BENEFITS OF A RENEWABLE ENERGY TRANSITION IN THE GCC

Scaling-up renewable energy in the GCC countries would reap multiple benefits across the region. IRENA assessed the socio-economic benefits of the 80 GW renewable energy capacity that would result from the announced 2030 plans and targets. The results clearly show that GCC countries stand to gain in terms of job creation, fossil-fuel savings, reduction in CO_2 emission, and decrease in water withdrawals.

Job creation

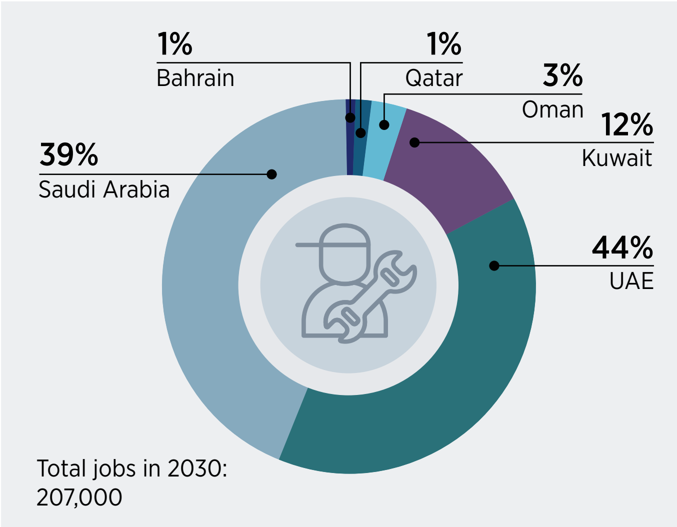
As global economies continue to struggle with economic boom-bust cycles, unemployment and its associated social and economic impacts remain a key concern and an instrumental driver of public policy. The GCC economies have been relatively more resilient in the aftermath of the most-recent financial crisis (Jaber, 2012). The recent collapse in oil and gas prices, however, has fuelled the debate around future growth strategies. With an uncertain economic outlook and rising populations, a failure to adequately absorb the large domestic population entering the labour force could pose certain challenges. Therefore, job creation is a key priority for the GCC governments.

Renewable energy offers a considerable potential for large-scale job creation. IRENA (2015d) estimates that the sector on a global basis (excluding large hydropower facilities) supported around 7.7 million direct and indirect jobs in 2014. Project-level data indicates that, on average, renewable energy technologies generate more jobs than fossil-fuel technologies. For instance, solar PV projects create at least twice the number of jobs per unit of electricity generation compared with coal or natural gas (UKERC, 2014). Likewise, countries in the GCC can expect significant job creation through renewable energy deployment.

Employment by country

IRENA's analysis indicates that achieving the region's renewable energy plans can result in an average of 140,000 direct jobs every year, reaching around 207,000 in 2030. Most of these jobs will be concentrated in the UAE and Saudi Arabia (Figure 3.13).

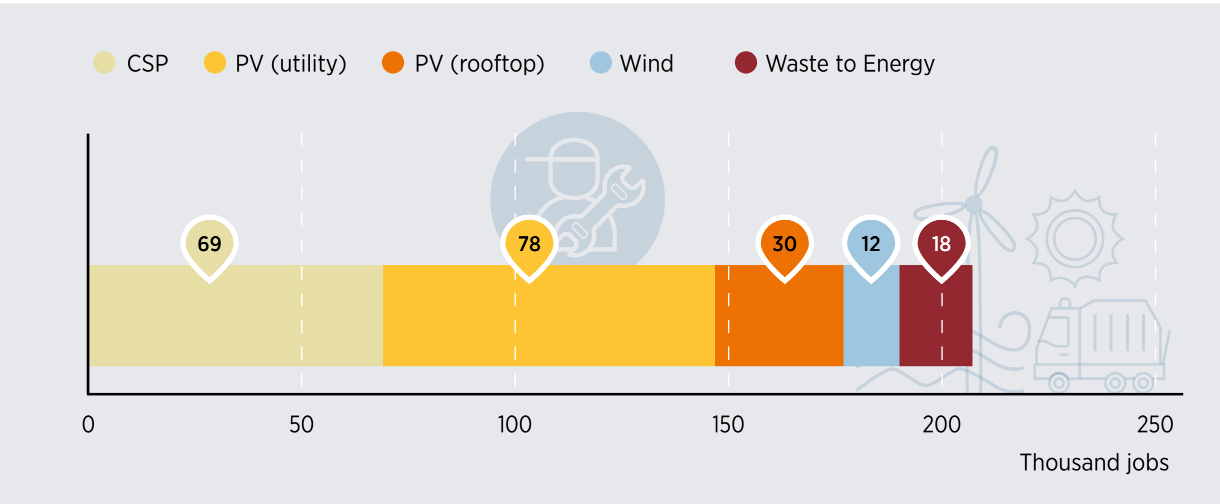
Figure 3.13 The breakdown of direct jobs in the renewable energy sector in the region by country in 2030 (%)



Employment by technology

Together, CSP and solar PV (small and large) would account for 85% of the jobs in 2030. Massive deployment of PV can result in more than 100,000 jobs in the GCC – making it the largest employing technology, followed by CSP at 31% of the jobs. Waste to energy can also be an important employer with

Figure 3.14 The breakdown of direct jobs in renewable energy in 2030 by technology (thousand jobs)



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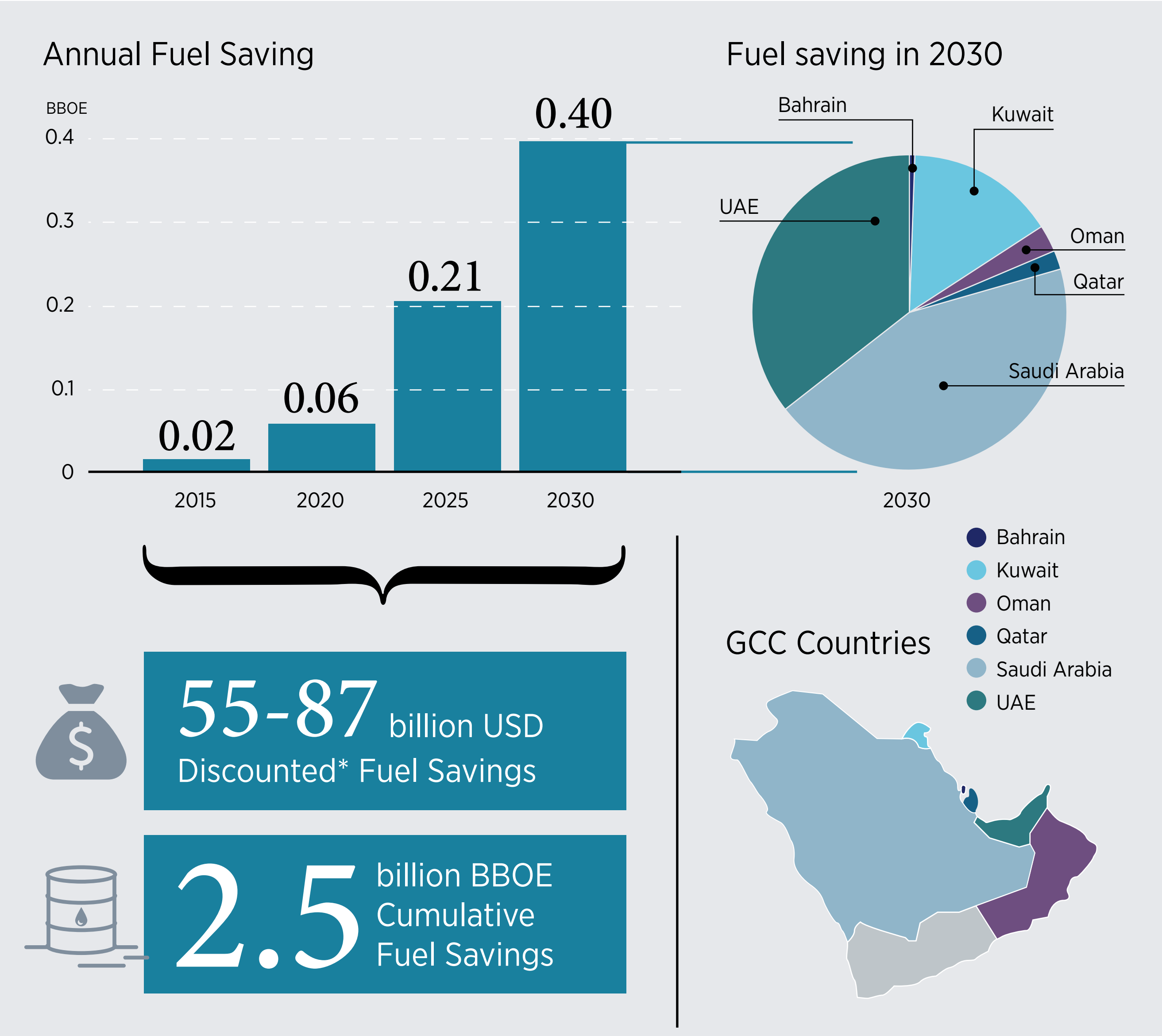
around 14% of the jobs - according to conservative estimates that do not account for operational jobs in waste collection and processing. Wind energy can also be a key employer, especially in Saudi Arabia, Kuwait and Oman (Figure 3.14).

Fuel and emissions savings

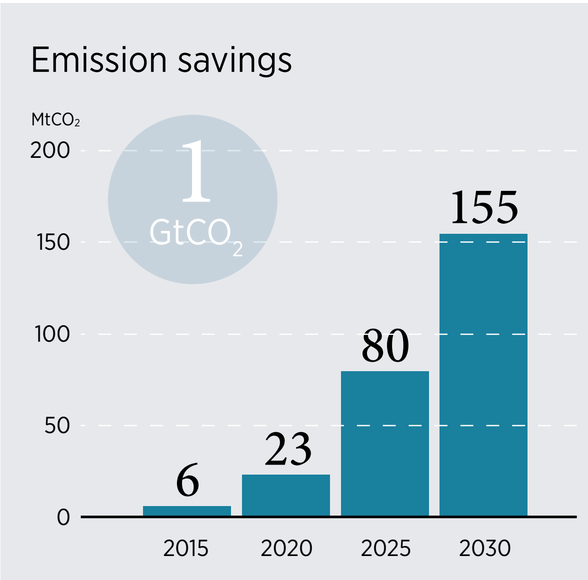
The results of IRENA's analysis also show that achieving the renewable energy plans for the electricity sectors in the region can result in cumulative savings of 2.5 billion barrels of oil equivalent (2015-2030). This reduction may lead to an overall savings of USD 55 billion to USD 87 billion, depending on oil and gas

Figure 3.15 Fossil fuel savings from GCC renewable energy targets by year and by country



** Discount rate 5%; Low price scenario (Oil: USD 40/barrel; Gas: USD 8/MMBtu); High price scenario (Oil: USD 80/barrel; Gas: USD 11/MMBtu)* prices[8]. As more renewable power plants are brought online every year, fossil fuel savings in the power and water sectors will reach a peak in 2030 at around 400 millions of barrels of oil equivalent (MBOE), representing a 25% decrease[9] (See Figure 3.15). Saudi Arabia, the largest consumer of fossil fuels for power production in the region, would save around 170 MBOE of oil and gas resources in 2030, or 44% of the GCC wide savings (Figure 3.15).

Figure 3.16 Emissions savings due to renewable energy deployment plans ($MtCO_2$)

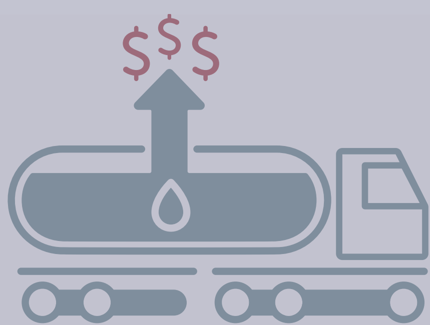


Studies have indicated that continued reliance on oil for domestic demand in Saudi Arabia can pose challenges for exports (Lahn and Stevens, 2011; Daya and Baltaji, 2012). IRENA analysis indicates that the fulfilment of renewable energy targets can cut power-sector fossil fuel consumption in Saudi Arabia by 25% by 2030 (a reduction of 0.17 BBOE). Renewable energy, therefore, offers the country, as well as the region, an important opportunity to optimise the use of its fossil fuels, either for exports or as industrial feedstock (Survey Box 3.7).

Similarly, renewable energy could also help mitigate the natural gas shortages GCC economies could 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 power sector in the UAE, for example, could be reduced by around

Survey Box 3.7: Opportunity Cost

80% of respondents believe renewable energy deployment would free up domestic fossil fuel supplies that could generate more revenue as exports or in the petrochemical industry.



8 *Assumptions: Discount rate 5%; Low price scenario (Oil: USD 40/barrel; Gas: USD 8/MMBtu); High price scenario (Oil: USD 80/barrel; Gas: USD 11/MMBtu)*

9 *The planned nuclear plants in the UAE and Saudi Arabia are included in the business as usual scenario. Therefore, these reductions are only due to renewable energy, and not because of nuclear.*

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50%, resulting in a savings of 20 million tonnes of oil equivalent (Mtoe) in 2030 and significant reduction in natural gas imports. Similarly, Kuwait and Oman could save 21% and 9% of their natural gas consumption in the power sector.

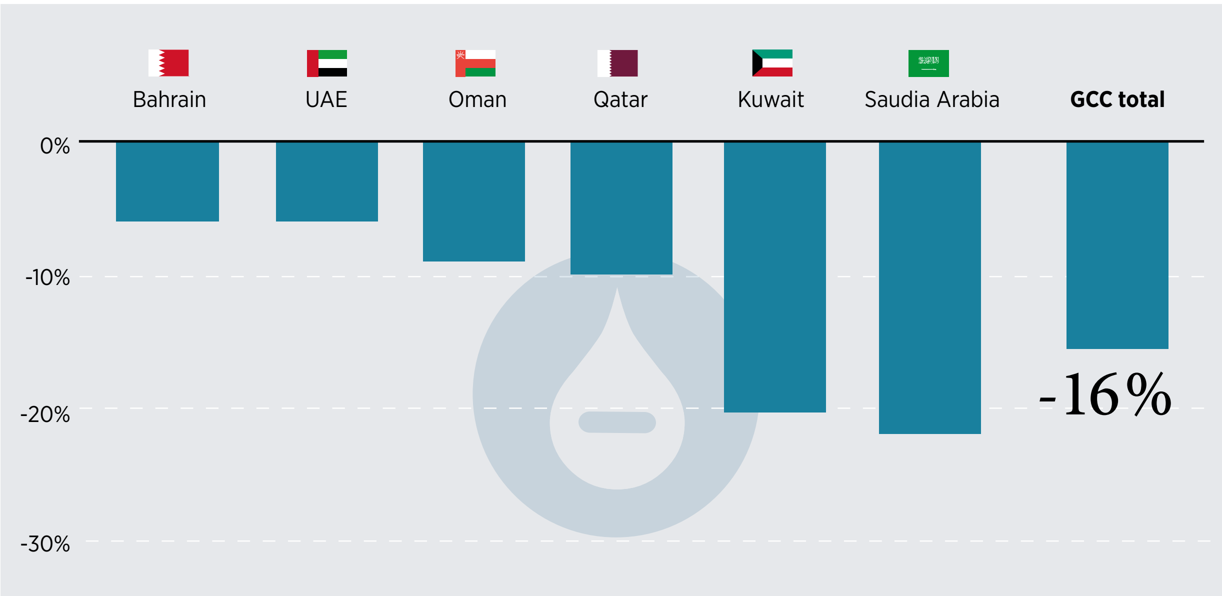
While renewable power can relieve resource constraints, its role in reducing regional carbon footprints will be instrumental. Achieving renewable energy targets in the region can reduce emissions by 1 Gt CO_2 to 2030, potentially resulting in an 8% reduction in the per capita carbon footprint of the GCC by 2030 (Figure 3.16).

Water savings

The region has among the world's lowest levels of renewable water supply, and the demand for water is expected to increase fivefold by 2050. Extraction of fossil fuels and cooling during power generation requires withdrawal and consumption of water that is slow to naturally replenish. Furthermore, treated water is needed for oil and gas extraction, resulting in even higher demand for desalination.

Realising the renewable energy plans in the GCC could result in an estimated overall reduction of 16% and 14% in water withdrawal and consumption[10], respectively, in the power sector[11] (Figure 3.17). This is equivalent to an annual reduction of 11 trillion litres of water withdrawn and 200 billion litres of water consumed. A large share of the reduction would come from Saudi Arabia and Kuwait, due to their heavy reliance on

Figure 3.17 Reduction in water withdrawal for power generation in the region in 2030 (%)



Source: Updated from (IRENA 2015e)

10 Withdrawal is defined as the total amount of water taken from a source that may or may not be returned to that source. Consumption is that portion of water withdrawals that is not returned to the original source (IRENA, 2015e).

11 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.

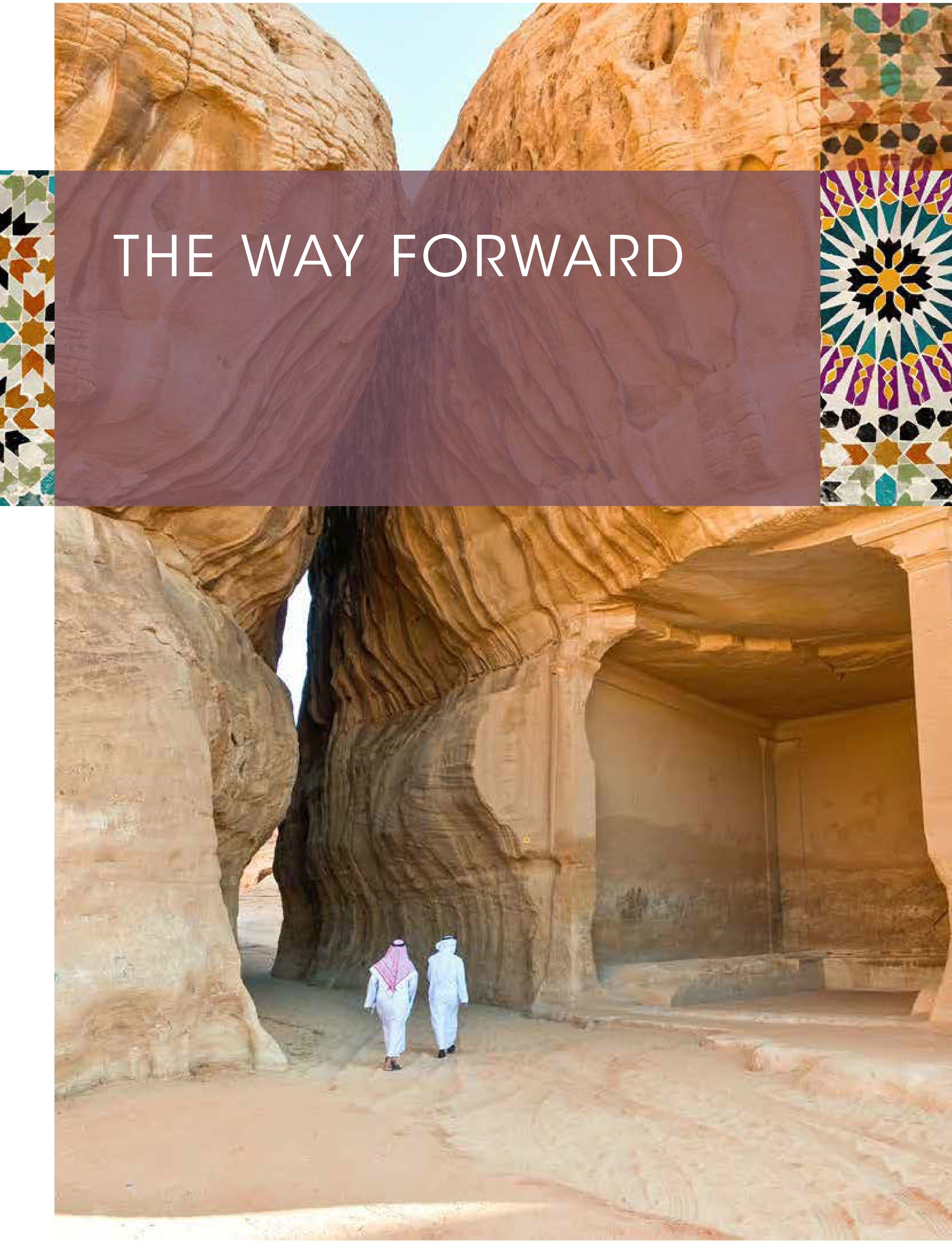
electricity generation from crude oil (which requires a high volume of water for extraction) and their plans to add significant shares of renewable energy in the power sector.

Most power plants in the region rely on seawater cooling, whereas crude-oil extraction uses treated water. Depending on technology choices, plant location and other factors, renewables often 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.

Renewable energy can clearly provide remarkable benefits in terms of fossil-fuel savings, emission reductions, job creation and water saving. However, achieving renewable energy targets and maximising their socio-economic impact requires the appropriate institutional and policy frameworks to encourage deployment, and to strengthen local industries through technology transfer, investment promotion mechanisms and education and training. As the analysis in this chapter has shown, policy and regulatory frameworks are in their early stages of development, but the promising initiatives already implemented could be replicated around the region.

Along with scaling-up renewable power supply, renewable-based desalination presents a promising avenue, where solar energy and other renewables can help address the strains on regional water resources in a sustainable way.

THE WAY FORWARD



THE WAY FORWARD

The development of fossil fuel reserves and exports in the GCC has underpinned impressive economic growth, bringing widespread prosperity and development. Hydrocarbon exports have been an engine of growth, but fossil fuel production is increasingly used to meet the fast-growing domestic energy demand. Rapid industrialisation, high demography and rising water desalination are the leading reasons for this growth and can have important implications for GCC countries' ability to maintain export levels over the long-term. In fact, as discussed in this report, some countries, have recently become, or are on the verge of becoming, net importers of natural gas. Governments are, therefore, compelled to embark on energy diversification strategies to meet growing energy demand with energy supply options that are domestically available, secure, cost-effective and environmentally-sustainable. Renewable energy is a key part of the solution.

Despite potential benefits, the pace of renewables deployment has, to date, fallen short of its potential in the region. This can be attributed to a range of factors, including institutional inertia faced with new markets, clarity in institutional roles and responsibilities, and lack of dedicated policies and regulations. In the recent past, efforts were undertaken to overcome existing barriers by setting up specialised institutions, building adequate capacities and providing a vision for the sector's development through renewable energy targets and auctions announcements. The DEWA solar auction of 2014 could be seen as an important milestone in this regard which brought to the forefront the cost-competitiveness of solar energy and the pace at which it can be deployed. Importantly, the auction demonstrated that when the government is able to provide the right market conditions, the private sector stands ready to actively participate in the transition. Looking forward, government commitment in the form of key policy and regulatory actions will be needed to catalyse investments into the sector and further accelerate the pace of deployment.

GOING FORWARD: THE CENTRAL ROLE OF ENABLING FRAMEWORKS

Government commitments can take the form of credible, time-bound renewable energy targets, which serve to anchor investor confidence and set out the trajectory for the development of the sector. To be effective, targets must be backed by dedicated policies and regulatory frameworks. These ensure predictable revenue stream for projects, create a stable investment environment and can help to overcome non-economic barriers. While a deployment policy triggers investment in renewables, a mix of policies is required to support the broader development of the sector.

WAY FORWARD

Deployment policies are essential market-creating measures to promote renewables as they trigger investments in the sector. GCC countries have adopted regulatory instruments tailored to specific market segments such as auctions for large-scale and net metering for small-scale projects.

Large-scale projects that have been implemented in GCC countries have been supported by auctions mainly for their ability to achieve deployment in a well-planned and cost-efficient manner. Early auctions were typically implemented under the EPC model (the Mohammed Bin Rashid Al Maktoum solar park 1 in Dubai). With the experience gained in procurement, financing, development and operation, governments adopted the Independent Power Producer (IPP) procurement model, and the auction was designed in a way that increased competition and brought the price down. The Mohammed Bin Rashid Al Maktoum Solar Park 2, for example, resulted in the lowest solar PV price globally. The auction was supported by an enabling environment, the long-term vision for solar deployment from the Emirate, as well as the creditworthiness of the off-taker, DEWA. Looking forward, it is important to ensure that projects are delivered under the conditions agreed upon, by implementing the compliance rules featured in the auction. It is essential to tailor the entire auction design to the country's specific objectives and context, including the level of development and the maturity of the sector.

For small-scale projects, net-metering can unlock the potential of roof-top solar market in the region but its success will require conducive financing conditions to overcome the upfront cost barrier. More importantly, the deployment of small-scale projects can benefit from electricity prices reflecting, as closely as possible, the real cost of supply, thus levelling the playing field for renewables. Reforms in the pricing of diesel can therefore create avenues of deployment for off-grid renewable energy in many GCC countries.

Aside from the power sector, integrating renewables in other applications, such as heating/cooling and desalination, also requires a conducive policy environment. Renewable energy-based desalination, in particular, can be supported through a two-pronged approach: firstly, the development of large-scale commercial projects to gather operational experience (e.g. Al-Khafaji solar desalination in Saudi Arabia); secondly, investment in R&D to improve the performance of renewable desalination, while increasing domestic technological know-how (e.g. Masdar's renewable energy desalination programme).

In general, deployment policies need to be part of a broad range of cross-cutting policy instruments – the "policy mix" – that supports the energy transition. Tailored to specific country conditions and the level of maturity of the sector, the policy mix should focus on building institutional and human capacity, promoting R&D, strengthening domestic industry and creating an investment-friendly environment.

- **Institutional development is essential to support sustainable renewable energy deployment.** The role of institution cannot be overstated in the decisions that influence the pace of the energy transition. Enabling institutional framework, with clearly defined roles and responsibilities, ensures effectiveness of renewable energy policies. Some GCC countries have mandated specialised institutions to promote renewable energy. The UAE, for instance, has established a separate unit, the Directorate of Energy and Climate Change, which promotes the development of sustainable energy, including renewable energy. Clarity in institutional roles (e.g. those related to project evaluation, permitting and licensing) can reduce transaction costs and make projects more attractive. Given the wide array of stakeholders traditionally involved in the energy sector, including policy makers, utilities, regulators and grid operators, coordination is also vital to ensure unfettered development, for instance planning for physical infrastructure to keep pace with deployment.

- **Skills development through education and training is essential to support the expansion of the renewable energy sector.** GCC governments are investing in education programmes covering a broad range of skills including engineering, economics, science, environmental management, finance, business and commerce and focusing on renewable energy. Examples include KISR, Sultan Qaboos University in Oman, Qatar Foundation, K.A.CARE and King Abdullah Petroleum Studies and Research Center in Saudi Arabia, Masdar Institute, an the University of Bahrain. This is of particular relevance to a region that heavily relies on foreign human capacity to fill technical jobs, such as scientists, engineers and technicians. Going forward, GCC governments need to anticipate skills requirements within the sector and identify the ways to meet them. These may include providing financial support for renewable energy education, developing partnerships between industry and academia as well as integrating renewable energy into curricula. Vocational training programmes can also offer opportunities to acquire specialisation and reap potential benefits from the growing renewable energy job market.

- **Capacity building can also benefit from technology cooperation through joint ventures, partnerships and consortiums.** Some examples include Masdar's partnership with Abengoa and Sener and Abdul Latif Jameel's acquisition of leading solar developer Fotowatio Renewable Ventures (FRV) of Spain. Local companies can partner with – or acquire – foreign companies that are well-established technology providers and EPC firms. This can benefit local companies in enhancing their capabilities, gaining experience and strengthening their renewable energy portfolio.

- **Programmes and policies such as industrial upgrading programmes, supplier development programmes and product specifications can further enhance the capabilities of local companies.** DEWA, for example, mandates the use of standardised components and installation to be performed by registered contractors and consultants. Such measures are benefiting Dubai's net metering programmes to avoid faulty installations and and ensure continued operation of projects. Moreover, the development of industrial clusters that promote co-operation across a range of stakeholders can also be effective in stimulating innovation and contributing to spill-over effects (e.g. Masdar City, Qatar Foundation).

WAY FORWARD

- **Measures to support the development of local industries can support deployment while fulfilling broader socio-economic goals.** GCC governments aim to support the development of nascent industries through local content requirements that can secure a local market for their products. Saudi Arabia's proposed competitive procurement programmes is a case in point. However, these requirements need to be time-bound and carefully designed. LCRs can also be introduced to promote other socio-economic benefits of renewable energy deployment such as job creation. Other measures supporting the development of local industries include free zones, supporting-infrastructure, and the potential for synergies with established industries such as glass, aluminium and steel.

- **Strengthening domestic capabilities and boosting the development of local industries can help maximise the benefits of deploying renewables.** As a result of increasing renewable energy deployment, new markets will emerge, creating new trade flows while providing opportunities for all economies to localise different segments of the renewable energy value chain. The ones that can be localised depend on the state and competitiveness of local complementary industries as well as the projected demand for goods and services. Some segments, such as construction materials and services, are more easily localised than others (e.g., manufacturing). Cross-cutting policy interventions, like industrial upgrades, supplier-development programmes and industrial-cluster cultivation can further contribute to increased competitiveness and production quality.

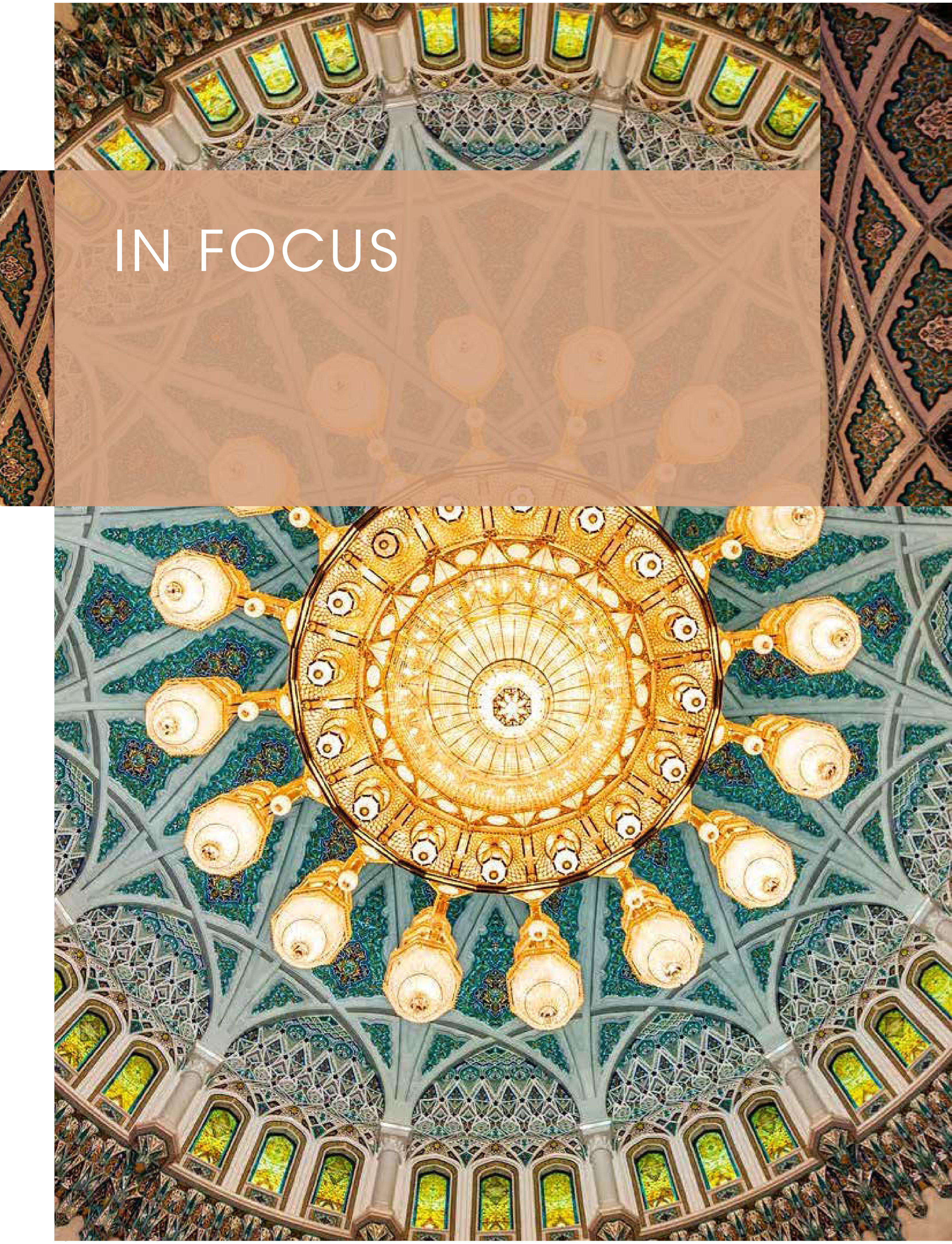
- **Support for R&D activities in the sector can enable technology adaptation to local contexts, improved performance and greater value added of domestic industries.** Several local universities and institutions are working on strategic research areas such as renewables-based desalination, the performance of PV panels in the region's hot and dusty climate, dry-cooling for CSP plants and different renewables and storage configurations. Furthermore, R&D activities can contribute to countries' overall objective of a knowledge-based economy.

- **An investment-friendly environment is essential to attract the private sector.** As deployment grows and new markets emerge, developers are improving in forecasting cash-flows, while financiers are able to more accurately assess risk and design financing products suited for renewable energy projects. Nevertheless, actual and perceived risks can slow down investment growth in renewable energy, especially in new markets. Policy makers and financial institutions must deploy the right policy and financial tools to address these risks and mobilise private sector investment, as seen in the case of DEWA. Any strategy to mobilise private investment needs to focus on risk mitigation instruments and other financing tools, both to develop a strong pipeline of projects, and to unlock private project financing and refinancing opportunities. Investment strategies need to be tailored to each phase of the renewable energy project cycle: planning, construction and operation. Given that investment decisions today can lock-in energy systems for decades, a greater focus is needed on planning in the short-term to ensure the development of a pipeline of attractive renewable energy projects. The success of any investment strategy will rely on the active participation of a broad spectrum of private and public actors, including development finance institutions, climate finance institutions, private equity funds, institutional investors, export credit agencies and green and commercial banks.

Scaling-up renewable energy in the GCC countries would reap multiple benefits across the region. IRENA assessed the socio-economic benefits of the 80 GW renewable energy capacity that would result from the announced 2030 plans and targets. The GCC region, in the long-run, has the potential to create an average of 140,000 direct jobs every year. Achieving existing renewable energy plans and targets can also result in cumulative savings of 2.5 billion barrels of oil equivalent in the period between 2015 and 2030. This reduction may lead to overall savings ranging from USD 55 to 87 billion depending on oil and gas prices. Moreover, achieving the renewable energy targets in the region can reduce emissions by 1 Gt CO_2 until 2030, potentially resulting in an 8% reduction in the per capita carbon footprint of GCC by 2030.

The GCC countries are endowed with hydrocarbon resources that have fuelled development over the past decades. Blessed with abundant solar resources, the region can fuel economic growth and provide employment for future generations in a sustainable manner.

IN FOCUS



RENEWABLE ENERGY-BASED DESALINATION

Rapid economic development in the GCC means that water demand has increased dramatically in recent years, and the trend is likely to continue. Faced with limited naturally renewable water resources, countries have turned to seawater desalination options, which now provide anywhere from 27% of total water demand in Oman to 87% in Qatar). Desalination is an expensive and energy-intensive process, which contributes to concerns about increasing consumption of fossil fuels, energy security and environmental degradation.

These factors have compelled governments and the private sector to explore more affordable and sustainable options to power desalination in the long-term. In this context, renewable options, especially those based on solar energy, are gaining increasing prominence.

DESALINATION IN THE GCC

Desalination provides a substantial proportion of the region's fresh water needs, which have been rising as demand outstrips the availability of natural water resources. Qatar, for instance, relies on desalination plants for 87% of its fresh water requirements – followed by about 50% in Saudi Arabia, 42% in the UAE and Kuwait, 36% in Bahrain and 27% in Oman. Desalination plants in the GCC currently have a total capacity of around 26 million cubic metres of water production per day (Mm^3/d), equivalent to 36% of global capacity. This capacity has grown steadily over the past decade and is expected to approach 45 million m^3/day by 2020 (Figure A.1) (GWI, 2015).

DESALINATION TECHNOLOGIES IN THE REGION

Generally, desalination technologies fall into two main categories – thermal and membrane-based (Box A.1). Thermal desalination technologies (in particular MSF) have traditionally been preferred in the region (Table A.1), for two main reasons. First, high salinity in the Arabian Gulf and the Red Sea

IN FOCUS

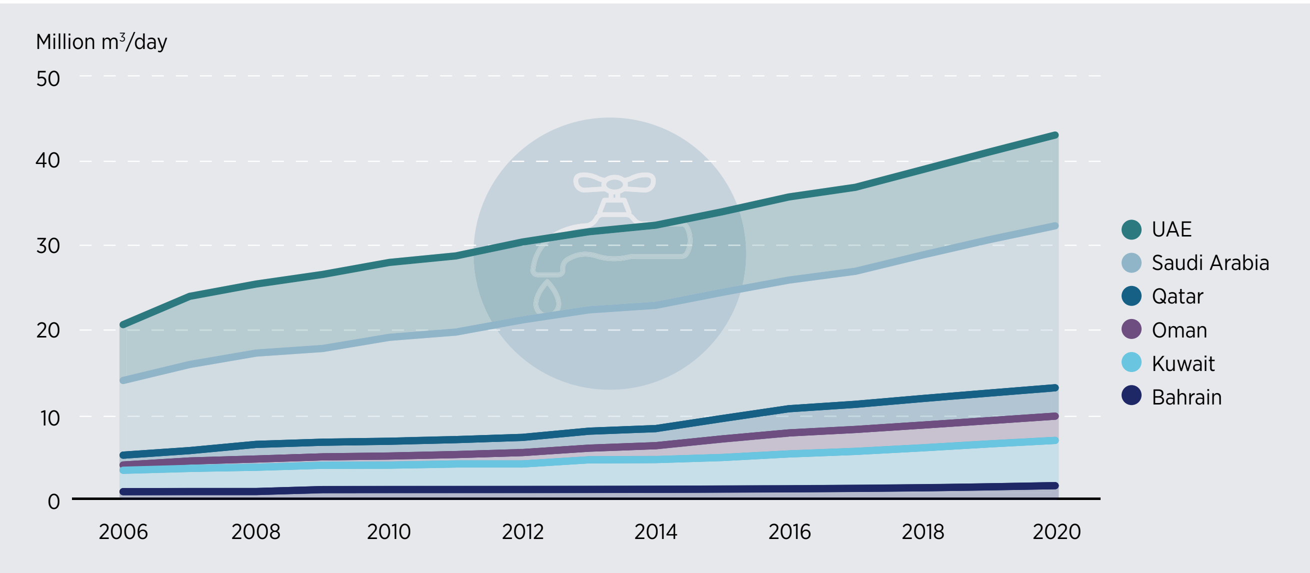
has meant that membrane-based technologies (in particular reverse osmosis (RO)), required expensive water-pre-treatment processes. Thermal desalination technologies, relying on vaporisation, are less vulnerable to such limitations. Second, integrated water-and-power projects use residual heat from power plants for thermal desalination. By co-locating water and power production plants, utilities benefit from greater economies of scale in construction and planning as well as distribution infrastructure. Thermal desalination, used for over 30 years in the region, is well-integrated into power-generation infrastructure.

The cogeneration of electricity and fresh water offers multiple benefits, but it may also result in inefficient production of power and water. While demand for water remains relatively constant throughout the year, power demand varies considerably from day to night and from summer to winter. This results in periods during which cogeneration plants do not have enough waste heat from power production to run desalination units and satisfy water demand. At these times, heat is produced from inefficient auxiliary burners to augment waste heat from power generation, lowering the overall fuel efficiency of cogeneration plants. More recently, cogeneration plants are also being designed with both thermal and membrane-based systems to even out the vast variations in water and power demand. Membrane-based desalination, such as RO, requires electricity inputs predominantly and are generally less energy-intensive compared to thermal desalination. In the past decade, a clear shift to membrane-based desalination has been observed.

SHIFT TOWARDS REVERSE OSMOSIS

There are now eight large (>100,000 m³/d) RO plants in the GCC, and most of the contracted capacity under development (for 2015-2020) is for RO or hybrid thermal-RO technologies. Earlier limitations associated with high salinity in seawater are being addressed through more advanced membranes. This reduces both the energy consumption for the process, and the extent of membrane fouling (when algae or other particles attach themselves to the membrane and interfere with the process), as well as the associated costs.

Figure A.1 Cumulative desalination capacity in GCC countries; 2006-2020



Sources: GWI 2015, Desalination Markets, Global Water Intelligence, 2016

Box A.1 Overview of desalination technologies

The process of water desalination involves separating saline water into a freshwater component and a concentrated salt component (brine). The water used for the desalination process may be brackish or sea water. Current global water desalination capacity stands at approximately 75 Mm^3/d, accounting for ~1% of global fresh water demand.

Current desalination technologies involve either thermal or membrane-driven separation processes. There are numerous thermal desalination processes, but the most relevant ones are multi-stage flash distillation (MSF) and multi-effect distillation (MED). For membrane processes, the most common approach is reverse osmosis (RO). All current commercial desalination processes are energy intensive, but thermal processes are much more so than those based on membrane separation.

As of 2014, RO accounts for about 60% of global desalination, with most of the balance being MSF and MED (GWI, 2015). Most RO capacity was built in the last fifteen years. RO has become the first choice because it is the most energy-efficient method, and because technological improvements such as enhanced membranes and energy-recovery devices have increased its performance and driven its costs down.

Source: (IRENA and IEA-ETSAP, 2012)

Table A.1 GCC desalination capacities and breakdown per technology

Countries	Population (million)	Online desali-nation capacity (106 m^3/d) (2014)	Break down of online capacity by technology (2014)				Additional Contracted* (106 m^3/d)
			MSF (%)	MED (%)	RO (%)	Other (%)	
Saudi Arabia	29.9	11.4	37.6	10.4	49.6	2.4	10.5
UAE	9.6	8.9	68.2	12.2	19.4	0.2	2.5
Kuwait	3.6	2.6	72.7	0.1	27.1	0	2.3
Qatar	2.3	1.8	69.4	19.9	9.8	0.8	1.5
Oman	4.2	1.1	36.3	7.6	55.9	0.2	1.7
Bahrain	1.4	0.6	16.9	46.2	36.9	-	-
Total	**51**	**26.4**					**18.6**

* Contracted to come on line in the period 2015-2020

Source: Based on (GWI 2015)

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In Oman, RO is considered for two upcoming plants, namely Salalah Integrated Water and Power Plant and the Barka II Power and Desalination Plant

“In general, economic assessments and recent procurement experience demonstrate the substantial cost advantage of RO over MSF desalination technology.”

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(OPWP, 2015). A similar trend is also underway in the Emirate of Abu Dhabi, where RO is now seen as the most suitable technology for water desalination, given its fuel efficiency and possible synergies with the expected introduction of nuclear and scale-up of solar PV power. Nuclear power plants (5.4 GW), once operational, are expected to meet the baseload electricity demand currently addressed by cogeneration plants. This pushes the cogeneration plants to the medium- to peak-load range, making their electricity generation more variable and their water production less efficient. Therefore, the rise of RO and the decoupling of the electricity and water sector are important trends (Smith, 2015; Parmigiani, 2015).

Although RO appears to be the preferred technology for the future, hybrid plant, that combine RO with thermal technologies (MSF or MED) are currently being installed. Combining these technologies offers several other benefits. First, when power demand is low, thermal desalination becomes inefficient, because waste heat is unavailable, therefore, RO can take over. Second, the cooling seawater from the MSF unit can feed the RO desalination system, increasing membrane performance (warm water increases permeability) (Gude et al, 2010). Third, facilities such as water inlets, outlets, and power infrastructure can be shared, and water outputs of the two types of plants can be mixed to reach acceptable average salinity levels. Several hybrid desalination plants have already been commissioned. Kuwait, for instance,

added a RO plant with capacity of 136,000 m³/d to the existing 534,000 m³/d Az-Zour South MSF plant in 1989. In the UAE, the 590,980 m³/d plant in Fujairah opened in 2015 is a hybrid MED-RO plant coupled with a 500 MW power plant. In Saudi Arabia the hybrid Ras Al-Khair Power and Water Plant scheduled for 2016, will have 307,000 m³/d and 728,000 m³/d of RO and MSF capacities respectively (GWI, 2015).

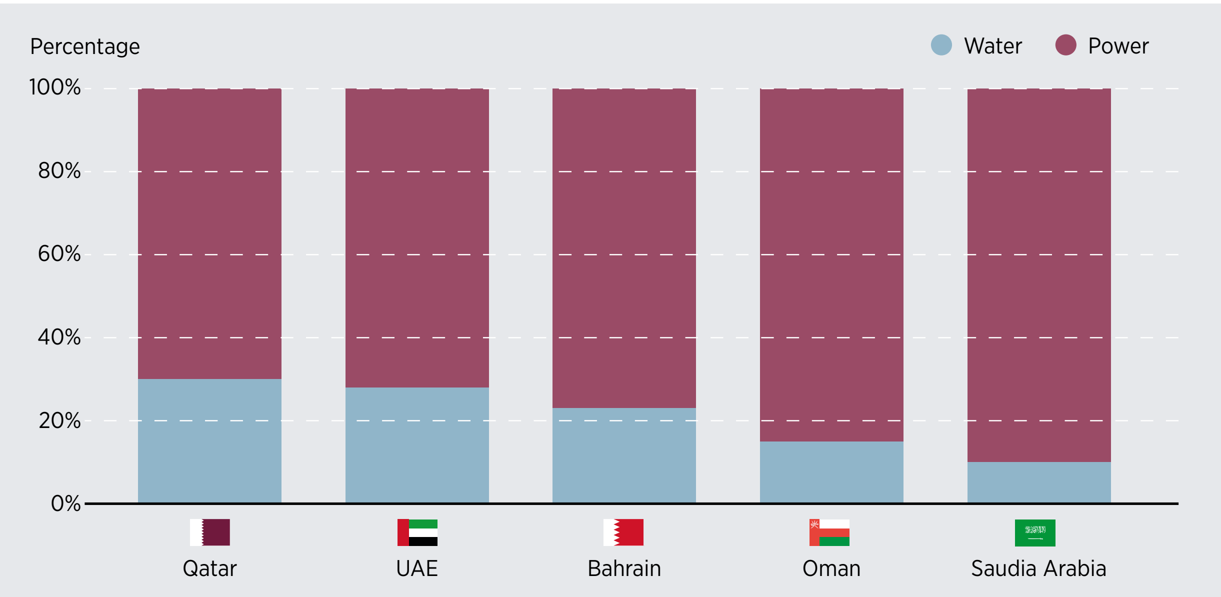
Beyond technology dynamics, fundamental factors, such as the availability of energy and environmental impacts, also influence decision-making on the development of future desalination infrastructure. The increase in RO can serve as an opportunity for greater integration of renewables, such as solar PV and wind, in the power system as they become a cost effective alternative to fossil fuel-based electricity generation.

RENEWABLE ENERGY IN DESALINATION

Energy intensity is one of the main factors determining the cost and economics of desalination. Conventional technologies for desalination are energy intensive and are responsible for a significant share of the total input fuel consumed in power and water sector (Figure A.2). With rising water demand, GCC countries are set to ramp up their desalination infrastructure (6% to 10% annually till 2040). If powered by hydrocarbons, such a ramp up could pose significant resources constraints.

The GCC countries will need new domestic energy sources to meet long-term energy needs for desalination, particularly if economies wish to preserve the ability to export oil and gas, and avoid costly imports. In Saudi Arabia, it is estimated that nearly 300,000 barrels of oil are already used daily for thermal desalination (Hamdan, 2015). Kuwait is experiencing the same challenge, though on a smaller scale (MEES, 2014). In addition to oil, natural gas is also used for desalination in the GCC. In net-exporting markets, such as Qatar, growing demand in the desalination sector, when combined with the power sector, means that larger quantities of natural gas have to be redirected to domestic use. In net-importing markets, such as the UAE, increasing natural gas use translates into rising costs and energy security concerns. Therefore, two key pillars of a long-term desalination infrastructure strategy

Figure A.2 Fuel consumed in the power and water sectors for desalination (% of fuel)



Source: Lahn, Stevens and Preston 2013

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are emerging – adopting more energy efficient desalination technologies (e.g. RO) and transitioning towards alternate energy fuels (e.g. solar).

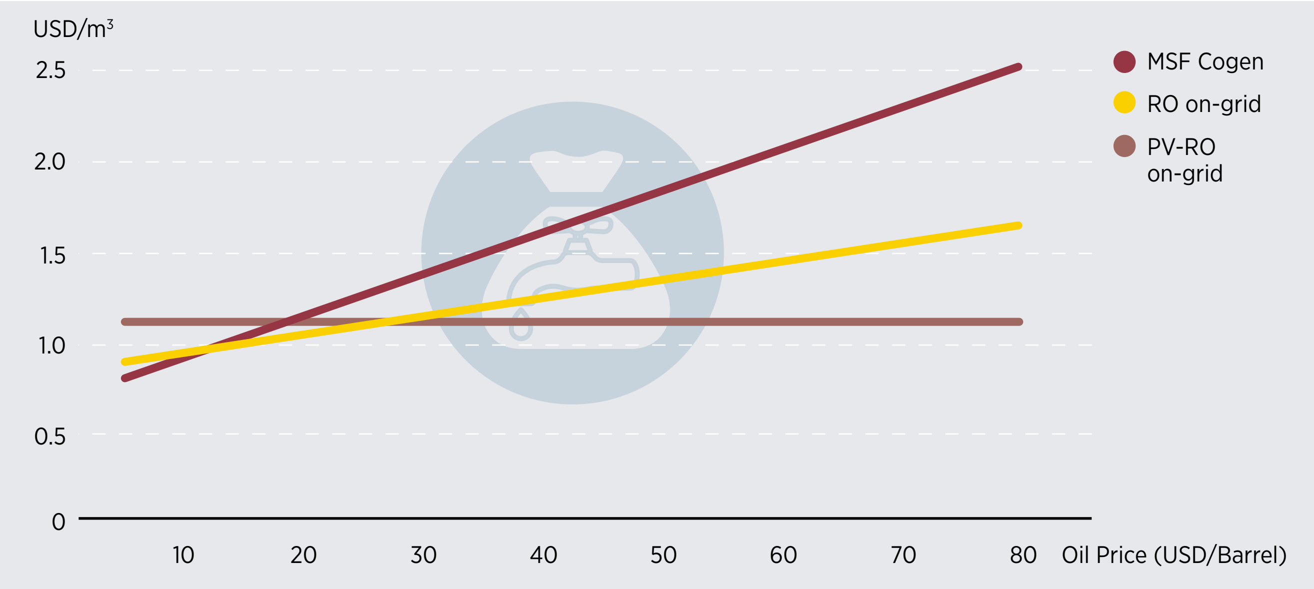
Abundant renewable energy resources, in particular solar and wind[1], can provide for the energy needs of the region's desalination infrastructure in the long-term. Their increasing utilisation in the sector can allow for a decoupling of water production and supply from fossil fuel availability and price volatility. Renewable energy technologies can be integrated into desalination infrastructure in several different ways.

- Solar energy can be tapped through CSP technology for thermal desalination. In fact, CSP-MED hybrid solutions have received substantial interest as a key solution for integrating renewable energy into existing thermal desalination-dominated market (World Bank, 2012). Real progress on testing and deploying the solution has been limited to date.

- Solar energy can also be used through solar PV technology for membrane desalination. Recently, PV-RO based solutions have been gaining substantial prominence owing to a combination of factors. First, PV costs have decreased substantially over the past five years making them a cost competitive option for power generation in the region. Second, is the general trend towards RO-based desalination in the region that requires electricity as input. Third, the decentralised nature of solar PV and minimal fuel supply infrastructure required increased competitiveness as a solution for stand-alone desalination.

- Finally, wind energy can also be utilised for membrane desalination. Wind-RO systems can be effective in locations with high wind resources. Given the promising wind resources in the coastal areas of Saudi Arabia, wind is considered as a key technology for powering water desalination in these areas (potentially through wind-RO systems) (K.A.CARE, 2013).

Figure A.3 Cost competitiveness of solar desalination at different oil prices (USD/m³)



Source: IRENA based on (KICP, 2014; Napoli and Rioux, 2015)

1 *Geothermal resources in the region are limited and can technically be used for low-grade thermal operations like preheating the sea water fed into MED or RO desalination plants.*

In light of the above dynamics, renewable energy-based desalination options are increasingly gaining prominence across the region. Abundant domestic renewable energy resources and decreasing costs of technologies mean that renewable energy technologies offer a reliable, cost-effective and environmentally-sustainable energy source to power desalination in the long-term.

ECONOMICS OF RENEWABLE DESALINATION

The declining costs of renewable energy technologies in the GCC are creating opportunities for renewable energy based desalination at large as well as small scale. The competitiveness of renewable energy based desalination is likely to increase in the future as costs continue to decline, installed capacity increases and larger-scale renewable desalination plants are brought online.

GRID CONNECTED SYSTEMS

Desalination in the GCC is predominantly fuelled by oil (predominantly in Saudi Arabia and Kuwait) and natural gas. In general, fuel inputs for desalination do not reflect market prices. Therefore, a more accurate comparison of water production costs using different energy supply options, including renewables, should be based on market prices. Up-to-date studies assessing the economics of renewable desalination are limited in the literature, especially compared to natural gas-based desalination. Assessments have been conducted for comparing solar and oil-based desalination options in the specific case of Saudi Arabia. The combination of grid connected solar PV with RO, for instance, can be competitive with fossil fuel based desalination such as on-grid RO and MSF cogeneration at oil prices as low as USD 30 per barrel and USD 20 per barrel respectively (Figure A.3) (KICP, 2014; Napoli and Rioux, 2015). In comparison, global oil prices stood around USD 35 per barrel at the time of writing. This points to a strong economic case for grid-connected PV-RO, if opportunity costs are accounted for. These findings are generally consistent with the evidence presented in Section 3.2. which shows the electricity from large scale solar PV is competitive with oil priced at USD 20 per barrel.

As GCC countries continue to transition towards RO-based desalination and costs continue to decline, the economic case for integrating renewable energy will grow stronger. Recent developments in the GCC point to a recognition of this development. In Saudi Arabia, for instance, the King Abdulaziz City for Science and Technology (KACST) signed an agreement with the Advanced Water Technology Company (AWTC) in January 2015 for the design and construction of a solar PV water desalination plant in Khafji with a production capacity of 60,000 cubic metres per day. This is a first phase of an ambitious plan to displace fossil fuels in desalination plants. KACST forsees that 70% of the production of desalinated water can be powered with renewable energy by 2030, increasing to 80% by mid-century. One of the main objectives of this initiative is to desalinate seawater at a cost lower than 1.5 Saudi riyals per cubic metre (USD 0.40/m^3) compared to current costs that range from SR2.5 to SR5.5 / m^3 (USD 0.67 to USD 1.50/m^3) (KACST, 2015). In the Emirate of Ras Al Khaimah in the UAE, construction is expected to start soon on an RO plant powered by a 22 MW PV plant, which will supply 80,000 m^3/day of drinking water. The emirate will rely on the experience gained from a 68,130 m^3/day reverse osmosis plant in Ghallilah, which opened earlier in 2015.

OFF-GRID SYSTEMS

Renewable energy-based desalination can also offer solutions that are cost competitive with diesel-based water production in off-grid and remote areas, if the opportunity costs of diesel are accounted for. Esti-mates indicate that for 24-hour operation, PV-diesel hybrids are more cost effective (USD 2.0/m^3) than systems powered entirely by diesel (USD 2.2/m^3). This assumes an unsubsidised diesel price of USD 0.70/li-tre and LCOE from solar PV at 9 cents/kwh. To put these numbers in context, diesel in Saudi Arabia was priced at USD 0.07/litre, at USD 0.50/litre in the UAE and above USD 1.0/litre in most European countries in December 2015 (Fuel Prices Europe, 2015).

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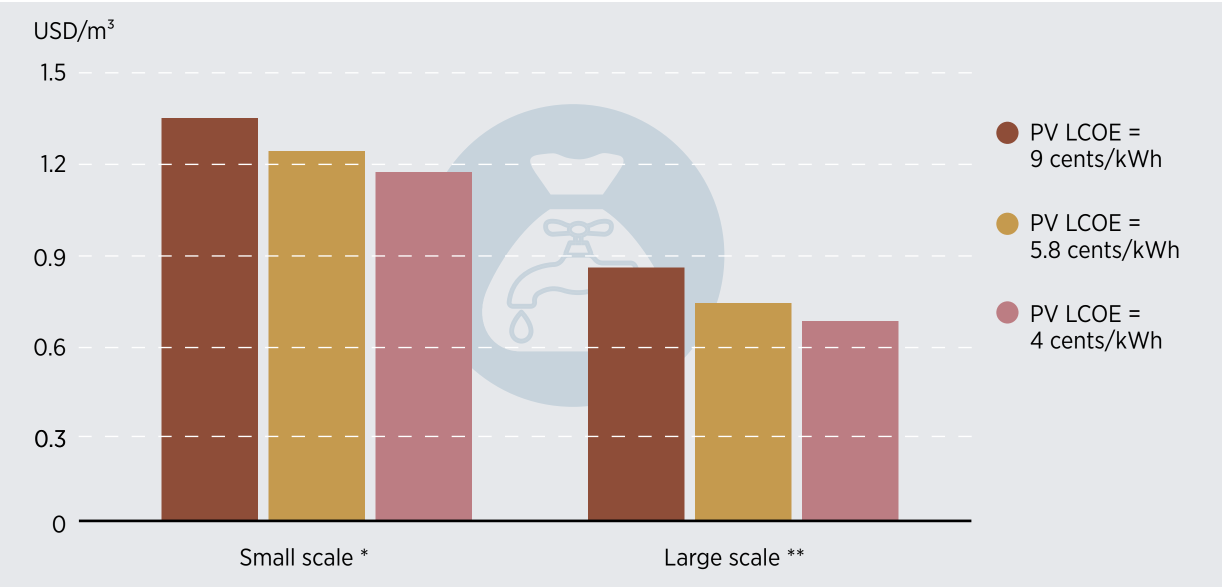
Therefore, at current diesel prices, a purely market-driven adoption of solar desalination options is unlikely in the region. However, current market dynamics are likely to change as public utilities look to renewable energy supply options for off-grid desalination and as several countries in the region are considering reforming energy pricing. If the opportunity cost of exporting diesel at prices greater than USD 0.70/litre is factored in, even in the current low oil price environment, hybrid solar PV-based desalination in remote areas is an economically attractive option for GCC countries. Oman, for instance, has a substantial capacity of small-scale desalination plants many of which are not connected to the main grid and, therefore, have to rely on diesel. In these conditions, renewable energy options, such as solar and wind, can offer a competitive alternative or substitution for diesel.

FUTURE OUTLOOK FOR COSTS

While comparisons based on current technology costs already show a viable economic case for renewable energy-based desalination in various applications, both technological improvements (both in renewable energy and desalination) and development of larger projects offer promising potential for further cost reductions. The impacts of maturing PV technologies and increasing desalination project sizes on water production costs are shown in Figure A.4. The impact from more cost effective solar PV technologies will be relatively small in both small and large-scale projects since power represents a small share of the RO cost structure (~30%). In the future, the development of large scale desalination units could lead to much lower water production costs due to economies of scale. However, such projects are yet to be built, since the renewable desalination industry is still at a relatively early stage of development.

Cost reductions can also be realised through continuing advancements in desalination technologies. A series of small-scale pilot projects initiated in the region, including the development of the first large-scale

Figure A.4 Levelised water production costs for grid-connected solar PV systems under various LCOE assumptions (USD/m³)



* Small scale RO capacity is 6550 m³/day ** Large scale RO capacity is 190000 m³/day

Source: Fthenakis et al. 2014

solar desalination plant in Saudi Arabia, will contribute to continuing advancements in technology design and capability development to better integrate renewable energy technologies. These pilot projects would also allow to test and enhance the overall reliability of the grid through improved demand response. Recognising this opportunity, Masdar in the UAE has been working with several industrial partners to develop more sustainable desalination technologies (Box A.3).

The strong interlinkages between the water and energy sectors in the GCC warrant a joint examination of the development pathways of those sectors moving forward. As evidenced throughout this report, a strong case exists for renewable energy when seen not just from an energy sector perspective, but also from the perspective of the water sector, which is itself undergoing a transition. This cross-sectoral approach was first analysed by IRENA in its Renewable energy in the water, energy and food nexus report (IRENA, 2015e) to inform decision making on renewable energy across sectors. Available evidence presented in this report points to a potentially substantial role for renewable energy in powering desalination in the region. Looking ahead, empirical, country-specific studies will be important to accurately assess the competitiveness of renewable energy-based desalination options.

Box A.2 Development of more energy efficient desalination technologies: The case of Masdar

In Abu Dhabi, the Masdar Institute of Science and Technology, began exploring options to research renewable-powered desalination in 2013. The organisation has selected four companies (i.e., Abengoa, Degrémont, Veolia and Trevi Systems) to build pilot (capacity 1500 m^3/d) solar-powered desalination stations in Ghantoot, UAE. Although it was not a condition of the solicitation of interest, the four selected companies are pursuing membrane desalination technologies (GWI, 2015), indicating that such technologies are the most promising for further reducing the cost of fresh water production. The results from the evaluation of the four projects are expected to be announced in mid-2017. The projects from Abengoa, Suez and Sidem/Veolia aim to desalinate water using less than 3.6 kWh per m^3 whereas the project by Trevi will aim for 3.1 kwh per m^3 – average RO in the region currently consumes 5 kWh per m^3 of water production.

Source: Masdar news, 2015; Desalination.biz, 2015

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ANNEX 1: MODEL ASSUMPTIONS

The benefits of renewable energy targets for the GCC are determined by calculating the difference between a Business as Usual (BAU) scenario and a renewable energy scenario.

- The BAU includes the plans by the GCC governments for nuclear energy (in Saudi Arabia and the UAE), but excludes renewable energy targets.
- The renewable energy scenario adds the renewable energy targets of GCC governments to the BAU scenario.

The electricity demand is calculated using projections for growth (Table 2). The renewable energy capacities for the year 2030 are based on the plans set by the governments. Where such national level plans are not available for 2030, assumptions have been made.

In United Arab Emirates, for instance, numbers reported in literature have been used (Masdar Institute, the Ministry of Foreign Affairs and IRENA, 2015). Similar assumptions have also been made for Bahrain and Oman.

The targets for renewable energy deployment are technology specific in some countries such as Kuwait and Saudi Arabia. For the UAE, a breakdown suggested by literature has been used (Masdar Institute, the Ministry of Foreign Affairs and IRENA, 2015). For other countries, assumptions have been made (Table 3). The generation from renewable energy is estimated based on the capacity factors shown in Table 4. It is assumed that renewable energy generation displaces fossil fuel based electricity generation.

Table 1 Renewable energy capacity by country in 2030

		Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	United Arab Emirates
Capacity (GW)	2030	0.7	10.9	2.4	1.8	29.3	33.3

Table 2 Demand projections by year and by country

		Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	United Arab Emirates
Growth Rate (used for projections of demand)	2016-2020	6.0%	7.0%	9.0%	6.0%	6.5%	6.5%
	2021-2025	4.0%	6.0%	7.0%	4.0%	4.5%	5.0%
	2026-2030	3.0%	4.5%	6.0%	3.0%	3.0%	4.0%

Table 3 Renewable energy targets by country and by technology

		Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	United Arab Emirates
% by technology of RE Target	CSP	10%	52.0%	20%	50%	47%	15%
	PV	74%	42.0%	45%	50%	27%	57%
	BIPV	10%	0.0%	23%	0%	3%	24%
	Wind	3%	6.0%	10%	0%	17%	2%
	W2E	3%	0.0%	2%	0%	6%	2%

Table 4 Capacity factors			
Technology	Capacity Factor (2010)	Capacity Factor (2020)	Capacity Factor (2030)
CSP	22%	35%	45%
PV	22%	22%	22%
BIPV	20%	20%	20%
Wind	24%	24%	24%
W2E	80%	80%	80%
Nuclear	80%	80%	80%

Renewable energy employment is calculated in the following three segments of the value chain: construction and installation, operation and maintenance and manufacturing using employment factor approach used by Rutovitz and Harris (2012). In order to calculate jobs in manufacturing, share of locally manufactured equipment has been assumed (Table 5).

Table 5 Share of equipment that is locally manufactured					
	2010	2015	2020	2025	2030
Bahrain	0%	0%	2%	5%	7%
Kuwait	0%	0%	5%	10%	13%
Oman	0%	0%	2%	5%	7%
Qatar	0%	0%	7%	15%	20%
Saudi Arabia	0%	5%	10%	25%	40%
United Arab Emirates	0%	5%	10%	15%	25%

ANNEX 2: OIL AND GAS RESERVES AND PRODUCTION

Table 6 GCC crude oil reserves and production, 2014

Countries	Crude Oil* Proved Reserves (Billion Barrels)	Share of proven world reserves (%)	Production of Crude Oil (Thousand Barrels per Day)	Share of global production (%)	R/P ratio (years)	Share of exports out of production (%) **
Bahrain	0.1	0%	49.5	0%	7.0	0%
Kuwait	104.0	6%	2618.6	3%	109.0	69%
Oman	5.0	0%	943.5	1%	14.0	77%
Qatar	25.2			2%	1540.4	2%
Saudi Arabia	268.4	16%	9735.3	13%	75.0	78%
United Arab Emirates	97.8	6%	2820.0	4%	95.0	87%
GCC Total	**500.5**	**30%**	**17707.3**	**23%**	**57.5**	**65%**
World	1655.6	100%	77832.8	100%	58.0	58%

* Crude oil and lease condensate, excluding NGLs and other liquids ** Latest year of data available 2012. *Source: EIA*

Table 7 Natural gas reserves and production, 2013/2014 (*)

Countries	Proved Reserves of Natural Gas (tcf)	Share of proven world reserves (%)	Dry Natural Gas Production (Billion Cubic Feet)	Share of global production (%)	R/P ratio (years)	Share of exports out of production (%)
	2014	2014	2013	2013	2014	2013
Bahrain	3	0%	554	1%	6	0%
Kuwait	64	1%	576	1%	110	0%
Oman	18	0%	1,127	1%	27	36%
Qatar	885	13%	5,598	5%	159	79%
Saudi Arabia	291	4%	3,526	3%	82	0%
United Arab Emirates	215	3%	1,928	2%	112	14%
GCC Total	**1,476**	**21%**	**15,323**	**11%**	**83**	**21%**
World	6,973	100%	121,283	100%	56	32%

*Data for Dry Natural Gas *Source: EIA*

ANNEX 3: SURVEY & INTERVIEWS

SURVEY

Over the course of two months IRENA and EY conducted an in-depth e-survey that captured the regional perception towards renewable energy in the Gulf Cooperation Council (GCC). A total of 243 regional professionals, across the 6 GCC countries and multiple industries and sectors completed the survey. The survey responses provide unique insights into the opinions that shape this rapidly developing market.

The survey covered various thematic areas including:

1. Government commitment, vision and targets
2. Technology landscape
3. Strategic drivers for renewable energy deployment
4. Market drivers for renewable energy deployment
5. Renewable energy investment & financing
6. Project development
7. R&D and human capital

To reach a wide regional survey audience, respondents were targeted through the networks of IRENA, EY, CEBC and MESIA. To ensure data integrity, respondents were invited to take part in the survey based on their exposure to the renewable energy market in the region, coupled with experience level. The average respondent possessed 15 to 20 years of professional experience. Furthermore, the minimum sample size required per country was calculated to ensure country level results are statistically significant. For this reason, Bahrain was excluded from country level analysis, due to the number of survey respondents falling below the minimum required sample size.

The outcomes of the survey have been included as survey boxes in the *Renewable Energy Market Analysis: The GCC Region.*

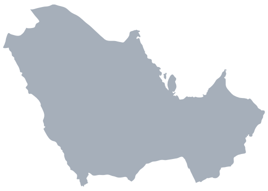
INTERVIEWS

In conjunction with the regional renewable energy market survey, IRENA and EY conducted regional interviews with various senior representatives from industry, government and academia. Interviewees were selected to ensure that they collectively provide a comprehensive overview of the renewable energy issues in the region.

An interview questionnaire was developed, which covered both broad and sector specific questions. The questionnaire was customized according to each interviewee, covering in total: technical obstacles to renewable energy deployment; renewable energy financing; renewable energy policies and regulatory outlook; local renewable energy competency and human capital; renewable energy competitiveness, energy prices and price distortions; and the role of renewable energy in desalination and water treatment.

The outcome of the interviews was specific expert insights, adding greater depth and breadth to the findings of the report. Some of these insights have been included as quotes in the report.

International Renewable Energy Agency



RENEWABLE ENERGY MARKET ANALYSIS

THE GCC REGION

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