آفاق الطاقة في دولة الكويت
Kuwait Energy Outlook

2019

Kuwait Energy Outlook

Sustaining Prosperity Through Strategic Energy Management

Energy Building and Research Center
Kuwait Institute for Scientific Research

آفاق الطاقة في دولة الكويت
Kuwait Energy Outlook

2019

Kuwait Energy Outlook

Sustaining Prosperity Through Strategic Energy Management

كويت جديدة
NEWKUWAIT

KISR
معهد الكويت للأبحاث العلمية
KUWAIT INSTITUTE FOR SCIENTIFIC RESEARCH

UNDP

الأمانة العامة
المجلس الأعلى للتخطيط والتنمية
General Secretariat of the Supreme Council for Planning and Development

Foreword

Kuwait Institute for Scientific Research (KISR) recently celebrated its 50th anniversary of scientific achievements. KISR has taken the lead in putting forward practical, sustainable roadmaps for various sectors in Kuwait, including the energy sector. Since the early 1970s, it pioneered the knowledge and technology transfer of energy efficiency and renewable energy technologies in the Gulf region. KISR continues to develop and enhance energy system technologies and associated best practices through scientific research to address domestic and global challenges.

In the Transformation Project in its 7th Strategic Plan, KISR established the Energy and Building Research Center (EBRC). The Center is comprised of five research programs, three of which are dedicated to supporting and facilitating the transition to a sustainable energy system in Kuwait. KISR is proud to be one of the primary actors in developing the country's energy policy strategy that was adopted by the Council of Ministers and the General Secretariat of the Supreme Council for Planning and Development (GSSCPD).

KISR, GSSCPD and United Nation Development Programme (UNDP) are pleased to present this first annual issue of the Kuwait Energy Outlook (KEO), which will serve as the essential foundation for addressing developments in Kuwait's energy sector in decades to come. We examine the energy sector in Kuwait today, from the upstream supply sector, to mid-stream conversion systems, to downstream demand. This KEO also provides an outlook for energy demand and supply to 2035 and the associated implications. Combined with enhanced coordination between energy stakeholders in Kuwait, it is our hope that the KEO will be a valuable tool for decision makers in their analysis and development of robust and cost-effective energy policies and plans.

Samira A.S. Omar
Director General
Kuwait Institute for Scientific Research

The General Secretariat of the Supreme Council for Planning and Development (GSSCPD) is Kuwait planning organization responsible for policymaking and strategic mapping necessary to achieve Kuwait Vision 2035; building a sustainable prosperous nation. Its main role is to oversee the Kuwait National Development Plan and to support individual and institutional capacities that positively reflect on Kuwait global competitiveness positioning in all sectors including energy and its economics.

The energy sector plays a vital role in Kuwait's economy, society and environment. Being aware of the impact of the dynamic nature of the global energy system on the country's social and economic wellbeing, the GSSCPD endorses the National Energy Policy, which streamlines with several national development plan initiatives, including energy production diversification and rationalization with more renewable energy contribution of 15% in the country's overall electricity mix by 2030. The objective of these initiatives is multidimensional. On one side it aims to divert the demand on locally produced hydrocarbons from domestic consumption to value products demanded by the international markets. On the other side it aims to create new economic sectors involving alternative and renewable energy technologies.

Achieving the national development plan targets requires efficient engagement and effective coordination among the national partners and stakeholders in the energy sector as well as other relevant sectors. One way to manage the energy stakeholders is through the establishment of a platform that periodically assesses all domestics and global status quo of the energy concerns, analyzes potential future scenarios, and provides policy implications and recommendations involving technology, economics, environment and geopolitics. The platform came in the form of *Kuwait Energy Outlook*, an energy policy platform supporting efficient coordination between the energy sector stakeholders that assures coordination and robust development among them to realize the country's domestics and international responsibilities operated and managed by national capacities.

GSSCPD is proud to launch Kuwait Energy Outlook (KEO) in collaboration with its government partner the Kuwait Institute for Scientific Research (KISR) and its strategic international partner the United Nations Development Programme (UNDP).

Khaled Mahdi
Secretary General
General Secretariat of the Supreme Council
for Planning and Development

Acknowledgements

This report was prepared by the Energy Policy Team of the Energy Efficiency Technology (EET) Program in the Energy and Building Research Center at Kuwait Institute for Scientific Research, in cooperation with the United Nations Development Programme of Kuwait. The work was directed by **Yousef Mohammad Al-Abdullah**, Associate Research Scientist in the EET Program, and supervised by **Fotouh Al-Ragom**, Program Manager of the EET Program, and **Osamah Al-Sayegh**, Executive Director of the Energy and Building Research Center. **Sreekanth K.J.**, Associate Research Scientist in the EET Program, was a key contributor. **Teresa Malyshev** was the lead author of the report. **Charlie Heaps** from Stockholm Environment Institute US designed the Kuwait Energy Model using the Long-range Energy Alternatives Planning software. **Ugur Ocal** of Ocal Energy Consulting designed the graphics for the report. **Mohamed Nassar** was the project coordinator from the UNDP.

Special thanks go to **Khaled Mahdi**, Secretary-General of the General Secretariat of the Supreme Council for Planning and Development, for his commissioning and sponsorship of this work.

The editorial committee of the **Kuwait Energy Outlook** provided valuable insights and feedback. **Samira A.S. Omar**, Director General of Kuwait Institute for Scientific Research, chaired the committee, and **Khaled Mahdi** was the Vice Chair. Other members included: **Salem Al-Hajraf**, Deputy Director General, Kuwait Foundation for the Advancement of Sciences; **Abdullah Ahmad Al-Hamoud Al-Sabah**, Director General, Environment Public Authority; **Talal Naser Al-Athbi Al-Sabah**, Undersecretary, Ministry of Oil; **Mutlaq Mubarak Al-Sanei**, General Manager, Kuwait Authority for Partnership Projects; **Wafaa Al-Zaabi**, Managing Director for Planning and Finance, Kuwait Petroleum Corporation; **Mohamed Hajji Boushehri**, Undersecretary, Ministry of Electricity and Water.

Many KISR research associates, including Fatma Al-Alawi, Eissa Al-Nasrallah, Mahdi Al-Saffar, Ali Al-Yakoob, Ahmed Ben-Nakhi, Sarah Al-Kandari, Mohammad Al-Jassam, Sarah Alosaimi and Aisha Ismael, assisted in the production of this report.

This study benefitted from substantial support provided by officials in many government institutions and ministries, including Kuwait Petroleum Corporation, Kuwait National Petroleum Company, Kuwait Oil Company, Ministry of Oil, Ministry of Electricity and Water, Ministry of Public Works, Public Authority for Roads and Transport, Public Authority for Housing and Welfare, Ministry of Interior and Ministry of Communications. In particular, we are grateful for the valuable contributions from: Abdulaziz AlDhafeeri, Planning Division – PAHW; Noura Al-Mutawa, Strategic Planning Department – KPC; Jenan Al-Gharabally, Strategic Planning Department – KPC; Shaima Al-Ghunaim, Deputy Managing Director, Planning and Finance Department – KPC; Khaled Albatini, Statistical Department – MEW; Faisal Alshammri, Mustafa Dashti and Sana Al-Ghreeb, Engineering Management Program – MEW; Ghannam Al Ajmi and Ahmed Al-Azmi, Private Sector Partnership Department – MEW; Farhan Alzubair, Public Authority for Agriculture and Fisheries; Hani Al-Mawash and Mohammad Amin, Port Authority Headquarters – Ministry of Communications; Mohammed Al-Kandari, Environmental Department – Ministry of Interior; and Nasser Al-Kazemi, Public Authority for Roads and Transport.

This report could not have been completed without collaboration from the International Energy Agency (IEA) and, notably, the guidance from Tim Gould and his colleagues on the World Energy Outlook team. The projections in this *Outlook* were based on energy balances provided by the IEA.

The individuals and organizations that contributed to this study are not responsible for any opinions or judgments contained herein. All errors and omissions are solely the responsibility of the Kuwait Institute of Scientific Research.

Table of Contents

List of Figures

List of Tables

Executive Summary

Kuwait is one of the world's top ten oil producers and holds the sixth largest proven oil reserves in the world. With its relatively small population, Kuwait has a very prosperous economy, but it is heavily dependent on oil-export revenues. The oil sector accounts for about 90% of export revenues, and net oil-export revenues are approximately 40% of GDP. Kuwait, like all oil-producing countries, is facing a changing energy world today. Shifting supply, demand and technology trends have ushered in an energy world where oil-price volatility and market uncertainty are the defining features. To ensure economic development and social prosperity in the years to come, Kuwait will require a new energy strategy, combined with a plan to foster economic diversification and reduce fossil fuel dependency.

Now is a particularly good time for an evaluation of Kuwait's current energy situation and how energy demand and supply might, and could, evolve over the next two decades. With valuable support from the General Secretariat of the Supreme Council for Planning and Development, Kuwait is releasing its first ever economy-wide, in-depth energy analysis and predictions. In the Business-as-Usual Case presented here, only current policies and plans are considered to have an impact on the projections. Under these assumptions, per capita greenhouse-gas emissions and energy demand per capita remain among the highest in the world, and carbon intensity of the economy is still persistently high. Viable options for public transport considerably lag behind other countries, and growth in renewable energy remains stymied by institutional and regulatory challenges. The final chapter of this report suggests a more sustainable path forward, but it will take a committed effort on the part of the government to come to fruition.

Today, Kuwait relies almost exclusively on oil products and natural gas to meet its energy needs, with each fuel accounting for about a half of total primary energy consumption. But while Kuwait is a major oil exporter, it is a net importer of liquefied natural gas, due to underdevelopment of its gas reserves. Kuwait plans to substitute natural gas for oil in the power generation sector in order to retain oil-export revenues for savings and investment. Government plans also encompass increasing the share of renewable energy in the power generation mix. Expanding natural gas and renewable energy use domestically are part of the government's plan to address the impacts from climate change. Renewable energy, however, satisfies less than 1% of energy demand today.

Consumption of oil products, electricity and water are all heavily subsidized in Kuwait. Due to lax energy efficiency regulations and codes in the past and its hot climate, demand for air-conditioning services in Kuwait accounts for some 70% of residential electricity demand. In addition, the share of personal passenger cars in the overall transport mix is quite substantial, about 80% in 2017. Motor gasoline and diesel prices are the lowest in the world. Vast potential exists for improvements in energy efficiency in both the buildings and transport sectors through actionable national energy efficiency plans, incentive/rebate programs and subsidy reduction.

In the Business-as-Usual Case, crude oil production in Kuwait is projected to be 3.5 million barrels per day in 2035, based on the country's plans to increase production capacity to 4 mb/d in the next decade. Like all producing countries, Kuwait will face increasing competition for its exports from unconventional oil supplies. The world's thirst for crude oil will also likely slowdown over the projection period, due to concerns over climate change impacts from burning fossil fuels and breakthroughs in cleaner and more cost-effective energy options. Natural gas production grows from 17.4 billion cubic meters in 2017 to 27.3 bcm in 2035. Domestic supply, however, will likely be unable to meet the expected increase in demand, and liquefied natural gas imports are expected to continue to be an important source of natural gas supply over the *Outlook* period.

In the period to 2035, energy demand in Kuwait is projected to increase by a third in the Business-as-Usual Case, growing at a much slower pace than over the past couple of decades, due to decelerating GDP and population growth. The share of oil in total primary energy demand steadily declines, to just over 40% in 2035, a result of the government's push to switch from oil to natural gas and solar energy for power generation. Natural gas demand is expected to grow at a fast clip, by 2.2% per year in 2015-2035. Despite some progress in adding renewables to the generation mix over the projection period, their share in total primary energy demand remains low in 2035, only 3% in the Business-as-Usual Case.

Kuwait faced recurring brownouts and blackouts throughout the 2010s, with reserve margins falling to alarmingly low levels. The Ministry of Electricity and Water is seeking to avoid these shortfalls in the future and plans to add 17.6 gigawatts of electricity generation capacity over the *Outlook* period. Total generating capacity is expected to be 32 GW in 2035, a 70% increase over capacity in 2018. Combined-cycle plants make up the lion's share of capacity expansions over the projection period, resulting in a more efficient and flexible fleet of power plants compared to today. These plants will use both oil and gas for generation, but Kuwait will favor the use of natural gas in combined-cycle and steam plants, and the share of oil products in total generation is likely to fall to about a quarter by 2035 in the Business-as-Usual Case. Renewable-energy capacity, mostly solar, will make up 16% of total generation capacity in 2035.

Keeping pace with rising demand for electricity will be critical to Kuwait's economic development, and reforms, such as opening up the power generation sector to independent power producers and independent water and power producers, are key to increasing the currently low share of private company involvement in the sector. Kuwait has several government institutions participating at varying levels in the power sector, all with different mandates. The Ministry of Electricity and Water oversees all aspects of generation, transmission and distribution of electricity. Kuwait Authority for Partnership Projects is tasked with negotiating power purchase agreements for independent water and power producers, and it negotiated the first such project in Kuwait, Az Zour North power station, on behalf of the government. Kuwait Foundation for the Advancement of Sciences sponsors distributed-photovoltaic projects, and the design and implementation of the first phase at the Shagaya renewable energy complex was overseen by Kuwait Institute for Scientific Research. Rigidities in the electricity sector's structure and the lack of coordination between the various institutions participating in the power sector are the main reasons for the lack of private sector involvement and the slow development and deployment of renewable energy technologies.

Kuwait uses desalinated water to meet about 90% of its water consumption. Despite its relatively small population, it produces the third greatest amount of desalinated water in Gulf Cooperation Countries, after Saudi Arabia and the United Arab Emirates. Multi-stage flash desalination technology dominates the water production sector but its share is expected to fall to less than 40% by 2035 in the Business-as-Usual Case. The more efficient and cost-effective multi-effect desalination technology will make considerable inroads, with its share in total desalination production accounting for nearly half by the end of the projection period. Despite being the preferred technology in most of the world, reverse osmosis is projected to account for only 13% of total production capacity in 2035 in Kuwait.

Improving energy efficiency in the buildings sector in Kuwait will require a clear long-term government commitment, combined with well-designed packages of efficiency policies reinforced by adequate capacity for implementation and sufficient enforcement. The energy conservation code put in force in 1983 in Kuwait lacked effective monitoring, verification and enforcement. The 1983 code was not revised for 27 years, and the buildings sector is a major source of inefficient energy consumption, with a very large stock of energy-inefficient buildings. Nearly three decades later, a revised version of the code was developed with more stringent requirements for energy efficiency measures in new buildings. This 2010 energy conservation code was again updated in 2014 with even more rigorous standards for the minimum requirements for energy-efficient design of new buildings in Kuwait. A 2017 code for government and commercial buildings, which sets minimum requirements in terms of power densities, material properties and the use of efficient air-conditioning systems, is under final approval.

Stricter enforcement of regulations and codes in the buildings sector are expected to play a major role in the significant deceleration in energy demand growth in the residential sector over the projection period. A slowdown in population and economic growth will also contribute. In the Business-as-Usual Case, residential electricity demand grows by 1.2% per year over the *Outlook* period, considerably slower than average annual growth of 5% in 2000-2015. Growth in energy demand for space cooling and heating, which will account for about 70% of total residential energy consumption, will be driven, in large part, by increases in the average annual temperature, estimated to be nearly 0.1° Celsius per year over the projection period. Kuwait has plans to construct 128,000 new houses over the *Outlook* period, all subject to the more rigorous standards of the recent energy conservation codes and regulations. Three government entities will be responsible for enforcing the building codes.

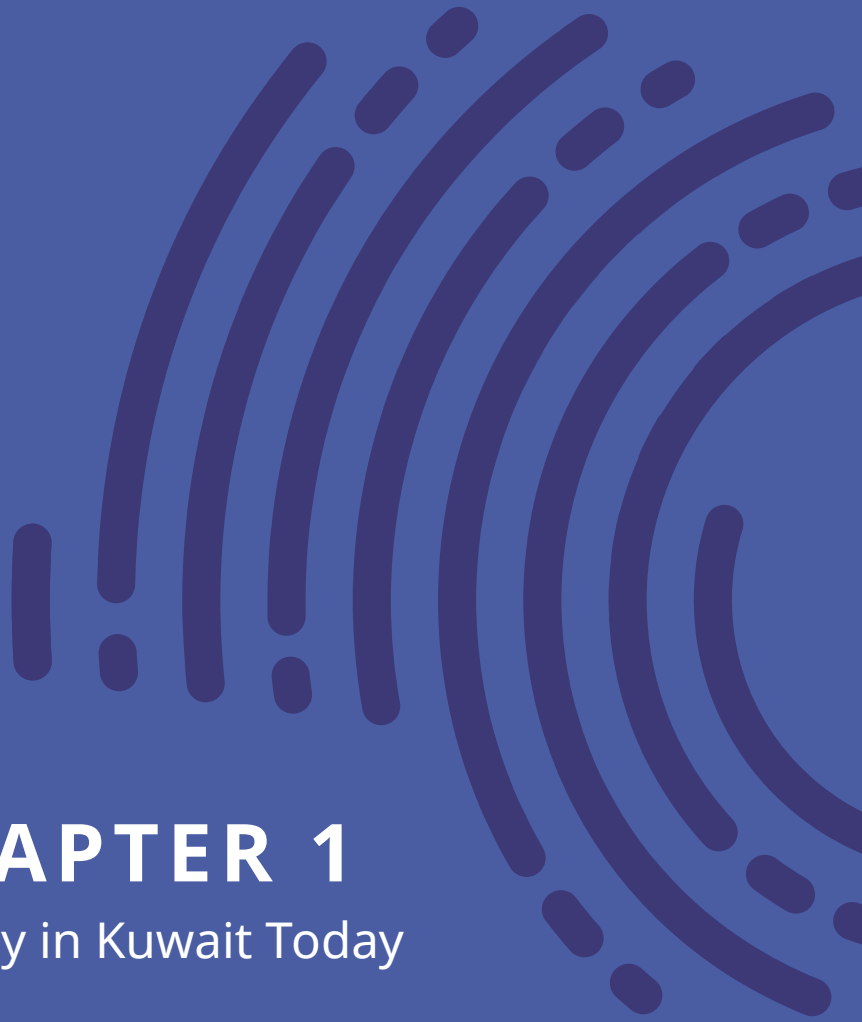
In the Business-as-Usual Case, oil demand in the transport sector grows by 3% per year, much faster than the growth rate worldwide. In most countries, the introduction of fuel efficiency standards for passenger vehicles has been the most effective way of cutting oil consumption in the transport sector. Providing citizens with a modern, efficient, mass public transportation system, including metro lines, trams and buses, have also proven to be a very successful way to better manage growth in demand for transport. But, in Kuwait, there are very few incentives to switch from current modal transport choices. Motor gasoline and diesel prices are low, and plans to build a metro have been stalled. The transport sector is projected to account for nearly a third of total final energy consumption in 2035 and for all of the increase in greenhouse-gas emissions from oil and oil product use.

Greenhouse-gas emissions increase from 83 million tonnes of CO_2-equivalent in 2015 to 103.4 Mt of CO_2-eq in 2035 - at an annual rate of 1.1% - twice the global average. Greenhouse gas emissions in Kuwait increased at a much more rapid clip in 2005-2015, due to a construction boom, high oil prices and heavy reliance on oil for power generation. The projected slowdown over the next couple of decades reflects the government efforts to decarbonize the economy by expanding the role of natural gas and renewables in the energy mix. In 2015, CO_2 emissions per capita were 21.1 tonnes of CO_2 per capita, among the highest in the world. Per capita emissions inch down over the projection period to about 20 tonnes of CO_2 per capita in 2035, in the Business-as-Usual Case, moving in the right direction, but clearly more work needs to be done.

Kuwait released the *White Paper on a Sustainable National Energy Strategy* in 2017, which recommended the establishment of a national champion to implement the strategy and coordinate its multiple dimensions. In those countries where a national champion was established over the past few decades, the most successful champions were those who were given the necessary power to carry out their tasks. In a promising first step, the Kuwait Council of Ministers set up the Higher Energy Committee in 2018 to improve coordination between ministries, regulatory agencies and infrastructure operators and service providers. The Committee also is tasked with strengthening Kuwait's participation in international decision-making forums and enhancing coordination between central, regional and local government agencies and stakeholders. As in other countries, successful implementation of the national energy strategy will require the separation of policy-making institutions from regulatory institutions, combined with a clear demarcation of their remit and procedures for improving coordination.

Price reform and energy efficiency offer major opportunities to rationalize consumption and encourage more diversified growth, without foregoing the economic opportunities to capitalize on abundant energy resources. The pace of energy subsidy removal in Kuwait has been slow compared to some other resource-rich countries. Energy efficiency measures offer the least-cost pathway to energy and greenhouse gas emission reductions and to an increase in energy supply security. The effectiveness of energy efficiency measures and price adjustments should be underpinned with measurable targets and objectives, which could be selected and monitored by the Higher Energy Committee.

Reliable data and robust projections will serve as the essential foundation for Kuwait's policy choices as it prepares for a more sustainable energy future. There is a pressing need to improve data collection efforts in Kuwait. This could be facilitated through more coordination and collaboration between energy players within Kuwait and improving the institutional capacity for data collection. The lack of collaboration and expertise contribute to long delays in receiving feedback and data from energy entities. The paucity of energy statistics was challenging for the production of this energy outlook. Addressing these challenges will certainly improve future energy outlooks and their capacity to guide meaningful reform of Kuwait's energy sector.



CHAPTER 1

Energy in Kuwait Today

Highlights

- Seated on vast resources of crude oil, Kuwait has a prosperous economy. The oil sector accounts for about 90% of export revenues, and net oil-export revenues in Kuwait are some 40% of GDP. Due to its small population, per capita net oil-export revenues in Kuwait amounted to $11,303 per capita in 2017. Recent declines in oil prices have strained the government's ability to provide cheap energy and water to its citizens.

- Kuwait relies almost exclusively on oil products and natural gas for electricity generation and its substantial desalination production. Each fuel currently accounts for about a half of total energy consumption in the economy. The country plans to increase the share of natural gas-fired power plants in the future, but, as gas production is underdeveloped, it is currently a net importer of liquefied natural gas. Renewable energy accounts for less than 1% of energy demand today.

- Per capita energy consumption in Kuwait is among the highest in the world. Due to lax energy efficiency regulations and codes in the past, generous energy subsidies and a hot climate, electricity consumption grew, on average, by 5% per year from 2000 to 2015. Today, electricity demand for air-conditioning services in Kuwait accounts for some 70% of residential electricity demand. Consumption of electricity and oil products are heavily subsidized in Kuwait which leads to overconsumption and a misallocation of energy resources. Energy subsidies were estimated to be close to 8% of GDP in 2016.

- Kuwait had an installed generation capacity of 18.8 gigawatts in 2018. Steam generation accounted for nearly half of total capacity, with combined-cycle steam and gas plants making up another 40%. Capacity expansions were not able to keep up with rapidly increasing demand in the past, and reserve margins fell from over 30% in 2000 to 21% in 2014, causing brownouts and blackouts extending beyond the summer months. Reserve margins are expected to be 8% in 2020.

- There is enormous potential in Kuwait to increase the energy efficiency of its buildings and transport sectors. The energy conservation code put in place in 1983 in Kuwait was poorly enforced, and, as electricity demand in the residential and services sectors experienced rapid growth over the last two decades, there is a large stock of energy-inefficient buildings in Kuwait today. The transport sector is dominated by the use of private passenger vehicles, and mass public transportation is underdeveloped. Given the very low price of electricity and transport fuels in Kuwait, there is little incentive on the part of consumers to invest in energy efficiency improvements.

- Because of Kuwait's heavy reliance on fossil fuels, and inefficient use of energy due to pricing distortions, CO_2 emissions per capita were 21 tonnes of CO_2 per capita, among the highest in the world. CO_2 emissions per GDP were also high, 0.32 kilograms of CO_2 per GDP (2010$) in 2015, compared with 0.25 kilograms of CO_2 per GDP for OECD countries.

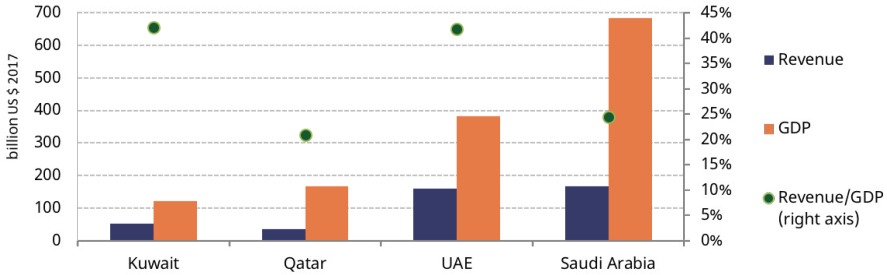
- There is a pressing need to improve data collection efforts in Kuwait. This could be facilitated through more coordination and collaboration between energy players within Kuwait and improving the institutional capacity for data collection. Continued efforts to improve the consistency and reliability of Kuwait's energy data will be essential for effective policymaking and the implementation of the energy strategy outlined in the 2017 *White Paper on a Sustainable National Energy Strategy*.

Energy Sector

Kuwait is an arid country, geographically 17,818 square kilometers in size, bordering Saudi Arabia to the south and west and Iraq to the north and west. With limited natural fresh water resources, desalination facilities provide for over 90% of Kuwait's water consumption. The population of Kuwait was 4.4 million in 2017.[1] The majority of the population occupies just 6% of the country's total landmass. Kuwaiti citizens account for 30% of the total population, but they use about two-thirds of the total amount of energy consumed in the country. Average temperatures hover in the upper 40s° Celsius during summer months. Over the past few years, these "summer" months have extended from April to October.

Seated on vast resources of crude oil, estimated to be 101.5 billion barrels in 2017, Kuwait has a prosperous economy. Gross domestic product (GDP) was $120,127 billion in 2017. The oil sector accounts for about 90% of export revenues. Net oil-export revenues in Kuwait were $46 billion in 2017, about 40% of GDP (Figure 1.1). Due to its small population, per capita net oil-export revenues in Kuwait amount to $11,303 per capita, the second highest per capita level in the Gulf Cooperation Council[2] (GCC), after Qatar.

Figure 1.1 | Net oil-export revenue relative to GDP in selected GCC countries in 2017



Note: GCC countries include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.
Source: Net oil export revenue from Organization of Oil Exporting Countries (OPEC) databases.
GDP from World Bank databases.

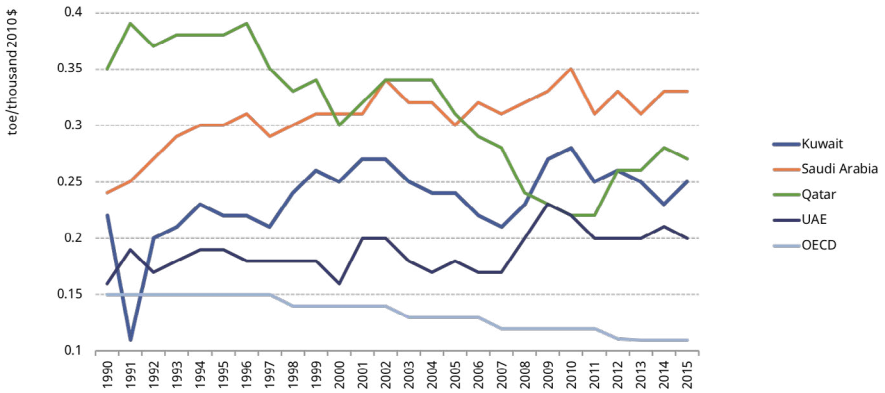
Kuwait relies almost exclusively on oil products and natural gas for electricity generation and its substantial desalination production. The country plans to increase the share of gas-fired power plants in the future, but as gas production is underdeveloped, it is currently a net importer of liquefied natural gas (LNG). Kuwait has a soft target of increasing the share of renewables in total energy demand to about 15% by 2030, up from less than 1% today. The potential for increasing the share of renewables in the electricity generation mix in Kuwait is huge, given its substantial solar and wind resources.

[1] Central Statistics Office, www.csb.gov.kw.
[2] The members of the Gulf Cooperation Council are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

Per capita energy consumption in Kuwait is among the highest in the world. Due to lax energy efficiency regulations and codes in the past and its hot climate, demand for air-conditioning services in Kuwait accounts for some 70% of residential electricity demand. In addition, the share of personal passenger cars in the overall transport mix is quite substantial, reaching 80% in 2017. Kuwait roads and highways cover 7,620 kilometers. In 2016, there were more than 2 million registered vehicles in Kuwait, and vehicle emissions contributed more than 4.7 millions tonnes of greenhouse gas emissions.[3] Other factors that contribute to large per capita energy consumption in Kuwait are the very generous subsidies for electricity and oil products. There exists vast potential for improvements in energy efficiency through actionable national energy efficiency plans, incentive/rebate programs and subsidy reduction. Energy subsidies approached 8% of GDP in 2016.[4] The government has begun tentative steps to reduce them. A new law was passed in 2016 and went into force in 2017 that raised tariffs for electricity and water consumption in all sectors except for the residential sector.

Figure 1.2 shows energy intensity in selected GCC countries and the OECD. In this figure, energy intensity measures the amount of energy needed to generate a US dollar of economic output. Energy intensity in Kuwait has fluctuated over the past two decades but the overall trend is upward. In 2015, Kuwait required over 50% more energy to generate a dollar of economic output than the OECD average. It comes as no surprise that oil-producing countries have higher energy intensities than more diversified economies, such as those in the OECD. In fact, high-energy intensity is not necessarily an unfavorable outcome for resource-rich economies - it could simply be a reflection of comparative advantage in energy-intensive industrial activities. Evidence suggests, however, that current pricing policies encourage wasteful energy consumption in ways that are damaging to the wider economy.

Figure 1.2 | Energy intensity in selected GCC countries and the OECD



Source: International Energy Agency databases.

[3] Environment Public Authority (2018).
[4] Oxford Institute for Energy Studies (2017b).

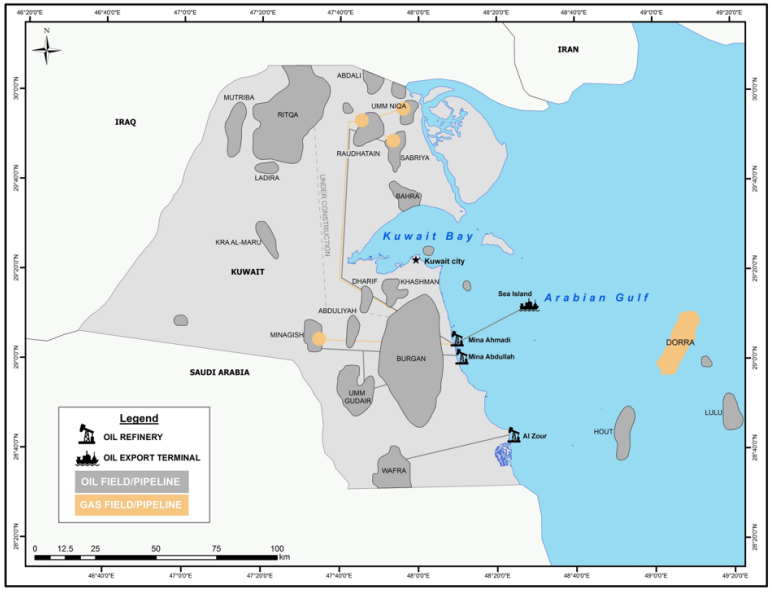
Overview of Energy Supply

Crude Oil

According to the OPEC *Annual Statistical Bulletin*, Kuwait had some 101.5 billion barrels of proven oil reserves in 2017, roughly 6% of the world total and the sixth largest among all of the world's producers. The Kuwait Petroleum Corporation estimates that Kuwait had a production-to-reserves ratio of 1% in 2017. Kuwait has two operational oil refineries, and, a third, Al Zour, is expected to come online in 2020 (Figure 1.3). Seven crude oil pipelines cover 218 miles.

The Burgan field in the south of Kuwait is considered to be the world's second-largest oil field, surpassed only by Saudi Arabia's Ghawar field. Greater Burgan's production accounts for about half of Kuwait's total production, and the field can produce as much as 1.7 million barrels per day (b/d). Kuwait Oil Company plans to boost the Greater Burgan's capacity through enhanced oil recovery methods such as injection of seawater and carbon dioxide.[5]

Figure 1.3 | Kuwait's crude oil and natural gas resources and infrastructure

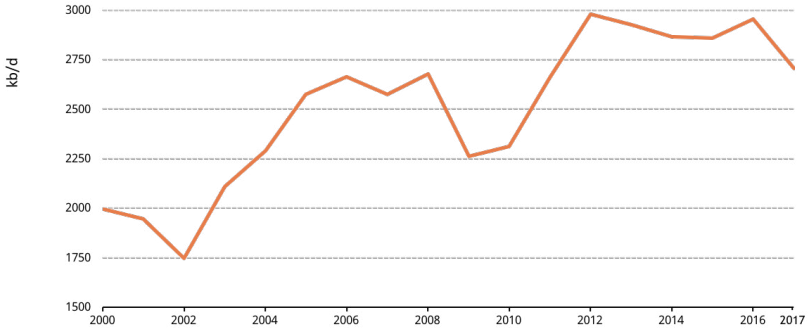


Source: Kuwait Institute of Scientific Research, Geographic Information Systems (GIS) Unit.

[5] US EIA (2016).

Kuwait produced 2.71 million barrels per day (mb/d) of crude oil in 2017, up from 1.95 mb/d in 2000 (Figure 1.4). Developments in the world economy usually have an impact on oil production levels. Figure 1.4 illustrates the impact on oil production in Kuwait following the global economic crisis of 2008-2009 that precipitated a downturn in global oil demand. For oil-exporting countries, such as Kuwait, lower oil production and prices can have a profound effect on socio-economic welfare.

Figure 1.4 | Kuwait's crude oil production



Note: Unit on vertical axis is thousand barrels per day.
Source: OPEC Annual Statistical Bulletin, 2018.

Kuwait produces a range of light to heavy crudes, which are blended into a single grade. According to the Kuwait Petroleum Corporation, production of petroleum products was 0.67 mb/d in 2017, a slight dip from production of 0.82 mb/d in 2016, due to the shutdown of Al-Shuaiba refinery in April 2017.

Currently all of Kuwait's current crude oil production comes from onshore fields. Kuwait Petroleum Corporation (KPC) plans to increase crude oil production capacity to 4 mb/d by 2020, where the additional production capacity is expected to come from technically challenging sour and heavy fields. Kuwait has accordingly awarded enhanced technical service agreements with international firms for development of heavy oil and Jurassic fields.

Three early production facilities (EPF) were brought online in 2018, which were constructed under contracts Kuwait Oil Company signed with private firms in 2016 – two went to US-based contractor Schlumberger and the third to domestic firm Spetco – to develop Kuwait's sour northern Jurassic fields. These three early production facilities will produce a combined 120,000 barrels per day (b/d) of ultra-light crude oil and more than 300 million cubic feet per day (mcf/d) of sour gas.[6] Four more Jurassic EPFs are planned to ramp up ultra-light crude oil production to 320,000 b/d and gas to more than 630 mcf/d.

[6] Ingram (2018).

Another EPF was commissioned in early 2017 for the production of about 25,000 b/d of heavy oil from the northern Um Niga field, where additional production will come from the development of the Ratqa heavy oil field. The expansion of the Ratqa field would add about 60,000 b/d by end-2019. Hence, Kuwait's total heavy crude oil production is expected to reach 85,000 b/d.

Natural Gas

With estimated natural gas reserves at end-2017 of 1.7 trillion cubic meters, Kuwait holds some 1% of the world's reserves.[7] Natural gas production was 17.4 billion cubic meters. Associated natural gas production makes up most of Kuwait's overall production at about 90% of total production, thus domestic supplies have fluctuated in tandem with liquid fuels production. Consumption of gas has been rapidly increasing, and, in 2017, reached 21.9 bcm.

Kuwait requires large supplies of natural gas to generate electricity, for water desalination and for petrochemical production, as well as for enhanced oil recovery techniques to boost oil production. The country has become increasingly reliant on LNG imports to meet domestic demand. Kuwait takes LNG deliveries at the floating storage and regasification services temporary port at Mina Al-Ahmadi, which, according to Kuwait Petroleum Corporation, has a base-load throughput capacity of 500 million standard cubic feet per day (mmscf/d) and a peak capacity of 900 mmscf/d. The facility was constructed to fill the gap between Kuwait's natural gas needs and the development of domestic gas reserves. Initially, Kuwait imported LNG to meet peak summer demand (April-October). However, since 2015, Kuwait has imported LNG cargoes from different sources through December and resumed LNG imports in February. Kuwait Petroleum Corporation plans to construct a permanent LNG import facility in the area of Al Zour, with a capacity of 3,000 billion British thermal units per day. The facility will house eight receiving tanks and import LNG year-round.

Refining and Oil Products

Kuwait's nameplate refining capacity from its two refinery complexes, Mina al-Ahmadi and Mina Abdullah, was 736,000 b/d in 2018. The refineries are located near the coast, about 30 miles south of Kuwait City and are owned and operated by Kuwait National Petroleum Company (KNPC), a subsidiary of Kuwait Petroleum Corporation (KPC). The largest refinery, Mina al-Ahmadi, was built in 1949 and has a refining capacity of 466,000 b/d. Mina Abdullah has a nameplate refining capacity of 270,000 b/d (Table 1.1). KNPC completed the planned closure of its 200,000 b/d Al-Shuaiba refinery in 2017, converting the facility to a storage terminal. The Al Zour refinery is under construction and expected to be completed by 2020, producing a nameplate capacity of 615,000 b/d.

[7] Estimates of natural gas reserves and production from BP Statistical Review of World Energy 2018.

Table 1.1 | Kuwait's refineries

	Current Capacity (b/d)	**Planned Capacity** (b/d)
Mina Al-Ahmadi	466,000	346,000
Mina Abdullah	270,000	454,000
Al Zour	0	615,000
TOTAL CAPACITY	**736,000**	**1,415,000**

Source: KPC website, Arab Oil & Gas Directory.

The Clean Fuels Project (CFP), due for start-up in 2019, aims to transform Kuwait's two refineries into a single integrated merchant-refining complex. As part of this integration project, Mina al-Ahmadi refinery will shed 120,000 b/d and the Mina al-Abdulla refinery will add 184,000 b/d. This will result in a net gain of 64,000 b/d with a total of 800,000 b/d refining capacity at the new integrated complex in 2019. The project will upgrade conversion capabilities, operational integrity, energy efficiency and safety performance. The oil products will conform to Euro-5 specifications. The upgrade will lead to a reduction in local emissions of SOx, NOx and other pollutants. According to Kuwait Petroleum Corporation, the upgrades will reduce the sulfur content in motor gasoline from 500 ppm to 10 ppm and in diesel from 5,000 ppm to 10 ppm.

KPC formed Kuwait Integrated Petroleum Industries Company (KIPIC) in late 2016 to manage refinery, petrochemicals, and LNG import operations at Al Zour in the south of the country. The $16 billion Al Zour refinery will produce low-sulphur fuel oil that will replace the high-sulphur fuel oil used in local power plants. KIPIC is charged with securing Kuwait's local demand for energy and contributing to growth of the private sector.

Crude Oil and Product Exports

Kuwait's crude oil exports are a single blend of all its crude types. Exports have an American Petroleum Institute (API) gravity of 31°, typical of medium grade Middle Eastern crude. Kuwait's main port for exporting crude oil is Mina Al-Ahmadi. Kuwait also has operational oil-export terminals at its other refineries. Kuwait consumes only a small portion of its total petroleum production, but domestic oil consumption has been steadily increasing, partially as a result of increased petroleum-fired electricity generation as average temperatures rise. According to the OPEC *Annual Statistical Bulletin*, oil demand in Kuwait rose from 230,000 b/d in 2000 to 370,000 b/d in 2016.

In 2017, Kuwaiti exported 2.01 million b/d of crude oil, up from 1.82 mb/d in 2010. Oil-product exports totaled 492,000 b/d of oil products in 2017, compared to 760,000 in 2010. Most Kuwaiti crude oil is sold on term contracts and is destined for the Asian market. The Asia-Pacific region receives approximately three-quarters of total Kuwaiti exports. South Korea receives about 21% of total exports, followed by China at 16% and Japan at 12%.[8] Kuwait exported ultra-light crude oil, with an API gravity of about 50°, for the first time in July 2018.

[8] US EIA (2016).

With most of its crude oil-export volumes headed to Asian markets, Kuwait's most significant price benchmarks for exports are average Dubai/Oman Crudes or Saudi Arab Medium. Generally, Kuwaiti oil exports are priced at a slight discount.

Oil Sector

Kuwait took over ownership of its oil industry in the late 1970s. The government of Kuwait owns and controls all development of the oil sector. The Prime Minister heads the Supreme Petroleum Council (SPC), which oversees Kuwait's oil sector and sets oil policy. The other members of the council (six ministers and six representatives from the private sector) all serve three-year terms, and are selected by the Emir. The Ministry of Oil supervises all aspects of policy implementation in the upstream and downstream sectors.

Kuwait Petroleum Corporation (KPC) was formed in January 1980 to establish an integrated oil industry in Kuwait. The new structure allowed central planning of the industry, more effective and efficient distribution of work and coordination between various bodies, and enhanced engineering economies of scale. The KPC subsidiaries responsible for exploration and production are Kuwait Oil Company (KOC), Kuwait Gulf Oil Company (KGOC) and Kuwait Foreign Petroleum Exploration Company (KUFPEC).

Kuwait Oil Company manages all upstream development in the oil and natural gas sectors. KOC is also involved in the storage of crude oil and delivery to tankers for export. Kuwait Gulf Oil Company partners with representatives of Saudi Arabia Aramco Gulf Operations Company, Ltd., at Khafji and Saudi Arabian Chevron, Inc., at Wafra. The Kuwait Foreign Petroleum Exploration Company handles foreign interests of KPC, including its foreign upstream oil and gas activities in 13 countries, with a portfolio comprising 47 assets. Headquartered in Kuwait, KUFPEC has nine regional offices in Canada, Norway, Netherlands, Egypt, Pakistan, Malaysia, Indonesia, China and Australia.

Kuwait National Petroleum Company (KNPC) and Kuwait Integrated Petroleum Industries Company (KIPIC) control the refining operation of the downstream sector. In addition, KNPC owns and operates domestic petrol stations. Two private companies also own petrol stations. Kuwait Petroleum International (KPI), a subsidiary of Kuwait Petroleum Corporation, manages international refining and marketing operations. KPI has a 50-50 joint venture with Italian oil major ENI in the 220,000 b/d capacity refinery in Milazzo, Italy. In addition, KPI is part of a joint venture with Vietnam Oil and Gas Group, Idemitsu and Mitsui Chemical in the Nghi Son Refinery and Petrochemical Complex. KPI's operations include more than 4,400 retail stations across Belgium, Spain, Sweden, Luxembourg and Italy. KPI markets approximately 390,000 barrels of products per day in Western Europe through retail stations. Petrochemical Industries Company (PIC) oversees the petrochemical sector, both domestically and internationally.

Kuwait Oil Tanker Company (KOTC) owns the country's 10 crude oil tankers, in addition to other vessels for LPG and barges for bunker fuel oil. KPC-International Marketing oversees contracts with third parties for crude and petroleum product exports and LNG imports.

Overview of Energy Demand

Demand by Fuel and End-Use

Total primary energy demand in Kuwait grew by an average annual rate of 4.3% from 2000 to 2015, reaching 34.9 million tonnes of oil equivalent (Mtoe) in 2015 and nearly doubling demand of 18.7 Mtoe in 2000.[9] Kuwait is almost solely reliant on oil and gas to meet its energy needs. Oil demand dominated total energy demand in the 1990s and early 2000s, but natural gas has made recent inroads. The share of natural gas in Kuwait's energy mix increased from 40% in 2005 to 48% in 2015. The majority of domestic natural gas consumption is for electricity and water desalination, and it is the preferred fuel in the government's attempt to reduce the impacts of climate change.

Per capita energy consumption in Kuwait is among the highest in the world. In 2015, per capita energy consumption was 8.9 tonnes of oil equivalent per capita (toe/capita), compared with 4.1 toe/capita in OECD countries on average and the Middle East average of 3.2 toe/capita. Consumption of electricity and oil products are heavily subsidized in Kuwait which leads to overconsumption and a misallocation of energy resources.

Total final consumption was 18.4 Mtoe in 2015. Industrial energy demand accounted for the largest percentage at some 31%. Final demand in the transport sector was a quarter of total demand and was comprised entirely of oil products. The transport sector is dominated by the use of private passenger vehicles. Mass public transportation is underdeveloped in Kuwait (see Box 2.2 in Chapter 2). The residential and services sectors accounted for 21% of total final energy consumption. Energy demand in these sectors is met predominately by electricity, with only a small amount of consumption of oil products in the residential sector. Non-energy use made up 16% of total final demand in 2015, and energy use in the desalination sector accounted for 7%.

There is enormous potential in improve the energy-efficiency of the building stock in Kuwait. The Ministry of Electricity and Water has enforced the minimum requirements for efficient energy use in buildings since 1983 through an energy conservation code of practice. In 2010, a revised version of the code was developed with more stringent requirements for energy conservation in new buildings (Table 1.2).[10]

[9] Historical energy data to 2014, unless otherwise indicated, is from the International Energy Agency, www.iea.org.
[10] Krarti (2015).

Table 1.2 | Energy efficiency requirements under the 1983 and 2010 energy conservation codes

Requirements	Code of Practice 1983	Code of Practice 2010
Design weather conditions	One set of conditions for all sites in Kuwait	Two sets of conditions: interior and coastal sites
Wall thermal insulation	Maximum U-value depending on mass and color levels	Maximum U-value depending on mass and color levels
Roof thermal insulation	Maximum U-value depending on mass and color levels	Maximum U-value depending on mass and color levels
Window to wall ratio/ glazing type	Maximum WWR value depending on glazing type and orientation	Maximum WWR value depending on glazing type and orientation
Thermal bridges		Columns and beams should be insulated. Windows should have thermal breaks
Lighting density		Maximum lighting power density
Ventilation rate	ASHRAE requirements from standard 62-1979	ASHRAE requirements from standard 62-2001
Programmable thermostats		Recommended for buildings with part-day occupancy levels with 5°C offset with switching off of air-circulating fans during non-occupancy periods as long as thermal comfort is maintained during occupancy periods
Motor efficiency		Minimum efficiency rating depends on motor type & size
Power factor		Minimum power factor for motor and fluorescent lighting systems
A/C energy efficiency	Minimum efficiency for select systems	Minimum efficiency rating depending on system type
Water-cooled A/C systems		Water cooled A/C systems required for buildings with cooling capacity of 1000 RT or above in the coastal areas and of 500 RT and above for interior areas
A/C capacities	Maximum power capacity depending on the building and A/C system types	Maximum power capacity depending on the building and A/C system types
Cooling recovery units		Required rotary-wheel cooling recovery units with a minimum efficiency of 75% for all buildings (coastal areas) and for buildings with high ventilation needs (interior areas)
Variable speed drives		Required for fan motors of cooling towers
Cool storage systems		Required for buildings with part-day occupancy and more than 100 RT cooling peak load
District cooling		Recommended based on cost analysis for large complexes such as university campuses and residential neighborhoods

Note: ASHRAE is American Society of Heating, Refrigerating and Air-Conditioning Engineers; RT is refrigeration ton.
Source: Krarti (2015).

Because the 1983 energy conservation code was not revised for 27 years, the buildings sector is a major source of inefficient energy consumption. In addition, the code was rather weakly enforced over the years, leaving a very large stock of energy-inefficient buildings. Enforcement improved after introduction of the 2010 codes and regulation, but Kuwait's building stock is quite old in general, and it will take years, if not decades, of stock turnover until Kuwait sees a dramatic reduction in energy consumption in its buildings sector. Initially, verification and enforcement of the energy conservation code required the involvement of three institutions: the Ministry of Electricity and Water; Kuwait Municipality; and the Ministry of Public Works. The responsibilities of these government institutions are described in Table 1.3. To date, the Ministry of Electricity and Water has been the primary enforcer of the conservation code.

Table 1.3 | Institutions and their responsibilities for enforcing the energy conservation code

Institution/Government Authority	Responsibilities
Ministry of Electricity and Water	Approval of W/m2 calculations for A/C and lighting. Approval of all electrical drawings before obtaining building permit from Kuwait Municipality. Approval of all energy conservation measures. Approval of kW/t for A/C systems and equipment.
Kuwait Municipality	Approval relating to compliance with zoning regulations. Inspection during construction of insulation materials and glazing application.
Ministry of Public Works	Testing and certification of building materials, including all insulation materials and systems.

Source: Al-Sayed and Assem (2003).

Electricity Generation and Demand and Desalination

In 2018, Kuwait had an installed electric generation capacity of 18.8 gigawatts (GW), with nine power plants. Steam generation accounted for nearly half of total capacity, with combined-cycle steam and gas plants making up another 40%. Open-cycle gas-fired generation accounted for some 8% in 2018. The Az-Zour complex accounts for nearly 40% of total power generation capacity. In 2017, the Umm Gudair photovoltaic plant and phase 1 of the Shagaya plant, based on PV and wind, came on line. The Umm Gudair plant is not connected to the national grid. In 2018, a concentrating solar power (CSP) plant at Shagaya joined the grid. The total contribution of renewables to Kuwait's power generation mix in 2018 was 80 MW, less than 1% of total generating capacity (Table 1.4).

Table 1.4 | Kuwait's power plants in 2018

	Technology	Installed Capacity (MW)
Doha East	Steam turbine (7) OCGT (6)	1,158
Doha West	Steam turbine (8) OCGT (5)	2,541
Az-Zour South	Steam turbine (8) OCGT (4) CCGT (15) CCST (4)	5,806
Az-Zour North	CCGT (5) CCST (2)	1,540
Sabiya	Steam turbine (8) OCGT (4) CCGT (8) CCST (4)	5,866
Shuaiba South	Steam turbine (6)	720
Shuaiba North	CCGT (3) CCST (1)	875.5
Shuwaikh	OCGT (6)	252
Shayaga	PV, wind, CSP	70
Umm Gudair	PV	10
TOTAL CAPACITY		**18,838**

Source: Ministry of Electricity and Water.
Definitions: OCGT – open-cycle generation turbine; CCGT – combined-cycle gas turbine; CCST – combined-cycle steam turbine; PV – photovoltaic; CSP – concentrated solar power.

Kuwait had one of the largest generation reserve margins in the Gulf Cooperation Council region before 2006, but over the past decade and a half, this level of generation capacity has increasingly struggled to meet summer demand. The use of oil for power generation at prices below cost squeezed revenues and held up capacity investments needed to meet demand. Reserve margins fell from over 30% in 2000 to 21% in 2014, causing brownouts and blackouts extending beyond the summer months. The Ministry of Electricity and Water estimates that reserve margins could drop to 8% by 2020.

Kuwait plans to increase base-load electricity generating capacity to 32 GW by 2035 (see Chapter 2).

Until very recently, the Ministry of Electricity and Water was solely responsible for the development of the electricity sector. But in the past few years, opportunities for independent power producers (IPP) and independent water and power producers (IWPP) were opened up through public-private partnerships (PPP) in accordance with Law number 39 of 2010 and Law number 116 of 2014. The Kuwait Authority for Partnership Projects (KAPP) and MEW are teaming up with domestic and international companies to spur investments in power generation and water production. In 2013, the Az-Zour North gas-fired power plant became Kuwait's first public-private partnership for an independent water and power plant. The Kuwaiti government holds a major share (60 percent), in a partnership with GDF Suez Energy International (France), Sumitomo Corporation (Japan) and Abdullah Hamad Al-Sager and Brothers (Kuwait). Total capacity of Az-Zour North is expected to be 4.8 GW. The Kuwaiti government will purchase the electricity generated and the water produced for 40 years. The Az-Zour desalination plant will account for approximately 20% of Kuwait's installed capacity. Another IWPP is being developed for Phase 1 of the planned Al-Khiran water and power plant.

Kuwait relies on oil and natural gas to generate electricity, with oil accounting for 64% of the generating capacity in 2015. Given Kuwait's dependence on oil-export revenues, there are significant financial incentives to move away from burning oil for domestic power use. Kuwait is seeking to diversify its electricity generation supply portfolio by replacing petroleum products with more natural gas, but shortfalls in natural gas production have forced the country to rely on LNG imports for gas-fired power generation.

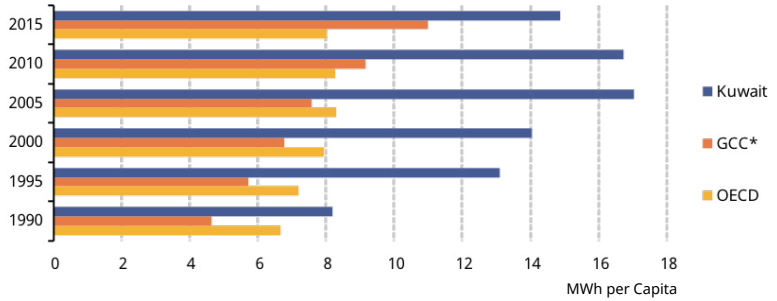
The Gulf Cooperation Council established a regional power grid to support high voltage networks in member countries in 2001. The intended purpose of the grid was to provide backup electricity during emergencies caused by power system outages, especially during the summer, and to share spinning reserves, optimize capital investments in electricity and reduce fuel costs.[11] The system to date, however, has been underutilized, but the GCC Interconnection Authority (GCCIA), the grid system's operator, sees potential in expanding electricity trading among countries. The Northern System of the grid was completed in 2009, connecting the Az-Zour complex in Kuwait to grids in Saudi Arabia, Bahrain and Qatar. The GCCIA manages the interconnection, and the transmission capacity of the interconnector is 1.2 GW. According to the GCCIA, electricity trading by member states has increased over the past decade. Since it commenced trading, Kuwait has imported slightly more electricity than it has exported, but overall trade has generally been unchanged, at around 550 GWh for both imports and exports.[12] Kuwait imports power in an emergency and only for a few hours at a time. Since 2016, Kuwait has exported as much as 750 MW during the summer peak period to Bahrain and the UAE. In return, Kuwait has imported "in-kind" power during winter months.

Final electricity consumption, 44.6 TWh in 2015, experienced rapid growth of 5% per year on average in 2000-2015 - growth peaked at over 9% in the period. Final consumption was comprised of residential sector demand, 27.2 TWh, services sector demand, 15.2 TWh, and electricity use for desalination, 2.2 TWh.[13] The Kuwait Institute for Scientific Research estimates that electricity demand for air conditioning accounts for roughly 70% of the annual peak load demand and over 45% of annual electricity consumption.

[11] Mollet et al. (2018).
[12] GCCIA (2018).
[13] Electricity demand in the desalination sector is included due to its importance in Kuwait's economy.

As illustrated in Figure 1.5, per capita electricity consumption in Kuwait was 14.95 MWh in 2015, close to double the average for OECD countries (8 MWh) and considerably higher than the average for GCC countries (11 MWh).[14] Due to a combination of factors, including declining oil prices and stricter enforcement of building codes, Kuwait's per capita consumption started to decline around 2005. A rapid rate of population growth also contributed to this decline – Kuwait's population increased by over 70% from 2005 to 2015.

Figure 1.5 | Electricity consumption per capita in Kuwait compared to average in OECD and GCC countries



**GCC countries excluding Kuwait.*
Source: International Energy Agency databases.

Water needs for residential and commercial use are met predominately through desalination. Desalination plants produce over 90% of water demand in the residential and services sectors. They also produce 60% of water demand in the industry sector. Kuwait has eight desalination plants, producing 627 million imperial gallons per day (MIG/d) of desalinated water in 2018 (Table 1.5).

Table 1.5 | Kuwait's desalination plants in 2018

	Desalination (b/d)	**Production** (b/d)
Doha East	7	42
Doha West	16	110.4
Az-Zour South	17	140.4
Az-Zour North	10	107
Sabiya	8	100
Shuaiba South	6	33
Shuaiba North	3	45
Shuwaikh*	4	49
TOTAL CAPACITY	**71**	**627**

**No power generation, only boilers.*
Source: Ministry of Electricity and Water.

[14] In Figure 1.5, per capita electricity consumption for Kuwait, GCC countries and the OECD is based on IEA data for total electricity consumption in 2015, which includes own use.

Multistage flash (MSF) desalinating technology accounts for about three-quarters of total desalinated water produced. The Az-Zour North desalination plant commenced production in 2017 and is the only unit using multi-effect distillation (MED) technology. MED units are able to adapt to fluctuations in water demand over time and are more energy efficient. In the near term, a reverse osmosis (RO) plant will be commissioned at the Doha West desalination plant and is expected to produce 60 MIG/d.

The Context for Kuwait's Energy Development

Economy and Government

Kuwait has a geographically small, but wealthy, relatively open economy. GDP per capita was $25,392 in 2016.[15] The industrial sector accounted for about 60% of GDP and the services sector for around 40%. Given Kuwait's arid climate, agricultural production is negligible.

Kuwait's economy is heavily reliant on oil and oil products, which account for over half of GDP. Oil prices have dropped significantly since mid-2014, and Kuwait experienced a budget deficit in 2015. In 2016, the deficit grew to 16.5% of GDP. The overall fiscal surplus fell from 18.5% of GDP in 2014/15 to a 0.5% of GDP in 2016/17.[16] The permanent nature of the shock highlighted the need to adjust fiscal policy to continue to save sufficient resources for future generations, preserve liquid buffers in case of future shocks, reduce financing needs, limit the build-up in debt and maintain strong credit ratings.

Despite Kuwait's dependence on oil, the government has cushioned itself against the impact of lower oil prices, by saving annually at least 10% of government revenue in the Fund for Future Generations. According to the Sovereign Wealth Fund Institute, Kuwait has the fourth largest sovereign wealth fund in the world. The Kuwait Investment Authority manages the fund, estimated to be close to US$530 billion (approximately US$380 billion in the Future Generations Fund, and US$148 billion in the General Reserve Fund which aims to support the budget).

Recent import growth has been robust reflecting healthy domestic demand related to government infrastructure projects. Outside the oil sector, economic activity has been supported by the implementation of large infrastructure, transport and refinery projects contained in the five-year Development Plan (2015/16-2019/20). To increase non-oil revenues, the Kuwaiti Government in August 2017 approved draft bills supporting a Gulf Cooperation Council-wide value added tax. The tax was scheduled to take effect in 2018 but its implementation has faced delays.

[15] OAPEC (2017).
[16] IMF (2018).

Absolute poverty and involuntary unemployment are virtually nonexistent. Nearly 80% of employed Kuwaiti citizens work in the public sector. In contrast, expatriates, who make up two-thirds of the population, constitute the bulk of lower-income residents and are largely employed in the private sector. The public sector in Kuwait is one of the largest in the world, with a spending to GDP ratio of 53%. Comprehensive reforms are needed to rebalance the economy away from the energy sector to a more diversified growth path underpinned by innovation, private sector entrepreneurship and job creation and the quality of its labor force. The Kuwait government is addressing these challenges through implementation of the Kuwait National Development Plan 2035. The main goals of the plan are to develop a prosperous and diversified economy to reduce the country's dependence on oil-export revenues; increase the number of small businesses by 3,500; realize the goal of producing 15% of electricity by renewable energy resources by 2030; and increase private investment by 11%.

Kuwait is a constitutional emirate with a parliamentary system of government. Its constitution combines aspects of both presidential and parliamentary systems of government. The Emir is a hereditary position, and it is the Emir who appoints the prime minister and deputy prime ministers. Kuwait's National Assembly has 66 seats and is comprised of 50 representatives who are elected by popular vote and 16 cabinet ministers who are appointed by the Prime Minister and approved by the Emir. Elected members serve four years. Kuwait has a civil law system, and the judiciary is independent.

Energy Subsidies

Despite reform efforts over the past several years, energy subsidies remain high in Kuwait. Before the collapse of oil prices in 2014, Kuwait's energy subsidies on fuel and electricity were estimated at around 11% of GDP. The subsidies continued to remain high even after oil price declines and subsidy reforms undertaken by the authorities during 2015–16, reaching close to 8% of GDP in 2016.[17] On average, subsidies in Kuwait are larger than in other oil exporters, due to remaining gaps between market and domestic prices. Until mid-2016, Kuwaiti electricity prices were less than one-twentieth of generation costs and had not changed since 1960. Water prices, for which the desalination techniques use local oil and gas resources, are heavily subsided. Before August 2016, Kuwait's prices were some of the lowest in the world. Artificially low domestic prices contributed to excessive consumption of natural resources.

Most of the energy subsidies in Kuwait are in the form of transfers to utility companies to compensate for the difference between production cost and the low domestic selling price. Kuwaiti authorities announced cuts to fuel subsidies in August 2016, provoking resistance among the public. Nevertheless, the government began raising utility prices in September 2016. Electricity and water tariffs, outlined in Law no. 20 and approved by Parliament, were raised for most customers.

[17] Oxford Institute for Energy Studies (2017b).

The electricity tariffs for residential villas and apartments did not change under Law no. 20 (Table 1.6). The current rates are substantially below the US$0.07 per kWh average tariff rates for GCC countries.[18] Price subsidies diminish fiscal resources available to potentially more productive expenditures including productive infrastructure spending or social spending. In fact, the level of Kuwait's energy subsidies was comparable to that of capital spending in 2016.

Table 1.6 | Electricity tariffs in Kuwait under Law no. 20, in force since 2016

Sector	**Tariff** (USD/kWh)
Residential villa	0.007 (no change)
Residential apartments	0.007 (no change)
Government and commercial	0.083
Industrial and agriculture	0.033
Others	0.067

Source: Ministry of Electricity and Water.

Energy subsidies discourage investment by producers and distributors, affecting the ability to produce energy more efficiently. They also encourage investment in energy-intensive activities that create relatively few jobs. The authorities have initiated several efforts to reduce subsidies, but more is needed. In 2015–16, the authorities substantially increased diesel and gasoline prices. Legislation was passed in 2016 that envisaged significant adjustment of electricity and water prices in 2017, although the actual price increases were lower than planned and residential properties (used mainly by Kuwaiti citizens) were exempted. Despite these efforts in the right direction, the energy price gaps remain high and electricity and water prices are much lower than the cost-recovery levels.[19] In order to minimize the rebound effect (*i.e.*, when consumption patterns revert to pre-subsidy levels due to the perception of lower energy requirements for efficient technologies), energy policies need to be formulated in a way that promotes energy-efficient technologies and rebate/incentive programs, when subsidy reforms are considered.[20]

Environment

Energy-related carbon dioxide equivalent (CO_2-eq) emissions in 2015 in Kuwait were 83 million tonnes. Because of Kuwait's heavy reliance on fossil fuels, and inefficient use of energy due to pricing distortions, CO_2–eq emissions per capita were 21.1 tonnes of CO_2–eq per capita, among the highest level in the world. Emissions per capita declined over the past decade, due primarily to rapid population growth (see Figure 2.9 in Chapter 2). CO_2–eq emissions per GDP were 0.3 kilograms of CO_2–eq per GDP (PPP) in 2015, compared with 0.25 kilograms of CO_2–eq per GDP for OECD countries.[21]

[18] Electricity price in August 2017 or latest available. GCC average excludes Kuwait (IMF, 2017).
[19] IMF (2017).
[20] Gillingham et al. (2016).
[21] CO_2 intensity figure for OECD from IEA data.

There is considerable need to improve the efficiency of water utilization in Kuwait. Kuwait is in the process of modernizing its desalination industry through the introduction of more efficient technologies like multiple-effect distillation and reverse osmosis. The environmental challenges facing Kuwait's water sector include the impacts of desalination intakes and brine disposal on marine life, reduced air quality from desalination production near urban centers and soil and groundwater pollution. Kuwait will increasingly need to tackle the impacts of climate change and adapt to a hotter climate. Given that the desalination industry is the backbone of the water sector, regulatory reforms, such as restructuring water tariffs, reducing water-related subsidies, mandating water saving fixtures and penalizing water wastage, will be required to shield Kuwait against the impacts of climate change on water availability.[22] In a promising move, the government, under Law 20 in 2016, restructured water tariffs and mandated water-savings fixtures. The Public Authority for Housing Welfare is also developing an integrated water system for future cities in the south of the country.

Projecting Future Developments

The analysis in this first annual *Kuwait Energy Outlook* is based on the Long Range Energy Alternatives Planning (LEAP) System developed at Stockholm Environment Institute US. LEAP is a model used to assist countries in their integrated energy planning and climate change mitigation assessments. This year's *Outlook* focuses on a Business-as-Usual Case. This Case reflects our judgment about a reasonable trajectory for developments in Kuwait's energy economy to 2035, based on an assessment of current and announced policies and projects. The challenges in accessing reliable, quality energy data in Kuwait limit the scope of the analysis, but the expectation is that, when these challenges are addressed, scenario analysis, in addition to the BAU Case, will be introduced in the years to come. In future *Kuwait Energy Outlooks*, the LEAP will serve as a good foundation for examining energy efficiency and renewable energy policies in Kuwait, such as the role of building and appliance standards, clean transportation policies, efficient desalination and large-scale deployment of solar and wind generation. The model will also be useful in the creation of Kuwait's next national communication on climate change.

Energy sector analysis relies fundamentally on robust data on energy supply and demand. The quality and availability of Kuwait's energy data varies widely by sector and fuel. Moreover, there is no comprehensive national source for energy data in Kuwait. In light of this, the International Energy Agency's (IEA) annual energy balances were used for historical data to 2014. The primary purpose of this analysis is to shine light on energy data deficiencies in Kuwait in the anticipation that establishing a comprehensive database and building a national energy balance will be priorities for the country in the near future.

[22] Fadlemawla, www.arabclimateinitiative.org.

Based on the IEA's historical data, analysts created a detailed bottom-up model that accurately matches the best available national data for the residential, transport and power generation sectors. National residential, transport and power sector energy demand data are somewhat reliable, but detailed energy demand data for the industry and services sectors were not available. The Office of Public Projects at the Ministry of Electricity and Water proved to be a comprehensive source for electricity generation and transmission statistics.

On the supply side, data deficiencies currently preclude the creation of a field-by-field bottom-up model for oil and gas production and trade. Historical oil and gas production data are from OPEC and IEA statistics, while refinery, petrochemical and import/export statistics are from IEA energy balances. The projections for energy supply are loosely based on oil and gas infrastructure and development plans, an expected boost in production levels from more collaboration with foreign companies on enhanced-oil recovery technologies and anticipated investments in LNG import facilities.

Table 1.7 provides the GDP and population assumptions for the period to 2035. The economy in Kuwait is expected to decelerate from the rapid pace of growth in 2000-2010. GDP growth will average 2.6% per year over the *Outlook* period. Kuwait experienced extraordinary growth in its population over the past decade – in 2010-2015, for example, population rose by 5.6% per year, on average. This trend did not escape the government's attention, and policies have already been put in place to stem the growing tide. Population growth is expected to average 1.6% per year in 2015-2025 and to slow to an average annual 1.1% in the final decade of the *Outlook* period.

Table 1.7 | Population and GDP growth rate* assumptions in the Business-as-Usual Case

	2000	2010	2015	2025	2035	2000-2010	2010-2015	2015-2025	2025-2035
GDP (billion $US PPP)	143	226	275	354	457	4.6%	4.0%	2.6%	2.6%
Population (thousand)	2,051	2,998	3,936	4,603	5,111	3.9%	5.6%	1.6%	1.1%

**Average annual growth rates.*
Source: GDP growth assumptions from OPEC to 2023 and from IMF (for GCC region as a whole) from 2023-2035. Population assumptions from United Nations World Population Prospects 2017.

The assumptions for economic and population growth are the main drivers behind energy demand growth in the residential, transport, and power generation and desalination sectors over the *Outlook* period. The number of households, household size and annual connected loads also impact the trajectory of energy demand growth in the residential sector. World oil prices are not used to drive the projections, except in that they are a major driver of GDP. Endogenous efficiency improvements are modeled as modest improvements of 0.5% per year in energy intensity in the industry and petrochemical sectors over the *Outlook* period.

There is a pressing need to improve data collection efforts in Kuwait. This could be facilitated through more coordination and collaboration between energy players within Kuwait and improving the institutional capacity for data collection. The lack of collaboration and expertise contribute to long delays in receiving feedback and data from energy entities. The situation, however, is expected to improve. Kuwait established the Higher Energy Committee (HEC) in 2018. The Minister of Oil and the Minister of Electricity and Water head the HEC. Other members include the Chief Executive Officer of Kuwait Petroleum Corporation (KPC), the Undersecretary of MEW, the Director General (DG) of Kuwait Institute for Scientific Research (KISR), the DG of the Public Authority for Housing Welfare, the DG of Kuwait Municipality, the DG of the Public Authority for Industry, the Secretary-General of the General Secretariat of the Supreme Council for Planning and Development of Kuwait, the Deputy DG for Scientific Affairs of Kuwait Foundation for the Advancement of Science (KFAS), and the Managing Director for Planning and Finance of KPC. A technical team was also formed to assist the Higher Energy Committee and to provide periodical reports on work progress. Continued efforts to improve the consistency and reliability of Kuwait's energy data will be essential for effective policymaking and the implementation of the energy strategy outlined in the 2017 *White Paper on a Sustainable National Energy Strategy*.[23]

[23] Oxford Institute for Energy Studies et al. (2017a).

CHAPTER 2

Kuwait's Energy Outlook to 2035

Highlights

- In the Business-as-Usual Case, crude oil production in Kuwait is projected to be 3.5 million barrels per day in 2035, based on the country's plans to increase capacity to 4 mb/d in the next decade. Like all producing countries, Kuwait will face increasing competition for its exports from unconventional oil supplies. The world's thirst for crude oil will also likely slowdown over the projection period, due to concerns over climate change impacts from burning fossil fuels and breakthroughs in cleaner and more cost-effective energy options.

- Natural gas production is projected to grow from 17.4 billion cubic meters in 2017 to 27.3 bcm in 2035. Much of the increase will be targeted to the oil and power generation sectors. Domestic supply, however, will be unable to meet the expected increase in demand, and liquefied natural gas imports are expected to continue to be an important source of natural gas supply over the *Outlook* period.

- The share of oil in total primary energy demand steadily declines to 42% in 2035, a result of the government's push to switch from oil to natural gas for power generation. Natural gas demand grows at a fast clip, by 2.2% per year in 2015-2035, and the share of gas in total energy demand climbs to 55% in 2035. Despite some progress in supporting solar generation, in the Business-as-Usual Case, the share of renewables in total primary energy demand remains low in 2035, only 3%.

- Electricity generation capacity in Kuwait increases by over 13.2 gigawatts over the *Outlook* period, reaching 32 GW in 2035, a 70% increase over capacity in 2018. Combined-cycle plants make up the lion's share of capacity expansions over the projection period, resulting in a more efficient and flexible fleet of power plants compared to today. These plants will use both oil and gas for generation, but Kuwait will favor the use of natural gas in combined-cycle and steam plants, and the share of oil products in total generation is likely to fall to about a quarter by 2035. Renewable-energy capacity, mostly solar, will make up 16% of total generation capacity.

- Multi-stage flash desalination technology dominates the water production sector in Kuwait but its share is expected to fall from 84% today to 39% by 2035. The more efficient and cost-effective multi-effect desalination technology will make considerable inroads, with its share in total desalination production increasing from only 6% in 2015 to nearly half in 2035. Despite being the preferred technology in most of the world, reverse osmosis accounts for just 13% of total production capacity in 2035 in Kuwait.

- The industry sector will still account for the largest share of final energy consumption in 2035, some 31%. In the Business-as-Usual Case, demand for oil in the transport sector grows by 3% per year on average, much faster than growth in the rest of the world. The transport share in total final energy consumption will be 30% in 2035. Growth in residential electricity demand is considerably slower over the *Outlook* period than in 2000-2015. Stricter enforcement of regulations and codes in the buildings sector play a major role in this deceleration. However, due to the absence of efforts to check rapid growth in oil demand in the transport sector, per capita energy demand in Kuwait continues to rise over the projection period, reaching 9.2 tonnes of oil equivalent per capita in 2035.

- Greenhouse-gas emissions increase from 83 million tonnes of CO_2-equivalent in 2015 to 103.4 Mt of CO_2-eq in 2035, at an average annual growth rate of 1.1%. Fuel-switching from oil products to natural gas in the power generation and industry sectors results in a 35% increase in emissions from natural gas, from 38.9 Mt of CO_2-eq in 2015 to 60.1 Mt of CO_2-eq in 2035. But oil-product emissions decline only slightly in 2015-2035, due to rapidly growing demand for oil products in the transport sector.

Overview of Energy Supply Trends

With a current production-to-reserves ratio of about 1%, Kuwait will no doubt remain one of the world's leading oil producers over the period to 2035. Kuwait Oil Company has commenced enhanced technical service agreements (ETSAs) with international firms and is also developing its offshore fields. Natural gas production is expected to increase, although the pace at which Kuwait can ramp up its gas production is more uncertain, given that its gas infrastructure is underdeveloped. Vast discoveries of non-associated gas in the Jurassic field in the northern region of the country have attracted foreign interest, but the resources are mainly in tight and sour natural gas deposits that require sophisticated development and have higher capital costs.

Kuwait Oil Company manages the production and export from more than twelve developed oil fields. The oilfields are divided into north, west, south and east fields, each of which is locally administered. Kuwait currently has 25 operational gathering centers that process and separate gas and water from crude oil for downstream operations.

Kuwait Oil Company has outlined plans for major developments at the Raudhatain, Sabriyah, Bahrah, Abdali border, Burgan, Umm Gudair, South Ritqa and Mutriba fields over the *Outlook* period. Enhanced-oil recovery projects are a major component of these plans to increase oil and natural gas production.[24] In the period to 2035, Kuwait Gulf Oil Company plans to implement the Wafra 1st Eocene steam-flood and the Wafra Ratawi chemical enhanced oil recovery programs, and an increased oil recovery project at the South Fawares field. Table 2.1 outlines other planned projects in the oil and natural gas sectors.

Table 2.1 | Planned oil and gas infrastructure and development projects

Upstream	
Oil	Build four gathering centers in the north and southeast. Develop heavy-oil enhanced oil recovery programs in the north. Develop Wafra pressure maintenance programs (Phases I and II). Develop offshore and oil shale fields.
Gas	Develop four Jurassic production facilities by 2024, each with a capacity of 4.5 million cubic meters per day. Complete Wafra Joint Operation to capture and process associated flared gas. Construct a gas pipeline from Khafji Joint Operation to Mina Ahmadi refinery.
Downstream	
Oil	Increase refinery capacity through the commissioning of capacity creep* projects at Mina Abdullah refinery and Al Zour. Build new, and revamp existing, sulphur-handling facilities at Mina Al-Ahmadi refinery. Build new crude and bitumen units at Mina Al-Ahmadi refinery. Commission a new acid gas removal unit and revamp the existing units at Mina Al-Ahmadi refinery.
Gas	Commission the 5th gas-processing train by 2020. Commission the new 3,000 billion British thermal units per day LNG import terminal in Az-Zour, to come online by 2021. Develop an ethane cracker by 2025. Initiate a joint venture for derivatives and specialty products.

** Capacity creep occurs as firms acquire additional production experience and able to achieve more production volume with their existing facilities.*
Source: Kuwait Petroleum Corporation.

In 2018, Kuwait Oil Company produced 14.2 million cubic meters per day (mcm/d) of natural gas and 11.3 mcm/d of non-associated gas. KOC has ambitious plans to develop further the Jurassic reserves with contracts for additional early production facilities. Currently, there are four production facilities being developed, two of which are anticipated to be on-stream by end-2022. The capacity of the new facilities is about 6.5 billion cubic meters per year (bcm/y). KOC's ultimate objective is to increase its output of non-associated gas to 20.5 bcm/y by 2040.[25]

Table 2.2 provides Kuwait Petroleum Corporation's plans to secure natural gas supplies for the power generation and industry sectors over the *Outlook* period. The oil sector will continue to get priority in terms of allocation of domestic gas supplies.

Table 2.2 | Natural gas supply to the power generation and industry sectors over the *Outlook* period

	2020	2025	2030	2035
Power generation sector (ktoe per day)				
Fuel gas	13.9	13.7	15.1	1.3
LNG	11.3	32.1	39.1	57.7
Industry sector (ktoe per day)				
Oil sector	26.7	37.0	40.8	52.1
Other industries	0.3	0.3	0.3	0.3

Source: Kuwait Petroleum Corporation.

[24] The projects include: the Raudatain-Zubair alkaline-surfactant-polymer flooding pilot design program; the Minagish Oolite miscible pilot design and drill pilot wells projects; and the Sabiriyah Mauddud reservoir enhanced oil recovery program.

[25] Alsayegh and Fattouh (forthcoming).

In the Business-as-Usual Case, crude oil production in Kuwait is expected to increase from 2.7 mb/d in 2017 to 3.5 mb/d in 2035, growing at an average rate of 1.5% per year (Table 2.3). This estimate is based on the country's plans to increase production capacity to 4 mb/d in the next decade, and it reflects the global oil industry's assessment of future production levels in Kuwait. The main factors influencing this assessment are a likely deceleration in global demand for oil, particularly in Asian countries, as governments strive to meet their climate change goals and commitments under the Paris Agreement, and increasing competition from unconventional oil supplies and from non-OPEC suppliers, who have significant upside production potential, especially over the medium-term.

Natural gas production increases, on average, by 2.5% per year, from 17.4 bcm in 2017 to 27.3 bcm in 2035. LNG imports are expected to continue to be an important source of natural gas supply over the *Outlook* period. Kuwait Integrated Petroleum Industries Company is building a new 3,000 billion British thermal units per day LNG import terminal at Al-Zour. The terminal, which is expected to come online in 2021, will have eight storage tanks. In addition, Kuwait Petroleum Corporation has signed a 15-year import contract with Shell to supply Kuwait an undisclosed volume of LNG from 2020.[26]

Table 2.3 | Crude oil and natural gas production in the Business-as-Usual Case

	2017	2025	2035	2017-2035*
Oil (mb/d)	2.7	3.2	3.5	1.5%
Gas (bcm/y)	17.4	21.5	27.3	2.5%

** Average annual growth rate.*

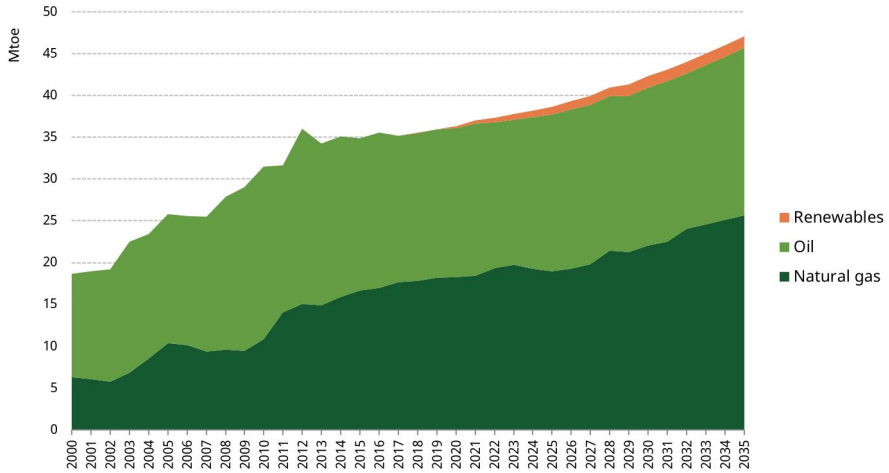
Overview of Energy Demand Trends

Total primary energy demand in Kuwait increases from 34.9 Mtoe in 2015 to 47 Mtoe in 2035, growing on average by 1.5% per year. This growth rate is considerably slower than the average annual 4.3% growth in 2000-2015[27], reflecting a deceleration in GDP and population growth, and serious efforts to enforce the energy conservation code, thus improving the average energy efficiency of Kuwait's building stock in the period to 2035. Oil demand grows by 0.5% per year, on average, over the projection period, compared to growth of 2.6% in 2000-2015. The share of oil in total primary demand steadily declines, from 52% in 2015 to 42% in 2035 due to fuel-switching in the power generation sector.

Natural gas demand grows at a fast clip, by 2.2% per year in 2015-2035, and the share of gas in total primary demand climbs to 55% in 2035, up from 48% in 2015. In the Business-as-Usual Case, the share of renewable energy demand in total primary energy demand remains low, only 3% in 2035 (Figure 2.1).[28]

Per capita energy demand in Kuwait continues to rise over the projection period, from 8.8 tonnes of oil equivalent per capita (toe/k) in 2015 to 9.2 toe/k in 2035.

Figure 2.1 | Total primary energy demand in the Business-as-Usual Case

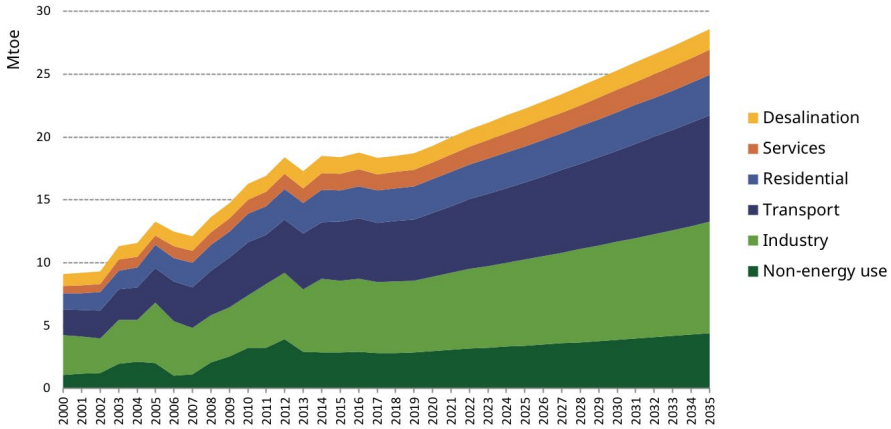


Total final consumption increases from 18.4 Mtoe in 2015 to 28.6 Mtoe in 2035, by an average annual rate of 2.2% (Figure 2.2). From 2000 to 2015, growth in final demand was considerably more rapid, 4.8% per year, due to a construction boom over the period and a rapid increase in population. Growth in GDP and population, however, is expected to slowdown over the *Outlook* period. The industry sector will still account for the largest share of final energy consumption in 2035, some 31%. In the Business-as-Usual Case, demand for energy in the transport sector grows by 3% per year on average, the fastest of all sectors, and the share of transport energy demand, all oil products, in total final energy consumption will be 30% in 2035. The residential and services sectors will account for 18% of total final consumption. Non-energy use will capture 16% and the desalination sector, 6%.

[26] Alsayegh and Fattouh (forthcoming).
[27] The kink in 2010-2013 reflects a period of high oil prices, and an increase in LNG imports for power generation.

[28] The share of renewable energy in total installed power generation capacity is 16% in 2035. Energy data through 2014 are from International Energy Agency databases.

Figure 2.2 | Total final energy consumption by sector in the Business-as-Usual Case



Outlook for Power Generation and Desalination

Electricity generation

Electricity generation capacity in Kuwait increases by 13.2 gigawatts in the period to 2035, reaching 32 GW in 2035, a 70% increase over capacity of 18.8 GW in 2018. In 2035, combined-cycle plants will account for 61% of total generating capacity and steam-fired plants for a further 19%. These plants will use both oil and gas for generation, but, as indicated in the supply section above, Kuwait will favor the use of natural gas in combined-cycle and steam plants, and the share of oil products in total generation is likely to fall to about a quarter by 2035. Combined-cycle plants make up the lion's share of installed capacity over the projection period, resulting in a more efficient and flexible fleet of power plants compared to today. Open-cycle gas-fired power plants will still account for some 4% of installed capacity in 2035. Renewable-energy capacity, mostly solar, will make up 16%. Renewable energy systems, however, are not expected to be limited to utility-scale installations, but will also be deployed through distributed generation systems, such as rooftop installations and local generation in new cities, suburbs and facilities.

Planned capacity additions, 17.6 GW over the *Outlook* period, are a mix of conventional steam plants, combined-cycle plants and renewable technologies (Table 2.4). Not all of these projects have been tendered. The projects are anticipated to be a mix of public-private partnerships and government ownership.

Table 2.4 | Planned power-plant capacity additions over the *Outlook* period

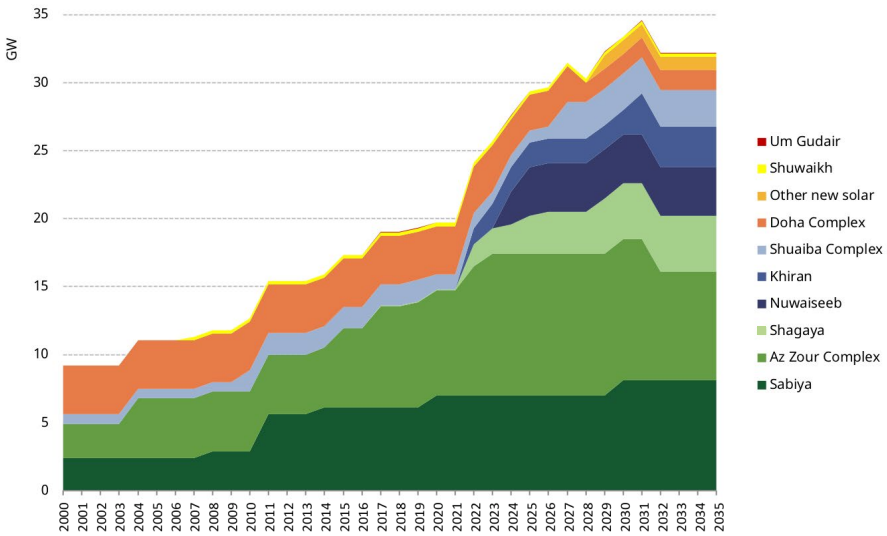
Power Station	Technology	Installed Capacity (MW)	Year Commissioned
Az-Zour North	CC	2,700	2023 – 2024
Az-Zour South	CC	250	2020
Doha East	CC	1,200	2028 – 2029
Al Khiran	CC	3,000	2023 – 2030
Al-Nuwaiseeb	ST	3,600	2024 – 2025
Sabiya	CC	1,980	2020 – 2030
Shagaya	RE	3,025	2019 – 2026
Shuaiba South	CC	1,800	2028
TOTAL		**17,555**	

Note: CC is combined-cycle; the Ministry of Electricity and Water had not made a decision as to whether new combined-cycle plants would be gas- or steam-fired at the time of publication of this report. ST is steam. RE is renewable energy.
Source: Ministry of Electricity and Water.

The Shagaya renewable-energy complex is expected to increase its installed generation capacity to 4 GW, with the construction of concentrated solar power (CSP) plants, solar PV farms and a wind farm by 2027. The mix of these technologies has yet to be decided. Phase 1 at Shagaya saw the construction of a 50-MW concentrated solar power plant, a 10-MW solar PV plant and a 10-MW wind farm. Spain's TSK Solar built the CSP plant, Kuwait's first utility-scale solar project, in collaboration with the Kuwait Institute for Scientific Research (KISR). The plant came online in 2018. Kuwait National Petroleum Company is overseeing Shagaya phase 2 –construction of the 1,500-MW Dibdibah solar PV project. The project will comprise five units, each with capacity to deliver up to 300 MW of electricity to the grid. The plant is expected to deliver its first electricity in 2021. A feasibility study was approved by the Ministry of Electricity and Water for phase 3 of Shagaya, and a tender process is underway. Phase 3 is expected to be a mix of renewable energy technologies. In addition to the planned capacity additions at the Shagaya complex, the Ministry of Electricity and Water anticipates that a further 1 GW of solar capacity will be connected to the grid over the *Outlook* period. Total installed renewable-energy generating capacity is expected to be 5 GW in 2035.

A combined-cycle power unit with a capacity of 1,648 MW was commissioned at the Az-Zour North power station in 2016. Further units with combined capacity of 2,700 MW will come on line in the period to 2023-2024. The two currently operating gas turbines at the Az-Zour South power plant will be converted to combined-cycle systems with the addition of a 250-MW steam turbine plant in 2020. The Sabiya plant will also be upgraded to a combined-cycle plant over the next decade. At Al Khiran's combined-cycle power plant, the installation of a total of 3,000 MW of natural gas and heavy fuel oil-based units will commence by 2023. The new units to come on line by 2025 at Al-Nuwaiseeb power plant, some 3,600 MW in total, will also run on natural gas and heavy fuel oil. At Shuaiba South and Doha East, new thermal units of 1,800 MW and 1,200 MW, respectively, are expected to come on line by 2028. Figure 2.3 shows the evolution of generation capacity at each plant over the *Outlook* period.

Figure 2.3 | Power generation capacity by location over the *Outlook* period



Note: "Other solar projects" refers to planned projects whose location is not yet finalized.
Source: Ministry of Electricity and Water.

Desalination

In 2015, Kuwait produced the third greatest amount of desalinated water in the GCC, after Saudi Arabia and UAE. Only Bahrain had a lower water availability level than Kuwait. Average annual rainfall is projected to decline over the next decade in Kuwait, resulting in higher demand for water, and energy to produce it. Desalinated water is considered Kuwait's only reliable option to meet the future water consumption needs of its population and economy. Today, desalinated water is coproduced at the Shuwaikh, Shuaiba North, Shuaiba South, Doha West, Az-Zour South and Sabiya stations.[29]

Table 2.5 presents Kuwait's planned future water desalination projects. Decommissioning of thermal desalinization units is assumed to occur at the same time as the coupled power plant's decommissioning over the *Outlook* period. Multi-stage flash (MSF) and multi-effect desalination (MED) units are assumed to have an estimated lifetime of about 30 years and reverse osmosis (RO) units, 25 years. All of the planned desalination capacity expansions are expected to be MED units, except for the 60-MIG/d reverse osmosis unit commissioned in 2021 at the Doha complex and the 30-MIG/d RO unit commissioned in 2025 at Al Nuwaiseeb.

[29] In 2035, desalinated water consumption in Kuwait is projected to be some 1,040 million cubic meters per year, or 626 million imperial gallons per day.

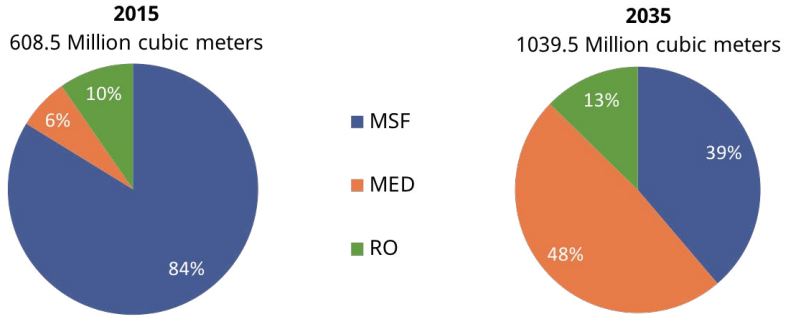
Table 2.5 | Planned desalination capacity additions over the *Outlook* period

Power Station	Output capacity (MIG/d)	Expected Year of Commission
Az-Zour North	107	2021
	66	2023
Doha Complex	60	2021
	100	2028
Al Khairan	125	2023
Shuaiba South	50	2025
Al Nuwaiseeb	75	2025
	30	2025
	75	2035
TOTAL (in 2035)	**688**	

Source: Ministry of Electricity and Water.

In 2015, multi-stage flash, which requires extensive amounts of process heat for the desalination process, accounted for 84% of desalination in Kuwait (Figure 2.4). The share of MSF is expected to fall to 39% by 2035. The more efficient and cost-effective MED technology will make considerable inroads, with its share in total desalination production increasing from only 6% in 2015 to nearly half in 2035. The share of desalinated water produced using the reverse osmosis process increases but still accounts for just 13% of total production capacity in 2035. Worldwide, reverse osmosis accounts for about 65% of desalinated water production. As a step towards minimizing energy consumption and reducing environmental impacts, a majority of the desalination plants under construction in GCC countries are RO or combined RO/MSF. Kuwait, however, is lagging behind these countries in its uptake of reserve osmosis technology.

Figure 2.4 | Shares of water production by desalination technology in 2015 and 2035



Note: MSF – multi-stage flash; MED – multi-effect distillation; RO – reverse osmosis.
Source: Ministry of Electricity and Water.

Environmental considerations, cost reductions in renewable energy technologies and higher than expected growth in electricity and water demand could persuade Kuwait to reevaluate its current expansion plans for the power generation and desalination sectors, particularly if MED and RO technologies prove to be more efficient and reliable. On average, the current design of the multi-stage flash process requires 25 kWh of heat input and 3.5 kWh of electricity input per cubic meter of desalinated water produced. The multi-effect desalination process requires less – about 12 kWh of heat and 1.5 kWh of electricity per cubic meter. Energy consumption needs in the reverse osmosis process are even lower, some 6.5 kWh of electricity input per cubic meter. What makes the RO process less appealing is the high cost of membrane replacement, the extensive feed treatment and lower plant factors. Over the *Outlook* period, however, these drawbacks to using the RO process are likely to be resolved through the development of more efficient and less expensive membranes and antiscalant chemicals. Accumulated global experience in construction, operation and maintenance of large reverse osmosis plants will likely induce further cost-reductions over the next two decades. Reverse osmosis technology is also ideally suited for hybrid gas-solar desalination production units. In the current climate of low-oil prices, Kuwait might also consider the revenue losses incurred by relying on domestic oil consumption for desalination and the environmental impacts of local pollution.

Box 2.1 | The role of renewables in Kuwait

According to the International Energy Agency's *WEO-2018*, worldwide, about a quarter of all electricity generation comes from renewables. Kuwait, like other countries in the GCC, is endowed with world-class solar and wind resources and is increasingly looking to tap this potential as a way to free up oil and natural gas for other uses. For Kuwait, the opportunity is clear: electricity demand increased at an annual average rate of 5% per year from 2000 to 2015, compared to growth of just over 3% per year globally, and oil-fired generators still play a prominent role in the generation mix. This diverts oil away from exports towards inefficient domestic consumption and incurs a significant opportunity cost – especially significant at a moment when global spare production capacity is starting to look thin.

Solar photovoltaic technology, in particular, is ideally suited to meet demand for space cooling and heating. In GCC countries, there has been a significant recent increase of interest in the potential of solar PV. The UAE, for example, plans to have a 25% share of renewables in power generation by 2030. A number of auctions in Saudi Arabia and the UAE have broken records for the lowest bids for solar PV generation globally. In Dubai, the bid for a 200-MW PV plant at the Mohammed bin Rashid Al Maktoum Solar Park was 5.84 US cents per kWh. The bid for the construction of an 800-MW PV plant in phase 3 of the Solar Park, 2.99 US cents per kWh, was even lower. The 1.17-GW PV Sweihan Plant in Abu Dhabi secured a bid of 2.94 US cents per kWh. The lowest bid so far was for the 300-MW PV plant in Saudi Arabia – 2.3 US cents per kWh.[30]

[30] The bid prices are from the following websites: www.pv-magazine.com; masdar.ae/en/energy; and www.pv-tech.org.

Exploiting solar energy to produce desalinated water is a low-hanging fruit in solar-rich, water-poor countries like Kuwait. In the past, artificially low energy prices have hindered the uptake of renewable desalination technologies. Globally, very little desalinization, about 1% according to some estimates, is powered by solar energy. Projects are emerging, however, to develop this form of desalinization. For example, Abu Dhabi constructed 22 small (25 cubic meters per day) solar desalinization plants for brackish groundwater in 2012. Chile also started a small pilot project partly powered by solar energy in the northern province of Arica in 2013.

Kuwait was a pioneer among GCC countries in the research and demonstration of renewable energy projects. In the 1970s, for example, Kuwait collaborated with a German company to construct a small concentrating solar pilot project southwest of Kuwait City. But Kuwait's substantial renewable energy potential is largely untapped today. Renewable energy generating capacity was 70 MW in 2018, less than 1% of total power generation capacity. Although the share is expected to rise to 16% by 2035 in the Business-as-Usual Case presented here, Kuwait will fall behind other countries in the GCC where the shares of renewable-energy generating capacity in total capacity are expected to well exceed 25% in the next two decades.

Electricity Demand

Final electricity demand, comprised of demand in the residential, services and desalination sectors, increased by 5% per year on average in 2000-2015 - growth peaked at over 9% in the period. Today, over 70% of annual peak electricity demand in the summer months is for air-conditioning. Over the projection period, electricity demand growth, however, is projected to slowdown, increasing at an average annual rate of 1.6% per year, reflecting an anticipated decline in economic and population growth and stricter enforcement of energy conservation codes for buildings. In the Business-as-Usual Case, final electricity demand in 2035 is anticipated to be 60.8 TWh[31], and per-capita final electricity consumption, 11.9 MWh.

Outlook for End-Use Sectors[32]

Residential

Energy demand in the residential sector is comprised of electricity and oil products, although oil product demand, comprised of kerosene and LPG, will account for only 7% of total demand in 2035. Residential electricity demand grows by 1.2% per year, from 27.2 TWh in 2015 to 34.4 TWh in 2035, considerably slower than growth of 5% per year in 2000-2015.

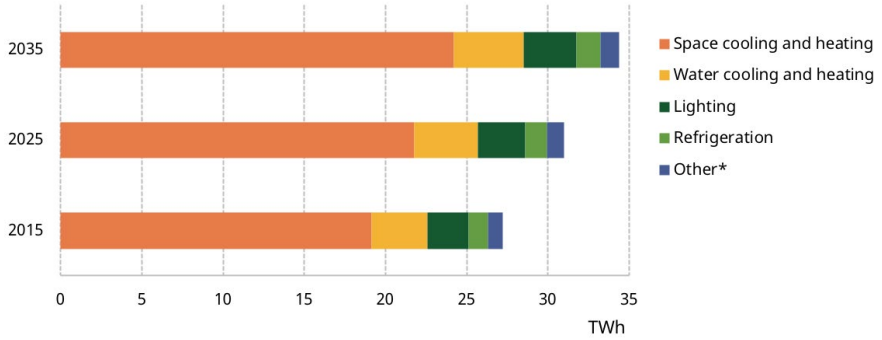
[31] Electricity demand excludes own use.

[32] The paucity of historical data for energy demand in the industry and services sectors precludes a robust analysis of trends in these sectors over the *Outlook* period.

Figure 2.5 shows electricity consumption in the residential sector broken down by end-use.[33] Space cooling and heating accounts for 70% of total residential energy consumption today, and this share is not expected to change over the projection period. Space cooling and heating energy demand increases from 19.1 TWh in 2015 to 24.2 TWh in 2035. Energy consumption for water heating and cooling will account for 13% of residential energy demand in 2035, and lighting for 9%. Refrigeration captures 4% of total demand in 2035.

Most of the air-conditioning and refrigeration systems in Kuwait are imported. While the Ministry of Electricity and Water sets the minimum efficiency requirement in kilowatts per refrigeration ton (kW/RT) at 48 degrees Celsius, some imported systems with lower efficiencies make it into the local market. This can jeopardize the Ministry's predictions for required power demand in new cities and hence necessary power station capacity additions. To control this, a government inspection scheme needs to be established to ensure that all air-conditioning systems meet the minimum efficiency requirements.

Figure 2.5 | Electricity consumption in the residential sector in the Business-as-Usual Case



**Other includes vacuum cleaners, televisions, pool pumps, dishwashers, cookers, computers and clothes washers and dryers.*
Note: Space cooling and heating includes fans; refrigeration includes refrigerators and freezers.

A major factor influencing the projected growth in demand for space cooling and heating is the expected annual increase in average temperatures over the projection period. Results from a modeling exercise carried out in Kuwait's UNFCCC 2012 submission show that average annual temperatures from 2010-2035 will be 1.6 Celsius higher than the average annual temperature of the previous decade.[34] Extreme weather events are also expected to occur more frequently over the *Outlook* period. In the longer-term, climate-induced sea level rises could put a proportion of the coastal areas and their populations at risk of inundation. These changes will have a profound impact on the buildings sector in Kuwait. New building envelopes will need to be constructed to withstand heavier downpours and more intense storms.

[33] The breakdown by end-use in the residential sector is based on analysis and data from Jaffer et al. (2018), the Central Statistics Bureau and Kuwait Institute for Scientific Research.
[34] EPA (2012).

Kuwait has plans to construct 250,000 new houses in the next two decades, of which 128,000 will be completed by 2028. The 2010 energy conservation code was updated in 2014 with more stringent standards for the minimum requirements for energy-efficient design of new buildings in Kuwait. A more recent version for government and commercial buildings, introduced in 2017, is under final approval. The 2017 code will set minimum requirements in terms of power densities, material properties and the use of efficient air-conditioning systems.

Transport

Kuwait has developed an extensive network of road infrastructure. According to the Ministry of Interior, registered private vehicles, nearly 1.8 million in 2018, accounted for over 80% of total vehicles. Transport oil demand increased by 5.6% per year from 2000 to 2015, much of the growth driven by strong demand for diesel. The share of diesel in transport oil demand mushroomed to over 20% in 2015, from 12% in 2000, due to the size and volume of construction and infrastructure projects carried out over the period. The rate of increase in diesel demand in the transport sector slackens over the projection period, but demand for motor gasoline remains strong, at 3.1% in 2015-2035 (Table 2.6). In 2035, motor gasoline demand accounts for 81% of total oil demand and diesel for 19%.

Table 2.6 | Transport oil demand in the Business-as-Usual Case

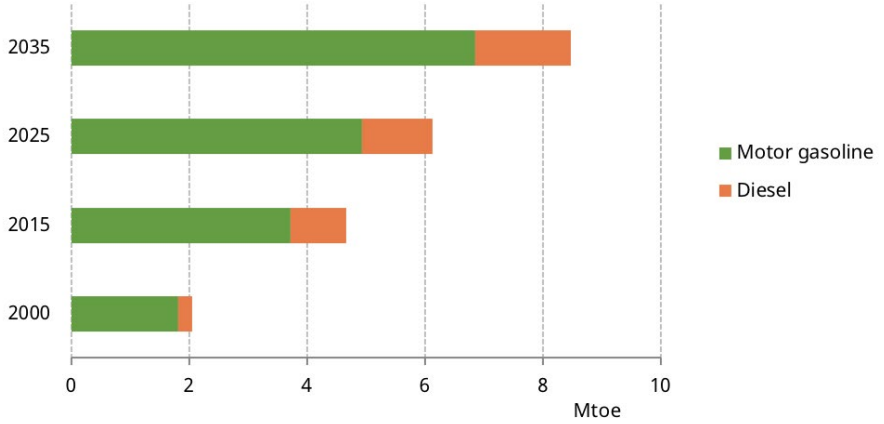
(Mtoe)	2000	2015	2035	2000-2015*	2015-2035*
Motor gasoline	1.8	3.7	6.9	4.9%	3.1%
Diesel	0.2	0.9	1.6	9.7%	2.7%
TOTAL	**2.1**	**4.7**	**8.5**	**5.6%**	**3.0%**

** Average annual growth rate.*

Compared to projected energy demand growth in the residential sector of 1.2% per year, transport energy demand grows rapidly over the *Outlook* period, by 3% per year. From 2015 to 2035, demand for both diesel and motor gasoline increases by over 40%. The vehicle fleet in Kuwait is expected to more than triple by 2035.[35] The share of SUVs in the private passenger vehicle stock was less than 40% in 2015 but is projected to be over 60% in 2035. Except for a niche market in electric vehicles, electricity is not used in the transport sector in Kuwait (Figure 2.6).

[35] Alsayegh et al. (2016).

Figure 2.6 | Transport oil demand by fuel in the Business-as-Usual Case



Passenger vehicle ownership in Kuwait, around 430 per 1,000 people, is the highest of GCC countries and is rising compared to declining trends in other high-income countries. In oil-producer countries, such as UAE, Saudi Arabia and Qatar, governments are pushing ahead with plans for massive public transport projects across their cities (Box 2.2). While bus services are available in Kuwait through the private sector as well as the state-owned Kuwait Public Transportation Corporation, private light duty vehicles will remain the overwhelming travel mode choice for personal mobility. Despite growing traffic congestion, alarming rates of traffic-accident fatalities[36] and poor air quality in Kuwait, investing in metro infrastructure is not an official priority. The government has, however, commenced a project to construct an integrated rail network to serve freight and passenger traffic and to link urban areas to airports and seaports and to rail networks in other GCC countries.

The transport sector is a major source of inefficiency in energy consumption in Kuwait. The GCC Standardization Organization set community-wide standards for the transport sector and has instituted a volunteer labeling program. Whereas in Qatar, Saudi Arabia and UAE, the labeling program is mandatory, in Kuwait, it is not. Motor gasoline and diesel are heavily subsidized. In 2016, Kuwait had the lowest domestic gasoline prices in the world.[37] Motor gasoline prices in Kuwait range from 85 fils per liter (fils/l) (28 US cents per liter) to 165 fils/l (54 US cents/l). Diesel prices are 115 fils/l (38 US cents/l).[38] Despite some effort on the government's part to increase prices under the Ministerial Council decision 32/2016, average motor gasoline prices in Kuwait today are still about one-fifth of average world motor gasoline prices.

[36] The number of traffic-accident fatalities in Kuwait is staggering, over 400 per year.
[37] Shehabi (2017).
[38] Kuwait National Petroleum Company website, www.knpc.com.

Box 2.2 | City metros: An increasingly enticing public transport option in GCC countries

There is a pressing need to overcome rising levels of traffic congestion and local pollution in GCC countries. Rail projects, especially metros and trams, will be essential for carrying large numbers of people over long distances quickly, efficiently and cost-effectively, and enhancing economic growth and mobility. In cities where traffic congestion often impacts commuting times, metros can provide a quick, efficient and safe way for people to get to work on time, ensuring no lost revenue or productivity. For the general public, a key advantage of rail projects is their inter-connectivity with other transport services, such as airports, ports and local transport services including buses and taxis. For daily commuters, this is especially important as walking in the heat of summer for even a short period of time can be a health hazard. Metros are especially effective at taking cars off the road and reducing local pollution levels that, in turn, support healthier communities. A citywide metro also supports countries in accomplishing their Paris Agreement goals of mitigating climate change.

Several GCC countries have built metros over the past decade. In the UAE, the Dubai metro has two metro lines with 29 stations spanning 52.1 kilometers (km). The Abu Dhabi metro system is supported by tram and bus feeder services on approximately 131 km, providing connectivity between Abu Dhabi Island and its suburbs and communities such as Saadiyat, Yas Islands and Al Raha Beach. Saudi Arabia is planning to construct three lines to expand its existing metro network. The developer of Riyadh Metro, the Riyadh Development Authority, is constructing a 1.5-km extension of Line 4 to cater to King Khalid International Airport. The additional lines are currently under construction and are scheduled to start operation in 2019.

Construction of a metro was included in Kuwait's National Development Plan to 2035.[39] The project was set up as a public-private partnership under the provisions of Law No. 116 of 2014, which provides a legislative framework for encouraging and facilitating partnerships between the public and private sectors in infrastructure projects in Kuwait. The cost of the project was anticipated to be $11.4 billion (KWD 3.46 billion). According to the National Development Plan, the metro would achieve multiple objectives: create jobs; alleviate traffic congestion; reduce use of private transport by residents; develop social and commercial centers around metro stations; reduce the number of accidents and road transport deaths; reduce air pollution; and reap benefits from private sector involvement through the transfer of knowledge and technology. As of end-2018, however, there has been no movement in Kuwait on construction of the metro. The project is currently under review, and it remains uncertain whether Kuwait will join other GCC countries in tackling the very real challenges in their transport sectors.

[39] The Plan was reintroduced as NewKuwait in 2018.

Outlook for Emissions

Total greenhouse-gas emissions[40] increase from 83 million tonnes of CO_2-equivalent (Mt CO_2-eq) in 2015 to 103.4 Mt of CO_2-eq in 2035, at an average annual growth rate of 1.1%. Fuel-switching from oil products to natural gas in the power generation and industry sectors results in a 35% increase in emissions from natural gas, from 38.9 Mt of CO_2-eq in 2015 to 60.1 Mt of CO_2-eq in 2035 (Figure 2.7). Oil-product emissions, however, decline only slightly in 2015-2035, due to rapidly growing demand for oil products in the transport sector.

Figure 2.7 | CO_2–equivalent emissions by fuel in the Business-as-Usual Case

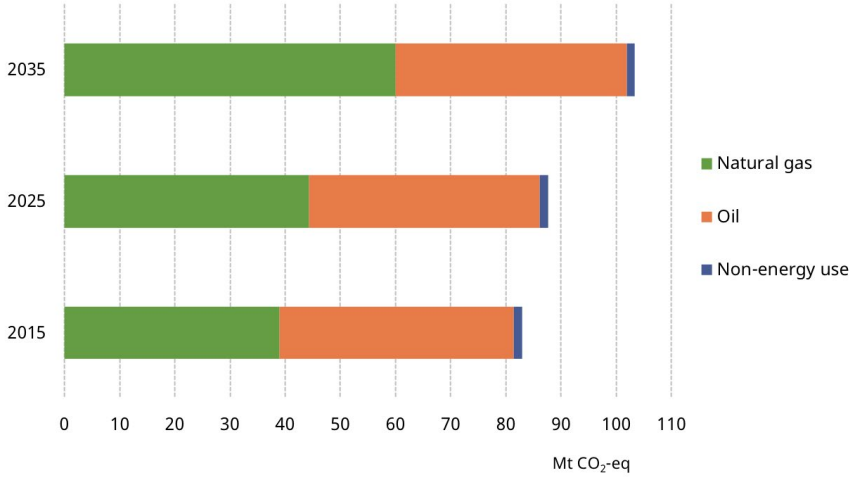
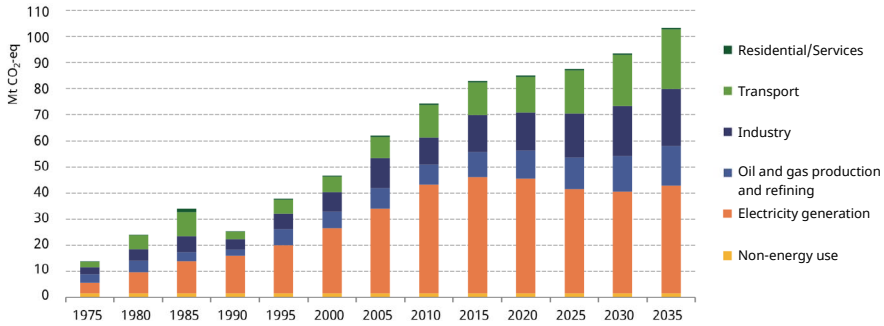


Figure 2.8 shows the trajectory of greenhouse-gas emissions in the transformation, demand and non-energy use sectors over the *Outlook* period. The transformation sector is further broken down into electricity generation and oil and gas production and refining. Switching from oil to natural gas and renewable energy in the power sector results in a modest decline in emissions, from 44.6 Mt CO_2-eq in 2015 to 41.4 Mt CO_2-eq in 2035, although emissions from oil and gas production increase by about 55% in 2015-2035.[41]

[40] The LEAP model used in this analysis measures the level and origin of greenhouse-gas emissions arising from the oil and gas supply chain in CO_2-equivalent terms.

[41] Methane and volatile organic compounds (VOCs) are emitted in oil and gas production from un-combusted fuel gas and diesel, emissions from tanks without vapor recovery units, offshore loading, vents, fugitive emissions (leaks and spills), gas flaring, and well testing.

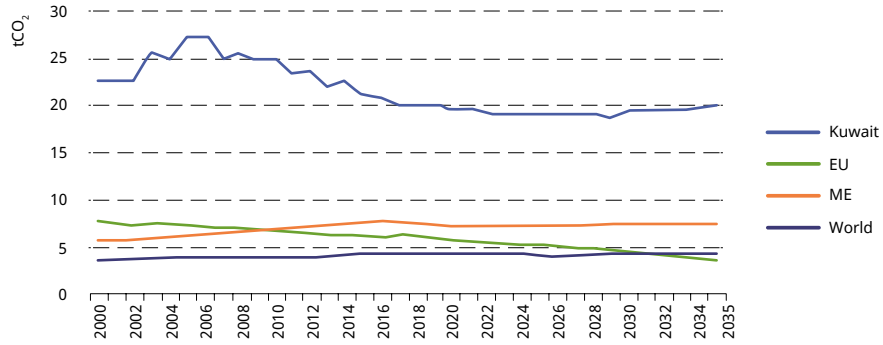
Figure 2.8 | CO_2–equivalent emissions by sector in the Business-as-Usual Case



The demand sector is comprised of the residential, services, industry and transport sectors. Greenhouse-gas emissions in these sectors increase from 27.2 Mt CO_2-eq in 2015 to 45.4 Mt CO_2-eq in 2035, at an average rate of 2.6% per year. Emissions in the industry and transport sectors account for nearly all of the increase. In the industry sector, emissions rise by 2.2% per year, reaching 21.8 Mt CO_2-eq in 2035, a 55% increase over emissions in 2035. It is the transport sector, however, that is the largest contributor to rising greenhouse-gas emissions over the projection period. The 10.4-Mt CO_2-eq increase in emissions outstrips increases in all other sectors.

Per-capita greenhouse-gas emissions fall slightly in Kuwait, from 21.1 tonnes of CO_2 per capita (tCO_2/k) in 2015 to 20.2 tCO_2/k in 2035, but are still far greater than the world average and the average in European Union and Middle East countries over the *Outlook* period (Figure 2.9).

Figure 2.9 | Emissions per capita in Kuwait compared to the average for the European Union, Middle East countries and the world in the Business-as-Usual Case



Note: Average emissions per capita for the world and for the European Union and Middle East are calculated using growth rates in the New Policies Scenario of the International Energy Agency's WEO-2018.

CHAPTER 3

Implications of the *Outlook* for Kuwait's Energy Future

Highlights

- Kuwait's economy is heavily dependent on oil-export revenues, and the country is thus vulnerable to oil price declines. The country's economic development initiative, New Kuwait 2035, will open up its communications, infrastructure, manufacturing and finance sectors to investment, but the government will retain full ownership of oil and natural gas resources. Instead of relying predominately on oil products exports, Kuwait might consider entering into joint ventures in refining and marketing of hydrocarbons, such as plastics and fibers, further up the value chain.

- Kuwait released the *White Paper on a Sustainable National Energy Strategy* in 2017, which recommended, among other things, the establishment of a national champion to implement the strategy. In a promising first step, the Higher Energy Committee was set up in 2018 to improve coordination between ministries, regulatory agencies, infrastructure operators, and service providers, a necessary first step to developing a national energy strategy.

- The lack of coordination between Kuwait's energy institutions is the primary reason for the slow development and deployment of renewable energy technologies. The dearth of private sector participation in Kuwait's power sector has also contributed to the slow adoption of renewables. Kuwait Authority for Partnership Projects negotiated Shagaya's public-private partnership on behalf of the government. The success of this project might just convince the government that opening up more sites for renewable energy is necessary for its plans to increase renewables capacity.

- Pricing reform and energy efficiency offer major opportunities to rationalize consumption and encourage more diversified growth, without foregoing the economic opportunities to capitalize on abundant energy resources. The pace of energy subsidy removal in Kuwait has been slow compared to some other resource-rich countries. Energy efficiency measures offer the *least-cost pathway* to energy and greenhouse gas emission reductions and to an increase in energy supply security.

- Oil demand in the transport sector in Kuwait is projected to grow rapidly, due to heavy subsidization of motor gasoline and diesel. Not surprisingly, greenhouse-gas emissions in the transport sector in Kuwait nearly double, from 12.5 Mt CO_2-eq in 2015 to 22.9 Mt CO_2-eq in 2035. Whereas, in 2015, emissions accounted for 15% of total greenhouse-gas emissions in Kuwait, they account for 22% of total emissions in 2035. The rapid growth in demand and emissions in the transport sector should be a significant cause for concern in Kuwait, primarily because both are anticipated to rise in an environment offering few alternatives to private vehicle transportation.

- The paucity and opacity of energy statistics preclude a more detailed and comprehensive analysis of Kuwait's energy future. While the Central Statistics Bureau in Kuwait has a critical role as the nation's data clearinghouse, its mandate is primarily to focus on collecting macroeconomic data. The energy sector is neglected as a result, particularly energy demand statistics in the industry and services sectors. Capacity training and a focus on hiring energy experts would vastly improve data collection and ultimately the quality of energy policy analysis. This first national energy outlook, spearheaded by Kuwait Institute for Scientific Research and sponsored by the General Secretariat of the Supreme Council of Planning and Development, is intended to raise awareness by shedding a light on the difficulties of undertaking the proper analysis to guide meaningful reform of Kuwait's energy sector.

Introduction

Kuwait is a major hydrocarbons producer and exporter, and, as such, its economy is characterized by one of the highest levels of energy and carbon intensity in the world. In the Business-as-Usual Case presented here, the energy sector is not expected to make much headway toward a more sustainable future. The role of renewables in the electricity generating mix will increase, although at a much slower pace than the global average and even compared to several GCC countries. Some improvements in energy efficiency will be achieved with the enforcement of stricter codes and regulations in the buildings sector, but meaningful energy price reform shows no sign of being a government priority. Oil products will still account for a quarter of fuel use for power generation, and demand for oil in the transport sector grows rapidly. This chapter highlights actionable plans, which, if implemented, could transform Kuwait's energy future.

Increasing the Economic Value of Oil Resources

Like all producer economies, Kuwait faces an uncertain future with respect to its potential oil revenues. Over the *Outlook* period, oil prices are likely to show more volatility. This will impact future income flows and could create obstacles to effective macroeconomic management. Moreover, given that climate and environmental concerns are likely to put pressure on global oil demand growth, Kuwait will face stiffer competition in key markets, particularly if unconventional oil supplies capture a growing share of global oil supply. In the downstream oil sector, Kuwait will need to ensure that its refineries, through upgrades, such as desulphurization and related secondary processing improvements, meet global demand for clean and high-quality oil products.

Kuwait's economy is heavily dependent on oil-export revenues, with the share of revenue in GDP topping 40% in 2017. This dependency leaves Kuwait extremely vulnerable to oil price declines. Policies aimed at diversifying the economy, through opening up certain sectors, including communications, infrastructure, manufacturing and finance, do not encompass Kuwait's oil and natural gas resources. To increase the value-added of its vast resources, Kuwait might consider increasing investment in the production and marketing of products further up the value chain, such as plastics and fibers.

Oil and gas currently dominate the chemical feedstock market. Regions, such as the Middle East, tend to contribute large volumes to the global production of primary chemicals. They are also at the lower end of the cost curve among producing countries.

Middle East countries account for less than 15% of the world's capacity for high-value chemicals (HVCs), ammonia and methanol.[42] Moreover, these countries, including Kuwait, tend to export oil products instead of using them as a local feedstock. Only about a quarter of crude oil produced in Middle East countries is refined locally.

Recognizing the potential for growth, the Petroleum Industries Company in Kuwait is pursuing opportunities to expand growth in Kuwait's petrochemical sector. Its most important strategic project was a recent joint venture with a Canadian company for a polypropylene plant, likely to be commissioned in 2023. A 4th Olefins project is also anticipated to get off the ground by 2025. Securing approval for these and other projects is, and will continue to be, a priority for Kuwait Petroleum Corporation.

Developing a "National Champion" in Kuwait

The implementation of a national energy strategy requires a "National Champion" to coordinate the multiple dimensions of the strategy and provide the interface between and across various levels of government and stakeholder institutions. Many countries have established a champion with positive results. After setting up its national coordinating institute, Nicaragua went from being a net energy-importing country to scaling up renewables to over 50% of electricity production in 2015. The country has set a target for a 90% share by 2020 (Table 3.1).

Table 3.1 | "National Champion" success stories

United Arab Emirates	Supreme Council of Energy (Dubai)	The Supreme Council was established in 2009 and tasked with ensuring that long-term growth be powered by a sustainable energy strategy. The Council develops strategy, governance and policy frameworks and is supported by the Regulatory and Supervisory Bureau, and Market Enabler and Advisory, in promoting renewable energy, energy efficiency and environmental protection. The Council launched the UAE's first Integrated Energy Strategy in 2011, setting diversification and efficiency targets for 2030 including a 30% savings compared to a business-as-usual scenario, achieved through an increase in energy tariffs and mandatory supply and demand-side efficiency measures such as energy-efficient appliances and temperature controls in government buildings.

[42] International Energy Agency (2018).

Qatar	National Champion for the Environment	The First National Development Strategy (2011-16) incorporated broad objectives for energy efficiency improvements in the electricity and water sectors and appointed a national champion for the environment to raise awareness and commitment through demonstration projects and conservation partnerships.
Nicaragua	Instituto Nicaragüense de Energia	The Nicaraguan Energy Institute (INE) was established in 1998 to implement energy policy and regulation. It is overseen by an executive board of three energy professionals who are elected by 60% of the National Assembly members for six-year terms. INE monitors environmental compliance, gathers commercial and technical information, and publishes legal information and actions taken by regulators on its website. The INE fosters relations with the following institutions: National Assembly; Ministry of Energy and Mines; Ministry of the Environment and Natural Resources; Ministry of Development, Industry and Trade; Ministry of Transportation and Infrastructure; Ministry of Finance and Public Credit; Attorney General's Office; and Public Prosecutor's Office.

Source: Oxford Institute for Energy Studies et al, (2017).

Kuwait released the *White Paper on a Sustainable National Energy Strategy* in 2017, which recommended, among other things, the establishment of a national champion to implement the national action plans in the *White Paper*. The Council of Ministers approved the recommendation and set up the Higher Energy Committee in 2018. The Committee is tasked with strengthening Kuwait's participation in international decision-making forums; improving horizontal coordination between ministries, regulatory agencies, infrastructure operators, and service providers; and enhancing coordination between central, regional, and local government agencies and stakeholders.[43] Successful implementation of the energy strategy will require the separation of policy-making institutions from regulatory institutions, combined with a clear demarcation of their remit and procedures for interface. National champions require support from a national research unit, such as the Kuwait Institute for Scientific Research, which has the technical expertise to monitor international energy markets and provide data and support for the implementation of the national energy strategy (see Box 3.1).

[43] International Energy Agency (2018).

Box 3.1 | Kuwait Institute for Scientific Research: leading Kuwait into a sustainable energy future

Kuwait Institute for Scientific Research (KISR) was established in 1967 to conduct research on crude oil recovery, desert agriculture and marine biology. Its mandate was broadened in the late 1970s and early 1980s to include applied scientific and technological research in solar energy adaptions and applications in Kuwait. At the time, the potential for solar air-conditioning in Kuwait was considered to be quite substantial. The Solar Energy Department at KISR spearheaded the construction and maintenance of a solar house, initiated a solar cooling project in a primary school and developed performance characteristics for a solar absorption cooling system. The department also developed the Sulaibiya co-generation solar thermal power plant, which included a power distribution network and a water pumping and distribution network (Figure 3.1).

Figure 3.1 | Solar thermal power plant at Sulaibiya in 1981

Note: The Sulaibiya solar thermal plant, with capacity of 100 kW electricity and 700 kW thermal, was inaugurated in February 1981.
Source: Photo from the Energy and Building Research Center Archives at Kuwait Institute for Scientific Research, courtesy of Dr. Majed Al-Rasheedi.

KISR played a fundamental role in the realization of Kuwait's first energy conservation code of 1983, with the implementation of energy and power-saving schemes and cost-benefit assessments of the potential impacts of the code on energy demand in the buildings sector. Energy efficiency is one of the most cost-effective ways to enhance security of supply, to boost competitiveness and welfare and to reduce the environmental footprint of the energy system. The Institute's efforts were focused on lowering peak power demand and energy consumption, accomplished through auditing office buildings, schools and shopping malls. The energy audits resulted in energy consumption reductions at various sites of up to 30%. Demand-side management programs were coupled with photovoltaic systems in schools for optimum energy savings.

Renewable energy and energy efficiency measures are two of the cornerstones of any strategy to guarantee sustainable and inclusive economic growth. Over the past several decades, KISR has taken an integrated approach in its applied research on renewable energy and energy efficiency. The Institute played a vital role in contributing to the analysis for Kuwait's 2017 *White Paper on a Sustainable National Energy Strategy*.

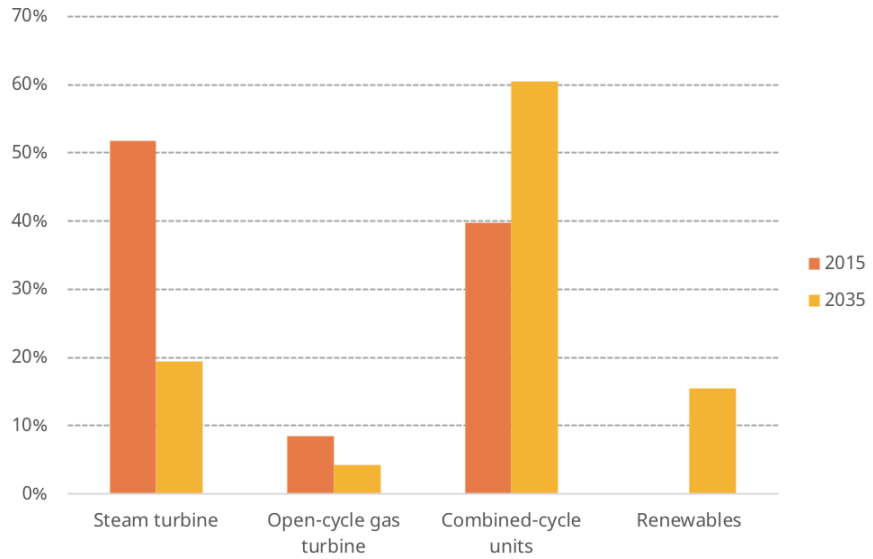
KISR's current role and responsibilities include the publication of reports addressing key challenges, such as the preservation of the environment, sustainable management of Kuwait's natural resources, responsible management of water and energy, and development of innovative methods of agriculture. KISR conducts scientific research and performs technological consultations, often in strategic partnerships with other regional and international institutes, agencies and academic bodies, allowing an exchange of knowledge, data and expertise. Today, KISR is home to over 580 researchers and engineers and over 100 laboratories, housed at 9 locations.

The national champion plays an important role in guiding countries toward a more sustainable future, which will enhance the socioeconomic welfare of their citizens. In this regard, efforts need to be made to raise public awareness and involve the public, civil societies, politicians and elites in energy planning. Communication campaigns targeting the private sector, businesses and educational institutions are an important way to increase awareness.

Boosting the Role of Renewable Energy

Despite Kuwait's vast solar and wind resources, the country has only recently started to harness its renewable energy potential. The first renewable-energy plants were built at the Shagaya complex. Today, renewable energy capacity at the plants accounts for less than 1% of total generating capacity in Kuwait. While, over the *Outlook* period, renewable-energy generation capacity is expected to increase to 5 GW, this capacity will still be insufficient in meeting the Emir's stated goal of 15% of energy demand from renewable energy by 2030 (see Annex A). Kuwait is planning a significant expansion in its generating capacity, mainly combined-cycle plants, over the next couple of decades (Figure 3.2). Ramping up renewables capacity and retrofitting or purchasing flexible units, however, would be a more sustainable path forward. While the choice of fuel for power generation can be largely attributed to the fact that Kuwait is rich in fossil fuel resources, the overall structure of the power sector itself in Kuwait adds to the slow adoption of renewables.

Figure 3.2 | Generation technology as a percentage of total installed capacity in 2035 versus 2015



Kuwait has several government institutions participating at varying levels in the power sector, all with different mandates. The Ministry of Electricity and Water is a vertically-integrated utility that oversees all aspects of generation, transmission and distribution electricity, as well as the production of most of Kuwait's drinking water. Kuwait Authority for Partnership Projects is tasked with negotiating power purchase agreements for IWPPs in the country. Kuwait Foundation for the Advancement of Sciences sponsors distributed-photovoltaic projects, and the design and implementation of the first phase at the Shagaya complex was overseen by Kuwait Institute for Scientific Research.

The lack of coordination between these various institutions is the main reason for the slow development and deployment of renewable energy technologies. The Higher Energy Committee, set up in 2018 by the Council of Ministers, was tasked with improving coordination between and among ministries, regulatory agencies, infrastructure operators and service providers. An important responsibility of the Committee will be to address the lack of coordination, which impedes additional renewables capacity in Kuwait. The Committee could eventually serve as a public utility commission and set policy for power sector participants in Kuwait. The committee could also be empowered to enforce decisions under a clear regulatory framework with minimal intervention from higher levels of government.

The dearth of private sector participation in Kuwait's power sector has also contributed to the slow adoption of renewables. The Az Zour North power station is the first independent water and power project in Kuwait. Kuwait Authority for Partnership Projects (KAPP) negotiated the public-private partnership on behalf of the government. Shagaya's public-private partnership was similarly negotiated by KAPP for the government. In order to increase renewable capacity, the government should consider allocating more sites for renewable projects. Private sector participation could also be expanded through foreign direct investment. While Kuwait has been trying to increase FDI for many years, laws, such as Kuwait Law No. 116/2014 governing PPPs, have discouraged these inflows. Law No. 116/2014 stipulates that a public joint company must be established with a 50% share for Kuwaiti citizens, at least 26% for the private investor, and at least 6% of the remaining shares allocated to the public entity (or entities) overseeing the project.

Tackling the Demand-Side

Pricing reform and energy efficiency offer major opportunities to rationalize consumption and encourage more diversified growth, without foregoing the economic opportunities to capitalize on abundant energy resources. The pace of energy subsidy removal in Kuwait is slow compared to other resource-rich countries. Energy efficiency measures offer the least-cost pathway to energy and greenhouse gas emission reductions and increasing energy supply security.

The policy solutions for energy efficiency are well known, including regulations and standards, market-based incentives and innovative financing models. Regulatory approaches are crucial in many sectors. Standards and codes should increase in strength incrementally over time, with coverage expanding to other sectors and economies. Other strategic supporting policies will also be required. These include information and incentive-based policies, such as labeling and fiscal measures, which help to develop the market for efficiency products and prepare the ground for tighter regulations in future.

Table 3.2 illustrates policies to increase energy efficiency. District cooling, for example, can take away the summer peak demand in electricity. Although district cooling needs electricity as a driving force itself, the demand for electricity per unit cooling delivered is much lower than with traditional local cooling production. Areas with district cooling are much less likely to be confronted with shortages in power supply. In many countries, standards and labeling programs have enhanced manufacturing innovation and market transformation by driving appliance manufacturers to find new and cheaper ways to improve efficiency. This has led to enhanced employment outcomes, and a range of other benefits, including improvements in air-quality and the reduction of public expenditure on health, and enhanced energy security.

Table 3.2 | Policy reforms to achieve energy-efficiency goals in Kuwait

Energy efficiency measures	Enforce and update building regulations and codes to reduce energy demand for air-conditioning. Enhance the arrangement of windows in buildings to increase efficiency and install photovoltaic building integrated systems. Invest in building retrofits. Invest in district cooling. Implement a standardized labeling program for appliances and equipment. Promote energy service companies to market energy efficiency programs to consumers and support consumers in estimating energy savings.
Energy pricing reforms	Gradually replace universal subsidies with targeted cash transfers or compensation schemes to eligible consumers. Clearly define a price adjustment mechanism for future price movements. Incorporate measures to protect energy-intensive firms in the economy from the inflationary effect of price increases. Launch a sustained, long-term public awareness campaign ahead of energy price reforms.

Source: Oxford Institute for Energy Studies, et al. (2017).

Focus on the Transport Sector: Unchecked Growth is Unsustainable

Oil demand in the transport sector in Kuwait is projected to increase by 3% per year from 2015 to 2035. According to the International Energy Agency, the growth rate in global transport oil demand will be dramatically lower, 0.6% per year in the period to 2040. Greenhouse-gas emissions in the transport sector in Kuwait also increase rapidly, by 3.1% per year over the projection period, nearly doubling, from 12.5 Mt CO_2-eq in 2015 to 22.9 Mt CO_2-eq in 2035. Whereas, in 2015, emissions accounted for 15% of total greenhouse-gas emissions in Kuwait, they account for 22% of total emissions in 2035.

Emissions of carbon monoxide, nitrogen oxide and non-methane VOCs increase by more than 80% over the projection period, with deleterious effects on air quality in Kuwait. The rapid growth in demand and emissions in the transport sector should be a significant cause for concern in Kuwait, primarily because both are anticipated to rise in an environment offering few alternatives to private vehicle transportation.

In Kuwait, the private vehicle stock is expected to triple and SUVs are anticipated to account for 60% of the market in 2035. Car-pooling and "park-and-ride" programs are nonexistent, and both public and private bus ridership is low. Motor gasoline and diesel prices are the lowest in the world.

In most countries, the introduction of fuel efficiency standards for passenger vehicles has been the most effective way of increasing fuel efficiency. Providing citizens with a modern, efficient, mass public transportation system, including metro lines, trams and buses, have proven to be very successful ways to better manage growth in demand for transport all over the world. Governments can also offer incentives for the purchase of electric and hybrid vehicles. A necessary first step, however, is often the most difficult – raising the price of motor gasoline and diesel.

Improving Data Collection and Reliability

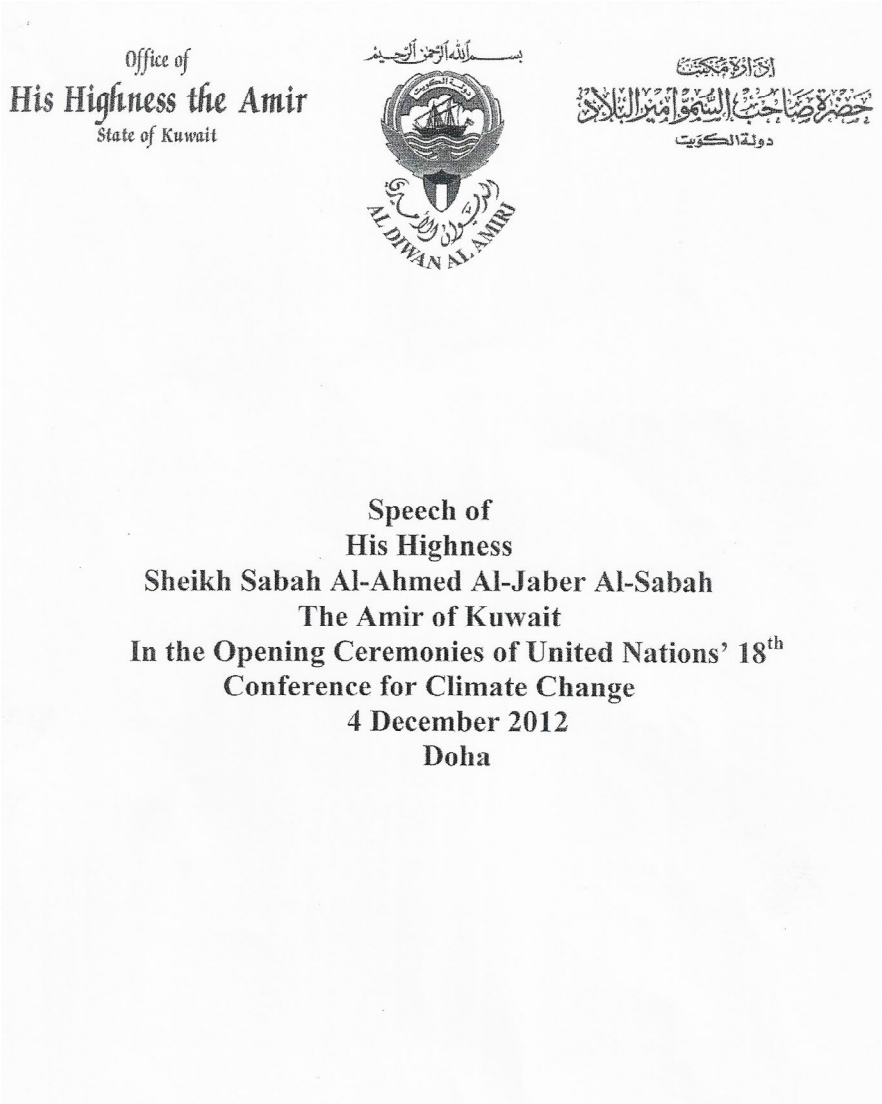
Collecting data from different sources for the energy analysis here was an inefficient, unnecessarily laborious and time-consuming process in most cases. Often government entities required the submission of an official letter, which hindered the data collection process. Some government entities would only receive these letters by courier. Even when electronic mail was acceptable, there was still considerable follow-up required to ensure that the enquiries were sent to the relevant department. The majority of the departments were found to have a cooperative and competent staff that was able to provide the required statistics. In some cases, however, data were only available in hard copy. Attention to rectifying the constraints in obtaining data and statistics would greatly improve the robustness and scope of future analyses and outlooks.

The Central Statistics Bureau (CSB) in Kuwait has a critical role as the nation's data clearinghouse, but its mandate is primarily to focus on collecting macroeconomic data. The energy sector is neglected as a result. Capacity training and hiring more energy experts would greatly improve the quality of CSB data and, consequently, energy policy analysis.

The ultimate goal for policy makers in Kuwait is the creation of a national energy balance. Since energy data are generally collected independently across different commodities, energy balances provide the simplest way to present the data for one fuel together, expressed in physical units. As energy products are ultimately used for their energy content, and can also be converted into one another through a number of transformation processes, there's a need to combine commodity balances to get a view of the energy system. This requires the development of an energy balance. The energy balance presents all the data in a common energy unit. This allows users to see the total amount of energy used and the relative contribution of each different source, for the whole economy and for each individual consumption sector. In addition, it allows users to compute the various energy transformation efficiencies; to develop several aggregated indicators (for example consumption per capita or per unit of GDP); and to estimate CO_2 emissions from fuel combustion.

Annex A

Emir's Statement on Renewable Energy



Office of
His Highness the Amir
State of Kuwait

بسم الله الرحمن الرحيم

ديوان الأمير
حضرة صاحب السمو أمير البلاد
دولة الكويت

AL DIWAN AL AMIRI

Speech of
His Highness
Sheikh Sabah Al-Ahmed Al-Jaber Al-Sabah
The Amir of Kuwait
In the Opening Ceremonies of United Nations' 18th
Conference for Climate Change
4 December 2012
Doha

Office of
His Highness the Amir
State of Kuwait

بسم الله الرحمن الرحيم

ديوان حضرة صاحب السمو أمير البلاد
دولة الكويت

In the Name of Allah, the Most Merciful, the Most Compassionate

His Highness and dear brother Sheikh Hamad Bin Khalifa Al-Thani
Amir of the State of Qatar

Highnesses and Excellencies,

His Excellency Mr. Abdullah Bin Hamad Al-Atiyya – Chairman of the conference

His Excellency Ban Ki-moon – UN Secretary General,

Ladies and Gentlemen,

Dear Attendees,

Peace be upon you all,,

I am pleased to take this opportunity to express my sincere thanks and deep appreciation to the Emir, government and people of the State of Qatar, for the warm reception and generous hospitality and good organization of this important international conference, held under the umbrella of the United Nations, and the great efforts exerted in order to make it a success and to achieve its desired objectives.

I would like also to congratulate His Excellency Abdullah Bin Hamad Al-Atiyya for his selection as a Chairman of this conference. I am confident that the wisdom and experience he enjoys shall contribute to the success of this conference, and reaching the desired objectives and results as anticipated by our states.

And I am also pleased to take this opportunity to express to His Excellency the Secretary-General of the United Nations Ban Ki-moon, and the executive head of the UN Framework Convention on Climate Change Ms.

Office of
His Highness the Amir
State of Kuwait

بسم الله الرحمن الرحيم

ديوان حضرة صاحب السمو أمير البلاد
دولة الكويت

Christiana Vigiris and her assistants my sincere thanks for their work for the well prepared for this conference, which deserves our appreciation and praise.

Highnesses and Excellencies,

It is our pleasure to see this high-level international participation in this conference, which reflects the great importance that the international community attaches to the issue of climate change, which has become an obsession for all the states and peoples of the world.

The State of Kuwait supports the efforts of the United Nations in the fight against climate change, through its active participation in the ongoing negotiations aimed at reducing the negative effects of this phenomenon, based on the principles and provisions contained in the United Nations Framework Convention on Climate Change and the Kyoto Protocol and their effective and sustainable implementation as the legal binding instrument and the basis for international cooperation in this field, especially the principle of shared responsibility, taking into account the variation of burdens and capacities, justice and sustainable development of different countries in line with their national priorities and capacities, in order to reduce emissions in materialization of the ambitions of all our peoples.

Highnesses and Excellencies,

This conference is held in the State of Qatar in a crucial stage which requires adopting decisions that pave the way for the next phase beyond 2012 towards this phenomenon, and adapting to it whether within the frame of long-term cooperation through effective implementation of the Bali Action Plan in all its elements, and the agreement on the second commitment period for developed countries, without imposing new obligations on developing countries, except for those voluntary actions which commensurate with their national potentials backed with financing, technology transfer and capacity building.

Office of
His Highness the Amir
State of Kuwait

بسم الله الرحمن الرحيم

إدارة مكتب
حضرة صاحب السمو أمير البلاد
دولة الكويت

AL DIWAN AL AMIRI

The State of Kuwait also hopes that the developed countries abide by their leading role in reducing emissions and helping developing countries adapt to the adverse effects of climate change, and the negative effects resulting from the measures of responding to mitigating the effects of climate change, especially those whose economies rely on the use of fossil fuels as a major and sole source of income, and this can be achieved through the transfer of technology and the diversification of income sources.

Highnesses and Excellencies,

In contribution to the emission reduction the State of Kuwait made great voluntary and thoughtful strides, according to available resources, in the rehabilitation of its oil and industrial installations , where the oil sector adopted a new strategy based on scientific and economic grounds that aim to reduce emissions, as well as setting mechanisms for improving energy efficiency, and the use of clean technology for fossil energy, without prejudice to its fundamental interests and obligations in its the development of clean industry.

In the field of renewable energy, the State of Kuwait attached great concern to the diversification of its energy sources, where the concerned entities started the executive phases of an ambitious plan for using wind and solar energy aiming to raise the percentage of using this energy to 1% of the total energy usage in Kuwait in 2015, and up to 15% in 2030.

In conclusion, I repeat my thanks and gratitude to the State of Qatar for hosting this conference, hoping to achieve its desired ambitions and hopes that will positively reflect upon our peoples and achieve good and benefit of all mankind.

Peace be upon you all,,

Annex B

Acronyms and General Conversion Factors

CFP	Clean Fuels Project
CO_2	Carbon dioxide
CSB	Central Statistics Bureau
CSP	Concentrated solar power
EIA	Energy information Administration, United States
EPF	Early production facility
FDI	Foreign Direct Investment
GCC	Gulf Cooperation Council
GCCIA	Gulf Cooperation Council Investment Authority
GDP	Gross domestic product
HEC	Higher Energy Council
IEA	International Energy Agency
IWPP	Independent water and power project
KAPP	Kuwait Authority for Partnership Projects
KFAS	Kuwait Foundation for the Advancement of Sciences
KGOC	Kuwait Gulf Oil Company
KIPIC	Kuwait Integrated Petroleum Industries Company
KISR	Kuwait Institute for Scientific Research
KNPC	Kuwait National Petroleum Company
KOC	Kuwait Oil Company
KOTC	Kuwait Oil Tanker Company
KPC	Kuwait Petroleum Corporation
KPI	Kuwait Petroleum International
KUFPEC	Kuwait Foreign Petroleum Exporting Company
KWD	Kuwaiti dinar
LEAP	Long-term Energy Alternatives Planning

LEAP	Long-term Energy Alternatives Planning
LNG	Liquefied natural gas
MED	Multi-effect distillation
MEW	Ministry of Electricity and Water
MSF	Multi-stage flash
OECD	Organisation for Economic Cooperation and Development
OPEC	Organization for Petroleum Exporting Countries
PIC	Petrochemical Industries Company
PPP	Purchasing power parity
RO	Reverse osmosis
SPC	Supreme Petroleum Council
SUVs	Sport utility vehicles
UAE	United Arab Emirates
UNFCCC	United Nations Framework Convention on Climate Change
VOCs	Volatile organic compounds
WEO	World Energy Outlook

General conversion factors for energy

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

Annex C

References

Chapter 1: Energy in Kuwait Today

E. Al-Sayed and O. Assem (2003), "Kuwait Code for Energy Conservation in Buildings," *Energy Efficiency for Fueling the World – Proceedings of Energy Conservation in Buildings Workshop, December.*

Environment Public Authority (EPA) (2018), "Greenhouse Gas Inventory Report, Kuwait's Second National Communications under the United Nations Framework Convention on Climate Change", EPA, State of Kuwait.

Fadlemawla, A., "Desalination Role in Kuwait's Water Sector", Kuwait Institute for Scientific Research, www.arabclimateinitiative.org.

Gillingham, K., D. Rapson and G. Wagner (2016), "The Rebound Effect and Energy Efficiency Policy," *Review of Environmental Economics and Policy*, Volume 10, Number 1, January.

Gulf Cooperation Council Interconnection Authority (GCCIA) (2018), "Annual Report 2017 – Energy Exchanges between GCC Countries," page 30, GCCIA, http://www.gccia.com.sa/Data/Downloads/Reports/FILE_22.pdf.

Ingram, Jamie (2018), "Kuwait Eyes Further Partnerships With IOCs To Secure Oil Production Gains", Gulf editor, *Middle East Economic Survey*, https://www.cwckuwait.com/wp-content/.../Jamie-Ingram-CWC-Kuwait-Article-3.pdf.

International Monetary Fund (IMF) (2018), *World Economic Outlook*, IMF, Washington, DC.
- (2017), "Kuwait: Selected Issues", IMF, Washington, DC, 21 December.

Krarti, Moncef (2015), "Evaluation of large scale building energy efficiency retrofit programs", *Renewable and Sustainable Energy Reviews* 50, 1069-1080.

Mollet, Paul, Imtenan Al-Mubarak, Brian Efird, Saleh Al Muhanna and Omar Al-Ubaydli (2018), "Assessment of the Political Feasibility of Developing a GCC Power Market", King Abdullah Petroleum Studies and Research Center, September.

Organization for Arab Petroleum Exporting Countries (OAPEC) (2017), *Annual Statistical Report*, OAPEC.

Oxford Institute for Energy Studies, Kuwait Institute for Scientific Research and Kuwait Foundation for the Advancement of Sciences (2017a), "The Future of Kuwait's Energy System: Mitigating threats and seizing opportunities", *White Paper on a Sustainable National Energy Strategy*, University of Oxford, February.

Oxford Institute for Energy Studies (2017b), "Assessing Kuwaiti Energy Pricing Reforms", University of Oxford, November.

United States Energy Information Administration (US EIA) (2016), "Kuwait Country Profile," US Department of Energy, 2 November.

Chapter 2: Kuwait's Energy Outlook to 2035

Alsayegh, O. and Fattouh, B. (forthcoming), "Present and Future Role of Natural Gas in Kuwait" in *The Future of Gas in the Gulf: Continuity and Change*, ed. Jonathan Stern, The Oxford Institute for Energy Research, University of Oxford.

Alsayegh, O., Saker, N. and Alqattan, A. (2016), "Embedding Energy Sustainability in the Second Development Plan of Kuwait", Kuwait Institute for Scientific Research.

Environment Protection Agency (EPA) (2012), "Kuwait's Initial Communications under the United Nations Framework Convention on Climate Change", Environment Protection Agency, State of Kuwait.

Jaffar, B., T. Oreszczyn, R.M. Raslan and A. Summerfield, (2018), "Understanding energy demand in Kuwaiti villas: findings from a quantitative household survey", *Energy and Buildings* 165.

Shehabi, Manal (2017), "Assessing Kuwaiti Energy Price Reforms", The Oxford Institute for Energy Studies, Oxford University, November.

Chapter 3: Implications of the *Outlook* for Kuwait's Energy Future

International Energy Agency (2018), *The Future of Petrochemicals: Towards more sustainable plastics and fertilisers*, IEA, Paris.

Oxford Institute for Energy Studies, Kuwait Institute for Scientific Research and Kuwait Foundation for the Advancement of Sciences (2017), "The Future of Kuwait's Energy System: Mitigating threats and seizing opportunities", *White Paper on a Sustainable National Energy Strategy*, University of Oxford, February.

آفاق الطاقة في دولة الكويت
Kuwait Energy Outlook