Regional Climate Change Initiative Republic of Cyprus

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Report of the Task Force on

Energy Systems

Eastern Mediterranean and Middle East Climate Change Initiative

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Abbreviations

ADNOC	Abu Dhabi National Oil Company
CCS	carbon capture and storage
CCUS	carbon capture, utilisation and storage
CH_4	methane
CO_2	carbon dioxide
CO_{2eq}	carbon dioxide equivalent
CSP	concentrating solar power
ECCI	Eastern Mediterranean and Middle East Climate Change Initiative
EMME	Eastern Mediterranean and Middle East
ESCO	energy service company
ETS	Emission Trading System
EV	electric vehicle
FSRU	Floating Storage and Regasification Unit
GCC	Gulf Cooperation Council
GHG	greenhouse gas
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producer
IRENA	International Renewable Energy Agency
ITCZ	Inter-Tropical Convergence Zone
JJA	June-July-August
LNG	liquified natural gas
MENA	Middle East and North Africa
Mtoe	million tonnes of oil equivalent
N_2O	nitrous oxide

NDC	Nationally Determined Contribution
NECP	National Energy and Climate Plan
NOC	national oil company
NPP	nuclear power plant
OPEC	Organization of the Petroleum Exporting Countries
O_3	ozone
PM	particulate matter
PV	photovoltaic
RCP	Representative Concentration Pathway
RD&D	research, development and demonstration
RE	renewable energy
RO	reverse osmosis
R&D	research and development
SDGs	Sustainable Development Goals
SO_2	sulphur dioxide
SMR	small modular reactor
TPES	total primary energy supply
UNFCCC	United Nations Framework Convention of Climate Change
VOC	volatile organic compound
WHO	World Health Organization

Abstract

Countries of the Eastern Mediterranean and Middle East region are far off the trajectory required to stabilise the global climate. Being responsible for about threequarters of greenhouse gas emissions, the energy system has to bear most of the burden of the decarbonisation effort. In such a context, this report identifies three pillars that need immediate and simultaneous attention from governments of the region: improving the knowledge base, mitigating growth in energy demand and ensuring that energy needs are met with low-carbon technologies. Considering that regional cooperation is essential, the report provides a policy toolkit for decarbonising energy systems, with a menu of options from which each country can choose the most relevant for its own resources, conditions and needs. The toolkit includes policy instruments that will enable satisfying energy needs with zero-carbon electricity and heat, utilising the region's resources to provide clean fuels like synthetic hydrocarbons and hydrogen, and improving energy efficiency. With a vision of a low-carbon future, the successful energy transition requires a holistic framework that addresses the systemic changes needed in our socio-economic structures. Such a framework would encompass enabling actions under a wide range of industrial, education, labour, social and financial policies.

Executive summary

The Eastern Mediterranean and Middle East (EMME) region comprises countries with various geographic and population sizes, at different stages of economic development, with a significant variety in natural, human and financial resources, and facing diverse political and economic challenges. **They share, however, a common future.** They are located in a hotspot for climate change, which is projected to cause substantial threats to their welfare in the coming decades.

This report reviews the socio-economic and technological trends in energy systems of the region and highlights gaps in policy and knowledge that have to be addressed rapidly. After outlining the geographical context and main demographic and economic indicators in Chapter 2 and summarising key climate change projections for the region in Chapter 3, the report examines the EMME energy system in more detail. Chapter 4 depicts the evolution of energy supply and demand in EMME countries, both in aggregate terms and by main energy carrier – oil, gas, renewables and nuclear energy. The region sits on huge reserves of crude oil and natural gas, while at the same time it enjoys a very substantial renewable energy potential that is largely unexploited up to now. Some countries are also building up nuclear power capacity.

Today, the EMME region hosts 5.5% of the global population, produces 4.7% of the world's economic output but generates more than 8% of global carbon dioxide emissions. **Most EMME countries emit much more carbon dioxide per capita than the world average**, and considering their population trends, economic growth prospects and emission projections, almost all of them are far off the trajectory required to stabilise the global climate in line with the objectives of the Paris agreement on climate change. Being responsible for about three-quarters of these greenhouse gas emissions, but also half the atmospheric pollution in the EMME, the energy system has to bear most of the burden of the decarbonisation effort to bring the region in line with the requirement for global climate stability.

Chapter 5 of the report reviews the landscape of energy and climate policies in the EMME. It starts with an overview of existing national strategies and decarbonisation plans and delves into individual aspects of such policies: regulatory approaches for the uptake of clean energy and energy efficiency investments; market-based instruments to abolish fossil fuel subsidies and adopt carbon pricing schemes; and institutional reforms, infrastructure investments and cross-cutting policies that can enable the clean energy transition. This review leads to the identification of **gaps in the design and implementation**

of appropriate decarbonisation policies, both in energy supply (power generation and production of clean fuels) and in energy use. Measures to promote energy efficiency in transport, industry and households are largely absent from several national strategies. Special attention is drawn to the impacts of the COVID-19 pandemic, its economic implications both for oil and gas producers and energy importers in the region and the challenges posed for economic recovery.

Based on these findings, Chapter 6 sets up a **decarbonisation agenda** for the energy systems of the EMME region, taking into account that **time is limited**, and the **progress needed for decarbonisation is very substantial**.

A path to low-carbon economies requires **interventions both to reduce energy demand and to satisfy this demand with energy sources having a low or netzero carbon footprint. Above all, it requires political willingness** to express a vision of a low-carbon economy that can be realized through appropriate clean energy transition plans that include actionable policies for the medium and long term. The European Green Deal that was announced in December 2019 intends to align most economic development priorities in Europe with the decarbonisation imperative and can serve as an example. Regional co-operation can greatly contribute to this objective through the exchange of technical expertise, best practices in policy implementation and mutual capacity building.

The energy sector cannot be considered in isolation from the broader socioeconomic systems. Interactions between the energy sector, the economy, society and the environment are fundamental for energy transitions. Indeed, a successful energy transition requires a systems approach that goes beyond the energy technology and policy layers to incorporate the challenges across all aspects of the transition (economy, society and environmental systems) and the dynamics between them. This means that **policies to scale up deployment and integrate larger shares of zero-carbon energy need to be supported by cross-cutting enabling policies such as appropriate industrial, skills and labour, social and financial policies** – all formulated from a holistic perspective. With all the different components of these comprehensive policy frameworks in place, the transition will be successful in achieving global climate goals and will result in millions of jobs, broader economic development and significant benefits for health and human welfare.

In this context, the report identifies **three pillars which need immediate and simultaneous attention** from governments of the region to enable the clean energy transition:

- **Planning the energy transition** with robust data, analyses and research.
- **Mitigating growth in energy demand** and promoting the uptake of green technologies and practices by consumers and firms.
- Ensuring adequate **supply of competitive, low-carbon energy**.

The schematic below outlines the major elements of each one of these pillars, which are further elaborated in Chapter 6 of the report.

Main pillars and policy priorities for enabling decarbonisation of EMME energy systems

Planning the Energy Transition

- Formulate a vision and a roadmap for a low-carbon economy
- Ensure proper governance of energy data and policies
- Collect and report adequate energy statistics and costs
- Perform energy projections for the medium and long term
- Implement, monitor, and revise clean energy plans
- Adopt enabling policies in industry, labour market, social protection, education and skills, and finance

Mitigating Growth in Energy Demand

- Promote energy efficiency in all end-use sectors (buildings, industry, transport) by facilitating investments and removing financial barriers
- Promote water conservation to reduce the energy needs of water supply
- Understand socio-economic aspects (e.g. poverty and energy access) that affect the adoption and acceptance of energy saving measures
- Stimulate behavioural change in the population to promote energy conservation; institutionalise post-pandemic low-energy lifestyles

Ensuring Low-Carbon Energy Supply

- Promote electrification of end-use sectors
- Invest in low-carbon electricity and sector coupling (e.g. waste heat of power plants to be used in industry and residential heating/cooling)
- Enable infrastructure investments (inter-connections, smart grids) and institutional reforms (flexible tariffs, energy communities) to allow increased penetration of low-carbon electricity
- Exploit opportunities to produce clean fuels (including hydrogen) for sectors hard to decarbonise (e.g. cement and steel industry, aviation, shipping)

To achieve progress in this ambitious decarbonisation agenda, **the importance of regional co-operation cannot be overstated**. Co-ordinated actions like sharing and co-developing energy infrastructures and networks, facilitating technical exchanges and capacity-building activities and conducting regional integrated assessments are essential elements towards decarbonisation. The European Union's model, although not fully transferable to EMME countries, can serve as a good example of a determined and consistent approach towards global climate stabilisation.

Finally, the report provides a **policy toolkit for decarbonising energy systems**. It comprises more than 30 possible interventions across the entire spectrum of public policies: regulations, institutional reforms, removal of investment barriers, green fiscal measures, infrastructure investments and information initiatives. Some tools are more relevant for some countries, while other policy instruments may be more suitable for others. Yet common features apply: satisfying a large portion of energy needs with zero-carbon electricity and heat; utilising the region's natural resources to provide low- and zero-carbon fuels like synthetic hydrocarbons and hydrogen; improving energy efficiency in industry, buildings and transport and aligning the economic and research priorities of the countries with the strategic vision of a low-carbon future.

Geography and climate make it imperative for EMME countries to address their common future in a co-ordinated manner. Policy makers can combine the available international knowledge with regional resources to facilitate the transition to climate neutrality, which will improve the well-being of all people in the region.

1. Scope

The Eastern Mediterranean and Middle East (EMME) Climate Change Initiative (ECCI) is a response led by the Government of the Republic of Cyprus to the growing scientific evidence that the extent of climate change and the severity of its consequences in the EMME region significantly exceed the global average. Recent studies from prominent institutions have classified the region as a global hotspot for climate change with particularly high vulnerability to its various impacts. Such research output, including from the Cyprus Institute (CyI) and its partners, has also provided important insights into the effects of climate change on water availability and agriculture, weather extremes, public health, ecosystems, tourism and humanitarian and security issues, including mass migration of environmental refugees. This is unquestionably of great concern not only to the EMME countries, but to the international community, especially Europe, considering the prospect of a humanitarian crisis of unprecedented scale and exacerbating regional geopolitical instabilities in the region, which is home to nearly 500 million people.

In March 2019, the Council of Ministers of the Republic of Cyprus approved the ECCI, a governmental initiative for co-ordinating regional actions to ameliorate the impact of global warming across the Mediterranean as well as the development of a comprehensive plan to reduce greenhouse gas emissions, in line with the 2015 Paris climate accord. The initiative has been widely communicated to the countries and leadership of the EMME Region, to European Union (EU) Member States, to the United Nations and other international organisations.

The aim of the initiative is to engage EMME countries:

1. To establish a common understanding with reliable projections of the regional climate change processes and impacts, identify gaps in knowledge and propose ways to address them;
2. To identify pathways for the most effective, rapid and economical way to implement the Paris Agreement targets at a national level;
3. To develop a policy "toolkit" for the amelioration of climate change impacts on various sectors; and
4. To enhance regional co-operation and capacity building in the most sustainable way, promoting international mobility, sharing of good practices, developing joint educational programmes, advancing research and innovation and participating in joint ventures/projects to achieve the aforementioned goals.

In the framework of the ECCI, the CyI has been delegated the responsibility of pursuing the first phase of the project: The articulation of comprehensive scientific foundations, and the subsequent development of a set of policy actions to be available to policy makers in order to achieve the aforementioned goals of the Initiative. The CyI and its partners are accomplishing this task in part through the work of a number of task forces with the following scientific foci:

1. The Physical Basis of Climate Change
2. Energy Systems
3. The Built Environment
4. Health
5. Water Resources
6. Agriculture and the Food Chain
7. Marine Environment/Resources
8. Education and Outreach
9. Migration
10. Tourism
11. Enabling Technologies
12. The Green Economy and Innovation
13. Cultural Heritage

Each task force, consisting of about 15 experts, shall collect and organise existing knowledge in order to assess the situation, identify gaps in research and policy needs and provide a "toolkit" of possible actions to address the climate challenges in the region. The task forces will consider the climatic conditions, and socio-economic and socio-political realities of the involved countries, and lean on the accumulated climate knowledge created within, but also outside, the region.

Each task force has been mandated to produce a thematic report ("white paper") in its respective areas of scientific focus. The thematic reports of the task forces will feed into a comprehensive scientific report that will contain an overarching conclusion, as well as technologically mature and economically affordable solutions for addressing the impacts of climate change in different socio-economic sectors.

2. Geographic setting

This report focuses on the region of the Eastern Mediterranean and the Middle East (EMME), as illustrated by Figure 1. The socio-economic, cultural and political context varies considerably across the countries considered: Bahrain, Cyprus, Egypt, Greece, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syria, Turkey and the United Arab Emirates (UAE).

The EMME region has experienced rapid population growth in recent decades (Table 1), as the total number of people residing across the region has increased from 243 million in 1990, to 360 million in 2010 and 409 million in 2017 [1]. The strongest population growth is observed in the Arabian Peninsula. During this time frame, the population of Saudi Arabia more than doubled, in the United Arab Emirates it grew more than five times, while in Qatar it grew by a factor of six. At the other extreme, the Greek population has been the most stagnant in the region. In the next decade, the median projection of the United Nations for the region [1] estimates an additional population growth of 20% (i.e. 80 million) from 2017 to 2030. As such, the challenge of satisfying demand for energy services and achieving a reduction in greenhouse gas emissions, as envisioned by the Paris Agreement, becomes evident.

Figure 1. Countries included in the Climate Change Initiative

Table 1 shows also that per capita income has improved significantly for most countries since 1990. However, the economic output of some of the countries in the region has only marginally improved or remained relatively constant in recent years. A few countries have experienced negative growth. Cyprus and Greece have been affected by financial crises and their aftermath in the period 200816, while Qatar has been affected by a diplomatic dispute with its neighbours. In June 2017, Bahrain, Egypt, the Maldives, Saudi Arabia, the

TABLE 1. Population (medium variant) and GDP trends in each of the countries in the EMME region

Country	Population (thousands) [1]				GDP per capita (current USD) [4], [5]		
	1990	2010	2017	2030**	1990	2010	2017
Bahrain	496	1 241	1 494	2 013	8 529	20 722	23 715
Cyprus*	767	840	864	934	9 642	31 024	26 339
Egypt	56 134	82 761	96 443	120 832	766	2 645	2 441
Greece	10 226	10 888	10 569	9 917	9 600	26 918	18 883
Iran	56 366	73 763	80 674	92 664	2 214	6 603	5 628
Iraq	17 419	29 742	37 553	50 194	10 327	4 657	5 205
Israel	4 448	7 346	8 244	9 980	12 663	30 694	40 542
Jordan	3 566	7 262	9 786	10 655	1 167	3 690	4 163
Kuwait	2 095	2 992	4 056	4 747	8 795	38 577	29 760
Lebanon	2 803	4 953	6 819	6 195	1 013	7 757	7 838
Oman	1 812	3 041	4 666	5 936	6 448	19 281	15 130
Palestine	2 101	4 056	4 747	6 342	921	2 387	3 397
Qatar	476	1 856	2 725	3 327	15 454	67 403	61 264
Saudi Arabia	16 234	27 421	33 101	39 322	7 246	19 263	20 804
Syria	12 446	21 363	17 096	26 677	897	2 830	771
Turkey	53 922	72 327	81 116	89 158	2 794	10 672	10 514
United Arab Emirates	1 828	8 550	9 487	10 661	27 729	33 893	39 812
Total	242 961	360 401	409 441	489 553			

* Population refers to the areas under control of the Republic of Cyprus.

** In order to keep the underlying assumptions constant across all countries, population projections for 2030 assume the medium variant scenario from the UN's latest World Population Prospects report [1], instead of using individual national projections.

United Arab Emirates and Yemen severed diplomatic ties with Qatar and implemented a variety of actions, such as refusing access to port to Qatari ships, restricting their airspace and expelling Qatari visitors [2]. Syria's economic output has been drastically reduced due to the civil war in the country since 2011. Since many countries are major oil exporters, their economic output has also been directly affected by fluctuations in international oil prices. As gross domestic product (GDP) growth is expected to continue in the region in the long term [3], it is imperative to achieve a reduction in the energy and carbon intensities of GDP to be in line with global climate targets.

Despite contextual differences, there are commonalities that present challenges and offer opportunities with regard to climate change mitigation and adaptation. As discussed in subsequent sections in this report, the EMME region will be adversely affected by rising temperatures and declining precipitation due to climatic change. In a region where some nations are dependent on oil imports to satisfy their demand for energy services while oil-rich nations depend on oil exports to support fiscal stability, climate change mitigation efforts can have a significant economic impact. In this context, the availability of renewable energy resources and the potential for deployment of other low-carbon technologies offer sustainable development pathways, which can be pursued depending on country-specific conditions, resources and needs.

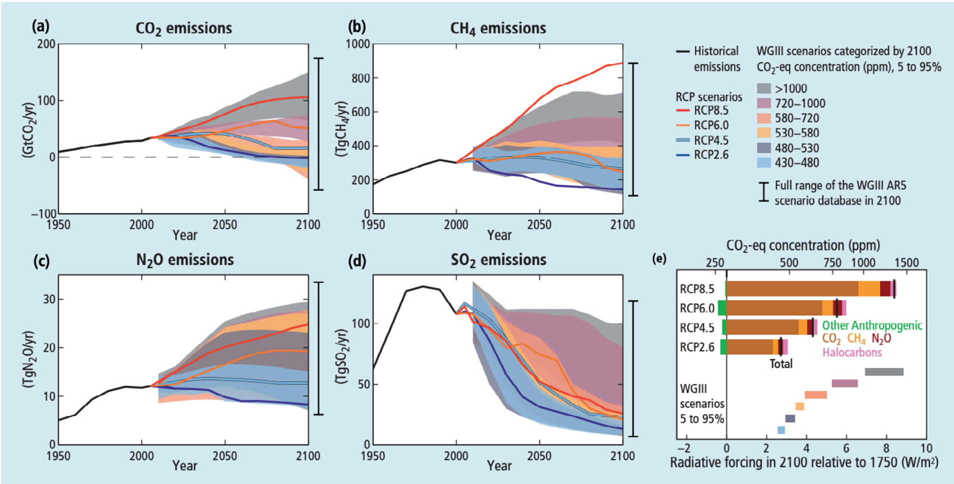
3. Climate change in the region

It is well established that climate change is one of the most significant challenges our planet faces. The atmospheric concentrations of greenhouse gases (GHG) have increased dramatically over the past few decades, and the international community decided to take measures in order to tackle the causes (mitigation) as well as the impacts (adaptation) of climate change. The Intergovernmental Panel on Climate Change (IPCC) assesses the state of the knowledge about global climate and provides policy-relevant information derived from this assessment. The most recent international climate accord is the Paris Agreement that was adopted in 2015, reflecting the will of the international community to take more drastic measures and set more ambitious targets towards the reduction of GHG emissions, aiming to keep the global temperature increase well below 2oC, and pursuing efforts to limit it to below 1.5oC above pre-industrial levels by 2100 [6].

Anthropogenic GHG emissions have several driving factors, including population size, economic activity, lifestyle, energy use, land use patterns, technology choices and climate policy. In its Fifth Assessment Report, the IPCC has depicted four scenarios, the Representative Concentration Pathways (RCPs), which are based on the evolution of these factors and are used for projections of global GHG emissions and atmospheric concentrations, air pollutant emissions and land use. Specifically, these include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with very high GHG emissions (RCP8.5), as shown in Figure 2. Corresponding projections for the primary energy supply on a global scale are shown in Figure 3.

Closer to the EMME – the focus of this report – Waha et al. [9] depicted the temperature projections for the broader Middle East and North Africa (MENA) region for IPCC's RCP2.6 and RCP8.5 scenarios, presented in Figure 4. Temperatures increased by 0.2oC per decade between 1960 and1990 and have continued on an even faster rate since then. Projections show a significant temperature increase up to 2100 in RCP8.5 and a marginal increase in RCP2.6; however, there are considerable uncertainty ranges for each of these. As shown in Figure 5, the strongest warming is projected to occur close to the Mediterranean coast with Algeria, Libya and Egypt experiencing an increase of temperature by 3oC until 2100. In the case of a 4oC global warming, a rise of up to 8oC is projected for the mean summer temperatures in Greece, Turkey, Saudi Arabia and Iraq by the end of the century, due to a simultaneous warming trend across the region.

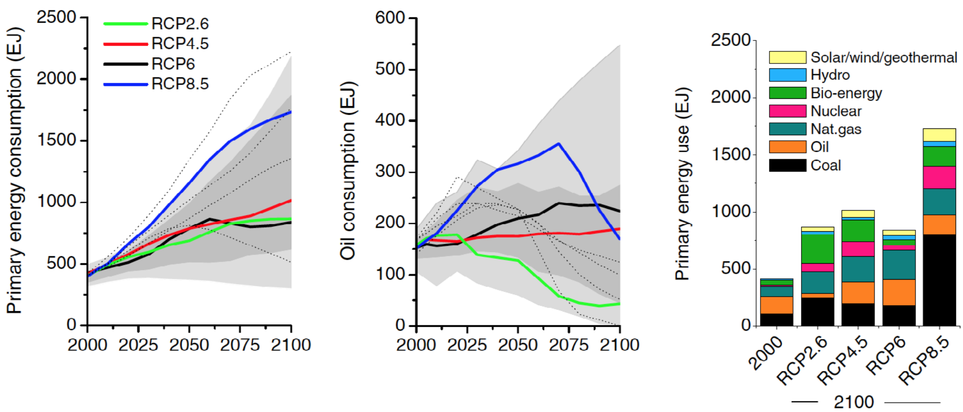
FIGURE 2. Emission scenarios and resulting radiative forcing levels for the Representative Concentration Pathways (RCPs, lines) and associated categories used in the IPCC Fifth Assessment Report



Source: [7].

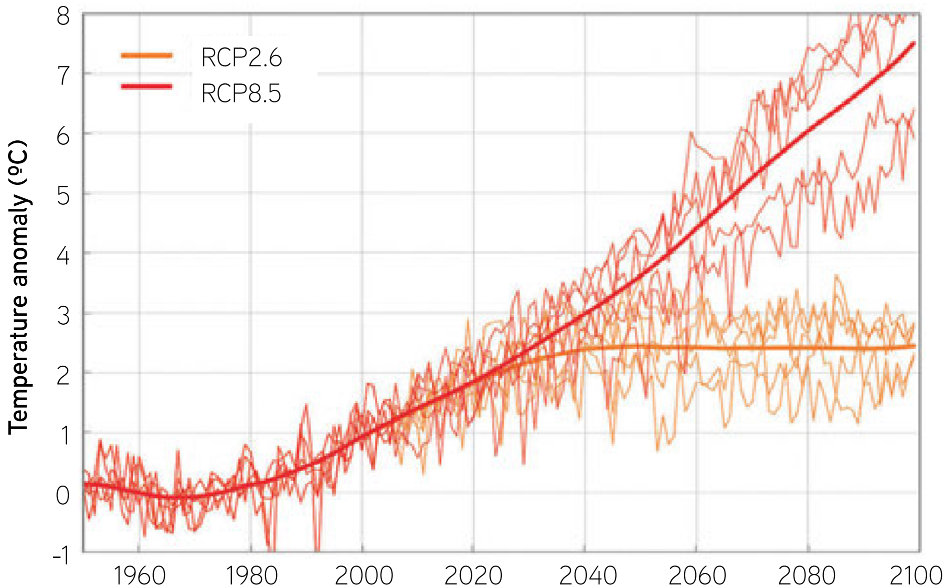
Note: Panels a to d show the global emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and sulphur dioxide (SO_2). Panel e shows CO_2-eq concentration levels and future radiative forcing levels for the RCPs.

FIGURE 3. Evolution of global total primary energy supply (left) and oil consumption (middle) in each RCP, 2000-2100; and projected primary energy mix in each RCP, 2100 (right)



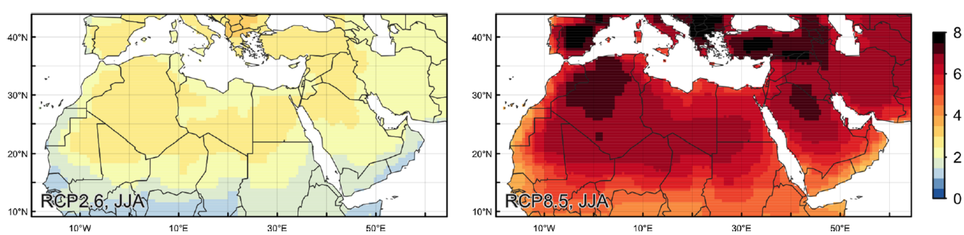
Source: [8].

FIGURE 4. Temperature projection anomalies for MENA land area compared to the baseline (1951–1980) for the multimodel mean (thick line) and individual models (thin lines) under RCP2.6 (2˚C world) and RCP8.5 (4˚C world) scenarios for the months of June-July-August



Source: Turn Down the Heat - Confronting the New Climate Normal. World Bank Group, Washington, DC, 2014. ISBN: 978-1-4648-0437-3

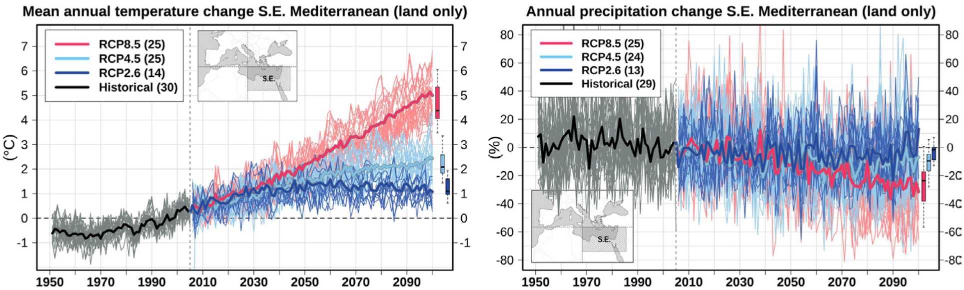
FIGURE 5. Temperature increase projections (in degrees Celsius) for the scenarios RCP2.6 (left) and RCP 8.5 (right) in the months of June-July-August in 2071–2099 per grid cell



Source: [9].

Bucchignani et al. [10] and Lange [11] have developed models showing similar projections, highlighting the increase of temperature and the reduction of precipitation in the region. Similarly, Zittis et al. [12] have developed regional climate projections for the Mediterranean Sea, with the results following the same pattern, i.e. increase of temperature and reduction of precipitation, as shown in Figure 6.

FIGURE 6. Projected time series of annual mean temperature anomalies (left) and projected precipitation anomalies (right), with respect to the reference period 1986-2005, for the historical and three RCP simulations (RCP2.6, RCP4.5 and RCP8.5) in the Southeast Mediterranean sub-region

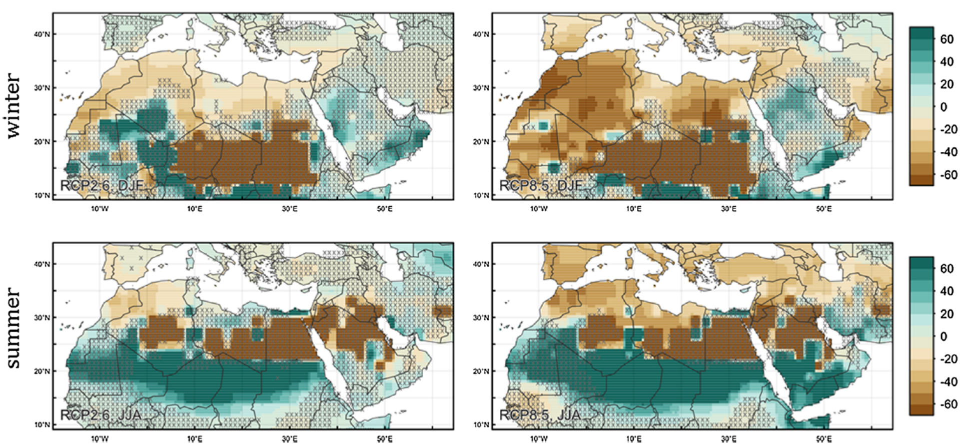


Source: [12].

Note: Thin lines denote individual ensemble members and thick lines a multimodel mean. Box plots indicate the minimum, 25th, 50th (median) and 75th percentiles of the ensemble set distribution of 20-year mean anomalies (2081 2100). Vertical dashed lines indicate the last year (2005) of the historical simulation data. The sub-region is indicated in the title of each plot and depicted in the respective quadrant.

Furthermore, despite the identified uncertainty in some areas of the region, climate change is expected to adversely affect precipitation, as shown in Figure 7. As discussed by Waha et al. [9] for a 2oC temperature increase, countries along the Mediterranean shore (Cyprus, Egypt, Greece, Israel, Lebanon, Syria, Turkey) will receive substantially less rain. However, the southern parts of the region may experience an increase in moisture due to a projected northward shift of the inter-tropical convergence zone. This part of the region

FIGURE 7. The percentage change in winter (December January February, top) and summer (June-July-August, bottom) precipitation for scenarios RCP2.6 (left) and RCP8.5 (right) by 2071-2099 relative to 1951-1980



is already under the influence of monsoon systems, particularly the southern Arabian Peninsula. Overall, the regions north of 25oN are projected to become relatively drier and regions to the south relatively wetter. Nevertheless, the absolute increase in precipitation in the southern region will be very small, considering the hyper-arid present-day climate conditions.

The increase in temperature will lead to sea-level rise, which will be challenging for the region considering the geography of the area, i.e. the semi-enclosed nature of the Mediterranean and Red Sea basins. A median sea-level rise ranging between 0.35 metres (m) and 0.65 m is projected with a probability of 67% [9]. This will affect the population of coastal zones, which is expected to increase in the following decades. Floods and damage from extreme events, intrusion of saltwater into coastal aquifers and increased erosion are expected. The most severe impacts will be in Egypt, which is projected to lose 13% of its agricultural land.

Climate change will also have impacts on agriculture and water. The EMME is a water-scarce region in which most countries have limited renewable internal freshwater resources as low as 16 and 3 cubic metres (m3) per capita in the United Arab Emirates and Bahrain, respectively [13]. Considering these limitations and the scarcity of arable land, the effects of global warming on water and agriculture will be significant. For instance, it is anticipated that there will be a shift of vegetation and agricultural zones, shortened growing periods for wheat and a decline of crop yields. Livestock will likely be affected as well due to changes to the quality and quantity of available feed, increased heat and reduced drinking water [9]. In addition, climate change will have effects on human health with an increase in related diseases, human security and migration. Driven by global warming, people may also migrate to other areas, which can cause social unrest with potentially adverse impacts [14], [15].

4. Overview of the EMME energy system

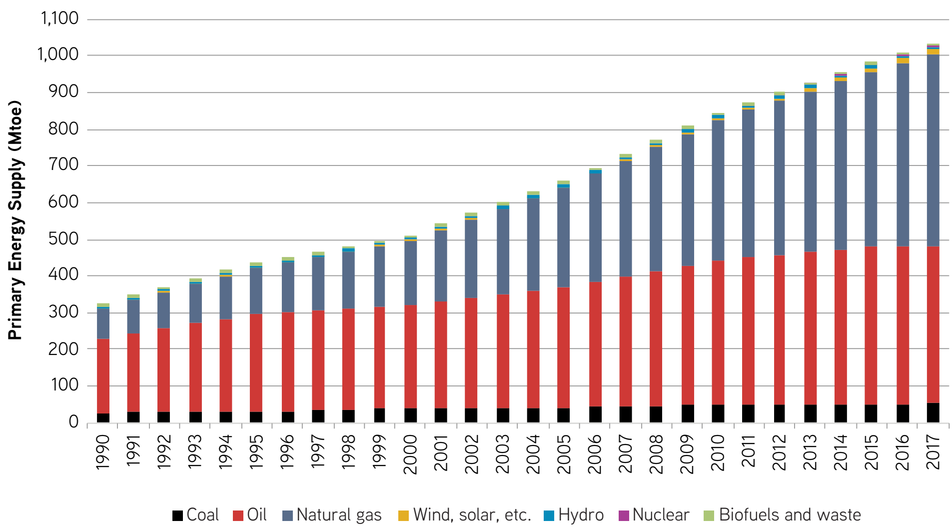
4.1. Supply and use of energy

This section presents major trends in energy supply and demand in the countries of the EMME region, primarily based on statistics published by the International Energy Agency (IEA).

4.1.1. Energy supply

As shown in Figure 8, oil has been the dominant energy source in the EMME region, followed by natural gas. Oil had the major share in the 1990s, but gradually the supply of natural gas has been increasing. In 2017 natural gas had a share of 50% in the primary energy supply mix, with oil following at 41%. All other sources have an approximate total of 8% in the energy mix, with coal accounting for most of this share. It is evident that the use of carbon-neutral energy in the whole region is low, which underlines the need for policies to accelerate decarbonisation, as outlined later in this report.

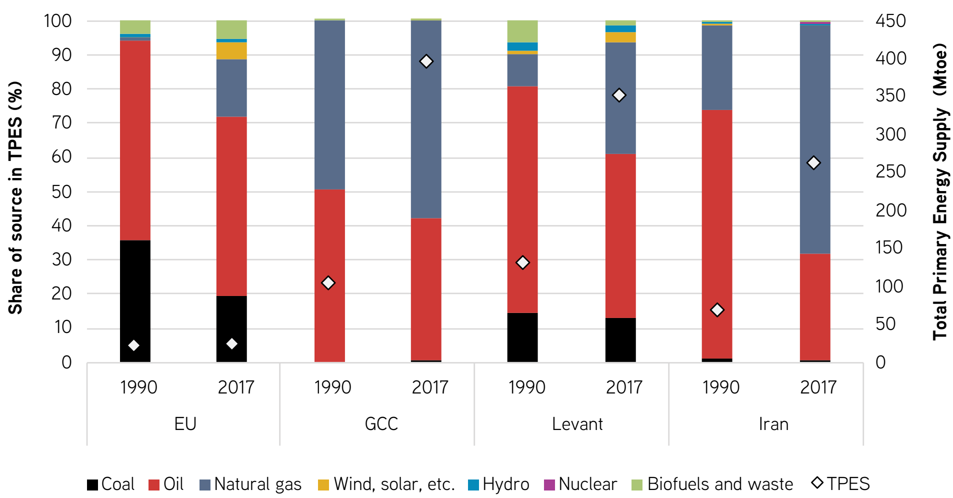
FIGURE 8. Total primary energy supply in the EMME region, 1990-2017



Source: [16].

Figure 9 presents an area-specific description of the evolution of primary energy supply, outlining fuel shares in 1990 and 2017. Due to their sizable fossil fuel reserves, Bahrain, Oman, Qatar and Kuwait are dependent on natural gas and oil. A similar pattern can be seen for Saudi Arabia, which has a small contribution from other sources, such as renewables, biofuels and waste. Syria has a small contribution from coal and hydro, and essentially no other renewables. Oil and natural gas are also the dominant energy sources in the United Arab Emirates, with a small stake of coal, biofuels, waste and renewables in recent years, as it looks to increase the share of renewable energy. Cyprus on the other hand is heavily dependent on oil, with the share of renewables and biofuels steadily increasing in recent years, driven by efforts to reduce costs of energy services and to comply with relevant EU directives. A similar pattern is observed in Lebanon, which also has a contribution from coal, hydro, biofuels and renewables. In Egypt, oil and natural gas take the largest share; the country has substantial reserves, much larger than for other sources of energy, such as coal, hydro, renewables and biofuels. In Greece, oil has the largest share of primary energy supply, followed by coal, which is extracted locally and used primarily for electricity generation. However, coal use is steadily declining, as it is gradually being replaced by natural gas and renewable energy technologies, influenced by the relevant EU policy, as discussed later in the report. As a major oil producer, Iraq is

FIGURE 9. Primary energy supply by source (% on the left axis) and total primary energy supply (white diamond in Mtoe on the right axis), by different geographical areas of the EMME region



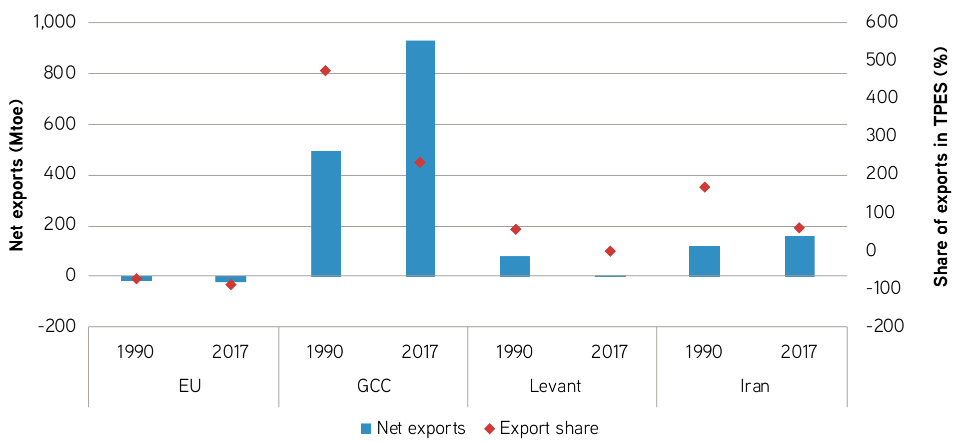
Source: [16].

Note: European Union (EU) countries include Cyprus and Greece; Gulf Cooperation Council (GCC) countries include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates; and Levant includes Egypt, Iraq, Israel, Jordan, Lebanon, Syria and Turkey. See Appendix for a more detailed graph including each individual EMME country.

heavily dependent on oil, with a small share of natural gas, hydro and biofuels. In Iran, natural gas has been the dominant primary energy source since 2005, followed by oil; other sources such as coal, hydro, renewables, biofuels and nuclear energy make up a relatively small percentage of the energy mix. In Israel, oil has the largest share, with that of natural gas increasing sharply over the past years as a result of recent substantial offshore gas findings; coal makes a significant contribution as well, although this is declining, while other sources such as renewables, biofuels and hydro make a small contribution. A similar pattern regarding natural gas and oil can also be seen in Jordan. Turkey has a relatively diverse energy mix, with oil, natural gas and coal having the largest shares.

The degree of energy dependency differs greatly across countries of the EMME region. Figure 10 presents net energy exports by country, showing that most countries are net exporters of energy, due to the large oil and natural gas reserves in the region. Saudi Arabia is the largest exporter, followed by the United Arab Emirates, Qatar, Kuwait, Iran, Iraq, Oman and Bahrain. On the other hand, some countries, which historically had minimal proven fossil fuel reserves, are net importers; Turkey is at the top of this list, followed by Greece, Israel, Jordan, Lebanon and Cyprus. Egypt and Syria were net energy exporters until 2010, and have been net importers since then. In Egypt, this is attributed to a substantial rise in demand for energy services domestically, while in Syria the ongoing civil war has had a negative impact on fossil fuel extraction and exports.

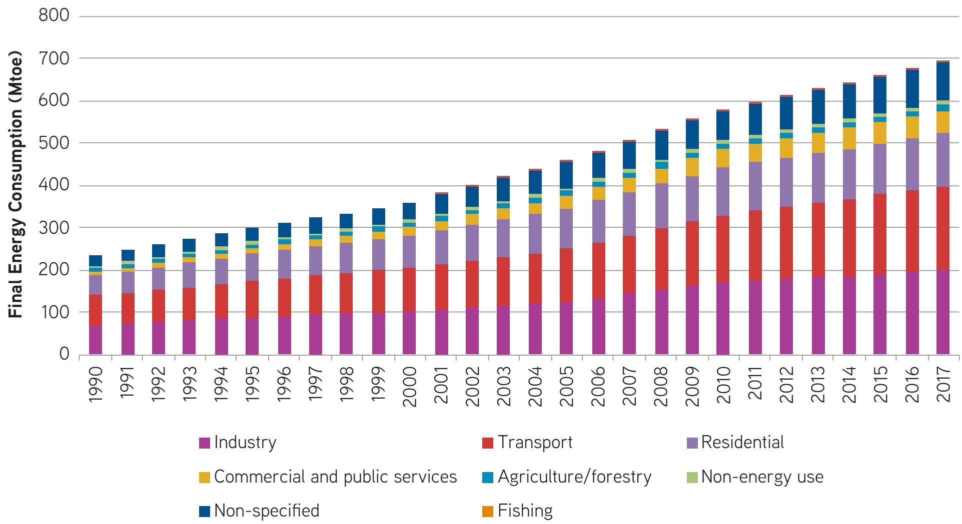
FIGURE 10. Total net energy exports (left axis) and share of exports in comparison to the total primary energy supply (TPES) (right axis) by different geographical areas of the EMME region, 1990 and 2017



Source: [16].

Note: See Appendix for a more detailed graph including each individual EMME country. TPES expresses essentially the annual energy needs of a country.

FIGURE 11. Total final energy demand by sector in the EMME region, 1990-2017



Source: [16].

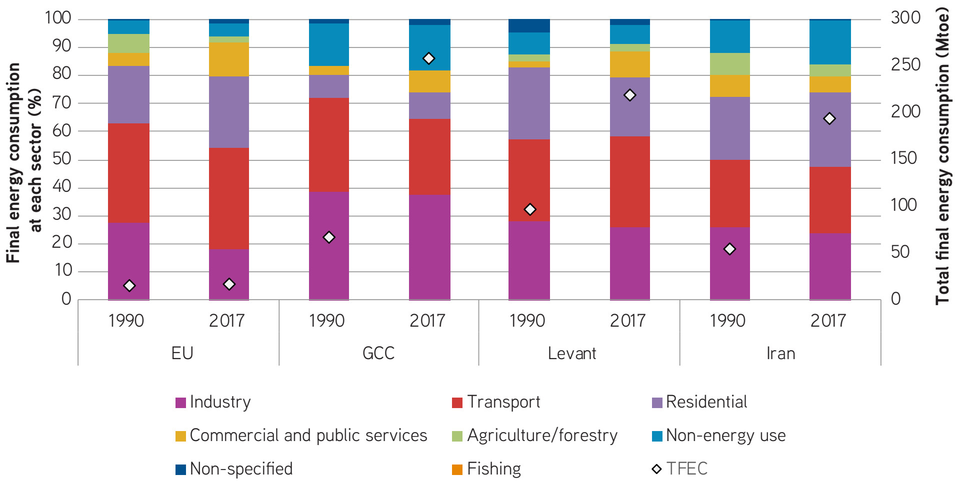
4.1.2. Energy use

Near-universal access to modern energy services has enabled an increase in energy demand across the region in the past few decades. Most countries of the region have universal access to electricity, with the exception of Saudi Arabia, Iraq and Iran, which have an electrification rate of 99% [17]. In Syria, which was fully electrified as of 2006, access to electricity has now decreased to 86%, mainly affecting the rural population [18]. This can be attributed to the long civil war and associated damages to critical infrastructure. With regard to access to clean cooking, 1% of the population lack access in Iraq, Jordan, Lebanon and Syria; 3% in Iran and 5% in Turkey, while no information is available for Palestine. All other countries of the region have universal access [17], [19].

Figure 11 presents the evolution of final energy demand in the EMME region. This almost tripled in less than 30 years. The contribution of the main economic sectors to energy needs remained essentially unchanged during this period; industry and transport each were responsible for about 30% of final energy use in 2017, with the residential sector accounting for about 20%.

Final energy demand by sector is also presented by area in Figure 12, for the years 1990 and 2017. Despite the diversity of the countries of the region, sectoral trends are similar, with industry, transport and residential sectors being dominant everywhere. In Bahrain, Qatar, Iran, Israel, Kuwait, Oman and Saudi Arabia the non-energy use of fuels also has

FIGURE 12. Share of sectoral demand in total final energy demand (left axis in %) and total final energy demand (diamond on the right axis in Mtoe) for different geographical areas of the EMME region, 1990 and 2017



Source: [16].

Note: See Appendix for a more detailed graph including each individual EMME country.

a large share, which indicates a strong petrochemical industry. The commercial sector's share of final energy demand is pronounced in Cyprus, Bahrain, Israel, Oman, Greece and Turkey, where tourism, financial services and other relevant economic activities drive the economy. Agriculture, forestry and fishing account for a small share of final energy use in all countries, as the energy intensity of these sectors is low, despite their importance in some of the economies of the region.

4.2. Energy carrier trends and outlook

4.2.1. Oil

The EMME region is the biggest producer of oil in the world, accounting for approximately 34% of global production in 2017 (Table 2). The largest producer is Saudi Arabia, responsible for the production of 592 million tonnes of oil equivalent (Mtoe), corresponding to 12.5% of the global production, over two times higher than Iran, which is the second largest with a 5.5% share. Iraq, Kuwait, Qatar and the United Arab Emirates have also a considerable share in global production, while Egypt, Oman and Syria are much smaller producers. It is noted that Syria's oil has dropped dramatically since 2010 due to the ongoing conflict. The countries of the region have the largest oil reserves in the world (Table 3) with 48% of global proven reserves. Saudi Arabia alone has 17.2% of global reserves; this is the largest

TABLE 2. Oil production (Mtoe) in the EMME region, 2010-2017

Country	2010	2011	2012	2013	2014	2015	2016	2017	Share 2017 (%)
Egypt	36	36	36	35	36	36	34	33	0.7
Iran	220	222	190	180	185	192	228	250	5.5
Iraq	123	138	153	154	161	198	220	226	5.5
Kuwait	127	145	158	156	154	152	156	149	3.3
Oman	43	44	46	47	47	49	50	48	1.2
Qatar	81	91	96	99	98	96	96	93	1.7
Saudi Arabia	491	552	579	567	573	597	618	592	12.5
Syria	19	18	9	3	2	1	1	1	0.02
United Arab Emirates	146	164	171	178	179	194	201	195	4.0

Source: [20].

TABLE 3. Major proven oil reserves in Mtoe

Country	At end of 1999	At end of 2019 (%)	Share of global reserves in 2019
Egypt	514	419	0.2
Iran	12 699	21 224	9.0
Iraq	15 345	19 781	8.4
Kuwait	13 163	13 845	5.9
Oman	783	733	0.3
Qatar	1 787	3 443	1.5
Saudi Arabia	35 844	40 590	17.2
Syria	314	341	0.1
United Arab Emirates	13 340	13 340	5.6

Source: [20].

share in the region and the second largest in the world. These reserves are about twice as large as those of Iran and Iraq and three times larger than those of Kuwait and the United Arab Emirates.

4.2.1.1. Oil market outlook

Despite international efforts to move away from fossil fuels, the Reference Scenario of the Energy Information Administration of the U.S. Department of Energy projects an increase of 20% in the consumption of crude oil and petroleum products between 2018 and 2050, driven by a 45% growth in consumption in countries that are not part of the Organisation for Economic Co-operation and Development [21]. This scenario expects that the Middle East will remain as the top oil-producing region, with its production increasing by 35%, from 1 580 Mtoe in 2018 to 1 770 Mtoe in 2040. Similarly, the IEA's Stated Policies Scenario projects that global oil demand will increase by 9.8% from 4 820 Mtoe in 2018 to 5 300 Mtoe in 2040; during the same time frame, oil demand in the Middle East is expected to grow by 36% [3]. The same scenario anticipates that increasing global demand is expected to drive the production of crude oil in EMME countries upwards (Table 4), while it assumes that in 2040 approximately 58% of global conventional crude oil production will originate from new fields that are yet to be developed or found.

The projected growth in demand and production will lead to significant requirements for infrastructure investments. For instance, the refining capacity in the Middle East is projected to increase from 460 Mtoe in 2018 to 630 Mtoe by 2040, requiring cumulative investments of USD 140 billion for the period 201940 [3]. Oil transport infrastructure investments in the region are estimated at $183 billion for the same period.

TABLE 4. Oil production (Mtoe) in key EMME countries in IEA's Stated Policies Scenario

Country	2018	2030	2040
Iran	229	204	224
Iraq	234	289	324
Kuwait	154	159	159
Qatar	100	115	139
Saudi Arabia	617	642	652
United Arab Emirates	189	204	219
Total	1 523	1 613	1 718

Source: [3].

Despite the projected increase in global oil demand in the aforementioned Stated Policies Scenario, a separate scenario that is in line with the Paris Agreement goals has an opposite trajectory: the IEA's Sustainable Development Scenario estimates a reduction in the world's oil demand of 10% by 2030 and 31% by 2040 as compared to 2018 [3]. This can have significant repercussions for countries in the region that rely on hydrocarbon export revenues to sustain their economies (Table 5). The fiscal balance in certain countries is heavily dependent on hydrocarbon revenues: the contribution of these revenues to overall fiscal revenues reached 90% in Kuwait, 75% in Qatar and 67% in Saudi Arabia in 2017 [22]. Additionally, hydrocarbon activities have a direct effect on local labour markets, while they are also linked to nonhydrocarbon sectors of the economy, such as construction, chemical or mining industries. It is thus evident that climate change mitigation efforts and adoption of low-carbon technologies can substantially affect hydrocarbon exporting economies of the region. In the past, economic diversification programmes drafted in response to oil price fluctuations were dropped following upswings in international oil prices [23]. However, the pursuit of existing diversification strategies following the 2014 oil price drop should continue, in order to address the

TABLE 5. Contribution of oil and gas to GDP

Country	Oil and gas rents as a share of GDP (%) in 2016	Fuel exports in 2016 (million current USD)
Bahrain	19.9	5 756
Egypt	3.2	4 043
Iran	2.6	47 636
Iraq	30.6	49 137
Kuwait	13.0	42 932
Oman	32.6	22 543
Qatar	19.8	52 620
Saudi Arabia	15.3	142 088
United Arab Emirates	11.4	103 989

Source: [26].

risks posed by a decline in hydrocarbon demand linked to global decarbonisation efforts [22]. A relevant study has indicated that there is considerable risk of stranded crude oil assets in the Middle East [24], which has to be accounted for in national planning, given the importance of the oil industry in many countries of the region.

The agreements of the Organization of the Petroleum Exporting Countries (OPEC) on regulating oil production in response to global oil demand fluctuations have a direct effect on international oil prices, and hence on hydrocarbon export revenues. A recent example is the agreement between OPEC and non-OPEC countries to reduce global supplies by 10%, reached during an early lockdown triggered by the COVID-19 pandemic [25].

4.2.2. Gas

The region is the third-largest producer of natural gas in the world. Iran leads with 206 Mtoe in 2018, a share of 6.2% of global production, followed by Qatar with 4.5% and Egypt with 1.5% (Table 6). However, the region has the biggest reserves in the world (Table 7), accounting for approximately 39% of global proven reserves, with Iran and Qatar holding 16.2% and 12.5%, respectively. The United Arab Emirates and Saudi Arabia follow with 3% of the global total, while the other countries have smaller shares. Israel is the only new entrant in the list of countries with proven reserves for 2018, due to the recent discovery of gas in the fields of Tamar and Leviathan. Other discoveries have been made in the Levantine basin, such as new fields in Cyprus, Israel and Egypt, with the companies involved still trying to assess the findings. In 2015 the Zohr field was discovered in Egypt's Exclusive Economic Zone, one of the largest ever discoveries, with more than 720 Mtoe of gas in place; its exploitation began in 2017 [27].

TABLE 6. Natural gas production (Mtoe) in the MENA region, 2010-2018

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	Share 2018 (%)
Bahrain	11	11	11	12	13	13	12	12	13	0.4
Egypt	51	51	50	46	40	37	35	42	50	1.5
Iran	124	130	135	135	151	158	171	189	206	6.2
Iraq	6	5	5	6	6	6	9	9	11	0.3
Kuwait	10	11	13	13	12	14	14	14	15	0.5
Oman	22	23	24	26	25	26	27	28	31	0.9
Qatar	106	129	140	145	146	151	149	148	151	4.5
Saudi Arabia	72	75	81	82	84	85	91	94	96	2.9
Syria	7	6	5	4	4	4	3	3	3	0.1
United Arab Emirates	43	44	45	46	45	50	52	53	56	1.7

Source: [20].

Even though natural gas is traded within the region, the bulk of the traded quantities is exported by Qatar outside the region (Table 8). Major importing economies within the EMME region are the United Arab Emirates, which imports gas from Qatar via a pipeline, and Turkey, which imports pipelined gas from Iran and liquified natural gas (LNG) shipments from Qatar [20].

TABLE 7. Natural gas proved reserves (Mtoe)

Country	At end of 1999	At end of 2019	Share of global reserves in 2019
Bahrain	248	66	< 0.1%
Egypt	1 012	1 838	1.1%
Iran	20 307	27 535	16.1%
Iraq	2 684	3 047	1.8%
Israel	2	399	0.2%
Kuwait	1 211	1 458	0.9%
Oman	673	573	0.3%
Qatar	9 931	21 226	12.4%
Saudi Arabia	5 021	5 147	3.0%
Syria	195	231	0.1%
United Arab Emirates	5 027	5 107	3.0%

Source: [20].

4.2.2.1. Gas market outlook

Partly driven by the recent discoveries in offshore gas reserves in the Eastern Mediterranean, several EMME countries are planning to increase the share of natural gas in their energy mix. As an indicator of what is expected in the region, IEA's Stated Policies Scenario projects that natural gas demand in the Middle East will increase from 460 Mtoe in 2018 to 555 Mtoe in 2030 and 695 Mtoe in 2040 [3]. The Reference Scenario of the Energy Information Administration foresees an increase in global natural gas consumption of more than 40% from 2018 to 2050 [21]; as a major exporting region, gas production in the Middle East is projected to increase by 70% over the same time frame. Such increases in demand and supply require relevant infrastructure investments.

TABLE 8. Major natural gas quantities (in Mtoe) traded by EMME countries in 2018 within the region and beyond via LNG shipments and pipelines

To	From				
Country	Egypt	Iran	Oman	Qatar	United Arab Emirates
Egypt	-	-	-	-	-
Kuwait	0.1	-	0.9	2.3	-
Turkey	0.4	6.4	-	2.2	-
United Arab Emirates	0.1	-	0.1	16.8	-
Other Middle East	-	7.9	0.1	1.8	-
Rest of world	3.3	0.3	11.0	87.5	6.6
Total	3.9	14.6	12.1	110.6	6.6

Source: [20].

Regional trade of gas could assist in satisfying the growing demand for gas in the region. Despite the considerable reserves available in several countries, exports of gas from the region are primarily directed beyond the region; major exceptions are gas exports from Qatar to Oman and the United Arab Emirates, via the Dolphin pipeline, and from Iran to Turkey [28]. The Arab Gas Pipeline has been used in the past to export gas from Egypt to Israel, Jordan, Lebanon and Syria, but its operation has been repeatedly disrupted by sabotage [29].

Despite the low exchange of pipelined gas within the region, demand for LNG is increasing, especially in the energy plans of Bahrain, Kuwait and the United Arab Emirates [28]. Similarly, until domestic offshore natural gas production commences, Cyprus seeks to diversify its energy mix by commencing imports of LNG from the region or beyond, enabled by the planned development of a floating storage and regasification unit, which is expected to be fully operational by mid-2022 [30]. In addition, Greece continues to invest in major gas infrastructure, including the increase in capacity of the LNG regasification terminal at Revithoussa and implementation or completion of several international gas pipeline projects [31].

Offshore gas from recent discoveries in the Levantine area and the Eastern Mediterranean could provide export opportunities to continental Europe. For instance, the EastMed pipeline, which is a recognised project of common interest, aims to connect the offshore gas finds in the area to Cyprus, Greece (through Crete) and eventually to Italy via the proposed Poseidon pipeline [32]. In January 2020, the leaders of Cyprus, Greece and Israel signed a deal for the construction of the 1 900 kilometre (km) EastMed gas pipeline [33], but the timeline for its construction and the availability of required funding remain unclear.

The COVID-19 pandemic has put a temporary halt to hydrocarbon exploration activities in the region. The recent collapse of oil and gas prices has created market instability with long-lasting impacts that are still unclear. Cumulative oil and gas supply investment requirements in the Middle East are projected at more than USD 2.7 trillion, of which upstream oil and gas activities require USD 2.1 trillion for the period 201940 [3]. By the time of this writing, the financial viability of these investments is uncertain. Given global decarbonisation efforts, the risk of stranded assets from such infrastructure investments should be considered in national planning efforts. The risk of stranded natural gas assets exists, even though at a lower level than for crude oil [24].

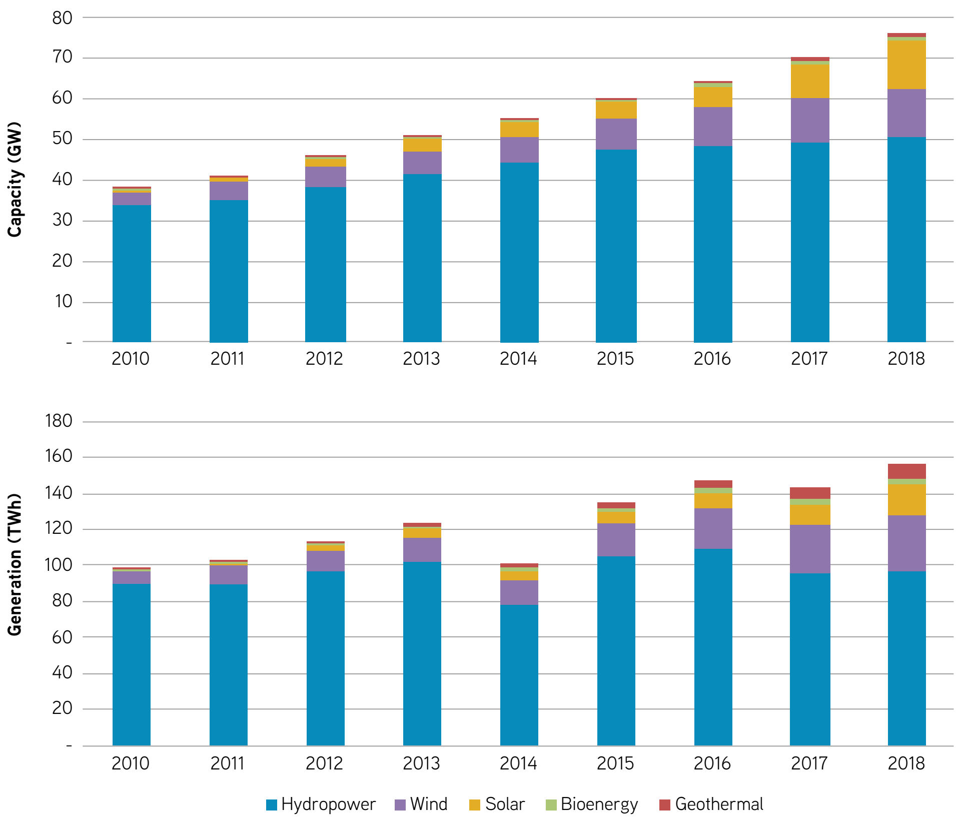
4.2.3. Renewables

4.2.3.1. Renewable electricity trends

The electricity sector in EMME countries is undergoing considerable changes in its generation portfolio towards renewable energy sources. In the previous decade, EMME countries doubled their installed capacity of renewable electricity, growing from 38 gigawatts (GW) in 2010 to 83 GW in 2019 [34]. This growth indicates an increasing trend in the adoption of renewables in the electricity sector at around 5 GW per year.

Hydropower[1] accounted for almost 40% of the decade-long growth in renewables for the region, increasing from 34 GW in 2010 to 51 GW in 2019, followed closely by solar energy, which increased by 16 GW during the same time frame (see top part of Figure 13). In fact, solar capacity additions overtook other renewables in the last few years. While

FIGURE 13. Renewable electricity capacity (top) and generation (bottom) trends, 2010-2018



Source: IRENA Renewable Energy Statistics 2020 [34].

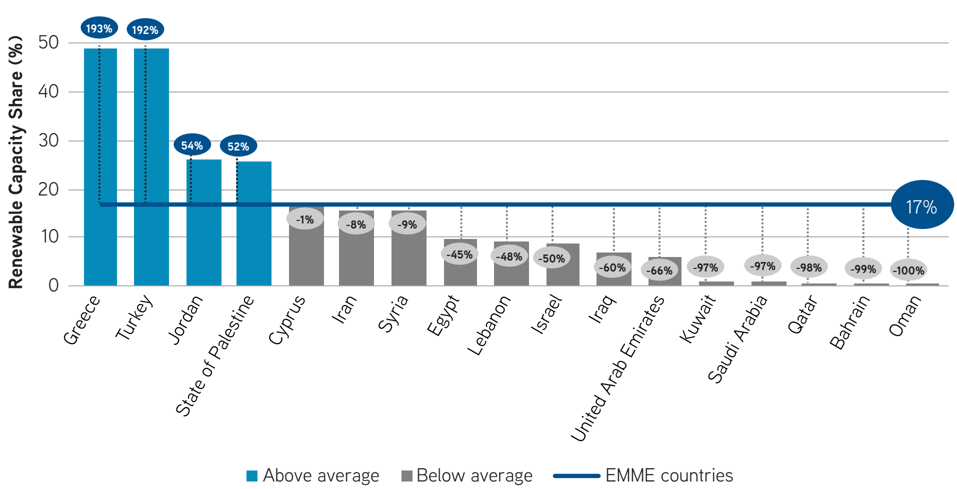
1. Excluding pumped storage.

solar power accounted for 8% of additions in 2015, it reached an all-time high of 63% of additions in 2019, driven by the substantial cost reductions experienced over the last decade [35]. Wind capacity increased by 10 GW during the decade; although at a smaller rate than solar power additions, wind capacity grew steadily in the region. Turkey, Iran and Greece together accounted for more than 80% of all renewable electricity capacity in 2019. According to the International Renewable Energy Agency (IRENA) statistics [34], Turkey alone has more than half of the installed capacity among EMME countries.

Even though renewable electricity capacity increased by 100% from 38 GW in 2010 to 76 GW in 2018, total generation from these technologies increased by 58% during the same period; from 99 terawatt hours (TWh) in 2010 to 156 TWh in 2018 (bottom part of Figure 13). This is attributed to the fact that renewable energy technologies with low-capacity factors, particularly solar photovoltaic (PV) and wind, are those that have primarily been added to the system. Additionally, hydropower electricity generation could vary considerably, depending on many factors like droughts, prolonged turbine maintenance and water management strategies, among others. In 2014, hydropower output reduced significantly in Turkey, Greece, Iraq and Lebanon, which can be attributed to drier conditions. Hydropower electricity generation in Syria dropped substantially from 2015 onward as a result of the ongoing civil war.

Integration of renewable energy technologies is quite low in the region (Figure 14). Despite the aforementioned doubling in installed capacity of renewable electricity during

FIGURE 14. Renewable electricity capacity share in EMME countries (in 2019, average 17%)



Source: IRENA Renewable Energy Statistics 2020 [34].

the decade-long growth of renewables, renewable capacity accounts for 17% of total installed capacity in EMME countries. This is a marginal increase of 4 percentage points since 2010, signalling that non-renewables maintained their dominant share of electricity-generating capacity [34]. The region has considerable potential for renewable power and collaboration. Particularly, countries with higher renewable capacity than average (Figure 14) could provide key recommendations and best practices to the region to develop a renewables-heavy electricity grid.

4.2.3.2. Renewable energy supply

EMME countries produced around 33 Mtoe of renewable energy in 2017 [36], a mere 1.4% of the total primary energy supply in these countries. The significant importance of fossil fuels, representing over 97% of primary supply, has created a lock-in situation and path dependency for fossil fuels, presenting a challenge in the integration of renewables in the region [37].

One of the links between renewable energy supply and demand is the direct use of heat from renewables, either with solar thermal energy or geothermal energy. Approximately 10% of the harvested renewable energy in the EMME region was used as direct heat in 2017. Specifically, Cyprus, Greece, Israel, Lebanon and Turkey consumed around 3.5 Mtoe of direct renewable heat. These countries generated 1.6 Mtoe of solar thermal heat, out of which around 80% is attributed to residential solar water heaters. Turkey, Greece and Cyprus also generated 1.9 Mtoe of direct heat from geothermal energy, which is mainly used in households and agriculture.

4.2.3.3. Renewable electricity costs

Global costs of renewable generation technologies keep decreasing. IRENA reports that the cost of electricity decreased by between 1% and 26% for different renewable energy technologies from 2017 to 2018, becoming the lowest-cost source of new power generation [35], when system integration costs are not considered. Cost reductions for solar and wind power technologies are set to continue beyond 2020. Nonetheless, renewable energy technologies remain more capital intensive than fossilfuel technologies, increasing the relevant risk for investors, especially in developing and emerging economies [38], and affecting the rate at which such investments take place.

Reductions in wind costs have been driven by lower technology costs and improved siting of wind farms. Improved solar costs are mainly driven by reductions in the price of solar panels and reduced installation and operation costs, while they are also directly affected by the relevant policy environment, discussed in more detail in Section 5. In Saudi Arabia, there was a decrease of 62% in the cost of solar PV modules in the 201318 period, reaching an all-time low of around USD 1 267 per kilowatt (kW) for utility-scale projects. Turkey, similarly, reached around USD 1 206 per kW in 2018. For both countries, about one-third of the costs are related to soft costs like margin and financing, and half are related to hardware costs such as modules, inverters, racking and mounting, and grid connection costs. As the global cost of this hardware declines, countries in the EMME region will also be able to install cheaper systems in the future.

4.2.3.4. Renewable energy outlook for the EMME region

The ambition of most EMME countries is to increase the penetration of renewables in the coming years. Most of these countries have specified renewable energy targets that will represent, if implemented, a steep incline in their renewable generation from electricity systems that are currently based mostly on non-renewable energy sources. In the region, most renewable energy projects have been utility scale, especially in countries of the Arabian Gulf [39]. Yet, distributed generation could become increasingly dominant in the coming years through auto-producing industries, and commercial and residential buildings. Such developments would likely require adaptation of utility tariffs, incentive schemes for auto-producers and long-term policies to liberalise regional electricity market structures. Further information about renewable energy targets and policy options is provided in Section 5.

Intermittency of renewable energy technologies can be addressed by coupling variable electricity generation with desalination, thus tackling the water scarcity issue of a large part of the region. It can also be coupled with hydrogen production, which can be used, for instance, as fuel for long-haul road freight, shipping and aviation or for high-temperature heat generation in industry [40]. With regards to hydrogen, availability of abundant solar resources allows for low-cost production; the relevant cost of renewable electrolysis in the region has been estimated at USD 1.8/kilogramme (kg) of hydrogen compared to USD 3.1/kg in Europe and USD 4.1/kg in Japan [41]. The relative proximity of the region to these markets allows for a gradual substitution of the current fossil fuel exports with hydrogen exports.

4.2.4. Nuclear

4.2.4.1. The global context

Nuclear power continues to provide a significant share of the world's electricity supply. At the end of 2019, 442 operating reactors provided 392 gigawatts electrical (GWe) of capacity [42] across 31 different countries, producing 2 563 TWh, corresponding to about 10% of the world's electrical supply. Demand for new nuclear power remains strong with 54 reactors currently under construction, with a combined net capacity of 57.4 GWe [43].

Most of the new builds are in China (10.6 GWe), India (4.8 GWe) and Russia (4.5 GWe), but that total also includes some new entrant countries that have not operated nuclear power yet, such as Bangladesh (2.2 GWe), Belarus (2.2 GWe), Turkey (4.8 GWe) and the United Arab Emirates (5.4 GWe). These data reveal that the centre for reliance on nuclear power is shifting from North America and Europe to Asia and Eastern Europe.

While the number of operating units increased significantly from 1960, when global capacity was just 1.1 GWe, it reached 318 GWe by 1990, after which the rate of capacity increase has slowed down. By July 2020, 389 GWe were in operation. Even though new nuclear reactors become operational, shutdowns affect the global total capacity. There are several reasons for these shutdowns: national phase-out policies, safety concerns, plant economics and end of operational lifetimes.

The nuclear industry and research and development (R&D) centres are active in improving the designs of the main large nuclear power plants (NPPs), but also in developing small modular reactors (SMRs) and using nuclear plants for co-generation purposes. SMRs have been part of the nuclear power R&D programme for several decades now and range in output from 70 to 300 megawatts electrical (MWe). There are several potential benefits of SMRs. A general trend towards prefabricating the plants in the production facility minimises the installation time on site. This leads to lower costs and reduced times for commissioning and decommissioning. Further, most designs offer improved safety features, such as through lower core inventories. Modular reactors are associated with lower capital exposure per unit, thus making them easier to finance. Such smaller units may also become more attractive to countries with relatively small electricity systems. Despite these advances, the main challenges associated with NPPs remain public acceptability, spent fuel management and financing.

Coupling NPPs (and SMRs in particular) with sub-systems for other, non-electric applications is also gaining attention. Prominent among these is the provision of desalination, either using rejected heat for thermal processes, or using established electricity-based techniques such as reverse osmosis (RO). Hydrogen production using nuclear power could also be a promising option, as a way to generate liquid fuel carriers that may become important in global decarbonisation efforts (e.g. see [44][46]). RO or electrolytic hydrogen production during off-peak demand periods would allow NPPs to operate as a baseload continuously, as both non-electric by-products could be stored more easily than electricity.

4.2.4.2. Nuclear power in the EMME region

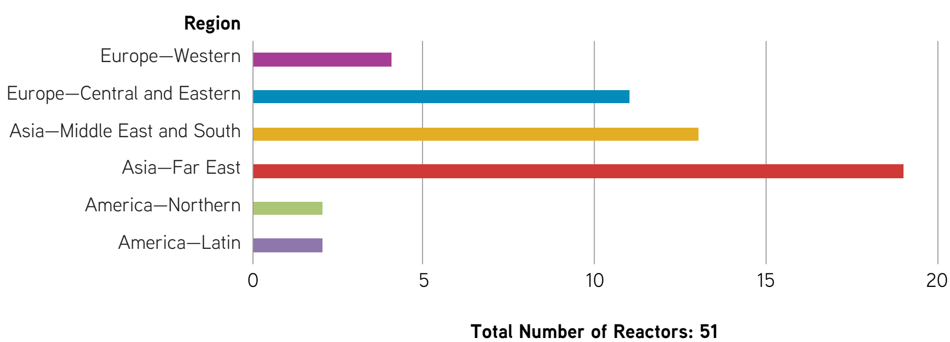
As mentioned above, nuclear power is declining in Western Europe, but there are emerging plans to build new plants in parts of Asia (Figure 15). The EMME region has three countries with NPPs already under construction: the United Arab Emirates (with three), Turkey (with three) and Iran (with one) [43].

The **United Arab Emirates** firmly decided in 2009 to proceed with the building of an NPP, and invited expressions of interest, answered by nine companies. A consortium won the bid at a value of around USD 24.4 billion [47]. The plant (Barakah nuclear power plant) started producing electricity in August 2020, with Unit 1 finished and now connected to the transmission grid, while the other three units are nearing completion and expected to enter commercial operation by 2024. This is the first NPP in the Arab world.

Turkey has developed plans in line with three considerations: security of supply, indigenous production and potential projections of the foreseeable domestic market. In line with these, the country has considered three sites for nuclear power development: at Akkuyu on the south coast of the country, at Sinop in the north and Igneada in the northwest. Of these, the plant at Akkuyu is the most developed. After several delays, the plant was granted a construction license on 2 April 2018 and is expected to start operation in 2023. Four large units of 1.1 GWe each are expected to be built on that site with an estimated cost of USD 20 billion.

Iran's interest in nuclear technology dates to the 1950s, when it received technical assistance under the U.S. Atoms for Peace programme. While this assistance ended with the 1979 Iranian Revolution, Iran remained interested in nuclear technology and developed an extensive nuclear fuel cycle, including sophisticated enrichment capabilities, which became the subject of intense international negotiations and sanctions between 2002 and 2015. Iran operates a single 0.9 GWe NPP in Busheher, which started construction in the

FIGURE 15. Total number of nuclear reactors under construction, by region



Source: [43].

Note: Out of the 51 in total, 13 are constructed in the Middle East and South Asia, and 7 out of those are in the countries examined in this report (3 in the United Arab Emirates, 3 in Turkey and 1 in Iran). All of these reactors are rated at about 1 GWe each.

1970s in collaboration with Germany but faced numerous delays and difficulties (including bombing of the site during the Iraq-Iran war). After more than two decades of suspended construction, Russia took over the completion of the plant. The facility was connected to the grid in 2011 and started commercial operations in 2013. There are plans to expand the site using four additional Russian-made reactors, with a schedule of completion within the next decade.

Establishment of a nuclear-free weapons zone in the region, abiding with all international treaties, especially the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), would be an important prerequisite for the promotion of widespread peaceful nuclear energy development in the region and would reduce concerns regarding nuclear weapons proliferation. Abiding with the provisions of the NPT [48] is essential for the transfer of nuclear power technology to EMME countries that wish to develop nuclear power facilities.

More detailed information about the evolution of nuclear power utilisation in each country of the EMME region is provided in the Appendix.

4.2.4.3. Nuclear energy outlook and policy drivers

Several challenges affect nuclear power's outlook. High upfront investment costs, a poor track record of unit commissioning on schedule and within budget, and long amortisation periods pose financial risks to potential investors. Costly spent fuel management along with public concerns about safety and security present additional obstacles.

Although advanced nuclear technologies hold the promise of low-carbon electricity necessary to combat climate change, much more must be done if these technologies are to be widely adopted by the market. Deploying the next generation of reactors will require specific and significant evolutions – making nuclear power's GHG emission benefits apparent to investors, a firm policy commitment with regard to GHG emission reductions and associated nuclear power development; an innovative, effective international regulatory system and a bold public-private financial partnership.

Government, political and public support would be essential for new nuclear energy technologies, as the level of support offered to date in the EMME region is not adequate to help these technologies cross from R&D to demonstration and deployment. The global regulatory framework must be strengthened if nuclear power is to continue being a provider of low-carbon energy. Stronger public confidence through enhanced safety and security measures would also be essential. Governments, international institutions, the nuclear industry and civil society need to work together to create effective, credible and rapid governance responses to these new realities. International co-operation is vitally important in this regard.

Economic efficiency coupled with enhanced safety will be major determining factors for these new technologies and may make advanced nuclear plants competitive with natural gas-power plants. In addition, nuclear plants that can offer base-load electricity coupled with the capability to switch to load-following or peaking power modes can further differentiate themselves in the marketplace as they will be able to operate in an environment of increased stochastic power generation caused by variable renewable sources.

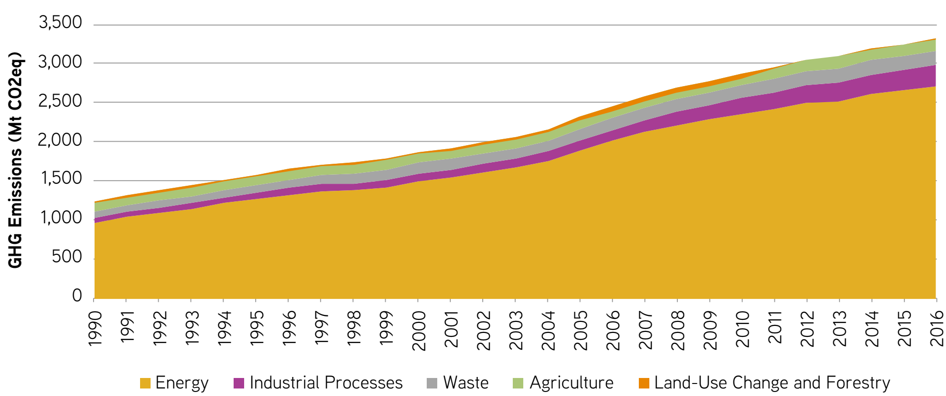
4.3. Alignment of EMME energy systems with global climate goals

4.3.1. The importance of energy-related greenhouse gas emissions

Figure 16 illustrates the evolution of GHG emissions in the EMME region for the period 19902016. Similar to global trends, the energy system is responsible for more than three-quarters of GHGs emitted in the atmosphere.

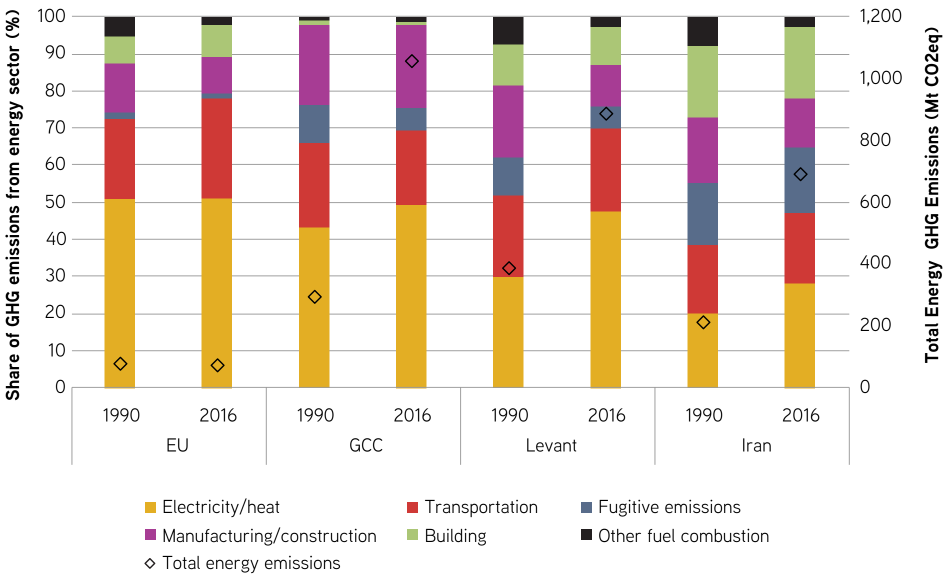
Emissions from the energy system are presented for selected countries and regions in Figure 17, for the years 1990 and 2016. In line with demographic and economic trends, emissions of the energy system have been increasing in all countries with the exception of Greece and Cyprus, which experienced economic recessions during the latter part of the period, and Syria due to the ongoing civil war. In almost all countries, power generation and transportation are the sectors with the largest share of emissions, followed by buildings and manufacturing. In some countries, such as Saudi Arabia, Qatar, the United Arab Emirates, Kuwait, Oman and Turkey, manufacturing makes a significant contribution due to the relatively high economic output of carbon-intensive industries.

FIGURE 16. Evolution of GHG emissions in the EMME region, 1990-2016



Source: CAIT [49].

FIGURE 17. Sectoral breakdown (left axis) and total energy-related GHG emissions (right axis) for different geographical areas of the EMME region, 1990 and 2016



4.3.2. Greenhouse gas emission projections

Recent IPCC assessments indicate that global carbon dioxide (CO_2) emissions should decrease by about 25% from 2010 levels by 2030 (1030% inter-quartile range) and reach net zero by 2070 (206580 inter-quartile range) to limit global temperature rise to 2oC relative to preindustrial levels [50]. Keeping in mind the inherent uncertainty in climate projections, to achieve no or limited overshoot of 1.5oC, a 45% CO_2 emission decrease from 2010 levels is required by 2030 (4060% inter-quartile range), while emissions should drop to net zero by around 2050 (204555 inter-quartile range). However, projections from major economies in the EMME region clearly indicate an opposite trend.

The current energy policy framework of the two G20 member countries in the region, Saudi Arabia and Turkey, is estimated to lead to an increase in GHG emissions of 16% and 63%, respectively, by 2030 as compared to 2010 levels [51]. Similarly, the unconditional Nationally Determined Contribution (NDC) targets of the two countries could lead to an emissions rise of 14% in Saudi Arabia and 132% in Turkey during the same time frame. Other countries estimate modest reductions; for example, Israel expects a reduction of 9% according to its NDC pledge [52]. On the other hand, the EU Member States in the region are on track to meet the EU and global climate targets. In the National Energy and Climate Plans submitted by Greece, a 50% reduction in GHG emissions is envisioned by 2030 in comparison to 2010 levels [31]; lower demand for energy services due to the economic crisis of the past decade helps the country stay on track to meet this target. Similarly, the planned policies and measures of Cyprus are expected to achieve a reduction of 2027% in GHG emissions by 2030 compared to 2010 levels [30]; further reductions are needed to achieve the specified national target for 2030, which can be achieved with additional measures under consideration. EU Member States will further strengthen their decarbonisation policies in the coming years, in view of the proposal tabled by the European Commission in September 2020 to substantially increase the ambition of GHG emission reductions up to 2050, on the road to achieving climate neutrality in 2050 [53]. This is in line with the EU Green Deal, the major initiative for a low-carbon and resource-efficient European economy, which was adopted by the leaders of EU Member States in December 2019.

Quantified GHG emission targets are not available for all countries of the region; hence it is difficult to provide an overall planned regional trajectory of emission pathways. Quantitative information on NDCs was available for Cyprus, Greece, Israel, Lebanon, Oman, Palestine and Saudi Arabia during the time of this writing, whereas it was unclear for Jordan and not available for Bahrain, Egypt, Kuwait, Qatar, Syria and the United Arab Emirates. Iran, Iraq and Turkey have declared quantitative emission reduction targets in their Intended Nationally Determined Contributions (INDCs) but have not yet ratified the Paris Agreement.

Despite this uncertainty, it is instructive to observe per capita carbon emissions in each country and compare them with the required level in order to stabilise the global climate according to the Paris Agreement. This is illustrated in Table 9: with the exception of Palestine and Syria, all other EMME economies have

TABLE 9. Carbon dioxide emissions per capita by EMME country in 2018 compared to world average levels, and global average levels in 2030 required to meet the goals of climate stabilisation at 2° and 1.5° above pre-industrial levels

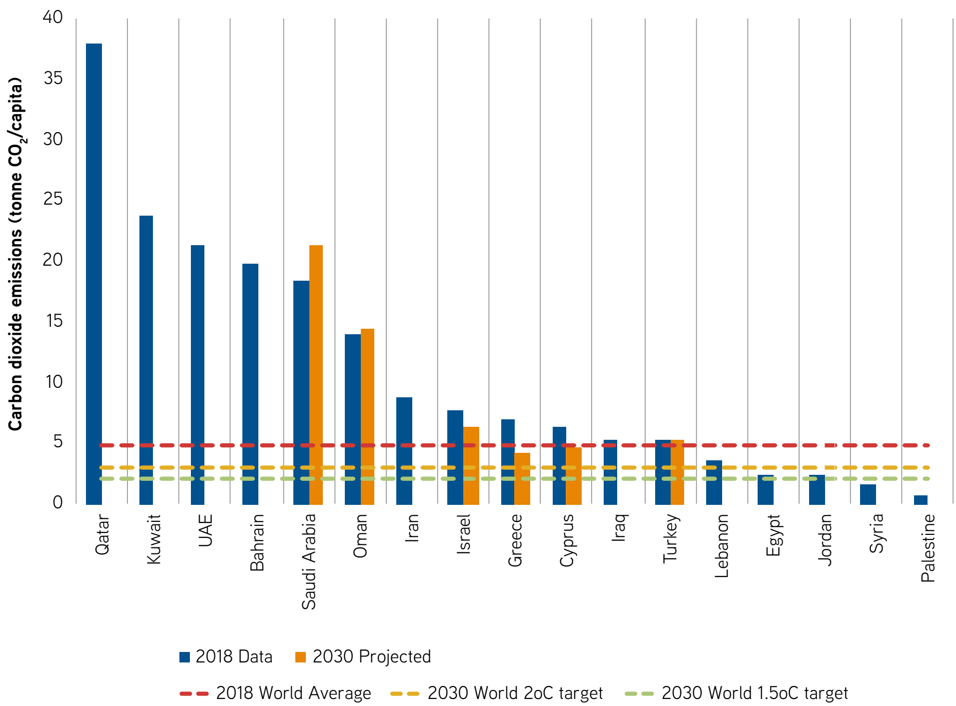
Country	Emissions per capita (tonnes CO_2)
Bahrain	19.80
Cyprus	6.30
Egypt	2.43
Greece	7.02
Iran	8.81
Iraq	5.31
Israel	7.67
Jordan	2.42
Kuwait	23.70
Lebanon	3.53
Oman	13.93
Palestine	0.66
Qatar	37.97
Saudi Arabia	18.43
Syria	1.67
Turkey	5.20
UAE	21.35
2018 World average	**4.79**
2030 World 2°C target	**2.91**
2030 World 1.5°C target	**2.13**

Source: [50], [54], [55].

higher emissions per capita compared to the world average today, and much higher emissions compared to what is necessary to stabilise the global climate. Trends of the past, as depicted in Figure 16, are unlikely to change in the coming decades in the absence of strong policies. Apart from EU Member Countries Cyprus and Greece, which will have EU-wide commitments to reduce their emissions considerably by 2030 and 2050, as well as Israel, all other countries are likely to experience increases in emissions per capita under business-as-usual conditions in the future. This will further enlarge the gap between business-as-usual developments in the region and what is necessary to stabilise the global climate.

Figure 18, which ranks the EMME countries according to their per capita emissions, highlights the enormous decarbonisation challenge that the region has to tackle in the near future. The picture depicted here is illustrative but should not lead to immediate

FIGURE 18. CO_2 emissions per capita in 2018 (for all EMME countries) and 2030 (for countries with officially reported emission projections) compared to world average levels, and global average levels in 2030 required to stabilise the climate at 2° and 1.5° above pre-industrial levels



conclusions about how much each country has to reduce emissions in the near term. Particularities such as current national living standards and climate conditions, and each country's share of total global emissions (both their current emissions and their historical contribution to total carbon emissions) are among the criteria that would have to be taken into account in order to fairly and efficiently allocate the decarbonisation effort between countries. This effort sharing is beyond the scope of this report and is recommended as the topic of a detailed study in the near future.

In addition to the overall emissions abatement gap outlined above, there is an equally large gap in fossil fuel production. As the EMME region is globally the main oil producer and exporter and since there are plans to ramp up natural gas production, consumption and exporting from recent discoveries in the Eastern Mediterranean, this metric compares national plans for fossil fuel production with the required production levels that would be in line with the Paris Agreement's targets. On a global scale, it is estimated that oil and gas production will exceed the median 1.5oC pathway by 59% and 70%, respectively, by 2030 [56]. As such, if the international climate targets are to be achieved, there will be considerable implications for the fossil fuel export prospects of several countries in the region; fossil fuel production plans will have to be revised downwards considerably if the region's countries are to contribute their fair share to decarbonisation.

Figure 18. CO_2 emissions per capita in 2018 (for all EMME countries) and 2030 (for countries with officially reported emission projections) compared to world average levels, and global average levels in 2030 required to stabilise the climate at 2o and 1.5 o above pre-industrial levels

4.4. The energy system's air pollutant emissions

Fossil fuel extraction, transformation and use are not only responsible for GHG emissions that lead to climate change; they also contribute significantly to air pollution. It is estimated that at least half of the air pollution in the region comes from natural sources (e.g. sand, dust, sea salt), and the rest is due to human activities (e.g. transportation) [57]. Air pollutants can be roughly divided into four categories: 1) gases such as sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), ozone (O_3) and volatile organic compounds (VOCs); 2) organics such as dioxins; 3) heavy metals and 4) particulate matter such as PM_{10}, $PM_{2.5}$ and PM_1 (i.e. particles <10, 2.5 and 1 micrometre in diameter) [58].

Electricity generation is the main anthropogenic source responsible for air pollution in the region. Transportation is also important, being responsible for a sizeable portion of air pollutant emissions. Road vehicles emitted more than 50% of NO_x, 90% of CO and 75% of non-methane VOCs in most EMME countries [58]. Atmospheric PM concentrations, largely due to anthropogenic sources, often exceed the guidelines set out by the World Health Organisation (WHO): according to the WHO database, urban air pollution has increased in more than two-thirds of the cities of the region, exceeding air quality limits by five to ten times [59].

Some examples of the importance of current energy system activities for air quality and human health are worth noting. In Bahrain, motor vehicles are responsible for half of NO_x-related air pollution, while industry is responsible for most SO_2 emissions. Egypt has air pollution levels six to eight times higher than the WHO recommended limits, which leads to increased pollution-related mortality. PM concentrations are extremely high, with Cairo ranked seventh among the world's deadliest cities due to air pollution. Similarly, Riyadh in Saudi Arabia is considered among the most polluted cities, mainly due to the transport and industry sectors that give rise to SO_2 and $PM_{2.5}$ concentration levels up to 15 times higher than the WHO standards. In Lebanon, air pollution is mainly attributed to the power sector, where emissions from oil-fired generators have been linked to asthma-related diseases. The economic costs of air pollution, mainly due to adverse health impacts, are considerable, and globally are expected to increase to USD 1825 trillion in 2060 compared to USD 3 trillion in 2015 [59].

4.5. The energy-water-food nexus

The energy-water-food nexus has gained attention in the past decades. These three resources are inter-linked, and this is particularly evident in the EMME region considering the limited availability of freshwater and arable land. Most countries of the region face serious water scarcity, having water availability levels well below the threshold of 1 000 cubic metres/year/capita, which is forcing countries to tap into the reserves of fossil groundwater for food production, and into the reserves of fossil fuels in order to pump groundwater and desalinate seawater. This approach is clearly unsustainable in the long term.

Agricultural production is directly linked to water availability; as precipitation is projected to decrease under a changing climate, increased reliance on irrigation and desalination will place additional stress on the water management systems of the region. Low water availability in most countries of the region hinders domestic production and use of biofuels; hence there is no real competition between biofuel and food production.

Energy, primarily electricity, is needed for several processes, such as irrigation, water distribution, pumping, water treatment, wastewater treatment and desalination. Several of these processes are energy intensive. On the other hand, water is required in energy processes, such as to extract and process natural resources, mining and cooling in power generation. For example, an average of 12% of total fuel consumed in the power and water sector in the countries of the Gulf Cooperation Council is attributed to desalination (10% in Saudi Arabia, 30% in Qatar) [11]. In Arab countries 15% of electricity generation is going to the water cycle [60], whereas about 8% of global water withdrawals are used for electricity generation.

Regional demand for both energy and water is rising due to economic and population growth, consumption patterns and inefficiencies in management. Additionally, subsidies to fossil fuels, electricity and water increase the challenges to sustainable management of these resources.

The strain on energy, water and food resources is expected to become stronger in the EMME region. Increased temperatures caused by climate change will lead to an increase of energy demand for space cooling and pumping of groundwater, lower thermal conversion efficiency due to warmer cooling water and higher ambient temperatures and more evaporation of water in dams that will reduce the generation output of hydropower. Reduced rainfall will in turn lead to less water being available for food production and hydropower generation. Non-conventional production of freshwater through desalination and wastewater treatment requires large amounts of electricity. All these considerations underline the need for decision-making processes to take into account integrated energy and water planning [60].

4.6. Gaps in knowledge of energy trends and projections in the region

Exploring data and analyses on energy supply and demand in EMME countries, as well as the review of regional technology options, reveals important information gaps for parts of the region. This section summarises these gaps to demonstrate items that national governments should carefully consider:

1. Energy system data availability. Not every country of the region has a detailed and consistent database of energy system information. Such databases would best feature up-to-date data on extraction, primary energy supply, transformation and final energy demand. As we progress in a transition to low-carbon energy systems, it is essential to have comprehensive data that are properly governed and available. As identified in a relevant IEA publication [61], and similar to approaches of the EU statistical office Eurostat, all countries should collect and make freely available the following energy system data:

- Energy balances, which typically cover the production, import and export of primary energy sources; their transformation into fuels for final end use and final consumption by various high-level demand sectors, including the residential, commercial, industrial, agricultural and transport sectors.
- Energy efficiency data and indicators that express the relationship between end-use consumption and the various physical and economic activities in a country that drive consumption within each major demand sector.
- Energy-related environmental emissions, which can include CO_2 and other GHGs, as well as other combustion-related air pollutant emissions (e.g. SOx, NOx, PM).
- Electricity and fuel prices and taxes.
- Investments in energy technology research, development and demonstration.
- Development indicators such as national and local access to clean energy, or the use of traditional biomass for home heating and cooking.

Standard data collection procedures should be set in place, using transparent methodologies for data collection and analysis. This will assist in maintaining highquality datasets. Available best practices in data governance in the region can be used as a starting point. Accountable entities should be identified in each of the EMME countries to facilitate this process.

Ideally, techno-economic performance data for key infrastructure, such as housing stock by age, and level of device and equipment adoption in buildings should also be available, to enable specialised analyses per sector. Moreover, additional information on topics such as energy poverty or water supply and consumption can contribute to understanding the socio-economic impacts of the energy profiles in the region, and allow for targeted governmental policies.

A special note is made for the scarce data availability for Palestine.

2. Energy and climate plans. As all countries are part of the United Nations Framework Convention of Climate Change (UNFCCC) and most have ratified the Paris Agreement, it is becoming ever more important for each EMME government to prepare comprehensive energy and climate plans. This will allow them to both fulfil their reporting obligations to the UNFCCC and develop a framework for planning, monitoring and regularly revising energy and climate policies for the medium and long term. Such plans will include energy projections by economic sector and fuel for different economic and policy scenarios, the associated emissions of GHGs and air pollutants, the costs for achieving specific targets and the other socio-economic impacts. The EU's National Energy and Climate Plans could serve as a guide for such plans of non-EU EMME countries.

3. Regional integrated assessments. Apart from national assessments and plans, the particularities of the EMME region and the need for regional co-operation call for an integrated approach to energy and climate policy aspects. Therefore, EMMEwide assessment studies that can be conducted with the aid of a variety of computational models and broad stakeholder participation (see e.g. [62]) are strongly encouraged.

5. Policy landscape

Public policies can strongly affect the direction and speed of the transition to a low-carbon economy. The attempt to mitigate climate change largely depends on the shift to clean energy, as energy supply and use is the predominant source of anthropogenic greenhouse gas (GHG) emissions. Because these emissions are driven by demand for energy services (mobility, heating and cooling, lighting, power), strong demand-oriented policies are key for emissions abatement. These include policies to improve energy efficiency, to induce behavioural changes among consumers and enterprises and to facilitate investments in energy supply, which can meet energy demand with the smallest possible carbon footprint.

While the region transitions away from carbon-intensive energy systems, progress in the policy and regulatory landscape so far has not been homogenous across countries and sectors. Several key barriers still hamper low-carbon energy deployment, ranging from technology and financial risks in new markets to integration challenges in markets with large shares of variable renewables. Moreover, despite significant progress in electricity generation, renewables are lagging in heating and cooling and transport applications.

This chapter provides an overview of policy instruments that can influence demand for and supply of energy services in order to support decarbonisation efforts in the EMME region. Thereby it identifies policy gaps, which lead to the policy recommendations of Chapter 6.

Table 13 in the Appendix summarises the different energy-related policies that are currently implemented in EMME countries, which can be considered to pave the way towards decarbonisation of the energy systems of the region.

5.1. Overall energy strategies and targets

National plans and strategies can be drafted based on national initiatives according to identified priorities or can be pursued in order to conform with regional and international frameworks. This section makes this distinction apparent wherever possible.

5.1.1. National plans

In the European Union, Member States such as Cyprus and Greece have to abide with the Governance of the Energy Union Regulation [63]. This regulation aims to ensure the achievement of EU's 2030 energy and climate targets, and Member States are required to prepare and submit integrated National Energy and Climate Plans (NECPs) that address the five dimensions of the Energy Union for the period 202130.[2] Cyprus and Greece have already submitted the final versions of their Integrated NECPs to the European Commission [64]. According to the specified national targets, by 2030 Cyprus should reach a renewable energy share in gross final energy consumption of 23% and reduce GHG emissions in sectors under the Effort Sharing Regulation (non–Emissions Trading System [ETS] sectors) by 24% as compared to 2005 levels [30]. The corresponding 2030 targets for Greece are 35% for the renewable energy target and 36% for the GHG emission reduction in non-ETS sectors [31]. Among other sectorspecific targets, EU Member States are obligated to improve their energy efficiency, and promote the use of second-generation biofuels and alternative transport fuels. The EU Green Deal, the major initiative towards a low-carbon and resource-efficient European economy, which was announced in December 2019 and was adopted by the leaders of EU Member States, will further strengthen all targets related to GHG emissions, energy efficiency and clean fuels and will drive decarbonisation in the coming years.

Non-EU countries of the EMME region all have targets to increase the contribution of renewable energy in the future, drafting relevant strategies, plans or programmes. Most of the countries focus on the power sector, setting relevant targets, albeit with variable levels of ambition (see Table 14 in the Appendix). Despite the extensive solar potential throughout the region [65], only Jordan and Lebanon have targets that aim to extend the use of solar water heaters [28].

It is important to highlight that some countries have drafted long-term plans that foresee considerable increase in the adoption of clean energy technologies. As a prominent example, the UAE's Energy Strategy 2050 aims at achieving an energy mix consisting of 44% renewable energy, 6% nuclear power, 38% natural gas and 12% clean coal by 2050; this strategy is estimated to require EUR 150 billion in public investments [66]. Israel has set an ambitious plan for the transport sector, as new registrations of conventional vehicles will be banned by 2030 and they will be replaced by electric vehicles (EVs) or vehicles powered by compressed natural gas [67]. Further details on national targets can be found in the relevant literature – see e.g. [5254] for the case of Egypt.

5.1.2. International climate change mitigation efforts

In addition to individual planning at the national level, all states were invited to communicate to the United Nations Framework Convention of Climate Change (UNFCCC) Secretariat their Intended Nationally Determined Contributions (INDCs) in preparation for the 21st

2. The five dimensions are: 1) energy security; 2) internal energy market; 3) energy efficiency; 4) decarbonisation and 5) research, competitiveness and innovation.

Conference of the Parties (COP21). These specify the mitigation and adaptation measures to be followed along with the corresponding GHG emission reduction targets that aim to be achieved. Upon ratification of the Paris Agreement by each state, its INDC was directly converted to an NDC. Table 15 in the Appendix provides an overview of the relevant submissions from each state of the EMME region and the measures proposed for the achievement of the relevant targets. It is interesting to note that improved energy efficiency and increased deployment of renewable energy technologies are both mentioned across all submissions. Additionally, seven of the submissions explicitly mention promotion of a modal shift away from passenger cars to more sustainable modes of transport (Iraq, Israel, Jordan, Syria, Turkey, Palestine, the United Arab Emirates). Certain oil- and gas-producing countries also mention reduced gas flaring as one of the mitigation measures (Iran, Iraq, Oman, Saudi Arabia, the United Arab Emirates).

5.2. Policy instruments

Various policy instruments are used by countries in the EMME region to promote energy efficiency measures and low-carbon energy technologies. These are typically classified as regulatory push, regulatory pull, fiscal and financial. Push policy tools mandate certain actions such as electricity quotas, use of solar water heaters or biofuels mandates, rural electrification and the use of biogas. Pull policy tools incentivise certain actions, for instance, through pricing or privileges given for the use of low-carbon technologies. Fiscal and financial policy instruments include tax incentives, grants, subsidies and loan facilitation schemes. Many of these policy tools have been used in the region to diversify energy systems and to increase the uptake of renewables and energy efficiency in the power generation, transport, and heating and cooling sectors.

The policy framework for renewable energy technology deployment in the power sector is among the most advanced and elaborated. Renewable energy projects in the region are mainly supported by policy tools such as auctions, net-metering, and fiscal and financial policies. According to Griffiths [28], the most popular measures for renewable energy in the power sector include feed-in tariffs that were largely used in the past (Israel, Jordan, Syria, Iran, Egypt, Cyprus, Greece);[3] net-metering or net-billing schemes (the United Arab Emirates, Israel, Jordan, Lebanon, Syria, Egypt, Cyprus, Greece) and public investment, loans or grants (Bahrain, the United Arab Emirates, Israel, Jordan, Lebanon, Iran, Cyprus and Greece).3 The use of energy auctions has also increased in recent years (the United Arab Emirates, Turkey, Israel, Jordan, Syria, Iraq, Egypt, Lebanon and Saudi Arabia) [69]. The policy landscape for renewable energy heating and cooling applications and transport

3. Information on Cyprus [30] and Greece [31] is derived from their respective NECP submissions.

has been limited compared to the power sector. That said, countries in the region are encouraging the uptake of renewable energy in heating through several direct policies and instruments such as mandates, fiscal and financial incentives, and demonstration projects. In the transport sector, EVs offer an opportunity to use renewable electricity. Regional efforts in the sector have focused on incentivising EVs through fiscal and financial incentives and direct investments.

5.2.1. Fiscal and financial incentives

Fiscal incentives and public financing have been used in numerous countries of the region to promote renewable energy technologies and – to a lesser extent – energy efficiency investments. Financial and fiscal incentives are often used to improve access to capital, lower financing costs and reduce the burden of high upfront costs of renewable energy projects. They can be introduced in the form of tax incentives, rebates, grants, performance-based incentives, concessional loans and guarantees, and measures to mitigate risk. Fiscal measures are in place in some countries, for instance, through the provision of tax credits (Israel, Syria, Iran) or reductions in value-added tax or other taxes (Israel, Jordan, Lebanon, Egypt) [28].

Several countries like Cyprus, Greece and Jordan operate dedicated renewable energy and energy efficiency funds to facilitate investments. Often, grants and concessional loans are provided to strengthen and support other deployment policy instruments such as net metering and feed-in tariffs, as is the case, e.g. in Egypt [70]. Further information on financial incentives for improving the energy efficiency of specific end-use sectors is provided in later sections, starting with Section 5.2.4. Carbon pricing is also an important fiscal measure that can accelerate economy-wide decarbonisation; it is included among the enabling policies outlined in Section 5.3 below.

5.2.2. Net metering and wheeling for renewable energy promotion

Net metering and wheeling regulations are used to encourage self-consumption of distributed renewable electricity in the region. In the EU context, Directive 2018/2001 [71] encourages the promotion of distributed energy technologies that may be used by consumers to satisfy their own demand for energy services, the storage and sale of excess generation of renewable electricity through power purchase agreements with electricity suppliers and peer-to-peer trading arrangements. This encourages the final end users of energy to become active consumers, or "prosumers". Net metering schemes often compensate the producer by crediting electricity generation, which can later be used to offset consumption of electricity within the current (or future) billing cycle. Net metering schemes are in operation in Cyprus and Greece. Even though not yet implemented in most countries of the region, wheeling regulations allow consumers to install renewable energy technologies in a different location from the point of use and connect them via the transmission or distribution grid.

Policies of this type are also implemented in some non-EU EMME countries. Jordan is using net metering and wheeling to support consumers to set up renewable energy projects [72]; the electric power wheeling scheme is targeted to large consumers whereas the net metering scheme is focused on the development of renewable energy, mainly solar PV, for small and medium residential and commercial consumers. In the United Arab Emirates, net metering regulations have been issued in both Abu Dhabi and Dubai to encourage the uptake of rooftop solar PV in residential, commercial and industrial consumers; this policy resulted in nearly 1 400 installations in Dubai (125 MW equivalent) as of October 2019. In Lebanon, net metering was introduced in 2011 [73] and offered the first opportunity to connect renewable energy projects to the national grid.

5.2.3. Renewable energy auctions

Due to the substantial drop in renewable energy technology costs in recent years [35], these technologies are directly competing with fossil fuel technologies and the need for direct financial support has receded. As a result, even though feed-in tariffs had been the dominant policy instrument globally for renewable power prior to 2010, adoption of competitive bidding via auctions has grown rapidly in recent years as a preferred policy measure to ensure provision of renewable energy at the lowest possible price [74]. Such a tendering process has been central to large-scale renewable energy deployment in EMME countries [69] and was implemented in the United Arab Emirates, Turkey, Israel, Jordan, Syria, Iraq, Egypt, Lebanon [28] and Saudi Arabia [35]. Since 2015, auctions have been used to award more than 11 700 MW of renewable energy projects in the region, of which close to 64% is for solar PV. The United Arab Emirates lead with 4 050 MW of awarded projects followed by Turkey at 3 000 MW; auctions in other countries such as Greece, Qatar, Saudi Arabia and Jordan are also picking up and more activity is expected in the near future.

Countries are using auctions to achieve renewable energy deployment at competitive prices and promote system integration of increasing shares of variable renewable energy technologies. Greece recently adopted auctions for wind and solar PV installations, instead of a fixed feed-in tariff scheme. Upon completion of three auction rounds, average bid prices dropped from USD 92/megawatt hour (MWh) for 53 MW to USD 70.6/MWh for 143 MW within two years [69]. Jordan switched from a feed-in tariff to competitive bidding for both solar PV and wind projects. The EMME region is now home to some of the lowest solar PV prices in the world. Saudi Arabia (USD 23.4/MWh), Egypt (USD 27.5/MWh), Jordan (USD 28/MWh) and the United Arab Emirates (USD 16.9/MWh) achieved similarly competitive prices. The prices and capacities of renewable energy auctions in the EMME region through early 2020 are summarised in Table 16 in the Appendix.

Auctions create competition, which allows falling technology costs to be more fully reflected in bid prices. Requests for expressions of interest in renewable energy projects in the region have regularly attracted large numbers of local and international companies. Although aggressive competition can indeed lower prices, it may also result in underbidding, leading to project delay or abandonment [69]. Several auctions in the EMME countries tend to minimise the probability of underbidding through strict financial and technical requirements during the prequalification and evaluation stages.

As countries in the region gain experience with large-scale renewable energy projects, auctions are becoming more sophisticated. Utilities are designing auctions to incentivise electricity generation that complements existing generation capabilities. Moreover, auctions are being used to create jobs and develop local industries, as demonstrated in examples from Saudi Arabia and Turkey. The technical criteria for the 300 MW solar PV and 400 MW wind tenders in Saudi Arabia include a 30% local content requirement (LCR), which is expected to gradually increase in future rounds to encourage the growth of domestic supply chains. Turkey has established a 65% LCR criterion for the auctions in its Renewable Energy Resource Areas [69].

5.2.4. Horizontal end-use energy efficiency policies

Policy measures do not focus solely on the supply side of the energy system but address the demand side as well, with the primary aim to improve the energy efficiency of buildings, processes, machinery and appliances. EMME countries display varying degrees of implementation of energy efficiency requirements in energy end-use sectors.

In EU Member States, promotion of energy efficiency at the consumer level receives considerable attention and could serve as a guide for best practices for other countries of the region. For example, the EU eco-design directive established minimum performance requirements for energy-related products, such as household appliances and information and communication technologies [75]. According to the Energy Performance of Buildings Directive [76], all new buildings should be nearly zero energy by the end of 2020, while all new public buildings should comply by 2018. To achieve this, Member States had to introduce minimum energy performance requirements for buildings, building elements and technical building systems. Cyprus and Greece submitted national plans for nearly zero-energy buildings, which detail the measures taken to conform with the EU legislation [77] [78].

Non-EU countries of the region are gradually adopting similar approaches. Israel has been implementing energy efficiency policies during the last decade; in a recent development in 2017, the Israeli government approved a National Plan for Energy Efficiency-Electricity Consumption Reduction. In the GCC countries, limited building codes and standards had been implemented until recently that would encourage adoption of energy efficient practices during construction [79]. The Emirate of Abu Dhabi has gradually established stricter requirements for new buildings [80]. Regulations enforce minimum energy performance standards for energy-intensive electric appliances in Bahrain, Oman and Saudi Arabia, while in 2011 Dubai set a target of 30% energy demand reduction by 2030 [80]. Turkey has published a National Energy Efficiency Action Plan for the period 201723, which aims to reduce primary energy consumption by 14% as compared to a baseline scenario in 2023 [81]. Egypt, Bahrain, Jordan, Lebanon, Palestine and Iraq also have developed action plans, in response to the Arab Energy Efficiency Guidelines [82].

5.2.5. Decarbonisation policies for industrial, residential and commercial sectors

Apart from energy efficiency requirements for buildings, machinery and equipment, decarbonisation in end-use sectors requires switching to clean energy. The policy and regulatory landscape for decarbonisation in heating/cooling processes in the industrial, residential and commercial sectors is not as developed as in the power sector.

Mandates for solar water heating in new buildings, often through building codes, have been employed by Jordan and Israel in the EMME region. In Jordan, mandates were issued to deploy solar water heaters in all new buildings exceeding a predefined floor space [83]. At a municipality level, the Greater Amman Municipality issued a special regulation in 2015 regarding solar system installations on building rooftops, vacant lands and parking lots in order to ensure that installed systems satisfy zoning requirements. Israel was the first country in the world to require the installation of solar water heating systems in all new buildings in 1980 [84]. These mandates have resulted in penetration levels of close to 90% in the building stock.

Although building codes and mandates work well for new buildings, fiscal and financial incentives are important to support the switch to solar water heaters in existing buildings. Incentives include a range of grants, low-interest loans and tax incentives. In this way, for example, the market for solar water heaters in Jordan was catalysed with the launch of dedicated financing programmes [85], which offered loan guarantees and covered interest on loans, while also offering grants of up to 50% for solar water heaters and 30% for solar PV. A national financing mechanism for solar water heaters was also developed in Lebanon offering subsidised loans at a 0% interest rate [86].

Renewable-energy-based heating has been around for a long time in many countries in the region, but experience, especially in large-scale projects, remains limited. Demonstration projects can help enhance local know-how of renewable energy technologies and could have tremendous outreach impacts, especially when implemented in government buildings, schools and places of worship. Oman was one of the first countries in the world to pilot a solar-assisted enhanced oil recovery project in the Amal-West oil field [87], with steam from 7 megawatt thermal (MWth) concentrating solar troughs being used to replace natural gas in the extraction of heavy oils. The facility has been expanded to around 107 MWth and is expected to reach around 1 gigawatt thermal (GWth) when completed. In 2015, a concentrating solar power Fresnel collector pilot was installed in Sahab, Jordan, for drying and sterilisation processes in the pharmaceuticals industry [88], and a solar steam generation unit was installed at a tobacco facility in Jordan [89] to cover 85% of annual steam consumption and 30% of cooling and heating needs. Geothermal-based heating and cooling solutions have also been piloted to meet heating and cooling demand, with the geothermal heating and cooling system at the American University of Madaba in Jordan serving as one successful example [90].

5.2.6. Decarbonisation policies in transport

The transport sector accounts for a substantial share of energy consumption in the region (see Section 4.1.2). Efforts to diversify the energy mix in the sector have focused mostly on incentivising hybrid and electric vehicles through fiscal and financial incentives and direct investments. Fiscal and financial incentives have been employed with varying success in several countries in the region. Exemptions and reductions in custom duties and registration fees are most commonly used.

Cyprus and Greece implemented Regulation (EU) 2019/631 on emission performance standards for new passenger cars and light commercial vehicles, setting targets for 2025 and 2030[4] and incentivising car manufacturers to pursue the production of zero- and low-emission vehicles [91]. Although this regulation applies at the EU level, Directive (EU) 2018/2001 [71] sets a renewable energy target of 14% in the final energy consumption of the transport sector by 2030, which applies at the national level. Renewal of aged passenger and light commercial vehicle fleets is often achieved through passenger vehicle scrapping programmes, linking road taxes with energy efficiency and CO_2 emissions, and adopting financing programmes that replace old freight vehicles with technologies with low carbon intensity. Other measures foreseen in the NECPs of Cyprus and Greece

4. The targets specify that CO_2 emission rates in newly registered passenger cars should drop by 15% by 2025 and 37.5% by 2030 as compared to 2021, while in light commercial vehicles the equivalent reduction should reach 15% in 2025 and 31% in 2030.

include promotion of public transport, development of sustainable mobility plans, use of alternative fuels and installation of electric charging infrastructure [31].

Such policies can be seen as best practices for non-EU EMME countries as well, which lag behind in transport-related initiatives. Saudi Arabia has implemented fuel economy standards in the non-EU part of the EMME region; these aim to improve the average fuel economy of light-duty vehicles annually by 4% until 2025 [80]. Qatar has set a target of increasing the share of EVs to 10% of the fleet by 2030 [92], while the Emirate of Dubai also aims to increase the proportion of hybrid vehicles and EVs to 10% by 2030 [93]. In an effort to curb urban air pollution in Israel, low-emission zones have been established in Jerusalem and Haifa, and polluting diesel vehicles have been prevented entry into these zones [94]. At the same time, a programme to reduce pollution by diesel vehicles subsidises the installation of particulate filters and provides grants for the scrapping of heavy diesel vehicles [95]. Furthermore, EVs were piloted in Jordan in 2014 with the establishment of the first electric charging station, leading to the number of EVs growing from 9 in that year to over 3500 in 2017 [96]. This was encouraged by incentives such as waiving of import duties on EVs and their components and installing dedicated electricity meters for EVs providing electricity. Deductions in registration or road taxes have also been adopted in Lebanon [97] and Turkey [98], especially for battery-operated EVs.

Several countries in the region are conducting direct investments in electric mobility through initiatives such as the establishment of charging infrastructure, direct purchase of EVs and investments in the EV value chain. In Israel, the purchase of hybrid taxis [99] and electric buses [100] has been subsidised by the Ministry of Environmental Protection, while the ministry also provides financial support for the establishment of electric car-sharing schemes [101]. In the United Arab Emirates, the Emirate of Dubai is aiming for 10% of all vehicles to be electric or hybrid by 2030 [102]. In Jordan, electric mobility is also being piloted for public transportation in tourism sites. In Saudi Arabia, the Saudi Energy Efficiency Centre is working to promote EV adoption, while Qatar has launched an Electric Car Charging Stations Project. Several sovereign wealth funds in the region are also investing in other avenues of sustainable development. For example, Saudi Arabia's Public Investment Fund had acquired a 5% stake in the EV manufacturer Tesla and recently invested USD 1 billion in Lucid motors, an EV start-up [103].

5.3. Enabling and integrating policies

Enabling policies contribute towards building a wider conducive environment for clean energy development in order to send clear signals to stakeholders. These include policies that level the playing field (e.g. fossil fuel subsidy reforms, carbon pricing policies), manage land use, ensure the reliability of technology (e.g. quality and technical standards, certificates), facilitate access to affordable financing and support labour market needs (direct measures and education and training). The development of a local industry can be supported through industrial policy (e.g. leveraging local capacity) and trade policies (e.g. agreements, export promotion).

Integrating policies incorporate the use of low-carbon energy and energy efficiency in the heating and cooling, transport and electricity generation sectors into the larger energy and economic system and into consumers' daily lives. This category includes policies to ensure the development of the infrastructure needed (e.g. transmission and distribution networks, charging stations for EVs, district heating infrastructure), to enhance system flexibility (e.g. support for energy storage deployment), to promote sector coupling and to support research, development and demonstration. Moreover, some EMME countries are revising their energy pricing structures to level the playing field. Many have initiated education and training programmes to strengthen local value chains and capabilities. This section reviews such aspects.

5.3.1. Levelling the playing field

Access to affordable modern energy services is a key enabler of economic growth. Fuel subsidies have historically been used across the EMME region as a financial support mechanism for households and to boost industrial production, while more recently there has been hesitation to remove these subsidies to avoid social unrest in light of the Arab spring uprising in parts of the region [104]. According to Al Ubaydli [105], based on calculations of the International Monetary Fund, energy subsidies accounted for a substantial share of national GDP in all GCC countries in 2013 and continued to be significant even after several subsidy reductions across the region in 2016 and 2018. This, in turn, impedes efforts for an energy transition. Due to differences in the level of subsidies, retail prices of fuels and electricity vary considerably across the region; this is illustrated in Table 10 for the case of automotive fuels.

Despite reluctance to remove subsidies, the reform of fuel subsidies is mentioned as a climate change mitigation measure in Egypt's NDC [106]. Moreover, a reform of energy subsidies has already been conducted in some of the countries in the region. In 2010, Iran became the first oil-producing country to implement such a reform, dramatically increasing fuel prices, which resulted in a decrease in consumption of up to 20% for diesel and gasoline [107]. As an indication of the increased cost, diesel prices jumped from USD 0.02 to USD 0.37 per litre [108]. Saudi Arabia also implemented a reform of fuel subsidies in 2015, which resulted in an increase in cost of about 50% [109]. The most promising leap forward has been indicated by the United Arab Emirates, which aims to eliminate fuel subsidies; it would be the first country in the Middle East to completely remove these.

Although some countries have moved forward with a reform of fuel subsidies without major protest, others face serious opposition. Energy prices in Kuwait, for instance, at the end of 2015 were 20% lower than the average across Gulf countries [107]. In September 2016, a subsidy reform in Kuwait led to an increase in gasoline prices in the range of 4283%; even though this was accompanied with monthly compensation of 75 litres per month, protests within the parliament eventually led to the dissolution of the body [28]. In the analysis by Shehabi [111], it is argued that the Kuwaiti energy pricing reform is unsustainable and a complete phase-out of energy subsidies is required to ensure fiscal stability. To avoid negative impacts on the cost of living and industrial expansion, the author suggests that an energy pricing reform should be accompanied with associated mitigation measures and investments that aim towards job creation, training of a skilled workforce and minimisation of potential sectoral losses.

TABLE 10. Recorded transportation fuel prices across the EMME region in November 2018

Country	Gasoline (USD/litre) [110]	Diesel (USD/litre) [110]
Bahrain	0.53	0.43
Cyprus	1.46	1.55
Egypt	0.43	0.31
Greece	1.75	1.60
Iran	0.29	0.07
Iraq	0.83	0.63
Israel	1.76	1.68
Jordan	1.50	0.88
Kuwait	0.35	0.38
Lebanon	0.88	0.69
Oman	0.61	0.68
Palestine	1.71	1.62
Qatar	0.58	0.57
Saudi Arabia	0.54	0.13
Turkey	1.22	1.18
United Arab Emirates	0.67	0.78

Note: Data do not include Syria.

A reform of fuel subsidies across the region removes existing market distortions, discourages overconsumption [105] and levels out to some extent the playing field for clean energy technologies. Shehabi argues that due to the political complexity surrounding such a process, subsidy reforms should be enforced within a broader package of restructuring and addressing energy, the environment, economy, society and institutional infrastructure [112]. It should be noted that the European Union encourages its Member States to phase out fuel subsidies as well [113].

5.3.2. Electricity trade and power sector reform

A key measure that could facilitate the decarbonisation efforts of countries in the region is the operation of regional electricity markets, as this would allow exchange of electricity that can enable integration of less flexible generation technologies, such as nuclear power and large shares of variable renewable energy technologies. It would also help alleviate to some extent the use of expensive generation infrastructure, as the peak demand occurs in different periods across the region [114].

There are a few examples of interconnections and electricity trade in the EMME region, with mixed results. A high-voltage network connecting the GCC countries has been fully operational since 2011, but it is currently underutilised [115]. Bilateral power purchase agreements have been established to a certain degree, but significant further cost savings can be achieved up to 2038 through increased electricity trade between the relevant countries [116]. In addition, there are plans to interconnect the GCC grid to that of Iraq, whose power infrastructure has been heavily damaged by the past two decades of war [117]. This interconnection will assist Iraq in meeting its domestic electricity demand.

Another example is the EIJLLPST interconnection that was initiated in 1988 between Egypt, Iraq, Jordan, Syria and Turkey, and has since grown to include Libya, Lebanon and Palestine. Despite a comprehensive interconnection agreement signed in 1996, trade among the EIJLLPST countries has been modest. Primary obstacles to electricity trade are lack of surplus generation capacity, lack of a harmonised regulatory framework, limited access to national transmission networks and the fact that trade is generally limited to a single government-owned entity in each country. Further, in some areas the transmission system is not synchronised, necessitating isolated generation to facilitate trade. For example, when Syria exports energy to Lebanon, part of the Lebanese grid must be disconnected from the main national grid.

Regardless, the EIJLLPST interconnection has brought significant benefits. For example, Jordan can rely on its interconnections with Egypt and Syria during system emergencies, and Jordan, Egypt and Syria share spinning reserves. By minimising spinning reserve requirements in this manner, generation is operated closer to its optimum output level, thus improving efficiency and reducing fuel and maintenance costs. Opportunities for short-term trades have also been realised through the diversity of demand. Syria's daily electricity demand experiences a peak in winter, while in Egypt and Jordan this occurs in summer. Thus, Syria can make sales to Egypt and Jordan during summer when it has surplus generating capacity, and Jordan and Egypt can make sales to Syria in winter when they have surplus generating capacity.

Apart from interconnections, liberalisation of national electricity markets can make the operation of a regional market a priority in the future [115], as it can remove potential national market distortions, making regulations across the region more homogeneous. Examples from the region demonstrate the progress achieved so far on this issue. Jordan has been a pioneer in the Middle East and North Africa (MENA) region in restructuring its power market. Following relevant legislation in 1996, the state-owned monopoly of generation and transmission ended [118], and in 2001 the Electricity Regulatory Commission was established to regulate electricity prices. Shortly after, independent power producers joined the market, thus increasing competition. Turkey has pursued a similar restructuring, ultimately managing to establish a competitive electricity market by 2006, while by 2010 roughly 400 private entities were operating within it [119]. Similarly, in Oman all generation assets are privately owned, with the exception of the Rural Areas Electricity Company [114]. In Abu Dhabi, a decision to proceed with electricity sector reform was taken in 1996 and relevant legislation was passed in 1998, breaking the monopoly of the Water and Electricity Department. The entity was broken down into four generation, one transmission and two distribution companies. In the years that followed, assets were sold to private investors, opening up the market to independent power producers, while in 2009 the Emirates Nuclear Energy Corporation made an entry as a market participant [120]. Furthermore, the electricity law of 2015 aimed towards the unbundling and liberalisation of the power sector of Egypt [70]. More recently, a decision was taken in 2018 to proceed with a reform of the electricity sector in Israel, moving away from a vertical monopoly and increasing competition in electricity supply [121].

5.3.3. Carbon pricing

Besides incentives that promote certain technology options, a policy tool that is used as a counter-incentive for the use of fossil fuel technologies is carbon pricing. It is widely accepted among economists that no serious decarbonisation effort can succeed without the implementation of carbon pricing schemes that apply to most economic sectors and set a price for carbon emissions sufficiently high to ensure substantial emission reductions in line with the Paris Agreement.

In the European Union, the Emission Trading System (ETS) has been implemented, which is basically a carbon market that regulates emissions from energy-intensive installations (power sector and heavy industry) [122]. Despite a slow start with many allowances being handed out for free and several exemptions, currently the EU ETS is considered an important and effective ingredient of the EU's decarbonisation policy. Hence the EU Member States of the EMME region, Cyprus and Greece, already have a system in place that penalises GHG emissions for the energy-intensive portion of the economy. Nonetheless, the EU ETS does not cover other crucial sectors such as road and maritime transport, and this could emerge as an option in the near future or would require separate carbon pricing schemes for these sectors. The possibility of imposing a carbon tax on fossil fuels across all sectors is mentioned in the recent Integrated NECP of Cyprus [30]. Even though carbon taxation is not yet implemented in any of the other EMME countries, Saudi Arabia is considering the introduction of a carbon trading system, in an effort to diversify its energy supply and reduce GHG emissions [123].

Carbon pricing is an essential ingredient of an ambitious low-carbon strategy and will have to be considered seriously throughout the EMME region – alongside removal of fossil fuel subsidies – in the coming years as a matter of priority. However, as carbon pricing is a horizontal measure that affects all strata of the population, its implementation should be designed in a way that is socially balanced and does not adversely affect low-income households. Generated revenues can in turn be used to finance achievement of other national policy goals and Sustainable Development Goals (SDGs). Key SDG investment areas include health, education, food security, energy, water and sanitation, transport, telecommunications as well as emergency aid. In most national contexts, it is estimated that more than 50% of the relevant financing requirements need to be covered by public funds [124]. SDG investments will improve infrastructure, education, health services and tackle poverty, leading to economic growth and potential additional public revenues. Carbon pricing, coupled with fossil fuel subsidy reforms as mentioned in Section 5.3.1, could have a synergistic effect by implementing effective climate policy and acquiring the necessary funds for the achievement of the sustainable development agenda. As an example, Egypt would be able to finance its entire public SDG needs if fossil fuel subsidies were removed. Implementation of carbon prices consistent with the 2oC target would have the same enabling effect for both Egypt and Syria [124].

5.3.4. Information and dissemination programmes

To attain global climate targets, wide-ranging measures are necessary that can have a drastic impact on national economies, affecting industry, businesses and consumers. In this regard, social acceptance of the relevant changes requires active participation of all relevant stakeholders in the decision-making process. In line with requirements of the EU Regulation on Governance of the Energy Union [63], the submission of the NECPs of Cyprus and Greece had to be preceded by public consultation, in which the proposed measures of the authorities were presented, discussed and scrutinised. Member States were expected to take into account the feedback provided on their final submission, while a dedicated section on the consultation process and the comments provided by the stakeholders is available in each EU country's NECP [30], [31]. Similarly, raising awareness of the importance of energy efficiency is a necessary measure for all relevant policy initiatives (see e.g. [77]).

The importance of dissemination as regards the national energy and climate policy is highlighted in numerous NDCs to the UNFCCC. For instance, in the case of Jordan, its NDC mentions several times the importance of awareness campaigns on a range of aspects – from the promotion of solar water heaters to the importance of energy efficiency measures, the potential for electricity generation from nuclear energy and incentives for renewable energy technologies [125]. Qatar's NDC also recognises the importance of public awareness of sustainable development practices. As such, programmes focus on educating the public on energy efficiency concepts as well as promoting environmental values. [126]. Other NDCs that recognise awareness as a means to promote more sustainable practices include those of Egypt, Kuwait, Lebanon, Palestine and Syria [127]. In Egypt, the most recent electricity price and subsidy reform was accompanied by a thorough communication strategy with public announcements that increased the transparency of the process and awareness of the necessity of reform, to maximise public acceptance [128]. In the United Arab Emirates, a National Environmental Education and Awareness Strategy has been introduced for the period 201521. This aims at improving environmental awareness and encouraging relevant action by individuals and stakeholders across all strata of society [129].

It is important for EMME countries to exchange ideas about such awareness and information initiatives in order to identify best practices that can promote decarbonisation and broader sustainable development objectives in the region.

5.4. Infrastructure investments

As net-zero-carbon energy is expected to be a dominant part of national energy systems in the near future, countries need to invest in infrastructure that can accommodate clean energy systems with sufficient flexibility. This section offers an overview of ongoing investment initiatives.

5.4.1. Zero-carbon energy technologies

Several investments in green technologies are planned across the region in an effort to diversify the energy mix and curb GHG emissions. In the United Arab Emirates, the Dubai Green Fund of USD 27.2 billion has been created to support clean energy projects, so as to achieve the Clean Energy Strategy's goal of reaching 25% clean energy consumption by 2030 [130]. Similarly, in Egypt's Integrated Sustainable Energy Strategy to 2035, renewable energy technology investments are expected to reach 31 GW of solar PV, 21 GW of wind and 8 GW of concentrating solar power (CSP) [70].

A renewable energy technology that is often overlooked due to its relatively higher cost is CSP. However, since CSP is typically coupled with thermal energy storage, a direct cost comparison with that of solar PV and wind power is difficult. CSP capacity in the

EMME region is currently limited; operational capacity by the end of 2018 was only 20 MW in Egypt, 50 MW in Saudi Arabia and 100 MW in the United Arab Emirates [131], while a 50 MW facility started operations in Kuwait in early 2019 [132]. Enabled by the considerable decrease in cost experienced in the last few years [35], recent tenders are reported at highly competitive prices – an example is a 700 MW CSP facility in the United Arab Emirates, which has been awarded at a tariff of USD 0.073/kWh [131]. At such a cost range and considering the cost reduction trends of the technology in recent years [133], it is plausible that CSP investments will grow in the region in the future, especially due to the integration of thermal storage, which makes CSP a dispatchable renewable generation technology. Some small CSP investments are also foreseen in the NECPs of Cyprus [30] and Greece [31].

As outlined in previous paragraphs, the heavy reliance on hydrocarbons either as a fuel or as an export commodity renders the region's rapid and deep decarbonisation unlikely in the immediate future. There is however some scientific consensus that liquid fuels will be required one way or another to decarbonise industry (especially high-temperature processes), shipping, aviation and heavy freight transport [134]. The discussion on the role of hydrogen is gathering pace, e.g. [135], [136], and the EMME is placed rather favourably to be at the forefront of the transformation: Given the abundance of solar radiation, costs for green hydrogen (i.e. using renewable electricity for water electrolysis) are significantly lower compared to other regions in the world [137], while transportation, storage and treatment needs of hydrogen are overlapping to some degree with natural gas, with which the region has much experience. Blue hydrogen (i.e. produced via methane steam reforming combined with carbon capture and storage [CCS]) also requires the expertise and infrastructure that already exist in the region, but the viability of CCS as a long-term solution is yet to be established [138] (see paragraph 5.4.2).

As outlined in Section 4.2.4, an alternative carbon-neutral technology pursued by some countries in the region is that of nuclear power. Egypt envisions nuclear power plant investments in the range of 45 GW by 202526 [70]. Iran has operational nuclear capacity of 1 GW and plans to increase it by another 2 GW by 202325, while one nuclear reactor of 1.3 GW has become operational and three others with a capacity of 4 GW are under construction in the United Arab Emirates at an initially planned investment cost of USD 20 billion [28]. There is ongoing construction of a 4.5 GW nuclear power facility in Akkuyu, Turkey [139]. Saudi Arabia at some point planned to develop 18 GW of nuclear power capacity by 2032, but more recent national plans aim at 3 GW by 2030 [28], while firm numbers are yet to be defined. Despite the plans of several countries in the region, the level of public support varies; some governments may find it difficult to pursue nuclear energy programmes. To gain public acceptance, international co-operation should be strengthened, mobilising funding from national governments and international institutions. The next generation of technologically advanced reactors, and especially small modular reactors, requires an international safety regime overseen by an international regulator, an innovative and effective regulatory framework and a public-private partnership that can provide the necessary funding [140].

5.4.2. Fossil fuel technologies and carbon capture utilisation and storage

Despite increased research, development and integration of clean energy technologies within national energy systems, energy planning in the region does not seem to exclude further development of fossil fuel technologies. As a result of low coal prices, several countries are interested in investments in coal-fired power plants [28]. For instance, Egypt plans to invest up to 14 GW by 2030 and 23 GW by 2035 in high-efficiency, low-emission coal facilities [70]; this is in contrast to the plan of Greek authorities to completely phase out lignite-fired thermal power plants by 2028, although they currently contribute to approximately 15% of the national power generation mix [31].

The continued dependence on fossil fuels in the region has sparked interest in the use of carbon capture, utilisation and storage (CCUS) technologies. These could however encourage further reliance on fossil fuels, leading to increased GHG emissions. The NDC of Saudi Arabia mentions that it would promote this alternative, while its initiative would capture up to 1 500 tonnes of CO_2 daily [141]. The country had planned to develop a pilot project, in which CO_2 would be used for enhanced oil recovery and therefore partially sequestered in oil reservoirs. Similarly, the first commercial-scale facility of the region was developed in the United Arab Emirates to capture CO_2 emissions at a steel manufacturing facility and then use the captured CO_2 for enhanced oil recovery [142]. Other countries of the region that mention CCS in their INDC submissions are Bahrain [143], Egypt [106], Iran [144] and Iraq [145]. Table 11 provides a brief overview of existing CCS facilities in the EMME. Another notable future project is the Jubail CO_2 plant in Saudi Arabia, in which captured CO_2 will be used for methanol and urea production [146].

TABLE 11. Major operational CCS facilities in the EMME region

Location	Company	Industry type	Capacity (kt CO_2/yr)	Use	Storage
Ras Laffan, Qatar	Qatar Petroleum	Oil	2 100	Enhanced oil recovery	Oil reservoirs
Uthmaniyah, Saudi Arabia	Saudi Aramco	Natural gas processing	800	Enhanced oil recovery	Oil reservoirs
Abu Dhabi, United Arab Emirates	Emirates Steel & Abu Dhabi National Oil Company	Steel production	800	Enhanced oil recovery	Oil reservoirs

Source: [146], [151], [152].

In line with pledges of governments, the role of national oil companies (NOCs) is significant for such investments. Many NOCs in the region aim for reduction of GHG emissions in their operations and through new technologies developed via research and development. For instance, Saudi Aramco has reduced its gas flaring via the installation of gas recovery systems [147], while it has invested in carbon capture, utilisation and storage (CCUS), using CO_2 emissions for enhanced oil recovery at its Uthmaniyah oil field [148]. In an effort to secure the market potential of oil in the transport sector, mobile carbon capture applications at the vehicle level are being tested by Saudi Aramco [149]; a 50% reduction in CO_2 emissions has been set as a target through this technology. Similarly, the Abu Dhabi National Oil Company (ADNOC) has developed a sustainability strategy for 2030, which aims at a 25% reduction of the company's GHG emissions intensity by 2030 by reaching 5 million tonnes of CO_2 capture, continuing efforts towards its long-standing zero intentional gas flaring policy and establishing mangrove plantations [150].

The substantial proven reserves of natural gas and continued dependence on fossil fuels of several countries across the region offer an opportunity to diversify away from oil and gas exports by investing in hydrogen. Blue hydrogen production through steam reforming of natural gas, coupled with CCS, can assist in the development of a hydrogen economy and contribute to the future transition to zero-carbon fuel production. However, since steam reforming generates CO_2 emissions, blue hydrogen production is also dependent on the cost-effective development of CCS [41].

5.4.3. Regional grid infrastructure

An important enabler of renewable energy technology investments is the increased capacity of electricity interconnections across the region that can enable electricity exchange, especially in periods of imbalance between domestic electricity supply and demand. As already mentioned in Section 5.3.2, there is a high-voltage network connecting the GCC countries which is underutilised; meanwhile, the EIJLLPST project connects the electrical grids of Egypt, Iraq, Jordan, Libya, Lebanon, Palestine, Syria and Turkey. The importance of such interconnections grows as the shares of intermittent renewable energy increase in the coming years.

A recent development in the region is the launch of the EuroAsia Interconnector, an EU-supported project scheduled to connect Israel with Cyprus and mainland Greece with a capacity of 2 GW [32]. Even though the project has been facing delays and obstacles [153], the first phase of the project will have a capacity of 1 GW and is projected to be operational at the end of 2023 [30]. A similar proposed project that could connect the grids of Egypt, Cyprus and Greece is the EuroAfrica Interconnector; this sub-sea cable also has a planned capacity of 2 GW [154]. As mentioned in Section 5.3.2, despite the significant economic incentives, limited electricity trade occurs between countries of the region. Nonetheless, it has been estimated that a fully integrated electricity grid across the region could reduce necessary investment costs by 35% [155]. As such, suppliers and consumers in the region could benefit from enhanced development and operation of a regional grid. In fact, Jordan is already moving forward with this prospect, as it intends to link to the GCC grid via an interconnector with Saudi Arabia, which in turn has plans to invest in an interconnector with Egypt [28]. The interconnection between Iraq and the GCC grid will also assist in tackling the issue of Iraq's unreliable electricity supply [117].

5.4.4. Storage technologies and smart grids

Even with an enhanced regional power grid, the increased deployment of variable renewable energy technologies in the electricity systems of the region will gradually increase the necessity for investments in storage technologies. In Jordan, a 12 MW solar PV project coupled with a 12 MWh lithium ion battery has been signed [131] and a 30 MW/60 MWh pumped hydro storage project, with an estimated cost of USD 40 million, was opened for tenders in 2018 [156]. In Lebanon, three individual solar PV plus battery storage projects with capacities between 70 and 100 MW have been auctioned, while in Dubai a 1.2 MW/7.2 MWh sodium sulphur storage system is being tested at the Mohamed Bin Rashid Solar Park and the installation of another 1.12 MW/8 MWh lithium ion battery has been pushed forward [131]. In Israel, the government has approved a quota of 800 MW of pumped storage [157], while an auction for 168 MW of solar PV projects with storage has been completed [158]. In the Planned Policies and Measures scenario of the Cypriot NECP, investments in storage technologies are not envisioned before 2030, but a pumped hydro facility of 130 MW/1 040 MWh is considered and its operation is projected by 2033; considerable investments in lithium ion batteries are also planned in the period 203140, with deployed capacity reaching 655 MW/2 620 MWh [30]. In the objectives achievement scenario of the Greek NECP, in which all relevant energy and climate targets are achieved, new central storage capacity, consisting of pumped hydro storage and batteries, is projected to increase from 0.7 GW in 2020 to 1.4 GW by 2030; parallel studies have estimated the required storage investment needs at EUR 500 million [31].

Managing energy demand through the introduction of key technologies in generation and distribution would advance the integration of renewable energy in the power sector. Such technologies include smart grids and smart meters. Dubai plans to invest USD 1.9 billion between 2014 and 2035 under its smart grid strategy [159]. When rolled out to end-use sectors, smart meters – a subsystem of smart grids – enable direct benefits, such as economic returns to both governments and consumers, and indirect benefits, such as load shifting during peak demand hours.

5.4.5. District heating and cooling

Infrastructure that offers the potential to reduce GHG emissions includes investments in district heating and cooling infrastructure as it is a more efficient method of heating or cooling cities, while it offers an option for driving the process with carbon-neutral energy in the future. As energy consumption for cooling is very high in the region, the potential for district cooling has been recognised in several countries. For instance, Bahrain Bay's district cooling plant was built to provide cooling for 1.5 million square meters (m2) of floor area [160]; and district cooling has been identified as an integral part of Dubai's Demand Side Management Programme [161]. A projected increase in population living in urban centres, rising electricity prices and warming temperatures are estimated to lead to growth of the district cooling market in the Middle East from USD 7 billion in 2018 to USD 14 billion by 2025 [162]. The opportunities presented by densely built residential or commercial areas will be taken up by other countries of the EMME region. The EU's Directive on Energy Efficiency [163] promotes the development of district heating and cooling, while recognising the importance of improving the energy efficiency of transmission and distribution networks; NECPs of Cyprus and Greece include the development of a few district heating and cooling facilities.

5.4.6. Digitalisation

Digitalisation can enhance the connectivity, efficiency and reliability of energy systems, contributing to the clean energy transition [164]. In electricity markets, smart demand response can contribute to system flexibility. Smart grids can allow further integration of variable renewable energy technologies by better matching supply with demand. Electrification of the energy system will further enable the process and intensify the benefits of digitalisation. For instance, smart charging of EVs can promote charging during periods of low demand and high supply, providing additional system flexibility.

The business potential of digital technologies is growing in the EMME region. Efforts to increase energy efficiency and incorporate larger shares of renewable energy will continue to provide a boost. It is estimated that the broader MENA region's smart lighting market will grow to USD 2.1 billion in 2023, while smart-grid investments will reach USD 17.6 billion by 2027 [165]. Digital optimisation of the power sector in the region can increase profits by 2030% [166]. In the transport sector, digitalisation and automation can have a positive impact on safety and efficiency. Ride-sharing enabled by mobile applications can improve efficiency and create new business opportunities – an example is the Careem application, which is widely used in several EMME countries and allows individuals to generate income by offering rides with their private vehicles [167]. Nonetheless, a preference for car ownership and unwillingness to participate in ride-sharing could present obstacles to the implementation of such a scheme in some countries of the region [168]. Similarly, use of automated vehicles can achieve fuel savings of 225% and potentially up to 40%, but could be impeded by the preference to drive, legal and ethical issues in collision cases or concerns regarding privacy and cybersecurity [169].

Despite the identified potential, there are obstacles to increased digitalisation in the region, among which are lack of infrastructure, regulation and digital skills [170]. Besides the obvious investments needed in information and communication technology infrastructure, conditions for the formulation of digital businesses should improve with the establishment of a favourable regulatory framework [167].

At the same time, digitalisation may be fraught with risks such as the danger of cyberattacks. In 2012, the "Shamoon 1" virus incapacitated 30 000 computers of Saudi Aramco, forcing the company to shift to paper and telephone operations for several weeks [164]. As such, digital resilience should be an integral part of technology research and development, while it should be accounted for during policy design. Also, the use of energy technologies enabled by artificial intelligence requires consideration of cultural factors that may lead to unintended system behaviours [169].

5.5. The impact of COVID-19 on energy planning and related stimulus packages

The COVID-19 pandemic has disrupted global economic activity, affecting national economic output across the EMME region (Table 12). The lockdown measures and restrictions on economic activity caused an unprecedented price shock for most globally traded commodities, among which are hydrocarbons [171]. Oil prices reached the lowest level in more than 20 years in April 2020 and remained at these levels for a period because of global economic contractions, especially due to sharp declines in the use of road vehicles and aviation.

Governments rushed to provide immediate relief to industries and households hit by the pandemic. This caused serious fiscal pressures around the world. Countries running budget deficits and fossil fuel exporters, like many EMME economies, which saw their fuel export revenues collapse, have been particularly stressed [173]. Reduced revenue and increased expenditure led to a rise in national government debt for most EMME countries (Table 12).

TABLE 12. Impact of COVID-19 pandemic on national GDP and government debt in EMME countries

	GDP, constant prices (% change)			General government gross debt (% change)		
	2019	2020	2021	2019	2020	2021
Bahrain	2.0	-5.4	3.3	102.1	132.9	129.4
Cyprus	3.1	-5.1	3.0	94.0	118.2	113.0
Egypt	5.6	3.6	2.5	84.2	90.2	92.9
Greece	1.9	-8.2	3.8	184.9	213.1	210.1
Iran	-6.8	1.5	2.5	47.9	42.8	36.6
Iraq	4.5	-10.9	1.1	47.7	81.2	69.7
Israel	3.4	-2.4	5.0	60.0	73.0	78.3
Jordan	2.0	-2.0	2.0	78.0	88.5	91.2
Kuwait	0.4	-8.1	0.7	11.8	11.5	13.7
Lebanon	-6.7	-25.0	n/a	174.3	154.4	n/a
Oman	-0.8	-6.4	1.8	60.0	81.1	71.3
Palestine	1.4	-11.0	5.7	34.5	47.3	47.9
Qatar	0.8	-2.6	2.4	62.3	71.8	59.8
Saudi Arabia	0.3	-4.1	2.9	22.8	32.4	31.0
Syria	n/a	n/a	n/a	n/a	n/a	n/a
Turkey	0.9	1.8	6.0	32.6	36.8	37.1
United Arab Emirates	1.7	-5.9	3.1	26.8	38.3	37.1

Source: [172].

5.5.1. The push for green stimulus recovery packages

After the initial relief provided to crucial economic sectors, and while vaccinations are gradually allowing a return to normality, the attention has been steered to post-pandemic economic recovery. Since spring 2020, global economic support for relief and recovery from the pandemic has risen to very significant levels – but as regards the conformity of such stimulus measures with climate-compatible growth and broader sustainability objectives, the picture is mixed, as indicated by the "Energy Policy Tracker" [174] and the "Greenness of Stimulus Index" [175]. Many stimulus measures lead to widespread increase in consumer demand, which gives rise to higher GHG emissions.

At the same time, the use of financial resources to cope with the short-term impacts of the pandemic presents financing hurdles for long-term decarbonisation efforts. Although renewable energy investments seem to have been hit less by the pandemic than those in fossil fuels, scarcity of financial resources is likely to pose barriers to the energy transition required for climate stabilisation.

The CO_2 emissions reduction in 2020 is probably unprecedented because of the strong economic downturn. However, as this drop in emissions is not due to structural changes, the COVID-19 pandemic is expected to have little effect on estimates of the 2030 GHG emission levels consistent with a least-cost pathway in line with the Paris Agreement goals. A similar rate of decrease would need to be maintained for decades in order to achieve the 1.5°C warming limit [176].

While the COVID-19 crisis has temporarily foreshadowed the mounting climate emergency, it provides an opportunity to act collectively and with a common purpose. To do that we need to ensure that the short-term COVID stimulus and recovery plans are in line with long-term climate and sustainable goals [177]. Leaders of international organisations have stressed the importance of adopting green economic stimulus policies in line with the United Nations Sustainable Development Goals and the Paris Agreement in Climate Change, as greener economies are more resilient to climate change, social unrest and epidemics [171], [177]–[179]. Transitioning from fossil fuels to a sustainable low-carbon economy requires commitments to public spending and pricing reforms over a period of at least 510 years [180], hence there is a trade-off between short-term growth-enhancing measures and decarbonisation objectives.

Hepburn et al. [181], IEA [171] and IRENA [177] identified priorities for a green post-pandemic stimulus that can boost employment and climate policy goals: clean physical infrastructure (e.g. renewable energy and modernised electricity grids), building efficiency retrofits, investment in education and training, clean energy R&D and natural climate solutions. Out of these, measures that can induce private investments may be preferable at times of severely limited public finances in most EMME countries. Furthermore, political acceptance and economic viability of green stimulus packages may be enhanced by giving priority to “green welfare expansion” measures, such as targeting subsidies for energy renovations, solar panels or public transport to low-income households, and excluding from subsidies nonessential high-carbon-emitting products like conventional cars [182].

The International Energy Agency’s Sustainable Recovery Tracker provides insights on national sustainable recovery policies from more than 50 countries [183]. Information for some EMME countries is available in this database. For instance, Greece has identified total investments of USD 4.9 billion, mostly focusing on energy upgrades of the building stock, installation of electricity storage systems, installation of charging points for EVs, additional island grid interconnections and improvements in the electricity transmission and distribution networks. In the case of Israel, USD 4.8 billion has been set aside to promote renewable (solar and wind) energy projects, improve energy efficiency in urban settings and enhance the electricity transmission and distribution networks. Similarly, Turkey plans to invest USD 9.5 billion in electricity distribution networks over the period 2021-2025. On the other hand, since the beginning of the pandemic Saudi Arabia has committed at least USD 5.9 billion that directly or indirectly support the fossil fuel industry, mainly through investments in gas infrastructure and further electricity subsidies [174].

Beyond investments and market-based instruments, the pandemic offers a number of opportunities for changes in social behaviour that could accelerate sustainability transitions [184]. The economic crisis caused by the pandemic opens several avenues for research on the interaction of economic, behavioural, institutional and technological factors in the short and long term.

5.5.2. The need for economic reform and diversification in net fossil fuel exporters of the EMME region

The alignment of post-pandemic stimulus with the energy transition in major economies across the world reinforces the need for economic diversification, energy subsidy and carbon pricing reforms in EMME countries. This is easier to be implemented in energy importers, but such reforms are harder for energy exporters due to the pressure on government finances, because of the collapse of export revenues and the broader economic recession.

Dependence on revenues from fossil fuel exports for national fiscal balance exposes several EMME countries to considerable vulnerability. According to the Carbon Tracker Initiative, in a low-carbon scenario Bahrain and Oman are among the most vulnerable economies, followed Iraq, Kuwait and Saudi Arabia; Iran, Qatar and the United Arab Emirates are in the middle of the vulnerability scale, while Egypt is estimated to be the least vulnerable of the EMME fossil fuel exporting countries [185].

The effort required for an economic diversification is also affected by the conditions of the respective national economies before the pandemic. Some of the countries of the region increased their dependence on fossil fuel export revenues or reduced their foreign exchange reserves in the years that followed the 2014 oil price collapse; Bahrain, Iraq and Saudi Arabia fall into both of these categories, making it more difficult to diversity with the current conditions [186]. On the other hand, during the same period Oman and the United Arab Emirates, not only increased their foreign exchange reserves, but also reduced the contribution of fossil fuel export revenues to the total export revenues of their economies.

An analysis taking into consideration the break-even oil prices of net exporting countries, their political stability and capacity to diversify away from oil exports, attempts to estimate how the energy transition will impact key net oil exporters [186]. The diversification capacity is estimated to be high for Qatar and the United Arab Emirates, moderate for Kuwait, Oman and Saudi Arabia and weak for Iran and Iraq. High-cost oil producing countries with low capacity to diversity and low political stability, such as Iraq, are most at risk. On the other hand, low-cost oil producers, such as Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates, have the political stability, institutional infrastructure and financial resources needed to survive the energy transition and allow for a smoother diversification of their economies.

5.6. Gaps identified

Based on the review presented in the previous sections, a number of policy gaps have been identified. This section provides an overview of key policy aspects that will affect the degree and success of decarbonisation of the EMME region.

- Disparities in the design and implementation of policies are largely due to the different positions and international partnerships of individual EMME countries. As EU Member States, Cyprus and Greece have to abide by EU energy and climate policy that is set at the regional level. Other EMME countries design and implement energy policies primarily at the national level and with their national or economic partners. For example, the Arab Energy Efficiency Guidelines, adopted by Arab states in 2010, encouraged the development of national energy efficiency action plans, while other nations (GCC countries, Israel and Iran) followed their own individual initiatives [28]. This makes it difficult to deal with climate change in the region in a co-ordinated and effective manner. Even though not one size fits all, increased co-ordination of regional climate mitigation efforts may offer synergies and reduce the overall cost of achievement of climate targets.
- Low-carbon investment targets for the power sector are declared in the official plans of all countries, as regional power sectors are vertically integrated to varying degrees and hence sector targets can be defined and implemented at a large scale and a fast pace. Even in power generation, however, many countries are only beginning to translate the plans and targets to actionable and concrete policies and regulations. Conversely, in the utility-scale market segment, renewable energy auctions have led to success in the deployment of solar PV, wind and CSP projects in some countries. In the small-scale solar PV market segment, progress has been slow in most non-EU EMME countries due to several challenges such as subsidised fuel pricing and lack of low-cost financing. Establishment of distributed energy systems,

a transformation of power system operation and the existence of assistive policy, regulatory and market frameworks are needed to support further investments in low-carbon technologies [187]. Moreover, decarbonisation objectives in energy end-use sectors are minimal.

- Transport is a major contributor to GHG emissions in the region but has been largely overlooked from a low-carbon policy perspective. Apart from the EU Member States Cyprus and Greece, no other country of the region seems to have a comprehensive policy addressing energy efficiency in transport [28]. Several countries recognise that sufficient focus should be given to the sector, as indicated in their NDC/INDC submissions. Iraq, Israel, Jordan, Oman, Palestine, Syria and Turkey define transport-related measures in their plans, mainly identifying the need for the promotion of public transport (Table 15).
- Promotion of renewable energy technologies in buildings is low in large parts of the region. In their NECPs, Cyprus and Greece include measures that encourage the adoption of solar water heaters and heat pumps [30], [31]. Jordan and Lebanon have targets for the adoption of solar water heaters, but such a policy does not seem to exist in the rest of the region [28].
- Even though energy efficiency is mentioned as a major component in nearly all NDC/INDC submissions of EMME countries, implementation of policy measures that would promote relevant practices does not seem to be very strong. Legislation that regulates energy performance standards for air conditioners and other electric appliances exists, but adoption of building code standards is minimal in some of the countries [80]; Iraq and Palestine, for instance, only have voluntary energy efficiency regulations for buildings [82]. Laws and bylaws have been implemented for aspects of energy efficiency measures in some countries, but by 2016 Kuwait, Oman and Saudi Arabia had no such policy measures [82]. Obviously, the existence of fossil fuel subsidies does not help the uptake of energy efficiency investments.
- Measures that focus on reducing emissions and improving efficiency in industry are negligible in certain countries of the EMME region. Across the Arab states of the region, only Jordan, Lebanon and Palestine have industry-specific energy efficiency targets defined [82]. In the GCC, the energy intensity in the industrial sector requires immediate measures, yet none of the countries has implemented industrial energy efficiency, while energy intensity targets for the sector are absent [28]. Beyond energy efficiency, direct process emissions from the region's cement, steel, aluminium, chemical and refining sectors require policy frameworks that would support mitigation via measures like CCUS [188].

- Many countries in the region rely on oil and gas exports for their fiscal revenues, while the economy is heavily reliant on the oil and gas industry. At oil prices of around USD 40 per barrel, which prevailed in the international markets after the COVID-19 pandemic, no EMME country except Qatar could balance its budget.[5] Considering the growing post-pandemic uncertainty as to the future global demand for fossil fuels, greater efforts towards an economic diversification are necessary for increased economic resilience in such states.
- Other than the inclusion of energy-intensive industries of Cyprus and Greece in the EU ETS, no other carbon markets exist in the EMME region.
- There is very limited information on energy poverty among the population of the region.
- Despite the availability of interconnection projects, electricity trade among the interconnected countries has been modest. The existing interconnection projects do not appear to be fully functional. A related and unexploited opportunity is in natural gas trade.

As energy-related GHG emissions are driven by demand of societies for energy services, reducing energy demand is key for decarbonisation. However, there is little, if any, research into lifestyle changes, which could shift societies away from past carbon-intensive socio-economic development paths. This becomes particularly evident in light of the recent experience with the COVID-19 pandemic and low-energy intensity practices adopted in response to it.

5. "The end of the Arab world's oil age is nigh". *The Economist*, 18 July 2020.

6. Policy proposals

Since the EMME region is expected to experience strong adverse impacts of climate change, it is in the interest of all countries to contribute to the international efforts to mitigate it. Achieving the goals of the Paris Agreement is key for this purpose but also poses an enormous challenge for the region, as highlighted in Table 9 and Figure 18. In this context, all EMME countries need to adopt ambitious climate strategies and be ready to share fairly the decarbonisation burden. Regional cooperation is crucial for the success of such an objective; this underlines the need to conduct region-specific thematic policy assessments that will highlight weaknesses and identify opportunities.

The need for ambitious decarbonisation policies in the region is illustrated by the large gap between what countries have declared in their NDCs and what is necessary for aligning with the objectives of the Paris Agreement. Projected growth in population and income levels in the coming decades is going to pose additional challenges. A path to low-carbon economies requires interventions both to mitigate the demand for energy and to satisfy this demand with energy sources having a low or net-zero life-cycle carbon footprint. Above all, it requires political willingness to express a vision for a low-carbon economy, which can be fulfilled through appropriate clean energy transition plans that include actionable policies for the medium and long term. The EU Green Deal that was announced in December 2019 intends to align most economic development priorities in Europe with the decarbonisation imperative and can serve as an example. Regional co-operation can greatly contribute to this objective through the exchange of technical expertise, best practices in policy implementation and mutual capacity building.

The energy sector cannot be considered in isolation from the broader socio-economic systems. Interactions between the energy sector, the economy, society and environment are fundamental for energy transitions. Indeed, a successful energy transition requires a systems approach that goes beyond the energy technology and policy layers to incorporate the challenges across all layers of the transition (economy, society and environmental systems) and the dynamics between them. This approach needs to address the systemic changes needed in our socio-economic structures upon which this transition relies. This means that policies to scale up deployment and integrate higher shares of zero-carbon energy need to be supported by cross-cutting enabling policies such as appropriate industrial, skills and labour, social and financial policies – all formulated from a holistic perspective. Once all the different components of these comprehensive policy frameworks are in place, we can ensure that the transition will be successful in achieving global climate goals and will result in millions of jobs, broad economic development and significant benefits for health and human welfare.

The approach to enable the clean energy transition in the region can be based on three pillars:

- Planning the energy transition with robust data and analyses.
- Mitigating growth in energy demand and promoting the uptake of green technologies and practices by consumers and firms.
- Ensuring adequate supply of competitive, low-carbon energy.

The following sub-sections outline major elements that should emerge as policy priorities in these three pillars; a summary of these elements is provided in Figure 19. Within each pillar, the figure displays major policy priorities to be pursued in approximate chronological order. Some EMME countries may be more advanced in one pillar while some others in another. In any case, because of the urgency to address climate change, all pillars have to be developed in parallel.

FIGURE 19. Main pillars and policy priorities for enabling decarbonisation of energy systems

Planning the Energy Transition

- Formulate a vision and a roadmap for a low-carbon economy
- Ensure proper governance of energy data and policies
- Collect and report adequate energy statistics and costs
- Perform energy projections for the medium and long term
- Implement, monitor, and revise clean energy plans
- Adopt enabling policies in industry, labour market, social protection, education and skills, and finance

Mitigating Growth in Energy Demand

- Promote energy efficiency in all end-use sectors (buildings, industry, transport) by facilitating investments and removing financial barriers
- Promote water conservation to reduce the energy needs of water supply
- Understand socio-economic aspects (e.g. poverty and energy access) that affect the adoption and acceptance of energy saving measures
- Stimulate behavioural change in the population to promote energy conservation; institutionalise post-pandemic low-energy lifestyles

Ensuring Low-Carbon Energy Supply

- Promote electrification of end-use sectors
- Invest in low-carbon electricity and sector coupling (e.g. waste heat of power plants to be used in industry and residential heating/cooling)
- Enable infrastructure investments (inter-connections, smart grids) and institutional reforms (flexible tariffs, energy communities) to allow increased penetration of low-carbon electricity
- Exploit opportunities to produce clean fuels (including hydrogen) for sectors hard to decarbonise (e.g. cement and steel industry, aviation, shipping)

6.1. Planning the energy transition

The current lack of a clear framework for energy and climate policy design in most countries of the EMME region is problematic and leads to uncoordinated action. Energy and climate policy in the region can be formulated in a stepwise process – the relevant EU strategy may provide guidance for this purpose. The political announcements and defined vision statements can be assessed in a series of energy scenarios, formulating broader national or regional strategies. Identification of the preferable pathways can then result in detailed roadmaps and action plans, leading to legally binding targets, obligations and standards [189].

Section 4.6 has elaborated further on gaps in knowledge and data needs. To be effective and useful to policy makers, such an approach requires a proper knowledge base in each country, consisting of information such as:

- Publicly available energy statistics of adequate quality, collected by specific governmental agencies which will be accountable for this information.
- Technical and cost data for different energy technologies.
- Additional information that will allow the exploring of economic, environmental and social impacts of energy systems (e.g. economic activity and employment data, energy access and poverty, air pollutant emissions, etc.).

Such information can then be utilised in energy-environment-economy models to perform projections and scenario analyses that will allow the analysis of costs, effectiveness, impacts and trade-offs between alternative decarbonisation pathways.

A further advisable step is to foster co-operation between EMME countries in order to prepare integrated assessment studies of energy and climate change policies which will be tailor-made to the conditions, resources and needs of the EMME region.

Besides the preparation of energy and climate plans, it is necessary to establish monitoring mechanisms for assessing the progress towards the set targets and the implemented policies and measures. The mechanism should include provisions for the measurement, control, verification and evaluation of planned policies.

6.2. Mitigating the growth in energy demand

Rising incomes usually increase consumer demand for energy services, and global experience over many decades has shown that it is difficult to decouple energy use from economic growth. If the demand side of the energy equation is neglected it becomes much more challenging to proceed to decarbonisation, since unmitigated energy use poses far greater requirements to the supply side for providing adequate and clean energy. Therefore, improving energy efficiency across the economies of EMME countries can substantially contribute to achieving low-carbon objectives, while at the same time it will improve the overall economic productivity of the region. The IEA calls energy efficiency "the first fuel", meaning that fuel consumption avoided due to efficiency measures is greater than the actual consumption of any other fuel.

Besides promoting energy efficiency, demand-side measures also enable governments to encourage the uptake of clean energy technologies by consumers and firms. Although several low-carbon options exist for all end uses at reasonable costs, energy users often ignore them due to lack of information, hidden costs, limited access to finance or behavioural reasons. Therefore, interventions on the demand side can strongly boost the clean energy transition.

Several policy approaches can contribute to these objectives. Regulatory standards for appliances, machinery and motor vehicles are important elements in this policy domain. In the built environment, building codes for energy performance and equipment standards for heating and cooling systems are needed, while regulations for the exploitation of district cooling are also essential due to the region's high demand for space cooling. Standards can help reap energy efficiency gains, which might otherwise go unnoticed due to information gaps or limited rationality by consumers.

At the same time, it is well documented that economic and financial incentives are crucial for unlocking the energy efficiency potential of an economy. Market-based instruments for the promotion of energy efficiency interventions can enable market actors to adopt the most cost-effective mechanisms for the delivery of energy efficiency improvements. Two broad categories of market-based instruments consist of obligations, in which energy utilities are required to achieve specific energy efficiency targets, and auctions, in which market actors bid for available funds aimed at energy efficiency outcomes [190]. Such approaches provide flexibility to the private sector to find the most cost-effective mix of technologies or measures that achieve the targeted efficiency improvements.

Private investments can also be leveraged through innovative mechanisms such as the promotion of third-party financing and energy performance contracting. Energy service companies (ESCOs) can be utilised for the mobilisation of private financing for implementation of energy efficiency or renewable energy technology investments, paying off the investments and generating profit from the resulting energy cost savings or renewable energy generation [191]. This incentivises ESCOs to ensure effectiveness of their interventions, shifting investment risk from the customer to the ESCO. The operation of ESCOs requires the establishment of a relevant regulatory framework.

Financial barriers to the adoption of energy efficiency measures can also be overcome through capacity building and technical assistance from international organisations and multilateral development banks. For this purpose, regional co-operation is also useful for exchanging knowledge about best practices.

In the largely overlooked transportation sector, EMME countries have to actively promote sustainable transport modes. Due to high urbanisation levels in the region, sustainable urban mobility should be prioritised in national and regional policy agendas. This is essential to ensure access to reliable transport services, avoid increases in both GHG and air pollutant emissions, and tackle other transport externalities like road congestion, accidents and noise. The challenges posed to public transportation by the social distancing requirements of the COVID-19 pandemic have pushed governments to consider new ways to lessen traffic and promoting non-motorised transport [177]. Key policy interventions include: 1) the reallocation of budgets away from road infrastructure benefiting private vehicle use to infrastructure promoting walking, cycling and use of public transport; 2) alignment of urban planning with transport planning and engagement of experts across the policy domain to formulate coherent sustainable mobility plans; 3) road pricing in which vehicles are charged for use of roads in certain areas of a city during peak traffic periods; 4) bundling key transport governance powers, such as fiscal measures, infrastructure delivery and operations, at the metropolitan level, taking into account regular commuters to city centres for work and 5) land-value capture, in which authorities generate income from improved property prices adjacent to public transport infrastructure, which can then be used to finance additional public transport projects [192].

Transportation is not only about cars and trucks. Rail interconnections should be explored to increase electrification, especially for high-speed transit between countries in the region. Further, as some of the world's biggest international airlines are present in the EMME region, efforts to reduce GHG emissions from the aviation sector should ramp up. Commercial flights contributed to 2.4% of CO_2 emissions from fossil fuel combustion in 2018, while the United Arab Emirates ranked sixth globally in the top departure countries in terms of passenger kilometres [193]. Both cleaner fuels and energy efficiency improvements of aircraft are crucial in this respect. It is still unclear how much the aviation sector will be affected by changes in international travel patterns after the COVID-19 pandemic; however, the importance of aviation is unlikely to recede in the future. Hence, with aviation, particularly long-haul aviation, which is among those sectors that are hardest to decarbonise, EMME countries operating big international airports and airlines have both the responsibility and the economic interests to reduce the carbon footprint of air travel.

The importance of urban planning to energy demand cannot be underestimated. Sustainable design of neighbourhoods and communities can enable the development of carbon-neutral cities by not only reducing the need for car mobility, but also by improving the energy efficiency of the built environment and promoting nature-based solutions, such as green roofs for improved insulation or urban parks and fountains to reduce the urban heat island effect [194], to adapt to a changing climate. Energyefficient residential areas are also climate-resilient areas and can improve the welfare of their inhabitants.

Incorporation of circular economy practices can optimise resource use, and thereby yield energy efficiency gains, by maintaining or prolonging a product's lifetime, reusing and redistributing the product, refurbishing and remanufacturing it or simply recycling materials for manufacture of new components or products [188]. As the energy transition requires heavy investments in clean energy technologies with finite lifetimes (e.g. batteries, solar photovoltaic panels, electric vehicles), applying circular economy principles can have a positive impact on resource use and energy efficiency. Extended producer responsibility is a key policy mechanism, by which manufacturers and retailers assume responsibility for items at the end of their technical lifetime. Regulations on product disassembly potential and creation of new business models, assisted by relevant policy design, can further promote the circularity of national economies.

Energy demand policies should consider the nexus of energy and water demand. As explained in Section 4.5, the most water-scarce EMME countries require vast amounts of energy to satisfy water needs; this trend is expected to continue in view of rising incomes and population and climate change. Investments in innovative water supply technologies (e.g. solar desalination or wastewater treatment) and demand-side measures for water conservation (e.g. reducing losses in water distribution networks and appropriate water pricing) can mitigate the growing water demand, which in turn may put less strain on the energy systems of the region.

Finally, besides measures addressing domestic energy demand, fossil-fuelexporting countries in the region should account for changes in the global demand as a result of the energy transition. An economic diversification in these countries should move from a stated policy goal to concrete actions. Diversification can be pursued by promoting policies that strengthen human capital, encourage innovation, enable low-carbon infrastructure investments, strengthen the financial sector and promote openness and transparency to international markets [24].

6.3. Ensuring adequate supply of low-carbon energy

Observed climate change and international policy initiatives make it clear that the transition to clean energy will most likely accelerate in the coming years. This will affect all countries of the EMME region, regardless of whether they are net energy exporters or importers. Energy-exporting nations need to diversify their economic activities and transform their fossil fuel industries to become suppliers of low-carbon energy. Energyimporting nations need to bear in mind the limitations of dependence on external supplies of fossil fuels for their energy needs and the associated impact on energy security. Unless there is absolute assurance that supply of fossil fuels is guaranteed to withstand any global political or other supply challenges, these have to be considered fragile when compared to the long-term availability and reliability of nuclear power and renewable sources.

To accelerate decarbonisation in the electricity system, the region's investment in intermittent renewables is almost certain to increase significantly. Both direct investments in renewable technologies and investments in enabling systems such as smart grids and energy storage capacity will be needed. However, such investments are more capital intensive than fossil fuel technologies and entail a greater level of risk for investors; this risk is even higher in developing countries [195]. Reducing risk via financial or policy de-risking can encourage investment interest in low-carbon technologies. Financial de-risking can occur through export guarantees for foreign investors [38] or by transferring a portion of potential negative financial impacts to other entities, such as publicly owned development banks [195]. These can agree to reduced or no payments by the relevant investors. Policy de-risking entails improvements in institutional infrastructure and reduction of barriers within the investment environment, minimising the probability of unwanted construction delays.

It is clear that, as the share of intermittent renewables increases, there is a growing need to deal with the intermittency challenges, as well as recognition that the costeffectiveness of renewables decreases substantially as their penetration increases. This hints to the development of more flexible power systems, which can be achieved through investments in flexible, dispatchable generation options and storage technologies, transformation of electricity to alternative fuels (e.g. hydrogen), improvements in grid networks and regulations to allow flexible tariffs and demand response management, enhanced regional interconnections and market integration [196]. In turn, sector coupling will offer an additional flexibility option to the power system. Electrification of the transport sector, for example, strongly supports such flexibility.

Regional grids will also allow for optimisation of capacity investments and sharing of excess electricity. Already interconnected countries have to develop their grids and regulations in order to maximise the utilisation of interconnection projects. Institutional reforms such as deregulation of electricity markets and regulation that allows the creation of energy communities, combined with investments in smart grids mentioned above, can allow a far greater penetration of renewables – primarily wind and solar – in the energy mix. Such reforms will also strengthen the role of consumers so that they become active participants of the future energy market and assume the role of "prosumers".

Electrification, however necessary for the energy transition, is unlikely to solve the decarbonisation challenge in heavy industrial sectors that require large amounts of process heat. The EMME region was responsible for 10% of aluminium, 8% of cement and 4% of steel production globally in 2016 [197]. Such heavy industrial activities present an additional challenge in decarbonisation efforts, which can be addressed with a range of policies [188]. On the technological front, renewables and alternative fuels such as hydrogen might contribute to reduced GHG emissions in industry sectors through the supply of process heat. Hydrogen has significant potential for uses in industry, transport, buildings and the power sector [40]. If existing heat distribution infrastructure is utilised, nuclear energy (especially high-temperature reactors) can also provide process heat. District heating and/or cooling can come from the utilisation of biomass or waste, or from the residual steam of NPPs as has been examined in some countries [198], [199]. Furthermore, oil-producing countries could explore blue hydrogen production from steam methane reforming in combination with CCS as an alternative to conventional fuels, such as natural gas, for both domestic use and export. Blue hydrogen may be either a long-term investment or stepping stone to zero-carbon green hydrogen production from renewable electricity coupled with electrolysis. On the policy front, carbon pricing, similar to the EU ETS scheme, is a tool that can push sectors towards low-carbon technology options. Innovative technological solutions can emerge through R&D, which can be promoted through funding or establishment of government laboratories, financial support of public or private research institutes, establishment of government-industry-academic research partnerships, support of entrepreneurial development of innovative low-carbon technologies and incentives to encourage industrial R&D (e.g. tax credits, research grants). Preferential government procurement of low-carbon materials can provide a niche market for industries investing in low-carbon manufacturing options. Other relevant policy instruments include mandatory disclosure or industrial emissions data, labelling of low-carbon products and materials, and recycling requirements, which can provide dematerialisation and subsequent reduction in embodied emissions.

6.4. Cross-cutting policies

The previous sections outlined policy options that are primarily targeted at either energy demand or supply. There are, however, also several cross-cutting policy instruments that can yield both energy efficiency and higher demand for clean energy systems on the demand side, and faster deployment of low-carbon technologies on the supply side. Such instruments are briefly described in this section.

Energy and carbon pricing have a prominent role among horizontal policy instruments that can bring about very substantial technological and behavioural changes. As explained in Section 5.3.1, despite recent reforms, energy prices in many EMME countries still do not reflect actual costs of energy supply and use. Therefore, further energy subsidy reform is needed in several countries across the region. As subsidies that support the use of fossil fuels distort the market and create unfavourable conditions for private investors in clean energy technologies, a gradual removal of these market distortions is essential for the envisioned energy transition. At the same time, energy subsidies discourage adoption of energy efficiency measures and generally prevent behavioural changes towards more energy-efficient lifestyles. Existing subsidies should be designed to include sunset clauses and performance indicators, with the intention of an eventual complete phase-out. Such a reform will also provide much needed public revenues, which could finance green investments or compensate vulnerable households that may be disproportionately affected by the rise in retail energy prices. Similar principles may be applied to water pricing in order to enable water conservation, which will also induce significant energy efficiency gains in many countries, as explained in Section 4.5.

Subsidy reform will also support a comprehensive power sector reform, in which competitive electricity markets can be set up, removing pricing discrepancies across countries. This will pave the way for more active electricity trade on the regional level, which can unlock renewable energy potential across the region. This necessitates an appropriate institutional and regulatory framework to establish smooth operation of the regional grid.

Apart from fossil fuel subsidy reforms, the energy transition can benefit from a careful and gradual implementation of carbon pricing schemes, keeping in mind potential adverse socio-economic impacts. These can provide the proper price signals to consumers and firms to adjust their behaviour and investments towards green energy. Subsidy reform would provide an implicit form of carbon pricing that perhaps could serve as a basis for explicit carbon pricing over time.

Beyond pricing, the green transition will greatly benefit from sector coupling, taking advantage of synergies between investments in low-carbon technologies and energy efficiency measures. Such options include, for instance, electrification of the transport and heating and cooling sectors, powered by low-carbon energy technologies; using waste heat from low-carbon thermal power generation (e.g. nuclear or CSP) for district heating and cooling or exploiting renewable energy to produce thermal storage that can be used by residential or industrial consumers or hydrogen that can be used as fuel for high-grade heat in industry and long-haul transport.

Consumers can also be influenced to change towards less energy- and carbon-intensive lifestyles. Institutional reforms can turn them to "prosumers" of energy, as mentioned in the previous section, thereby adjusting their consumer habits [196]. Education and awareness raising can promote both greener lifestyles and public approval of policies supporting the energy transition effort. Policy design that considers socio-economic impacts and concerns of vulnerable households is important in this respect [169]. Therefore, understanding consumer viewpoints and social norms in each country is essential; a combination of official statistics, surveys and analyses together with information campaigns can provide a clearer picture that can make a significant impact. Promotion of socio-economic research in these aspects should also be a priority for national governments.

Moreover, new lifestyles and everyday practices that have been adopted in response to the COVID-19 pandemic, if continued and institutionalised, can also enhance energy efficiency and GHG emission reductions. This opportunity should not be missed; governments have to consider policy measures that can sustain those pandemic-stimulated practices that have a positive environmental impact and can be continued even after the public health emergency has been overcome [177].

6.5. A policy toolkit

In view of the considerations and recommendations provided in this chapter, Figure 20 summarises the main policy instruments that can be used for enabling a low-carbon energy transition in EMME countries. Obviously, some options are more suitable for some countries than for others. Investments in specific technologies (CCUS, nuclear, hydrogen, energy storage) are much more relevant in nations with an industry that is already active in deployment or research in the respective systems. Water conservation is more relevant for water-stressed countries. Urban planning can be more effective in countries with expanding urban settlements that can take advantage of sustainable design. Depending on governance features, some regulatory measures may be more realistic or effective in some countries than in others.

FIGURE 20. A policy toolkit for decarbonising energy systems in the EMME region

		Mitigating Growth in Energy Demand					Ensuring Low-Carbon Energy Supply					
		Energy efficiency in buildings	Energy efficiency in industry	Energy efficiency & modal shift in transport	Water conservation	Behavioural changes	Electrification of end-use sectors	Low-carbon electricity investments	Regional electricity trade	Smart grids	Electricity market reforms	Clean fuels for heavy industry, transportation, aviation & shipping
Regulations	Electric utility quota obligation / Tradable white & green certificates	■	■				■	■				
	Mandatory biofuel blending	■	■									■
	Renewable heat obligation	■	■	■								
	Energy efficiency / CO2 emission standards	■					■	■				■
	Building codes	■	■	■	■			■				
	Cicrcular economy provisions											
Institutional changes / reforms	Net metering/billing						■	■		■	■	
	Tendering/Auctions for renewable energy projects							■				
	Deregulation in electricity markets & tariffs						■	■		■	■	
	Institutionalising post-pandemic changes (e.g. teleworking)			■		■						
	Urban planning for low-carbon cities	■		■		■		■		■		
	International cooperation								■	■	■	■
Removal of investment barriers	Voluntary energy certification schemes	■	■	■		■						
	Energy performance contracting	■	■	■								
	Third-party financing with the aid of private and development banks	■	■	■								
	Green bonds	■	■	■	■	■		■				
	Risk-mitigation instruments (guarantees, interest rate subsidies)	■	■	■	■	■		■		■		
Green fiscal measures	Feed-in tariffs / premium payments						■	■		■		
	Grants and subsidies	■	■	■	■	■	■	■		■		■
	Tax rebates for clean energy investments	■	■	■		■	■	■				■
	Removal of fossil fuel and water subsidies	■	■	■	■	■	■	■				■
	Carbon pricing (emissions trade or carbon taxation)	■	■	■		■						
	Road pricing			■		■						
Infrastructure investments	Direct investments in low-carbon electricity (renewables, SMR, CCUS)						■	■				
	Installation of smart electricity & water meters	■	■		■	■	■	■	■	■	■	
	Modernisation of electricity network						■	■	■	■	■	
	Renovations of water network to reduce losses				■							
	Sustainable transport modes (public transit etc.)			■		■						
	Research on innovative technologies (storage, hydrogen etc.)	■	■	■			■	■		■	■	■
	Electricity interconnections						■	■	■		■	
Info-rmation	Education & awareness campaigns	■		■	■	■						
	Understanding socio-economic aspects (energy access and poverty)	■		■	■	■					■	
	Surveys of consumer behaviour	■		■	■	■					■	

This toolkit is meant to be a starting point for governments to screen policy options, identify those that are more appropriate for each national context and then elaborate on details of their design and implementation. Regional co-operation among EMME countries is crucial for the exchange of best practices and experiences towards the selection of nationally appropriate policy instruments. The Cyprus Climate Initiative can contribute to this objective by facilitating dialogue, capacity building and active collaboration between policy makers and researchers of the region.

6.6. A research agenda for the EMME region

In accordance with the gaps in knowledge identified in Section 4.6 and the policy proposals described in the previous sections of this chapter, it is evident that a wideranging regional research and innovation agenda is urgently necessary. Areas of research to be pursued encompass the following topics:

- *Technologies* (clean fuels such as hydrocarbons and hydrogen, green desalination processes, zero-carbon power generation, e.g. renewables/nuclear for electricity and process heat, energy storage, carbon capture and utilisation)
- *Enabling infrastructure* (inter-connections, energy communities)
- *Digitalisation* (smart grids, vehicle-to-grid, automation)
- *Circular economy* (impact of resource efficiency and waste prevention on the carbon footprint of industries and households)
- *Attitudes* (lifestyle changes and behavioural aspects to lower energy demand and adopt sustainability practices, especially after the pandemic)
- *Policies* (simulations of inter-connected/liberalised markets, decarbonisation pathways and their impact on economic growth and social equity)

Out of this research agenda, each country can choose the options that best fit its natural resources, accumulated expertise and comparative advantages. It is important to emphasise that, regardless of national strategies, regional co-operation can accelerate research and innovation in the region. This can be enabled by targeted initiatives such as the creation of highly capable regional energy/climate/economic modelling networks, which will not only involve research institutions but will also establish strong links with national decision makers in order to enable a policy-relevant decarbonisation agenda for the EMME energy system.

7. Concluding remarks

The Eastern Mediterranean and Middle East (EMME) region comprises countries of various sizes and population levels, at different stages of economic development, with a significant variety in natural, human and financial resources, and facing diverse political and economic challenges. They share, however, a common future. They are located in a hotspot for climate change, with substantial adverse impacts on their welfare expected.

Today, the EMME region hosts 5.5% of the global population, produces 4.7% of the world's economic output but generates more than 8% of global carbon dioxide emissions. Most EMME countries emit much more carbon dioxide per capita than the world average, and considering their population trends, economic growth prospects and emission projections, almost all of them are far off the trajectory required to stabilise global climate. Being responsible for about three-quarters of these greenhouse gas emissions, the energy system has to bear most of the burden of the decarbonisation effort to bring the region in line with the requirement for global climate stability.

Time is very limited, and the progress needed for decarbonisation is very substantial. After reviewing socio-economic and technological trends in energy systems of the region, this report has highlighted gaps in policy and knowledge that have to be addressed rapidly. It has identified three pillars which need immediate and simultaneous attention by governments of the region: 1) improving the knowledge base with better data, policy analyses and decarbonisation roadmaps; 2) reversing the trend of evergrowing energy demand in order to improve energy productivity and reduce the need for emission-generating activities and 3) ensuring that energy needs are met with lowcarbon technologies on the road to climate neutrality in the 21st century.

The importance of regional co-operation cannot be overstated. Co-ordinated actions like sharing and codeveloping energy infrastructures and networks, facilitating technical exchanges and capacity-building activities, and conducting regional integrated assessments are essential elements towards decarbonisation. The European Union's model, although not fully transferable to EMME countries, can serve as a good example of a determined and consistent approach towards global climate stabilisation.

The report has provided a policy toolkit for decarbonising energy systems. Some tools are more relevant for some countries than others. However, common features apply: satisfying a large portion of energy needs with zero-carbon electricity and heat; utilising the region's natural resources to provide low- and zero-carbon fuels like synthetic hydrocarbons and hydrogen; improving energy efficiency in industry, buildings and transport; and aligning the economic and research priorities of countries with the strategic vision of a low-carbon future. Beyond technologies and sectoral approaches, a successful energy transition requires a holistic framework that addresses the systemic changes needed in our socio-economic structures. Such a framework would encompass enabling actions under a wide range of industrial, education, labour, social and financial policies.

Geography and climate make it imperative for EMME countries to address their common future in a co-ordinated manner. Policy makers can combine the available international knowledge with regional resources to facilitate the transition to climate neutrality, which will improve the well-being of all people in the region.

8. References

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