STUDY

CLIMATE CHANGE, ENERGY AND ENVIRONMENT

# SUSTAINABLE TRANSFORMATION OF ENERGY SYSTEMS IN MENA COUNTRIES

## Comparative Report

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The Middle East and North Africa (MENA) Energy Transition Phase Model was applied to analyse the transition process to renewable energy (RE) in ten MENA countries.

The characteristics of the energy sectors are analysed with regard to the role of renewable and fossil energies in supply and demand, the political framework conditions for energy efficiency, the infrastructure conditions, the development of greenhouse gas (GHG) emissions, the governance structures, and the social involvement and acceptance of the energy transition.

The results are intended to stimulate discussion on future energy systems in the MENA region.

FRIEDRICH EBERT STIFTUNG

CLIMATE CHANGE, ENERGY AND ENVIRONMENT

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Wuppertal Institut

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# 1

# INTRODUCTION

The Middle East and North Africa (MENA) region faces a wide array of challenges, including rapidly growing population, slowing economic growth, high rates of unemployment, and significant environmental pressures. These challenges are intensified by global and regional issues, such as climate change and regional tensions. In addition, the global coronavirus disease 2019 (COVID-19) pandemic has exacerbated economic challenges and has created new social vulnerabilities. Energy matters are embedded in many of these troubles. The region is characterised by a high dependence on oil and natural gas to meet its energy needs. Although the region is a major energy producer, many of the MENA countries are struggling to meet growing domestic energy demand. Transitioning to energy systems that are based on renewable energy (RE) is a promising way to meet this growing energy demand. The transition would also help to reduce greenhouse gas (GHG) emissions, which is needed under the Paris Agreement. Moreover, the use of RE has the potential to increase economic growth and local employment and reduce fiscal constraints. Against this backdrop, most MENA countries have developed ambitious plans to scale up their RE production. However, despite these RE strategies and large-scale implementations of solar and wind power on GW scale, fossil fuels remain the dominant energy source.

The transition to a RE-based energy system in the MENA region will, therefore, require increased efforts at all levels. The transition will necessitate not only the development of large-scale RE projects but also the establishment of related infrastructures, the implementation of appropriate legal and regulatory frameworks, increased community involvement, and the creation of new markets and industries. Thus, a clear understanding of the socio-technical interdependencies in the energy system and the main dynamics of system innovation is crucial. To promote this understanding, a phase model for the transition to RE in MENA countries was developed and applied to ten countries in the region: Algeria, Egypt, Iraq, Israel, Jordan, Lebanon, Morocco, Palestine, Tunisia, and Yemen. The current status of the energy transition in these countries was assessed and analysed using the MENA Energy Transition Phase Model, and the information was summarised in the form of individual country studies. This publication synthesises the results of these ten country studies and relates the findings.

This project was developed together with the Friedrich-Ebert-Stiftung's Regional Climate and Energy Project MENA to initiate a debate on energy transformation processes, identifying the barriers while showing the concrete steps for a complete energy transformation towards 100% REs.

# 2

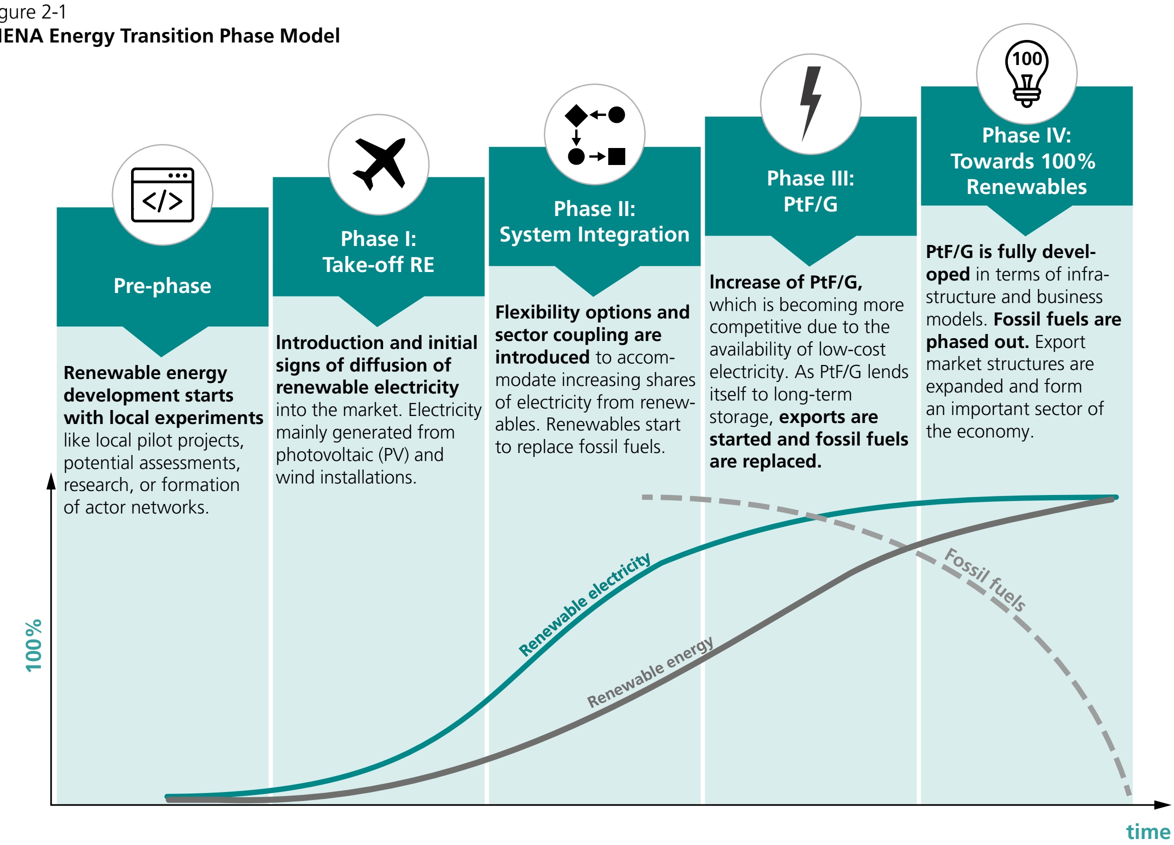
# THE MENA ENERGY TRANSITION PHASE MODEL

The applied phase model for energy transitions towards renewables-based low-carbon energy systems in the MENA region was developed by the Wuppertal Institute (Fischedick et al., 2020) with the support of the Friedrich-Ebert-Stiftung. The model provides a structured overview of the energy transition process over time through a set of four transition phases. It builds on the German phase model and is further complemented by information about transition preconditions and governance processes as well as characteristics of the MENA region. The state of the energy sector in the MENA region varies from country to country. For instance, some countries, such as Iraq, Algeria, or Egypt, are rich in fossil fuels, while others like Morocco, Tunisia, and Jordan are highly dependent on energy imports. Yet, several underlying trends are present in all these countries; in the majority of these countries, energy prices are subsidised and energy markets are mostly not liberalised. Also, in contrast with the German context, there is an upward trend in energy demand in the MENA region. Furthermore, most grid systems are poorly interconnected across borders. Nevertheless, the expansion of RE in the MENA region can benefit from significant global progress and cost reductions in RE technologies.

Taking into account the characteristics of the MENA region, the four phases of the MENA Energy Transition Phase Model correlate with the main assumptions derived from the basic characteristics of RE sources, which are labelled as follows:

- »Take-off RE«,
- »System Integration«,
- »Power-to-Fuel/Gas (PtF/G)«, and
- »Towards 100% Renewables« (Fig. 2-1).

Figure 2-1
**MENA Energy Transition Phase Model**



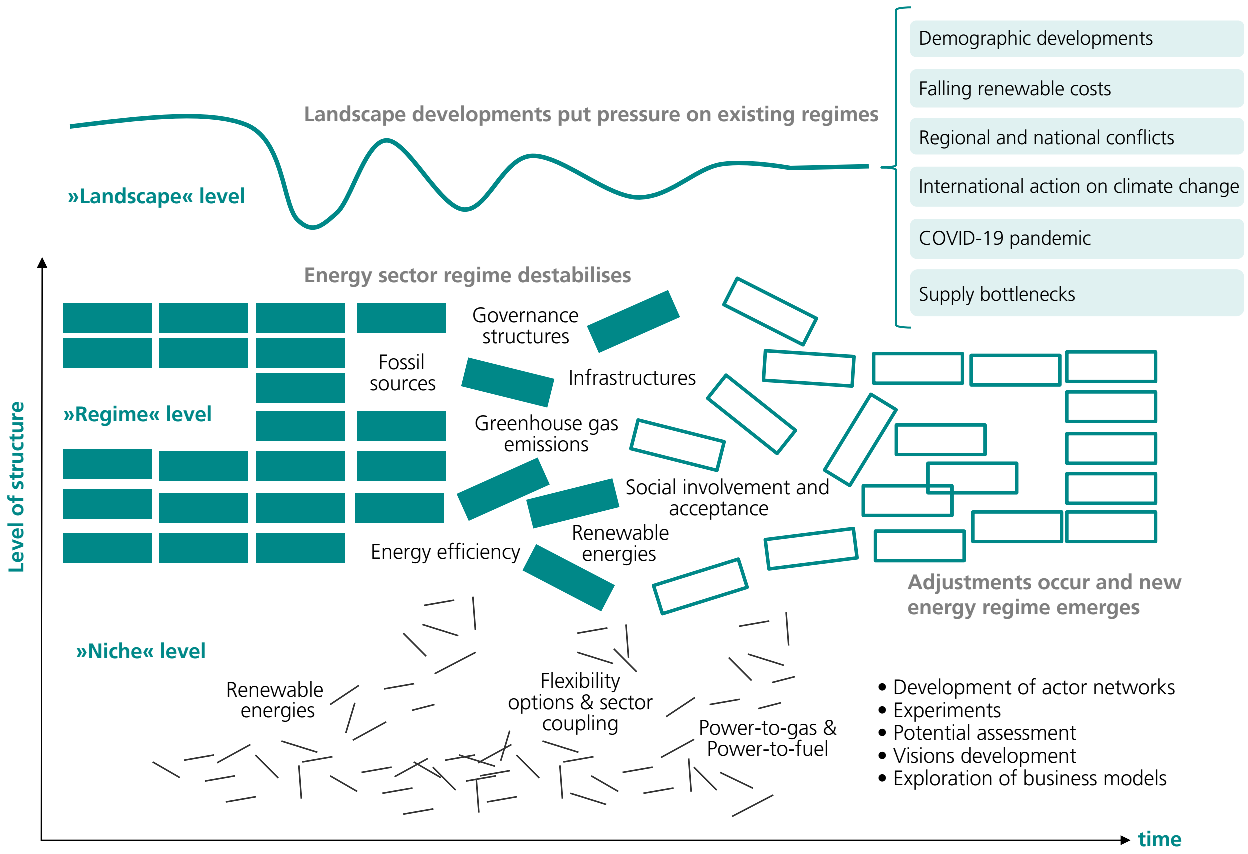

(Source: Own compilation based on Holtz et al. (2018))

A specific cluster of innovations was identified for each phase: RE technologies (phase 1), flexibility options (phase 2), PtF/G technologies (phase 3), and sectors, such as heavy industry or aviation, that are difficult to decarbonise (phase 4). Before RE technologies enter the start-up phase, initial developments become visible in the form of local experiments, which can be described as the pre-phase of the RE transition. Proceeding from this pre-phase, the renewable electricity supply capacities are expanded throughout the phases to meet the increasing demand for energy from all sectors. Due to the electricity demand being four or five times higher in a renewables-based low-carbon energy system, improving energy efficiency is also a prerequisite for a successful energy transition during all phases.

In all phases, the transformation takes place on different levels. Building on the multi-level perspective (MLP), which is a prominent framework that facilitates the conceptualisation of transition dynamics, the applied phase model structures the transition on three levels (Geels, 2012) (Fig 2-2). At »landscape« level, pervasive trends such as demographic shifts, climate change, and economic crises affect both the »regime« level and the »niche« level. The »regime« level (also referred to as »system« level) captures the socio-technical system that dominates the sector of interest. In this study, the analysed system is the energy sector. It comprises the existing technologies, regulations, user patterns, infrastructure, and cultural discourses that combine to form socio-technical systems. To achieve system changes at the »regime« level and avoid lock-in and path dependencies, innovations at the »niche« level are essential, as they provide the fundamental base for systemic change in the next phase.

The transition process at the »regime« level and »niche« level occurs in different interacting layers. Changing the deployment of technologies across markets is described in a »techno-economic layer«, while the governance stages are captured in the »governance layer«. The aim of this layer is to connect developments in the »techno-economic layer« with governance approaches to support the transition phases. On the »techno-economic layer«, the transition towards renewables will require a strong emphasis on adapting the electricity infrastructure to maintain grid stability. This includes storage and flexibility options as well as information and communication technologies (ICT) that support flexibility management. By using PtF/G applications, different sectors can be more tightly coupled. The »governance layer« is concerned with adapting and developing new policies and targets, creating legal frameworks and regulations, and adapting institutions to new market structures. The phase model outlines the socio-technical interdependencies of the described developments, which build on each other in a temporal order.

Figure 2-2
**Multi-Level Perspective Applied in the MENA Energy Transition Phase Model**




(Source: Own compilation based on Geels and Schot (2007))

# 3

# APPLICATION OF THE MENA ENERGY TRANSITION PHASE MODEL

## 3.1 DEVELOPMENTS AT THE LANDSCAPE LEVEL

Energy transitions on a national level are influenced by the national, regional, and global landscapes where the energy system is embedded. The »landscape« level is considered to be the exogenous environment at the macro level that cannot be directly influenced but can itself have a strong effect on developments at the »regime« level and »niche« level. The »landscape« level can put pressure on existing regimes and create opportunities for system change.

On a global scale, the international decarbonisation efforts to reduce GHG emissions (to prevent a global temperature increase and the associated negative effects) also directly and indirectly influence the energy systems in the MENA region. For oil and gas exporting countries in the MENA region, the sales markets are expected to shrink in the future due to importing countries gradually decarbonising their economies. Moreover, international financing institutions, developing banks, private and commercial banks, and investors are starting to restrict investments in fossil fuel infrastructures. This restriction is either due to political reasons for reducing carbon emissions or because fossil fuel infrastructures may become stranded assets in a decarbonising world. This can also affect the exploration and exploitation of new discovered fossil fuel sources in the region and the construction of new fossil-fuelled power plants. Simultaneously, as more countries commit to being carbon neutral, political pressure at the international level to move to a low-carbon energy system will intensify.

Additionally, falling prices for renewable technologies have a positive influence on energy transition. With continuous reports of record low prices, further price reductions are expected in the coming years, making renewables more competitive with fossil sources. Another important influential factor is demographic development. The population is expected to continue growing in all the countries analysed. As a result, the demand for energy also rises. In this case, REs can play an important role in meeting the increasing demand. However, existing or former regional and internal political conflicts and violent disputes hinder the implementation of RE strategies and projects. This is especially true for Yemen, Palestine, and Iraq but also (to some extent) for almost all other countries analysed.

The COVID-19 pandemic is another factor that has already interfered with the energy transition in the short term, leading to delays of RE projects but also to economic challenges that may impede the implementation of RE strategies. It remains to be seen whether the consequences of the pandemic will also have long-term effects on the energy sector. The shortages in the supply of raw materials and technology components have also become obstacles to the execution of RE projects, at least in the short term. It is unclear whether this situation might continue to exist in the future and whether transformation efforts in the MENA region, but also worldwide, could weaken as a result.

## 3.2 DEVELOPMENTS AT THE REGIME LEVEL

The analysis at the »regime« level focuses on the current status of the energy transition in the ten countries studied. For this purpose, the characteristics of the energy sectors are analysed with regard to the role of renewable and fossil energies in supply and demand, the political framework conditions for REs and energy efficiency, the infrastructure conditions, the evolution of GHG emissions, the governance structures, and the social involvement and acceptance in the energy transition.

According to the first phase of the applied MENA Energy Transition Phase Model, the characteristic development at the energy system level is the introduction and initial increase of RE, particularly electricity generated by photovoltaic (PV) and wind power plants. In most of the countries studied, this phase has already begun, and some countries, including Jordan and Morocco, have almost completed it. Yet, in other countries like Iraq, Palestine, or Yemen, the development of REs is only at an initial stage, which can be described as a pre-phase of the applied MENA Energy Transition Phase Model. In the second phase, renewables become an integral part of the energy system at the »regime« level, while the growing electricity markets still leave room for the coexistence of fossil fuel-based energy systems. In the second phase, the following important processes occur: grid expansion continues, and efforts are made to build transnational and cross-border electricity lines to compensate for regional differences in wind and solar

Table 3-1
**Overview of »Regime« and »Niche« Level Developments According to the MENA Energy Transition Model**

| | Algeria | Egypt | Iraq | Israel | Jordan | Lebanon | Morocco | Palestine | Tunisia | Yemen |
|---|---|---|---|---|---|---|---|---|---|---|
| **Niche level before phase 1** | | | | | | | | | | |
| Assessment of RE potential | ● | ● | ● | ● | ● | ● | ● | ◍ | ● | ● |
| Local experiments with RE | ● | ● | ◍ | ● | ● | ● | ● | ◍ | ● | ◍ |
| RE visions | ● | ● | ● | ● | ● | ● | ● | ◍ | ● | ○ |
| RE related actor networks | ● | ● | ◍ | ● | ● | ● | ● | ◍ | ● | ◍ |
| **Phase 1: Take-off** | | | | | | | | | | |
| RE does not replace fossll fuels | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Efficiency efforts | ◍ | ● | ◍ | ● | ● | ◍ | ● | ● | ● | ◍ |
| Grid retrofitting and extension | ◍ | ● | ◍ | ● | ● | ◍ | ● | ○ | ● | ○ |
| Transnational grid extension efforts | ◍ | ◍ | ◍ | ○ | ● | ◍ | ● | ○ | ◍ | ○ |
| RE market development | ◍ | ● | ◍ | ● | ● | ◍ | ● | ◍ | ● | ◍ |
| RE regulations and incentives | ● | ● | ◍ | ● | ● | ◍ | ● | ◍ | ● | ○ |
| Awareness of environmental issues | ◍ | ◍ | ◍ | ◍ | ◍ | ◍ | ◍ | ◍ | ◍ | ◍ |
| **Niche level before phase II** | | | | | | | | | | |
| Assessment of flexibility options | ○ | ○ | ○ | ◍ | ● | ○ | ● | ○ | ◍ | ○ |
| Experiments with flexibility options | ○ | ○ | ○ | ◍ | ● | ○ | ● | ○ | ○ | ○ |
| Flexibility business models | ○ | ○ | ○ | ◍ | ○ | ○ | ◍ | ○ | ○ | ○ |
| Visions for energy system integration | ○ | ○ | ○ | ○ | ○ | ○ | ● | ○ | ○ | ○ |
| Actor networks around flexibility | ○ | ○ | ○ | ○ | ○ | ○ | ◍ | ○ | ○ | ○ |
| **Phase II: System integration** | | | | | | | | | | |
| Replacement of fossil fuels | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Direct electrification | ○ | ○ | ○ | ○ | ○ | ○ | ◍ | ○ | ○ | ○ |
| ICT integration | ○ | ○ | ○ | ○ | ○ | ○ | ◍ | ○ | ○ | ○ |
| Alignment of regulations | ○ | ○ | ○ | ○ | ○ | ○ | ◍ | ○ | ○ | ○ |
| PtF/G related actor networks | ○ | ○ | ○ | ○ | ○ | ○ | ◍ | ○ | ○ | ○ |
| **Niche level before phase III (PtF/G)** | | | | | | | | | | |
| Assessment of PtF/G pathways | ○ | ○ | ○ | ○ | ◍ | ○ | ◍ | ○ | ○ | ○ |
| Assessment of PtF/G potentials | ○ | ○ | ○ | ○ | ○ | ○ | ◍ | ○ | ○ | ○ |
| PtF/G pilot projects | ○ | ○ | ○ | ○ | ○ | ○ | ◍ | ○ | ○ | ○ |
| Exploration of new DSM potentials | ○ | ○ | ○ | ○ | ○ | ○ | ◍ | ○ | ○ | ○ |
| PtF/G vision development | ○ | ○ | ○ | ○ | ◍ | ○ | ○ | ○ | ○ | ○ |

● (Being) Implemented ◍ In progress/planned ○ Missing

*(Source: Own compilation based on country studies)*

energy supply. In this phase, flexibility potentials, such as demand side management (DSM) and storage, shall also be expanded, and the electricity market design needs to be adapted accordingly. At the political level, the regulations in the electricity, mobility and heating sectors must be gradually aligned to create a level playing field for the different energy sources. Israel, Jordan, and Morocco have started these activities, but none of the countries assessed has yet fully completed the second phase. In the following sections and in Table 3-1, an overview of the current status and trends of the energy transition at the »regime« level in the ten analysed countries is given.

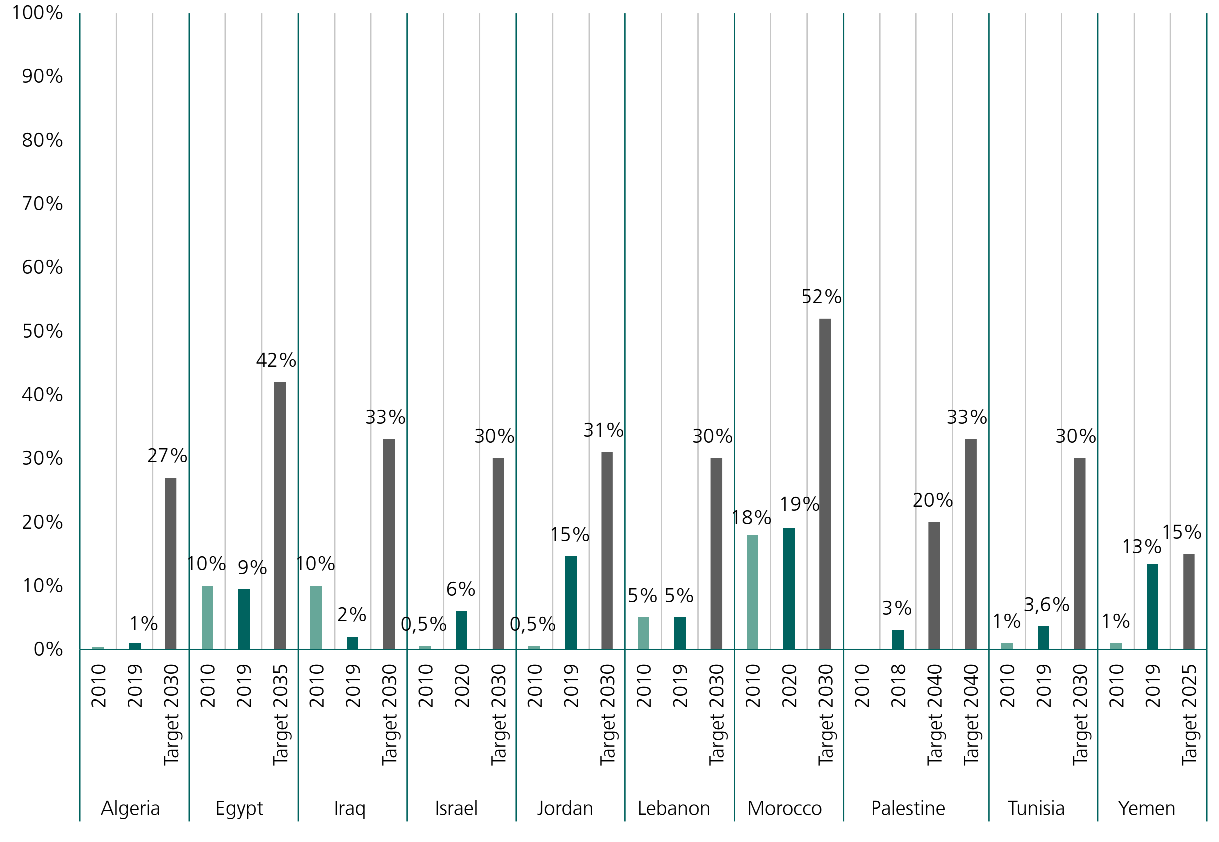
### 3.2.1 Renewable Energy

All countries studied have set RE targets (Fig. 3-1). To achieve these targets, a high share of solar energy and wind energy is envisaged. Wind energy is of particular importance in Tunisia, Morocco, Egypt, and Jordan. In addition, hydropower is considered an important RE source in countries such as Lebanon, Egypt, and Iraq.

On the one hand, some of the countries will need to improve their efforts to expand renewable electricity generation in order to meet their goals. For example, renewables in Algeria accounted for 1% of the country's electricity generation in 2019, while the 2030 target is set at 30%. Despite priority grid access for RE in Algeria and the promotion of large-scale RE through various incentive measures, the implementation of RE remains limited due to regulatory and financial barriers. Similarly, in Tunisia, where the promotion of RE and energy conservation started more than 20 years ago, the development of large-scale RE projects has been slow. In order to reach the target of a 30% share of renewable electricity by 2030, which has been set in the Tunisian Solar Plan (TSP), the country needs to improve the framework conditions for RE by taking steps to unbundle the electricity sector. It must create transparent structures and regulations for private investors and take measures to reform fossil fuel subsidies. Iraq has increased its target from 10% to a 33% share of RE to be achieved in the electricity sector by 2030. In 2019, the share was 2%, and most of it was derived from existing hydropower plants (REN21, 2019).

Some countries have even less ambitious targets. For example, Yemen aims to reach a target of a 15% share of RE by 2025, but this goal was set before the Yemeni war. Nevertheless, small solar panels have now become widespread sources of electricity generation in Yemen, seeing as the electricity grid, which originally supplied only 40% of the population, is badly damaged, and diesel to run electricity generators is either unavailable or increasingly expensive in the war-torn country's black market. Palestine's targets also lie within a lower range, for the country aims to reach a 20-33% share in 2040. The higher target depends on the development of the political situation with Israel, as most of the large solar and wind energy potential is located in Area

Figure 3-1
**Overview of Renewable Shares in Electricity Generation 2010 and 2019/20 and Renewable Targets**




(Source: Based on IEA, 2021 data)

C, which is currently inaccessible and is under Israeli control. Israel's targets for the share of RE in the electricity mix are set at a 30% share to be reached by 2030.

On the other hand, countries such as Egypt, Israel, Jordan, and Morocco are well on their way to meeting their targets. For example, Morocco has set ambitious targets, aiming to reach a 52% share of renewables in the electricity mix by 2030. This target may even increase to 64% (Zawya, 2021), seeing as the deployment of renewables is progressing at a fast pace. Thus, the 52% target is expected to be reached before 2030. Morocco has enacted effective RE laws and regulations, and RE is strongly supported by the Moroccan King and at the political level, thus facilitating its rapid development. Under the Moroccan Solar Plan (MSP), large-scale solar energy plants, such as the NOOR Ouarzazate project that has a capacity of 580 MW, have been built, and further NOOR projects are under development. Increasing private sector involvement and community participation by promoting small-scale and decentralised solar solutions alongside large-scale developments can further support the transition to a 100% RE system in Morocco.

Like Morocco, Jordan, a country heavily dependent on energy imports, has also made great strides in its energy transition. However, these advancements have somewhat been delayed in recent years due to regulatory issues. Nevertheless, the current target of 31% RE to be achieved by 2030 is expected to be raised soon, given that the expansion of RE is proceeding rapidly. Compared to Morocco, the expansion of REs in Jordan is mainly driven by private producers. Stable and clear policy frameworks, attractive incentives, and the availability of financing mechanisms have contributed to strong private sector participation in the form of private-public partnerships (PPPs). Similar to Jordan and Morocco, Egypt also shows strong development in the RE sector. The country's RE targets are ambitious, seeing as it intends to achieve a 42% share of renewables in the electricity mix by 2030. Implementation programmes have successfully attracted investors, resulting in a steady increase in the number of large-scale projects in recent years. One of the flagship projects is the Benban solar park, which will be the largest solar park in the world when completed with 1.5 GW. Benban, like many other large-scale RE projects in Egypt, Jordan, and Morocco, has been built by independent power producers (IPPs) under Build, Own and Operate (BOO) or Build, Own, Operate and Transfer (BOOT) schemes. Through such schemes, the energy is sold under a long-term Power Purchase Agreement (PPA) (usually around 20 years) to the national transmission company, which is the sole buyer. As in Morocco, REs in Egypt could also be increasingly used as decentralised or off-grid solutions in remote areas, in urban areas, or to supply businesses with clean electricity in order to further advance the energy transition at all levels.

In terms of RE regulations and incentives in the countries studied, most countries use more than one instrument to promote the use of RE. In all countries studied (excluding Yemen), large-scale projects are often awarded through tendering procedures. Net metering systems also exist in all countries except Iraq and Yemen, mainly for small decentralised systems (for example, in households). As for feed-in tariffs (FiTs), which are one of the most widely used RE promotion mechanisms in the world, five countries, namely Algeria, Egypt, Israel, Jordan, and Palestine, use this instrument. So far, RE quotas and priority access to the grid for RE have only been used by a smaller number of countries (Table 3-2).

Overall, it is evident that countries with limited fossil energy resources, such as Morocco and Jordan, are showing strong momentum and potentially exceeding their targets. In countries with fossil energy resources, such as Algeria or Tunisia, the energy transition is currently rather slow due to the partly unfavourable framework conditions for REs and due to a strong lobby for fossil energy sources. The introduction of renewables in Egypt has been strongly driven by the need to meet the rapidly growing energy demand. Simultaneously, fossil fuel power generation has also been increasing as a result of new gas discoveries. In countries with difficult political situations, such as Yemen and Palestine, renewable development is mainly driven by the introduction of small-scale solar energy systems to meet the daily energy needs of the population, while large-scale systems are

Table 3-2
**Overview of Renewable Energy Regulations**

| | Algeria | Egypt | Iraq | Israel | Jordan | Lebanon | Morocco | Palestine | Tunisia | Yemen |
|---|---|---|---|---|---|---|---|---|---|---|
| **RE Regulations and Incentives** | | | | | | | | | | |
| Feed-in-tariff | ● | ● | ○ | ● | ● | ○ | ○ | ● | ○ | ○ |
| Electric utility quota obligation | ○ | ● | ○ | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Net metering/billing | ● | ● | ○ | ● | ● | ● | ● | ● | ● | ○ |
| Tendering | ● | ● | ● | ● | ● | ● | ● | ● | ● | ○ |
| **RE Grid Access Conditions** | | | | | | | | | | |
| Priority dispatch for RE | ● | ● | ○ | ○ | ● | ○ | ○ | ○ | ○ | ○ |
| | | | | | ● Existing/being implemented | | ○ Missing | | | |

(Source: Own compilation based on country studies) missing. Hence, the path to transition to a RE-based energy system varies from country to country and depends on the preconditions, which are influenced by various underlying structural factors.

### 3.2.2 Fossil Fuel Sector

Despite progress in RE, in 2019 and 2020, fossil fuels were still the main source of electricity generation in all analysed countries (Fig. 3-2). The main sources were oil and natural gas, along with coal in Morocco and Israel.

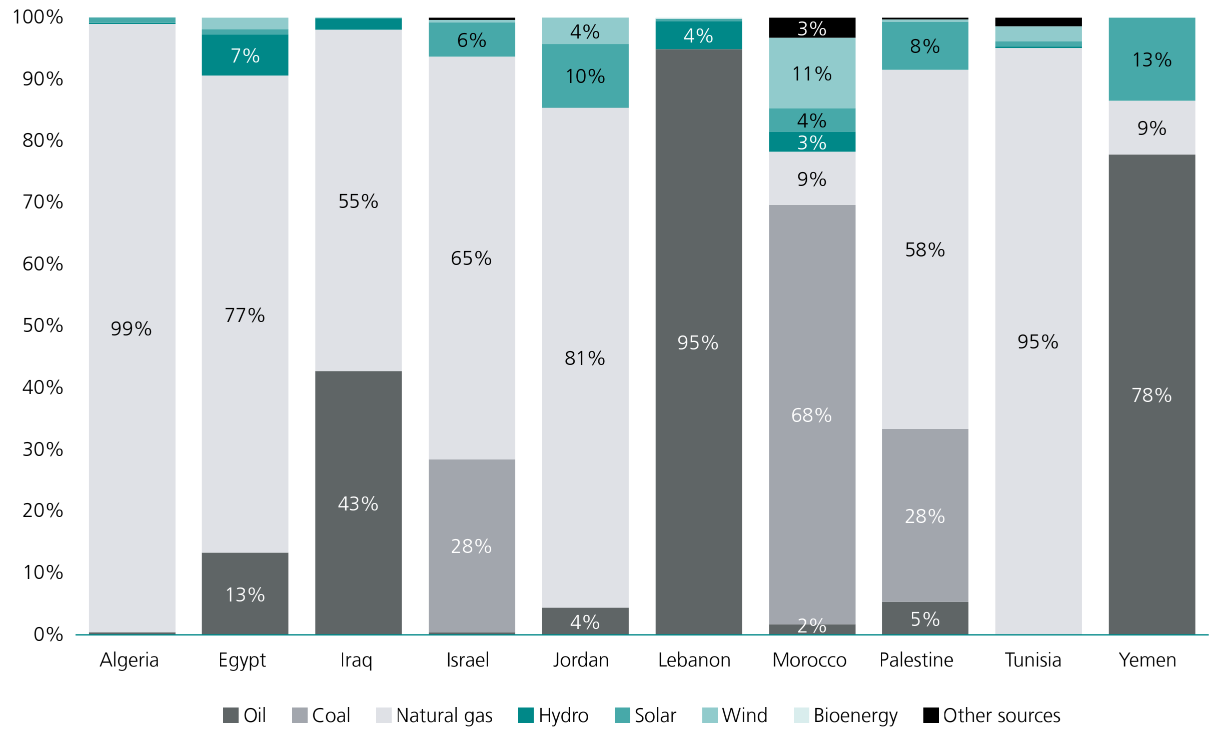
Morocco and Jordan are heavily dependent on fossil fuel imports, which is one of the main drivers for the rapid development of RE sources in both countries. Likewise, Palestine and Lebanon are reliant on fossil fuel imports. Lebanon's energy system largely depends on imported heavy fuel oil and diesel oil, which account for 93% of total electricity generation (Salameh and Chedid, 2020). In Palestine, 100% of fossil fuels for domestic energy use is imported from Israel. Israel was also once almost entirely dependent on energy imports until the discovery of the Tamar and Leviathan natural gas fields off the Mediterranean coast. Currently, Israel exports natural gas to Jordan but continues to rely on oil imports, mainly from Russia and Norway. A similar situation can be observed in Egypt, which (in contrast to Israel) was formerly a large oil and gas producer. Also, hydrocarbon production represents one of the largest industries in the country, but due to high domestic energy demand, Egypt became a net energy importer in 2010. Yet, with the newly discovered gas fields, Egypt is becoming an exporter once again.

Until 2000, Tunisia was also a gas exporter. Since then, the country has become a net importer of fossil fuels due to the decline in oil and gas reserves combined with growing demand. Still, the dependence on fossil fuel imports has not yet led to a rapid expansion of REs but has increased the national deficit. This, in turn, has delayed the energy transition. Moreover, the COVID-19 pandemic has contributed to a shift in budget priorities in Tunisia towards the health sector, and a number of RE projects have been postponed until further notice.

Alegria and Iraq, however, are among the world's largest exporters of fossil fuels. The hydrocarbon sector contributes to a large share of the Gross Domestic Product (GDP) in both countries. Algeria considers renewables as an opportunity to meet rapidly growing domestic demand; thus, it is exporting more natural gas products. Iraq has also recently announced the development of new solar energy projects in collaboration with foreign firms to raise the share of clean energy to 33% by 2030 (Chandak, 2021). Yemen's fossil energy sector was also the largest contributor to the state budget before the war, as the oil and gas sector in Yemen is mainly run by the state. Yet, the ongoing military conflict is significantly affecting the fossil fuel sector, and many oil companies have halted production.

In line with the predominant role of natural gas and oil, fossil fuel subsidies are widespread in the region. Most of the ten countries studied (Algeria, Egypt, Iraq, Lebanon, Tunisia, and partly Yemen) still subsidise fossil fuels either directly

Figure 3-2
**Overview of Electricity Generation by Source 2019/2020**




**Palestine: 86% imports estimated based on Israeli electricity mix*

(Source: Based on IEA, 2021 data)

or indirectly through non-cost-recovery electricity tariffs. However, Egypt, Jordan, Morocco, and Tunisia have clearly made efforts to regressively subsidise energy, which have already led to considerable success (IMF, 2019). While the high solar and wind potentials in all the countries studied indicate that renewable electricity can be generated at competitive costs compared to fossil fuel electricity generation in many locations, subsidies can mask these advantages. Consequently, the subsidies are a major obstacle to the transition to a 100% renewable-based energy system in the majority of the analysed countries. Overall, it can be concluded that subsidies and the strong dependence on oil and gas are major obstacles to the transition to 100% RE systems. In particular, new investments in fossil fuel production and fossil-based electricity generation capacities can lead to technological lock-in effects, which is critical for the later stages of the transition when fossil fuel phase-out becomes necessary.

### 3.2.3 Energy Efficiency

Next to RE technologies, energy efficiency is the second strategic pillar of the energy transition, and it is crucial to increase energy efficiency in all phases described in the applied MENA Energy Transition Phase Model. All countries studied have recognised the relevance of energy efficiency, and many have developed national energy efficiency plans and targets, but there are stark differences in the implementation of efficiency measures between countries. Tunisia has one of the most effective energy efficiency policies, which has led to a decrease in energy intensity of about 20% over the last decades (The World Bank, 2021). Various instruments and mechanisms have been introduced in Tunisia, including laws, taxes, awareness campaigns, research initiatives, investment incentives, consultations with companies that want to save energy, energy audits of companies, and feasibility studies for combined heat and power (CHP) projects (Detoc, 2016).

Most efficiency targets and measures focus on the energy sector, but some countries also include other sectors, such as households and industry (Table 3-3). For example, Israel plans to convert old oil-based power plants to gas-fired electricity generation plants and install new CHP plants to increase efficiency up to 80%. Lebanon has defined energy savings by sector in its National Energy Efficiency Action Plan (NEEAP), conducted a cost analysis for each measure, and formulated quantifiable, time-bound targets. Morocco also includes energy efficiency measures that cover all sectors: energy, agriculture, forestry, transport, waste, industry, residential, and commercial to meet its target of reducing energy consumption by 20% by 2030. Jordan has similarly included a series of 35 measures in its NEEAP, including cross-sectoral projects that cover housing, services, industry, water pumping, street lighting, and transport.

Algeria's efficiency strategy also includes efficiency targets in the buildings, transport and industry sectors. The country, moreover, has introduced energy certification and labelling for new technical devices that consume electricity, gas, or other fuels. Egypt's NEEAP II includes efficient lighting, financing mechanisms for the use of solar heating in the residential and hotel sectors, rationalisation of energy use in water and sanitation stations, and awareness programmes. Yemen also developed initial energy efficiency targets before the war, aiming to increase efficiency in the energy sector by 15% by 2025, but the war prevented the achievement of these targets. Currently, Yemeni households use their electricity more rationally, mainly due to limited availability and high prices rather than efficiency-related reasons. Iraq aims to reduce energy consumption by 7% by 2022 (ESCWA, 2019), but strategies to implement the targets are mostly missing. Despite the more or less concrete measures, energy subsidies are also a major obstacle to energy efficiency efforts in most of the countries studied, as low electricity prices do not encourage energy-saving behaviour.

Table 3-3
**Overview of Energy Efficiency Policy Measures**

| | Existing Efficiency Strategies | Efficiency Targets |
|---|---|---|
| **Algeria** | Renewable Energy and Efficiency Development Plan 2011–2030 | • Building sector: saving 30 million toe by 2030<br>• Transport sector: saving 15 million toe by 2030<br>• Industrial sector: saving 34 million toe by 2030 |
| **Egypt** | National Energy Efficiency Action Plan I and II (NEEAP) | • 5% reduction of energy consumption during 2012–2015 |
| **Iraq** | No specific efficiency strategy but National Sustainable Development Plan includes efficiency improvements as topic | • No efficiency targets |
| **Israel** | The Updated Energy Efficiency Plan (NEEP) | • 17% reduction in electricity consumption by 2030 |
| **Jordan** | National Energy Efficiency Action Plan I and II (NEEAP) | • Saving 2,000 GWh of electricity for the period 2018–2020 comprising 35 measures |
| **Lebanon** | National Energy Efficiency Action Plan I and II (NEEAP) | • Energy saving of 302.9 GWh per year |
| **Morocco** | National Energy Strategy | • Energy saving of 20% by 2030 |
| **Palestine** | National Energy Efficiency Action Plan I and II (NEEAP) | • Energy consumption reduction of 5,000 GWh by 2030 |
| **Tunisia** | National Energy Efficiency Programme | • 34% reduction of energy consumption by 2030 |
| **Yemen** | National Strategy for Renewable Energy and Energy Efficiency | • Energy saving of 457 GWh by 2025 |

(Source: Own compilation based on country studies)

### 3.2.4 Infrastructure

The energy transition towards renewables requires the modernisation and development of electricity generation, transmission, transformation, and distribution infrastructure. In all analysed countries, the existing transmission and distribution infrastructures, such as grid lines and substations, are not ready to integrate large shares of renewables. Furthermore, the often old and inefficient grid infrastructure results in considerable losses in nearly all countries. For example, in Lebanon, grid losses reach approximately 40%. These losses on a technical and a non-technical level can weigh heavily on the financial performance of the electricity sector. In some countries (for example, in Iraq, Lebanon, Palestine, or Yemen), it also contributes to load shedding. Besides, in a number of countries, including Algeria, Jordan, Morocco, Tunisia, Egypt, and Israel, the RE potential and the centres of demand are geographically far apart. If the transmission infrastructure does not sufficiently connect the centres of supply and demand, the injection of large amounts of renewable electricity into the grid can lead to congestion on the electricity lines, posing a risk to grid stability. Faced with these challenges, many countries have started to improve grid infrastructure. For example, Egypt has made significant improvements over the past decade to overcome the severe load shedding that occurred in the early 2010s. This includes, among others, the development of the »Green Corridor« project that aims to expand the transmission grid by 500 kV in order to connect wind and solar farms to the national grid.

Another important step that was taken to stabilise the grid and manage the variable loads is the transnational interconnection of grids. In the MENA region, the economic integration as well as the integration of the electricity grid infrastructure is extremely low. Several plans for regional interconnections exist that include a number of the analysed countries. An example is the eight-country interconnection project (EIJLLPST) (Egypt, Iraq, Jordan, Libya, Lebanon, Palestine, Syria, and Turkey), which was initiated in 1988. However, this interconnection made little progress over a long period of time due to an array of challenges ranging from technical, financial, political, and organisational factors to limited surplus capacity. Another transnational interconnection project is the Pan-Arab Electricity Market or the North African interconnection that would involve the countries of Libya, Egypt, Jordan, and Syria. The aim of these transmission corridors today is to create a joint electricity market that will help accommodate the increasing shares of electricity generated from RE in the MENA region. Weak infrastructure and a lack of interconnected grids (that could help balance fluctuating generation through electricity imports or exports) pose a challenge for the expansion of REs in the MENA region. Palestine is particularly affected by the lack of grid connections. Owing to the political circumstances, Palestine is almost only linked to the Israeli grid, while the domestic grid is highly fragmented.

Altogether, it is clear that in addition to the expansion of RE capacities, the parallel expansion of the infrastructure and the stronger regional interconnection of the electricity grids must be accelerated for the energy transition to succeed. Without the necessary adjustments to the infrastructure, it will be difficult to feed high shares of REs into the grids, and it will also be more difficult to balance the fluctuations in the renewable electricity generation.

### 3.2.5 Institutions and Governance

Institutional and governance aspects constitute another layer in the MENA Energy Transition Phase Model, as they structure the existing and new energy regimes and are central to a successful transition. The expansion of RE on a broad scale, and the introduction of new technologies such as smart grids or green hydrogen technologies will strongly depend on the quality of the institutions as well as the policy and regulatory framework. Policymakers, therefore, have an important role to play in shaping the transition by creating sound institutional frameworks. In all the countries studied, the Ministry of Energy is a key player in the development and implementation of RE strategies (Table 3-4).

Some countries, such as Morocco, Algeria, Egypt or Tunisia, have renamed the Ministry of Energy and included »renewable energy« or »energy transition« in its name to emphasise the importance of RE.

Despite much progress in most countries, existing institutions often focus on the structure and requirements of the fossil fuel-based energy system; therefore, they tend to have a vested interest in fossil fuel energy production and may not always be supportive of the transition to RE. Thus, in order to pave the way for REs, either existing institutions need to be restructured from within to meet the requirements of RE or new institutions need to be created. For example, Morocco established the Moroccan Agency for Sustainable Energy (MASEN) as an independent institution to drive the energy transition. In Jordan, the Energy and Minerals Regulatory Commission (EMRC) facilitates the implementation of RE projects as a »one-stop shop«. In Egypt, the New and Renewable Energy Authority (NREA) was created to promote and develop RE projects.

In addition to the institutional level, the management of the electricity sector is also an important element influencing the development of RE. Traditionally, the electricity sectors in the MENA region have been state-dominated and vertically integrated. For example, in Iraq, the electricity sector has still not been liberalised. In Lebanon, generation, production, and distribution are regulated by the state-owned electricity utility Électricité du Liban (EDL), although public-private partnerships for electricity generation were allowed in 2010. The vertically integrated structure also persists in Tunisia and Algeria, despite private power producers being allowed to participate in the market. In Morocco, the National Office for Electricity and Drinking Water (ONEE), a state-owned electricity operator, also remains active throughout the value chain (generation, transmission, distribution) and acts as the sole buyer of electricity. However, Morocco is one of the few countries that established an independent energy regulator, the Moroccan Energy Authority (ANRE), which began operating in 2021. Another example is the

Table 3-4
**Overview of Selected Institutions Responsible for Renewable Energies**

| | Algeria | Egypt | Iraq | Israel | Jordan |
|---|---|---|---|---|---|
| **RE Institution** | | | | | |
| Electricity Regulatory Agency | Commission de Régulation de l'Electricité et du Gaz (CREG) | Egyptian Electric Utility and Consumer Protection Regulatory Agency (EgyptERA) | | Israel Electricity Authority (EA) | Energy and Minerals Regulatory Commission (EMRC) |
| Power Off-taker for (large-scale) RE Projects | Société Algérienne de Gestion du Réseau du Transport de l'Electricité (GRTE) | Egyptian Electricity Transmission Company (EETC) | Directorate of Transmission | Israel Electricity Company (IEC) | National Electric Power Company (NEPCO) |
| Main Responsibility RE Policy Design | Ministry of Energy Transition and Renewable Energy | Ministry of Electricity and Renewable Energy and NREA | Ministry of Electricity | Ministry of Energy | Ministry of Energy and Mineral Resources |
| Sustainable Energy Fund | National Fund for Renewable Energy and Cogeneration (FNER) | Green Economy Financing Facility (GEFF) | | | Jordanian Renewable Energy and Energy Efficiency Fund (JREEEF) |

| | Lebanon | Morocco | Palestine | Tunisia | Yemen |
|---|---|---|---|---|---|
| **RE Institution** | | | | | |
| Electricity Regulatory Agency | National Electricity Regulatory Authority (NERA) *(not operational yet)* | National Electricity Regulatory Authority (ANRE) | Palestinian Electricity Regulatory Council (PERC) | Specialised Authority | |
| Power Off-taker for (large-scale) RE Projects | Electricité du Liban (EDL) | Office National de l'Electricité et de l'Eau potable (ONEE) | Palestinian Electricity Transmission Company Ltd. (PETL) | Société Tunisienne de l'Electricité el du Gaz (STEG) | Public Electricity Corporation (PEC) |
| Main Responsibility RE Policy Design | Council of Ministers; Lebanese Centre for Energy Conservation (LCEC) | Ministry of Energy Transition and Sustainable Development; MASEN | Palestinian Energy and Natural Resources Authority (PENRA) | Ministry of Energy, Mines and Renewable Energy; ANME | General Administration of Renewable Energy within Ministry of Electricity and Energy |
| Sustainable Energy Fund | National Energy Efficiency and Renewable Energy Action (NEE REA) (GEFF, LEEREFF) | Energy Development Fund (EDF) by SIE | Revolving Fund | Energy Transition Fund (Fonds de Transìtion Energétique) | |

(Source: Own compilation based on country studies)

Electricity Authority (EA) of Israel, which is an independent regulatory body responsible for the provision and supervision of electricity services. Yet, overall, the Israeli electricity market remains highly centralised and vertically integrated. The only electricity supplier in Israel is the Israel Electricity Company (IEC), which is a state-owned company responsible for electricity generation, transmission, and distribution. Still, more recently, the Israeli electricity market has opened up to private generation as a result of growing demand for electricity. Before the war, Yemen also had plans to establish an independent regulator, but those plans have not yet materialised. Egypt has already legally unbundled the electricity market, but the Egyptian Electricity Holding Company (EEHC), a state-owned company with various subsidiaries, remains the dominant player, owning and operating 90% of the electricity generation capacity. Thus, Jordan is the only country studied where the electricity sector has gradually opened to competition, and electricity generation and distribution are largely privatised. Meanwhile, the state-owned National Electric Power Company (NEPCO) remains the sole transmission system operator and single-buyer of electricity. Jordan's example shows that liberalisation of the electricity sector can successfully encourage private sector participation and investment, which will be critical for transitioning to 100% renewables. Overall, the institutional dynamics and structures will be determinant factors for the success of the energy transition in all the countries studied.

### 3.2.6 Greenhouse Gas Emissions

Reducing GHG emissions under the Paris Agreement is one of the key drivers of global efforts to transition to a clean and sustainable energy system. This is also true for the MENA countries studied. Other concerns such as meeting rising demand, reducing import dependence, enhancing energy security, as well as opening up new economic development opportunities are equally, if not more, driving the transition efforts. All countries, nevertheless, have committed in their Nationally Determined Contributions (NDCs) to reduce their GHG emissions. Iraq is targeting a 6% reduction in emissions per capita compared to 2010. Similarly, Algeria aims to reduce its $CO_2$ emissions by 7% by 2030. Tunisia has committed to lower GHG emissions in all sectors, including the energy sector, by 41% from a 2010 baseline by 2030. Morocco submitted updated NDCs in June 2021, raising its conditional target to a 45.5% reduction in GHG emissions. Jordan has also increased its GHG emissions reduction target from 14% to 31% in the first NDC. Israel has set an economy-wide, unconditional target to decrease GHG emissions to 7.7 tons of $CO_2$ per capita by 2030, which is a 26% reduction from 2005 levels. Yemen aims to reduce GHG emissions by 14% by 2030. The country's unconditional target without international support was set to 1%. Lebanon commits to an unconditional target of 20% and a conditional target of 31% reduction in GHG emissions. Egypt's NDC does not include a clearly quantifiable GHG reduction target. Some of the countries studied, including Morocco and Israel, developed national monitoring, reporting, and verification (MRV) systems to facilitate progress on GHG reductions and measurement of policy effectiveness.

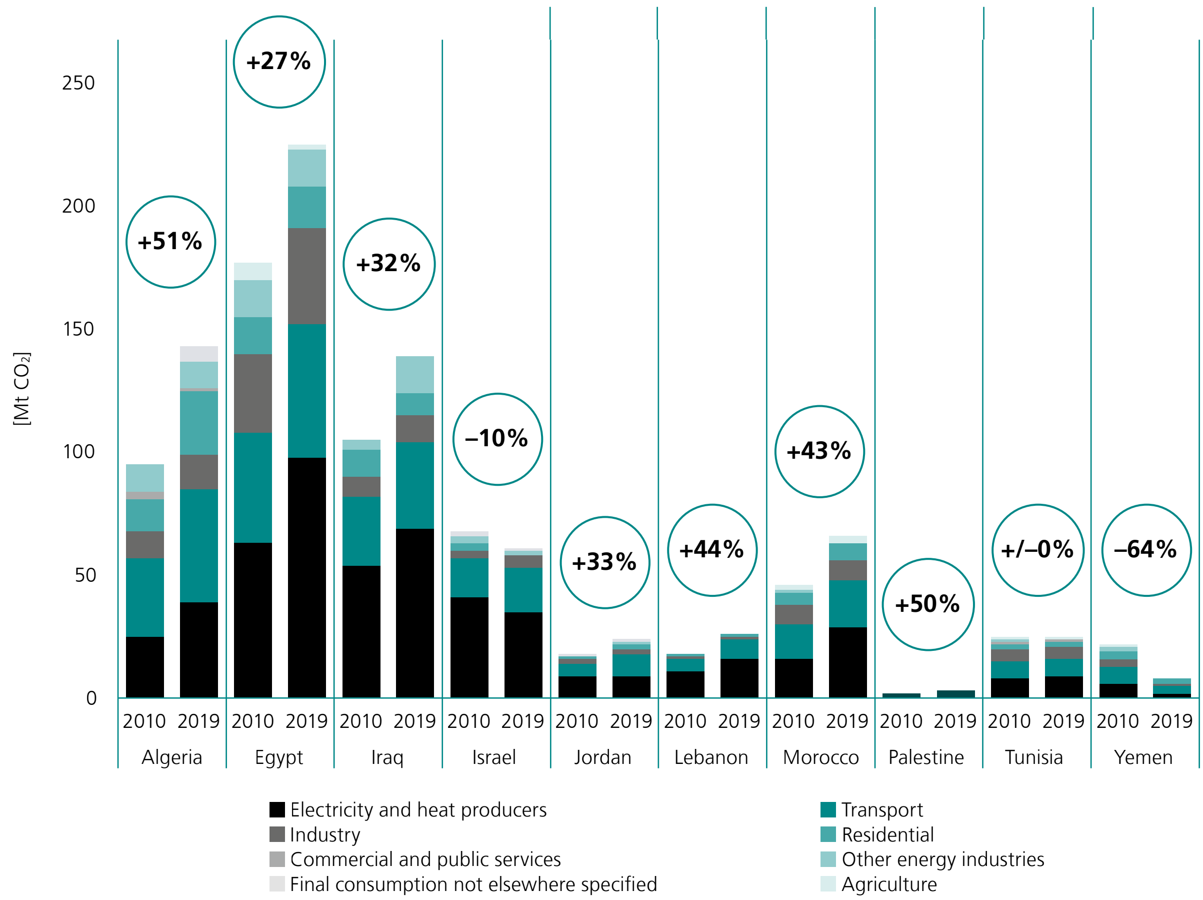
Despite these ambitious targets in the NDCs, emissions from 2010 to 2019 increased in all countries except Yemen and Israel (Fig. 3-3). In Yemen, the decline was due to the war-related slump in fossil fuel electricity generation, the disruption of economic activity, and the decline in transport due to fuel shortages. In Israel, the main reason for the decrease in emissions was the conversion of electricity generation from coal and oil to natural gas. The major causes for the increase in emissions in the other countries were growing energy demand due to population growth, urbanisation, economic development, and changing consumer habits. As these trends are expected to continue, it will be very challenging for countries to reduce their emissions, especially that RE is not yet replacing fossil fuels in most countries. Overall, the electricity sector is the largest contributor to $CO_2$ emissions in all the countries studied.

### 3.2.7 Societal Involvement and Acceptance

Social awareness, acceptance, and active support for the energy transition are as equally important as technical, institutional, and market factors. However, detailed information on the awareness and acceptance of REs in the countries studied is often limited.

On the one hand, there are a few reasons for the lack of awareness and acceptance of REs. In Lebanon, awareness of RE is low due to the limited number of visible installations.

Figure 3-3
**$CO_2$ Emissions by Sector (in Mt $CO_2$) 2010 and 2019**




(Source: based on IEA (2021); Global Carbon Project (2021))

In Iraq, many people are also unaware of the benefits of RE, and awareness programmes are largely lacking. In Israel, awareness of environmental, energy transition, and energy efficiency issues is moderate.

In countries where small-scale residential solar energy applications are more widespread, such as Yemen, Palestine, Israel, Jordan, or Tunisia, knowledge and awareness seem to be generally higher, as people there are directly involved in the realization of RE potential and benefits. Yet, this awareness is often limited to solar energy applications and does not include other technologies or a broader awareness of environmental issues. For example, in Palestine, awareness of solar energy is high, seeing as it provides an alternative energy source to offset frequent load shedding.

Unpleasant experiences with solar systems for households often negatively affect the acceptance of REs. This was the case in Egypt when solar thermal water heaters were introduced as an alternative to electric and gas heating as early as the late 1990s, and the market was populated with products from unknown suppliers – most of which came from China. Many of these units were built using inferior components; hence, the devices often malfunctioned. This negatively impacted the reputation and public perception of RE. The same trend can be seen today in Yemen and other countries, where low-quality PV panels are being installed but are often faulty. As a result, the demand for high-quality solar panels has increased, which is also reflected in the import figures for these panels.

Another bottleneck is the lack of qualified personnel due to the absence of training opportunities for technicians and engineers. In Yemen and Palestine, for example, there is a shortage of technical professionals and know-how, which poses a significant challenge to the implementation of decentralised RE systems. Jordan does have relatively strong established institutions that help raise awareness and acceptance and provide technical training for RE specialists. However, these offers must be expanded, as they do not yet meet the demand for skilled workers in the RE sector. Overall, more opportunities and incentives need to be created to engage small and medium sized players in the RE sector so that the local population can also benefit from RE development. This is also true for countries such as Egypt and Morocco that tend to strongly focus on large-scale RE projects.

On the other hand, there are factors in some MENA countries that positively influence the awareness and acceptance of REs. In Egypt and Morocco, RE enjoys strong political support, and large-scale energy projects are often portrayed as prestigious objects of national importance, which contributes to a positive perception of RE. Moreover, RE in these countries as well as in Jordan is frequently discussed in social media, newspapers, and on television. In Jordan, the majority of the population is aware of RE projects and is in favour of them. In Morocco, solar energy infrastructure is generally well received, and in order to ensure that local communities can benefit from RE projects, several strategies and measures are in place that improve development at the local level. This includes campaigns to raise awareness of large-scale energy projects. Overall, in addition to the general public and professionals, awareness and knowledge about RE is also important at the decision-making level, in institutions, and in the private and banking sectors in order to create an enabling environment for the diffusion of REs. In this area, there is still a lot of need for action.

## 3.3 DEVELOPMENTS AT THE NICHE LEVEL

Developments at the »niche« level during each phase are crucial for reaching the subsequent stages of the energy transition. Accordingly, alongside the above-mentioned progress at the »regime« level, prior and parallel developments at the »niche« level must take place.

In the three countries Iraq, Palestine, and Yemen (where the transition to RE is still in its early stages), there are important developments at the »niche« level to prepare for the take-off of RE (Phase 1). These include potential assessments, the implementation of local pilot projects, support for the formation of actor networks, the strengthening of local capacities, and the exchange of knowledge about the energy transition. In some of these areas, the three countries have already made significant progress. For instance, all three countries have already developed RE targets, and both Iraq and Yemen have introduced solar energy tendering procedures. So far, however, no large-scale project has reached the implementation stage. All three countries face major challenges due to political instabilities and previous or ongoing violent conflicts. Due to such situations, the introduction of small-scale solar energy systems to supply households or businesses has been favoured, especially in Yemen and Palestine. Yet, this development cannot be observed on a relevant scale in Iraq. Owing to its large fossil resources, Iraq has not yet made much progress in the up-take of RE projects. For Yemen and Palestine, detailed estimates of renewable potential are lacking. Overall, considerable efforts are needed in all countries to increase the share of REs and make them an integral part of the energy system. REs can, however, be a part of the solution to improve the limited energy supply, thus increasing the chances for economic development in all three countries.

Currently, there are countries that are already in Phase 1. Some of them such as Lebanon are at an early stage, while others such as Algeria, Egypt, and Tunisia are further ahead. Countries such as Israel or Jordan have even almost completed Phase 1. Yet, in all these countries, developments need to take place at the »niche« level to pave the way for Phase 2 »System Integration«. This entails that the potential of different flexibility options should be assessed and tested, the role of sector coupling (for example, e-mobility, power-to-heat, and storage) needs to be explored, and business models in this area ought to be investigated. On the one hand, in Lebanon, the development of RE systems is still in its infancy. So far, therefore, there is no significant »niche« development to prepare for Phase 2. On the other hand, in Egypt, Tunisia, and Algeria, different advancements are already taking place at the »niche« level to prepare the ground for Phase 2 developments according to the applied phase model. This includes the discussion and, in the case of Egypt, the establishment of strategies related to hydrogen and its derivates. In terms of flexibility planning, Egypt is still in the early stages, but there are already initial studies assessing different aspects of flexibility planning. Regarding sector coupling, Egypt supports e-mobility through tax exemptions for electric vehicles (EVs) and a strategy to promote local manufacturing of EVs. In Algeria and Tunisia, concrete e-mobility measures are still under development. Additionally, Tunisia has already developed a national transport master plan for 2040, which also supports e-mobility projects. In Israel, which is classified as being in an advanced stage of Phase 1, there are already concrete targets, such as significantly increasing the number of EVs and making all private vehicles 100% electric by 2030. DSM measures like the use of smart meters, smart appliances that can be operated automatically or remotely, or EV batteries as storage options, are also currently being tested in Israel as a form of flexibility. Moreover, the country has set a quota of 800 MW for pumped storage power plants and is exploring hydrogen technologies by supporting research and pilot projects. Similarly, Jordan, which is evaluated to be between Phase 1 and Phase 2 of the applied phase model, has signed a Memorandum of Understanding (MoU) with an Australian company to explore the feasibility of green hydrogen production in southern Jordan, Aqaba. Jordan is considered a pioneer in the MENA region in the field of e-mobility as well as in the field of energy storage, where the potential for battery storage in the country has also been explored, and a PPA has been signed for the largest battery storage project in the MENA region. Thus, some of the elements at the »niche« level (which are defined as important in the MENA Energy Transition Phase Model) to prepare Jordan for the next steps in Phase 2 have already been fulfilled.

For a country like Jordan, which is moving to Phase 2, but even more so for Morocco, which is already in Phase 2, developments need to be initiated at the »niche« level to prepare for the transition to Phase 3 »PtF/G«. This includes, for example, PtF/G applications in the form of pilot projects that test the production of synthetic fuels and gases under local conditions. In this context, Morocco is currently developing a hydrogen strategy and is already planning pilot projects for the production of green hydrogen and green ammonia. The country is further developing its grid infrastructure, concentrating on stabilisation measures and smart grids. It is also discussing potential electricity exports to Portugal and the United Kingdom (UK) as well as future exports to Spain. Thus, depending on the stage of the energy transition according to the applied MENA Energy Transition Phase Model, the analysed countries show different levels of activity at the »niche« level. As the developments at the »niche« level are particularly important to prepare for the next steps of the energy transition, the countries are well advised to continue fostering such advancements at an early stage.

# 4

# KEY FINDINGS FROM THE APPLICATION OF THE MENA ENERGY TRANSITION PHASE MODEL

A clear understanding and structured vision are prerequisites for advancing and managing the transition to a fully RE-based energy system. To facilitate this understanding, the MENA Energy Transition Phase Model can be employed as a tool to analyse and structure the transition process in the MENA countries, thus supporting this process. The model was applied to the ten countries Algeria, Egypt, Iraq, Israel, Jordan, Lebanon, Morocco, Palestine, Tunisia, and Yemen to examine and better comprehend the energy transition processes in these countries. From the analysis, the status of the energy transition in the individual countries can be derived and classified according to the different phases of the applied model. (Fig. 4-1) shows the progress of the individual countries towards a 100% RE system.

Indeed, the transition is always context-specific and depends on the given conditions in the individual countries, but the synthesis of the individual country studies illustrates the following overarching insights about the energy transition in the MENA region:

- While countries such as Morocco, Jordan, Egypt, and Israel are on track to meet their RE targets, other countries need to improve their efforts to expand renewable electricity generation to meet their goals.

- Countries with limited fossil energy resources, such as Morocco and Jordan, are showing strong progress and may exceed their targets. Meanwhile, in countries with fossil energy resources, such as Algeria or Iraq, the energy transition is progressing at a slow pace.

- In countries with difficult political situations, such as Yemen and Palestine, RE development is mainly driven by the introduction of small-scale solar energy systems to meet the daily energy needs of the population, while large-scale systems are missing.

- Despite the progress in renewables, fossil fuels are still the main source of electricity generation in all the countries studied.

- Although there is a high potential for generating electricity from solar and wind energy at competitive costs, this advantage is not being fully exploited in part due to high subsidies for fossil fuels.

- All countries surveyed have recognised the importance of energy efficiency, and many have developed national energy efficiency plans and targets, but there are stark differences in the implementation of energy efficiency measures between countries.

- Energy subsidies are a major barrier to energy efficiency efforts in most of the countries studied, as low electricity prices do not encourage energy-saving behaviour.

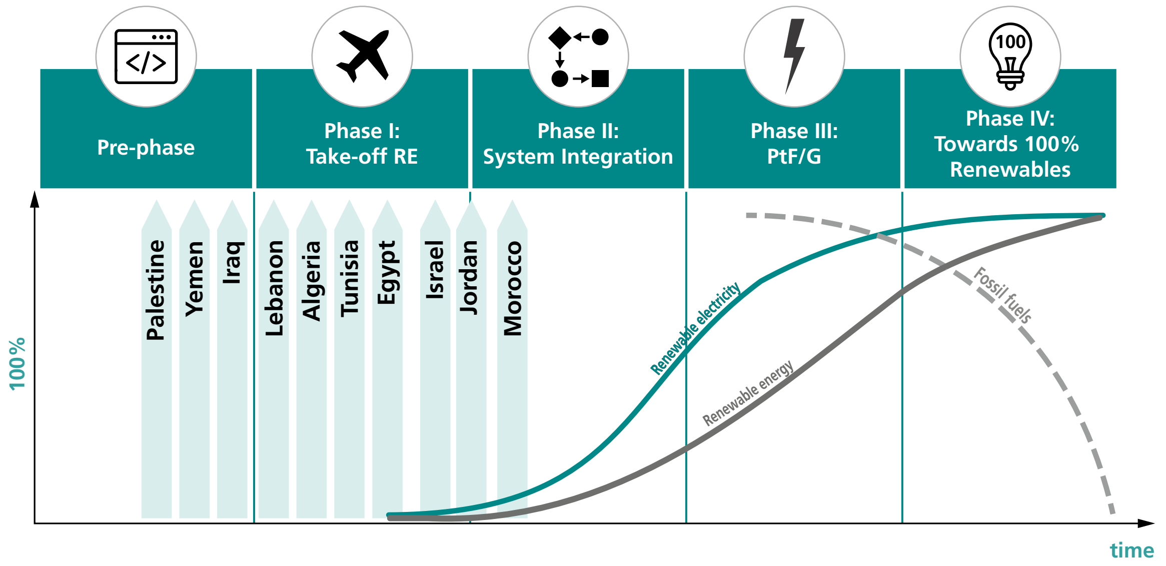
- Expanding and retrofitting the transmission grid are both crucial, seeing as RE potentials and demand centres are far from one another in most countries, and the transmission infrastructure is not sufficient enough to connect supply and demand and accommodate large amounts of renewable electricity.

- The development of the transnational interconnections of the electricity grid will be vital to manage the fluctuating loads from REs across the region. Although first developments in this direction have been announced, they need to be implemented and scaled up rapidly.

- Reducing GHG emissions is not the only key driver for energy transition. In fact, the main motives for transition are that RE can help meet growing demand, reduce dependence on imports, increase energy security, and provide opportunities for economic development.

- All countries studied expect to reduce GHG emissions by 2030. Currently, however, emissions are rising in almost all countries and will likely not decrease or end, seeing as energy demand is expected to continue growing.

Figure 4-1
**Categorisation of the Analysed Countries According to the MENA Energy Transition Phase Model**




(Source: Own compilation based on country studies)

– Existing institutions often concentrate on the fossil sector and have a vested interest in it. Countries such as Morocco or Egypt show that it may, therefore, prove beneficial to create new institutions tailored to the needs of the RE sector.

– Liberalisation of the electricity generation and distribution sector can promote private sector engagement and spur the development of RE. In most of the countries studied, liberalisation of the electricity market is still at an early stage. However, Jordan (even though it remains a single buyer market) has shown that the liberalisation of the generation sector benefits REs.

– The promotion of small and medium-sized applications can help raise awareness and acceptance. Quality standards for the technology and the installation have proven to be important, as negative experiences can quickly lead to lower acceptance levels. This requires education and training measures to increase the number of skilled workers in the RE sector.

– Awareness and knowledge about RE needs to be increased at all levels of decision-making, including the banking sector, which will, in turn, improve the availability of finance from local sources.

In summary, energy systems in the MENA region are in a developmental phase. REs are attractive, for they offer sustainability and energy security. They also have the potential to increase economic prosperity. However, RE targets and policies could be more ambitious in most countries. The framework conditions for the development of the RE industries are also still insufficient in a number of countries. On the one hand, this is due to a lack of supportive framework conditions for entrepreneurship and technological innovation. On the other hand, the state still plays an important role in the electricity sector in the MENA countries studied, and the liberalisation of the electricity market is still in its early stages in most countries. State-owned enterprises are often at the centre of large-scale projects. Mobilising private capital is usually a challenge; therefore, the participation of private actors has often been limited despite the fact that private and institutional capital will have to play an important role in the development of small to medium-sized PV and wind electricity projects in the future. A balance must be struck between political backing and state support on one side and encouragement of private actors on the other. To move towards 100% RE, all actors must cooperate at all levels, otherwise the energy transition cannot be successfully implemented.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ANRE | Moroccan Energy Authority |
| BOO | Build, Own and Operate |
| BOOT | Build, Own, Operate and Transfer |
| CHP | Combined heat and power |
| COVID-19 | Coronavirus disease 2019 |
| CSP | Concentrated solar power |
| DSM | Demand side management |
| EDL | Électricité du Liban |
| EEHC | Egyptian Electricity Holding Company |
| EIJLLPST | Eight-country interconnection project |
| EMRC | Energy and Minerals Regulatory Commission |
| EU | European Union |
| EV | Electric vehicle |
| FiT | Feed-in tariff |
| GDP | Gross Domestic Product |
| GHG | Greenhouse gas |
| GW | Gigawatt |
| ICT | Information and communication technologies |
| IEC | Israel Electricity Company |
| IPP | Independent power producer |
| LCOE | Levelised cost of electricity |
| MASEN | Moroccan Agency for Sustainable Energy |
| MENA | Middle East and North Africa |
| MLP | Multi-level perspective |
| MoU | Memorandum of Understanding |
| MRV | Monitoring, reporting, and verification |
| MSP | Moroccan Solar Plan |
| NDC | Nationally Determined Contribution |
| NEEAP | National Energy Efficiency Action Plan |
| NEPCO | National Electric Power Company |
| NREA | New and Renewable Energy Authority |
| ONEE | National Office for Electricity and Drinking Water |
| PPA | Power Purchase Agreement |
| PPP | Private Public Partnership |
| PtF | Power-to-fuel |
| PtG | Power-to-gas |
| PtX | Power-to-X |
| PV | Photovoltaic |
| RE | Renewable Energy |
| TSP | Tunisian Solar Plan |
| UK | United Kingdom |

# LIST OF UNITS AND SYMBOLS

| | |
|---|---|
| % | Percent |
| $CO_2$ | Carbon dioxide |
| GWh | Gigawatt hour |
| ktoe | Kilo tonnes of oil equivalent |
| kW | Kilowatt |
| kWh | Kilowatt hour |
| MW | Megawatt |
| TWh | Terawatt hour |

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## ABOUT THE AUTHORS

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## ABOUT THIS STUDY

This study is conducted as part of a regional project applying the energy transition phase model of the German Wuppertal Institute to different countries in the MENA region. Coordinated by the Jordan-based Regional Climate and Energy Project MENA of the Friedrich-Ebert-Stiftung, the project contributes to a better understanding of where the energy transition processes in the respective countries are at. It also offers key learnings for the whole region based on findings across the analysed countries. This aligns with FES's strategies bringing together government representatives, civil society organisations along with supporting research, while providing policy recommendations to promote and achieve a socially just energy transition and climate justice for all.



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# SUSTAINABLE TRANSFORMATION OF ENERGY SYSTEMS IN MENA COUNTRIES

## Comparative Report

A clear understanding of socio-technical interdependencies and a structured vision are prerequisites for fostering and steering a transition to a fully renewables-based energy system. To facilitate such understanding, a phase model for the renewable energy (RE) transition in the Middle East and North Africa (MENA) countries has been developed and applied to ten countries: Algeria, Egypt, Iraq, Israel, Jordan, Lebanon, Morocco, Palestine, Tunisia, and Yemen. This report synthesises the results of these ten studies.

The analysis shows that the state of the energy sector in the MENA region varies from country to country, but some underlying trends are present in all countries. In the majority of countries, energy prices are subsidised, and energy markets are mostly not liberalised. The energy demand in all analysed countries is growing and most grid systems are poorly interconnected across borders. Still, the expansion of RE in the MENA region can benefit from significant global progress and cost reductions in RE technologies.

Reducing greenhouse gas (GHG) emissions is not the only key driver for energy transition. In fact, the main motives for transition are that RE can help to meet growing demand, reduce dependence on imports, increase energy security, and provide opportunities for economic development.

All countries studied have RE targets. While some countries are on track to meet these targets, others need to increase their efforts to expand renewable electricity generation in order to meet their goals. Strong progress has been made in countries with limited fossil energy resources, while in some countries that produce and export large amounts of fossil energy resources, the energy transition is progressing rather slowly.

For further information on this topic:
**https://mena.fes.de/topics/climate-and-energy**

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