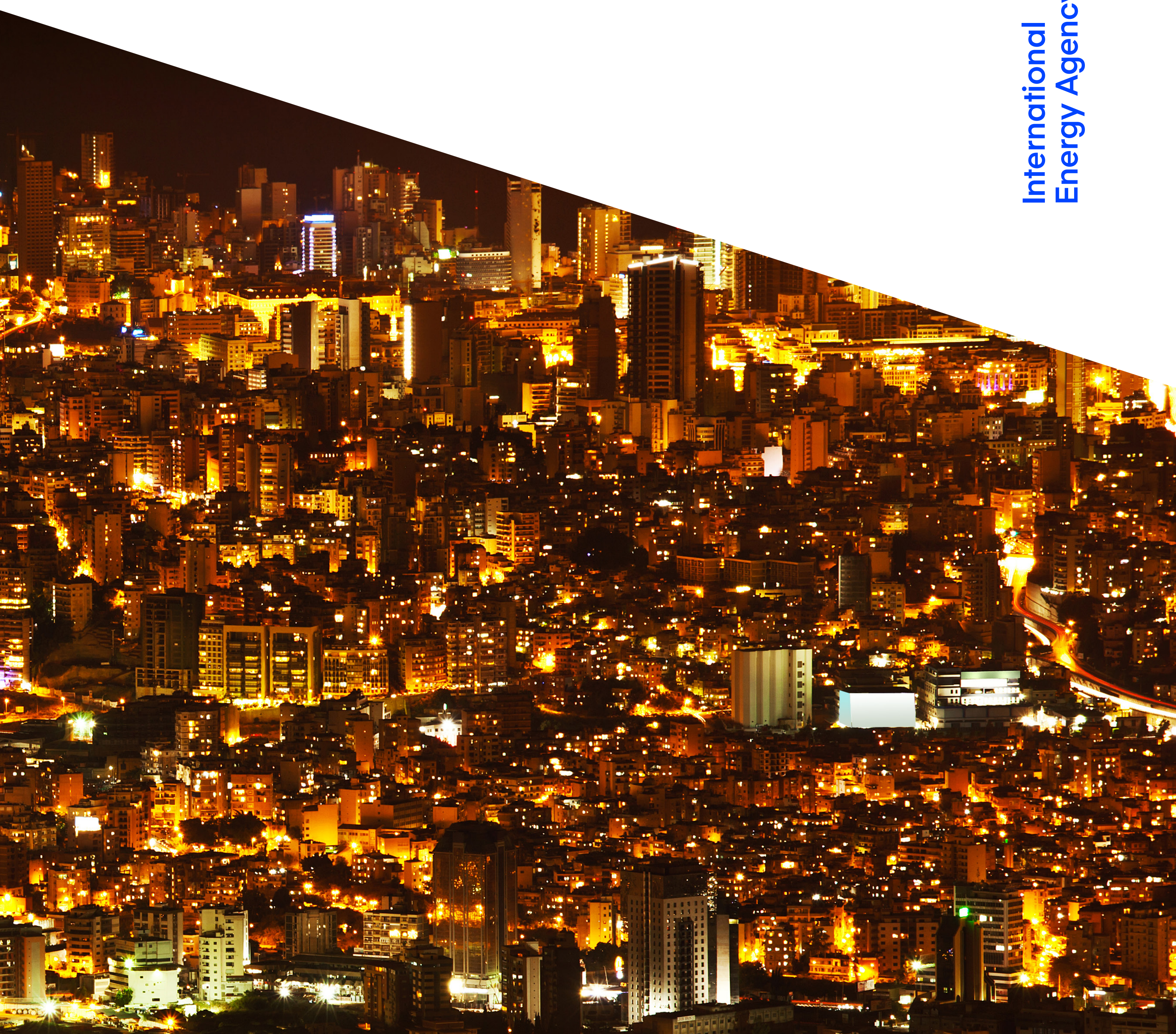
The Future of Electricity in the Middle East and North Africa



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Abstract

This study analyses electricity demand in the Middle East and North Africa (MENA) region and its evolution to 2035. MENA has long been a cornerstone of global energy supply. But the region is fast becoming a central character in the story of global energy demand, particularly that of electricity use. Rapid population growth, urbanisation, and rising temperatures are driving up electricity demand. Since 2000, MENA has become one of the top contributors to global electricity demand growth.

The region's climate, characterised by extreme heat and water scarcity, implies that reliable and resilient electricity systems are integral to meeting soaring demand for cooling and water desalination. This outlook provides an unprecedented regional overview of demand patterns for cooling and water desalination including country-level data.

How countries across the region meet this increased demand will have profound implications for the region's economic future but also for global energy markets. This report also explores the challenges and opportunities to sustainably meet electricity demand growth by exploring the potential of both demand and supply side policies and measures.

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The study was designed and directed by Brent Wanner, Head of the Power Sector Unit, and Ali Saffar, Head of Division for Europe, Middle East, Africa and Latin America. The lead authors and co-ordinators of the analysis were Yasmine Arsalane (electricity supply); Anthony Vautrin (electricity demand) and Nadim Abillama (regional overview). Key contributors to the report were: Yasmina Abdelilah (renewables), Julie Dallard (hourly modelling), Michael Drtil (grids), Eric Fabozzi (electricity supply), Sangitha Harmsen (electricity demand), Nikolaos Papastefanakis (hourly modelling), Ryota Taniguchi (policies), and Matthew Van der Beeuren (state of play).

Other contributors were: Oskaras Alsauskas, Alessandro Blasi, Annie Berget, Jose Miguel Bermudez Menendez, Mathieu Breier, Eren Çam, Nouhoun Diarra, Musa Erdogan, Insa Handschuch, Jérôme Hilaire, Martin Kueppers, Rena Kuwahata, Alex Martinos, Pietro Rinaldi, Max Schoenfisch, Olivier Sussfeld, Courtney Turich and Jacques Warichet.

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They include:

Abdulaziz Al-Shalabi	Environment Public Authority, **Kuwait**
Abdullah Al-Abri	Sohar Port and Free Zone, **Oman**
Abdullah Shiriqi	Authority for Public Services Regulation (APSR), **Oman**
Abdulrahim B. Al Baram	Ministry of Energy and Minerals, **Oman**
Abdulrahman Baboraik	Majan Council
Ahmed Abdel Magied	EDF
Ahmed Al Abri	Hydrom, **Oman**
Ahmed Al Falasi	Abu Dhabi Department of Energy, **United Arab Emirates**
Ahmed Al Hatrooshi	Integrated Engineering & Technology LLC
Aisha Al Sarihi	Ministry of Economy, Oman
Al Mukhtar Al Saifi	SIPC
Ali Alsamawi	International Energy Forum (IEF)
Ali Moshref	Ministry of Electricity, Energy and Water, **Yemen**
Ammar Naji	Hitachi Energy
Badr N. Yasser Al Shaqsi	GCC-STAT
Carlos Travesedo	Abu Dhabi Department of Energy, **United Arab Emirates**
Dawud Al Ansari	Majan Council
Firas A Al-Abduwani	Ministry of Energy and Minerals, **Oman**
Haitham Al Omairi	Sohar Port & Freezone, **Oman**

Haneen Ahmad	Ministry of Energy and Mineral Resources, **Jordan**
Hesham Tashkandi	ACWA Power
Hilal Al Adawi	SIPC, **Oman**
Hiroshi Hasegawa	Japan External Trade Organization (JETRO)
Hisham Riyami	Oman Electricity Transmission Company (OETC), **Oman**
Hitesh Shah	Integrated Engineering & Technology LLC
Ismail Al Arfi	General Secretariat of the Council of Ministers, **Oman**
Jauad ElKharraz	Water Energy Climate Experts Network (WECEN)
Karim Benamrane	Ministry of Energy, **Morocco**
Karim Elgendy	Carboun Institute
Marc Ayoub	American University of Beirut, **Lebanon**
Mariam Al Busaidi	Sustainability Advisor at SOHAR Port and Freezone
Mariya Mohammed	Ministry of Electricity, **Iraq**
Maryam Al Hashimi	Ministry of Energy and Minerals, **Oman**
Michel Farah	Daikin Middle East & Africa FZE
Moath Alneis	Schneider Electric Sustainability Research Institute
Mohamed A. Elhaj	Prime Minister's Office, **Libya**
Mohamed I. Eissa	Ministry of Electricity and Renewable Energy, **Egypt**
Mohammed Al Badi	SIPC
Mohammed Al-Hashemi	OQ Alternative Energy
Mohammed Kalbani	Authority for Public Services Regulation (APSR)
Muhannad Al Hinai	Ministry of Energy and Minerals, **Oman**
Racem Kammoun	Bureau Veritas
Radia Sedaoui	UN Economic and Social Commission for West Asia
Rohan Lobo	Siemens Energy
Said Al Sarmi	Oman Net-Zero Centre
Salim Al Ghaiti	Sohar Port and Freezone
Sean Ratka	UN Economic and Social Commission for West Asia
Suhas Deshpande	ABB

Takafumi Omiya	Ministry of Foreign Affairs, Japan
Yasin Kasirga	GE Vernova
Zaina Al Ojaili	Embassy of Japan, Oman
Hossam Mohamed	Ministry of Electricity and Renewable Energy, **Egypt**
Abdallah Al Nahas	National Electric Power Company, **Jordan**
Steffen Behrle	GIZ
Salem Alhajraf	Baker Institute
Jessica Obeid	Independent Consultant
Laury Haytayan	Natural Resource Governance Institute (NRGI)
Zoheir Hamedi	Regional Center for Renewable Energy and Energy Efficiency (RCREEE)
Eva March	International Organization for Migration (IOM)
Kate Dourian	Independent Consultant
Youssef Al Abdallah	Kuwait Institute for Scientific Research, **Kuwait**
Harry Istepanian	Independent Consultant
Isabelle Gerkens	Elia Group
Barakat Ahmed	nternational Solar Alliance
Fareed Yaseen	Former Climate Envoy, **Iraq**
Adnan Shihab-Eldin	Kuwait Foundation for the Advancement of Sciences, **Kuwait**
Kamel Bennaceur	Nomadia Energy
Harmeet Bawa	Hitachi Energy
Noe van Hulst	Independent Consultant

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Executive summary

A cornerstone of global energy supply and, increasingly, demand

The Middle East and North Africa (MENA) region is at a pivotal moment in its energy journey. The region has long been a cornerstone of the global energy system. In 2024, it supplied over 30% of the world's oil and nearly 20% of its natural gas. At the same time, it is emerging as a major centre of electricity demand growth, driven by a rapidly expanding population, urbanisation, rising living standards, and accelerating climate pressures. Between 2000 and 2024, electricity demand tripled – increasing by more than 1 000 terawatt-hours (TWh). This made the MENA region the third-largest contributor to global electricity demand growth after China and India. Looking ahead, demand is projected to rise by another 50% by 2035, adding the equivalent of the current demand of Germany and Spain combined – with significant implications for global energy markets.

Cooling and desalination: Twin pillars of surging electricity demand growth

The region's climate, characterised by extreme heat and water scarcity, means that reliable and resilient electricity systems are vital to sustaining everyday life. Average temperatures in MENA are rising at more than twice the global rate, and summer temperatures regularly exceed 40 °C. Today, cooling makes up nearly half of peak electricity demand in the region and one-quarter of annual electricity demand – an amount larger than the total electricity use in all but 15 countries globally. While air conditioner ownership is high in Gulf Cooperation Council countries, it is relatively low in all other MENA countries. To 2035, cooling is set to be the largest driver of electricity demand growth in the region.

The MENA region also faces extreme water stress, with an imbalance between freshwater demand and renewable water supply four times the global average. Seven of the eight most water-stressed nations globally are in the region. To meet demand, MENA produced 12 billion cubic metres (bcm) of desalinated water in 2024, equivalent to the annual flow of the Euphrates River. Production is set to triple by 2035. While most desalination today relies on oil and gas, the last major investment in thermal desalination took place in 2018. Future growth is set to be met entirely by electricity-powered, high-efficiency reverse osmosis technologies.

Between now and 2035, cooling and desalination together are on course to account for close to 40% of projected growth in electricity demand in the MENA region, several times the global average. Other key drivers of increasing demand include industrial growth, the electrification of transport and the expansion of cities. New digital infrastructure, including data centres, and growing interest in producing hydrogen for export are also projected to be sources of rising electricity demand.

Natural gas and oil dominate the electricity mix in the region today

Natural gas and oil overwhelmingly dominate the electricity mix in the MENA region, accounting for over 90% of total generation. In 2024, natural gas provided 70% of MENA's electricity, serving as the primary fuel for power generation in Algeria, Bahrain, Egypt, Iran, Oman, Tunisia, United Arab Emirates (UAE) and Qatar. Meanwhile, oil supplied 20%, requiring 1.8 million barrels per day – equivalent to the current production of Mexico. Oil-fired power plants accounted for an even higher share of generation in major oil exporting countries such as Iraq, Saudi Arabia and Kuwait. This heavy reliance on oil and gas is reinforced by high levels of subsidies in many countries, which keep domestic energy prices low and encourage continued consumption. Even net importers – including Egypt, Lebanon, Morocco, Tunisia and Yemen – depend heavily on oil and gas, and subsidise their use, underscoring the region's deep-rooted dependence on hydrocarbons for electricity supply. Coal accounts for less than 5% of MENA's electricity generation, though it plays a more important role in Morocco.

The use of natural gas is set to keep expanding, complemented by solar

Based on today's policy settings, natural gas is set to meet half of the region's electricity demand growth to 2035, remaining by far the largest source of electricity as countries leverage abundant reserves and established infrastructure. Over the next decade, gas-fired capacity is on course to rise by over 110 gigawatts (GW), adding to the 350 GW in operation in 2024. Expanding gas use, alongside other sources, would support efforts by countries in the region – particularly Iraq, Lebanon and Saudi Arabia – to cut oil use for electricity. In turn, the share of oil in MENA's electricity mix is set to shrink to just 5% by 2035.

Solar PV is also growing rapidly in the MENA region, driven by falling costs, abundant resources, alignment of supply availability with cooling needs, and strategic efforts to free up oil and gas for higher value uses or export. Solar PV capacity is set to increase tenfold to 2035, growing by 200 GW. This would drive the share of renewables in generation to one-quarter, up from 6% in 2024. The expansion of solar PV would also improve resilience in post-conflict areas by bypassing reliance on weakened grids, including across Lebanon, Syria and Yemen.

Nuclear energy is gaining momentum regionally

Nuclear power generation is poised to expand as countries seek reliable, affordable, low-emissions energy sources to enhance energy security and grid stability. Currently, five reactors are operational in the region, including four in the United Arab Emirates that have been commissioned in the past five years. Construction is underway on five additional reactors – four in Egypt, and one in Iran – while Saudi Arabia is advancing plans for its first nuclear units and the UAE is exploring further expansion. Nuclear capacity in the region is projected to triple by 2035 to reach 19 GW, a notable shift in the regional energy landscape.

Ensuring electricity security relies on grids, storage and flexible thermal power

As electricity demand rises and MENA's power mix diversifies, ensuring electricity security will remain essential. Integrating more solar PV and wind requires robust and flexible power systems, modern grids, regional interconnections, and advanced management. Storage solutions, including batteries, and demand-side flexibility will be key to balancing variability, while gas-fired power will continue to support system adequacy. With ageing thermal assets, strategic decisions on their future will shape reliability. A balanced approach – combining grid upgrades, storage and thermal power – will be critical for electricity security.

Improving efficiency would curb demand growth and strengthen power systems

Energy efficiency is a critical lever for managing electricity demand growth, particularly in buildings. Currently, the average efficiency rating of an air conditioner in the MENA region is less than half that of the average unit in Japan, for example. Improving air conditioner efficiency could reduce peak demand growth by 35 GW by 2035 – equivalent to the total power generation capacity of Iraq today. Some countries in the region, including Jordan, Saudi Arabia and the UAE, are strengthening appliance performance standards and introducing targeted financial incentives – to help curb demand growth and also to improve electricity security.

Power sector investment needs are rising

Investment in the region's power sector is increasing. In 2024, it reached USD 44 billion and by 2035, it is projected to grow by 50%. Renewables and nuclear are set to capture a larger share of investment over this period, aligning MENA more closely with the global average. Investment in gas-fired power capacity remains significant in the region, and it is set to account for 20% of global investment in gas-fired capacity to 2035. Addressing high grid losses, expanding regional interconnections, and modernisation mean grid investment is projected to account for close to 40% of total power sector investment over the next decade.

Countries that miss targets to reduce oil-fired generation may bear a great cost

If diversification strategies fall short and oil and gas continue to dominate the region's electricity mix, demand for both fuels would rise by over 25% by 2035. In this case, over 80% of additional oil demand would be concentrated in five countries: Iran, Iraq, Kuwait, Lebanon and Saudi Arabia. And more than 60% of extra natural gas demand would be in Egypt, Saudi Arabia and the UAE. This would have both macroeconomic and environmental consequences. It would reduce oil and gas export revenues by USD 80 billion in 2035 and raise import bills by USD 20 billion, and carbon dioxide emissions would also continue to rise.

Delivering on national ambitions could further accelerate diversification

Building on growing international momentum – catalysed in part by the UAE's leadership at COP28 in 2023 – eight MENA countries have set net zero targets (Bahrain, Lebanon, Kuwait, Morocco, Oman, Saudi Arabia, Tunisia and the UAE) and 14 have joined the Global Methane Pledge, an effort to reduce global methane emissions by at least 30% from 2020 levels by 2030. Full delivery of countries' announced national pledges would transform electricity systems. Faster demand growth would be more than offset by the accelerated uptake of renewables and nuclear, with slower growth for natural gas – halving the carbon intensity of the region's electricity by 2035. Achieving these goals would requires a tripling of power sector investment to build a more diverse, resilient and sustainable system.

Policy choices will determine the path ahead

The stakes for the MENA region are high. For oil and gas producers, diversifying their power mixes can free up hydrocarbons for export and strengthen their fiscal stability. Meanwhile, by scaling up solar PV, nuclear power and energy efficiency, importers can boost their energy security and reduce their exposure to global price volatility. Diversifying power systems can drive industrial growth and job creation, but this will require more investment in solar PV, nuclear, grids and regional interconnections. Streamlined regulations and innovation in new energy technologies will be essential to attract private investment and deliver widespread benefits. Decisions this decade will shape the region's energy future and climate resilience.

Chapter 1. State of play

Overview

The Middle East and North Africa (MENA) region has for decades been the cornerstone of the global energy markets. Countries across the region produce one-third of the world's oil and one-fifth of its natural gas, accounting for 50% of global oil trade and 15% of traded gas. The energy equation in the MENA region cannot, however, be limited to the production and export of fossil fuels. Demographic and economic growth are rapidly driving up local energy consumption. Meeting this demand is imperative, particularly as climate change raises temperatures and exacerbates pressures to cool habitats and workplaces and to desalinate water. How the region meets its growing energy demand in the future will have implications far beyond its borders. With domestic energy consumption set to surge, electricity will become a central pillar in meeting the region's growing needs.

This report explores current and future electricity needs driven by common structural factors, such as population growth, rising living standards and rapid urbanisation. It analyses the options on the supply side, with consideration of specific country and regional resource endowments, as well as the current power sector assets in play, focusing on 17 countries: Algeria, Bahrain, Egypt, the Islamic Republic of Iran (Iran), Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, the Syrian Arab Republic (Syria), Tunisia, the United Arab Emirates and Yemen.[1]

Economics, demographics and climate

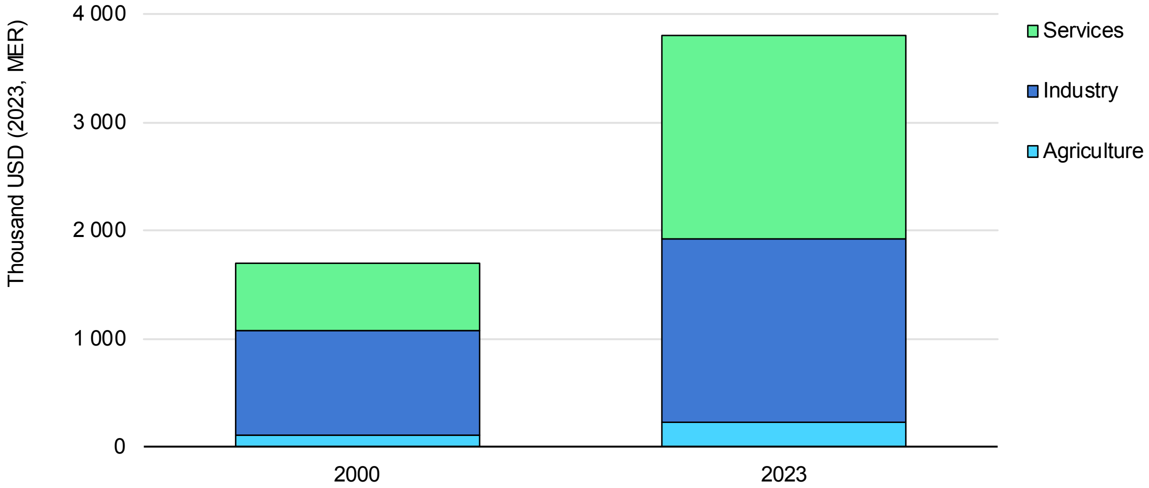
Economic growth

Since 2000, the MENA region's economy has nearly doubled in size, growing at a rate of 3.4% per year, slightly above the global average of 3.3% globally. This growth has been driven by the rapid expansion of the services sector, which has tripled in size since 2000. This has changed the structure of the region's economy: while industry was traditionally the mainstay of economic output, its share has

[1] When this report refers to North Africa, it specifically includes Algeria, Egypt, Libya, Morocco and Tunisia. References to the Middle East refer to Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, the United Arab Emirates and Yemen.

decreased from 60% to 45%, with services now taking the top spot, accounting for almost half of the regional economy.

Figure 1.1 Middle East and North Africa GDP size and composition, 2000 and 2023



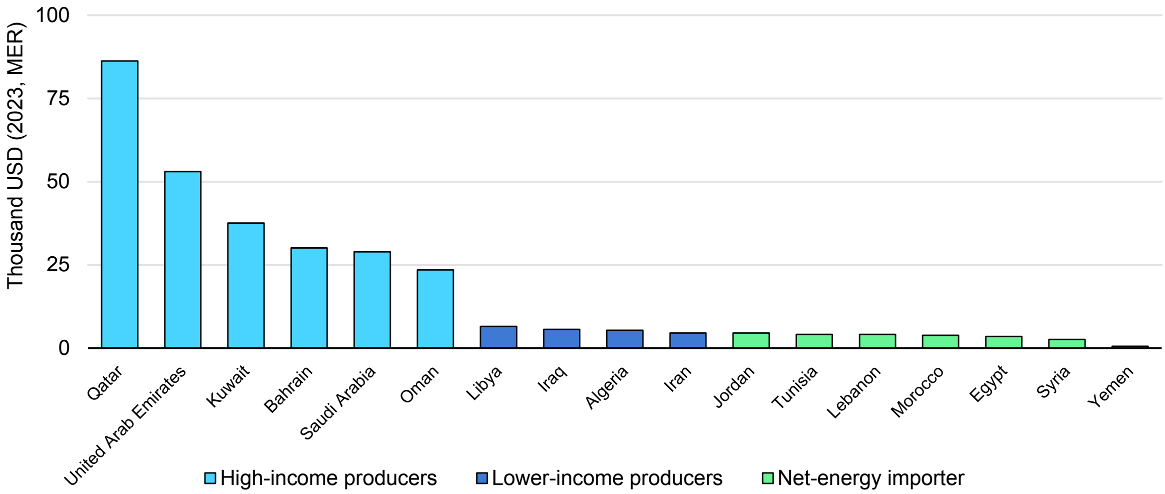
Note: MER = market exchange rate.
Sources: IEA analysis based on International Monetary Fund (2025), World Economic Outlook: April 2025 Update and United Nations Statistics Division (2025), National Accounts Main Aggregates Database.

Growth has been far from uniform across the region. The Gulf Cooperation Council (GCC), which includes Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates, has accounted for over 55% of the region's growth since 2000. It now collectively accounts for 37% of the region's total GDP, far outsizing its share of the population, which is only around 12% of the region's total. This is reflected in significant disparities in per capita GDP levels across countries, ranging from USD 550 per capita in Yemen to over USD 80 000 per capita in Qatar, a gap that is not limited to differences between the region's oil and gas exporters and its net importers.

Nevertheless, oil and gas wealth has generally not been the sole determinant of economic development. Prolonged conflict and political instability have also severely undermined economic performance in several countries, notably Iraq, Lebanon, Libya, Syria and Yemen. The MENA region's economies can be grouped into three broad categories: net energy exporters or producer economies, divided into high rent per capita countries (such as Kuwait, Qatar, Saudi Arabia and the United Arab Emirates) and lower rent per capita producers (which tend to be more populous, including Algeria, Iran and Iraq), and net energy importers.

The first group benefits from substantial hydrocarbon revenues and generally maintains strong fiscal positions. Some of these countries have among the highest per capita GDP levels in the world, which are mirrored by correspondingly high levels of per capita energy use, also among the highest globally. With the exception of Saudi Arabia, most countries in this group have relatively small populations, excluding expatriate workers. Lower-income producers (Algeria, Iran and Iraq) also rely heavily on oil and gas exports but generally do not enjoy the same macroeconomic position or fiscal space and have rapidly growing populations. Net energy importers include Egypt, Jordan, Lebanon, Morocco, Syria, Tunisia and Yemen. These countries lack major hydrocarbon resources and are more vulnerable to global energy price movements, often grappling with fiscal pressures and energy security concerns.

Figure 1.2 GDP per capita in Gulf Cooperation Council and other Middle East and North African countries, 2023



Note: MER = market exchange rate.

Sources: IEA analysis based on International Monetary Fund (2025), World Economic Outlook: April 2025 Update and United Nations Department of Economic and Social Affairs (2024), 2024 Revision of World Population Prospects.

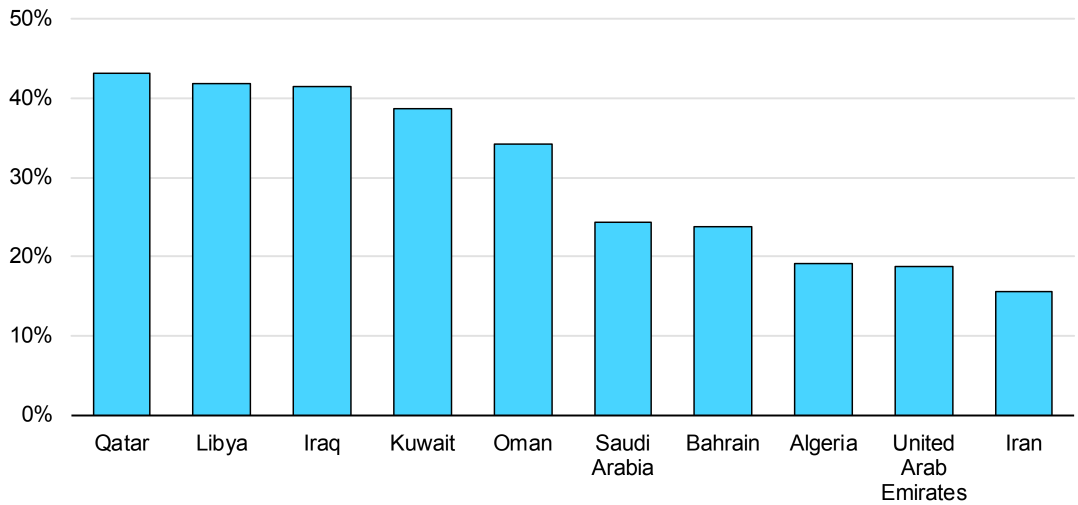
Hydrocarbon revenues enabled rapid economic development, notably in the second half of the 20th century, supporting socio-economic progress and large-scale infrastructure expansion. However, they also created a heavy dependence on fossil fuels in producer economies, leaving them with varying degrees of vulnerability to the volatility of global oil prices. For these countries, oil and gas exports account for the majority of export earnings and fiscal revenues. Recognising the need to build greater economic resilience through diversification, many have launched ambitious economic programmes that seek to expand the non-hydrocarbon segments of their economies, making them less exposed to the vagaries of international oil and gas prices. At the same time, these programmes aim to ensure sufficient domestic job creation for their fast-growing and relatively young populations (see Demographics).

Initiatives like Saudi Arabia's Vision 2030, the United Arab Emirates' We the UAE 2031 strategy and Oman's Vision 2040 exemplify this shift, placing economic diversification at the heart of national strategies across producer economies. These large-scale initiatives channel public and private investment towards stimulating economic growth in high-income producer economies, contributing to rising energy demand, notably for electricity.

Some countries across the MENA region are increasingly focused on high-tech innovation in their diversification efforts. In the GCC, Saudi Arabia and the United Arab Emirates are making significant investments in data and artificial intelligence (AI) as part of their economic diversification and digital transformation strategies. Saudi Arabia's Data and Artificial Intelligence Authority has set a target of 1.9 GW of data centre capacity by 2030, with plans to increase this to 6.6 GW by 2034. The United Arab Emirates' Artificial Intelligence Office has brokered a deal with the United States to build the world's largest set of AI data centres outside of the United States, with a total planned capacity of 5 GW.

While most efforts are concentrated in the GCC, other countries in the region, such as Egypt and Morocco, are also moving to expand their AI and data infrastructure. Egypt is preparing to establish a data centre with a planned capacity of approximately 200 MW. Meanwhile, Morocco has announced a 500 MW AI-focused data centre project through an international consortium. As these projects scale up, AI and data infrastructure are set to become key drivers of regional power consumption.

Figure 1.3 Oil and natural gas rents as a share of GDP in selected economies, 2023



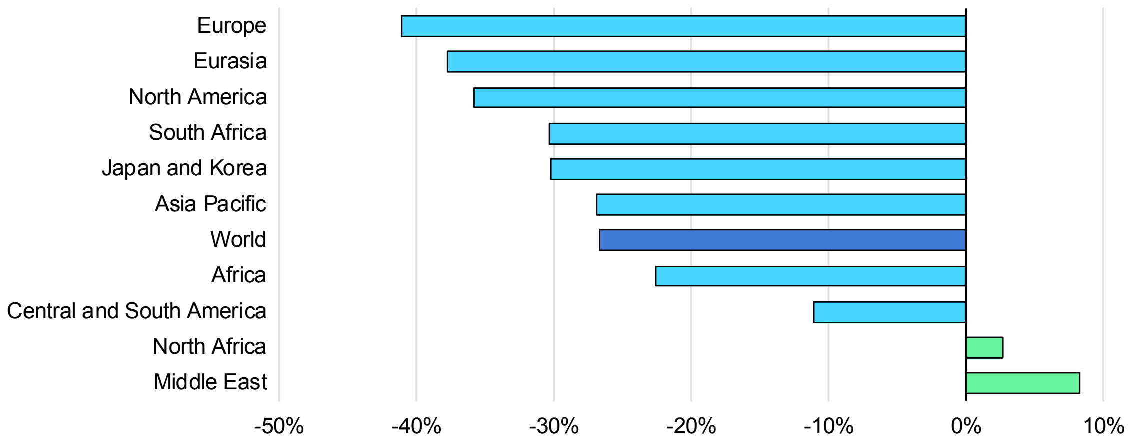
Notes: Oil and natural gas rents are the economic gains from extracting hydrocarbon resources, calculated as the difference between their international market value and the total cost of production. Domestic subsidies may affect how these rents are used but do not reduce the rents generated.

Fossil fuel subsidies

Energy costs play a critical role in shaping countries' economic competitiveness. Countries around the world strive to access secure, reliable and affordable energy for economic activity. This is especially evident in the MENA region, where producer economies have leveraged their fossil fuel endowments to develop energy-intensive sectors, such as petrochemicals, steel, aluminium and related industries. Non-industrial sectors, including buildings and transport, have also benefited from a secure supply of oil products and natural gas for heating, electricity and transport fuels. This widespread access is often supported by government policies that keep energy relatively cheap. The MENA region has some of the highest fossil fuel subsidies in the world, often resulting in lower domestic energy prices relative to reference prices.

Fossil fuel consumption subsidies occur when consumer prices are kept below reference prices that have been adjusted, as necessary, for transport costs and value-added tax. While some subsidies can help achieve social goals – such as improving access to clean cooking – most encourage suboptimal use of fossil fuels. However, the predominance of producer economies where fossil fuels are seen as a national endowment, in MENA's economic output, along with their reliance on energy-intensive sectors to drive growth, partly explains the high energy intensity of GDP in the region. From 2000 to 2023, however, the MENA region stands out as the only region where producing a unit of GDP required more energy in 2023 than it did in 2000, even in comparison with energy-intensive emerging economies. This trend is particularly striking given that much of the region's economic growth during this period was driven by less energy-intensive sectors, primarily services.

Figure 1.4 Change in energy intensity of GDP in selected regions, 2000-2023



Note: Calculated based on GDP expressed in purchasing power parity terms.

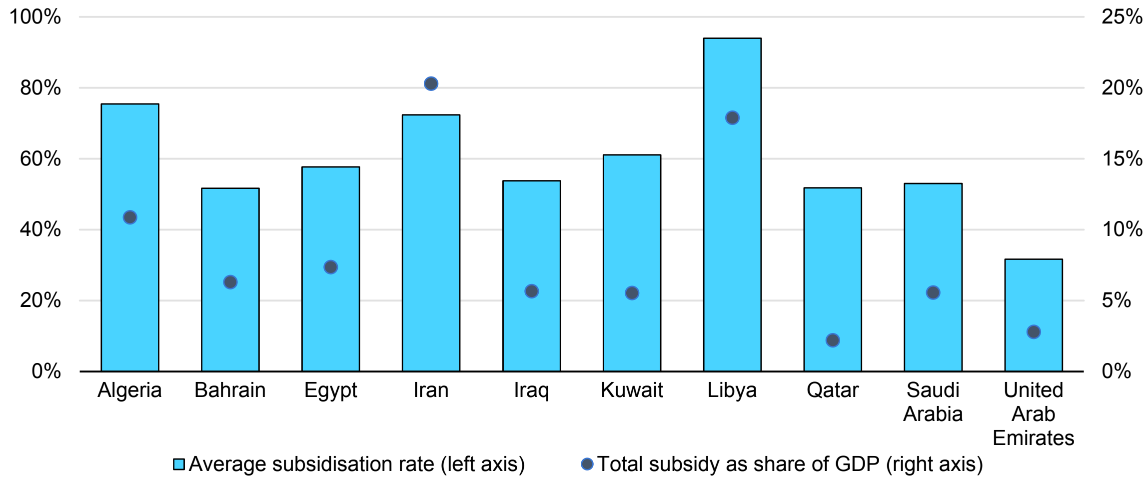
Residential consumers across the region have also benefited from low energy prices, which are usually set below reference prices. While this has played an important role in supporting welfare, the absence of clear price signals in many countries has exacerbated increases in energy demand and, in some cases, strained public finances. Over the past decade, the region has spent an average of USD 250 billion per year on fossil fuel subsidies, a figure that is close to the entire 2024 GDP of Bahrain, Jordan, Oman, and Tunisia combined. Electricity subsidies alone accounted for more than USD 80 billion, covering Algeria, Bahrain, Egypt, Iran, Iraq, Kuwait, Libya, Oman, Qatar, Saudi Arabia and the United Arab Emirates. The sum of electricity subsidies hovered around USD 50 billion per year between 2010 and 2015, before reaching a decade low in 2016, at under USD 35 billion. However, this amount surged to more than USD 140 billion in 2022.

In many emerging and developing economies, including those in MENA, electricity utilities often cannot cover their operating costs and debt payments because retail prices are kept low for affordability reasons. While tariffs are not the only factor, keeping retail prices unsustainably low frequently results in widespread revenue shortfalls. This creates a cycle where utilities struggle to pay their bills, attract investment in clean energy projects and maintain service quality, ultimately leading to mounting debts and requiring further government subsidies. The size of fossil fuel subsidies, including electricity, relative to total economic output, is significant in some countries, reaching as high as 20% of GDP in Iran in 2023 and close to 10% in Algeria and Egypt – despite Egypt being a net energy importer that year.

There is nonetheless a movement towards subsidy reforms in many MENA countries, signalling a positive shift to more sustainable energy pricing but despite the positive short-term effect on countries' public finances, subsidy reforms need to be paired with effective social redistribution measures to shield low-income households from higher energy prices. Experiments such as Egypt's *Takaful w Karama* ("Solidarity and Dignity") cash transfer programme have helped phase down energy subsidies by supporting lower-income households. In Jordan, after phasing out energy subsidies from 2018, the government implemented a cash transfer system and developed a universal cash transfer system to shield households from price increases, including for food.

In countries heavily reliant on private generators, such as Iraq and Lebanon, households often also face significantly higher energy costs. The shock can be more acute in countries where residential consumers remain reliant on diesel-fired generators, which accounted for over 20% of the electricity supply in Iraq and 80% in Lebanon. In 2021, Lebanon faced economic backlash for slashing its electricity subsidies. The reform occurred during the country's financial meltdown, which started in 2019 and reduced its ability to import fuel. As a result, both formal and informal power generation (through diesel-fired generators) were affected, nearly plunging the country into darkness for weeks.

Figure 1.5 Subsidisation rate and total subsidy as share of GDP in selected countries, 2023



Note: The subsidisation rate refers to the ratio of fossil fuel prices to international market prices (including electricity generated from fossil fuels).

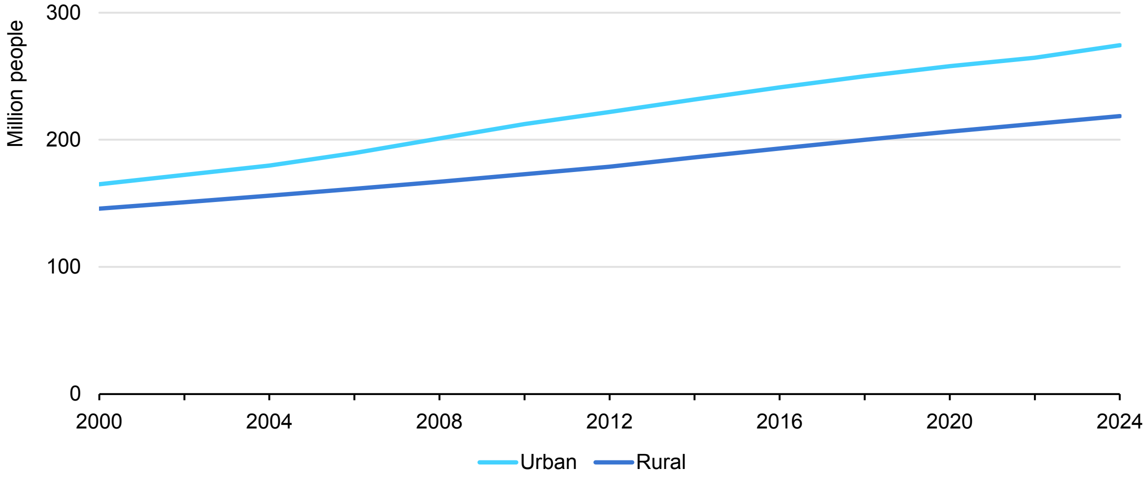
For producers, the opportunity cost takes the form of lost export revenue from oil and gas volumes traded below market value, the allocation of feedstock for value-generating industries and reduced potential investment capacity. For net energy importers, subsidising imported fuels constrains their energy security and ability to invest in domestic energy sources, while further exposing fiscal balances to energy market volatility.

Demographics

Rapidly evolving demographic trends play a central role in shaping the region's energy future. This is evident in three key areas: the rate of population growth, the age of the overall population and the increasing share of urban residents across the region.

Since 2000, the MENA region's population has grown at nearly twice the global average rate – 61% compared to 31% – adding around 175 million people during this period and pushing the total population beyond 500 million. Most of these people now live in cities, with urbanisation reaching two-thirds of the total population, up from around 58% in 2000.

Figure 1.6 Middle East and North Africa population (urban and rural), 2000-2025



Sources: IEA analysis based on United Nations Department of Economic and Social Affairs (2024), 2024 Revision of World Population Prospects.

Crucially, the region's population is relatively young, with 55% under the age of 30, making MENA the second youngest region in the world, behind only sub-Saharan Africa. The median age of 22 (six years lower than the global median age) throws into sharp relief the issue of employment. Indeed, with youth unemployment rates reaching around 25%, the highest in the world and double the global average rate, the "youth bulge" and unemployment remain top priorities for most countries in the region where structural labour market challenges persist. These include the limited role of the private sector in driving employment, low rates of female labour participation and the persistent informality that characterises several markets in the region. Improvements in access to education mean that around 60% of the population now holds at least a lower secondary degree, and that the number of people entering the job market will continue to increase. Apart from sub-Saharan Africa, MENA is the only region expected to see an increase in its youth labour force between 2023 and 2050. One of the main challenges faced by countries across the region will be finding ways to leverage this large young labour force for future economic growth.

Climate change and rising temperatures

Rising temperatures

The MENA region is disproportionately affected by climate change, warming at a rate two and a half times faster than the average global rate, with temperatures in subregions, such as parts of the central Arabian Peninsula, rising up to three times this rate. Between 1980 and 2023, regional temperatures increased by an estimated 0.46 °C per decade, resulting in a stark increase in cooling degree days, an indicator how hot average daily temperature were. Measured relative to a base threshold of 21 °C, cooling degree days are now 40% higher than they were in 2000. This reflects a sharp rise in the exposure of the region's population to extreme heat and has direct consequences for energy demand and infrastructure resilience across the region. Given that the use of air conditioning units is directly related to the number of cooling degree days, these trends highlight the growing impact of rising temperatures on energy demand, particularly electricity.

In addition to the clear impact on energy and electricity demand, rising temperatures also negatively affect the supply side. Higher ambient temperatures can significantly decrease thermal plant efficiencies, reducing power output at the very time demand hits its heat-induced peak. This is particularly stark in open-cycle gas turbines, which account for almost 20% of the region's electricity generation, as they rely on cool airflow to prevent overheating. Higher temperatures directly reduce transmission performance, further constraining supply during periods of peak demand.

These factors were evident in Iraq, which in June 2022 suffered a catastrophic full grid failure when temperatures exceeded 51 °C, leaving millions without electricity in the southern governorates of Basra, Dhi Qar and Maysan. Power cuts during the summer months are becoming increasingly common, highlighting the strain on the power system. In response, in June 2024, the Iraqi government reduced public sector working hours to protect employees from extreme heat and to rationalise electricity consumption during peak hours. Oil companies operating in the country have introduced "Purple Flag Days" to prevent sending workers into the fields when it is too hot. In much of the Gulf, where extreme summer temperatures are the norm, labour laws mandate outdoor work stoppages once temperatures surpass certain thresholds, typically around midday during the hottest months. These laws aim to protect workers, particularly those in construction and other outdoor sectors, from dangerous heat exposure, though enforcement can vary.

Extreme heat is placing increasing pressure on critical infrastructure, even in countries that have typically enjoyed stable systems. In the summer of 2024, Egypt experienced an extreme heatwave resulting in widespread power outages as temperatures skyrocketed above 50 °C towards the southern border. High cooling demand combined with gas shortages resulted in rolling blackouts across the country, lasting up to 6 hours daily, further exacerbating the detrimental effects of the heat. In response, the government implemented scheduled power cuts to reduce the strain on the already overloaded grid.

In May 2025, in response to a demand surge caused by unseasonably high temperatures exceeding 50 °C, Kuwait scheduled power outages across 51 geographical areas, spanning industrial, agricultural and residential uses. The Ministry of Electricity, Water and Renewable Energy implemented planned power cuts for consumers throughout April, May and June 2025, with expectations that outages would continue through the end of the summer. This followed the country's first load-shedding programme, implemented in 2024. This programme is an excellent example not only of the momentary surges in summer-time electricity use but also the increase in structural and supply demand that current infrastructure struggles to keep pace with.

Similar incidents are being witnessed across the region, as various countries have been forced to implement power cuts due to the blistering summer heat. Kuwaiti officials have recently issued statements attributing these cuts to the effects of climate change and the drastic impacts it is having on the energy sector, underscoring the need for scheduled load-shedding.

Water scarcity

The MENA region is the most water-scarce region in the world, holding only 1% of global freshwater resources despite being home to over 6% of the world's population. Climate change is placing further stress on water resources by increasing the frequency and length of droughts across the region. Other exacerbating factors include challenges related to river flow management in countries such as Egypt, Iran, Iraq and Jordan. Moreover, the consistent under-pricing of water and energy in parts of the region has encouraged inefficient water use and contributed to unsustainable levels of water withdrawals from non-renewable sources.

To alleviate water stress and address growing water demand, countries are increasingly relying on desalination as a key source of freshwater. As of 2023, desalination accounted for 4% of total energy demand and produced approximately 11 billion cubic metres of water annually, equivalent to nearly 3.5% of the region's total freshwater withdrawals. This amounts to over 40% of global installed desalination capacity and requires significant energy use.

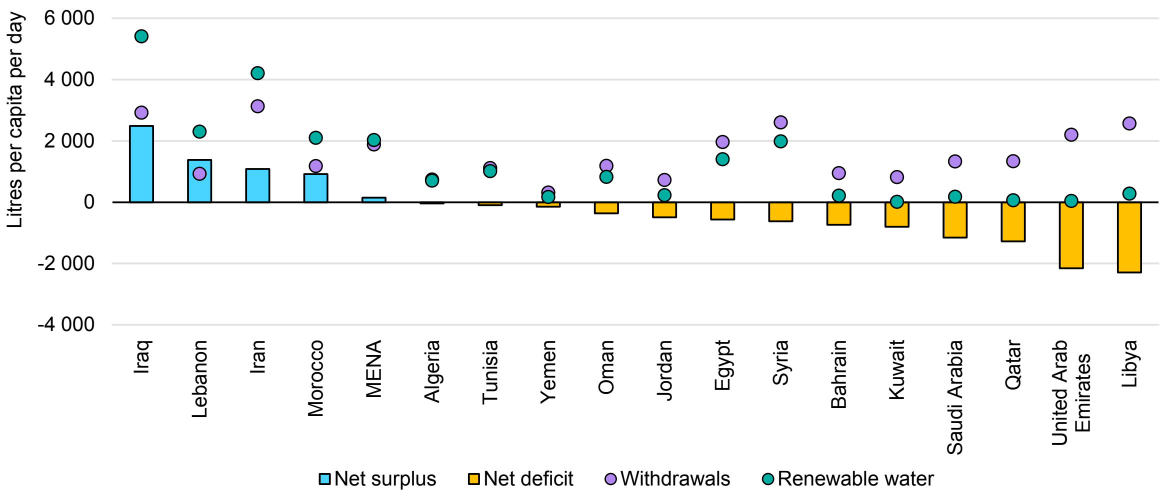
The MENA region accounts for roughly 90% of the thermal energy used for desalination worldwide. The capital-and energy-intensive nature of desalination infrastructure, alongside climate considerations, helps explain why existing capacity has been concentrated in the six GCC economies. However, as water stress intensifies more broadly, projects are proliferating across the region, notably in countries like Algeria and Morocco (see Chapter 3, "How will new desalination technologies and rising water stress impact electricity demand?").

Desalination is energy-intensive, with energy costs accounting for up to 50% of total desalination expenses. Current facilities can use 3-6 kWh of electricity per cubic metre of water produced, depending on the desalination technology, feedwater and other factors, in addition to the much greater amounts of thermal energy used by thermal desalination technologies. Low hydrocarbon prices, combined with the widespread use of co-generation facilities for power and water, have historically led to heavy reliance on fossil fuel-based thermal desalination in the MENA region.

Although electricity production in the region is still heavily reliant on oil and gas, integrating renewable energy into desalination offers strategic advantages: it reduces operational costs, lowers emissions and frees up hydrocarbons for export in producer economies. For net importers, using renewables for water desalination can contribute to reducing the energy import bill. As water demand and desalination capacity continue to grow, the shift towards more sustainable energy sources will be key to long-term resilience and efficiency.

Membrane technologies, particularly reverse osmosis, are the most prevalent desalination systems installed globally – accounting for over 70% of installed capacity – and have captured recently the largest share of capacity additions in the MENA region. These electricity-powered systems are more energy-efficient and can more easily integrate with renewables, unlike fossil fuel-based systems.

Figure 1.7 Water availability in selected Middle East and North African countries, 2023

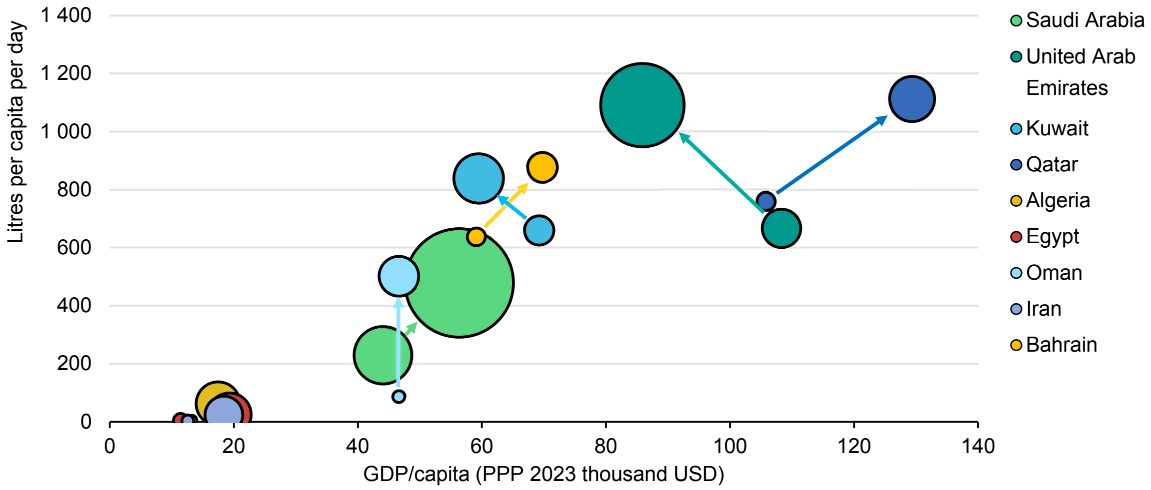


Note: MENA = Middle East and North Africa.
Source: IEA analysis based on data from FAO AQUASTAT.

In most MENA countries, freshwater demand is primarily driven by the agricultural sector, followed by municipal and industrial uses. The increasing frequency and intensity of droughts across the region are further limiting the availability of freshwater to meet existing demand. With the exception of Iran and Iraq, all countries in the region fall below the Food and Agriculture Organization's definition of water stress threshold.

In some countries currently facing chronic freshwater deficits, or those that have been experiencing deficits in recent years, desalination capacity has expanded significantly. For example, Saudi Arabia's desalination capacity more than tripled between 2000 and 2023, while the United Arab Emirates almost increased fivefold over the same period. Both countries have also seen a sharp rise in per capita desalination capacity, which doubled in Saudi Arabia and increased by 50% in the United Arab Emirates during this time.

Figure 1.8 Installed desalination capacity compared to GDP per capita for selected countries, 2000 and 2023



Source: IEA analysis based on data from GWI DesalData.

Despite capacity being concentrated in the GCC, new capacity additions are starting to emerge in North Africa, in countries such as Algeria, while the desalination capacity pipeline is also growing elsewhere in the subregion.

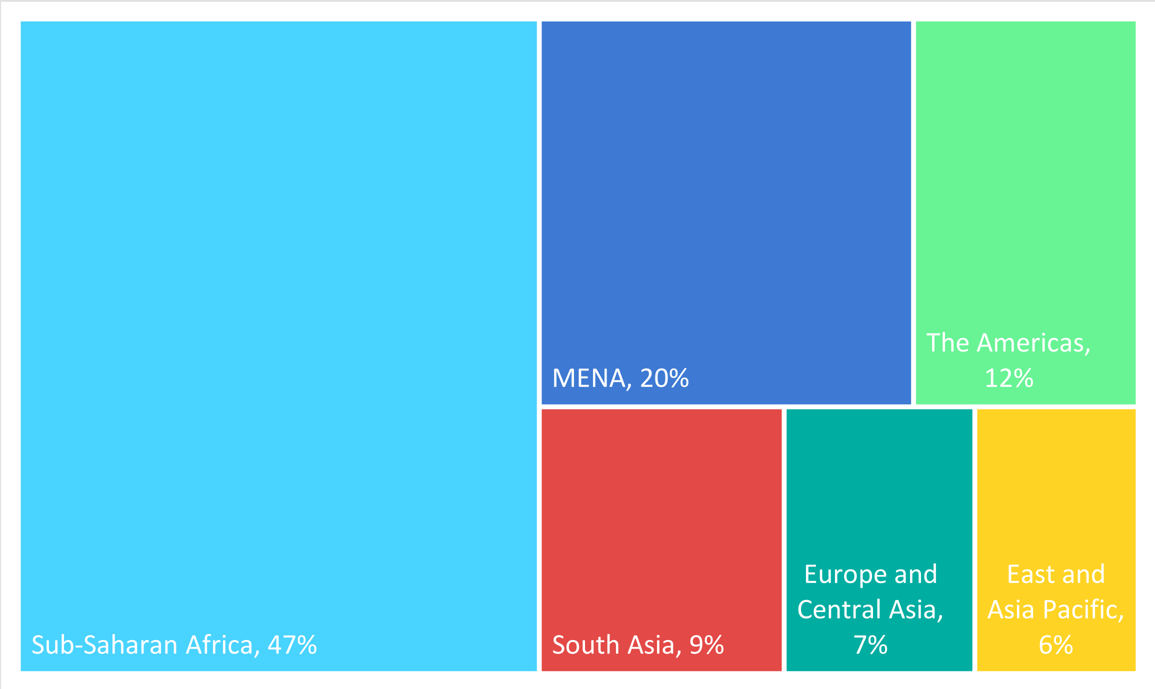
Conflicts and population displacement

At least five of the 17 countries in the MENA region have experienced armed conflict over the past 20 years. Beyond the humanitarian tragedies and physical damage, these conflicts have crippled energy infrastructure and hindered essential investment and maintenance in crucial assets such as power plants and electricity networks, particularly in Iraq, Lebanon, Libya, Syria, the West Bank and Gaza Strip and Yemen. In some [2], such as Iraq, improved stability in recent years has enabled crucial investment in gas capture, electricity and refining infrastructure, although significant challenges remain.

[2] The Palestinian Authority is not included in this analysis, but the war taking place there has severely impacted neighbouring countries, notably Egypt, Jordan, Lebanon and Syria, including from an energy perspective.

Conflict and violence have also caused large-scale population displacement, compounding challenges related to electricity access. A recent example is the ongoing war in Gaza, which has left hundreds of thousands of people without access to basic services, including electricity. Most displaced people in the MENA region are internally displaced persons. As of the end of 2024, the region was home to over 16 million internally displaced persons – almost all displaced by conflict and violence – accounting for one-fifth of the world's internally displaced population.

Figure 1.9 Regional distribution of internally displaced persons, 2024



Notes: MENA = Middle East and North Africa. According to the Guiding Principles on Internal Displacement, internally displaced persons are persons or groups of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalised violence, violations of human rights or natural or human-made disasters, and who have not crossed an internationally recognised state border. UNHCR's country grouping includes Israel, Mauritania and the Palestinian Authority but excludes Iran. Due to rounding, the total does not correspond with the sum of the separate figures.

Source: IEA analysis based on data from IDMC (2025), Global Report on Internal Displacement 2025. Internal Displacement Monitoring Centre.

From an energy perspective, the impacts of population displacement are clearly visible in the disruption of electricity distribution patterns and the limited ability to deliver electricity to large segments of the population, creating significant electricity access challenges. The International Organization for Migration estimates that 94% of displaced people living in refugee camps globally have no meaningful access to electricity, while 81% rely on basic fuels for cooking. Although this figure is based on surveys of refugee camps in sub-Saharan Africa, most refugees in the MENA region are located in urban areas with comparatively better access to electricity.

While there is no accurate data on the share of displaced people with limited or no access to electricity in MENA, country-level assessments indicate the existence of significant energy access challenges, notably with regards to electricity. In the case of Syria, 30% of assessed locations reported access to public electricity, but over 80% of those receive less than 4 hours of electricity per day. More strikingly, close to 20% of key informants[3] reported no public or private electricity usage at all. The inability to address this challenge limits prospects for economic recovery and generates safety hazards. In the longer term, the possibility for Syrian internally displaced persons to return to their places of origin may also be delayed if basic services such as electricity provision are not restored. The situation varies across countries. For example, in Jordan, where the majority of displaced people are refugees living in urban areas, electricity access remains an issue of affordability rather than a supply challenge. These examples underline the heterogeneity of electricity access conditions across the region.

As a result of conflict, post-conflict instability and governance challenges, several MENA countries continue to experience electricity supply disruptions. Iraq, Lebanon, Libya, Syria and Yemen have all faced chronic power shortages, which severely impact the ability of the populations to maintain adequate levels of thermal comfort and undermine economic competitiveness. A study on the economic impact of power shortages in Iraq by the International Energy Agency estimates that over a five-year period between 2014 and 2020, power outages alone cost the economy over USD 95 billion.

The absence of stable grid supply has led to the expansion of informal power generation networks in many countries. These primarily rely on diesel-fired neighbourhood generators, which have accounted for 20-75% of electricity supply in Iraq – with acute demand in the summer months – and over 80% in Lebanon today. This widespread reliance on informal generation has introduced serious safety risks. For example, in March 2024, a generator caught fire in a building in Tripoli, Lebanon, tragically killing five children. Similar incidents have been reported across the region in recent years.

Informal power generation also contributes significantly to air pollution across the MENA region. Major cities frequently record particulate matter ($PM_{2.5}$) concentrations that far exceed the World Health Organization’s recommended annual average limit of 5 µg/m³ as an annual average. In 2024, for instance, Baghdad recorded average levels as high as 40.5 µg/m³, Cairo reached 39.9 µg/m³ and Dubai measured 33.4 µg/m³. These values are five to ten times

[3] Key informants working with the International Organization for Migration collect information about communities, including data related to energy access.

higher than the World Health Organization's guideline, underscoring the severity of urban air quality challenges in the region.

Moreover, the rise in informal power generation has also had a deleterious impact on the affordability of electricity. Neighbourhood generator tariffs in Iraq ranged from USD 600 to USD 1 200 per megawatt-hour – among the highest globally – and were paid in addition to utility bills. In Lebanon, the range is around USD 400 to USD 500 per megawatt-hour, placing a significant burden on households already facing economic distress.

These tariffs impose a heavy financial burden on households and businesses, as billing for informal electricity is often based on flat fees rather than actual consumption. This means that there often is little incentive for system efficiency, and it encourages full use of the contracted electricity, even when it is not needed. In response to such challenges, countries such as Jordan and Morocco have recently introduced time-of-use tariffs and have expressed a willingness to deploy industrial and tertiary demand-side flexibility. These measures aim to reduce peak loads on the grid and enhance overall system flexibility, marking a shift towards more dynamic and efficient energy use.

Box 1.1 Off-grid electricity production at scale: Opportunity or challenge?

In recent years, the region has witnessed an uptake in the adoption of off-grid solar PV systems for electricity generation. Driven by falling solar PV and the desire to improve supply reliability, reducing dependence from both the grid and neighbourhood generators and to reduce electricity bills over the medium term, this growth has been largely led by private initiatives with relatively little government financial support. As such, deployment has been relatively dispersed and often only been accessible to higher-income households and businesses that can afford the upfront investment. For instance, Lebanon has seen an exponential increase in off-grid solar PV capacity mostly in the residential sector, increasing almost tenfold between 2020 and 2024.[4] This capacity growth occurred in the context of Lebanon's economic meltdown following its 2019 financial crisis, in which electricity subsidies were slashed and tariffs were revised upwards, while the country's finances impeded its capacity to import oil products on which it is reliant for almost all formal and informal power generation. The price per megawatt-hour neared USD 600 for informal power generation at the height of the crisis in 2021.

In addition, these off-grid solar PV systems hold significant untapped potential to deliver even more electricity through improved planning and system integration. To date, deployment has largely been driven by individual consumer adoption, leading

[4] These numbers are estimates in the absence of updated and reliable statistics.

to fragmented, stand-alone systems that often lack batteries or connections to nearby systems. As a result, electricity must be consumed immediately upon generation, constraining both supply and demand.

Targeted government planning and support, such as incentives for battery storage, mini-grids and interconnection with neighbouring systems, could help align production with consumption through storage and local grid integration. The uncoordinated increase in off-grid capacity has therefore led to over-generation, as not all produced electricity is consumed. Some estimates indicate that up to 1 TWh electricity is lost every year in Lebanon. Interconnecting existing off-grid rooftop solar panels could quadruple the energy security of a particular community. Moreover, space limitations and a lack of financial incentives for lower-income households further limit growth potential. Interconnecting existing off-grid rooftop solar panels could quadruple the energy security of a particular community. Moreover, space limitations and a lack of financial incentives for lower-income households further limit growth potential.

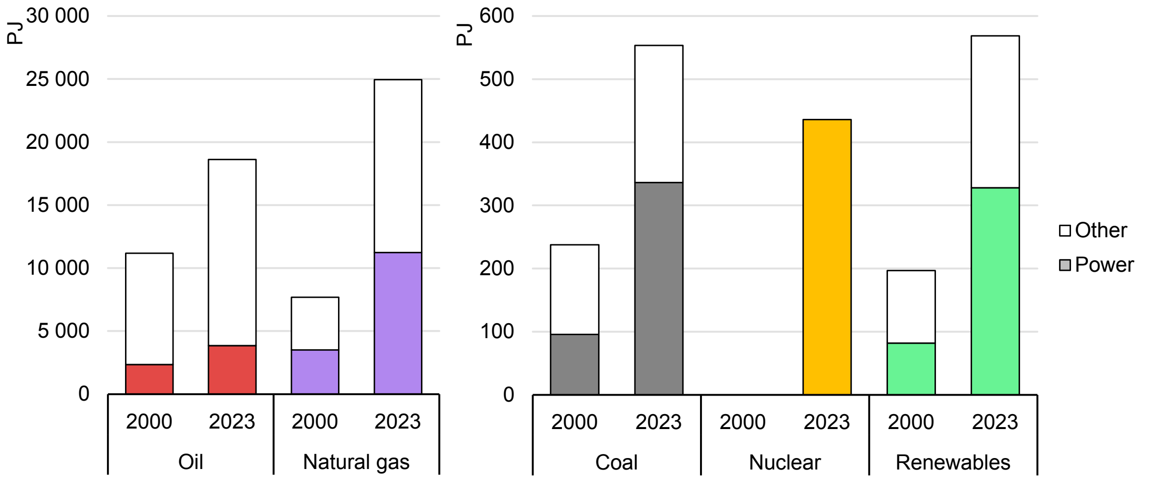
Moving towards municipal or community-based solutions to optimise the benefits of off-grid solar PV in Lebanon, or in other countries facing electricity supply disruptions, could be explored in the future. Hybrid models such as grid-connected microgrids and virtual power plans have not yet been fully leveraged, while off-grid growth would benefit from being integrated into national planning frameworks with a view to strengthening transmission infrastructure. Other challenges, including access to quality products and services, will also need to be addressed, as seen in Syria and Yemen.

Energy in the MENA region

Total energy demand

Energy demand in the MENA region has more than doubled over the past two decades, with an average annual growth rate of 3.7% from 2000 to 2023, almost twice the global average rate of 1.9% over the same period. Fossil fuels represent over 95% of the region's total energy mix, led by natural gas at 55% and oil at over 40%, with coal contributing just 1%. Each fossil fuel has been growing over the past two decades. Natural gas demand has tripled, coal demand has more than doubled and oil use has increased by two-thirds. Low-emissions sources of energy have also grown rapidly, quadrupling since 2000, although from a much smaller base. Renewables now represent 1% of total energy demand, led by bioenergy, hydro and solar. Nuclear power also represents 1% of total energy demand in the MENA region.

Figure 1.10 Total energy demand in the Middle East and North Africa, 2000 and 2023



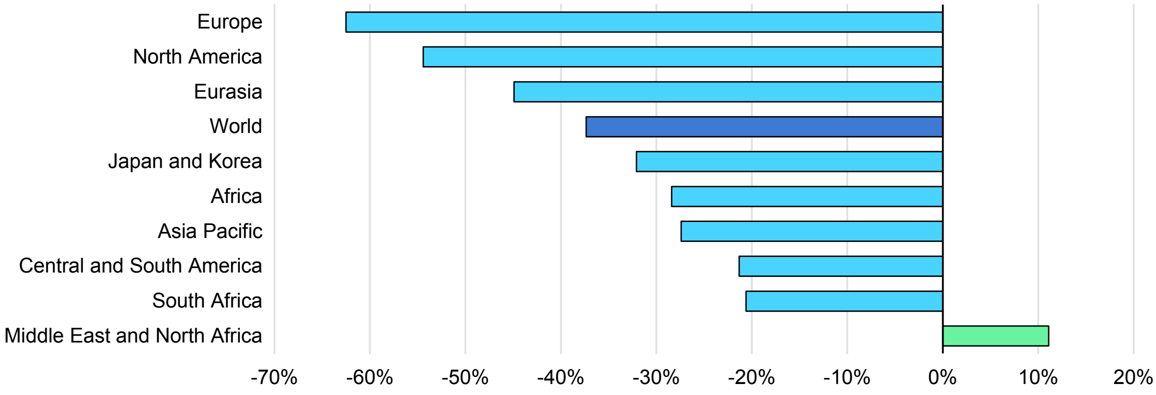
Note: PJ = petajoule.

The electricity sector has been a key driver of total energy growth in the MENA region. Over the past two decades, it has accounted for close to 40% of total energy demand growth in the region. Increased use of fossil fuels for electricity generation has accounted for 20% of total demand growth for oil, over 40% for natural gas, 75% for coal, over 65% for renewables and all of the increase in nuclear energy.

Emissions

Rapidly rising energy demand has been accompanied by a significant increase in the emission intensity of GDP. Over the period 1990 to 2023, the CO_2 intensity of GDP in the MENA region rose by 11%, compared to a global average decrease of 37% over the same period. This means the region has generated more emissions for each unit of GDP at a time when nearly all other geographies experienced a decline.

Figure 1.11 Change in CO_2 intensity of GDP in selected regions, 1990-2023



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Note: Calculated based on GDP expressed in purchasing power parity terms.

Total final energy consumption

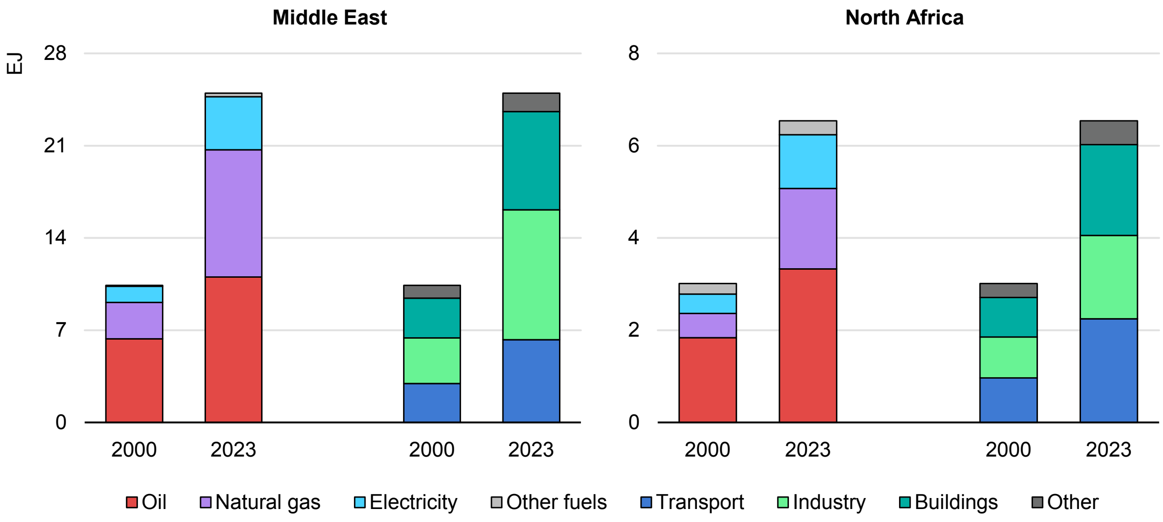
Total final energy consumption has also been growing rapidly in the MENA region, outpacing the global rate. Across end-use sectors, industry has been the main driver of this growth and currently accounts for 37% of final consumption, followed by buildings at 30% and transport at 27%.[5] While the services sector has seen the strongest economic growth in the region since 2000, its greater reliance on electricity improves its energy efficiency and lowers its share in final consumption.

Oil remains the dominant energy source, making up 46% of the region's final energy consumption in 2023. Natural gas follows closely, accounting for 36% of final consumption. Together, they account for more than 80% of regional final consumption, one of the highest shares in the world. This compares with a global average of 55% of final consumption met by oil and gas.[6] Coal use in final consumption is marginal, at around 0.7% in the Middle East and 1.6% in North Africa.

The share of electricity in total final consumption increased by 4 percentage points between 2000 and 2023, reaching 16.4%. While this increase is significant, fuelled by rising living standards and increased access to cooling, it remains well below the global average of 20.5% in 2023. The MENA region is among those with the lowest electrification rates, ranking only above the Russian Federation (Russia), the Caspian region and sub-Saharan Africa.

[5] Throughout the report, desalination is categorised within buildings.
[6] More details on the balance between oil and gas production and consumption can be found in Chapter 3, section "9. What impact could increase renewables have on oil and gas export volumes?"

Figure 1.12 Total final consumption by fuel and by sector in the Middle East and North Africa, 2000-2023

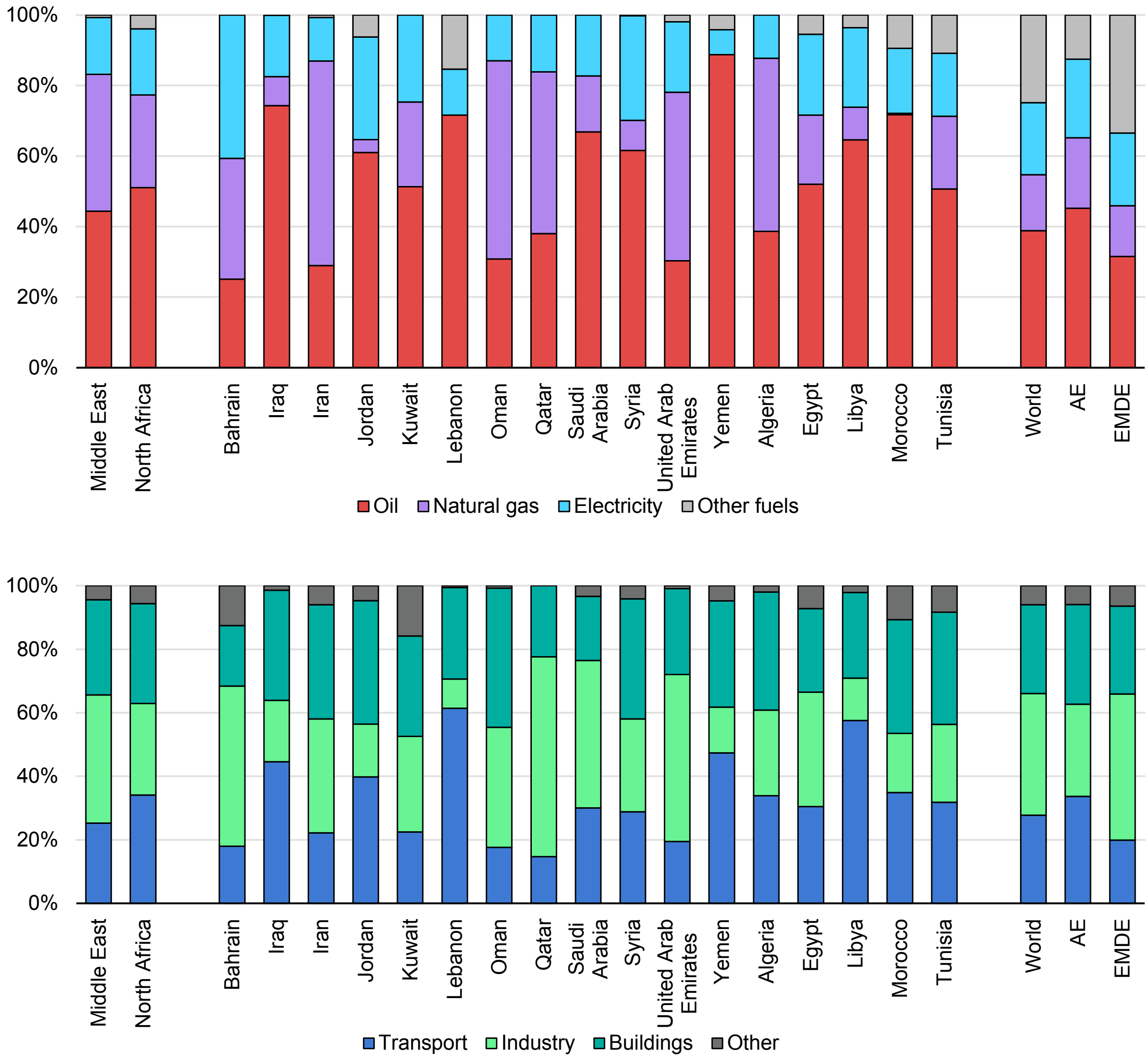


Note: EJ = Exajoule.

Demand has increased significantly across all end-use sectors this century, reflecting structural and socio-economic changes. Industry remains the largest energy-consuming sector, with demand almost tripling, primarily due to sustained industrial expansion and increased output. The transport sector has experienced a doubling of energy use, driven by growth in vehicle ownership and greater mobility. Residential energy consumption more than doubled, fuelled by population growth and higher incomes. Commercial and public services have registered the fastest relative growth, with energy use almost tripling in line with the rapid expansion of infrastructure and service-based economic activity.

Energy use patterns in the MENA region vary widely at the country level. Seven countries have a share of oil and gas in final consumption higher than the regional average of 82%. In Algeria, Yemen and Iran, this share reaches almost 90%, with the remainder being mostly electricity. The country with the lowest share is Bahrain at 59%, which is still more than 10 percentage points higher than the average for emerging market and developing economies. In some countries, oil is the dominant fuel, often due to the large share of transport within final consumption, as seen in Lebanon, Libya and Yemen.

Figure 1.13 Total final energy consumption by fuel, sector and country in the Middle East and North Africa and selected regions, 2023

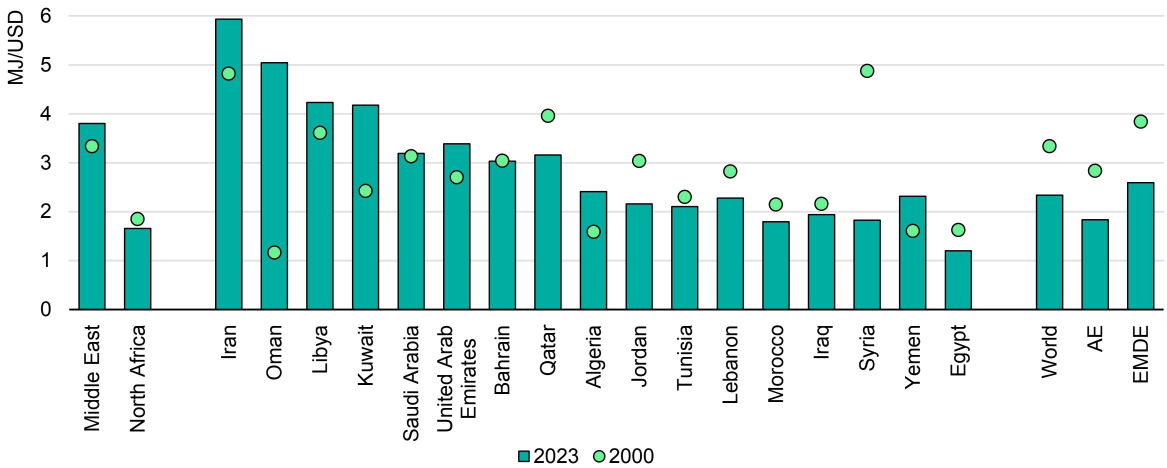


Note: AE = advanced economies; EMDE = emerging market and developing economies.

Similarly, six countries fall below the region's average electrification rate of 16.4%. Yemen's rate is barely half the regional average, at around 7%, while Algeria, Lebanon, Oman and Iran all sit at around 12% to 13%. In contrast, six countries in the region have an electrification rate higher than the world average. This is in some cases explained by the larger share of the buildings sector within final consumption and significant cooling consumption.

The MENA region is the only major market globally that has seen its energy intensity increase since 2000. While energy intensity declined by 10% in North Africa, this was offset by a 14% increase in the Middle East. Across the region, the six countries with the highest intensities in 2023 are also those whose intensities have increased since 2000, while all the other countries (except for Yemen and Algeria) have moved in the opposite direction.

Figure 1.14 Total final consumption intensity by country in the Middle East and North Africa, 2000-2023

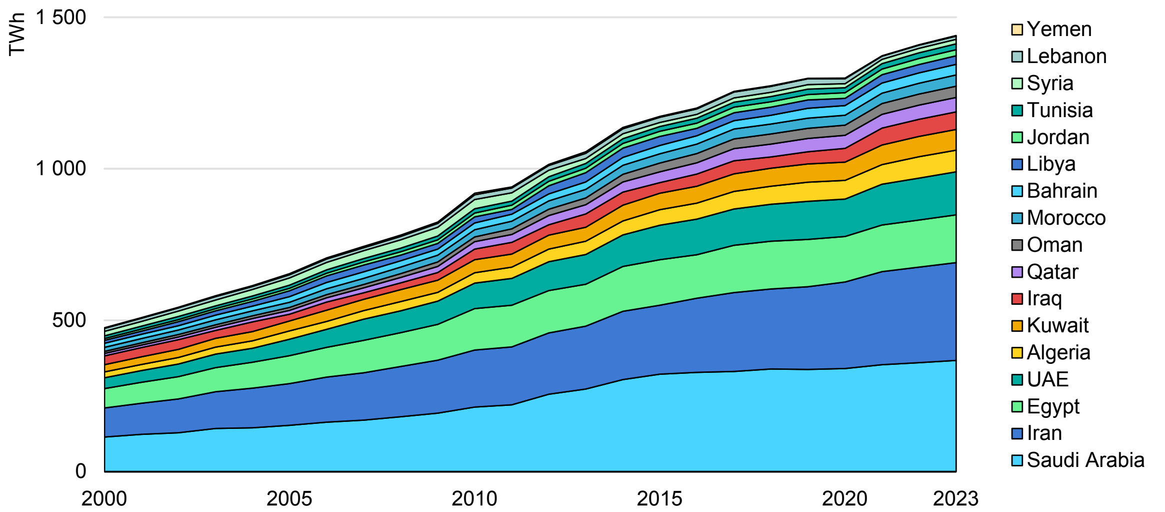


Note: AE = advanced economies; EMDE = emerging market and developing economies; MJ = megajoule.

Electricity in the MENA region

Electricity demand

Figure 1.15 Electricity demand in the Middle East and North Africa by country, 2000-2023

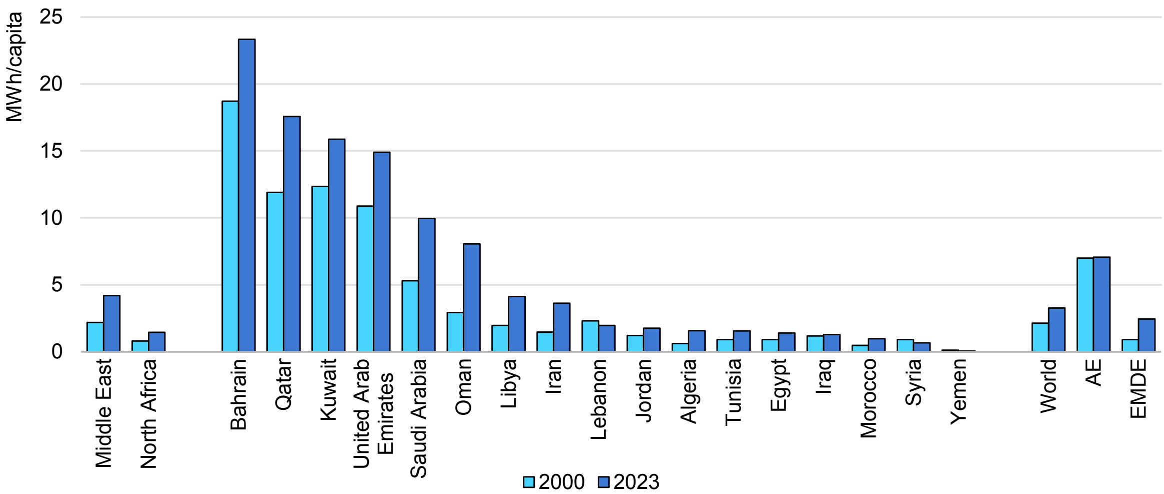


Since 2000, electricity demand in the MENA region has tripled, reaching 1 440 TWh in 2023 and growing at an annual rate of 5% – significantly higher than the global average of 3%. Of the total growth of almost 1 000 TWh, four countries alone accounted for 70% of the increase: Saudi Arabia and Iran each contributed 25%, while Egypt and the United Arab Emirates each contributed 10%. These shares are roughly equivalent to their contribution to regional electricity demand in 2023. Conversely, the 11 countries with the lowest electricity consumption together make up no more than 20% of the region's electricity demand.

Since 2000, most countries in the region have experienced average annual demand growth of 4% to 6%, except for Qatar and Oman, where growth reached around 8%. Iraq and Tunisia recorded growth of only around 3%, while in Syria, Lebanon and Yemen, growth remained below 1%.

On a per capita basis, electricity demand varies widely across the MENA region. While the average demand in the region stands at 3 MWh/capita, lower than the world average of 3.3 MWh/capita, country-level demand per capita can be as high as eight times the regional average and as low as just 2% of it. These extremes are held by Bahrain and Yemen, respectively, but are not isolated cases. Six countries have demand per capita higher than the average for advanced economies, while nine are below the average for emerging market and developing economies. These disparities are generally the result of high electricity needs for specific end uses (such as desalination) combined with small populations, or by local instability, and form a pattern not typically seen in other regions.

Figure 1.16 Electricity demand per capita in the Middle East and North Africa by country, 2000-2023



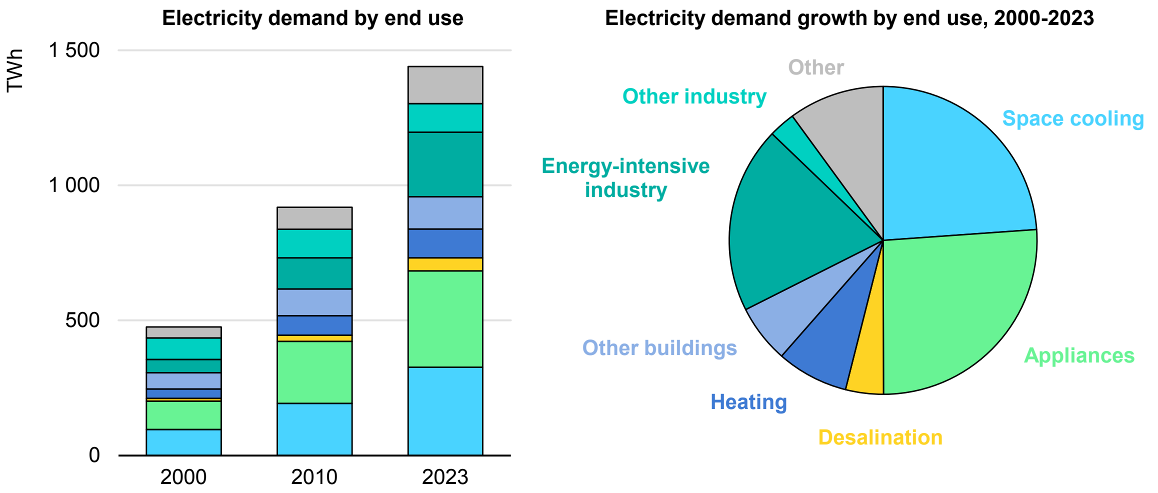
Note: AE = advanced economies; EMDE = emerging market and developing economies.

At the sectoral level, buildings accounted for two-thirds of final electricity demand in 2023, followed by industry at 24%. In absolute terms, electricity demand from the buildings sector tripled between 2000 and 2023, reaching 960 TWh in 2023, driven by rapid growth in demand for cooling and appliances. Demand for space cooling rose above 320 TWh in 2023, accounting for 23% of total electricity demand in the region.

Since 2000, demand for air conditioning has more than tripled, a trend similar to that for all appliances. Around 27% of households in the MENA region now have air conditioning, totalling about 40 million air conditioning units. Efficiency levels, however, vary widely, with many units not covered by minimum energy performance standards (MEPS), highlighting significant potential for efficiency improvements. Nevertheless, many countries in the region have put in place dedicated energy efficiency strategies, regulatory frameworks and institutions.

As of 2023, electricity demand from data centres remained relatively low, accounting for less than 1% of total electricity demand. However, demand is expected to rise in the coming years, as Gulf countries pursue plans to develop data centre infrastructure, driven by the expansion of digital services and artificial intelligence applications.

Figure 1.17 Electricity demand and demand growth by end use in the Middle East and North Africa, 2000-2023



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Rapid electricity demand growth is placing mounting pressure on power systems across the MENA region, with both average and peak loads rising sharply in recent years. Record peak demand levels are being exceeded nearly every year, particularly during the summer months. For instance, in July 2024, Algeria's peak load reached a record high of over 19 GW. Oman, Saudi Arabia and the

United Arab Emirates are facing similar challenges, although both average and peak demand have so far been reliably met.

In 2024, several energy-producing countries in the region, including Egypt, Iran, Iraq and Kuwait, were forced to implement load-shedding to cope with peak demand periods. Iraq's grid came close to collapse, while Egypt, Iran and Kuwait introduced rolling power cuts. Outages have become longer and more frequent, especially during summer months, but also during the winter when heating demand rises, as seen in Iran.

Box 1.2 Electricity access in the Middle East and North Africa

As of 2023, over 10 million people in the Middle East and North Africa (MENA) region still lack access to electricity, equal to 2% of the population. The majority of those without access live in remote or rural areas, accounting for 90% of the population without access to electricity.

Over the past two decades, the MENA region has made significant progress in expanding electricity access. Out of the eleven countries in the MENA region that had significant populations without access to electricity in 2000, eight have achieved universal access as of 2024. However, the remaining three countries, Libya, Syria, and Yemen, are not on track to reach universal access by 2030 under today's trends and policies.

Extending last-mile connections remains a major challenge, especially in areas that are economically marginalised, logistically difficult to reach or affected by conflict. The current geopolitical context in the region is likely to further undermine reliability, with electricity infrastructure increasingly at risk of being targeted by conflict.

Over the past decades, countries affected by conflict have faced major setbacks in electricity access due to damaged infrastructure, displaced population and prolonged instability. For example, the rate of electricity access in Syria dropped from 93% in 2000 to 89% in 2020, as available power generation capacity in 2022 fell to just 38% of pre-conflict levels, far below the county's needs. Similarly, in Libya, electricity access fell from nearly full access in 2000 to around 70% in 2020, as power generation capacity halved during the civil war. In contrast, Yemen saw its electrification rate rise from around 60% in 2010 to above 80% in recent years, largely due to off-grid solar systems and donor-backed initiatives.

Reliability remains a critical challenge across the region, including in some countries with universal access. In 2024, in regions of Syria where Oxfam operates, around 5.3 million people receive fewer than two hours of electricity per day from the public grid. Similarly in Yemen, the quality and reliability of grid electricity have sharply deteriorated and access to the public grid remains limited and below pre-conflict levels. The shutdown of the Marib power plant in March 2015 – the country's largest power plant responsible for powering most of the country, marked a major setback for the national electricity sector. Some regions with universal electricity access also face continued low levels of reliability with electricity supply. In 2024, Iraq experienced over seven hours of daily blackouts in most of the areas due to high demand and fuel shortages because of high imports from its neighbours to supply its power plants.

To close the remaining access gaps, particularly in fragile states and rural communities, action plans must prioritise revitalising damaged power infrastructure. This includes rebuilding power plants, transmission and distribution networks to restore essential services. Efforts should also extend to last-mile connections for under-served and conflict-affected areas by strengthening institutional capacity and ensuring sustained investment, such as the Qatar's USD 7 billion investment to support network in Syria. For the areas where grid is absent or extension is not affordable, scaling up decentralised renewable energy solutions such as mini-grids and solar home systems can enhance system resilience against natural hazards and fuel dependency. Building resilience into power systems and embedding inclusive planning processes are essential to ensure that no one is left behind as the region advances toward universal electrification.

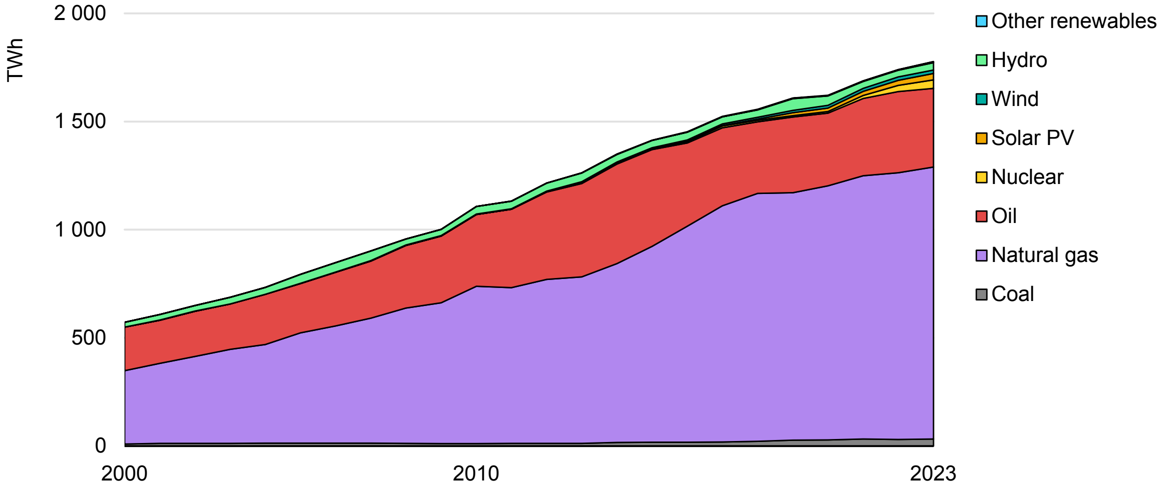
Electricity supply

Overview

In 2023, the electricity mix in the MENA region was dominated by fossil fuels, accounting for almost 95% of the total. Natural gas was the largest source of electricity (71% of the total), followed by oil (20%). Coal provided less than 2% of total electricity in the region. Renewable energy sources provided 5%, including 2% from hydropower, 2% from solar PV and 1% from wind. Nuclear power accounted for just over 2% of total electricity supply.

Since 2000, the electricity mix in the MENA region has remained heavily reliant on fossil fuels. Natural gas generation has more than tripled over the period and has been the largest source of electricity each year, ranging from between 59% and 74% of total annual generation. Oil-fired generation has nearly doubled over the past two decades and has consistently been the second-largest source, reaching its highest share in 2014 (34%) and lowest in 2023 (20%). Renewables, mainly hydropower, have played a complementary role throughout, although the share has never been higher than it is today.

Figure 1.18 Electricity generation in the Middle East and North Africa by source, 2000-2023



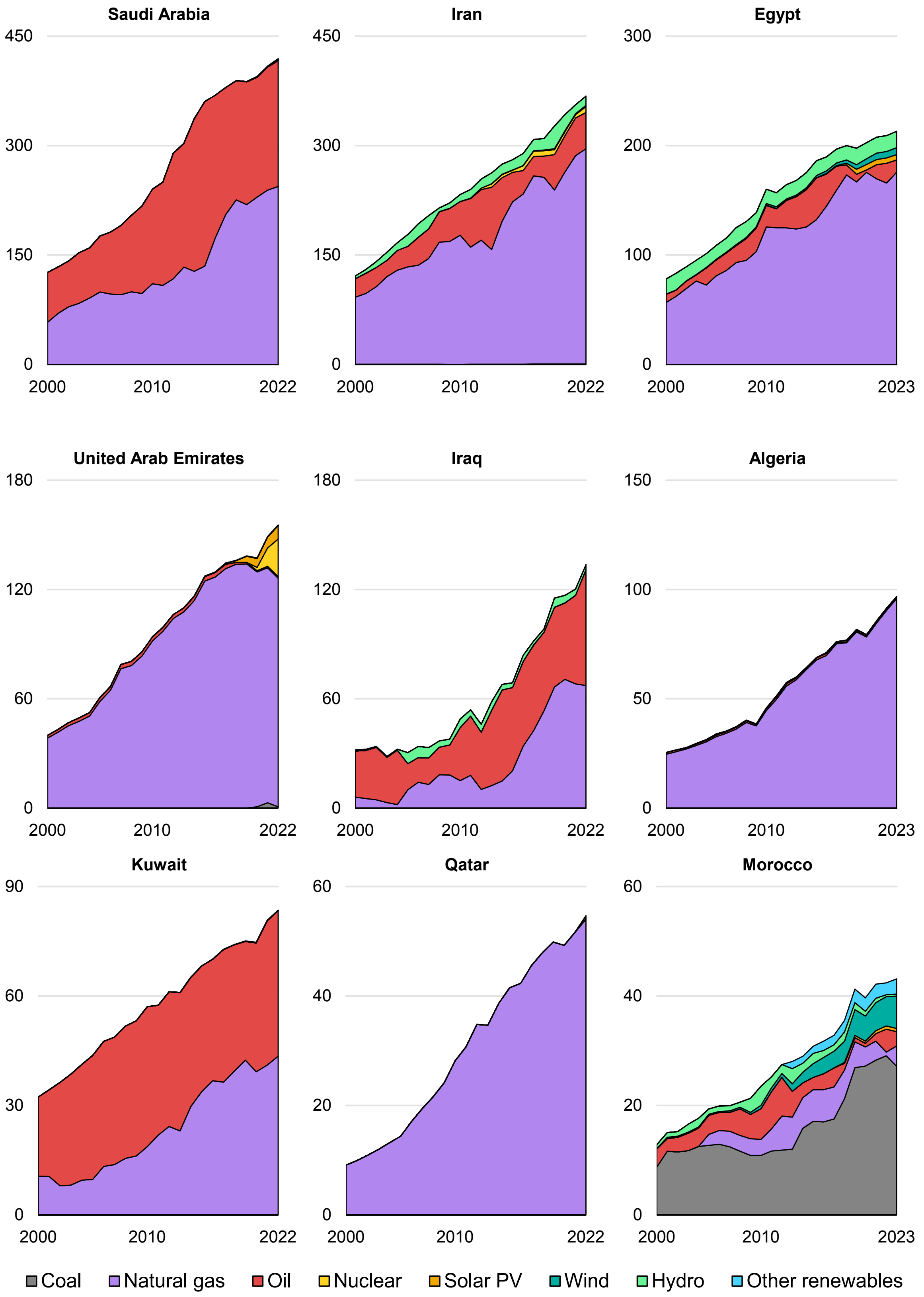
Note: Other renewables include concentrating solar power, bioenergy and geothermal.

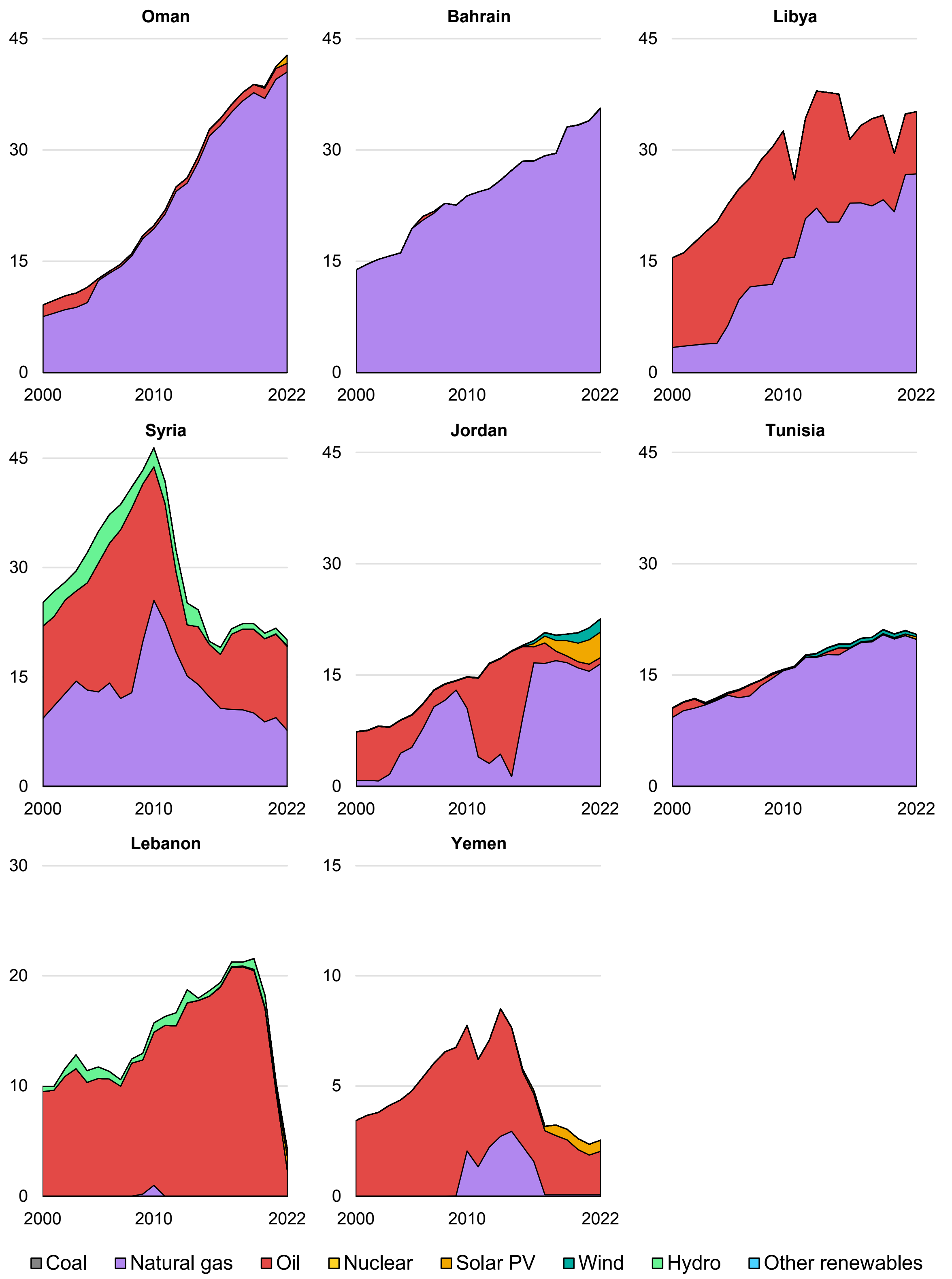
In the last five years, the electricity mix in the MENA region has begun to change. While natural gas has seen the largest increase, meeting half of all new demand, nuclear power was second-largest contributor, increasing more than fivefold from 2018 to 2023. Renewables growth has accelerated as well, led by a fivefold increase in solar PV output and an 80% increase in wind power. Combined, low-emissions sources met 30% of electricity demand growth over this period.

Since 2000, MENA countries have followed distinct paths in shaping their electricity mixes, shaped by differences in natural resources, policy priorities and national development. A common theme across most countries in the region is that electricity demand has surged, often doubling or tripling over the past two decades due to rapid population growth, urbanisation and industrial development. However, countries experiencing prolonged conflict – particularly Lebanon, Syria and Yemen – have seen sharp declines in electricity demand due to infrastructure destruction, economic hardship and population displacement.

To meet rising demand, most MENA countries have expanded fossil fuel-based generation. Yet, some are beginning to shift course. In the United Arab Emirates, the combined growth of renewables and nuclear energy has outpaced demand growth in recent years, reducing reliance on fossil fuels in the electricity sector. Egypt and Morocco have also made notable progress in scaling up renewables, which has slowed the growth of oil- and gas-fired generation.

Figure 1.19 Electricity generation (TWh) in the Middle East and North Africa by country and fuel, 2000-2023



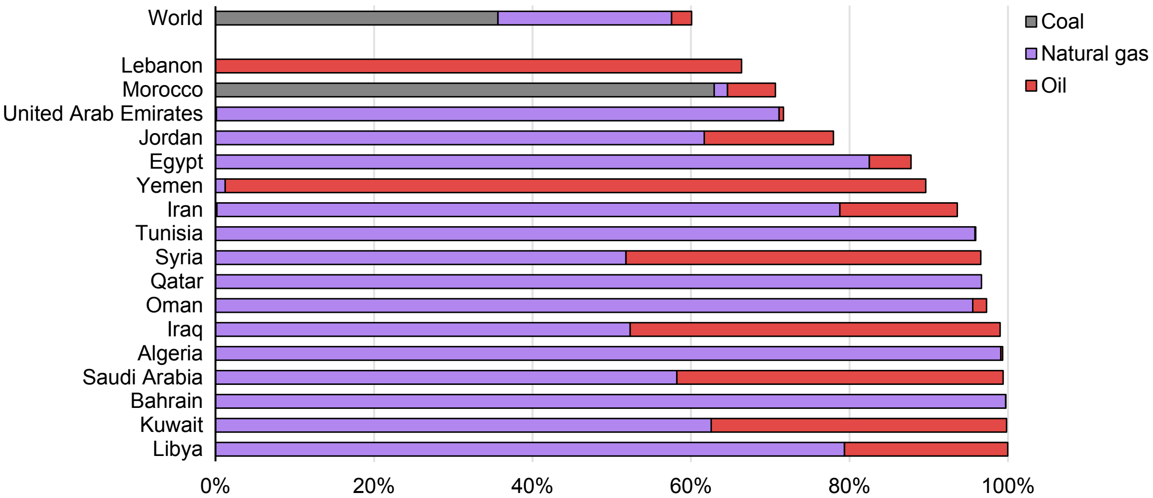


Note: Other renewables include concentrating solar power, bioenergy and geothermal.

Fossil fuels in the electricity sector

Across the 16 countries in the MENA region, fossil fuels provided between 66% and 100% of electricity generation in 2023. Three countries – Bahrain, Kuwait and Libya – generated close to 100% of their electricity with fossil fuels, while another seven countries exceeded 95% – Algeria, Iraq, Oman, Qatar, Saudi Arabia, Syria and Tunisia. The countries most dependent on natural gas for power generation were Algeria, Bahrain, Oman, Qatar and Tunisia, each relying on gas for more than 95% of their electricity. The 2023 share of oil in the electricity mix was highest in Yemen (88%), Lebanon (66%), Iraq (47%), Syria (45%) and Saudi Arabia (41%). Coal played a significant role in only one country in the MENA region: Morocco, where it accounted for over 60% of total electricity generation.

Figure 1.20 Share of fossil fuels in electricity generation by country, 2023



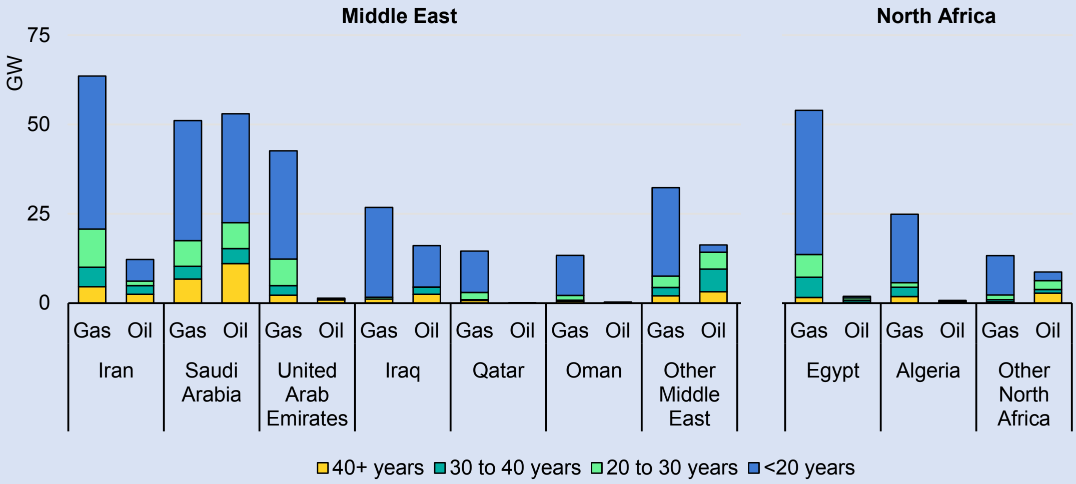
Note: Oil includes oil shale.

Box 1.3 The age of the natural gas and oil fleet in the MENA region

The age profile of thermal power plants across the MENA region is a key factor shaping the outlook for the electricity sector. As of 2023, natural gas- and oil-fired generation remain the foundation of electricity supply, supported by significant installed capacities – each exceeding 50 GW in countries such as Egypt, Iran and Saudi Arabia. Notably, Saudi Arabia alone surpasses this threshold for oil-fired generation. A large portion of these assets is relatively young: around 75% of gas-fired and 40% of oil-fired capacity is less than 20 years old. Given that such plants typically operate for over 40 years, much of this fleet still has substantial operational life remaining, underscoring its continued strategic value in meeting growing power demand.

At the same time, the region faces mounting challenges from ageing infrastructure. Approximately 45 GW of natural gas and 40 GW of oil-fired capacity are more than 30 years old and approaching the end of their technical lifespan. This issue is particularly pronounced in Saudi Arabia, where 20% of oil-fired and over 10% of gas-fired capacity has been in service for more than 40 years. As these older units near retirement, MENA countries will increasingly need to choose between extending the life of ageing plants through refurbishment or replacing them with modern, more efficient and ideally lower-emissions technologies. This tension highlights the balancing act facing the region: sustaining reliable and affordable electricity supplies while advancing towards a more sustainable and diversified energy system.

Age of natural gas- and oil-fired plants in selected countries in the Middle East and North Africa, 2023

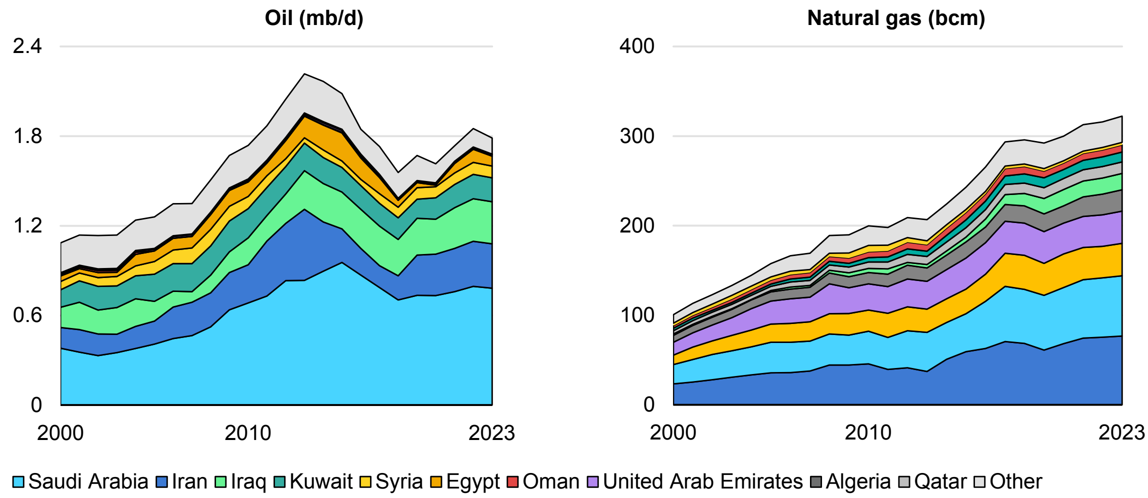


Note: Other Middle East includes Bahrain, Jordan, Kuwait, Lebanon, Syria and Yemen. Other North Africa includes Libya, Morocco and Tunisia.
Sources: IEA analysis based on Global Energy Monitor (2025), Global Oil and Gas Plant Tracker database and S&P Global (2025), Power Plant Units database of S&P Capital IQ Pro, S&P Global Market Intelligence platform.

Although the relative share of oil in power generation has declined, its absolute consumption remains significant. Oil-fired power generation peaked at over 2.2 million barrels per day in the early 2010s, declined to approximately 1.5 million barrels per day later in the decade, but has subsequently shown an upward trajectory with an estimated 1.8 million barrels per day in 2023, with four countries accounting for 85% of oil use in the power sector (Iran, Iraq, Kuwait and Saudi Arabia). One of the key drivers of this trend is the seasonal peak in electricity demand, particularly during the summer months when cooling demand spikes and gas availability tightens due to upstream constraints or export commitments. In such cases, many countries revert to burning oil or using more fuel oil. An additional, though less regionally widespread, outcome has been the increased use of mostly informal small diesel generators in countries with limited grid or generation capacity. While not representative of the region as a whole, this pattern highlights the challenges faced in specific contexts where insufficient infrastructure compels reliance on costly and less efficient solutions.

An even more consequential trend has been the rise of natural gas. In many cases, governments have positioned gas as a cheaper and more efficient alternative, underpinned by regional reserves and supported by infrastructure expansion. Accordingly, natural gas use in power generation more than tripled over the past two decades. Four countries – Egypt, Iran, Saudi Arabia and the United Arab Emirates – account for two-thirds of all the natural gas used in the power sector in the MENA region in 2023.

Figure 1.21 Oil and natural gas consumption in electricity generation by country, 2000-2023

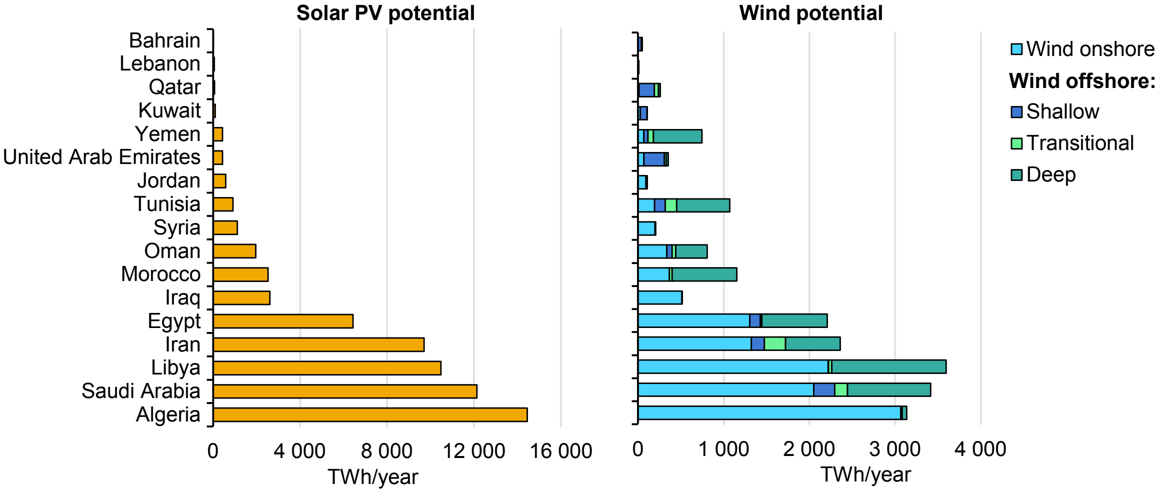


Low-emissions sources of electricity

The MENA region is endowed with some of the world's most favourable conditions for renewable electricity generation, particularly for solar but also for wind. In terms of solar energy, the region being located on the Sunbelt, benefits from one of the highest levels of solar irradiation, making it one of the most solar-rich regions globally. Wind resources are also promising, with many coastal and elevated areas consistently exceeding wind speeds of 7 m/s to 9 m/s at 100 metres height, making them ideal for utility-scale wind power generation.

A comprehensive study assessed the theoretical generation potential of solar PV and wind (both onshore and offshore) using high-resolution spatial data combined with layers of constraints, such as land use, water depth and technology-specific performance. The methodology integrates capacity factor modelling, land suitability and the identification of exclusion zones to estimate annual potential generation.

Figure 1.22 Solar PV and wind annual potential by country



Note: The definitions of the offshore wind depth categories are as follows: shallow = 0-40 metres; transitional = 40-60 metres; deep = 60-1 000 metres.

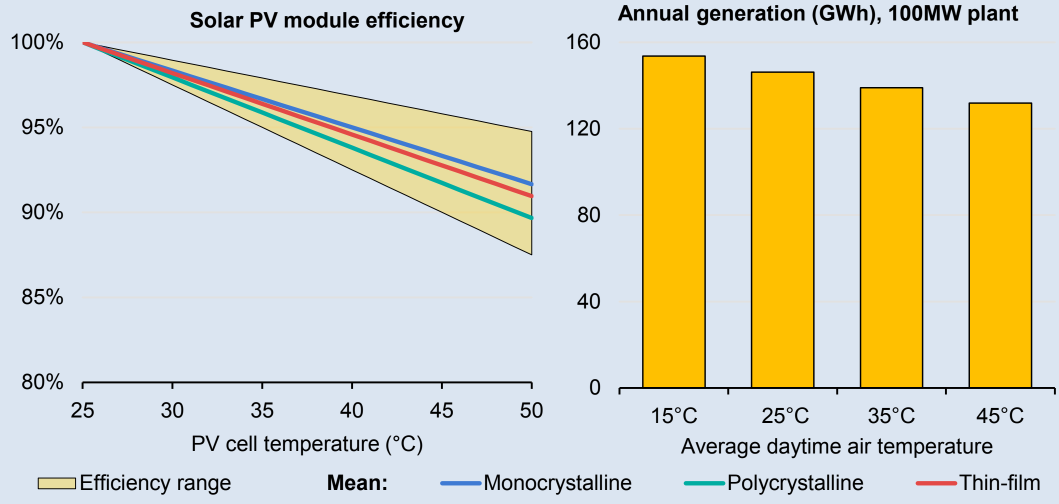
Source: IEA analysis based on Basimile et al. (2025), What is the cost and potential of low carbon electricity transition in the MENA region?

The study estimates that solar PV could generate up to 65 000 TWh/year, far exceeding the region's projected electricity demand. Algeria leads with a potential of 14 446 TWh/year, followed by Saudi Arabia (12 132 TWh/year) and Libya (10 477 TWh/year). These figures reflect both high solar irradiance and vast available land.

Box 1.4 Solar PV performance in high temperature conditions

The physical processes underpinning solar photovoltaic (PV) output are intrinsically impacted by temperature, such that PV cell performances decrease when PV cell temperatures rise above 25 °C. Higher solar cell temperatures lead to voltage drops within the cells that outweigh increases in current, causing power output to decrease. This effect is summarized in a linear relationship approximated by the cell temperature coefficient, measured as the percentage loss of maximum power output per degree Celsius. Different photovoltaic cell technologies have different sensitivities, varying from -0.2% to -0.5% per extra 1 °C, with monocrystalline cells performing better under higher temperature conditions. For example, an air temperature difference of +10 °C can decrease cell efficiency by 3.3% and annual output by 7.2 GWh for a 100 MW monocrystalline plant, all else equal.

Impact of temperature on PV module efficiency and annual output



Note: Module efficiency losses against module temperature were obtained from screening manufacturer datasheets. Yearly generation is for an assumed 100 MW utility solar plant in Egypt, assuming all else equal and without considerations for operational downtime or curtailment.

Source: ENF (accessed 2025), Solar Panel Global Database.

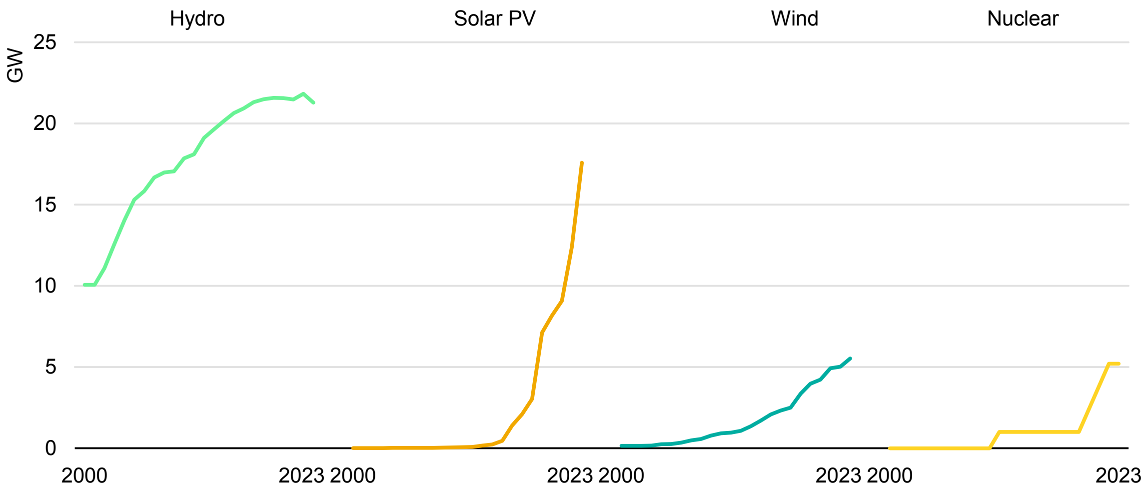
The cell temperature depends on ambient conditions (temperature, wind speed, surrounding albedo, irradiation), cell materials, as well as module and plant design. Many of the locations with the highest solar potential also correspond to some of the warmest locations on the planet. Hence, the choice of location, adaption measures to local conditions, and mitigation of rising temperatures cannot be understated. Some measures have already been implemented while others are the subject of active research. There is a lot focus on improving cell design and materials, for example with N-type cells being less sensitive to temperature. Some cooling methods are already well understood like wind convection cooling or water cooling, having been tested in Morocco or the United Arab Emirates amongst others, while more novel ones are being explored like phase-change materials (PCM), hybrid systems in Malaysia or reflective coatings in Australia. Many remain to be widely adopted.

Wind energy also holds significant promise, with a combined onshore and offshore potential of approximately 20 000 TWh/year across the MENA region. Onshore wind represents 60% of this potential, with Algeria, Libya and Saudi Arabia leading the way thanks to favourable wind speeds and ample land availability that support high-yield installations. Offshore wind potential is less substantial overall, and three-quarters of it is located in deep-water zones (60 m to 1 000 m). These areas offer the highest theoretical yields but require floating wind turbine technologies, which are still emerging and not yet widely deployed in the region. In contrast, shallow (0 m to 40 m) and transitional (40 m to 60 m) offshore zones are more accessible and suitable for established technologies. Countries like Qatar, Tunisia and the United Arab Emirates have significant potential in these zones.

Tapping into the vast technical potential, supportive policies have spurred a substantial increase in low-emissions sources of electricity over the past two decades, with significant growth in solar PV, wind, nuclear and hydropower. Hydropower capacity has more than doubled since 2000, reaching over 21 GW in 2023. Solar PV has taken off in recent years, rising from 3 GW in 2018 to 18 GW in 2023, mainly in the form of utility-scale projects. Wind power has also been growing steadily, exclusively through onshore projects, surpassing 5 GW by 2023.

Nuclear power has also made notable strides, with the first reactor brought online in Iran in 2011. The United Arab Emirates has been at the forefront of nuclear development in the region, commissioning over 4 GW of capacity between 2020 and 2022 through the Barakah 1-3 reactors, with Barakah 4 beginning operations in 2024. These developments, together with Iran's existing nuclear capacity, bring the region's total to just over 5 GW, marking a strategic diversification of the power mix and complementing the broader push towards renewables.

Figure 1.23 Capacity expansion for hydro, solar PV, wind and nuclear power in the MENA region, 2000-2023

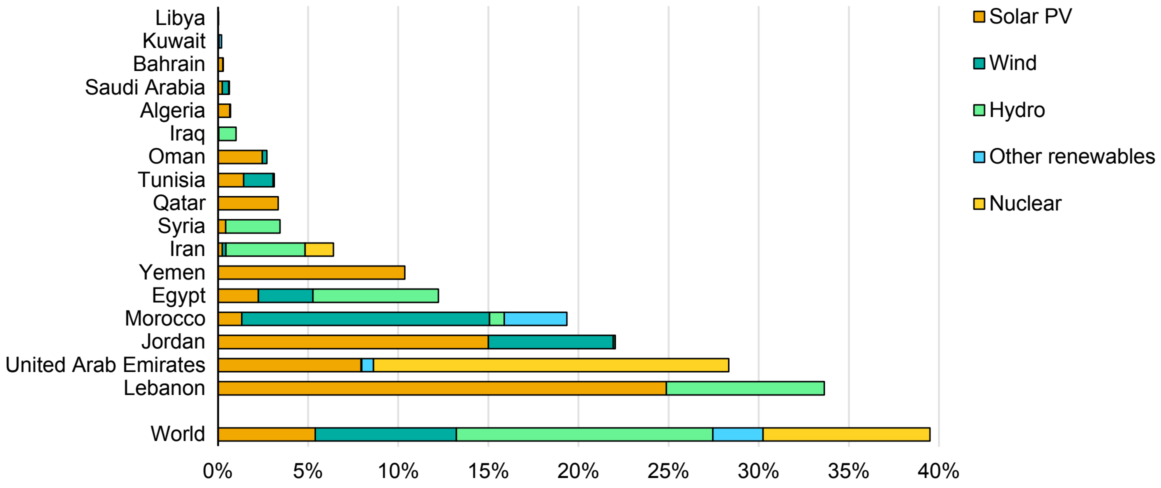


In 2023, the share of low-emissions sources in the electricity mix varied widely across MENA countries. In countries like Bahrein, Kuwait and Libya, the contribution from these sources remained below 0.5%, while others had significant shares, such as the United Arab Emirates and Jordan with over 25% and 20%, respectively.

Jordan and Morocco led the region in renewable electricity, each supplying around 20% of their total electricity from renewables. In Jordan, solar PV accounts for

15%, one of the highest shares globally, while in Morocco, wind plays a key role, also contributing 15%. Egypt and Yemen followed with notable shares, while most other countries had renewable contributions of 5% or less. Lebanon also had a significant contribution from renewables in 2023, though total electricity output was very low.

Figure 1.24 Share of renewables and nuclear in electricity generation by country, 2023



Note: Other renewables include concentrating solar power, bioenergy and geothermal.

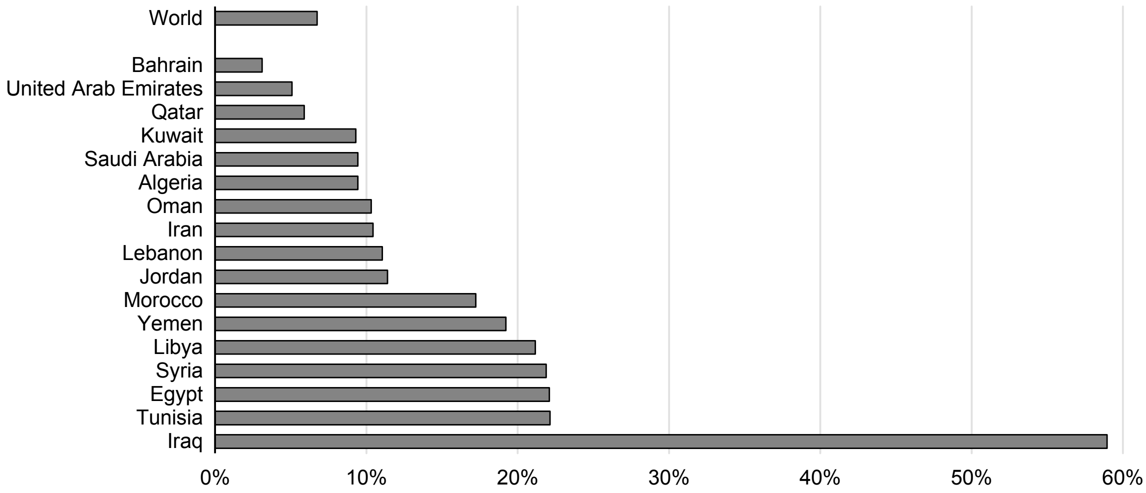
While solar PV and wind were the most prominent sources of renewable electricity, hydropower played a role in countries such as Egypt, Iran, Iraq, Lebanon and Syria, though its share consistently remained below 10% of supply. Nuclear power was most prominent in the United Arab Emirates, where it accounted for 20% of electricity generation, while it played a much smaller role in Iran, compared with the global average of 9%.

Grid losses

While electricity generation has expanded across the region, grid infrastructure in many places has struggled to keep pace, resulting in persistent losses and reliability issues that undermine the benefits of increased supply. In 2023, transmission and distribution losses across the region averaged 15% of total electricity generated, equivalent to over 260 TWh, surpassing Egypt's entire electricity supply. These losses stem from a mix of technical inefficiencies, such as undersized conductors, overloaded transformers and ageing infrastructure. Additionally, network topology plays a role: longer radial feeders and lower sub-transmission voltages lead to higher currents and increased losses. Non-technical factors, including electricity theft, inadequate metering and weak enforcement, further compound the problem.

About half of the countries experience electricity losses of 2 to 5 percentage points higher than the global average. Only a few, such as Bahrain, Qatar and the United Arab Emirates, have maintained losses below the global benchmark of 7%. This success is largely due to their modern infrastructure, advanced grid management and dense, well-meshed networks. In contrast, many other nations continue to grapple with significantly greater challenges, with losses exceeding twice the global average. In Iraq, losses are among the highest in the world, with nearly 60% of electricity generated not delivered or not metered to end users. This stark inefficiency underscores the urgent need for investment in grid rehabilitation and modernisation, a key priority identified in the IEA report, Iraq's Energy Sector: A Roadmap to a Brighter Future.

Figure 1.25 Average electricity losses by country, 2023



The consequences are felt across Iraq's economy: about 67% of firms identify electricity as a major constraint, and close to 80% rely on backup generators. These generators, though essential for continuity, impose high fuel and maintenance costs that weigh heavily on businesses and households. Egypt, Syria and Tunisia also report losses near or above 20%, placing them among the least efficient systems in the region. In Tunisia, more than half of firms cite electricity as a key constraint, reflecting persistent issues with supply quality and reliability.

Reducing electricity losses is not merely a technical fix, it is a strategic economic priority. Loss reduction offers one of the most cost-effective pathways to enhance energy security, lower emissions and improve outcomes for consumers and utilities alike. As demand rises and climate pressures intensify, tackling transmission and distribution inefficiencies will be central to building resilient, efficient and affordable energy systems across the MENA region.

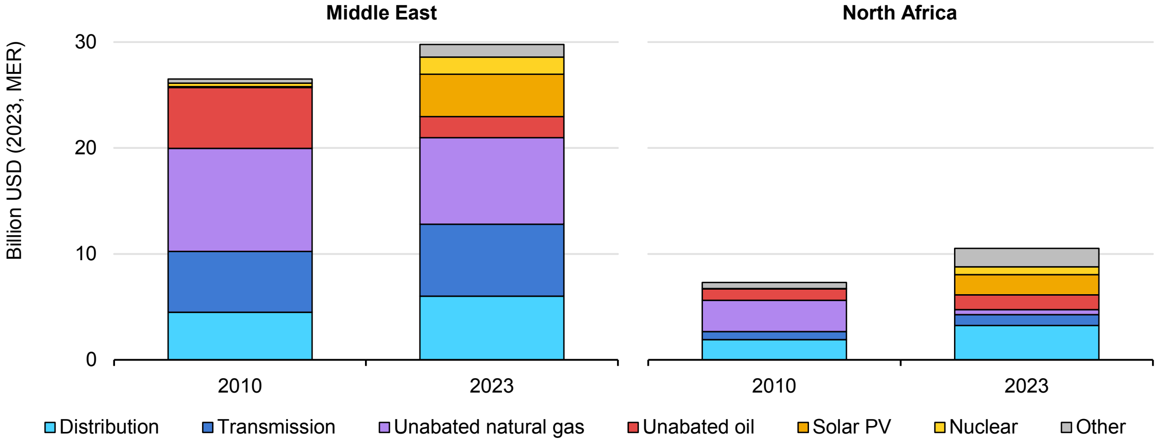
Power sector investment

Power sector investment in the MENA region has grown by nearly 20% since 2010, reaching USD 40 billion in 2023, led by rising investment in clean energy stimulated by falling technology costs for sources such as solar PV. Nuclear power investment has also increased in both the Middle East and North Africa, with the successful start of commercial reactor operations in the United Arab Emirates. Clean energy investments accounted for over 20% and 40% of total power sector investment in the Middle East and North Africa, respectively, in 2023. Despite a significant decrease in investment compared to 2010 levels, natural gas and oil still represented around 35% and 20% of total power sector investments in the Middle East and North Africa in 2023, respectively, and continue to form the foundation of the regional power mix. This continued diversification of power sector investment will allow the MENA region to begin leveraging its vast clean energy potential while ensuring energy security as electricity demand continues to rise.

Investment in transmission and distribution networks – which accounted for around 40% of total power sector investments in both the Middle East and North Africa in 2023 – increased significantly compared with 2010 levels. Grid investments, as highlighted in Electricity Grids and Secure Energy Transitions, will need to continue accelerating as electricity demand rises and power systems diversify to accommodate the higher penetration of variable renewables. Given the region's clean energy ambitions and growing pressures on the grid due to extreme weather events, interconnections within the region will also be a crucial addition to these power systems (see Chapter 3, section "5. What role do grid interconnections play in the MENA region?").

As noted in Box 1.1, the region is also home to a rising number of off-grid distributed power systems; however, investment schemes remain uneven and uncoordinated. These systems have mainly been driven by oil and gas companies benefiting from the competitiveness of solar PV compared to diesel-fired generation, especially in areas where supply reliability has been challenged, such as in Lebanon and Yemen.

Figure 1.26 Investment in power generation by type in the Middle East and North Africa, 2010 and 2023

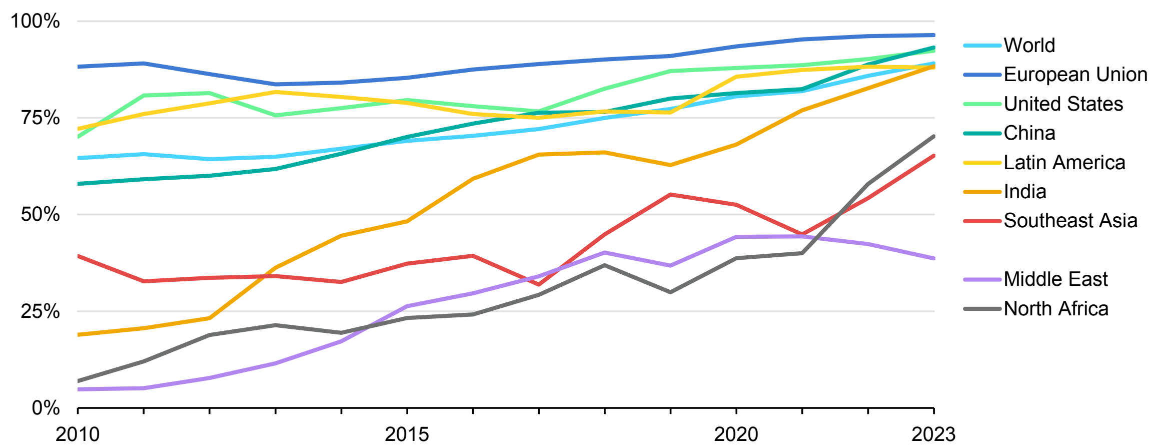


IEA. CC BY 4.0.

MER = market exchange rate.

Over the past decade, the share of investments in power generation technologies – not including investments in transmission and distribution networks – dedicated to low-emissions technologies in the MENA region has risen substantially. By 2023, these shares had risen from around 10% in 2010 to 40% in the Middle East and 70% in North Africa, reaching levels comparable to those seen in Southeast Asia. However, compared with many other regions, countries in the Middle East and North Africa still invested a lower share of total power sector investment in low-emissions technologies than the global average of around 90% in 2023. In other regions, such as the People's Republic of China (hereafter "China"), the European Union and the United States, the share of investment in low-emissions technologies is already far higher.

Figure 1.27 Share of power generation investment for low-emissions technologies by selected region, 2010-2023



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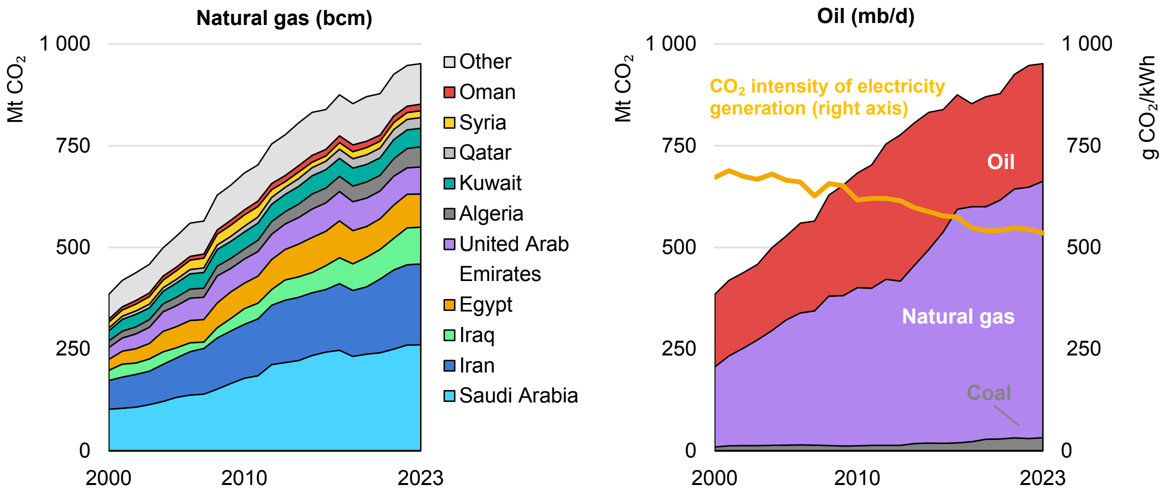
Power sector CO₂ emissions

Figure 1.28 Power sector CO_2 emissions in the Middle East and North Africa by country and fuel, 2000-2023



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Since 2000, power sector CO_2 emissions in the MENA region have more than doubled, reaching over 950 million tonnes in 2023. Saudi Arabia and Iran are the two largest emitters, together accounting for roughly half of the MENA region total. While these two countries dominate in absolute terms, emissions have risen significantly across most of the region, driven by rapid electricity demand growth and continued reliance on fossil fuels for power generation.

Natural gas-fired power generation is the primary source of power sector emissions in the region, contributing nearly two-thirds of the total. Oil-fired generation accounts for 30%, while coal contributes less than 5%. Since 2000, emissions from natural gas have tripled, reflecting its growing role in meeting electricity demand. Emissions from oil-fired power have increased by more than 60%, and although coal remains a minor part of the mix, its associated emissions have increased significantly, by a factor of 3, albeit from a low base.

Despite the overall rise in emissions, the carbon intensity of electricity generation in the MENA region has steadily declined, from nearly 700 g CO_2/kWh in 2000 to over 500 g CO_2/kWh in 2023. This improvement is largely due to the increasing share of natural gas, which is more efficient and emits less CO_2 per unit of electricity than oil or coal. Modern gas-fired power plants can operate with emissions intensities below 400 g CO_2/kWh, while oil- and coal-fired plants often exceed 900 g CO_2/kWh.

Chapter 2. Pathways for electricity demand and supply in the MENA region

Which way from here?

Scenarios

The projections described in this chapter explore possible pathways for electricity systems in Middle East and North Africa to 2035, the levers that decision makers can use to reach them and their implications for energy markets, security and emissions. They build on the World Energy Outlook 2024 scenarios:

The Stated Policies Scenario (STEPS) is designed to provide an indication of the prevailing direction of the energy system's progression under today's policy settings, based on a detailed sector-by-sector review of the energy, climate and related industrial policy landscape.

The Announced Pledges Scenario (APS) considers all energy and climate commitments made by governments and industries, including nationally determined contributions (NDCs) and longer-term decarbonisation targets, as well as national objectives for access to electricity and clean cooking. It assumes that these commitments will be met in full and on time.

The scenarios include the latest energy market and cost data, and build on the latest projections for economic and demographic trends.

Policy landscape

Table 2.1 Cross-cutting policy assumptions for selected regions and countries by scenario

Middle East		
Scenario	**Sector**	**Policies and targets**
Stated Policies Scenario	**Cross-cutting policies/ targets**	• Bahrain: 30% emissions reduction by 2035, stated in the country's National Energy Strategy • Kuwait: Announcement to reach carbon neutrality in the oil and gas sector by 2050 and other sectors by 2060. • Qatar: Executive by-law for the Environmental Protection Law, including methane regulations and standards • Saudi Arabia: Partial implementation of the Saudi Vision 2030 • United Arab Emirates: Conservation of Petroleum Resources Law, including flaring or venting methane restrictions
	Demand (transport/ industry/ buildings)	• Saudi Arabia: 2024-2028 Corporate Average Fuel Economy standards • Saudi Arabia: IE3 Minimum Energy Performance Standards for industrial electric motors (2018) • Qatar: Clean Energy and Eco-Friendly Financing programme proving low-interest loans to small and medium-sized enterprises doing energy efficiency renovations (2023) • Saudi Arabia: Updated minimum energy performance standards (MEPS) for air conditioners in buildings (2021) • United Arab Emirates: National Green Building Regulation setting minimum standards for new buildings (2021)
	Power	• Iran: Target to increase the share of nuclear power to 20 GW by 2040 • Jordan: Energy Strategy 2020–2030 sets a target of 31% renewables share in its electricity generation, equivalent to 3.2 GW of installed capacity • Lebanon: At least 30% of generation capacity from renewable sources by 2030 (Lebanon's Policy Statement) • Qatar: Increase the share of renewable energy to 18% in its power mix by 2030 (National Renewable Energy Strategy)
Announced Pledges Scenario	**Cross-cutting policies/ targets**	• Net zero emissions targets by 2050 in Lebanon, the United Arab Emirates and Oman; Saudi Arabia, Bahrain and Kuwait aiming for 2060 • Ten countries (Bahrain, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, United Arab Emirates and Yemen) are signatories to the Global Methane Pledge • Six national oil companies in the region have signed the Oil and Gas Decarbonization Charter • Four countries (Bahrain, Iraq, Oman and Saudi Arabia) are endorsing Zero Routine Flaring by 2030 initiative • Oman: Updated nationally determined contribution (NDC) (2023), from 7% to 21% emissions reduction by 2030 compared to business-as-usual
	Demand (transport/ industry/ buildings)	• Qatar: Plans to convert 35% of car fleet and 100% of public buses to electric by 2030 • United Arab Emirates: Increase the share of electric vehicles (EVs) to 50% of the total fleet by 2050 • Saudi Arabia: Public Investment Fund target to invest USD 20 billion for sustainable projects, including green buildings.

Middle East		
Scenario	**Sector**	**Policies and targets**
Announced Pledges Scenario (continued)		• United Arab Emirates: Target to decrease by 2050 the energy consumption of buildings by 40% compared to 2019
	Power	• Iraq: Plans to add 12 GW of solar PV and 1.25 GW of wind by 2030 • Kuwait: Announcement of increase in the share of renewable energy production to 30% by 2030 and 50% by 2050 • Oman: Pursuing 60% renewables penetration in its power supply mix by 2034 (Sultanate of Oman's National Strategy for an Orderly Transition to Net Zero) • Saudi Arabia: Saudi Vision 2030 sets a target of increasing the share of renewables to 50% of its electricity mix by 2030 • United Arab Emirates: The updated UAE Energy Strategy 2050 aims to triple the share of renewable energy by 2030
North Africa		
Scenario	**Sector**	**Policies and targets**
Stated Policies Scenario	**Cross-cutting policies/ targets**	(None included in this scenario)
	Demand (transport/ industry/ buildings)	• Morocco: Adopted the light duty vehicle Euro 6 standard for second-hand vehicle imports (2023) • Egypt: Updated MEPS for industrial motors (2023) • Egypt: Updated MEPS for air conditioners and heat pumps (2022) • Morocco: Updated MEPS for air conditioners (2025)
	Power	• Algeria: Renewable Energy Program sets a target to achieve share of 27% electricity generation by renewables by 2030; also aims to increase its renewable capacity to around 22 GW by 2030 • Libya: National Strategy for Renewable Energy & Efficiency 2023-2025 aims to increase the share of renewable energy to 20% by 2035 • Morocco: Long-term low-carbon strategy sets a target of increasing the share of renewables to 52% of electrical capacity by 2030 • Tunisia: Target of increasing the share of renewables to 30% in its electricity mix
Announced Pledges Scenario	**Cross-cutting policies/ targets**	• Net zero emissions targets by 2050 in Morocco and Tunisia • Four countries (Egypt, Libya, Morocco and Tunisia) are signatories to the Global Methane Pledge • Two national oil companies in the region have signed the Oil and Gas Decarbonization Charter • Two countries (Egypt and Morocco) are endorsing Zero Routine Flaring by 2030 initiatives
	Demand (transport/ industry/ buildings)	• Egypt: National Railways Modernization Project • Morocco: EV roadmap with targets for EV and charging points deployment • Morocco: Plan Maroc Rail Strategy to improve and develop the network
	Power	• Egypt: 2023 Second Updated NDC, targeting 42% of low-emissions sources in the electricity mix by 2030

Energy Strategy in Qatar, the Updated UAE Energy Strategy 2050 in the United Arab Emirates and the National Strategy for Energy and Efficiency 2023-2025 in Libya. While most countries with renewable targets are aiming to increase their renewable share (either in capacity or generation) to around 20% to 40% by 2030, Morocco, Oman and Saudi Arabia have set more ambitious targets of 52% by 2030 (Morocco), 60% by 2034 (Oman) and 50% by 2030 (Saudi Arabia). The 28th Conference of the Parties (COP28), hosted in the United Arab Emirates in 2023, also served as a notable moment in advancing this transition. Five countries in the region – Jordan, Oman, Tunisia, the United Arab Emirates and Yemen – endorsed the COP28 pledge to triple global renewable capacity by 2030.

As a dispatchable source of low-emissions electricity that is available around the clock, nuclear power is receiving attention in several countries. Iran has announced its ambition to expand nuclear capacity to 20 GW by 2040, while the United Arab Emirates continue to expand their use of the technology. Some countries are in the process of introducing the nuclear power for the first time into their electricity supply. Saudi Arabia is also exploring the use of nuclear power to diversify its electricity mix.

Many countries across the region are integrating carbon capture, utilisation and storage (CCUS) into their national decarbonisation strategies to address emissions from hard-to-abate sectors. Saudi Arabia and national oil companies in the United Arab Emirates as well as Qatar have set ambitious annual capture targets of 44 Mt CO_2/year, 10 Mt CO_2/year, and 6-8 Mt CO_2/year, respectively. These efforts are backed by emerging regulatory frameworks, national CCUS roadmaps and infrastructure-sharing plans. Governments are also promoting carbon pricing and developing regional CCUS hubs to encourage private sector investment and regional collaboration.

CCUS is currently operational at three major facilities in the region: Ras Laffan LNG in Qatar (2.1 Mt CO_2/year), Uthmaniyah CO_2-EOR in Saudi Arabia (0.8 Mt CO_2/year) and Emirates Steel Industries in the United Arab Emirates (0.8 Mt CO_2/year). Although expansion has been gradual, momentum is growing. Over the past five years, over 20 commercial projects have been announced. If all announced facilities are completed by 2030, regional capture capacity could reach close to 25 Mt CO_2 annually, half of which is already operational or has reached final investment decision. While the power sector has not yet been a primary focus of CCUS deployment in the region, it holds strong potential given the dominance of fossil fuel power plants in the electricity mix.

Amid growing momentum for renewables and low-emissions electricity, a wave of initiatives is emerging across the region to support efforts to reduce the climate impact of fossil fuel production. In addition to regulatory developments in Qatar and the United Arab Emirates, as of August 2025, 14 countries in the region have signed the Global Methane Pledge. These countries – Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, the United Arab Emirates and Yemen – represent more than 50% of the region's methane emissions from energy and have committed to collectively reduce methane emissions by at least 30% below 2020 levels by 2030.

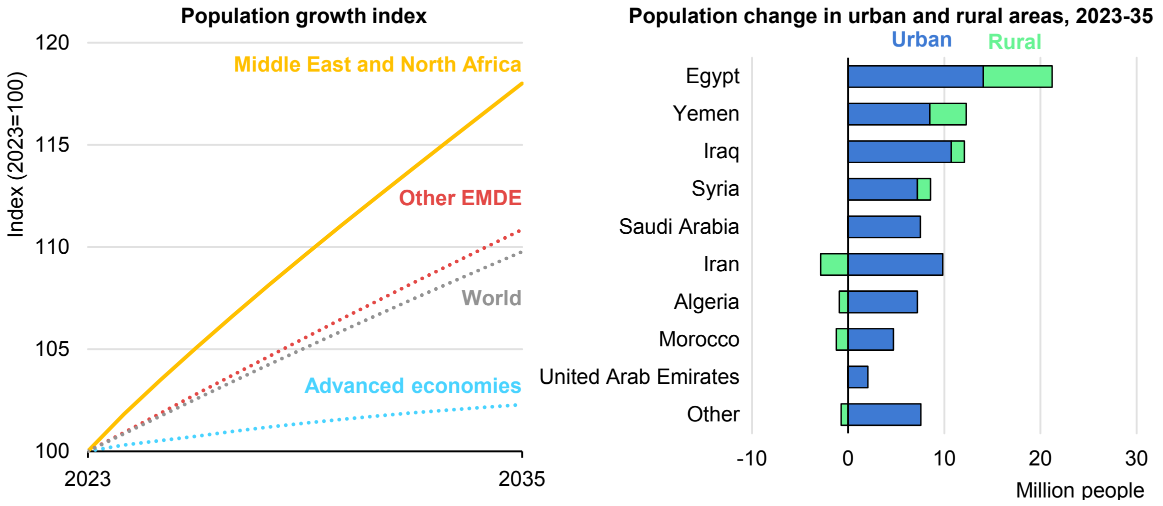
Medium- and long-term climate commitments have also evolved in the MENA region. Eight countries have pledged to achieve net zero emissions by 2050 or 2060. Collectively they account for around 40% of the region's GDP and a similar share of its energy-related emissions. A total of 14 out of 17 countries have submitted their first NDCs, and 11 countries have updated their NDCs since their initial submissions, including NDC 3.0 submitted by the United Arab Emirates in 2024. However, most countries in the region except the United Arab Emirates have set their mitigation targets based on counterfactual business-as-usual scenarios, which allow absolute emissions to rise above current levels, with annual growth averaging up to 2% from 2024 to 2030.

Population and macroeconomic outlook

By 2035, the MENA region's population is projected to grow from around 485 million in 2023 to 570 million, based on the United Nations' median population projection. This increase represents about 10% of the world's population growth over that horizon – meaning one in every ten people added globally will be from the region. With an annual growth rate of 1.4%, the MENA region ranks among the fastest growing in the world, nearly double the global average. Just four countries (Egypt, Iraq, Syria and Yemen) are projected to account for more than 60% of the region's total population growth. These countries also face power shortages and are the only ones in the region where rural populations are expected to continue expanding, in contrast to the broader regional trend.

Urban areas already house nearly two-thirds of the Middle East and North Africa's population and will see the majority of anticipated growth. Between now and 2035, cities across the region are expected to absorb an additional 80 million people. As climate risks intensify, strategic investments in urban infrastructure – including energy-efficient buildings and electrified public transit systems – will be essential for achieving significant energy savings and ensuring long-term resilience.

Figure 2.1 Population growth by economic grouping in the Middle East and North Africa, 2023-2035

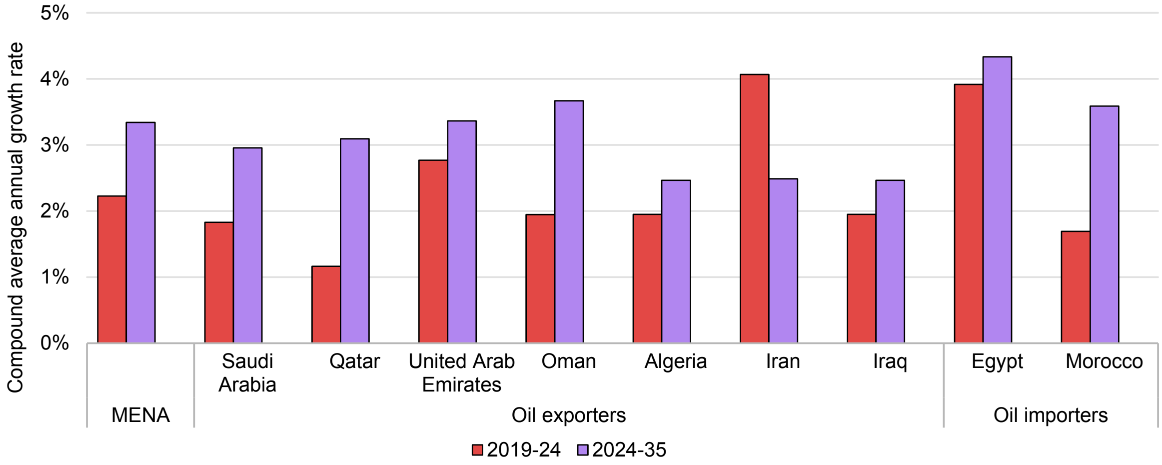


Note: EMDE = emerging market and developing economies.
Source: IEA analysis based on United Nations Department of Economic and Social Affairs (2024), 2024 Revision of World Population Prospects.

The economies of the MENA region are expected to enter a phase of recovery after a period marked by overlapping challenges, including geopolitical tensions, global trade disruptions and structural rigidities. Real GDP growth in the region is projected to rise to an average of 3.3% annually in the period to 2035, from an average of 2.2% over the past five years, reflecting easing inflationary pressures and the continued rollout of diversification strategies.

However, the macroeconomic growth outlook is highly differentiated across subregions. Among oil exporters, GCC economies are expected to lead the recovery, underpinned by robust non-oil activity, notably in Oman, Qatar, Saudi Arabia and the United Arab Emirates, where average growth over the period to 2035 is projected to range between 3.0% and 3.7%. In contrast, some non-GCC oil exporters, such as Algeria and Iran, face a more subdued outlook, with growth projected at around 2.5%, constrained by fiscal pressures, limited progress on structural reforms and, in the case of Iran, the continued impact of international sanctions.

Figure 2.2 Average annual GDP growth in the Middle East and North Africa and selected countries, 2019-2035



Notes: MENA = Middle East and North Africa. Calculated based on GDP expressed in 2024 USD in purchasing power parity terms.
Sources: IEA analysis based on International Monetary Fund (2025), World Economic Outlook: April 2025 Update and Oxford Economics (2025), Oxford Economics Global Economic Databank, April 2025 Update.

Among oil-importing economies, the outlook is also mixed. Countries such as Egypt and Morocco are benefiting from resilient domestic demand and external investments inflows, while others continue to grapple with the effects of conflicts and elevated debt burdens. In fragile and conflict-affected states, including Lebanon, Libya, Syria and Yemen, economic activity is projected to improve but remains depressed, with recovery contingent on political stabilisation.

Clean technology costs

Clean electricity technologies are projected to continue to move down the cost curve worldwide, including in the MENA region.

The average levelised cost of electricity (LCOE)[7] for utility-scale solar PV is projected to drop below USD 30/MWh by 2035, a 40% reduction from 2023 levels. This decrease is driven primarily by reductions in overnight capital costs, which are expected to fall by 45% to USD 420/kW, alongside performance improvements in module efficiency and tracking systems. Onshore wind power is expected to see more modest cost reductions, with average LCOEs decreasing by less than 10% globally by 2035. Assessing the competitiveness of power technologies, however, requires looking beyond the costs alone, as is accomplished through the value-adjusted LCOE applied in the Global Energy and Climate Model.

[7] The LCOE measures the average cost of generating electricity over a power asset's lifetime. It includes capital, fuel, operations and maintenance, carbon and decommissioning costs.

Box 2.1 Value-adjusted levelised cost of electricity as a robust metric of competitiveness

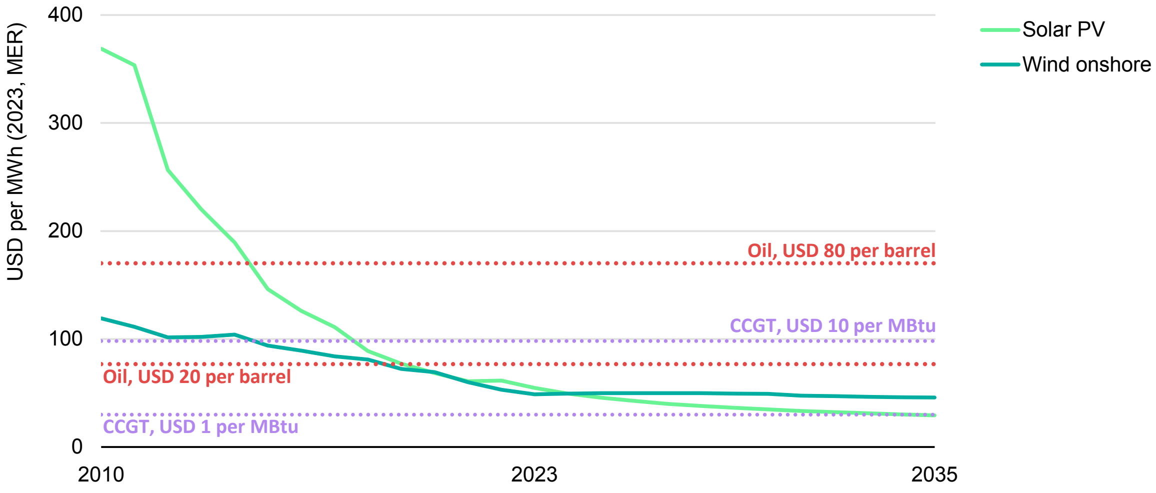
The levelised cost of electricity (LCOE) is a metric that aggregates all direct costs associated with a given technology – including construction, financing, fuel, carbon and maintenance costs. It represents the average cost of producing each unit of electricity over the technology's lifetime and is therefore widely used to evaluate the cost competitiveness of various power generation technologies, providing a point of comparison based on cost alone. However, it does not account for impacts on or interactions with the overall power system and does not necessarily indicate the least-cost option for the system. To address this limitation, the IEA developed the value-adjusted LCOE (VALCOE), a more complete metric for competitiveness that combines the technology cost (LCOE) with the value of three key system services provided by the technology – energy, flexibility and capacity – drawing on detailed hourly modelling of electricity demand and supply, an important part of the IEA Global Energy and Climate Model.

Power systems have differing needs depending on generation mix, demand patterns and the level of renewables penetration. As shares of solar PV and wind continue to rise, the value of energy provided by these sources tends to decrease compared to the system average, while the value of flexibility tends to increase. Both trends underscore the importance of looking beyond the LCOE alone to determine competitiveness.

The VALCOE is part of a broader family of metrics that go beyond the LCOE, including the System LCOE and traditional measures of profitability and cost-benefit analysis. Although the VALCOE provides a broader metric of competitiveness than the LCOE, it does not include the cost of emissions from power generation that are not priced in the market, nor does it include grid-related costs, as these are highly site-specific and influenced by the power generation mix. Grid-related costs, which represent between 10% and 30% of total power system costs in major economies today, tend to rise as the share of solar PV and wind increases, and this relationship is non-linear, with costs increasing at a faster rate at higher shares of variable renewables. These additional grid costs include transmission costs, such as extensions to connect new wind and solar PV projects (which tend to be further from existing grids, particularly for offshore wind parks) and costs for grid reinforcement or upgrades, as well as distribution grid costs. Such grid-related costs are not captured in the LCOE or VALCOE, as they can only be captured properly through comprehensive assessments of the system costs.

Auction schemes for solar PV in the Middle East and North Africa have consistently delivered some of the lowest awarded bid prices globally; however, these auction prices should not be directly equated with LCOEs. While LCOEs represent the average cost across a spectrum of projects with varying conditions, auction prices typically reflect the most competitive bids from large, best-in-class projects often under favourable circumstances. For example, projects have been awarded at USD 14/MWh in the United Arab Emirates for 1.8 GW and USD 12.9/MWh in Saudi Arabia for 2 GW. While low prices can be attributed to good irradiation and cost reductions, other country-specific conditions also likely played a role, including low labour costs, advantageous land and financing conditions, and state ownership (see Chapter 3, section "6. What are the policy frameworks driving renewables deployment in the MENA region?").

Figure 2.3 Solar PV and wind levelised costs of electricity relative to oil- and gas-fired generation, 2010-2035



Notes: CCGT = combined-cycle gas turbine; MBtu = million British thermal units; MER = market exchange rate. Capacity factors were assumed to be 50% for gas CCGT and oil.

Sources: IEA analysis based on IEA (2024), World Energy Outlook 2024, IEA (2025), Cost of Capital Observatory and International Renewable Energy Agency (2024), Renewable Power Generation Costs in 2023.

Policies play a crucial role in accelerating the scale-up of innovative technologies and in reducing financing costs, which can account for 20-50% of the LCOE for new utility-scale solar PV projects. Long-term contracts for output, such as those often provided through auction schemes, improve long-term revenue visibility and can help secure lower financing costs.

With these cost ranges, clean electricity technologies are becoming increasingly attractive for electricity production, offering cost-competitive alternatives to gas-fired generation, even with gas prices as low as USD 1/MBtu. As a result, there are significant opportunities to displace fossil fuels in the region while also reducing the system costs of electricity.

Nuclear power development in the MENA region is gaining momentum, with Egypt and the United Arab Emirates leading the way. Alongside the United Arab Emirates' Barakah nuclear power plant, Egypt is accelerating the construction of the El Dabaa plant, aiming to begin production of the first unit by the fourth quarter of 2027 and to complete all four units by 2028-2029, potentially reaching full capacity by 2030. Both projects feature large-scale pressurised water reactors and have estimated LCOEs in the range of USD 90 to USD 100 per megawatt-hour (based on assumed financing costs of 5%). Despite relatively high LCOEs compared with renewables, nuclear offers a dispatchable, low-emissions option that can enhance energy security.

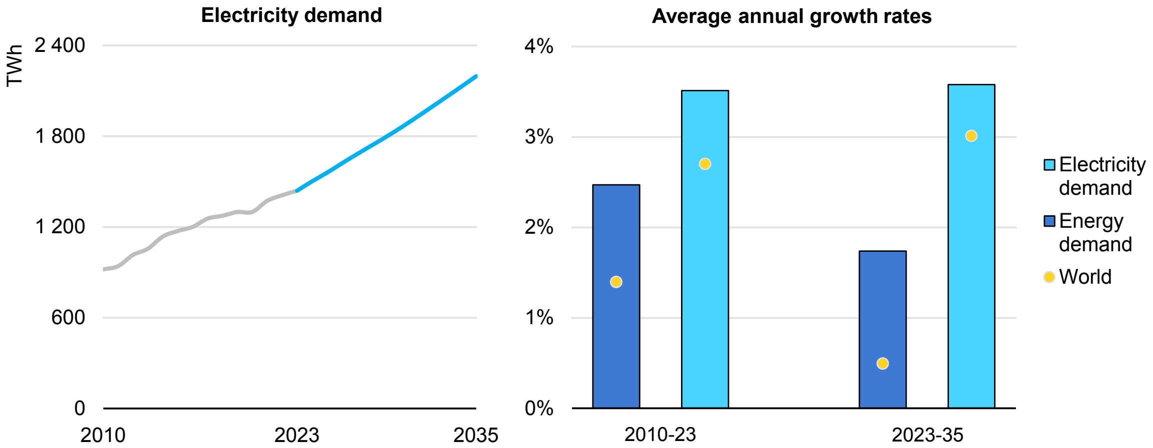
Small modular reactors, which most often have capacities of 300 MW or less, could also be an attractive option in the MENA region. With the first commercial reactors anticipated around 2030, there is great potential for the technology as China, Europe, Russia and the United States look to develop them domestically and abroad. Successful development of small modular reactors, as described in The Path to a New Era for Nuclear Energy, could rapidly bring down their costs in line with large-scale reactors and further expand the market.

Electricity demand outlook

Electricity demand growth

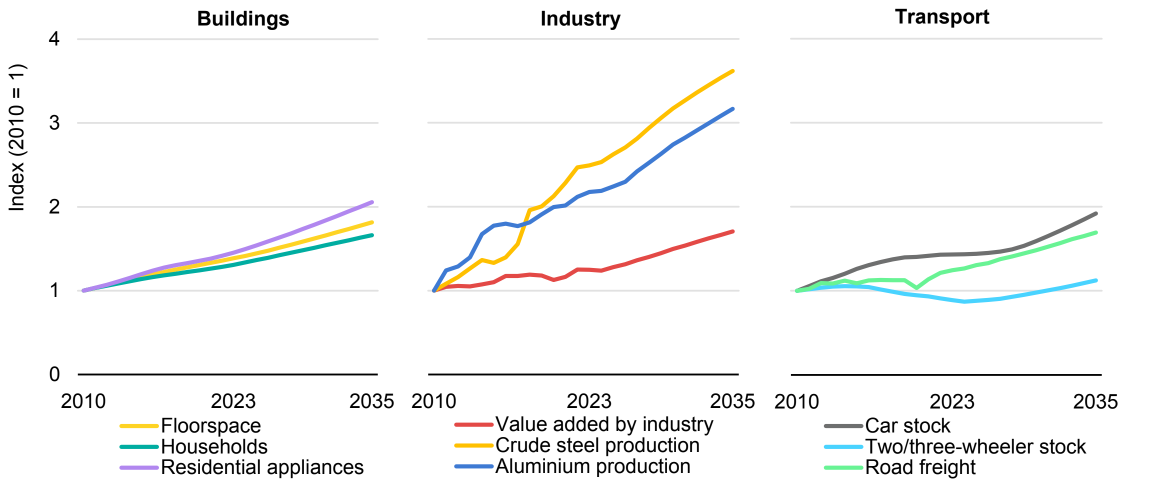
Electricity demand in the MENA region is set to grow rapidly, increasing at an average annual rate of 3.6% from 2023 to 2035 in the STEPS, driven by growing populations, rising GDP and increasing electrification of energy end uses. This is similar to the average pace of growth since 2010, which was around 3.5%, but represents a significant acceleration compared to recent years, as electricity demand growth since 2017 slowed to 2.3% per year on average. This trend contrasts with overall energy demand growth in the region, which is projected to slow from 2.5% since 2010 to below 2% in the 2023-2035 period.

Figure 2.4 Electricity demand and average annual growth rates of electricity and energy demand in the Middle East and North Africa in the Stated Policies Scenario, 2010-2035



Electricity demand in the region, which totalled over 1 400 TWh in 2023, is heavily concentrated in the buildings sector, which accounted for two-thirds of the total, while the industry sector accounted for one-quarter. Other uses, such as transport and agriculture, made up the remainder. Of the absolute increase in electricity demand from 2023 to 2035, nearly 760 TWh in the STEPS, the buildings sector continues to account for the majority, contributing around 70% of the growth (with an average annual increase of 3.7%). For the industry sector, electricity demand grows at a slower rate, contributing almost 15% of the total increase in the region to 2035. Demand in transport grows much faster, at more than 20% annually, but from a much lower base.

Figure 2.5 Growth of selected activity drivers by sector in the Middle East and North Africa, 2010-2035



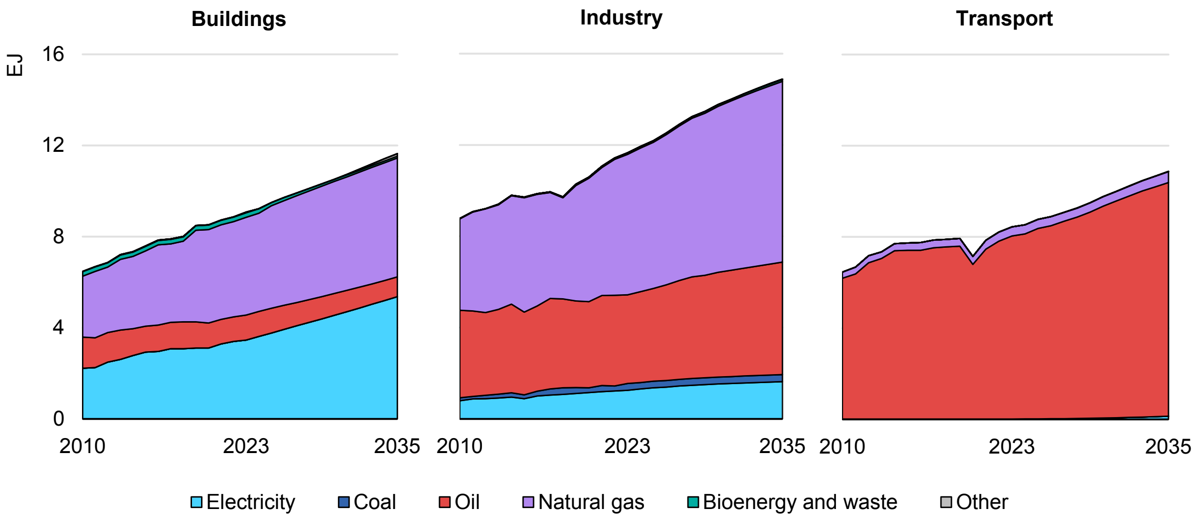
The overall increase in energy demand is driven by factors including a rising population and growing GDP. Additional factors contribute to the rise in each major end-use sector:

- The **buildings** sector sees relatively steady increases in key drivers, due to the long lifespan of most buildings and equipment. Nevertheless, the stock of residential appliances, such as televisions and cleaning equipment, more than doubles between 2010 and 2035 in the STEPS.
- In **industry**, crude streel and aluminium production in the region grows by a factor of more than three from 2010 to 2035, much faster than the overall value added by industry, making a substantial contribution to rising electricity demand.
- In **transport**, growth in both the stock of passenger cars and the volume of road freight is projected to accelerate for 2024 to 2035 in the MENA region.

Energy needs by sector: The role of electrification

The role of electricity in meeting energy needs continues to grow in the MENA region. In the STEPS, electricity's share of total final consumption in the region is projected to increase from 14% in 2010 to 19% in 2035. This trend is supported by multiple factors, ranging from the rise in demand for appliances and cooling in buildings to the growing electrification of industrial processes and increasing use of electricity in transportation and data centres. Globally, the share of electrification is set to rise even higher (to 26% by 2035), indicating scope for the region to move even faster, and some MENA countries have ambitious goals to develop large-scale infrastructure and smart cities with higher shares of electricity use.

Figure 2.6 Energy sources by sector in the Middle East and North Africa in the Stated Policies Scenario, 2010-2035



Buildings

In the MENA region, the buildings sector is the end-use sector with the highest total electricity consumption and also the highest electrification rate, at almost 40%. However, behind these numbers lies a more diverse picture across end uses and countries. Historically, electricity demand growth in buildings has primarily been driven by rising appliance and air conditioner (AC) ownership, which has increased by around 50% since 2010, and by higher incomes. This trend is set to continue: cooling and appliances are projected to add more than 300 TWh of electricity demand from 2023 to 2035 in the STEPS.

Cooking, water heating and space heating currently run almost exclusively on fossil fuels, which meet almost 90% of demand for these end uses. In the STEPS, electrification in these areas accelerates modestly: from 9% in 2010, it is projected to reach 12% in 2035. While oil accounted for 8% of lighting demand in the year 2000, its share halved to 4% as electricity access rates grew to more than 95%.

At the country level, the picture is very diverse, largely due to local temperature profiles and heating or cooling requirements. In Qatar and the United Arab Emirates, more than 90% of buildings energy demand is met by electricity, driven by significant cooling needs, while Iran and Algeria feature rates around 20%, with significant natural gas consumption dedicated to space and water heating (see Chapter 3, “How can efficiency opportunities in buildings help manage electricity demand growth?”).

Desalination, categorised within the buildings sector, is another major energy consumer, accounting for over 13% of demand in the sector. Historically desalination had very low electrification rates in the region and, unlike in most other parts of the world, ran mostly on natural gas and oil. This is now changing: the last major thermal-based desalination plant in the MENA region was installed in 2018. The electrification rate for desalination rose from 8% in 2010 to 15% in 2023 and is set to rise more rapidly to reach 36% by 2035, contributing to 20% of total electricity demand growth within buildings (see Chapter 3, “How will new desalination technologies and rising water stress impact electricity demand?”).

Industry

In recent years, electricity demand growth in industry, especially in the Middle East, has been driven by energy-intensive industries, notably aluminium, iron and steel. These industries alone account for two-thirds of industrial electricity demand today in the MENA region and made up almost all of the increase in electricity demand in the sector since 2010 (120 TWh). Underpinning this trend is the strong growth in aluminium and steel production, which have more than doubled over the same period, pushed by infrastructure and trade developments – including the

Middle East's increasing aluminium exports and the region's efforts to reduce its dependency on steel imports.

Over the next decade, despite a slight slowdown in production growth, aluminium and steel are still projected to account for almost two-thirds of growth in industrial electricity demand in the STEPS. A combination of low prices for natural gas, for electricity and potentially also for low-emissions hydrogen together supports a strong pipeline of new iron and steel plants in the region. Outside of Iran (which itself has ambitious growth plans), this includes around 20 Mt of electric arc furnaces and around 30 Mt of direct reduced iron plants, mostly initially operated with natural gas but many with plans to transition to some use of low-emissions hydrogen in the future.

The MENA region is well-positioned – both for steel and aluminium – to benefit from its extensive potential for renewable electricity generation. This could offer opportunities for the region to produce low-emissions materials that can be exported to markets with stringent carbon intensity criteria. For now, the emissions intensity of grid electricity typically remains high, but options like direct power purchase agreements (PPAs) or even the direct operation of renewable power can reduce indirect emissions for aluminium smelters and electric arc furnaces. Activity includes, as a first step, aluminium producer Emirates Global Aluminium using electricity from a solar park in the United Arab Emirates through credits.

Transport

Transportation in the MENA region remains dominated by oil-derived fuels, but there are some signs of increasing uptake of electrification. This trend is partly driven by the road sector and the rise in adoption of electric vehicles (EVs). The adoption of passenger EVs has been relatively slow in the region, with their share of new car sales rising from 0.1% in 2020 to around 2% in 2024. As a result of this limited uptake, the share of EVs in the passenger car fleet remains below 0.2% in 2024, more than 20 times lower than the world average of 4.2% and only half the rate in emerging market and developing economies excluding China. However, there is evidence of faster uptake of electric cars in some countries: in Jordan, the EV sales share reached over 50%, while in the United Arab Emirates, it was close to 15% in 2024. The region is also seeing some signs of policy backing to support this. For instance, the United Arab Emirates has introduced some EV incentive programmes, while the government of Saudi Arabia plans to roll out charging infrastructure.

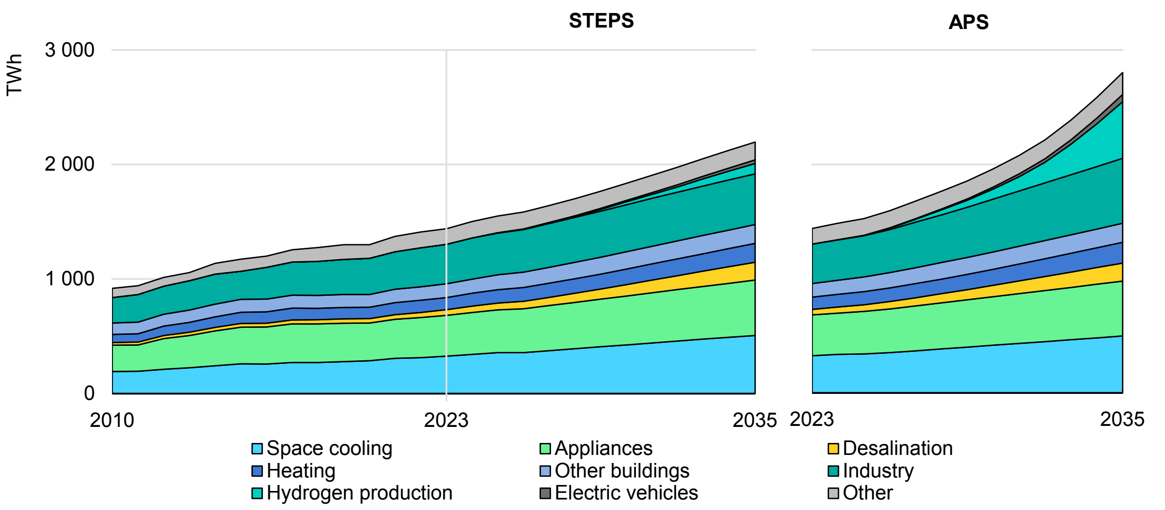
The rail sector is also seeing advances in electrification in the region. Notable developments include Morocco's high-speed rail, which is now being expanded further, and recent metro developments in Saudi Arabia, including the newly opened Riyadh network. While these projects are not major consumers of electricity themselves, they can support a modal shift away from cars and buses. There are also planned or under-construction high-speed rail and metro projects including in Bahrain, Egypt, Iran, Iraq, Qatar and Saudi Arabia that drive rail electricity consumption in the Middle East in the APS.

Evolution of electricity demand by end use

Overall electricity demand in the MENA region grows by around 750 TWh from 2023 to 2035 in the STEPS due to the combined effect of population and economic growth, greater electrification across sectors and the addition of new end uses. This growth is partially offset by efficiency improvements, which could have a significant impact in sectors like cooling and appliances in buildings (see Chapter 3, “How can efficiency opportunities in buildings help manage electricity demand growth?”).

The buildings sector is set to be the largest overall driver of growth in electricity demand to 2035 in the STEPS. Of total electricity demand growth in the region, 40% comes from higher demand for space cooling and appliances, with cooling adding around 175 TWh of demand and appliances adding around 130 TWh. Technological shifts result in electricity demand for desalination tripling by 2035, an increase of over 100 TWh. Growing electrolyser capacity leads to a sharp rise in electricity use for low-emissions hydrogen production, up from close to zero today to nearly 100 TWh in 2035 in the STEPS. An expanding industrial base and increasing electrification result in growth of around 75 TWh in electricity demand from energy-intensive industries.

Figure 2.7 Electricity demand by end use in the Stated Policies Scenario and Announced Pledges Scenario, 2010-2035

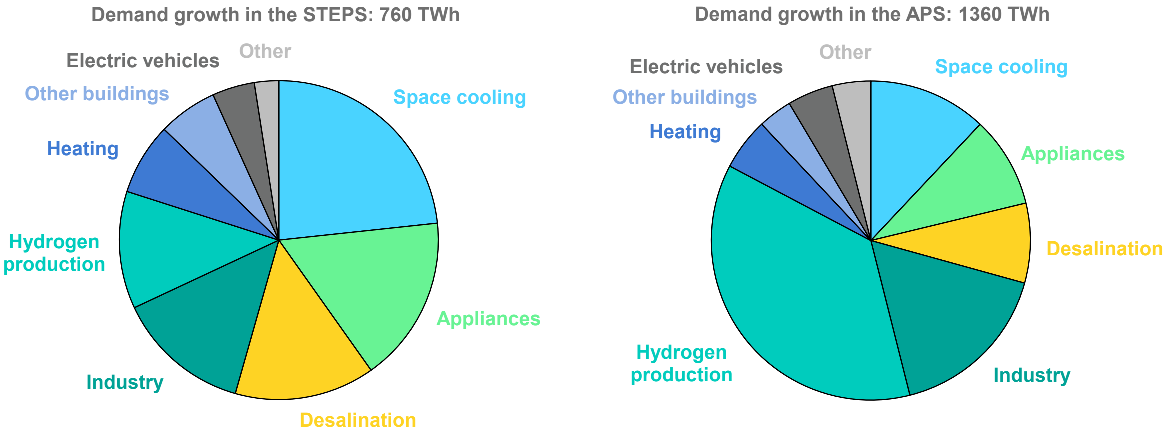


Note: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario.

Overall demand grows notably faster in the APS, with growth from 2023 to 2035 of over 1 350 TWh. Faster efficiency gains result in lower growth from some sectors, such as space cooling and appliances in buildings. However, this is more than offset by the impact of faster electrification in many other end uses across industry, transport and buildings. Much faster projected growth in electrolyser capacity sees hydrogen production account for almost 40% of the total growth in electricity demand over the period.

The MENA region has in recent years seen extensive and ambitious plans to expand production of low-emissions hydrogen. These developments remain subject to considerable uncertainty but have the potential to result in major growth in electricity demand. The region benefits from good conditions to produce hydrogen from natural gas in combination with CCUS, and it also enjoys excellent solar PV and good wind resources for producing hydrogen via electrolysis from renewable electricity. With low renewable electricity costs, renewable hydrogen production costs in the MENA region are among the lowest in the world.

Figure 2.8 Share of electricity demand growth by end use in the Stated Policies Scenario and Announced Pledges Scenario, 2023-2035



Note: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario.

The region is home to the largest electrolytic hydrogen project in the world that has reached final investment decision: the NEOM Green Hydrogen Project, with an electrolyser capacity of 2.2 GW. Many more projects are under development. Based on announced projects, total electrolyser capacity in the region could reach 60 GW by 2030, although half of these projects are still at a very early development stage, and only 2.5 GW are under construction or have reached final investment decision.

In the APS, the MENA region becomes a major producer of low-emissions hydrogen, with production of 16 Mt by 2035, corresponding to 20% of global low-emissions hydrogen production. Around 75% of this production in 2035 is electrolytic hydrogen from renewable electricity, with installed electrolyser capacity of 140 GW. Three-quarters of the produced low-emissions hydrogen is exported in the form of ammonia, synthetic hydrocarbon fuels or pipeline hydrogen to Europe, where these hydrogen derivatives are eventually used in fertilisers, shipping and power generation.

Data centres are another new use of electricity that is expanding in the MENA region. While they account for less than 1% of electricity demand today in the MENA region, several major projects are under development.

Box 2.2 Electricity demand from data centres in the Middle East

The Middle East currently hosts around 750 MW of installed commercial data centre capacity (i.e. colocation and hyperscale), accounting for around 1% of the global total. However, there is some uncertainty around these figures. Several governments in the Gulf region are actively promoting the localisation of data centres, and recent announcements have indicated strong interest in the region. This is motivated by several factors, including the desire to reap the economic benefits of the growing digital and AI sectors, for which data centres are an important enabler. Data sovereignty is also an important motivation.

Oman and Saudi Arabia, for example, have implemented special economic zones for data centres and digital infrastructure, aiming to attract investment by offering fiscal, permitting and electricity price incentives. Several Middle Eastern countries have large public investment bodies, which offer financial firepower to support data centre projects. Low energy prices are also cited as a key source of competitive advantage in the data centre sector for the region. However, data centres are so capital intensive that annual electricity consumption typically contributes less than 5% to their levelised costs. Rapid access to energy and grid connections is likely to be as important a factor as electricity prices.

Recent announcements point to potentially substantial growth in data centre capacity in the Middle East. The region's hot climate has traditionally been a disadvantage for conventional data centres, but more efficient liquid cooling technologies, required for AI racks, are reducing the relevance of this factor in location decisions, especially for AI-focused data centres. In May 2025, UAE telecommunications firm G42 announced a 5 GW data centre campus, with the first phase encompassing a 1 GW buildout. Saudi AI firm HUMAIN, owned by the Public Investment Fund, announced projects equivalent to 1 GW of capacity. If these gigawatt-scale projects materialise, they could increase the current outlook for electricity demand from data centres by an order of magnitude. While they come with uncertain delivery timelines and ramp-up schedules, they testify to the growing interest and attractiveness of the region in the digital sector.

Major country-level electricity demand projects

A growing number of large-scale projects are emerging that will significantly reshape electricity demand in the MENA region. These include data centres, EV infrastructure, desalination plants, hydrogen production facilities, industrial hubs and more. Table 2.2 provides an illustrative (non-exhaustive) snapshot of recent and planned projects, showcasing the region's dynamic shift towards electrification, including in energy-intensive applications. Developments like these are set to contribute substantially to the rise in electricity consumption in the coming years.

Table 2.2 Major country-level electricity demand projects and targets by country in the MENA region

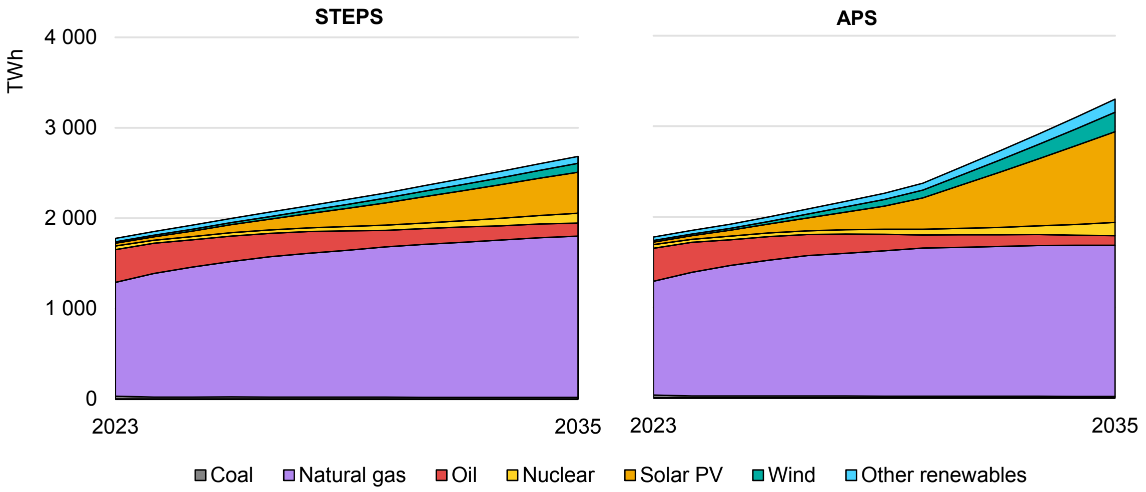
Country	Project	Date	Description
Iran	Data centre	2025	Iran plans to launch its first **Graphics Processing Unit-based data centre** by 2025.
	Water transfer	2027	The second phase of the **Persian Gulf Water Transfer Project** will transfer 200 million m³/year of desalinated water over 730 km.
Iraq	Hydrogen	2025	A **low-emissions hydrogen plant** and a solar power facility are planned for the South Refineries Company.
	Railway	2028	Iraq is extending and modernising its railways spanning Al-Faw Port to Türkiye, with the first stage planned to be completed by 2028.
Jordan	Desalination	2029	**The Aqaba-Amman Water Desalination and Conveyance Project** will supply 300 million m³/year to 3 million people by 2029.
	Electric vehicle	2030	Plans to deploy over 1000 EV charging points across Jordan by 2030.
Oman	Industry, mining, data centre	2025	Oman plans to connect several **high-profile energy-intensive projects** to the national grid over the next three years (industrial, oil and gas, mining, power and crypto-mining sectors).
	Electric vehicle	2025	The sultanate plans to double the number of **charging stations** to 300 by 2025. Taxi fleets are also undergoing electrification, with plans to convert 25% of the fleet to EVs by 2025.
	Hydrogen	2030	Hydrom, Oman's green hydrogen orchestrator, announced the signing of **two new low-emissions hydrogen projects**.
Saudi Arabia	Electric vehicle	2030	The Public Investment Fund aims to produce **500 000 EVs** annually and install **5 000 fast chargers** across the kingdom by 2030.
	Hydrogen	2026	Saudi Arabia is building the world's largest **low-emissions hydrogen-based ammonia production plant** in NEOM. The plant will use 4 GW of renewables to produce 600 tonnes of hydrogen daily by 2026.

Country	Project	Date	Description
United Arab Emirates	Data centre	2025	Major data centre project with a first phase of 1 GW, expanding up to 5 GW, to be built by Emirati AI company G42.
	Electric vehicle	2030	The United Arab Emirates aims to install **1 000 EV** charging points by 2030.
	Desalination	2025	The **M2 Reverse Osmosis desalination plant** will produce 550 000 m³/day of water for 210 000 homes.
		2027	ACWA Power and SEWA are building the Hamriyah **Independent Water Project**, which can produce 272 000 m³/day of desalinated water by 2027.
	Hydrogen	2031	The UAE Hydrogen Strategy targets 1.4 Mt/year of **low-emissions hydrogen** by 2031, scaling to 15 Mt/year by 2050.
Algeria	Desalination	2030	**Seven new desalination stations** will be built during the period 2025-2030.
	Electric vehicle	2030	Algeria plans to install **30 000 domestic charging stations** by 2030.
Morocco	Desalination	2030	**Plan to build additional nine desalination plants by 2030**, aiming to produce 1.7 billion m³/year.
	Electric vehicle	2026	Morocco announced the installation of **2 500 new charging stations** by 2026.
	Green ammonia	2032	Morocco aims to produce 3 million tonnes of green ammonia annually by 2032.
	Data centre	2026	A United States-based tech startup announced the signing of a memorandum of understanding for the establishment of a **386 MW data centre** and AI hub in Tetouan.
Egypt	Desalination	2025	Egypt will build **15 desalination plants** with a combined capacity of 3.35 million m³/year by 2025. The goal is to achieve a total capacity of 8.85 million m³/year by 2050.
	Railway	2025	The 1 825-km Egypt High-Speed Rail network will connect 60 stations throughout the country.
	Electric vehicle	2025	Egypt is working to establish a network of around **3 000 dual stations**.
	Hydrogen	2029	**New low-emissions hydrogen project** to produce 50 000 tonnes of hydrogen and 250 000 tonnes of ammonia annually.

Electricity supply outlook

Electricity generation

Figure 2.9 Electricity generation in the Middle East and North Africa by source in the Stated Policies Scenario and Announced Pledges Scenario, 2010-2035



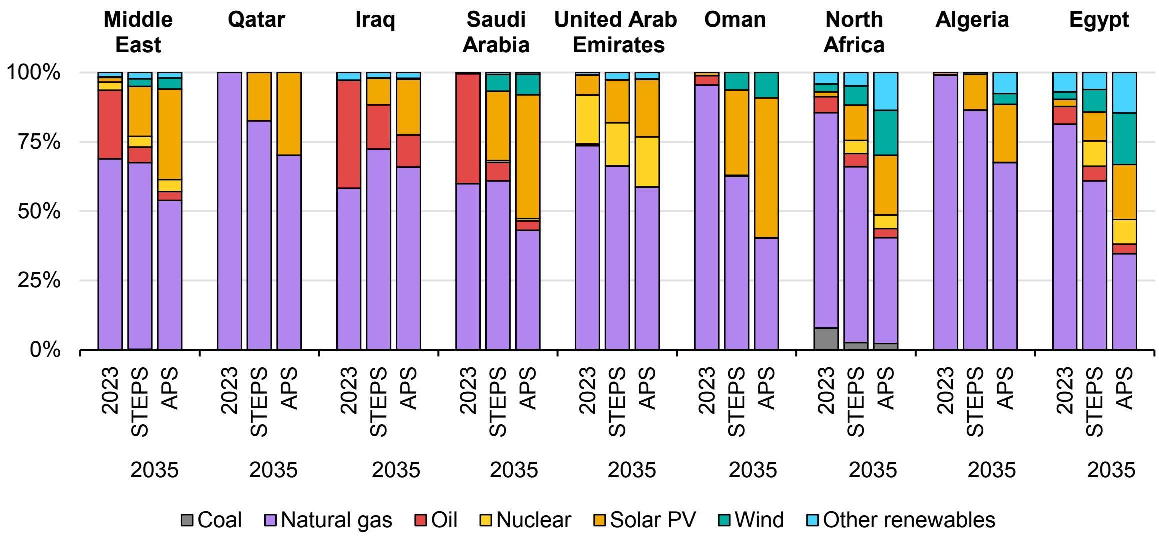
Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario. Other renewables include hydropower, concentrating solar power, bioenergy and geothermal.

Total electricity generation in the MENA region is projected to increase by around 50% from 2023 to 2035 in the STEPS, reaching nearly 2 700 TWh. Fossil fuels continue to provide the bulk of electricity in the region, though their share of total generation declines from over 90% in 2023 to around 75% to 2035. Natural gas remains the largest source of electricity in the region, increasing by 40% to 2035, though its share of the total declines slightly. Oil-fired generation declines by 60% and falls to just 5% of total electricity generation. Coal-fired power remains at less than 2% of the electricity mix in the MENA region.

Low-emissions sources of electricity meet the vast majority of electricity demand growth over the period to 2035 in the STEPS. Solar PV is set to lead the way, increasing fifteen-fold from 2023 to 2035 and making up around 50% of the total increase in generation in the region. Wind power and other renewables – including hydropower, concentrating solar power (CSP), bioenergy and geothermal – combined meet over 10% of the overall increase. Nuclear power also contributes to the growth, with output increasing two-and-a-half-fold to 2035. In total, low-emissions sources of electricity increase from 7% in 2023 to about 25% by 2035.

In the APS, where country-level policies, plans and ambitions are delivered in full and on time, low-emissions sources of electricity grow even faster and nearly keep pace with faster electrification of end uses. Natural gas-fired generation increases by one-third to 2035 and remains the largest source of electricity in the region. Oil-fired generation declines more rapidly as it is displaced by other sources. Solar PV grows over thirty-fold to 2035 in the APS, accounting for nearly one-third of total electricity generation in 2035. Together with additional growth for wind, other renewables and nuclear, low-emissions sources of electricity reach nearly 50% by 2035.

Figure 2.10 Electricity generation mix in the Middle East and North Africa and selected countries in the Stated Policies Scenario and Announced Pledges Scenario, 2023 and 2035



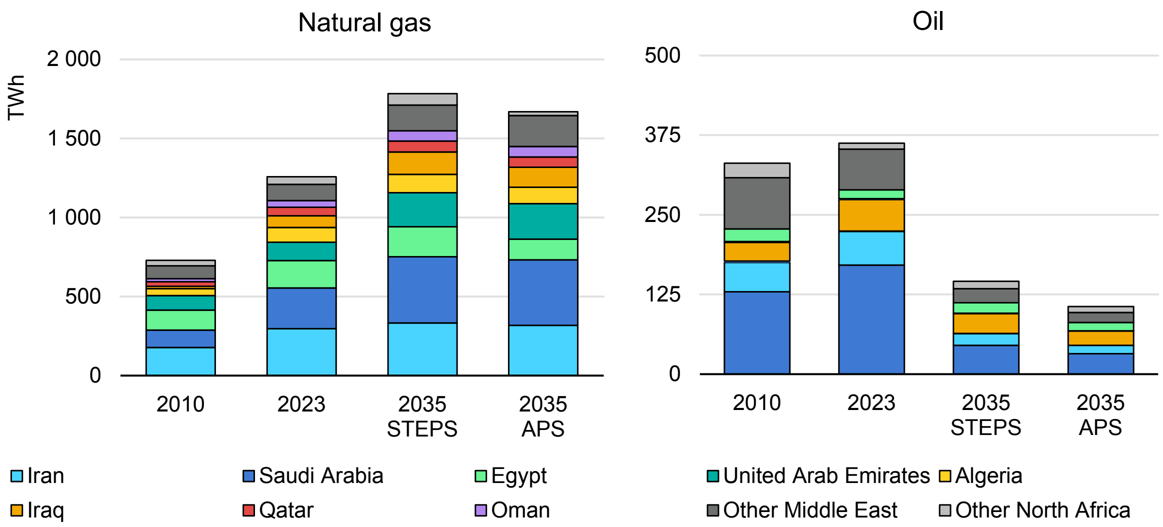
Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario. Other renewables include hydropower, concentrating solar power, bioenergy and geothermal.

Across the Middle East, the electricity generation mix is set to become much more diversified by 2035. In the STEPS, the share of natural gas in electricity generation remains broadly unchanged in the region as a whole but declines in several key countries, including Oman, Qatar and the United Arab Emirates. Saudi Arabia, the region's second-largest gas consumer, maintains a stable gas share. The changing role of gas in some countries is driven by the rapid deployment of low-emissions technologies, led by solar PV and complemented by growing contributions from wind power, particularly in Oman and Saudi Arabia. Nuclear power also expands its role, most notably in the United Arab Emirates. As a result of concerted policy efforts, oil-fired generation sees a substantial decline, especially in Iraq and Saudi Arabia. In the APS, these trends accelerate, with faster growth in renewables displacing oil and driving down the share of natural gas towards half of total electricity generation by 2035.

In North Africa, a similar trend towards diversification in the electricity mix is evident, with the share of natural gas in generation declining notably in countries such as

Algeria and Egypt, despite some absolute increases. Egypt also sees significant growth in wind and nuclear power, supporting a broader shift towards low-emissions technologies, with solar PV playing a central role across the subregion. These transitions are underpinned by supportive policy frameworks and align with broader energy security and sustainability goals. In both the STEPS and the APS, oil-fired generation continues its rapid decline, becoming a marginal contributor by 2035. In the APS, the share of natural gas in electricity generation in North Africa falls below 40% as the subregion pursues broader decarbonisation goals.

Figure 2.11 Electricity generation from natural gas and oil by selected countries in the Middle East and North Africa in the Stated Policies Scenario and Announced Pledges Scenario, 2010-2035



Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario. Other Middle East includes Bahrain, Jordan, Kuwait, Lebanon, Syria and Yemen. Other North Africa includes Libya, Morocco and Tunisia.

In the STEPS, natural gas-fired generation rises by 520 TWh between 2023 to 2035 in the Middle East and North Africa. The region is home to several of the world's ten largest natural gas producers – including Algeria, Iran, Qatar and Saudi Arabia – which combined constitute over 40% of natural gas use in 2035 in the STEPS. Although growth is somewhat more moderate in the APS, natural gas-fired power generation still increases by around one-third from 2023, underscoring the importance of the fuel in the region's electricity supply.

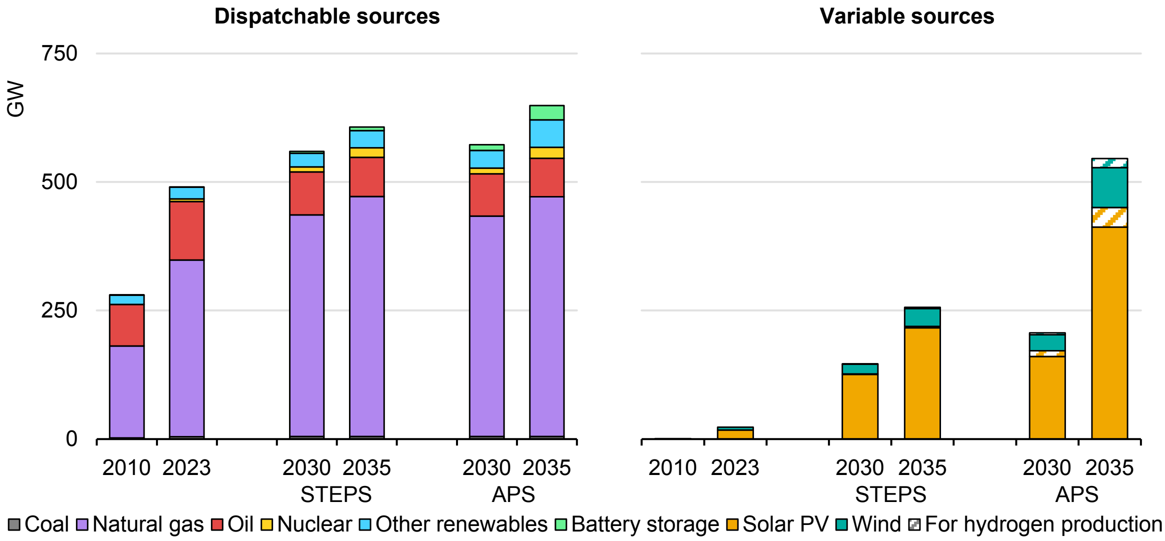
Oil-fired electricity generation in the MENA region is projected to decline by 60% by 2035 in the STEPS, with steep reductions in the Middle East. In Saudi Arabia, oil use declines by three-quarters, contributing to an overall 60% decline in regional oil demand from 2023 levels. This follows a decade marked by fluctuations in oil consumption, where major consumers such as Iran and

Saudi Arabia experienced major volatility in demand before stabilising in recent years. Despite this downward trend, MENA's oil dependency remains significantly higher than the global average, with oil accounting for 20% of the region's electricity mix in 2023 compared to just 3% worldwide, with the MENA region accounting for nearly half of global oil use in the power sector. In the APS, the shift away from oil accelerates further, with oil-fired generation falling by 70% from 2023 to 2035.

Power capacity

Overview

Figure 2.12 Installed power capacity of dispatchable and variable electricity sources in the Middle East and North Africa in the Stated Policies Scenario and Announced Pledges Scenario, 2015-2035

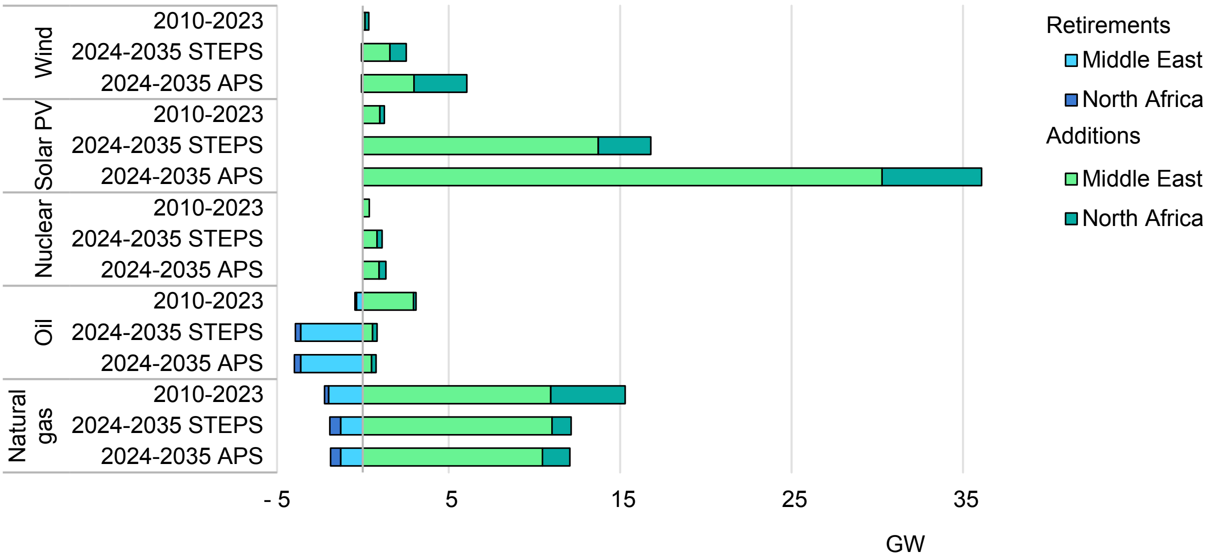


Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario. Other renewables include hydropower, concentrating solar power, bioenergy and geothermal.

In the STEPS, installed capacities of dispatchable power sources in the MENA region continue to grow steadily through to 2035, maintaining their role as the backbone of the regional power system. This growth is led by natural gas, which has accounted for the majority of dispatchable capacity additions over the past decade and continues to expand. In addition to natural gas, nuclear power emerges as an increasingly important dispatchable source, contributing to diversification and decarbonisation. Battery storage also begins to play a supporting role, particularly under the APS, by enhancing system flexibility and facilitating the integration of variable renewable energy sources.

Variable renewable energy capacity sees strong growth to 2035, with solar PV dominating additions, in part due to the region's exceptional solar resource potential. Wind power also contributes meaningfully, bringing total variable renewable capacity in the STEPS to around 250 GW. This growth reflects MENA's increasing focus on low-emissions energy, although the pace accelerates significantly in the APS, where capacity more than doubles compared with the STEPS. In the APS, expanded deployment is partly driven by ambitions to scale up hydrogen production, with flagship projects, such as Green Hydrogen Oman, the Ra Green Ammonia project and initiatives under the NEOM plan, illustrating the region's commitment to leveraging renewables for decarbonisation and industrial development.

Figure 2.13 Average annual capacity additions and retirements in the Middle East and North Africa by selected technology in the Stated Policies Scenario and Announced Pledges Scenario, 2010-2035



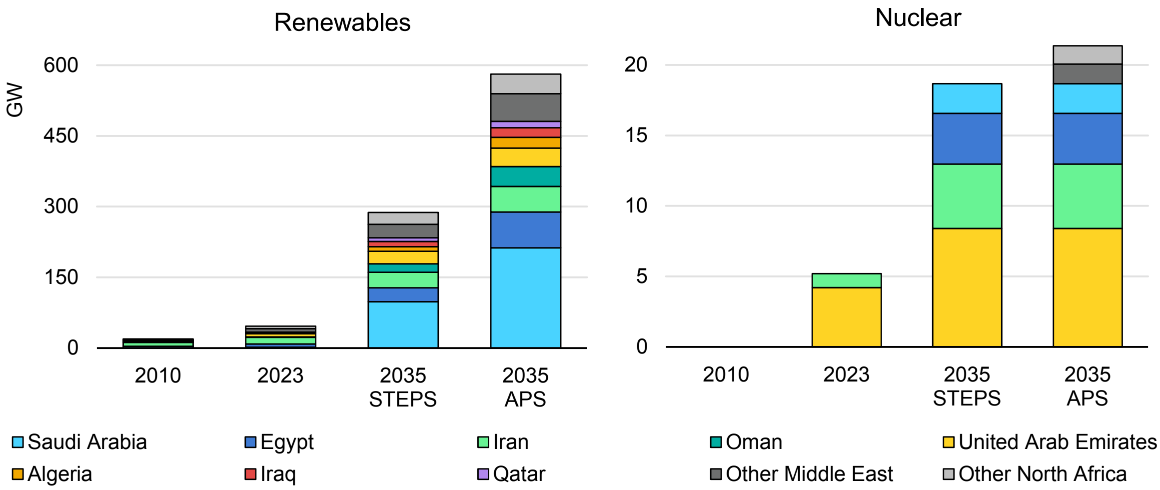
Note: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario.

During the period to 2035, total power capacity additions in the MENA region's power sector accelerate markedly, with over 30 GW of new capacity added annually in the STEPS. Close to 60% of these additions come from solar PV and wind, marking a significant shift from the previous decade when fewer annual additions were made, and 90% of new capacity was dominated by natural gas and oil. Meanwhile, oil-fired capacity is expected to decline in both the STEPS and the APS as retirements in the Middle East outpace slower new builds elsewhere in the region. In contrast, while natural gas sees continued retirements of its fleet to 2035 in both scenarios, the rate of this is slower than the past decade and is vastly outweighed by the many new capacity additions, notably in the Middle East. In the Middle East, the pace of additions remains stable to 2035 across the scenarios, while in North Africa, there is a substantial decline compared to the past decade. At the same time, renewable sources, including solar PV and wind along with nuclear, are set for substantial increases in both the Middle East and North Africa – at a rate that far outpaces (more than 10-times faster than) the growth seen over the past decade.

Renewables and nuclear capacity

Renewable energy capacity in the MENA region continues its rapid expansion to 2035 in the STEPS, where installed renewable capacity reaches nearly 300 GW. This growth builds on a decade of strong momentum, during which capacity more than doubled from 2010 levels to nearly 50 GW by 2023 led by countries such as Egypt, Iran, Saudi Arabia and the United Arab Emirates. The majority of new installations are wind and solar, including both solar PV and concentrating solar power (CSP), supplemented by other renewable sources. Notable projects include Egypt's 500 MW Zafarana wind farm – one of the region's earliest renewable ventures – and the United Arab Emirates' Mohammed bin Rashid Al Maktoum Solar Park, currently at 3 GW and with planned expansion to 5 GW. Saudi Arabia, a key driver of growth, adds nearly 100 GW of renewable capacity in the STEPS and has already commissioned the region's largest utility-scale PV project, the 2 GW Al Shuaibah 2, in 2024. In the APS, renewable deployment accelerates even further, approaching 600 GW of capacity in operation by 2035.

Figure 2.14 Installed power capacity of renewables and nuclear in the Stated Policies Scenario and Announced Pledges Scenario, 2010-2035

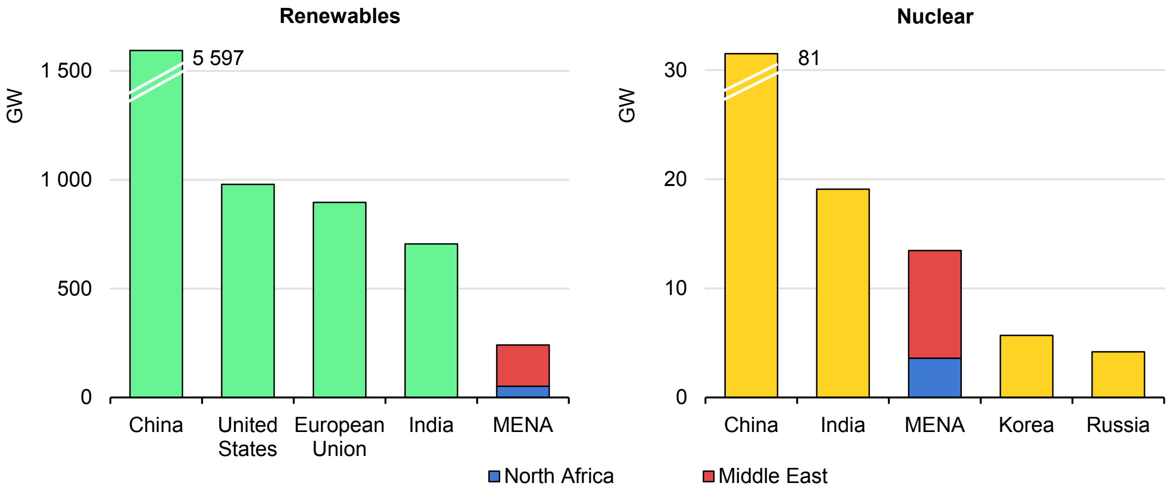


Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario. Other Middle East includes Bahrain, Jordan, Kuwait, Lebanon, Syria and Yemen. Other North Africa includes Libya, Morocco and Tunisia.

Nuclear power also sees substantial growth in the MENA region from 2023 to 2035, reaching nearly 20 GW in the STEPS. This expansion is primarily driven by continued development in Iran and the United Arab Emirates, alongside the completion of new projects such as Egypt's El Dabaa nuclear power plant and planned capacities in Saudi Arabia. In the APS, nuclear capacity expands slightly faster, reflecting interest from additional countries looking to develop their first nuclear reactors.

The MENA region is emerging as a major contributor to the global energy transition, with the rapid expansion of low-emissions technologies placing it among the most ambitious globally. In renewable energy, MENA is set to become the fifth-largest region worldwide for capacity growth by 2035. This growth is expected to be heavily concentrated in the Middle East, which will account for more than three-quarters of the region's total additions.

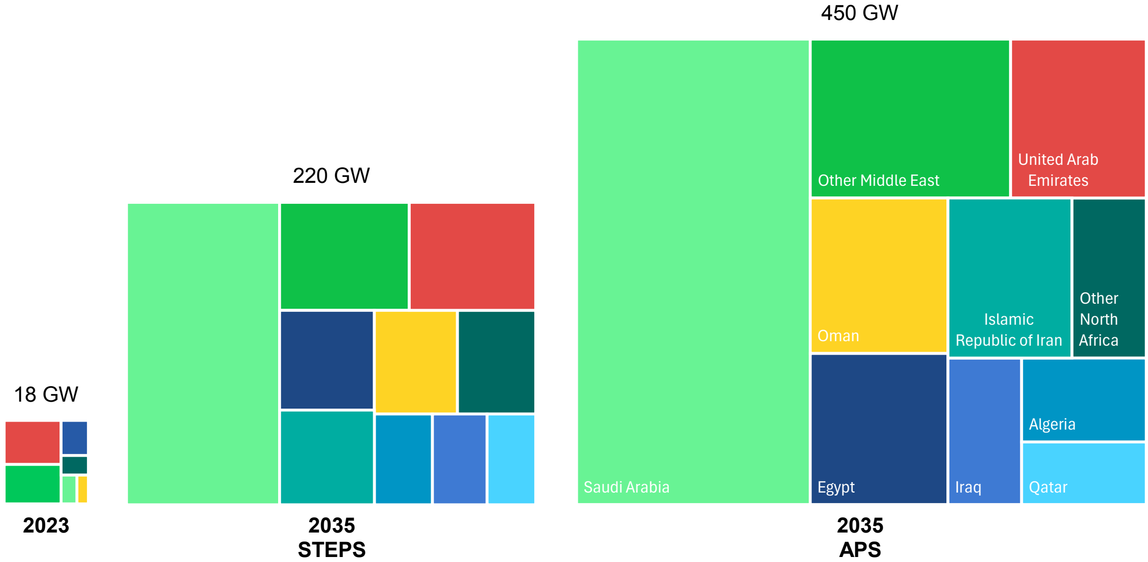
Figure 2.15 Expansion in low-emissions electricity capacity in the top five global regions in the Stated Policies Scenario, 2023-2035



Note: MENA = Middle East and North Africa.

In parallel, the MENA region is projected to be the third-largest region globally for nuclear capacity growth to 2035. With over 13 GW of expansion expected, this positions the region behind only China and India in nuclear development, reinforcing its broader commitment to a more diversified and lower-emissions power sector.

Figure 2.16 Installed capacity of solar PV in the Middle East and North Africa by selected countries in the Stated Policies Scenario and Announced Pledges Scenario, 2023 and 2035



Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario. Other Middle East includes Bahrain, Jordan, Kuwait, Lebanon, Syria and Yemen. Other North Africa includes Libya, Morocco and Tunisia.

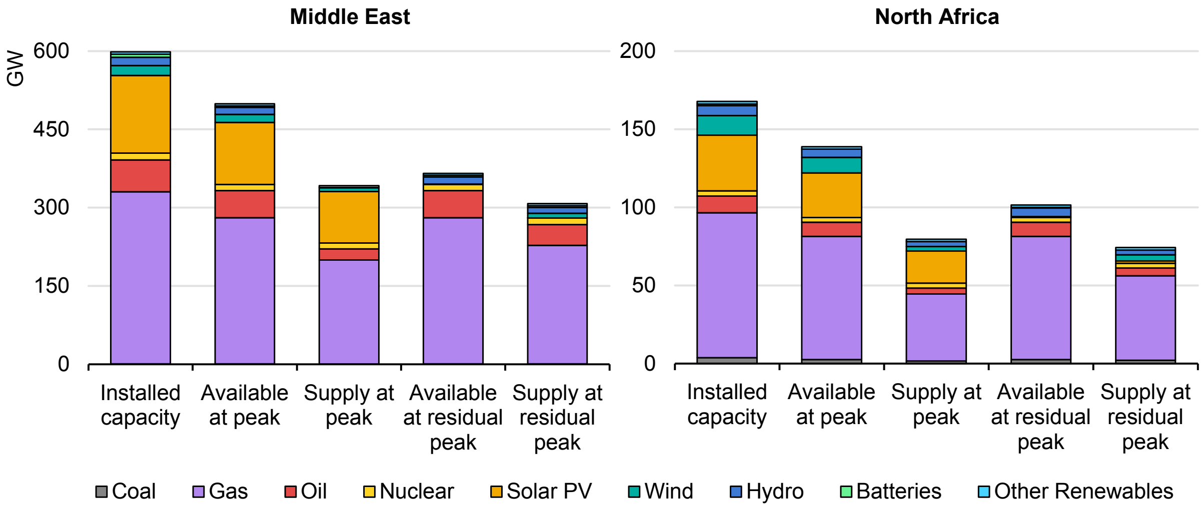
Solar PV capacity is projected to grow more than twelve-fold from 2023 to 2035 in the MENA region, reaching 220 GW in 2035 in the STEPS. This is due to strong growth in several countries as a result of policy support and falling technology costs. Saudi Arabia alone is responsible for over one-third of the growth to 2035 in the STEPS, alongside significant contributions from Egypt, Oman and the United Arab Emirates. In the APS, this uptake of solar PV moves at twice the pace, reaching 450 GW of installed capacity by 2035 – a twenty-five-fold increase from 2023 levels.

Electricity security

Electricity security – the ability to ensure a reliable, stable and affordable supply of electricity at all times – is fundamental to the functioning of modern power systems. This requires not only continuously meeting demand down to the scale of seconds but also maintaining system stability under increasingly complex conditions. In the Middle East and North Africa, where electrification is accelerating and renewable energy deployment is expanding rapidly, two components of electricity security are becoming especially critical: adequacy, which ensures sufficient capacity to meet peak demand, and flexibility, which enables the system to respond to fluctuations in demand and variable renewable generation. Ensuring a continuous balance between supply and demand will also depend on secure, resilient and intelligently managed electricity networks capable of adapting to evolving challenges.

Power system adequacy

Figure 2.17 Installed capacity and electricity supply during load and residual load peaks in the Middle East and North Africa in the Stated Policies Scenario, 2035



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Notes: Peak hours are defined as the top 100 hours with the highest electricity consumption (including activation of demand response and storage charge). Residual peak hours are defined as the top 100 hours with the highest residual load (unoptimised electricity demand minus non-dispatchable generation from solar PV, wind and hydro run-of-river).

The MENA region's shift to sustainable energy and renewable sources requires a reliable electricity supply, even as demand grows and environmental challenges intensify.

Traditionally, the assessment of critical hours for power system adequacy has focused on ensuring a sufficient capacity margin to meet gross peak demand. However, as the share of variable renewables such as solar PV and wind increases, the most critical hours for system adequacy increasingly align with periods of high residual demand – defined as total demand minus renewable generation. As the share of renewables grows, adequacy risks shift to when electricity demand is high and the availability of renewables is low. During these hours, dispatchable generation often operates near maximum capacity. Gross peak hours and residual peak hours occur at different times of the day. Gross peak demand hours now tend to occur around midday, when solar PV output is strong, and flexible demand shifts to take advantage of abundant, low-cost electricity. In the MENA region, cooling demand contributes to this midday peak. Residual peak demand, by contrast, typically occurs in the early evening, when solar PV generation has declined but electricity demand remains important.

During peak hours, often occurring around noon, the available capacity exceeds demand by a margin of 1.45 in the Middle East and 1.75 in North Africa. Around one-third of supply during this period comes from solar PV in both the Middle East and North Africa. The share of fossil fuel generation reaches 50% during these hours. This share tends to be lower than the average share in the mix of 70-75%, as natural gas-fired power plants operate more flexibly to account for the important availability of solar PV during these hours.

During hours when residual load peaks, often in the early evening, renewable generation is less available, and the system has to rely on other sources to meet electricity demand. Natural gas and oil-fired generation meet over 85% of the demand in the Middle East and 80% in North Africa during these hours. The capacity margin during residual peak hours is 1.2 in the Middle East and 1.35 in North Africa.

Flexibility

Flexibility needs define the ability of electricity systems to ensure reliable and cost-effective electricity supply while managing variability and uncertainty in both demand and generation across all relevant timescales (from short-term hour-to-hour ramping needs to seasonal balancing across weeks). In the MENA region, electricity systems are currently dominated by oil- and gas-fired power plants, which provide nearly all system flexibility. However, the region's abundant solar resources offer a strategic opportunity to diversify the generation mix. Scaling up solar PV can reduce dependence on fossil fuels, provided that power plants are operated more flexibly to accommodate the variability of solar output. High temperatures, which are common in the region, can reduce the efficiency of dispatchable thermal generation. In this context, leveraging solar PV during the hottest hours of the day can help ease pressure on the thermal fleet and enhance system resilience. These dynamics and their implications for energy planning are explored in more detail in Chapter 3 (see Chapter 3, section "1. How can electricity systems stay balanced with rising shares of solar PV and wind?").

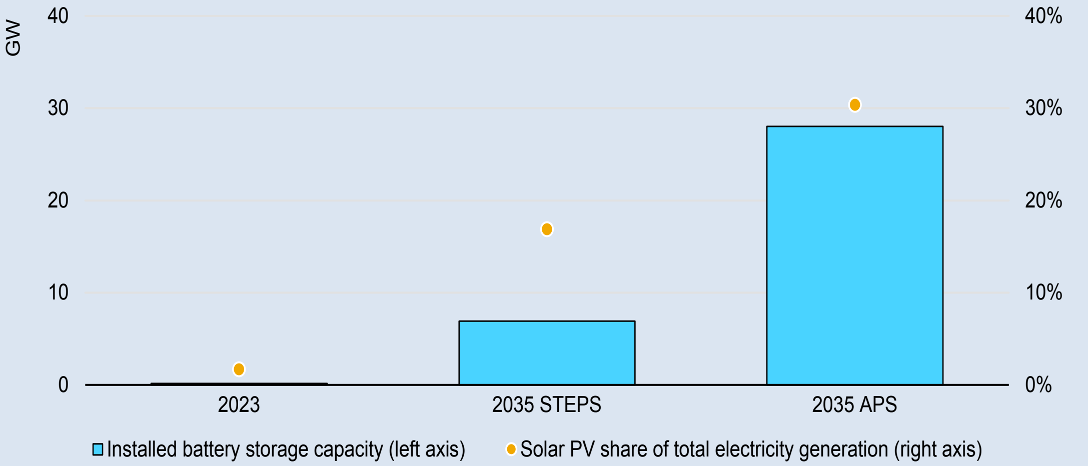
Box 2.3 Development of battery storage in the MENA region

Battery storage can provide short-term flexibility, ancillary services, secure capacity and grid congestion management services in power systems with increasing shares of variable renewables. Over the past decade, technological improvements, rising economies of scale and intensifying competition have seen upfront investment costs for battery storage projects plummet by over 90%. In 2024 alone, costs fell by about 20% year-on-year, driven by growth in manufacturing capacity outpacing demand, particularly in China, and lithium prices dropping over 80% from their 2022 peak. This decline in costs, combined with the versatility of battery storage, has sparked growing interest in the technology and triggered a wave of developments of utility-scale battery energy storage projects across the

Middle East and North Africa. In 2024, the region's installed battery storage capacity grew by nearly 1 GW, a tenfold increase from 2023.

Saudi Arabia, which commissioned its first utility-scale battery storage project in 2024, has emerged as the front-runner. In early 2025, the 500 MW/2 000 GWh Bisha energy storage project, one of the world's largest utility-scale battery storage projects, came online. Several additional large-scale projects are currently in various stages of development, and the country has ambitions to deploy 48 GWh (equivalent to 12 GW assuming an average storage duration of 4 hours) of utility-scale batteries until 2030. Solar farms are also increasingly paired directly with batteries. In January 2025, the United Arab Emirates launched a gigawatt-scale solar PV-battery project consisting of a 5.2 GW solar farm and 19 GWh of battery storage designed to provide up to 1 GW of power continuously, 24 hours a day. Other countries in the region with utility-scale battery storage projects at various stages of development include Egypt and Morocco.

Installed battery storage capacity and share of solar PV in the electricity mix in the Middle East and North Africa, 2023 and 2035



Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario.

The increase in the pace of additions is reflected in the growth in aggregate regional installed battery storage capacity to 7 GW by 2035 in the STEPS and to nearly 30 GW in the APS. The rise in battery capacity is driven mainly by the need to integrate rising shares of solar PV into the region's electricity systems (see Figure above).

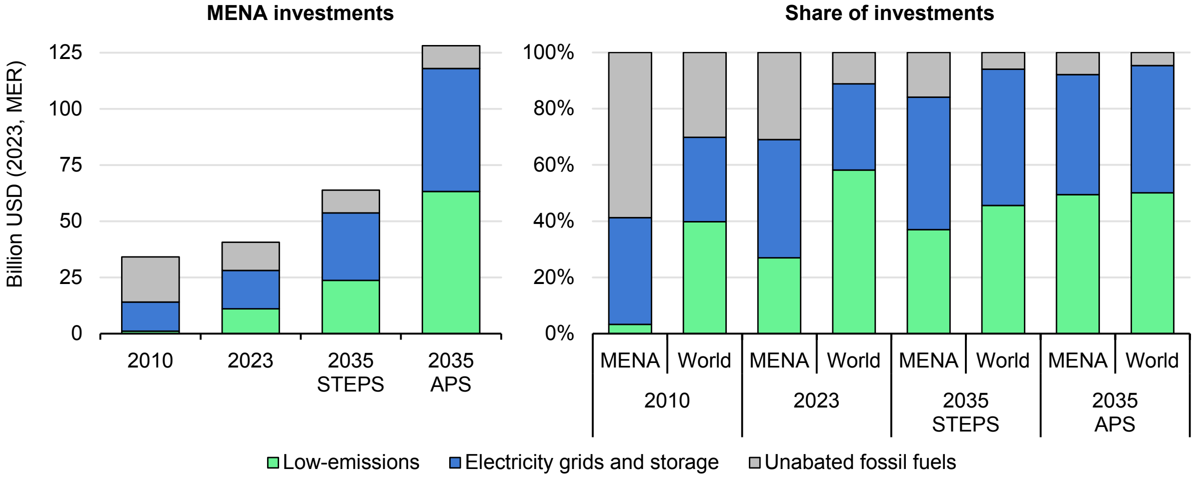
The flexibility provided by batteries lies in their ability to shift electricity generation from periods with surpluses to periods when the residual load is high. Since batteries are primarily designed for short-duration storage, they are particularly well suited to smoothing the daily cycle of solar PV-based electricity generation. They can be charged when solar PV generation peaks during the day and discharged when residual demand is high, such as in the evening when solar is not generating electricity. In addition to energy shifting, battery storage can provide a broad suite of services to the electricity system, including the provision of ancillary services and secure capacity to maintain the reliability of the power supply while meeting peak residual demand. If placed strategically in grids, batteries can also provide congestion management services, potentially enabling the deferral of investments in transmission and distribution infrastructure, especially in regions where the expansion of power grids lags behind the growth in the share of variable renewables and the pace of end-use electrification. In emerging economies with weaker electricity grids, batteries are likely to be increasingly used to provide essential services beyond energy shifting and to help increase the reliability of power supplies, offering functionalities such as black-start capability, islanding and grid stabilisation at the local level.

Grids

Significant grid upgrades are essential to support rapid electrification and the expansion of renewable energy across the MENA region. Transmission and distribution networks must expand to connect both large-scale and distributed solar PV as well as wind projects to demand centres. Cross-border and regional interconnections can reduce reliance on other flexibility sources and enhance system integration (see Chapter 3, section “5. What role do grid interconnections play in the MENA region?”). However, grid infrastructure projects are complex and, especially for transmission, can easily take over a decade to become operational – far longer than it takes for renewable energy developments – creating a risk of delays in connecting new capacity. Early action and holistic planning are therefore critical. Beyond lines and transformers, investments in digitalisation, smart grids and advanced power electronics are needed to enhance control, stability and efficiency, enabling better integration of variable renewables and more targeted, cost-effective grid development.

Power sector investment

Figure 2.18 Power sector investment by type in the Stated Policies Scenario and Announced Pledges Scenario, 2010-2035

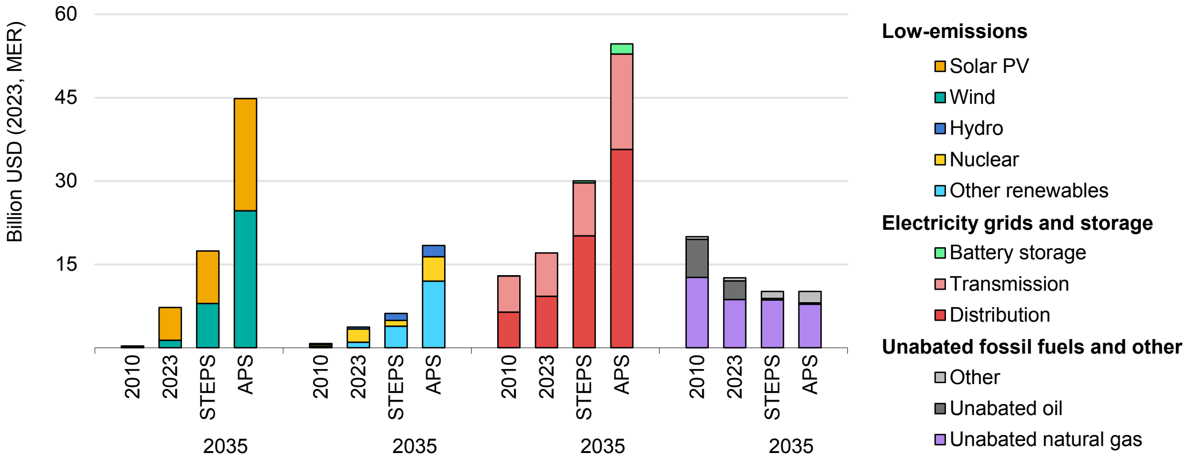


Notes: MER = market exchange rate; STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; MENA = Middle East and North Africa. Low-emissions include renewables and nuclear.

In the STEPS, power sector investment in the MENA region is projected to increase from USD 40 billion in 2023 to over USD 60 billion in 2035, a 50% increase. Investment shifts away from unabated fossil fuels towards low-emissions technologies, grids and storage. Low-emissions technologies make up over 35% of total power investments, while networks and storage account for nearly 50%. Investment in unabated fossil fuel capacity drops to just over 15% by 2035. In the APS, investment in low-emissions technologies rises to half of total power sector spending.

The MENA region has historically lagged behind global trends in low-emissions power investment. In 2010, these technologies made up only a small share of regional spending, compared to about 40% globally. By 2023, MENA's share had risen to nearly 30%. In the STEPS, it reaches over 35% by 2035. Investment in networks and storage remains broadly in line with global averages. In the APS, MENA's investment in low-emissions technologies matches global levels by 2035.

Figure 2.19 Investment in power sector in the Middle East and North Africa by technology in the Stated Policies Scenario and Announced Pledges Scenario, 2010-2035



Notes: MER = market exchange rate; STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario. Other renewables include concentrating solar power, bioenergy and geothermal. Other includes unabated coal and non-renewable waste.

In the STEPS, investments in low-emissions power technologies in the MENA region exceed USD 20 billion in 2035, more than double the level in 2023. This growth is led by solar PV and wind, which together account for over USD 15 billion, surpassing recent investment levels in fossil fuel power plants. Investment in solar and wind becomes more balanced over time, in contrast to 2023 when around 70% of total renewables investment was focused on solar PV. Hydropower and other renewables also attract additional investment to 2035. Nuclear power investment continues as well, maintaining recent momentum and contributing to a more diversified electricity mix. In the APS, combined investment in solar PV and wind by 2035 reaches USD 45 billion, several times higher than investment in fossil fuel power plants.

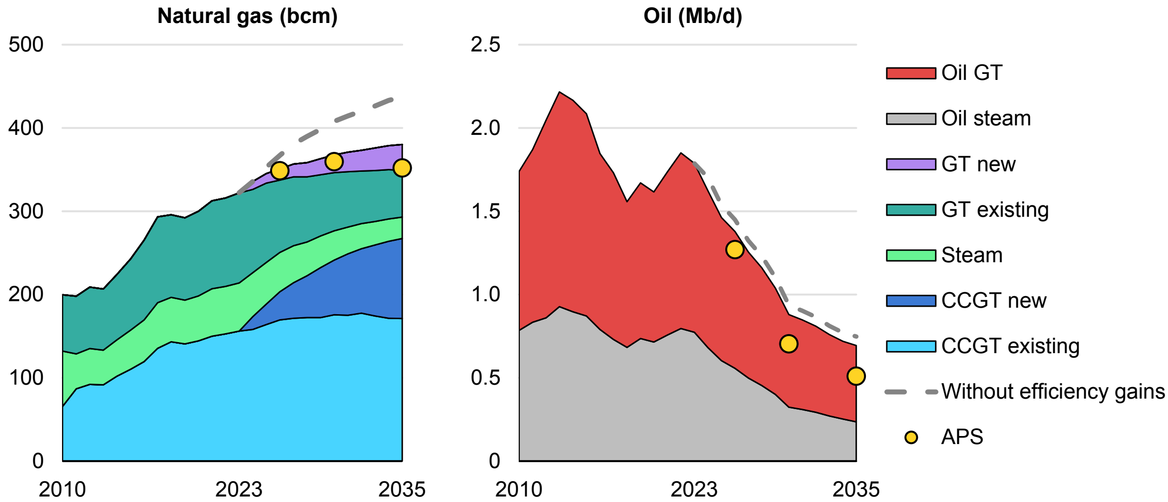
Investment in transmission and distribution infrastructure increases by three-quarters in the STEPS to 2035, reaching USD 30 billion to meet rising electricity demand and improve energy security. Grid modernisation and storage solutions play a growing role in supporting system flexibility. In the APS, grid investments more than triple from 2023 levels by 2035, reflecting the increased need to integrate expanding renewable capacity.

In the STEPS, investments in unabated fossil fuels continue to decline, especially for oil, while spending on natural gas remains broadly stable, reflecting its ongoing role in the region's energy mix. In the APS, investments in unabated fossil fuels are similar to the STEPS, reflecting projects already in development.

Power sector fossil fuel consumption and emissions

While electricity generation from natural gas in the MENA region is projected to grow by over 40% by 2035 under the STEPS, efficiency improvements play a crucial role in curbing the associated rise in gas consumption, which increases by less than 20% to reach 380 bcm by 2035. This moderation is largely due to the widespread deployment of high-efficiency combined-cycle gas turbine (CCGT) technologies and enhancements in conventional steam and gas turbines.

Figure 2.20 Natural gas and oil consumption in electricity generation in the Middle East and North Africa by scenario, 2010-2035



Note: GT = gas turbine; CCGT = combined-cycle gas turbine; APS = Announced Pledges Scenario.

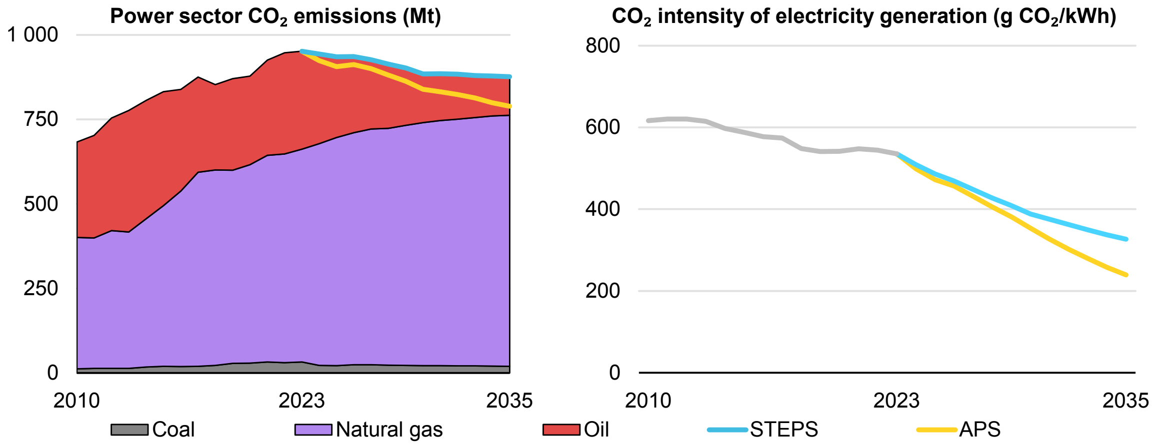
This trend is already visible today, with several major projects across the region – for instance, Egypt's Megaproject and United Arab Emirates' Hamriyah CCGT plant are among the most efficient in the world. As a result, the average efficiency of the gas-fired power fleet in the MENA region is expected to improve from 40% to 48%. However, if the anticipated efficiency gains fail to materialise, gas consumption could be higher by approximately 85 bcm. To put this into perspective, Qatar's annual liquefied natural gas exports have averaged around 100 bcm in recent years, underscoring the importance of continued investment in advanced and efficient technologies.

In the case of oil, the ongoing shift away from its use in power generation across the MENA region marks a significant structural transformation in the energy landscape. By 2035, oil consumption in the power sector is projected to decline by nearly 60% compared to current levels, equivalent to a reduction of 1.1 Mb/d. The implications of this shift extend well beyond domestic energy balances. Freed-up oil volumes can be redirected to international markets, potentially increasing export availability and generating several billions of dollars in additional annual revenue for producing countries (see Chapter 3, section "9. What impact could increased renewables have on oil and gas export volumes?").

In the STEPS, emissions in the MENA region are projected to fall by nearly 10% by 2035 compared to 2023 levels. This reduction is achieved despite an increase in emissions from gas-fired generation, which is more than offset by a significant decline in oil-related emissions.

This decline occurs even as electricity demand in the region expands by 55% over the same period. To achieve this, the average CO_2 emissions intensity of electricity generation is expected to drop from over 530 g CO_2/kWh in 2023 to below 330 g CO_2/kWh by 2035. In the APS, where national decarbonisation goals are met, emissions drop below 800 Mt by 2035 – 10% lower than in the STEPS.

Figure 2.21 Power sector CO_2 emissions by fuel, and CO_2 intensity of electricity generation in the Stated Policies Scenario and Announced Pledges Scenario, 2010-2035



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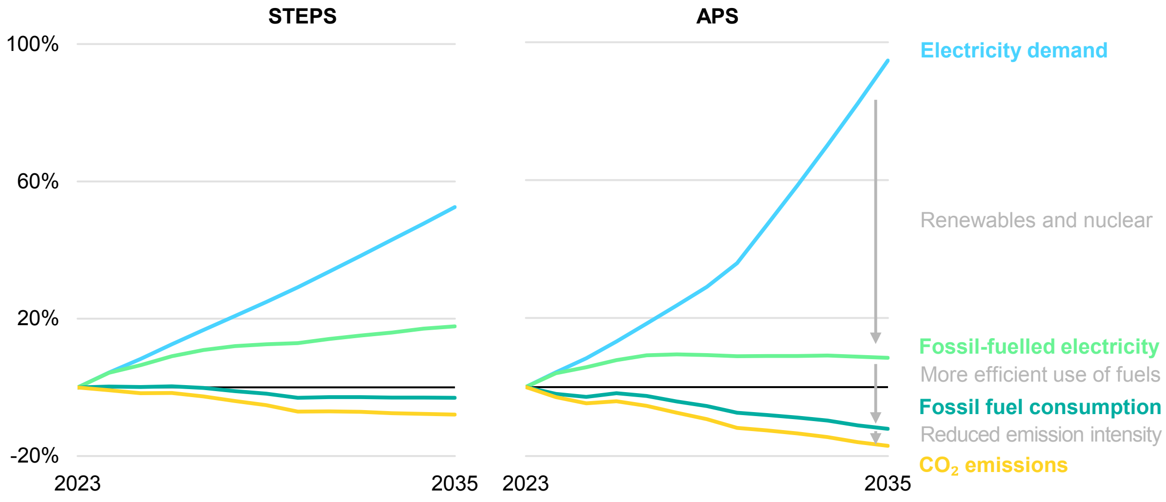
Note: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario.

This improvement in CO_2 emissions is driven by a three-stage decoupling process in power systems across the MENA region. In the STEPS, the diversification of the electricity supply mix – incorporating more renewable energy sources and more nuclear power by 2035 – ensures that a 55% growth in electricity demand leads to only a 20% increase in fossil-fuelled generation. Efficiency measures, such as transitioning from inefficient oil-based generation to more efficient gas-fired power plants, translate this growth into a 5% reduction in fossil fuel consumption. Further reductions in emission intensities amplify these effects, resulting in an overall 10% decrease in related emissions. In the APS, the decoupling effect is even more significant. Faster transitions across the region result in emissions decreasing by 20%, despite electricity demand nearly doubling.

Figure 2.22 Decoupling of electricity demand growth, fossil fuel consumption and related CO_2 emissions in electricity generation in the Stated Policies Scenario and Announced Pledges Scenario, 2023-2035



Note: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario.

Chapter 3. Designing future-proof power systems

Nine vital factors

Designing electricity systems in the MENA region with a forward-looking approach is critical to ensuring reliable, affordable power while aligning with broader decarbonisation objectives. To support this aim, this chapter explores nine key factors that are vital to future-proofing power systems. These include aspects of electricity demand, such as cooling, desalination and efficiency, alongside supply-side elements like integrating increasing shares of solar and wind energy. The analysis also considers the importance of enhanced grid interconnections, robust policy frameworks and rebuilding energy infrastructure in post-conflict settings. Together, these elements form a foundation for sustainable and resilient electricity systems in the region. In doing so, it seeks to answer the following questions:

1. How can electricity systems stay balanced with rising shares of solar PV and wind?
2. What is the role of cooling in peak demand growth?
3. How can efficiency opportunities in buildings help manage electricity demand growth?
4. How will new desalination technologies and rising water stress impact electricity demand?
5. What role do grid interconnections play in the MENA region?
6. What are the policy frameworks driving renewables deployment in the MENA region?
7. Can clean energy spur industrial development in the region?
8. What role can distributed power generation play in bringing resilience in post-conflict areas?
9. What impact could increased renewables have on oil and gas export volumes?

1. How can electricity systems stay balanced with rising shares of solar PV and wind?

As the share of solar PV and wind in the MENA region rises, maintaining the balance between total electricity supply and electricity demand at all times becomes increasingly challenging. Dispatchable power plants will need to operate with greater flexibility to accommodate variations in solar PV output, especially during winter when midday solar PV remains significant despite lower overall electricity demand. By adjusting their operations, these plants can integrate renewable generation and ensure a stable and secure electricity system.

Additionally, the growth in solar PV offers the MENA region a chance to efficiently address the increasing peak demand driven by cooling needs without adding to the strain on dispatchable power plants. This is particularly important given the region's hot climate, which can have adverse impacts on the performance of thermal power plants. Meeting growing flexibility needs also requires strengthening grid infrastructure. While the flexibility of dispatchable power plants remains essential, the successful integration of renewables depends equally on expanding and modernising electricity networks, enabling demand-side flexibility and deploying storage solutions. A resilient grid is the backbone of a reliable and clean power system.

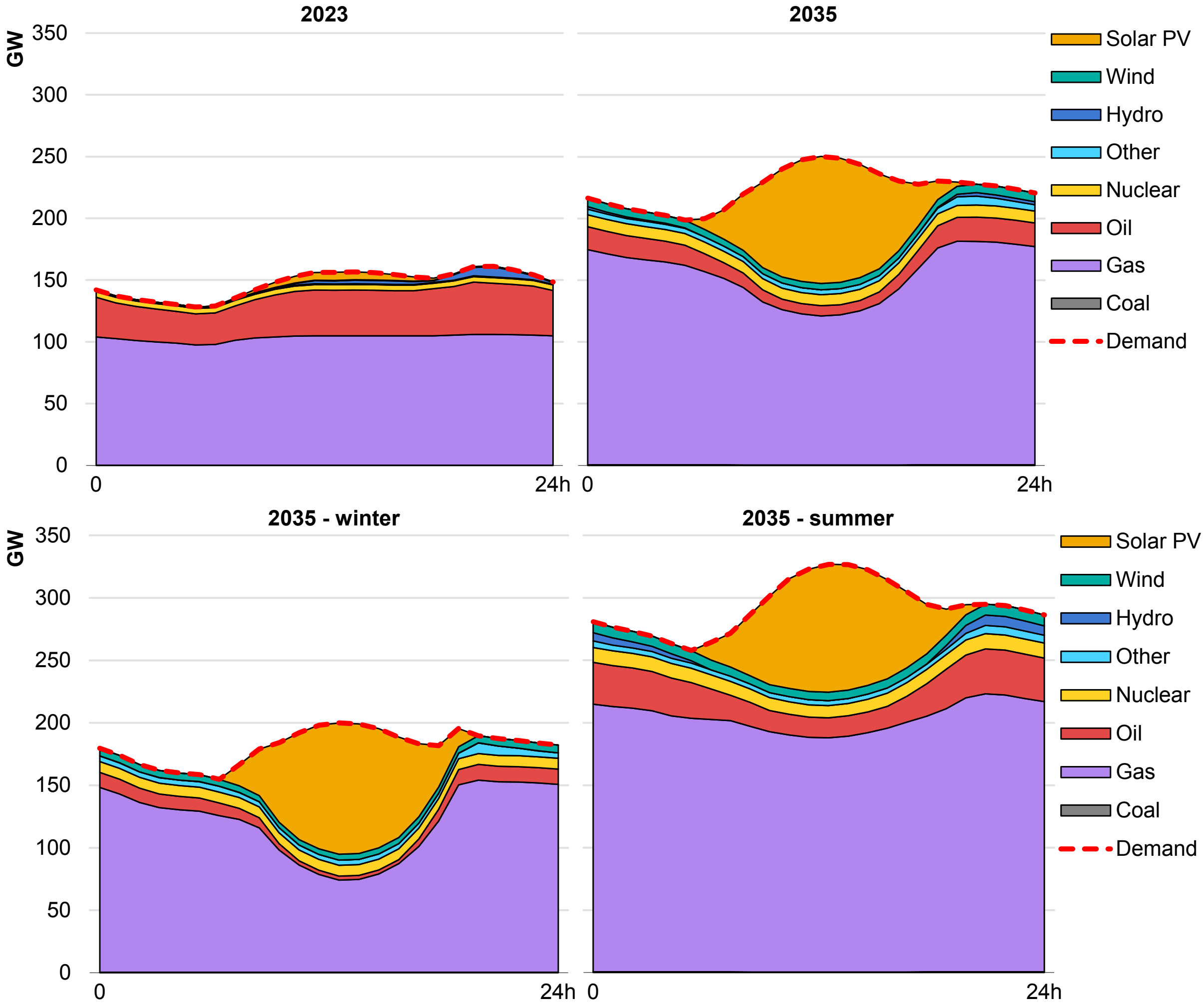
Balancing the Middle East's electricity system

In 2023, electricity consumption in the Middle East often follows typical daily patterns, with peak demand occurring in the early evening. The power system is dominated by fossil fuels, which supply approximately 95% of electricity, and natural gas contributes 65% to 75% of supply during each hour of the day on average. Demand is heavily shaped by cooling needs, especially in the summer, leading to pronounced seasonal variation. Natural gas- and oil-fired generation ramps up during the hotter months, although high ambient temperatures can reduce plant efficiency. These patterns highlight the existing dependence on fossil fuels and the early signs of

strain on dispatchable generation in extreme weather conditions.

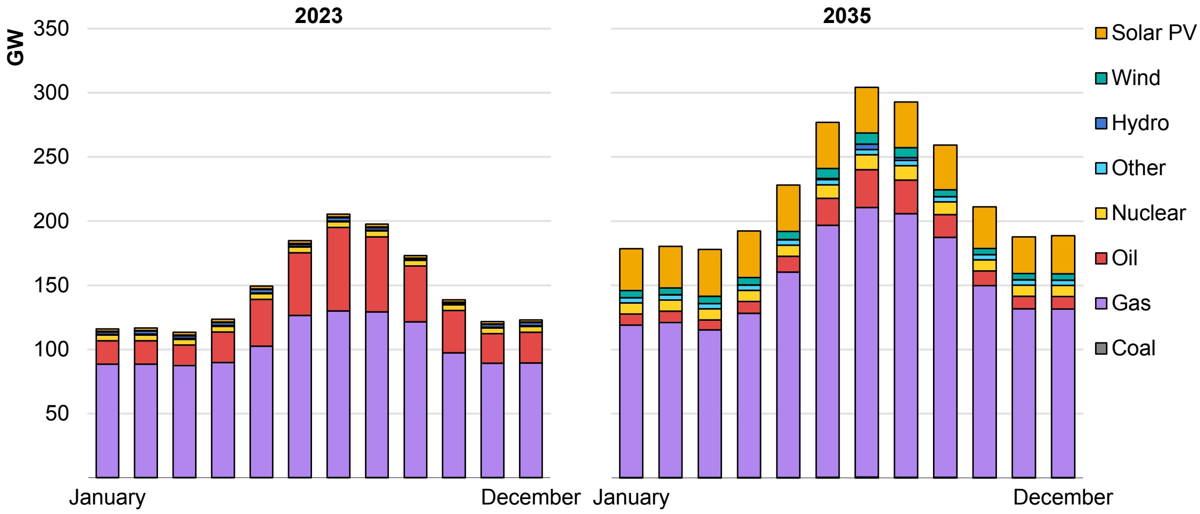
By 2035, the region's power system grows by 75% in the STEPS, including an additional 160 GW of solar PV and 120 GW of natural gas-fired power capacity. This transformation reshapes the residual load, as solar PV increasingly supplies daytime demand – up to 50% in winter – requiring natural gas-fired plants to ramp down during solar peaks and ramp up as solar output declines in the evening. These plants operate over a wider range and at a higher average capacity factor than in 2023. In summer, increased cooling demand allows better integration of solar PV, which can provide up to 30% of supply, easing the burden on gas-fired plants.

Figure 3.1 Average daily electricity supply by source in the Middle East in the Stated Policies Scenario, 2023 and 2035



Note: The term Middle East includes Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, the United Arab Emirates and Yemen.

Figure 3.2 Average monthly electricity supply by source in the Middle East in the Stated Policies Scenario, 2023 and 2035



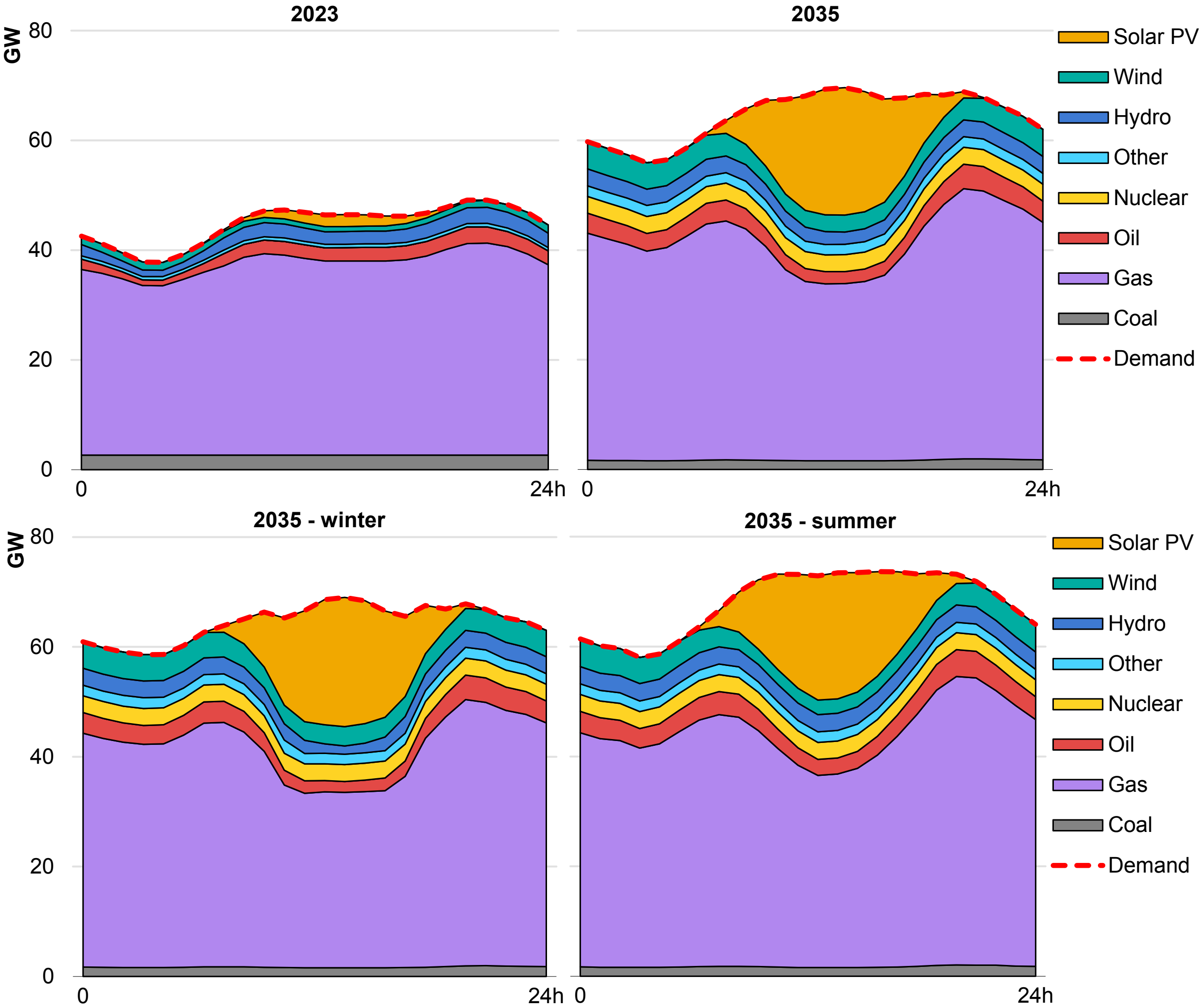
Note: The term Middle East includes Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, the United Arab Emirates and Yemen.

Balancing North Africa's electricity system

In 2023, the daily electricity generation mix in North Africa is characterised by a mix of fossil fuels (90% of the total) and renewable sources. Although the region shows progress in developing renewable capacity, fossil fuels play a major role in meeting overall electricity demand. The share of natural gas in the hourly electricity supply ranges from 75% to 80%. The electricity system in North Africa has a stable electricity supply mix throughout the year, with minimal seasonal variations on average.

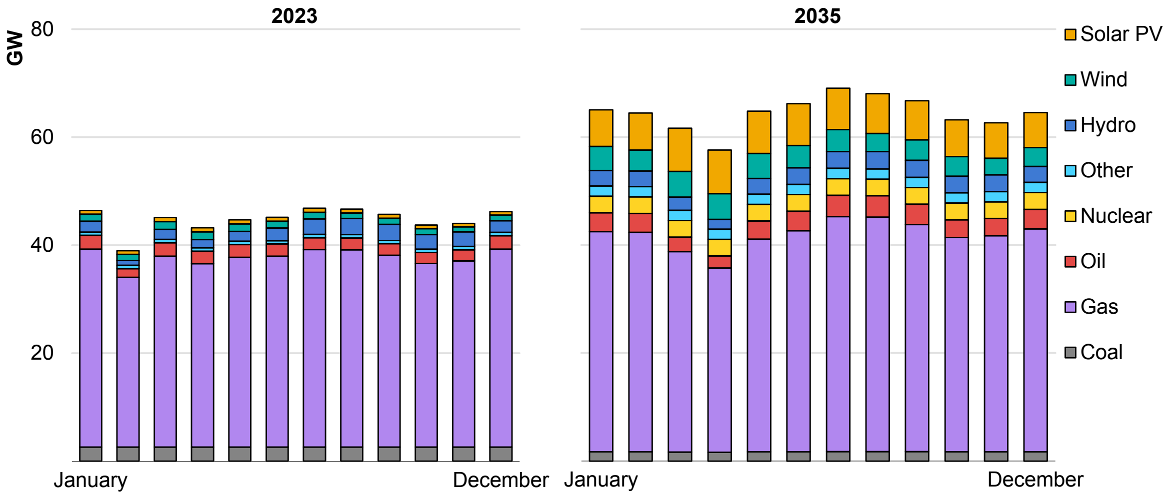
Between 2023 and 2035, the power system grows by 50%, driven by the growth in renewables, with increases in solar PV (37 GW) and wind (10 GW). As the share of solar PV and wind in the electricity mix grows, by 2035 the supply of electricity will become more weather dependent. Solar PV generation peaks at midday, and dispatchable power plants (mostly natural gas-fired) operate more flexibly as a result, with two daily generation peaks: one in the morning and another in the early evening. By 2035, the share of natural gas in the hourly electricity supply is more volatile, ranging from 45% to 70% on average. Thermal power plants need to adjust their output more frequently to respond to the variable patterns of electricity demand and renewable generation. Increases in cooling demand create some seasonality in the North African power system, but structural variations across the year remain relatively small.

Figure 3.3 Average daily electricity supply by source in North Africa in the Stated Policies Scenario, 2023 and 2035



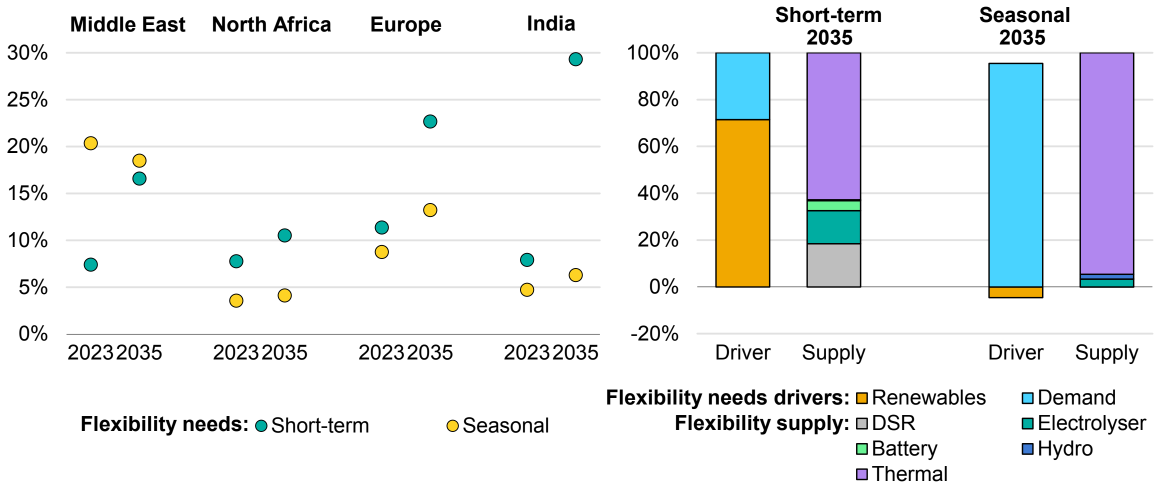
Note: The term North Africa includes Algeria, Egypt, Libya, Morocco and Tunisia.

Figure 3.4 Average monthly electricity supply by source in North Africa in the Stated Policies Scenario, 2023-2035



Flexibility is crucial for electricity systems because it allows them to efficiently balance supply and demand, integrate renewable energy sources and maintain reliability and stability. The need for flexibility in electricity systems can be assessed by examining the variability of the residual load across different timescales, ranging from hour-to-hour fluctuations (short term) to seasonal variations.

Figure 3.5 Flexibility needs (left), drivers of flexibility needs and flexibility supply by source (right) in the Middle East and North Africa and selected countries in the Stated Policies Scenario, 2023 and 2035



Notes: DSR = demand-side response; STEPS = Stated Policies Scenario. Short-term flexibility needs are calculated as the average hourly ramp (difference in the residual load between a given hour and the previous hour) of the residual load over the top 100 hours with the highest upward ramps, divided by the average hourly electricity demand for the year (which does not include battery charging, pumped storage pumping, electricity consumption from electrolysers or net exports). Seasonal flexibility needs are assessed by computing the absolute difference between the weekly and annual averages of the residual load, divided by the annual electricity demand.

In the MENA region, and more generally around the world, short-term flexibility needs increase by 2035, mainly due to the rising share of solar PV generation and evolving patterns of electricity demand. Short-term flexibility is projected to double in North Africa and more than triple in the Middle East by 2035 compared to 2023. These increases are 1.35 to 2.2 times greater than the growth in electricity demand, indicating that these systems are evolving at a faster rate than their growth in size. Europe and India show higher short-term flexibility needs than the MENA region by 2035, due to higher integration of renewables.

Today, most of the flexibility in electricity systems comes from dispatchable power plants in almost all systems. By 2035 in the MENA region, this is still the case. Thermal power plants provide over 60% of the short-term flexibility needs and almost 95% of the seasonal needs. By 2035, the portfolio of short-term flexibility sources expands, with demand response contributing 18%, including from a growing electric vehicle fleet, and batteries 4% to meet these needs in the MENA region. Electrolysers help meet both short-term (15%) and seasonal needs (3%).

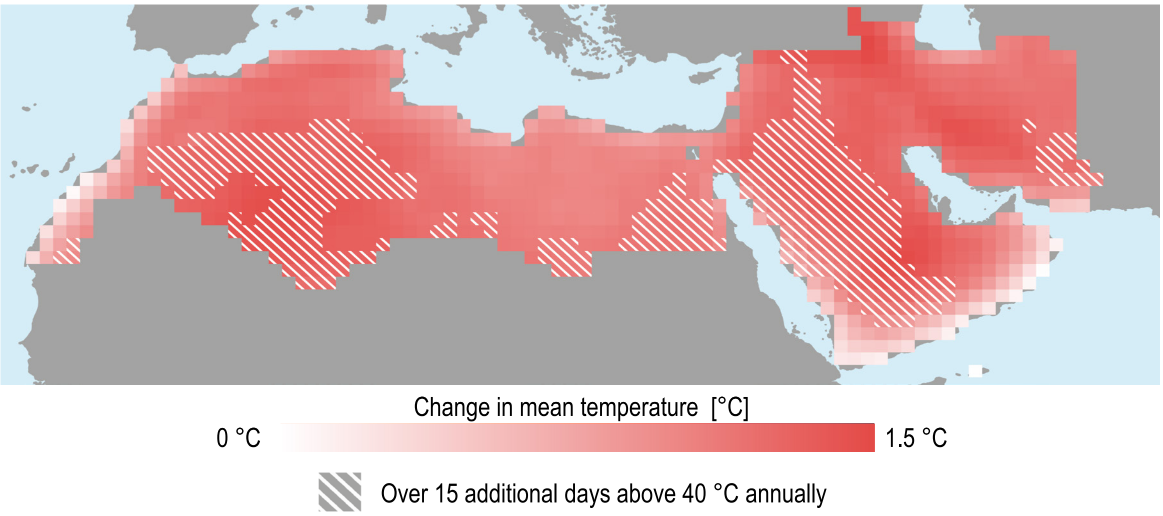
Seasonal flexibility needs increase by more than 60% in North Africa and 30% in the Middle East by 2035. The Middle East has the highest seasonal flexibility needs across selected regions already in 2023 due to high cooling demand. However, when compared to the average growth of the system, seasonal flexibility needs increase broadly in line with the average demand. By 2035, seasonal flexibility needs in the Middle East are growing but at a slightly lower rate compared to the increase in average demand. This is due to solar PV integration, which aligns with cooling demand profiles and helps to reduce the need for seasonal flexibility.

2. What is the role of cooling in peak demand growth?

The climate in the MENA region, with very high summer daytime temperatures, creates significant and growing demand for space cooling, which in turn has major implications for electricity consumption and especially for managing peak electricity demand. The region regularly sees summer temperatures exceed 40 °C, among the highest globally, with limited relief at night when temperatures rarely fall below 25 °C. Yet, the region also faces wide seasonal variations, with daily temperature averages in December to January falling 15 °C to 25 °C lower than the summer peak.

Over the next decade, temperatures are set to rise further across the region, with cooling degree days – a key indicator of demand for cooling – projected to increase by 10%, a faster rate than in most of the rest of world. The result is both higher average temperatures and a greater incidence of extreme heat, leading to more frequent heatwaves. As rising temperatures are also linked to increased health risks and mortality, access to cooling is increasingly recognised as a critical public health priority. Historically, cooling demand has increased from 190 TWh in 2010, to around 340 TWh today, and it is projected to increase further to more than 500 TWh by 2035 in the STEPS, higher than France's annual electricity consumption.

Figure 3.6 Changes in mean temperature in the Middle East and North Africa under the SSP2-4.5 scenario, 2021-2040



Notes: The increase in days above 40 °C annually is calculated with respect to the 1995-2014 average (baseline). SSP2-4.5 is an emission scenario considered in the IPCC's Sixth Assessment Report (AR6), in line with the upper end of aggregated NDC emissions levels by 2030 and associated to a global warming estimate for 2100 of around 3 °C.
Source: IEA analysis based on the Intergovernmental Panel on Climate Change (2021), Working Group I Interactive Atlas.

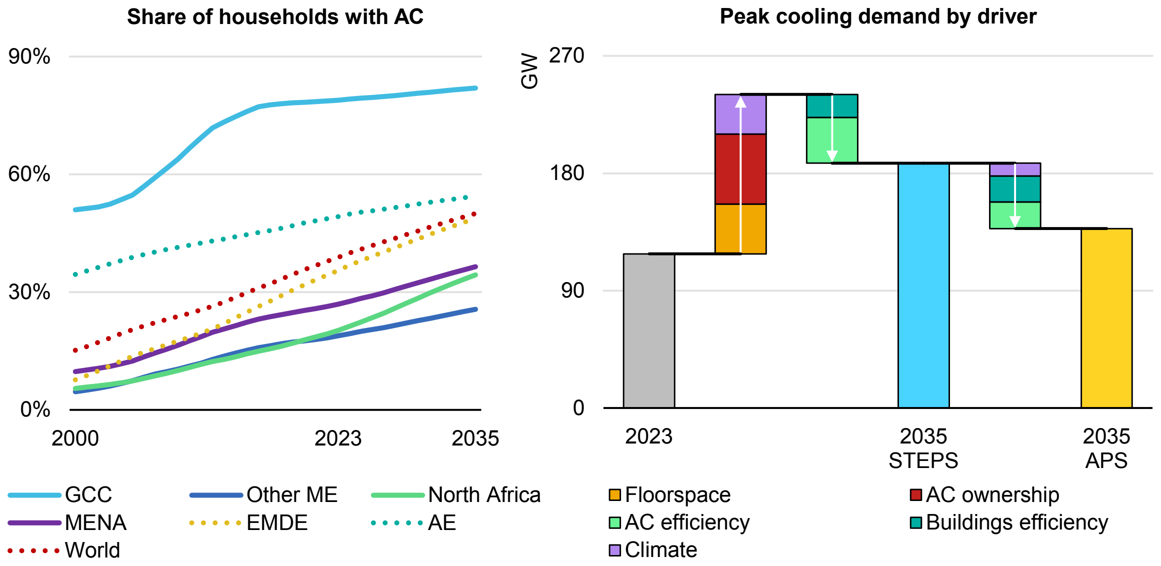
These weather trends directly influence electricity consumption patterns in the region, driving higher demand for cooling and accentuating seasonal differences. In Saudi Arabia, for example, air conditioners are used on average for less than 20 hours per week in winter but for over 60 hours per week during the rest of the year. When assessing hourly load over the year, summer demand is 50% higher than the winter average, highlighting the strong link between temperature and electricity demand. As peak demand records are broken almost every summer, system adequacy – ensuring peak electricity demand can be met – remains a key electricity security challenge for the region.

Cooling demand is set to surge by 2035

Peak electricity demand from cooling in the MENA region was nearly 120 GW in 2023. By 2035, assuming no improvement in building insulation or the efficiency of the stock of appliances, peak electricity demand from cooling is set to more than double.

Several factors explain this rapid increase in demand. First, more households acquire air conditioners: while GCC countries are already almost at saturation, with around 80% of households equipped with air conditioners, the rest of the MENA region is poised for growth. Average air conditioning diffusion across the region stands at 27% today, but North Africa and non-GCC countries are still at around half of the emerging market and developing economies average.

Figure 3.7 Share of households with air conditioning and peak cooling demand by driver in the Stated Policies Scenario and Announced Pledges Scenario, 2023-2035



Notes: GCC = Gulf Cooperation Council; Other ME = Other Middle East; MENA = Middle East and North Africa; EMDE = Emerging market and developing economies; AE = Advanced economies; AC = air conditioning; STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario.

Growth in air conditioner ownership may follow the historical trend of continued increases in access to cooling, with an average of 1.1 million households gaining access to cooling each year since 2010. Alternatively, it could accelerate further, driven by rising incomes combined with recurring heatwaves, which are set to accelerate the adoption of air conditioning units. In the World Energy Outlook 2024, we estimated that more frequent, stronger and more persistent heat waves could increase cooling demand by more than 50 TWh in the region, equivalent to one-third of the anticipated growth by 2035 in the STEPS.

Increasing building floorspace in the region is another driver of rising cooling demand, with more than 4 billion m^2 set to be added by 2035 – equivalent to a 30% increase, almost twice the pace of population growth. In the next decade, in addition to the rise in air conditioner ownership, further temperature increases in the MENA region are set to result in more frequent and intense use of air conditioning units.

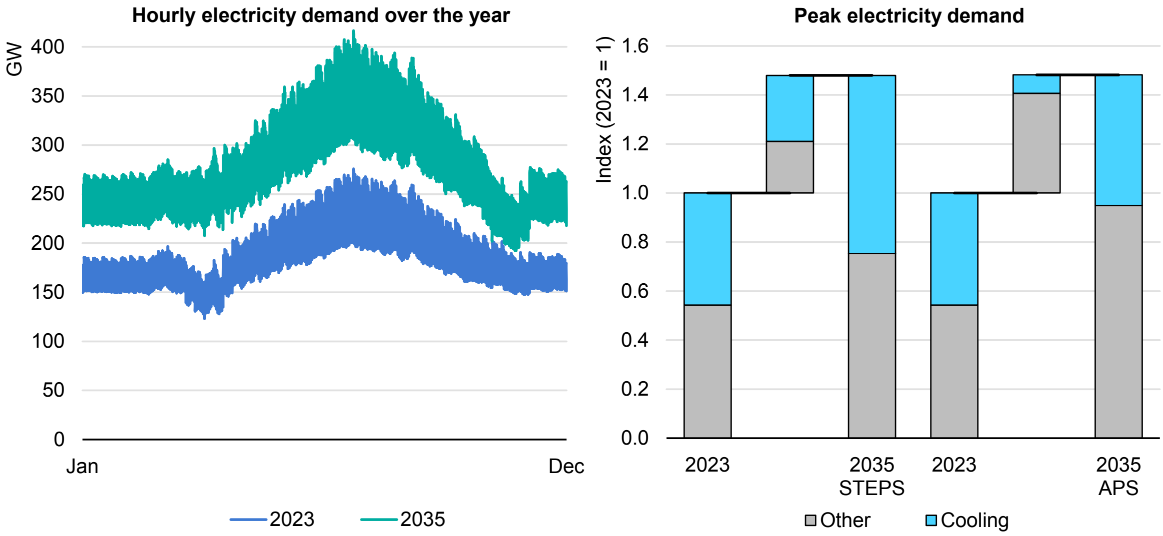
Improving efficiency may help partially balance out these growth trends. By 2035, new air conditioning units are expected to be 10% more efficient than today in the STEPS, and this increases up to 15% in the APS, making it possible to meet the same cooling needs with lower electricity consumption. Combined with improved buildings insulation, and a lower expected temperature rise in the APS, this reduces the increase in peak demand to 2035 by more than 50 GW in the STEPS and an additional 50 GW in the APS (see "How can efficiency opportunities in buildings help manage electricity demand growth?").

Minimum energy performance standards (MEPS) play a key role in regulating and improving air conditioning efficiency. Other measures may be taken to limit both overall and peak demand growth from space cooling, such as by promoting high-efficiency alternative cooling technologies, district cooling solutions and passive cooling designs through architectural innovation, reflective materials or effective shading. In the United Arab Emirates, for example, regulations limit the minimum temperature setting for residential and commercial air conditioning to 20 °C. Several countries in the MENA region, including Egypt, Jordan, Lebanon and Morocco, have developed or are working on National Cooling Action Plans. These frameworks support countries in addressing the growing cooling demand across sectors.

Cooling is the main driver behind peak electricity demand growth to 2035

Peak electricity demand is set to grow further by 2035 in the STEPS, increasing by 50% above 2023 levels, or about 125 GW for the region. Space cooling already accounts for nearly half of peak demand today and is projected to maintain a similar share out to 2035. Cooling also contributes more than half of the growth in overall peak electricity demand growth to 2035 – more than the combined contribution of other end uses in the buildings and industry sectors.

Figure 3.8 Hourly electricity demand profile for the Middle East and North Africa and the space cooling share in peak electricity demand in the Stated Policies Scenario and Announced Pledges Scenario, 2023 and 2035



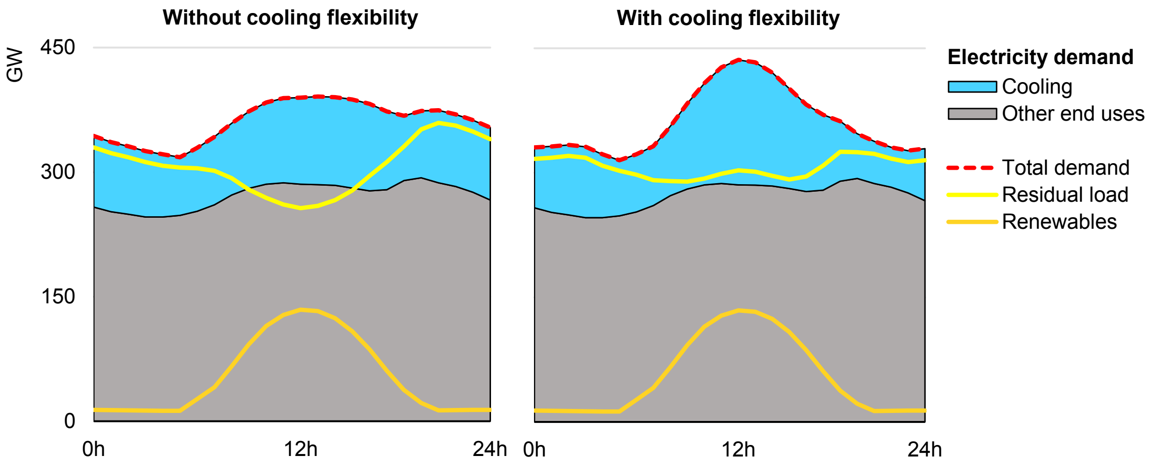
Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario. Peak demand is the average level of demand for the 100 hours of the year with the highest demand. Hourly demand profiles reflect the reduction in demand during Ramadan, which fell in March-April in 2023 and is scheduled for November in 2035.

The concentration of demand for cooling in the hot summer months means that its share of peak electricity demand is more than twice its share of total electricity demand. This highlights the need to manage the rise in cooling demand to ensure secure and resilient electricity systems in the region. In the APS, stronger efficiency gains help offset some of the growth in cooling demand. As a result, cooling's contribution to peak demand growth is much lower (less than one-third of its contribution in the STEPS), but this is offset by a higher contribution to peak demand from electric vehicles, keeping total peak demand growth at similar levels.

Cooling can support the integration of renewable power, offering potential for increased system flexibility

Cooling is a driver of peak demand growth in the STEPS, but it also represents an opportunity to support the integration of renewable power generation. Cooling demand is highest around midday, coinciding with maximum solar PV output. By 2035, the cooling demand profile matches some of the generation from solar PV, offsetting part of the typical daily increase, but does not fully compensate for the total added output. As a result, the residual load (electricity demand minus solar PV and wind generation) falls sharply around midday, requiring dispatchable power plants to reduce their output and increasing flexibility needs for the system.

Figure 3.9 Average daily summer load curve and flexibility potential for cooling in the Stated Policies Scenario, 2035



Note: STEPS = Stated Policies Scenario.

Cooling can offer significant potential for flexibility. Depending on the thermal inertia of buildings – their ability to maintain relatively constant internal temperatures, for example through insulation – demand loads can be shifted over the day by anything from a few dozen minutes up to several hours. More advanced cooling systems can even benefit from thermal storage systems, which can use water, solid or other storage mechanisms to shift loads over much longer durations.

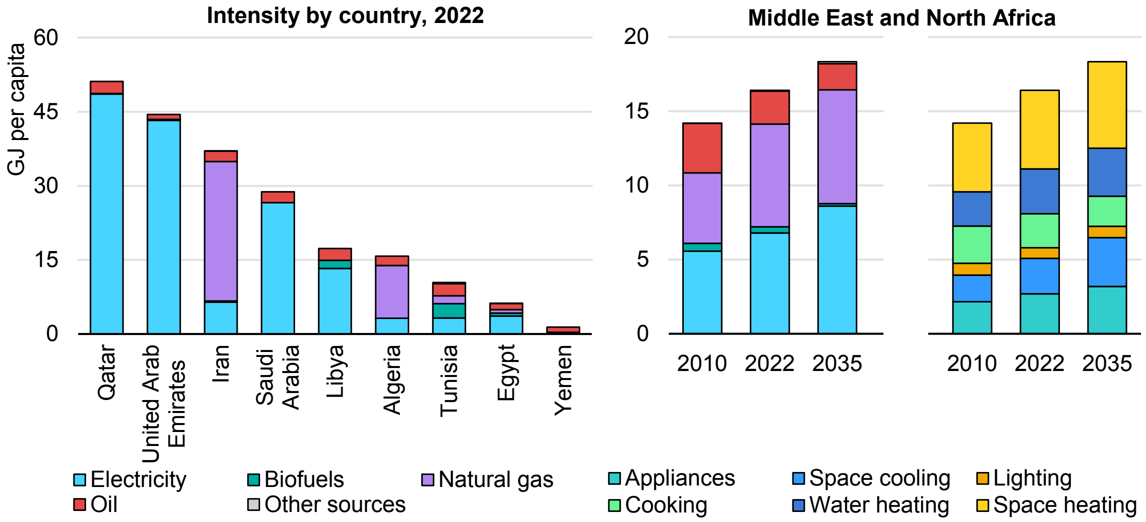
When activated, these flexibility options can shift additional electricity consumption from cooling closer to midday, thereby benefiting from peak solar PV generation without requiring too much flexibility from conventional generators. By 2035 in the STEPS, the daily variations in the residual load can be more than halved by cooling flexibility, from 100 GW to less than 40 GW. As a result, fewer cycles are required from conventional power plants, which reduces their daily generation variation from above 30% to only 12%. This flexibility is even more relevant in systems with higher shares of renewables, where significant solar PV and wind generation can lead to curtailment. Cooling flexibility ultimately reduces the potential curtailment but also the stress on the grid if solar PV is deployed close to cooling demand centres. Ultimately, the deployment of rooftop solar PV limits the burden on the grid while incentivising the flexible loads within the building to adjust to its electricity generation patterns.

3. How can efficiency opportunities in buildings help manage electricity demand growth?

The buildings sector, including the residential and service sectors, comprises a major share of rising energy consumption in the MENA region, accounting for around 30% of projected growth in final energy consumption from 2023 to 2035. Buildings play a proportionately greater role in electricity demand, accounting for two-thirds of the region's demand in 2023. Increasing electricity use in buildings – including space heating and cooling, lighting and appliances, as well as data centres and desalination – is set to contribute 70% of the region's electricity demand growth over this period. A continued focus on energy efficiency will be critical to managing this growth.

Energy intensity in the MENA region is around 50% higher than the average in buildings for emerging market and developing economies. However, there are significant differences in levels of energy use in buildings among countries in the region. At around 100 GJ per capita, Oman's per capita energy consumption in buildings was around six times the MENA average in 2022, while in Yemen it was around one-twelfth of the regional average. The share of electricity in energy consumed in buildings is particularly high in GCC countries: in 2022, over 90% of buildings' energy needs were met by electricity in Bahrain, Kuwait, Qatar, Saudi Arabia and the United Arab Emirates. By contrast, in Iran, electricity meets only 17% of buildings sector energy use, with most demand covered by natural gas. Among the different end uses, space cooling and appliances make up the largest share of electricity consumption, together consuming over 70% of the electricity used in buildings in 2023. They also contribute the most (in absolute terms) to demand growth to 2035. Cooking, space heating and water heating remain largely non-electrified, primarily relying on oil and natural gas.

Figure 3.10 Buildings energy intensity by fuel and country, 2022, and the Middle East and North Africa's average intensity by end use and fuel in the Stated Policies Scenario, 2010-2035



Notes: STEPS = Stated Policies Scenario. Biofuels include waste; other sources include coal and solar thermal. In this figure, buildings exclude data centres and desalination.

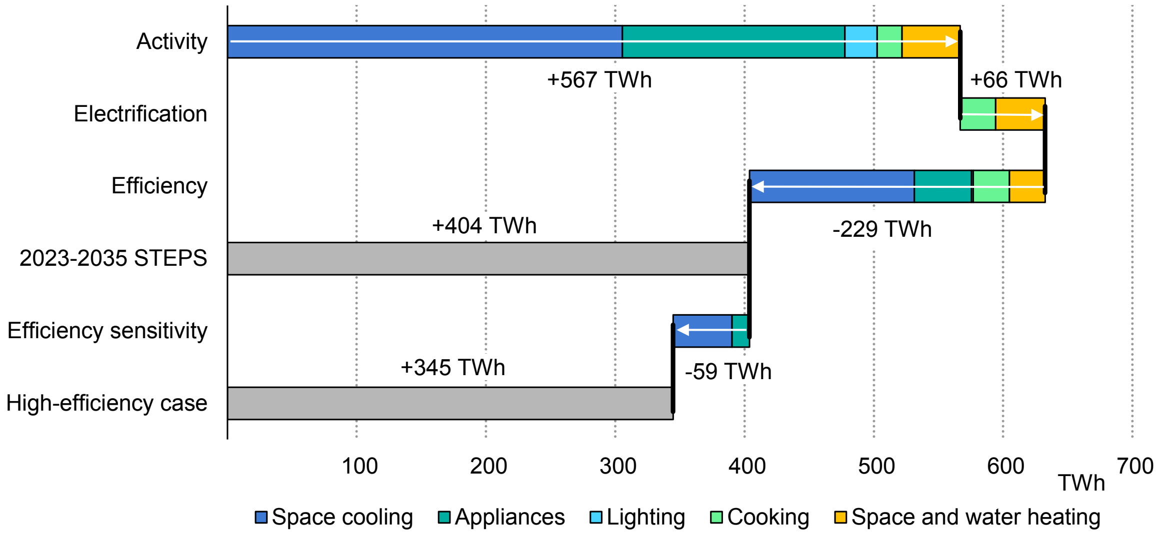
Efficiency plays a critical role in managing electricity demand growth

The central contribution of the buildings sector in driving electricity demand growth places a major focus on energy efficiency and the role it can play in moderating future consumption increases.

Buildings electricity demand in the MENA region (excluding data centres and desalination) was around 915 TWh in 2023. Increases in activity drivers alone – such as population, floorspace, per capita income, and air conditioner and appliance ownership – are set to support growth equivalent to 60% of today's demand, i.e. almost 570 TWh, by 2035. Most of this growth comes from cooling (306 TWh) and appliances (172 TWh). These drivers are linked to higher demand for services such as cooling, and the corresponding increase in energy demand can therefore be mitigated by efficiency improvements.

Additional electrification of cooking, space heating and water heating further increases electricity demand to 2035. While this shift increases electricity consumption, it is important to note that it leads to a reduction in overall energy demand, since electric technologies, such as cooking stoves, are typically more efficient than the ones they displace.

Figure 3.11 Decomposition of buildings electricity demand growth by driver in the Middle East and North Africa in the Stated Policies Scenario, 2023-2035



Note: STEPS = Stated Policies Scenario.

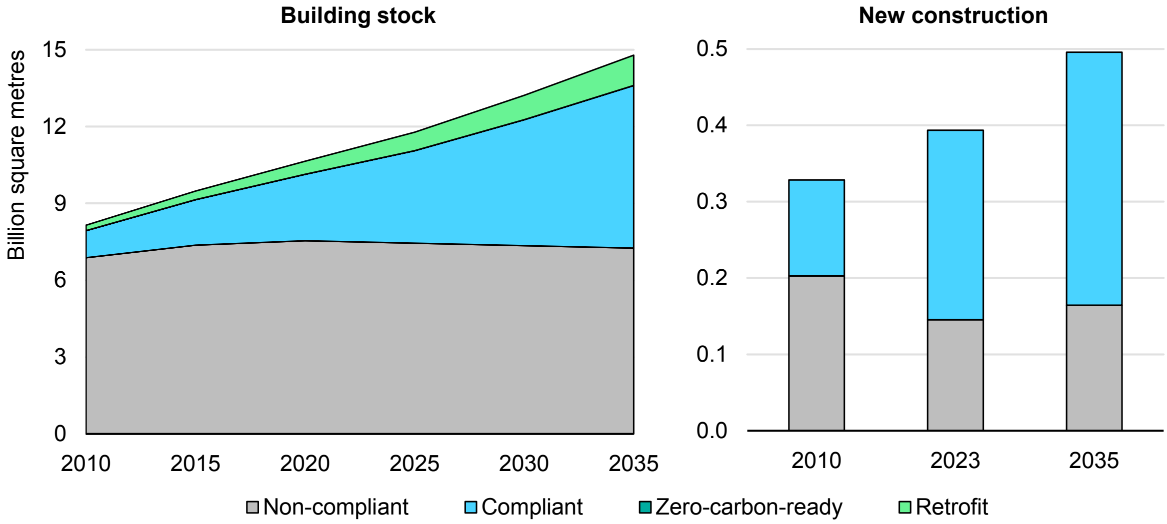
Efficiency improvements play an important role in offsetting some of this projected demand growth. Gains in efficiency are set to reduce the increase in demand by nearly 230 TWh from 2023 to 2035 – over one-third of the unmitigated growth – in the STEPS. Moreover, faster improvements in cooling and appliance efficiency could mitigate nearly an additional 60 TWh of electricity demand, in a high-efficiency sensitivity case, based on analysis in the World Energy Outlook 2024. This analysis assumes the implementation of strong MEPS and widespread labelling in emerging market and developing economies, encouraging manufacturers to standardise efficient products and phase out inefficient ones.

Building codes and appliance efficiency standards can play a major role in shaping the efficiency outlook across the region

Policy measures, such as building codes for new and refurbished buildings, as well as performance standards and incentive schemes for appliances, can play a major role in supporting advances in energy efficiency in the MENA region. However, given the wide diversity in current market development and policy implementation across countries, the priority areas for action vary widely.

Built floorspace is growing rapidly in the region. Residential floorspace expanded at an average annual rate of over 2.5% from 2010 to 2023, compared to a global rate of growth of under 2.0% per year during the same period. This trend is set to continue, with residential floorspace in MENA projected to grow by nearly 2.3% per year from 2023 to 2035 – while the global average slows to 1.6% per year – and total residential floorspace increasing from around 11 billion m^2 in 2023 to nearly 15 billion m^2 in 2035. Many, but not all MENA countries have codes that regulate the energy performance of new buildings. Due to the rapid pace of construction, these codes can have a sizable impact on the projected energy demand for space heating and cooling over the period.

Figure 3.12 Residential buildings in the Middle East and North Africa by envelope type for stock and new construction in the Stated Policies Scenario, 2010-2035



Note: STEPS = Stated Policies Scenario.

The share of floorspace in the region not compliant with building codes is projected to continue to decline to 2035, with non-compliant floorspace falling gradually in absolute terms. A growing share of new construction is expected to be compliant with building codes: between 2010 and 2023, the share of newly constructed residential floorspace with an energy code increased from 38% to 63%, with a further increase to 67% projected by 2035. The rate of annual new construction is projected to rise to 500 million m^2 added in 2035, up from 390 million m^2 in 2023. This increase is also expected to be accompanied by an increase in non-compliant construction, as informal settlements also marginally increase with rising floorspace additions.

Although some building codes in MENA countries target both new construction and major renovations, these laws typically only cover large commercial and public buildings, limiting their impact on reducing energy consumption in the STEPS. Renovation could play a more substantial role in mitigating energy demand if the scope of building codes were expanded to include most residential buildings undergoing renovation or change of ownership.

Table 3.1 Key buildings sector energy efficiency policies in selected countries

Country	Building codes	Space cooling		Refrigeration		Water heating	
		MEPS	Incentives	MEPS	Incentives	MEPS	Incentives
Algeria	●	●	○	●	○	○	○
Egypt	●	●	●	●	○	○	◑
Iran	●	●	○	●	○	○	○
Iraq	○	○	○	○	○	○	○
Jordan	●	●	◑	●	◑	○	○
Lebanon	●	○	○	○	○	○	●
Morocco	●	●	○	●	○	○	○
Oman	○	●	○	●	○	○	○
Saudi Arabia	●	●	●	●	○	●	●
United Arab Emirates	●	●	●	○	○	○	○
Policy implemented: No ○ Yes ●							

Notes: MEPS = minimum energy performance standards. Building codes refer to mandatory requirements applied to new construction.
For incentives, ● indicate direct consumer incentives (rebates, subsidies and grants) and ◑ indirect support (e.g. producer incentives, low-interest loans and utility programmes).

For domestic electric appliances such as air conditioners, refrigerators and water heaters, relevant policy measures include MEPS and financial incentives for purchasing more efficient equipment. While strong MEPS can be sufficient to yield efficiency gains in advanced economies, financial incentives tend to be more impactful in driving efficiency improvements in emerging markets. In recent years, several MENA countries have implemented subsidies, scrappage schemes, tax credits and preferential loans.

In Saudi Arabia, the Window Air Conditioner Replacement initiative, launched in 2022, offers SAR 1 000 (USD 267) to encourage citizens to replace outdated, inefficient window air conditioners with newer, high-efficiency models. The Saudi government also introduced preferential electricity tariffs and tax credits for solar-assisted heat pumps. In Jordan, the Green Economy Financing Facility provides a credit line to local financial institutions, enabling consumers to obtain loans of up to JOD 120 (USD 170) for the purchase of air conditioners and refrigerators. The United Arab Emirates supports low-income households through a social welfare programme that provides one-time cash assistance for the purchase of air conditioners.

A growing number of MENA countries now regulate the efficiency levels of new air conditioners. As discussed, while space cooling can contribute a large share of the increase in electricity demand, due to rising underlying demand for cooling, efficiency improvements help mitigate much of the electricity demand growth for cooling specifically.

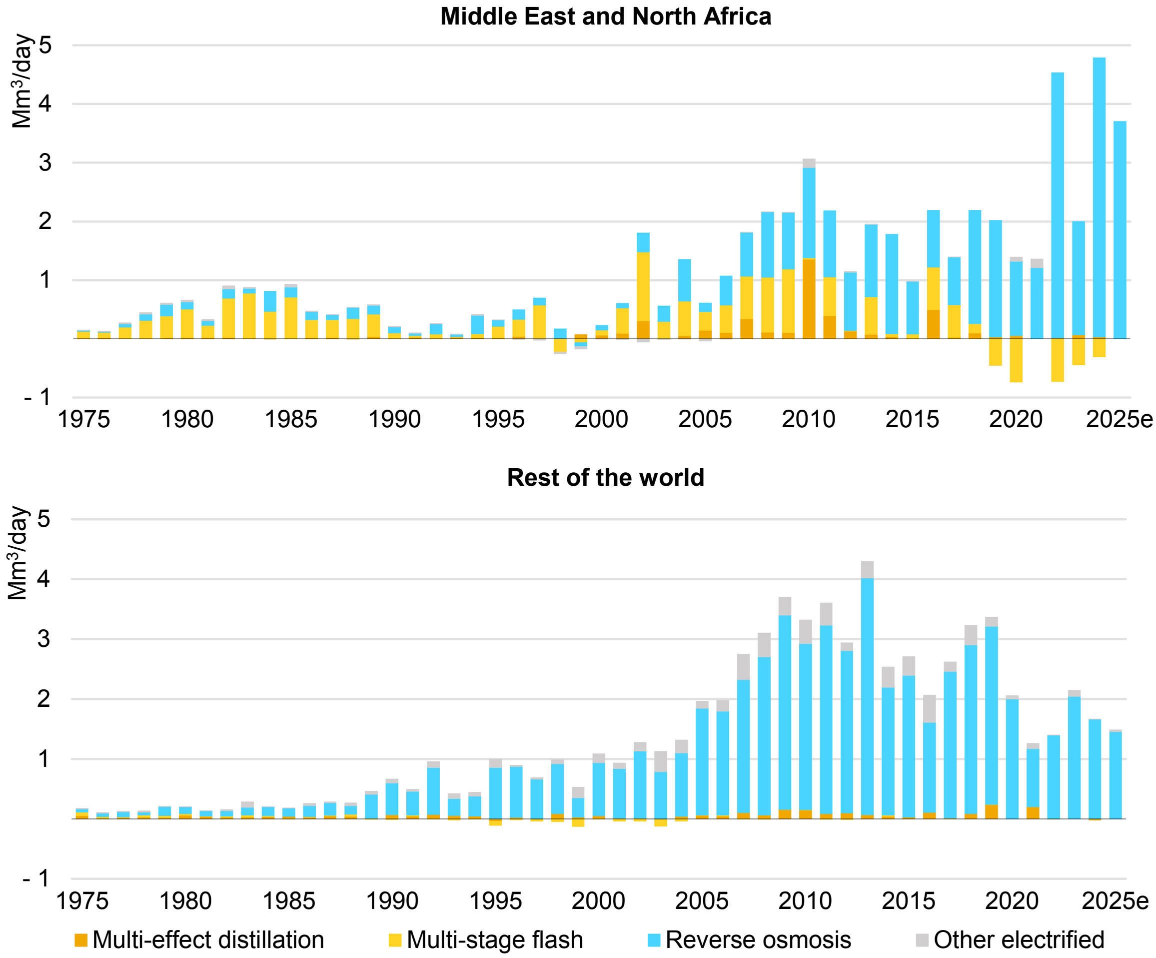
Of the MENA countries, Saudi Arabia currently has the most extensive set of buildings energy policy measures. As well as buildings energy codes, it has minimum efficiency standards for space cooling and refrigeration and was the first country in the region to have MEPS for water heating. Saudi Arabia is also a good example of the dynamism within the region: MEPS for refrigerators and washing machines date back to 2007 but were only optional at that time. Stringency later improved with several phases of implementation in 2018 and 2021, and MEPS were eventually reviewed last year, ensuring their continued improvement supports further efficiency gains.

While the efficiency policy picture for the region is generally improving, many gaps remain, and several countries do not have standards in place or relevant incentives promoting efficient technologies. Once implemented, the stringency of these standards needs to further improve in order to achieve additional savings and support the security of the electricity system.

4. How will new desalination technologies and rising water stress impact electricity demand?

Desalination plays a substantial role in energy consumption in MENA countries. Over 40% of today's global installed desalination capacity is located in the region, with around 15% in Saudi Arabia alone. Rising water stress and unsustainable usage patterns in the region are driving a rapid increase in demand for desalination. The process – removing salt from seawater, making it suitable for human consumption, agriculture and other uses – can be energy-intensive, and desalination currently makes up a significant share of gas demand in the region (more than 5% of the region's natural gas demand in 2010, dropping down to 4% in 2023). In recent years, new desalination capacity has been shifting towards much more energy -efficient electricity-based desalination technologies – a change which is set to significantly reshape the outlook for related energy demand.

Figure 3.13 Net desalination capacity additions by technology in the Middle East and North Africa and the rest of the world, 1975-2025



Note: 2024 and 2025 are estimated.
Source: IEA analysis based on GWI DesalData.

Desalination is shifting to more efficient electricity-based technology options, which can use 10 times less energy

Thermal desalination technologies like multi-effect distillation (MED) and multi-stage flash (MSF) have historically made up the largest share of capacity in the MENA region. These technologies primarily use natural gas for thermal processes (with some oil use, especially in Gulf countries), as well as some electricity for pumping and pre- and post-treatment of the water.

The world's largest desalination facilities are found in the MENA region, often combined with power generation and featuring multiple phases, fuels and even multiple desalination technologies on the same project site. Notable examples include the oil-fired Shoaiba CCGT power and water complex in Saudi Arabia – Shoaiba Phase 3 alone providing 0.88 million cubic metres per day (Mm^3/day) of desalination capacity. Hybrid plants combine desalination technologies, such as Ras Al-Khair in Saudi Arabia with MSF and reverse osmosis units, delivering a combined capacity of over 1 Mm^3/day. The United Arab Emirates' largest thermal desalination plant, Jebel Ali M (0.636 Mm^3/day), uses gas (with diesel as a backup), while Taweelah in the United Arab Emirates uses a combination of MSF and reverse osmosis.

In recent decades, electricity-powered membrane technologies, especially reverse osmosis, have quickly gained share, transforming the outlook. The last major new MSF/MED capacity in the region was added in 2018. Reverse osmosis and other membrane-based plants now make up over 60% of installed capacity in the region, and all projected capacity additions to 2035. Examples of large plants in the region include ACWA Power's Rabigh 3 Independent Water Plant in Saudi Arabia, which can produce 600 000 m^3/day of desalinated water.

These membrane technologies are now preferred thanks to their significantly higher energy efficiency, especially as reverse osmosis membrane efficiencies more than doubled between 1980 and 2008. Seawater reverse osmosis plants use around 11 MJ to 22 MJ of electric energy per m^3 of desalinated water produced (3 kWh/m^3 to 6 kWh/m^3). Some countries in the region, such as Iraq and Jordan, have a higher share of desalination from brackish water, which requires as little as half the energy for reverse osmosis due to the lower salt content. Ongoing development of membrane technologies can also extend efficiency gains. The thermodynamic efficiency limit of reverse osmosis membranes is now being approached in laboratory research, but improvements are still being achieved in real-world plants. For example, nanofiltration can yield 30% energy savings for reverse osmosis when used as a pretreatment step. However, other factors can downgrade the process or plant efficiency, such as high water salinity, harmful algal blooms or the need to discharge the brine over longer distances – all of which apply in part to the MENA region, notably for plants around the Red Sea. For regions with more limited sea access, pumping desalinated water to long-distance inland consumption centres decreases the overall system efficiency.

Thermal plants vary greatly in efficiency (with MED plants typically slightly more efficient than MSF plants) but can use ten times more energy (around 250 MJ/m^3 of water) than reverse osmosis plants to power the core thermal desalination process. These plants also require electricity to power various additional steps, including water intake, pre- and post-treatment, brine disposal and control systems, and typically use 7 MJ/m^3 to 14 MJ/m^3 of electric energy for these steps.

Desalination capacity in the MENA region could quadruple by 2035, while energy demand grows more slowly due to electrification

Desalination capacity across the MENA region is expected to continue to grow rapidly over the next decade, with nearly all growth coming from membrane technologies. Several countries in the region have set ambitious national goals to expand their desalination capacity. For example, Morocco aims to increase output to 1.7 bcm/yr by 2030, up from nearly 0.32 bcm/yr today. Elsewhere in the region, major projects currently planned or under construction include the Aqaba-Amman Water Desalination and Conveyance Project, which will supply 300 million m^3/year to 3 million people by 2029.

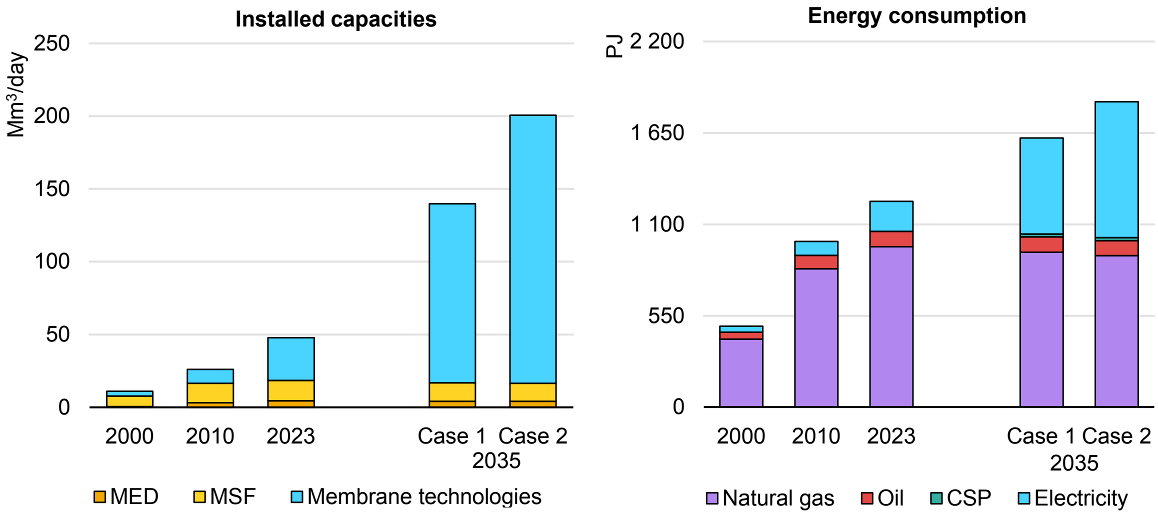
This report sets out two possible cases to project future growth in demand from desalination:

- Case 1 projects the growth of installed desalination capacities based on current trends, targets and projects in the pipeline, with growth in desalination capacity expected to continue beyond 2035. This is the framework adopted for the STEPS.
- Case 2 models an alternative scenario with an accelerated adoption of desalination capacities, particularly in the most water-stressed regions, along with a faster phase-out of thermal technologies in favour of more efficient reverse osmosis.

In Case 1, membrane technology capacity is expected to more than quadruple between 2023 and 2035. Over the same period, the capacity of thermal technologies falls by around 10% as thermal plants at the end of their lifetimes are typically replaced by more efficient technologies. From 2023 to 2035, the annual electricity consumption for desalination is projected to increase more than threefold in Case 1, from 50 TWh (180 PJ) to over 160 TWh (580 PJ). Case 2 projects additional electricity demand growth of nearly 67 TWh (240 PJ) by 2035.

Natural gas demand for desalination peaks in the current decade and then declines as older plants are taken offline. However, due to the much lower efficiency of thermal plants, gas will likely continue to be the largest energy source for desalination even in 2035, especially in Case 1.

Figure 3.14 Installed desalination capacities by technology (left) and consumption by energy source (right) in the Middle East and North Africa, 2000-2035

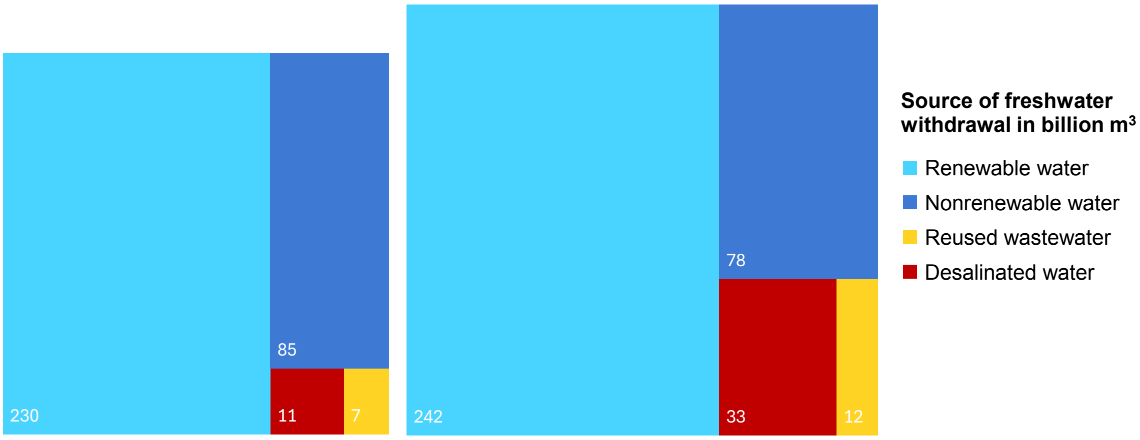


Notes: MED = multi-effect distillation; MSF = multi-stage flash; CSP = concentrating solar power. Membrane technologies include reverse osmosis.
Source: IEA analysis based on GWI DesalData.

The rapid growth of membrane technology desalination could have wider implications for electricity demand. While not widely used for demand response so far, desalination has the potential to contribute to demand flexibility as its capacity grows, alongside the increasing share of variable renewable energy. When desalination plants are combined with (water) storage facilities, operations can be shifted to align with peak power production, while maintenance and reduced water production can be planned for periods of low renewable power production.

Desalination's fast growth in the region may face obstacles. Cost is a potentially prohibitive factor in several countries, especially where there are constraints on investment. Concentrated brine, a byproduct of desalination, can cause environmental damage if not properly managed. Infrastructure such as distribution systems, along with practical issues like permitting and water regulation – all important enablers of the uptake of desalination – still need further development in some countries.

Figure 3.15 Withdrawals by freshwater source in the Middle East and North Africa in the Stated Policies Scenario, 2023 (left) and projected for Case 1 in 2035 (right)



Source: IEA analysis based on FAO AQUASTAT and GWI DesalData.

The rapid increase in demand for desalination is driven by rising water stress and non-renewable water extraction

Nearly all countries in the MENA region face some degree of water stress, with demand for water often exceeding supply, or poor water quality limiting its use. The picture is not uniform: water availability varies over time and by country. Freshwater scarcity is nevertheless driving significant investments in water infrastructure across the region, and the urgency of action is increased by projected population growth, changing climate and weather patterns, and heightened geopolitical tensions (given ongoing dependence on cross-border water flows).

Current unsustainable usage patterns underscore the need for further investment. Around one-quarter of water withdrawals in the region are from non-renewable water sources (also known as "fossil" water). In the long term, this usage leads to the depletion of freshwater aquifer systems, especially in the Arabian Peninsula, where the exploitable parts of major aquifers could be entirely depleted in 60-90 years. Despite large investments in desalination capacity and its significant energy consumption, desalinated water represents only 3% of water withdrawals in the region today and is projected to reach 9% by 2035. While desalination is essential for basic needs such as drinking and municipal water, it cannot by itself solve the region's water stress.

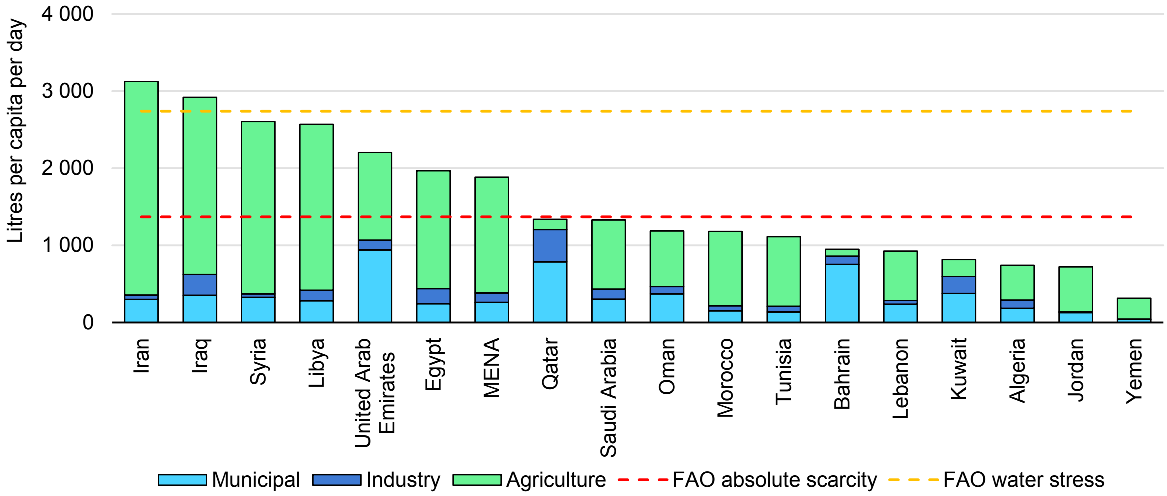
A wide range of investments in water infrastructure is underway, including desalination, as well as water storage, pipelines, wastewater treatment, water meters and upgrades to ageing or leaking components. Investments to improve infrastructure and reduce leaks can address water needs and help moderate the growth in desalination demand. Between 2013 and 2023, contracts worth USD 115 billion were awarded for water infrastructure in the region. Of this total, spending on desalination is on par with water treatment, at around USD 27 billion. Measures such as rainwater harvesting, greater reuse of wastewater, integrated water resources management and more efficient water use can also help mitigate water stress.

Water usage patterns, desalination capacity and future demand needs vary considerably by country

Today, there are wide variations in water usage by country across the region. Out of 17 MENA countries, 15 have per capita water withdrawals that fall below the Food and Agriculture Organization of the United Nations' water stress threshold. Of these, 11 are at or below the level of absolute water scarcity. In these countries in particular, water demand is likely to rise significantly as water supply infrastructure is developed and improved.

Across the region, agriculture is typically the largest single end-use sector for water, except in some geographically small countries like Bahrain and Qatar with limited agriculture. While desalinated water is typically used for municipal (tap water) and industrial purposes, with rising efficiencies and falling costs, there is also scope for its use in irrigation in some cases. For example, Morocco's Greater Casablanca Desalination Plant, currently under construction and due onstream in 2028, is set to produce 300 Mm^3 of water annually, of which 50 Mm^3 will be available for agriculture.

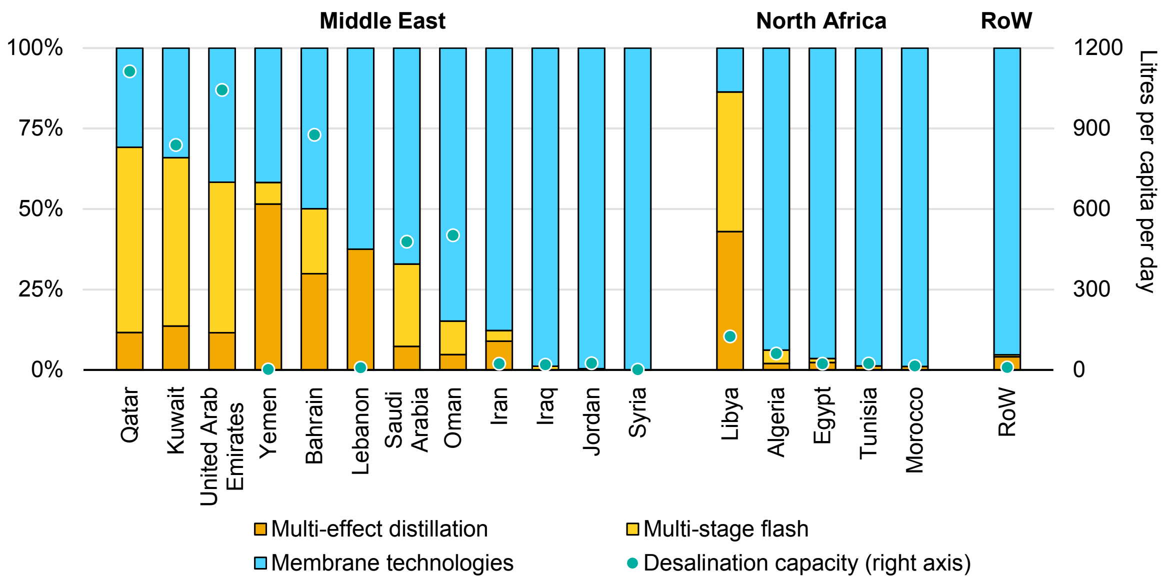
Figure 3.16 Daily freshwater withdrawals by country and sector, 2023



Notes: MENA = Middle East and North Africa.
Source: IEA analysis based on FAO AQUASTAT and World Resources Institute.

Total installed desalination capacity varies greatly across MENA countries. Four Gulf countries – Saudi Arabia, United Arab Emirates, Kuwait and Qatar – account for 70% of the installed capacity in the region, with Saudi Arabia alone making up over a third of the region's desalination capacity. On a per capita basis, the variation is even wider. Among the six GCC members, capacity ranges from nearly 500 litres per day per person to over 1 100 litres per day per person. By contrast, in most of the rest of the region, capacity remains below 30 litres per day per person. Current technology deployment also varies significantly, with high shares of MSF/MED in use in several countries with major fossil fuel production, including Kuwait, Qatar, the United Arab Emirates and Yemen, while other countries have much higher shares of electricity-powered reverse osmosis capacity.

Figure 3.17 Shares of installed capacities of desalination technologies and total installed desalination capacity per capita by country, 2023



Notes: RoW = rest of the world. Membrane technologies include reverse osmosis.
Source: IEA analysis based on GWI DesalData.

5. What role do grid interconnections play in the MENA region?

Historically, electricity systems in the MENA region were developed in isolation. However, growing electricity demand, diversification of energy sources – especially the pursuit of ambitious renewable energy targets – and greater geopolitical co-operation have driven efforts towards regional integration. Today, the MENA region features several established and developing electrical grid interconnections, operating at varying scales and levels of effectiveness. These include regional grids that connect multiple countries, as well as key bilateral interconnectors designed to enhance energy exchange between specific nations.

Overview of existing regional grids

The Gulf Cooperation Council (GCC) Grid represents a significant interconnection initiative linking the power systems of Bahrain, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. The project was initiated and is managed by the GCC Interconnection Authority, which was established in 2001 to plan, construct, operate and maintain the interconnection infrastructure.

The initial project was divided into three phases. In Phase I, completed in 2009, the GCC Interconnection Authority formed the GCC Northern System by connecting the power grids of Bahrain, Kuwait, Qatar and Saudi Arabia. This involved building a 400 kV grid across Kuwait, Qatar and Saudi Arabia, including a 400 kV submarine cable to Bahrain and a high-voltage direct current back-to-back converter to link Saudi Arabia's 60 hertz (Hz) system with the 50 Hz systems of other GCC countries. Phase II, which was completed in 2011, and Phase III, completed in 2014, extended the grid to Oman and the United Arab Emirates via a 220 kV overhead line, merging the Southern and Northern Systems into a unified 950 km regional grid. This interconnection, with a total capacity of 2.4 GW, features high-voltage lines, substations and reactive power compensation, though individual link capacities vary by country.

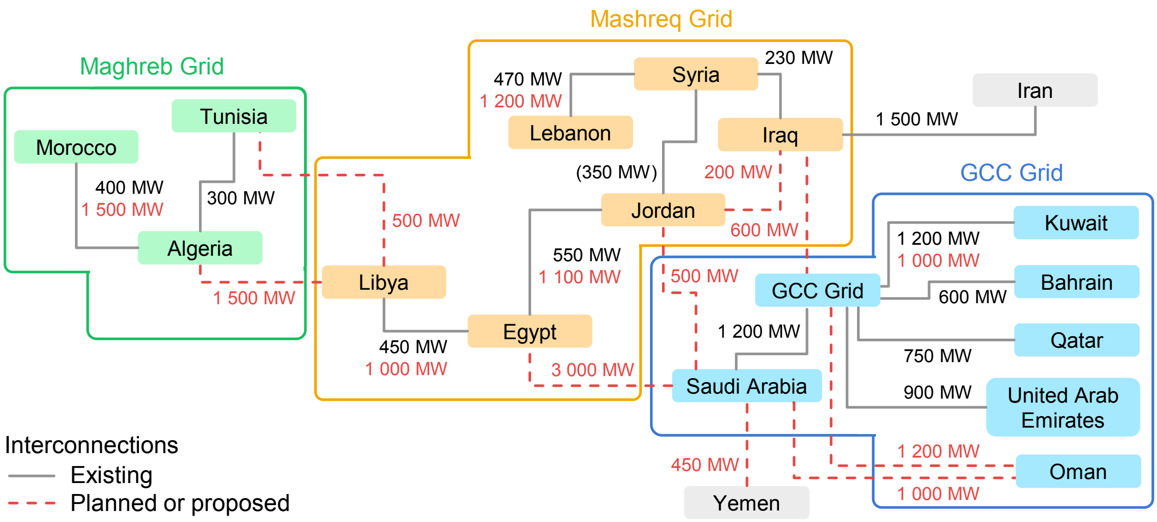
The Mashreq Grid connects a wider array of countries, including Egypt, Iraq, Jordan, Lebanon, Libya, Syria, Türkiye, the West Bank and Gaza Strip. The interconnection was initiated in 1988 by Egypt, Iraq, Jordan, Syria and Türkiye and later expanded to include Libya, Lebanon and the West Bank and Gaza Strip. At the outset, each country signed an agreement to commit to upgrading its electricity system to minimum standards. After four years, in October 1992, the original five countries signed a general trading agreement for mutual assistance through the exchange of surplus power in the region. This was followed in 1996 by a general energy interconnection agreement outlining the terms and conditions for use of the energy interconnection.

The Mashreq Grid was designed to enable synchronised operation and power exchange among the participating countries, facilitate economic electricity trade, improve power system reliability and eventually create the foundation for a regional electricity market. It mainly uses 400 kV alternating current transmission lines to support high-capacity, long-distance power transfers. The participating countries operate at 50 Hz, with synchronisation mechanisms used where needed. Egypt serves as a key hub, linked to Jordan and Libya via 400 kV interconnectors. Jordan also connects to Syria, extending the network towards Lebanon and Iraq, although this link has faced interruptions due to regional instability.

In North Africa, the Maghreb Grid, initialised in the 1950s, facilitates electricity trade between Algeria, Libya, Morocco and Tunisia. In 1997, it was linked to the

European power grid through two 400 kV subsea cables between Morocco and Spain, with a combined capacity of 1.4 GW allowing electricity trade with Europe, supporting Morocco's renewable energy exports and imports during peak demand. In 2003, the European Commission and Maghreb energy ministers signed a protocol to build a regional energy market integrated with the European Union. The protocol aimed to address tariffs, cross-border networks and compensation mechanisms. By 2010, the Algiers Declaration saw the Maghreb countries commit to aligning legal, regulatory and technical standards to create a transparent, fairly-priced and open electricity market. However, market development has lagged behind. Trade volumes between countries, especially between Morocco and Algeria, remain limited compared to the available interconnection capacity, which operates mainly at 400 kV, with additional 220 kV and 90 kV lines providing flexibility. These interconnections continue to serve mainly for supply security rather than active market exchange.

Figure 3.18 Existing and proposed future electrical interconnections by 2035



Note: The interconnector between Libya and Egypt is currently not active.

Beyond the existing regional grids, there are several bilateral interconnectors in the MENA region under construction. A prime example is the Egypt-Saudi Arabia Interconnector, a landmark initiative with the primary objective of significantly enhancing electricity trade between these two major energy players, and set to come online this year. This ambitious project aims to achieve a total electricity exchange capacity of 3 GW. The Egypt-Saudi Arabia Interconnector holds the distinction of being the first large-scale high-voltage direct current interconnection in the MENA region, spanning an impressive 1 300 km and poised to benefit over 20 million people in both countries.

Challenges and barriers to grid interconnection

Expanding regional grid interconnections in the MENA region faces several challenges. Political and geopolitical factors play a significant role, with existing rivalries and instability often hindering co-operation among nations. Successful market integration relies on political support, trust and long-term commitment, which can be difficult to achieve given the region's complex political landscape.

Economic challenges also pose significant barriers, particularly due to the high initial costs associated with developing grid infrastructure. These challenges are compounded by factors such as low population density, which leads to long distances between infrastructure points. Additionally, equipment and materials may require specialised design or upgrades to endure local weather conditions, including high ambient temperatures and extreme heat events. Energy subsidies, particularly for fossil fuels, further distort market incentives and complicate cross-border trading by creating unfair advantages for countries with subsidised energy.

Regulatory and policy inconsistencies across countries may further hinder progress. Fragmented energy policies and evolving regulatory frameworks create uncertainty for investors, making it difficult to establish clear paths for cross-border interconnection. Even more important is the bankability of interconnection projects, which depends largely on the strength of their underlying business models. Crucial considerations include the allocation of wheeling charges, responsibility for the cost of reserved capacity and the presence of financial risk mitigation measures. In the absence of clear and predictable revenue frameworks, investor confidence can falter, putting the viability of interconnection projects at risk.

From a technical perspective, varying grid codes and communication technology standards across countries can complicate efficient cross-border power exchange. Furthermore, Saudi Arabia operates its grid at 60 Hz, which necessitates the use of high-voltage direct current technology to facilitate integration with neighbouring systems operating at 50 Hz.

Security concerns, particularly cybersecurity, are increasing as grids become more interconnected and reliant on digital technologies. Vulnerabilities in one part of the network can have widespread impacts, and governments must address the evolving threats to ensure the resilience of critical energy infrastructure.

Key regional initiatives and organisations

Several key regional initiatives and organisations are playing a pivotal role in driving the agenda for electrical grid interconnection in the MENA region.

The Pan-Arab Electricity Market (PAEM), led by the League of Arab States, aims to create a unified regional electricity market across all Arab countries. Initiated in

2017 and supported by the World Bank, PAEM seeks to lower electricity costs, boost renewable energy integration and generate job opportunities. Key governance agreements were ratified in 2024, with full implementation targeted by 2038. By co-ordinating expansion plans and optimising resources, PAEM can significantly reduce overall costs, allowing countries to optimise investments aimed at meeting peak national demands. This strategic co-ordination could save the region between USD 107 billion and USD 196 billion in system costs by 2035.

The GCC Interconnection Authority, established in 2001 and based in Saudi Arabia, has played a key role in linking the power grids of the GCC countries into a single, resilient network since 2009. Its focus is on enabling efficient electricity trade, integrating renewables and improving energy reliability and sustainability in the Gulf. Its efforts have led to cost savings, reduced CO_2 emissions and enhanced energy security.

The Med-TSO initiative, founded in 2012, brings together Mediterranean electricity transmission operators to support regional grid integration and renewable energy development. It promotes cross-border interconnections, harmonised standards and co-ordinated planning through initiatives like the Mediterranean Master Plan and TEASIMED (Towards an Efficient, Adequate, Sustainable and Interconnected MEDiterranean power system), while also working closely with regional and European partners, such as the Association of Mediterranean Energy Regulators and the European Network of Transmission System Operators for Electricity.

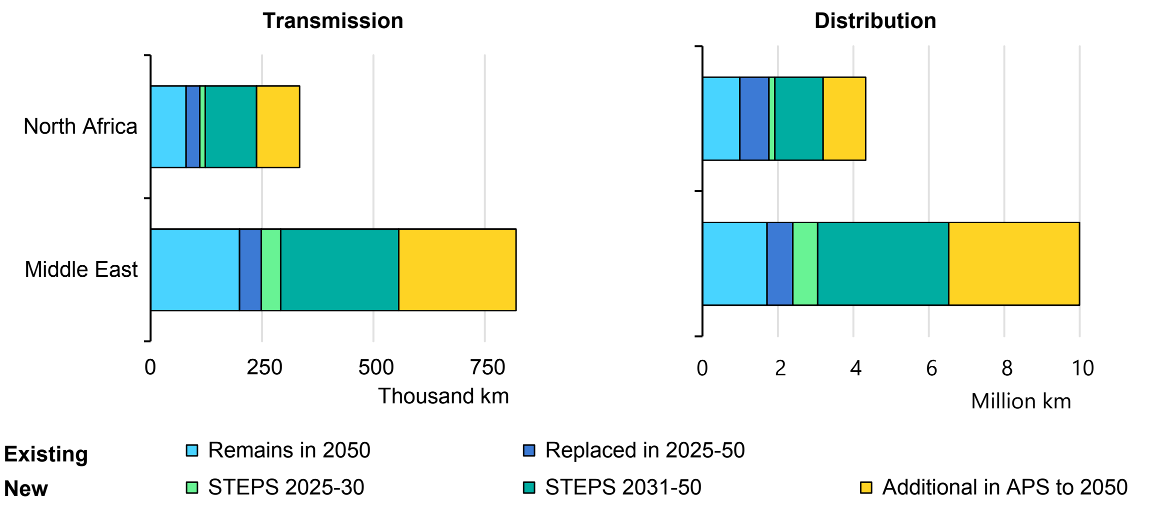
The World Bank has also been a major supporter of regional energy integration in the MENA region. It has provided financial and technical backing to projects such as the ELMED interconnector and has played a key role in supporting PAEM. Through the Energy Sector Management Assistance Program, it also promotes solar and wind integration, highlighting the importance of infrastructure.

Outlook for grids and interconnections in the Middle East and North Africa region

Electricity grids are projected to increase substantially to 2035 to support the expansion of electricity supply and demand in the MENA region. Over the past decade, the Middle East has witnessed a substantial expansion of its electricity infrastructure, with transmission lines increasing by 76% and distribution lines by 66%, significantly outpacing the global averages of 36% and 28%, respectively. While this pace is expected to decelerate over the coming decade, growth is still projected to remain robust, with transmission and distribution lines expanding by over 40% and 60%, respectively, in the STEPS. In the more ambitious APS, the increases are even more pronounced, reaching over 60% for transmission and about 80% for distribution.

In comparison, North Africa has experienced more moderate grid development. Over the past ten years, transmission and distribution line lengths have both increased by around 40%. Looking ahead, expansion slows further in the STEPS, with projected growth of more than 30% for transmission and just over 20% for distribution. In the APS, to meet higher ambitions, grid development picks up slightly, with projected increases of nearly 50% and about 30% for transmission and distribution lines, respectively – though this remains more restrained than in the Middle East. Meanwhile, climate change introduces new risks to power system resilience, as extreme weather events, such as extreme heat, can create additional challenges for grid stability. In this context, strong and interconnected electrical grids can bolster energy security and support the shift to cleaner energy sources.

Figure 3.19 Grid development by type and region in the Stated Policies Scenario and Announced Pledges Scenario, 2025-2050



Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario.
Source: IEA analysis based on Global Transmission.

Ongoing efforts to strengthen regional electricity interconnection are being advanced by initiatives such as PAEM and the continued expansion of the GCC grid, which aims to reach a capacity of 3.5 GW. Notable projects include the planned increase of the Oman-GCC link to 1.7 GW, the Kuwait link to 3 GW and new connections with Iraq. Additionally, the discussed expansions in the Mashreq region, particularly involving Iraq, are paving the way for future interconnections with Türkiye of up to 3 GW and, ultimately, with the European Union. These connections could be realised either through high-voltage direct current lines or through the Great Sea Interconnector, an EU Project of Common Interest. This subsea electricity cable will link the region to the Greek power grid and thus to the larger EU grid. Spanning over 1 200 km, the cable will have an initial capacity of

1 000 MW, expandable to 2 000 MW, with construction having started in 2024 and full operation expected by 2028.

Table 3.2 Selection of electrical interconnectors under construction and planned

Countries	Capacity (MW)	Estimated completion
GCC ↔ Iraq	600	2025
GCC ↔ Kuwait	3 000	2025
Jordan ↔ Iraq	200	2025
Egypt ↔ Jordan	2 000	2026
Saudi Arabia ↔ Oman	1 000	2027
Italy ↔ Tunisia	600	2028
Egypt ↔ Libya	1 000	2030
Algeria ↔ Libya	1 500	By 2035

Similarly, the ELMED interconnector aims to create a 200 km, 600 MW HVDC submarine link between Tunisia and Italy, further integrating North African and European electricity markets.

Integrating the GCC and Mashreq networks would address a key challenge in intra-GCC electricity trade: synchronised load patterns with pronounced summer and afternoon peaks. The Saudi Arabia-Egypt interconnection will allow for reserve sharing and electricity exchange, capitalising on differing demand cycles. Comparable projects with Jordan and Iraq are also underway, enabling Saudi Arabia to export surplus electricity during its off-peak hours.

Going a step further, the India-Middle East-Europe Economic Corridor, launched in September 2023, envisions broader connectivity across trade, infrastructure and energy. Another emerging aspect of this initiative is the potential electricity interconnection between India and the Middle East. Under the "One Sun, One World, One Grid" initiative, feasibility studies indicate that such a link could deliver substantial cost savings by harnessing the Middle East's abundant low-cost solar power to displace fossil fuels in India.

Box 3.1 Technology enablers for grid development and interconnection

Ongoing technological advancements are essential to improving the efficiency, reliability and performance of electrical grids and interconnections across the MENA region, especially when integrating higher shares of renewable generation.

High-voltage direct current links are strategically important because they transmit large volumes of electricity with lower losses than alternating current systems and enable power exchange between grids with different frequencies, such as in Saudi Arabia. Recent innovations have made smaller high-voltage direct current systems more cost-effective, offering benefits such as fully controllable four-quadrant operation for flexible management of both active and reactive power, precise alternating current voltage regulation, contribution to network fault currents for reinforcing weak alternating current systems and the ability to black-start power networks after outages.

Flexible alternating current transmission systems encompass a range of technologies designed to enhance reactive power support, improve grid stability, increase controllability and boost the power transfer capacity of alternating current systems. These functions are critical for integrating variable renewable energy sources, distributed generation and newly electrified loads. Recent advancements also include enhanced grid-forming static synchronous compensators which deliver both static and dynamic system support, including synthetic inertia, without the need for rotating machinery. Similarly, converters in battery energy storage systems have been upgraded to provide grid-forming capabilities and inertia support, reinforcing network stability.

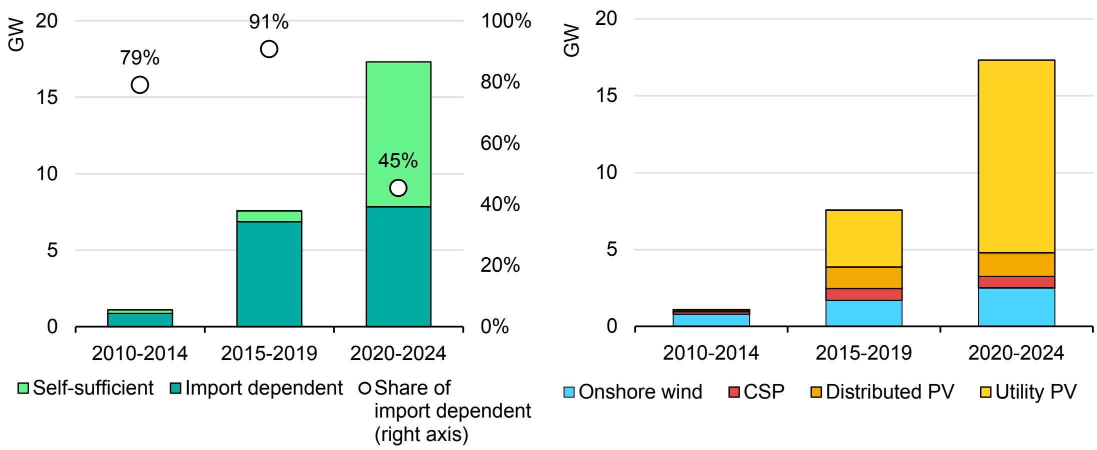
Wide area monitoring systems use time-synchronised data from phasor measurement units to provide real-time visibility of grid conditions across large areas. They enhance fault detection, stability and situational awareness, which are critical for managing modern, complex power systems. As grids evolve into smart grids with higher shares of renewables and distributed energy resources, wide area monitoring systems become essential for real-time co-ordination and control. Integrating artificial intelligence with these systems enables predictive analytics, automated fault detection and optimised decision making. Artificial intelligence can process vast data streams to anticipate disturbances, balance supply and demand, and enhance operational efficiency. Together, wide area monitoring systems, artificial intelligence and smart grid technologies create more resilient, adaptive and intelligent power systems, capable of supporting the energy transition across the MENA region.

6. What are the policy frameworks driving renewables deployment in the MENA region?

Renewables were initially deployed for energy security but have since become a part of economic development and climate goals

The primary objective of renewable policies in the MENA region has historically been energy security, specifically targeting power sector diversification. Initial growth was driven by countries that were reliant on fossil fuel imports for power, accounting for almost 80% of non-hydropower renewable capacity additions between 2009 and 2014. The majority of onshore wind was from Morocco, seeking to reduce reliance on imported coal, and Tunisia, aiming to avoid natural gas imports. Concentrating solar power (CSP) was also deployed by Morocco and joined by the United Arab Emirates, also seeking to reduce natural gas imports. The following five years, the share of net-importing countries rose to over 90%, with additions from Jordan as well as Egypt, by then a net importer of natural gas. Over half the growth during this time was from solar PV as costs began to fall.

Figure 3.20 Renewable electricity capacity additions excluding hydropower by country profile in the Middle East and North Africa (left) and by technology (right)

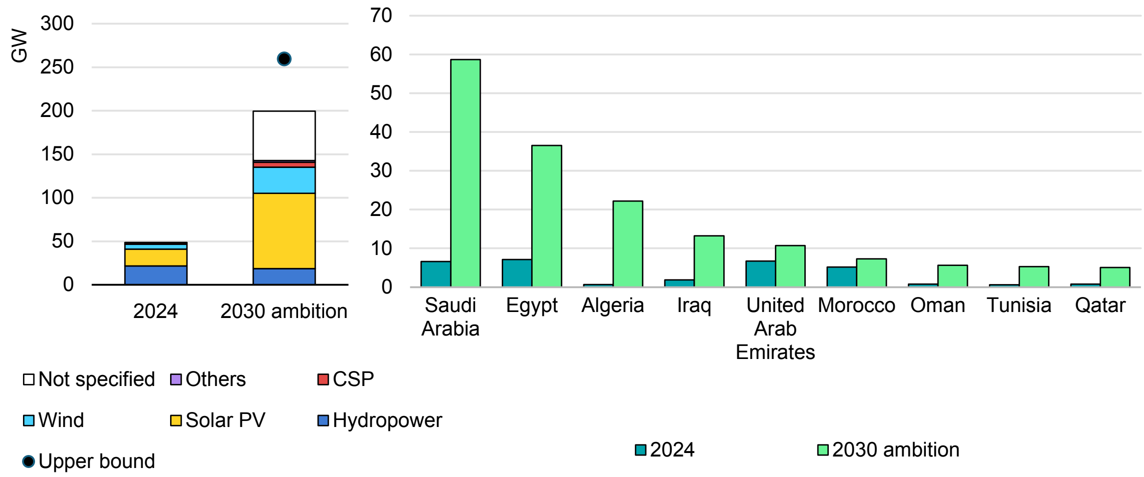


Notes: Import dependent refers to countries that have a majority of power generation from a fossil fuel that they are a net importer of. Self-sufficient refers to countries that have a majority of power generation from a fossil fuel that they are a net exporter of. Between 2015 and 2019, Egypt was a net importer of natural gas, which accounted for between 70% and 80% of electricity generation, and it is, thus, included as an import dependent country during this time. Installed capacity for bioenergy is less than 400 MW and excluded from this graph.

By 2020, however, renewable deployment spread beyond these import dependent countries to include those that are self-sufficient in meeting their power demand. Between 2020 and 2024, more than 50% of new renewable capacity was added by Saudi Arabia, Oman, Qatar, and Egypt, which by this time could sufficiently meet power demand with domestically produced fossil fuels, up sharply from 9%

during 2015 to 2019. The main driver of this shift was the need to curb domestic fuel consumption in response to fast-growing power demand, enabling more fuel to be freed up for export. In addition, declining global solar PV costs have made the technology an increasingly attractive and economically viable alternative to fossil fuel-based power generation.

Figure 3.21 Renewable electricity capacity ambition by 2030 by technology (left) and selected country (right)



Notes: "Not specified" corresponds to capacity that was classified as "renewable" in national ambitions but not assigned to a specific technology.

Sources: For Saudi Arabia, the 2030 ambition corresponds to the 58.5 GW of renewable capacity announced by the Saudi Industrial Development Fund, however plans to tender up to 130 GW were announced in the Saudi Green Initiative launched in 2021. For Egypt, the capacity is calculated based on the 42% electricity generation in the Integrated Sustainable Energy Strategy for 2035. For Algeria, capacity is from the Programme de Développement des Energies Renouvelables. For Iraq, the source of the 2030 ambition is the Arab Future Energy Index 2023. For the United Arab Emirates, capacity was calculated based on the National Energy Strategy 2050. For Morocco, capacity is from the UNFCC Nationally Determined Contribution 2021. For Oman, capacity is estimated from the Nama Power and Water Procurement Seven Years Statement (2023-2029). For Tunisia, capacity is estimated from the Stratégie Énergétique de la Tunisie à l'horizon 2035. For Qatar, values are estimated from Qatar National Renewable Energy Strategy.

By the end of 2024, renewable capacity stood at 48 GW, almost equally split between import dependent and self-sufficient countries, and the MENA region has plans to further expand the fleet to 200 GW by 2030. Over 75% of the ambition is from self-sufficient countries, led by Saudi Arabia, Egypt, and Algeria. This highlights not only the growing importance of energy security but also reflects the broader benefits that these countries expect from renewables, such as economic diversification, job creation, industrial development and emissions reductions. The renewable electricity goals for fuel-importing countries are more modest in absolute terms, but this is likely due to their lower power demand needs compared to self-sufficient countries.

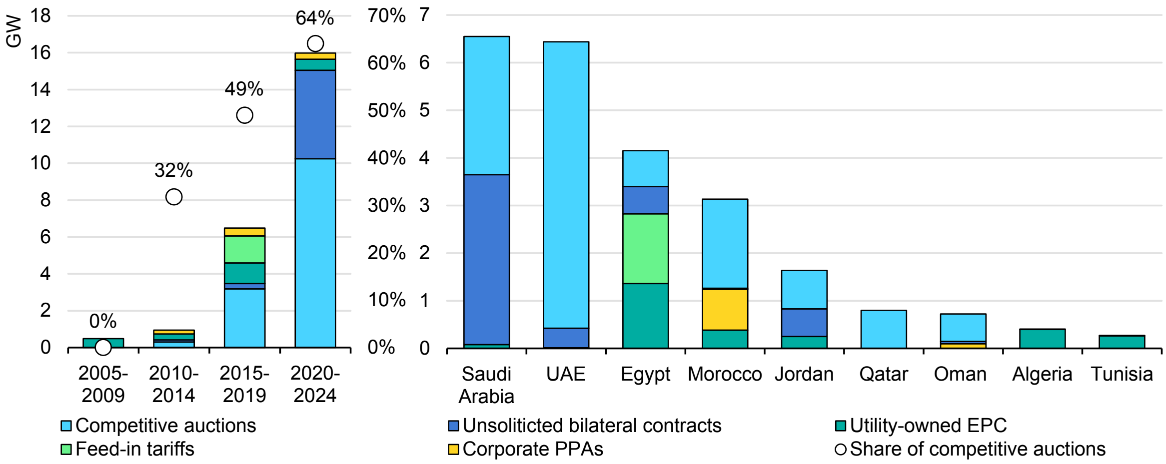
The ambition for renewables could exceed 250 GW if plans from institutions with broader goals are taken into account. For example, in Saudi Arabia, climate policies have even higher renewable ambitions and envision developing up to

130 GW of renewable energy capacity – not only to reduce emissions but also to support broader sustainability goals, such as afforestation and the protection of land and marine ecosystems. Ambitions can also be higher depending on the timing of the announced policy and the level of political commitment.

Competitive auctions are the main policy tool for renewable deployment

Governments have employed a variety of policy tools to promote renewable electricity, but the most widely implemented has been competitive auctions, accounting for almost 60% of cumulative installed capacity in 2024. In these auctions, governments invite developers to bid for renewable power projects, awarding power purchase contracts to those offering the lowest prices. This process helps governments discover market prices as well as enable cost-efficient project development.

Figure 3.22 Utility-scale renewable electricity capacity additions excluding hydropower by procurement type, 2010-2024 (left) and cumulative capacity by country, 2024 (right)

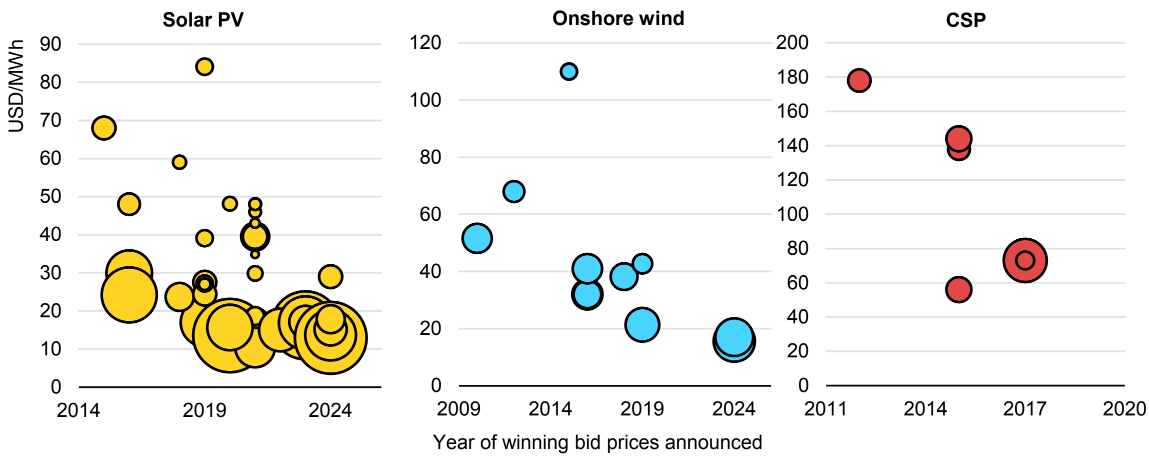


Notes: Data for Iran are excluded from this analysis. EPC = engineering, procurement, and construction. Data for bioenergy is included. Utility-scale plants with self-consumption are excluded.

Since they were first introduced in Morocco in 2010, their use has gradually increased throughout the region. Between 2015 and 2019, nearly half of all new renewable capacity installed was procured through competitive auctions following their adoption in the United Arab Emirates, Jordan, and Egypt. The share increased to two-thirds from 2020 to 2024 as they were implemented by more countries, including Oman, Qatar and Saudi Arabia.

Today, 13 out of 17 countries in the MENA region use competitive auctions to procure renewable power – and they have become the largest driver of renewable investment in Jordan, Morocco, Oman, Qatar and the United Arab Emirates. Competitive auctions offer several advantages for governments, including price discovery, volume control and, when well-designed, potential socio-economic benefits. A main reason for their frequent use is their ability to help governments obtain the lowest costs for their market environment. This is achieved through competitive bidding, which drives developers to be as cost-efficient as possible to win.

Figure 3.23 Awarded bid prices in auctions for utility solar PV, onshore wind and Concentrating Solar Power



Notes: The size of the bubble represents the size of a project. Values are listed in nominal prices. Values for hybrid projects (i.e. solar PV and CSP, or other storage) are not included. CSP = concentrating solar power.

Since their introduction, competitive auctions have significantly reduced the awarded prices for utility-scale PV projects. For instance, awarded prices for a 200 MW PV system dropped by 57%, from USD 68/MWh in Jordan in 2016 to USD 29/MWh in Tunisia in 2024. Even lower bids, below USD 20/MWh, were awarded for larger projects over 600 MW in Qatar, Saudi Arabia and the United Arab Emirates. These exceptionally low prices were due not only to competition but also economies of scale, as well as cost reductions in PV technology. Average module costs also fell by 86% between 2014 and 2024.

However, the prices discovered through competitive auctions are extremely market-specific and are not necessarily reflective of the true project costs. Many of the projects awarded at prices below USD 20/MWh likely also benefit from partial state ownership and favourable land and financing conditions provided by governments that may not be present in all regional markets. In addition, winning projects from the first auctions in Algeria, Iraq and Tunisia have yet to be commissioned, so it remains to be seen whether projects can actually be realised at these low prices.

Competitive auctions have also contributed to lower awarded prices for onshore wind and CSP, though other factors are also at play. For CSP, the price reductions observed by 2017 are partly due to the inclusion of thermal storage, which helps achieve lower generation costs. The weighted average price for onshore wind of USD 16.2/MWh in Saudi Arabia’s 2024 auction also likely benefits from advantageous land and financing conditions.

Beyond auctions, governments have implemented other procurement practices to expand renewable capacity. Unsolicited bilateral contracts – purchase power agreements (PPAs) bilaterally negotiated between independent power producers and utilities outside of a call for tenders – have become the second-largest procurement method in the region. Morocco signed the first unsolicited bilateral contract for CSP in 2011 for 20 MW, and the number and size of contracts have since grown. The largest have been in Saudia Arabia, where three solar PV projects of 2 GW each were signed between 2022 and 2024. Unsolicited bilateral contracts account for half of the country’s installed renewable capacity.

Corporate PPAs account for 4% of the region’s renewable capacity deployment, however they are mostly limited to Morocco, where a favourable regulatory environment allows power to be sold directly to industrial consumers. Feed-in tariffs were used in Iran and then briefly introduced in Egypt. However, Egypt abandoned its feed-in tariffs due to challenges with setting attractive prices for developers. Utility ownership accounts for 11% of deployment and is the only procurement model that has successfully commissioned large-scale-projects in Algeria and Tunisia to date, as both countries have faced delays in commissioning projects from their competitive auction systems.

Auction design, regulatory regimes, and permitting need improvement to accelerate deployment

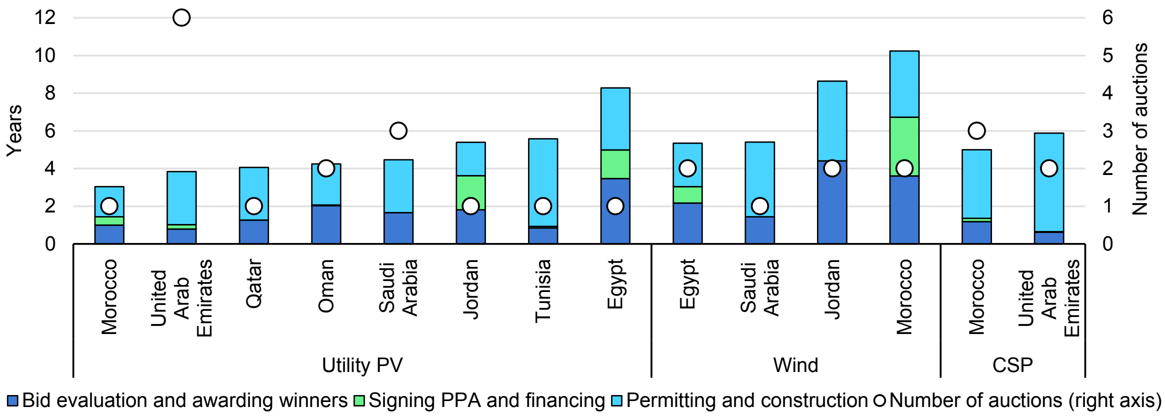
Despite the range of policy tools utilised in the region, the pace of renewable capacity expansion remains below what is needed to achieve 2030 ambitions. This is largely due to several regulatory and policy challenges, with one main issue being the lengthy project development timelines associated with competitive auctions. From the opening of an auction to commissioning, solar PV projects typically take between three and eight years, wind projects between five and ten years, and CSP projects around five to six years. These extended timelines stem from the time required for implementing the auction, securing financing, signing power purchase agreements and constructing the plant. For instance, in Egypt, more than 40% of the total project lead time was spent on awarding the auction, while in Jordan, this stage accounted for 50% of the lead time for wind projects.

One of the key factors influencing auction implementation time is the level of experience a country has with the process. Competitive auctions involve several complex steps, including soliciting expressions of interest, pre-qualifying bidders, evaluating bids and awarding contracts. For countries with limited experience, the process can be a steep learning curve, leading to extended implementation timelines.

For example, evaluating bids and awarding winners for the first utility-scale PV auctions in Jordan and Egypt took two and three years, respectively. Jordan's only wind auction took more than four years, and Algeria has yet to select winners for an auction despite issuing several requests for proposals.

However, as the frequency of auctions increases, stakeholders gain experience and familiarity with the processes, and times are shortened. For example, in the United Arab Emirates, where at least six auctions have commissioned utility-scale PV plants, the average bid evaluation time is just nine and a half months, the fastest in the region. Other factors that can contribute to long tender times include securing land and assessing the network's ability to integrate new capacity additions.

Figure 3.24 Average project development lead times for capacity awarded through competitive auctions



Note: CSP = concentrating solar power.

Once bidders are awarded, securing financing and signing the PPA can also take time due to risk perceptions associated with the project. For example, securing financing and signing PPAs have taken almost two years for PV projects in Jordan and over three years for onshore wind in Morocco. Even longer is Morocco's Midelt I solar project, which was awarded in 2019 and has yet to sign a PPA. Contractual terms, such as a lack of international arbitration or denomination in the local currency, have made PPAs unbackable in Egypt, while developers cite PPAs lacking sovereign guarantees and inflation indexation as some of the reasons that have delayed signing contracts in Iraq's first auction.

Permitting and construction times also vary depending on the technology and geographic market. For utility-scale PV projects, permitting and construction can take as little as 1.6 years for smaller projects on pre-approved sites in Morocco but can exceed to four years in Tunisia due to complex authorisation procedures. Egypt's only auctioned utility-scale PV project took more than three years to build, as developers postponed equipment purchases to take advantage of falling costs. Additional factors, such as grid connection and land acquisition, can also stretch timelines. Onshore wind projects take on average three-and-a-half to four years to build, while CSP projects take nearly four to five-and-a-half years to complete.

Competitive auctions are likely to remain a key policy tool in the MENA region. However, reducing project lead times will be essential for accelerating progress towards reaching long-term renewable energy ambitions. The following areas merit attention:

- improving auction design – setting balanced prequalification criteria, improving resource mapping and/or pre-site selection
- reducing contractual risk – standardising PPAs, ensuring terms are bankable and economically attractive to developers
- ensuring a supportive regulatory framework – clarifying authorisation procedures, closing regulatory loopholes
- streamlining permitting – simplifying permitting procedures, reducing barriers to land acquisition
- grid infrastructure – ensuring sufficient grid capacity and infrastructure to facilitate connection.

7. Can clean energy spur industrial development in the region?

Global clean energy investment is estimated to have reached close to USD 3 trillion in 2024. While the MENA region still represents only a small share of this amount, its largest economies have in recent years heightened their ambitions across a range of clean energy sectors. These include energy efficiency measures and low-emissions power capacity deployment (e.g. nuclear and renewables) and the development of low-emissions fuels (e.g. hydrogen). To meet these goals, the region is still dependent on concentrated global supply chains to access raw materials, manufactured components and, in some cases, skills. As with other regions, capturing value from clean energy supply chains would represent a significant economic opportunity.

Currently, 40% to 98% of global manufacturing capacity for key clean technologies and components is located in China. Based on today's policy settings, the value of China's clean technology exports could exceed USD 340 billion by 2035, more than the combined current oil revenues of Saudi Arabia and the United Arab Emirates. Similarly, reserves and processing capabilities for many critical minerals vital to clean industries are highly concentrated in a limited number of countries. As other leading economies work to catch up technologically and diversify supply chains, the MENA region's value proposition becomes particularly compelling. Its strategic location at the cross-roads of three continents, the availability of energy resources and mining potential, and the existence of critical infrastructure, such as ports and export-led industries, can all be leveraged to integrate MENA into global energy supply chains. Moreover, the availability of a young, and often educated, labour force offers an abundance of skills if these are aligned with market demand.

Producer economies

The MENA region has experienced rapid growth since 2000, with GDP doubling between 2000 and 2023. This growth has been led by high-income producer economies in the GCC, largely due to an expanding services sector. While oil and gas exports have long driven economic growth in producer economies, large-scale economic diversification programmes are aimed at shielding fossil fuel-based economies from energy market shocks. The increase in non-hydrocarbon revenues has become a stated policy for producers. In earlier reports, notably the Outlook for Producer Economies published in 2018, the IEA explored and described the risks stemming from energy transitions, as well as the opportunities that might arise from them, provided they occur in an orderly and fair manner, taking into account the need for differentiated pathways that reflect domestic political economies.

MENA producers' most prominent economic diversification programmes include industrial development as a key driver of future growth. Access to domestically sourced energy, whether from fossil fuels or renewables, provides producer economies with a significant comparative advantage, both in terms of supply and prices. Hydrocarbon and non-hydrocarbon sectors are set to benefit from available and affordable energy sources. For instance, Saudi Arabia's Vision 2030 underscores the importance of moving up the value chain by promoting energy-intensive industries, such as steel, aluminium and petrochemicals, enabling the country to extract greater value from its oil resources.

As is the case with the other MENA producer economies, Saudi Arabia aims to leverage its renewable energy potential with the ambitious target of generating 50% of its electricity from renewable sources by 2030. The United Arab Emirates is aiming for a 32% share of low-emissions electricity generation by 2030, which includes its recently added nuclear capacity. Oman also has a similar target of 30% of its power to be generated from renewables by 2030. These targets are designed not only to significantly transform producers' energy systems but also to underpin these countries' industrial strategies. For the most part, these targets have been integrated into each country's NDCs to provide at least medium-term economic certainty.

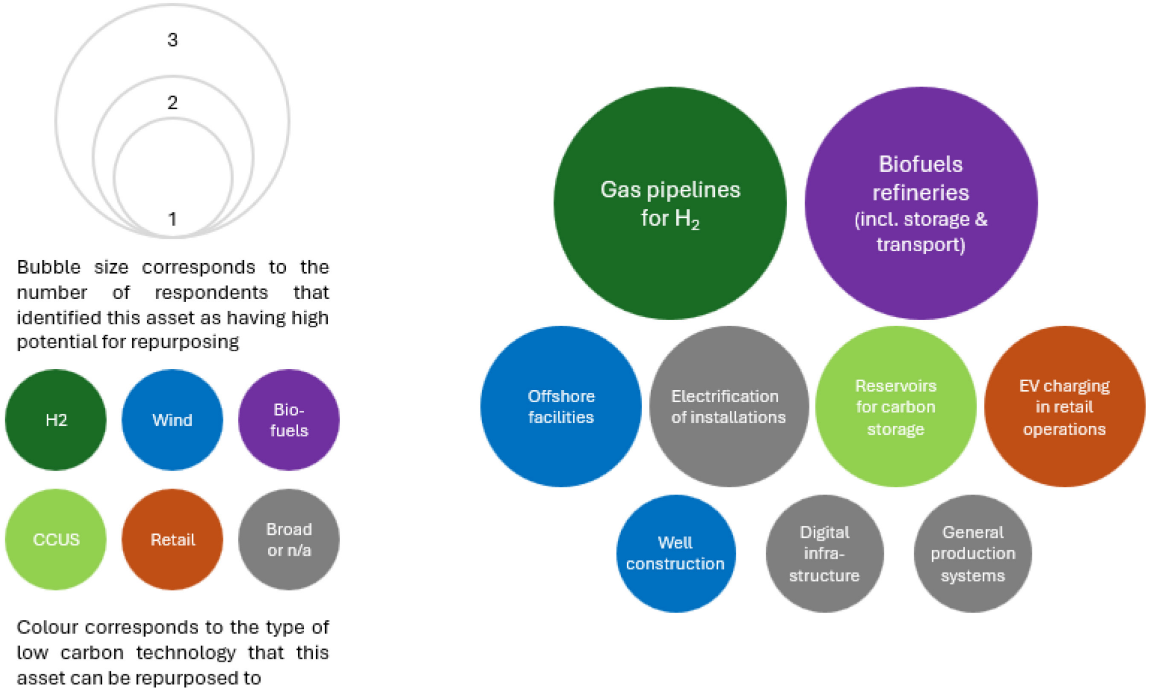
Large-scale industrial initiatives are already underway to decarbonise heavy industries by accelerating the deployment of renewables in key industrial clusters.[8] For instance, the ports of Duqm and Sohar in Oman are building partnerships to supply renewable electricity to steel plants near their facilities. Both ports have also been building infrastructure to accommodate the production of low-emissions hydrogen, which is linked to the production of ammonia. With low-emission energy being the bedrock of these industrial ambitions, the integration of energy and industrial visions is more closely related than ever.

While producer economies benefit from reliable and affordable energy supply, one of their key comparative advantages lies in their established oil and gas supply chains. The infrastructure, assets and technical expertise developed over decades – during which MENA producers supplied global energy markets – provide a strong foundation for capturing future industrial opportunities. In 2023, the IEA published a report focused on Oman, Leveraging Fossil Fuel Capabilities for Clean Energy Transitions, which analysed how existing oil and gas assets can support the development of clean energy supply chains and contribute to broader economic diversification.

The survey-based study revealed that important assets, such as biofuel refineries or reservoirs for carbon storage, hold the potential to support the development of low-emissions hydrogen in countries like Oman. Moreover, skills traditionally concentrated in oil- and gas-related industries could be leveraged to stimulate the development of industries such as solar, wind and low-emissions hydrogen. For example, chemical engineering expertise is particularly valuable across various elements of the lifecycle of solar PV panel components, including solar cell manufacturing and recycling. Similarly, thermal and fluid engineering skills can be leveraged for hydrogen industrial applications.

[8] The recycling of renewable materials, including solar and wind components, relies on energy-intensive processes, an area in which MENA producer economies are well positioned to compete.

Figure 3.25 Infrastructure assets with potential for repurposing based on survey results



Source: IEA (2023), Leveraging Fossil Fuel Capabilities for Clean Energy Transitions.

In a region where over half of the population is under the age of 30 and the youth unemployment rate is the highest globally, job creation remains a priority for MENA economies. As clean energy investment accelerates, manufacturing must also overcome bottlenecks related to the supply of critical materials, energy costs and access to technology and skills. This is particularly relevant for industries such as solar and wind, and the MENA region is well-positioned on maritime trade routes. By linking more deeply with global supply chains, countries can capture greater value and localise sections of production that would stimulate their economies as they look for new economic growth engines.

MENA producer economies have been exploring domestic critical mineral supply chains to tap into potential reserves for energy applications. The region is currently not a large producer of key energy minerals, although mining capabilities exist in Algeria, Iran, Oman and Saudi Arabia. All these countries are either accelerating or launching exploration efforts. In 2023, Iran claimed to hold significant lithium reserves, while Saudi Arabia has discussed its own deposits of lithium, rare earths, zinc and copper. In January 2025, Saudi Aramco and Saudi Arabia's leading mining company, Ma'aden, announced a USD 2 billion joint venture for lithium production and the advancement of technologies such as the extraction of lithium from oilfield brine. Saudi Arabia's Vision 2030 supports the development of the mining sector. In late 2024, Oman's Mazoon Mining announced that it had broken ground on the Mazoon copper project as part of its plans to develop copper and explore other critical minerals.

Leading MENA producers, such as Qatar, Saudi Arabia and the United Arab Emirates, are investing heavily to secure offtake from major mining producers like Brazil, Canada, the Democratic Republic of the Congo and Indonesia. The Public Investment Fund, Saudi Arabia's sovereign wealth fund, established Manara Minerals, a joint venture with Ma'aden to acquire stakes in overseas mining projects. Manara Minerals acquired a 10% stake in Vale Base Metals, a leading mining company with operations in Brazil and Indonesia, among others. Other producer economies, including Algeria and Iraq, are reviving plans to develop phosphates as well as other relevant minerals, particularly in Algeria's case.

Net energy importers

Net energy importers are also trying to integrate into global clean energy value chains through renewables or critical mineral mining. Egypt, Jordan and Morocco have all been designing plans to stimulate their mining industries in support of industrial sectors such as fertilisers and clean energy manufacturing. For instance, Jordan has been looking to develop its phosphates production, while Morocco, a phosphates giant with around 70% of global reserves, is looking to leverage its production to meet future demand for phosphate derivatives. Egypt is also looking to accelerate the development of its phosphate, iron and zinc reserves.

Morocco is an example of a significant industrial success story. The country has been building a resilient automotive supply chain in recent years that it is now leveraging to successfully enter EV markets by establishing itself as an EV manufacturing hub. The 2024 IEA Energy Technology Perspectives report estimates that North Africa has the potential to produce up to 3.7 million EVs per year by 2035. Moroccan automotive industrial exports totalled USD 14 billion in 2023. More importantly, the country was able to stimulate the development of a range of domestic suppliers. The sector currently employs around 200 000 people, or 9% of Morocco's industrial workforce, and contributes to around 20% of its GDP. Morocco's ability to grow its automotive sector will lie in its capacity to localise EV manufacturing. The wide availability of phosphate reserves already provides a significant advantage in the development of battery technologies such as lithium iron phosphate. In 2024, the government signed a USD 1.3 billion agreement to establish the first gigafactory in the Middle East and North Africa with Sino-European battery manufacturer GOTION High Tech. The first phase of the project aims for 20 GWh of EV battery cell production capacity. The project will be powered by a 500 MW wind power plant coupled with a 2 000 MWh storage system from Saudi renewables developer ACWA Power.

A key consideration for net energy importers is how to remain competitive without exposure to price volatility of imported energy, which also carries security of supply risks. The scarcity of domestically available conventional energy sources makes them vulnerable to energy imports, both physically and financially. Supply disruptions and high energy import bills remain threats to long-term industrial development, resilience and, more broadly, to macroeconomic stability. Energy import bills have significantly limited net importers' ability to invest in value-generating industries. For instance, Lebanon's refined petroleum products import bill reached almost USD 5 billion in 2024, almost 25% of the country's GDP. In Tunisia, the overall import bill reached 7% of GDP in 2024, with Jordan displaying a similar figure. The development of alternative, domestic and secure energy sources will enhance these countries' energy security and foster industrial competitiveness.

Net importers have already taken significant steps to accelerate the development of renewable energy capacity, which has already exceeded 20% of installed capacity in Egypt, Jordan and Morocco. With decreasing renewables costs, notably solar PV, opportunities to localise energy production will rest on good governance, access to capital for generation and grid investments, as well as market reforms to support a higher share of renewables in energy mixes. Scaling up renewables and diversifying the energy mix will enhance resilience to external shocks and offer lower and more stable energy costs.

MENA economies – whether energy producers or net importers – have numerous industrial opportunities, given the region's clean energy potential. There are multiple linkages between conventional and clean energy supply chains, and with the right strategic use of the region's geography, infrastructure, capabilities and natural and human resources, these opportunities can generate significant value and help address some of the region's most pressing socio-economic challenges.

8. What role can distributed power generation play in bringing resilience in post-conflict areas?

Several countries have been affected by conflict and suffered significant damage to critical electricity infrastructure, including power plants and transmission infrastructure. The lack on investment in times of war has been directly linked to lower investment in maintenance and grid expansion, further complicating the landscape. Other factors, such as a lack of governance and oversight, have encouraged theft and illegal grid connections, further disrupting power distribution.

The dual challenge of population displacement and damaged infrastructure creates unique energy needs that centralised systems may struggle to meet. Distributed energy resources – such as solar PV, battery storage and grid-connected mobile fuel generators – offer a flexible alternative. Typically under

1 MW in capacity and located close to the point of use, these small-scale systems are often deployed by households, businesses or industries for self-consumption. They can play a critical role in restoring energy access in post-conflict areas while also strengthening long-term resilience to future disruptions. Post-conflict energy strategies must carefully balance urgent humanitarian needs with opportunities to advance peacebuilding and recovery efforts, while also enhancing regional energy security and affordability.

In most cases in the MENA region, conflict has also been associated with large-scale migration, both internal and cross-border. Whether internally displaced persons or refugees, a significant share of migrants have relocated to urban areas with limited or no grid coverage, where electricity demand is largely met by expensive diesel-fired generators. Many households also still lack access to electricity.

As mentioned in Chapter 1, countries that have experienced major conflicts in the past still experience power system disruptions. This is notably the case in Iraq and Lebanon, where even areas that have enjoyed relative stability from a security perspective continue to face challenges with reliable electricity supply and often have to rely on informal power suppliers.

Short-term solutions for post-conflict areas: The case of Ukraine

The case of Ukraine is particularly relevant, as it demonstrates the impact of distributed energy resources on a system under extreme stress, providing insights into their ability to enhance system resilience and robustness. Since the Russian invasion of Ukraine in February 2022, Ukraine has lost over 50% of its centralised power generation capacity, yet has maintained electricity supply through the rapid deployment of distributed resources. By December 2024, Ukraine had installed over 3.5 GW of residential and commercial rooftop solar (up from just 0.6 GW pre-invasion) and deployed more than 1 million backup generators with a combined capacity exceeding 15 GW. Thanks to this decentralised design, Ukraine has managed to ensure continued electricity supply even when primary centralised systems were compromised, enabling critical infrastructure and essential services to remain operational despite sustained attacks.

These decentralised assets proved considerably less vulnerable to missile and drone attacks, with only 7% of distributed generation capacity damaged compared to 51% of centralised infrastructure. Notably, while Russia's ongoing attacks have left Ukraine with insufficient flexible generation capacity, variable renewable energy assets have shown remarkable resilience, with their share in the generation mix remaining largely stable at 8.7% in 2024 compared to 9.4% in 2021. At the time of writing, most of these variable renewable energy resources were distributed energy assets, underscoring their ability to withstand targeted attacks on energy infrastructure. The economic benefits have been substantial – distributed systems have reduced restoration costs by approximately EUR 2.2 billion and lowered system operation costs by 18% during peak crisis periods. Beyond the immediate resilience benefits, Ukraine's accelerated distributed energy resources deployment aligns with its longer-term goals, having already achieved its 2030 renewable target of 8 GW five years ahead of schedule while laying the foundation for its EU integration and decarbonisation objectives.

A lesson learned is that the standardisation of key components, such as transformers and other substation equipment, can significantly accelerate repair timelines and reduce supply chain vulnerabilities. Stockpiling reserve equipment and spare parts is also helpful, although compatibility may be an issue. Global manufacturing constraints and labour shortages have increased lead times and the prices of critical components like transformers, with procurement times for distribution transformers increasing from a few months to over a year, and exceeding two years for large transformers.

Rapidly deployable solar and storage microgrids can deliver critical electricity services to displaced populations within days rather than months. Container-based power solutions also offer scalable electricity access that can evolve from emergency response to more permanent infrastructure.

Table 3.3 Comparison of deployment speeds in conflict areas

Solution	Speed	Case studies
Solar PV and battery microgrid	7-50 days	In Yemen, a solar microgrid managed entirely by women was established near the conflict zone (just 32 km from the front line), transforming the community by providing reliable electricity where traditional grid infrastructure had been damaged or destroyed.
Container-based power solutions	5-7 days	Containerised mobile (solar and battery storage) solutions can be rapidly deployed in emergency situations, as demonstrated by NGOs who transported “a containerised mobile, energy storage trailer” to crisis areas and had it operational within days.
Mobile generators	Up to 3 days	In humanitarian crisis settings, diesel generators can be deployed quickly but face significant challenges in fuel delivery, as observed during Hurricane Sandy (in the northeast of the United States) where “over 50% of diesel generators failed to start” due to fuel access issues.

Solution	Speed	Case studies
Traditional grid restoration	45-180 days	In Ukraine, despite impressive repair capabilities where "the ability to repair transformers rapidly has been dramatically improved", full grid restoration in conflict zones takes months or years. According to Kyiv School of Economics data, repairs to even minor transmission infrastructure damage take an average of 17 days.
Centralised power plant repair	180-365+ days	In Ukraine, the refurbishment of damaged thermal plants takes at least 26 weeks. Rebuilding severely damaged or destroyed large, centralised power plants, such as thermal or hydroelectric power stations, could take years, potentially equating to the cost and time required for constructing new facilities.

Source: IEA analysis based on Danish Energy Agency (2024), Urgent Technology Catalogue for the Ukrainian Power; Kyiv School of Economics (2024), Assessment of Damages and Losses to Ukraine's Energy Sector.

Distributed power generation in the Middle East and North Africa region

The persistence of conflicts in the MENA region have also offered important lessons on the role of distributed power generation. These conflicts have varied in nature and duration, and the resulting electricity supply disruptions have differed across countries. Such variations have had direct implications for fuel switching and technology adoption. In a region where fossil fuels still dominate power generation, fuel availability has shaped both consumer behaviour and technological choices. In countries like Lebanon and Yemen, which faced severe power supply disruptions, off-grid solar PV deployment surged. In contrast, Libya – despite experiencing years of conflict – saw fewer disruptions to its fuel supply. Combined with extensive energy subsidies, this has limited the growth of distributed renewable power generation.

In recent years, distributed variable renewable energy has emerged as an alternative to power supply disruptions. Distributed solar PV has gained momentum in the MENA region, and installed capacity totalled around 3 GW in 2024. While this represents less than 1% of total renewable capacity in the region, the distribution across countries points to a wide range of uses. Off-grid systems account for approximately 40% of MENA's distributed solar PV capacity, largely concentrated in Lebanon and Yemen. In Lebanon, the cost competitiveness of solar PV – compared to informal diesel generation – has driven rapid household adoption amid growing financial and economic crises. By 2024, off-grid solar PV capacity neared at least 800 MW, a notable figure relative to its 3 GW nameplate grid-connected utility plants. This suggests that off-grid solar PV may account for roughly one-third of Lebanon's total installed capacity, although this figure remains an estimate, as reliable statistics on the topic are currently unavailable.

Box 3.2 Decentralised solar PV deployment in Yemen

Yemen also stands out as a striking example of the role decentralised electricity generation can play in conflict-affected areas. The war in the country has severely damaged the national electricity infrastructure, with an estimate 55% of assets impaired and an additional 5% destroyed. Generation capacity fell from approximately 1 500 MW before the conflict to just 200 MW in 2016, and grid access dropped from 66% in 2014 to well below 10%, making Yemen the least-electrified country in the Middle East. Crucially, the collapse of the grid coincided with acute fuel shortages – driven by heavily restricted and politically controlled inflows of refined petroleum products – which rendered diesel generators unfeasible for many. In response, households and private businesses led a bottom-up "solar revolution": privately purchased, owned and maintained PV systems increased fifty-fold, becoming the country's most important source of electricity. Between 2014 and 2017, Yemen's solar market was valued at an estimated USD 1 billion, and surveys indicate that a majority of households – especially in the sun-rich, temperate north-western highlands – now rely on some form of stand-alone solar power. Ironically, many commercial and residential users who had no electricity access before the war were introduced to it only through solar energy as a direct consequence of the conflict.

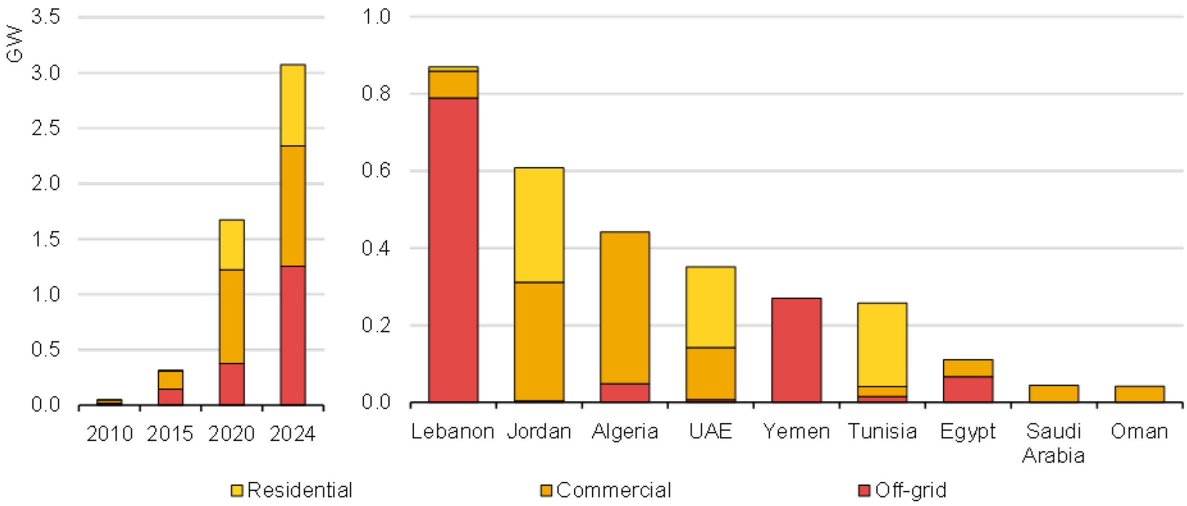
International donors, particularly after 2016, supported this development by facilitating access to solar panels through microcredit schemes and donations. However, this led to a surge in unregulated and unsupervised individual supply, while community-level solutions – especially mini-grids, which could have provided significantly higher levels of electricity – were not introduced. Possible bridging solutions, such as so-called swarm grids, remain underexplored. As a result, many households are still dependent on underperforming PV systems that risk becoming stranded assets.

From 2019 onwards, solar diffusion stagnated due to persistently high equipment costs, import challenges, limited quality standards and a widespread shortage of skilled technicians. In a vacuum of regulation, confidence in solar solutions has waned, and wealthier users have reverted to private diesel mini-grids, deepening both geographic and socio-economic disparities. These dynamics underscore the need for national authorities and international donors, not only to better steer bottom-up processes but also to ensure that short-term relief efforts are aligned with long-term national energy objectives.

As shown in the cases of Lebanon and Yemen, these arrangements can partly address disruptions in the short run, but they are suboptimal solutions and risk causing fragmentation that does not align with viable long-term infrastructure development. Moreover, a disproportionate share of off-grid capacity complicates future grid planning and adds to the cost of integration by making it harder to utilise the full potential of existing solar PV capacity for optimisation within the consumer base. The load mismatch can be mitigated by large-scale storage, which is generally not a possibility in post-conflict areas. In the absence of that, while acknowledging the impact of supply-related emergencies in accelerating fuel switching, governments generally need to rapidly establish quality control, technical standards and user protection mechanisms before bottlenecks start to emerge. The alignment of short- and long-term priorities is essential to build and maintain consumer trust.

Solutions for post-conflict distributed power generation can be derived from commercial and residential experiences in other parts of the MENA region. Commercial solar PV applications have been led by oil and gas companies that managed to displace diesel-fired generators to meet on-site power needs, while residential distributed solar PV has increased in the region to currently represent a quarter of distributed solar PV, enabled by net metering programmes. Jordan and the United Arab Emirates encouraged self-consumption to increase solar PV's attractiveness for small industrial and services sectors. Other policy instruments were adopted by Tunisia with the government's Prosol programme of subsidies for investment costs and low-cost loans.

Figure 3.26 Distributed solar PV by segment for the Middle East and North Africa (left) and by country (right), 2024



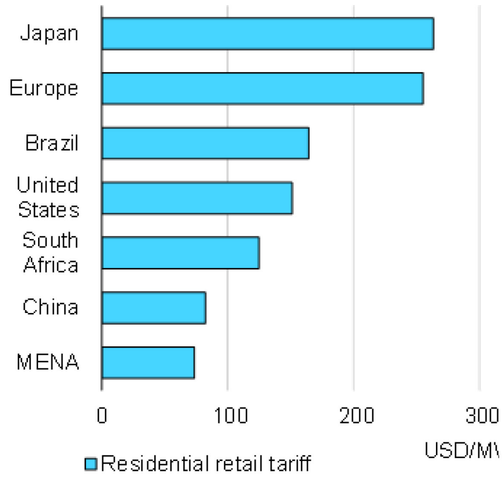
Notes: "Residential" refers to grid-connected systems installed in households, typically less than 10 kW. "Commercial" refers to grid-connected systems by industry or commercial sectors. Typically, these systems are less than 1 MW, but in some cases, they are larger than 1 MW. "Off-grid" refers to systems that are not connected to the country's main distribution grids and includes mini-grids.

While incentives, whether policy-based or circumstantial, differ among countries in the region, the installed capacity of distributed energy resources remains lower than what has already been achieved in regions experiencing lower solar irradiation.

One constraint is the regulatory environment, despite some early successes mentioned earlier. Not all countries allow residential and commercial sectors to generate their own electricity or to sell it back to the grid, which is a key factor in making the business case for self-consumption. Prior to 2024, only five countries allowed the sale of excess generation, and of those, just three had developed the necessary regulations to implement the policy. Even where legislation allows net metering on paper, additional regulatory barriers remain, such as the lack of access to the low-voltage grid in Morocco.[9]

Table 3.4 Policies for remunerating excess electricity from self-consumption (left) and residential retail prices, 2022 (right)

Country	Year in force	Remuneration rate
Jordan	2012	Retail credit
Egypt	2013	Utility-set rates
United Arab Emirates	2015	Retail credit
Morocco	2015	To be determined
Saudi Arabia	2020	Utility-set rates
Lebanon	2024	To be determined
Tunisia	2024	Utility-set rate
Bahrain	2024	Retail credit



Another key barrier to the uptake of distributed solar PV in the MENA region is the limited economic incentive for self-consumption, primarily due to electricity subsidies. Retail electricity tariffs in the region are among the lowest globally, averaging approximately USD 73/MWh in 2023 – significantly below rates observed in China, Europe, Japan, South Africa and the United States. These low prices result in non–cost-reflective tariffs that weaken the business case for self-consumption. Additional financial challenges include limits to excess generation sold to the grid, such as in Egypt and Morocco, as well as the high cost of imported equipment and elevated financing costs, which further constrain project viability. Some notable initiatives in MENA include Egypt's back-to-back regulations for private-to-private power trading overseen by the regulator, EgyptERA. Relatively fast growth, albeit due to exceptional circumstances, has been seen in conflict-affected countries.

[9] Legislation exists, but regulatory steps are still needed.

9. What impact could increased renewables have on oil and gas export volumes?

While current plans and policies across the region emphasise diversification of the electricity mix, including through the deployment of low-emissions sources, delays or setbacks in implementation could have consequences that reach beyond the power sector. This analysis explores a High Oil and Gas Case, which examines the implications of a future in which the MENA region is unable to accelerate the deployment of renewable and nuclear energy in its power sector. In this case, the share of fossil fuels in the generation mix is kept constant at today's levels of over 90% of the total.

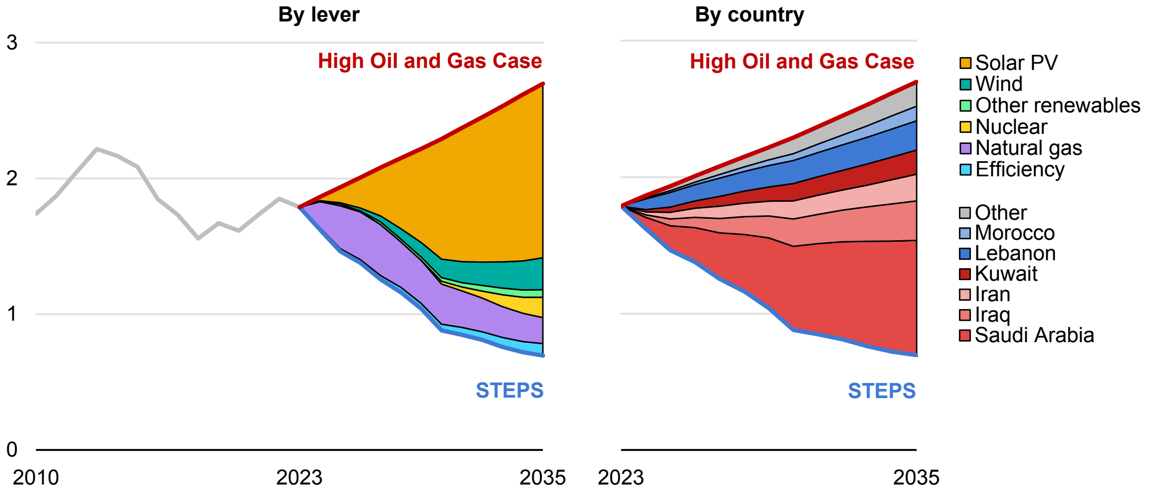
Continued heavy reliance on oil and gas to meet fast-growing electricity demand growth would have significant implications on the region’s fossil fuel consumption going forward. Rather than declining by 1.1 mb/d between 2023 and 2035, oil use in power generation would rise from 1.8 mb/d in 2023 to 2.8 mb/d in 2035. Similarly, natural gas consumption would increase by 180 bcm, to reach 500 bcm in 2035 – three times the projected growth in the STEPS.

These shifts would have significant implications for regional and international energy balances and trade. Countries that are net exporters of oil and gas could see reduced export volumes and revenues, as more production is diverted to meet domestic power demand. Net importers who fail to diversify their electricity mix would face increased energy import bills, heightening exposure to price volatility and supply risks. The results underscore the critical importance of accelerating the diversification of the power mix for both the MENA exporters and its importers, to avoid forgoing potential valuable export product and to ensure that the import bill does not become more onerous.

The analysis was conducted on a country-by-country basis across the MENA region, using the most recent historical data available for electricity generation by fuel type. The three core assumptions for the alternative case were that: 1) electricity demand would grow in line with projections in the STEPS; 2) oil and natural gas would increase to meet electricity demand growth in proportion to their use today; and 3) oil- and gas-fired power plants would maintain their current operating efficiencies.

This approach allowed for a detailed assessment of how much fossil fuel consumption is avoided by the expansion of renewables and nuclear power, along with the impacts of fuel switching and efforts to improve power plant efficiencies. In addition to estimating changes in oil and gas use, the analysis includes calculations of the resulting shifts in import and export revenues for both oil and natural gas, providing insights into the broader economic implications of a stalled energy transition.

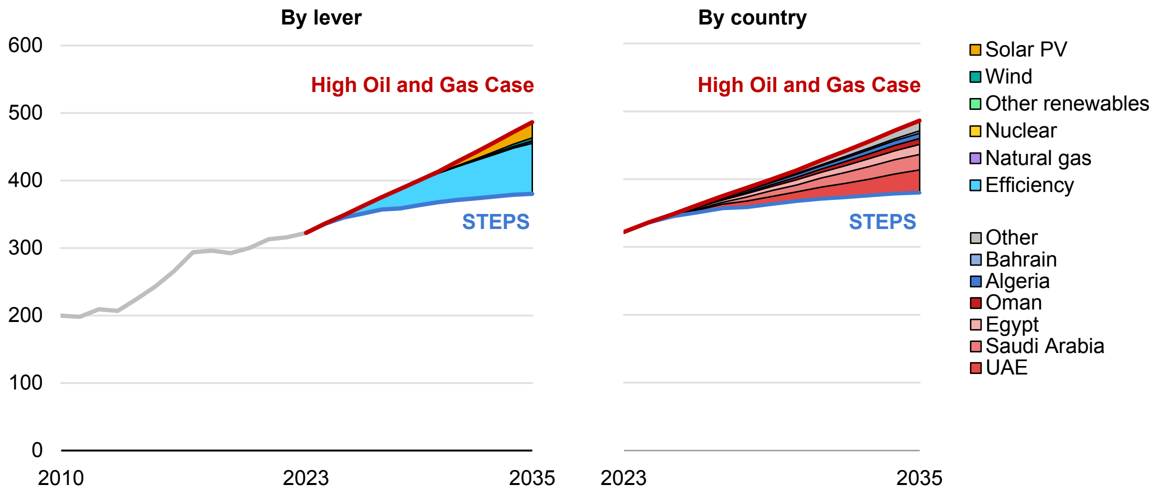
Figure 3.27 Change in oil use for power generation in the High Oil and Gas Case, mb/d



The divergence in oil use between this analysis and the STEPS is primarily accounted for by the differences for low-emissions technologies. Together, the expansion of renewables and nuclear displace approximately 1.9 mb/d of oil use by 2035. Solar PV is by far the largest contributor to reducing oil use in power generation, accounting for more than 60% of the difference – close to 1.3 mb/d by 2035 – followed by wind and nuclear. In addition, the shift from oil to natural gas contributes annual savings of 0.2 mb/d, while improvements in the efficiency of oil-fired power plants account for a further of 0.1 mb/d by 2035.

Over 80% of the additional oil demand in this scenario is concentrated in just five countries: Iran, Iraq, Kuwait, Lebanon and Saudi Arabia. Among them, Saudi Arabia accounts for the largest share – approximately 40% of the total increase across the MENA region – reflecting its substantial reliance on oil-fired power and the scale of its electricity demand. Iran, Iraq and Kuwait also see significant increases due to their dependence on oil in the power sector. Lebanon, while smaller in absolute terms, shows a notable relative increase due to its limited diversification.

Figure 3.28 Change in natural gas use for power generation in the High Oil and Gas Case, bcm



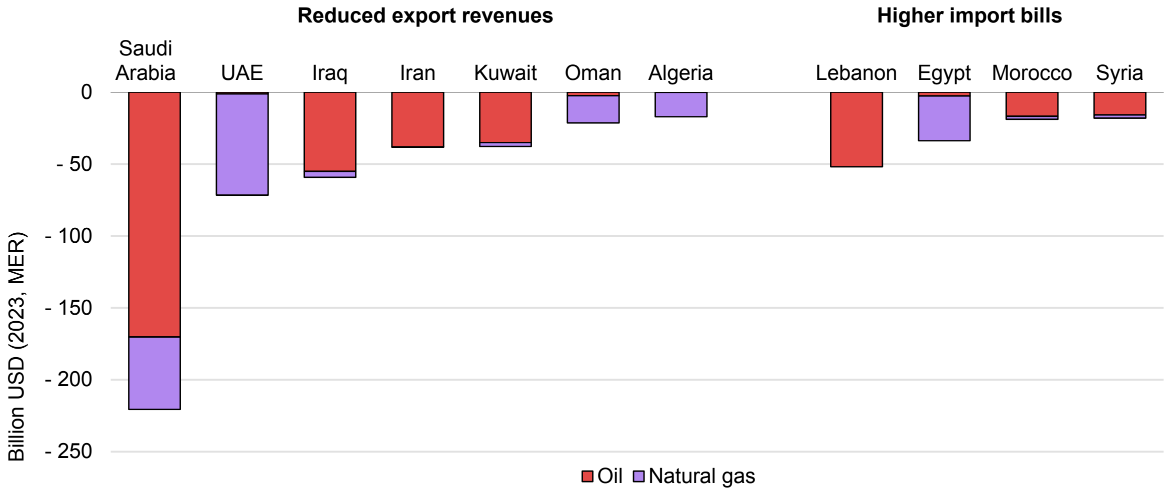
The primary driver of the divergence in natural gas use between this case and the STEPS is the absence of improvements in the efficiency of gas-fired power plants. These efficiency gains account for over two-thirds of the difference, reducing gas demand by close to 80 bcm by 2035. The remainder of the gap is filled by the expansion of low-emissions sources, led by solar PV, which displaces additional gas-fired generation. Without these changes, natural gas use in the MENA power sector would rise by 55% by 2035, significantly outpacing the 20% growth projected in the STEPS.

More than 60% of the additional natural gas demand in this case is concentrated in just three countries: Egypt, Saudi Arabia and the United Arab Emirates. These countries have large, gas-dependent power sectors and are experiencing rapid electricity demand growth, making them particularly sensitive to delays in clean energy deployment. Significant increases are also observed in Algeria and Oman, where gas plays a central role in power generation and domestic demand is rising.

Impact on revenues

Oil and gas income in MENA producer economies has historically been highly volatile, shaped by global market conditions that are susceptible to political and economic shocks. Revenues fell to under USD 400 billion in 2020 during the Covid-19 pandemic, then surged to nearly USD 1.1 trillion in 2022 following Russia's invasion of Ukraine. According to the *World Energy Outlook 2024's* STEPS projections, net oil and gas incomes are set to decline slightly on average through 2035, from about USD 700 billion in 2023, reflecting shifts in global demand and supply. In the High Oil and Gas Case modelled here, where the deployment of renewables and nuclear stalls, domestic fossil fuel use rises, reducing export volumes and reducing oil and gas income by USD 480 billion over the period to 2035.

Figure 3.29 Cumulative revenue losses in selected countries in the High Oil and Gas Case, 2024-2035.



Note: MER = market exchange rate.

The largest reductions in oil and gas export revenues in the High Oil and Gas Case are concentrated in a few key producer economies, each affected by different dynamics in the STEPS. Saudi Arabia, which has notable ambitions to eliminate oil use in power and deploy large amounts of renewable power, would see the most significant decline in revenues, reflecting the volumes of oil and natural gas that would otherwise be displaced should these ambitions not be met. Iran, Iraq and Oman would also experience major losses, driven largely by the expansion of renewables to displace domestic fossil fuel use. In the United Arab Emirates, the combination of renewables and nuclear power is set to play a central role in reducing domestic gas demand in the STEPS, making the absence of these developments particularly costly in terms of forgone export revenues.

The impact on the region's importers, like Jordan and Lebanon, could be especially acute. The increased reliance on oil and gas could mean that these countries would collectively see their import bills balloon by an additional USD 140 billion over the period to 2035. Such countries are often fiscally constrained and run budget and trade deficits that are largely influenced by fossil fuel import costs. In Lebanon, for example, oil purchases accounted for 25% of the country's total import bill in 2024, and the cumulative additional cost of imports to 2035, totalling about USD 50 billion, would amplify these pressures significantly.

The differing dynamics for both the region's net importers and its net exporters highlight the imperative for a more diversified power mix and highlight how clean energy deployment would support fiscal stability across the region.

Potential of turning the cost of burning fuels into high-value exports

Several countries across the region, including some of its largest hydrocarbon producers, are increasingly reliant on imports of fuel oil, diesel, natural gas and even direct electricity imports to meet rising power demand, particularly during the peak summer months. Saudi Arabia, for instance, supplements its domestic fuel supply with imported fuel oil to cover seasonal electricity spikes. The United Arab Emirates relies on natural gas imports via pipeline from Qatar. Iraq, despite being the region's second-largest oil producer, remains heavily dependent on imported energy. It procures costly diesel for widespread use in small, privately operated generators and imports natural gas from neighbouring Iran. These arrangements are not only vulnerable to seasonal disruptions, particularly during periods of peak demand in Iran, but are also subject to geopolitical uncertainty. This highlights the need for more diversified, efficient and secure domestic power generation in the region for both producer economies and net energy importers.

Maintaining the status quo in the face of growing electricity demand in the region exposes MENA economies – importers, and in some cases, producers – to larger import bills and mounting fiscal pressures. For some producer economies with constrained access to financing, rising electricity demand, and the corresponding increase in hydrocarbon use for power generation, will necessitate steep capital injections to sustain or increase domestic oil and gas production. This would be essential not only to meet domestic demand but also to avoid eroding export capacity and revenues.

Diverting oil and gas volumes away from low-efficiency power generation towards higher-value applications can offer solid alternative pathways for economic development. Investing in sectors such as refining and petrochemicals, especially when both are integrated, enables the production of higher-value products, such as gasoline, jet fuel, naphtha, fertilisers and polymers.

For instance, an average of approximately 720 000 b/d of crude oil was directly burned in MENA's power plants between 2021 and 2023. While this crude was valuable on its own and could have been sold on international markets at prices of between USD 70 and USD 100 per barrel during that period, equating to roughly USD 15 billion to USD 25 billion annually, refining this crude into higher-value products would have yielded significantly higher returns. Depending on the product slate, refinery configuration and complexity, as well as the prevailing crack spreads, this additional value would have ranged from USD 7 to USD 25 per barrel and could have generated an estimated incremental annual value of USD 5 billion to USD 18 billion. This is also true for heavy fuel oil used in power generation across the MENA region, which averaged about 710 000 b/d between 2021 and 2023. Investing in hydrotreating or conversion capacity, such as hydrocracking, could generate additional revenue, either through direct sales of very-low-sulphur fuel oil to the market or by converting it into higher-value products. In addition, gas can also serve as a low-cost feedstock for energy-intensive industries, such as aluminium, steel and cement, or as fuel for sectors that are hard to electrify, like long-distance road and maritime transport.

Beyond the imperative of climate and emissions mitigation, reducing electricity generation from oil and gas is increasingly regarded as a pragmatic strategy to alleviate fiscal pressure from imported fuels and the use of valuable domestic hydrocarbon resources for power generation. For net energy importers, such as Egypt, Jordan and Morocco, the expansion of domestic renewable capacity offers a means not only to mitigate exposure to import risks but also a way to lower import bills and enhance energy independence. The region's power sector presents a compelling opportunity to diversify electricity supply away from fossil fuels to leverage the potential revenues from either exports or industrial uses, bringing value for producer economies and shielding net energy importers from energy supply and price disruptions.

As an illustration, the MENA region currently generates around 360 TWh of electricity using crude oil and refined petroleum products.[10] Generating an equivalent amount of electricity from solar PV would require approximately 205 GW of installed capacity at a conservative 20% capacity factor, or 164 GW if operating at a more favourable factor of 25%. While solar PV would not replace all the power system services provided by oil-fired power plants,[11] the scale of electricity currently produced from oil offers a useful benchmark for assessing the cost to displace oil volumes in power generation. Assuming an average capacity factor, the total investment needed would amount to approximately USD 115 billion at the current installed cost of around USD 615/kW,[12] or under USD 70 billion based on an installed cost projected to decrease to USD 360/kW by 2035.

[10] Based on 1.8 million b/d of oil (crude oil and oil products) used as feedstock in 2023.
[11] Oil-fired power plants, in addition to generating electricity, also support power system adequacy and grid stability by providing inertia thanks to their large spinning turbines.
[12] Estimates assume the deployment of large-scale, utility-grade PV systems.

The significance of the required investment to displace oil-fired power plants by solar PV lies less in its absolute magnitude than in the relative ease with which it could be recovered. At prevailing oil export prices, diverting the 1.8 Mb/d currently used for domestic power generation towards international markets would yield sufficient revenues to pay back the estimated USD 115 billion in capital expenditure in just above two years, or equivalent to 25 months of export earnings from the displaced oil volumes.[13] This makes the economic calculus of displacing a portion of domestic oil consumption to be invested in renewable capacity not only fiscally rational but strategically compelling.

[13] The payback period is estimated by applying international crude oil and oil product prices in 2023 to the volumes used in MENA's power sector in the same year.

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