STUDY

CLIMATE CHANGE, ENERGY AND ENVIRONMENT

SUSTAINABLE TRANSFORMATION OF IRAQ'S ENERGY SYSTEM

Development of a Phase Model

Sibel Raquel Ersoy, Julia Terrapon-Pfaff
May 2021

→ By applying a phase model for the renewables-based energy transition in the MENA countries to Iraq, the study provides a guiding vision to support the strategy development and steering of the energy transition process.

→ Iraq is currently lagging behind its regional peers in the development of renewable energy technologies and has no distinct strategy to develop the renewable energy sector.

→ A shift towards a sustainable energy system could help Iraq secure a reliable and affordable electricity supply, achieve cost savings and create long-term opportunities for economic development.

FRIEDRICH EBERT STIFTUNG

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Wuppertal Institut

مركز البيان للدراسات والتخطيط
Al-Bayan Center for Planning and Studies

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Pfaff, Julia Terrapon
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Head of the Regional Climate and Energy Project MENA: Sarah Hepp
FES Jordan & Iraq P.O. Box 941876 Amman11194 Jordan
Email: fes@fes-jordan.org
Visit our website: www.fes-jordan.org

Al-Bayan Center for Planning and Studies
Email: info@bayancenter.org
2268 Al-Jaderyyah- Baghdad
www.bayancenter.org

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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 exacerbated by global and regional issues, such as climate change. The region, which is already extremely vulnerable due to its geographical and ecological conditions, will become more affected by the negative consequences of climate change in the future. In particular, drought and temperatures will increase in what is already one of the most water-stressed regions in the world. With large sections of the population concentrated in urban areas in the coastal regions, people will also be more vulnerable to water shortages, storms, floods, and temperature increases. In the agricultural sector, climate change effects are expected to lead to lower production levels, while food demand will increase due to population growth and changing consumption patterns. Moreover, the risk of damage to critical infrastructure is increasing, and expenditure for repairs and new construction is placing additional strain on already scarce financial resources. These multi-layered challenges, arising from the interplay of economic, social, and climatic aspects, should not be ignored, as they pose serious risks to prosperity and economic and social development – and ultimately to the stability of the region.

Energy issues are embedded in many of these challenges. The region is characterised by a high dependence on oil and natural gas to meet its energy needs. Although the region as a whole 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 is a promising way to meet this growing energy demand. The transition would also help to reduce greenhouse gas (GHG) emissions under the Paris Agreement. In addition, the use of renewable energy has the potential to increase economic growth and local employment and reduce fiscal constraints.

Against the backdrop of rapidly growing energy demand due to population growth, changing consumer behaviour, increasing urbanisation, and other factors – including industrialisation, water desalination, and the increased use of electricity for cooling – renewable energy is gaining attention in the MENA region. In order to guarantee long-term energy security and to meet climate change goals, most MENA countries have developed ambitious plans to scale up their renewable energy production. The significant potential in the MENA region for renewable energy production, in particular wind and solar power, creates an opportunity both to produce electricity that is almost CO_2 neutral and to boost economic prosperity. However, most countries in the region still use fossil fuels as their dominant energy source, and dependency on fossil fuel imports in some of the highly populated countries poses a risk in terms of energy security and public budget spending.

A transition towards a renewables-based energy system involves large-scale deployment of renewable energy technology, the development of enabling infrastructure, the implementation of appropriate regulatory frameworks, and the creation of new markets and industries. Therefore, a clear understanding of socio-technical interdependencies in the energy system and the principal dynamics of system innovation is crucial, and a clear vision of the goal and direction of the transformation process facilitates the targeted fundamental change (Weber and Rohracher, 2012). An enhanced understanding of transition processes can, therefore, support a constructive dialogue about future energy system developments in the MENA region. It can also enable stakeholders to develop strategies for a transition towards a renewables-based energy system.

To support such understanding, a phase model for renewables-based energy transitions in the MENA countries has been developed. This model structures the transition process over time through a set of transition phases. It builds on the German phase model and is further complemented by insights into transition governance and characteristics of the MENA region. The phases are defined according to the main elements and processes shaping each phase, and the qualitative differences between phases are highlighted. The focus of each phase is on technological development; at the same time, insights into interrelated developments in markets, infrastructure and society are provided. Complementary insights from the field of sustainability research provide additional support for the governance of long-term change in energy systems along the phases. Consequently, the phase model provides an overview of a complex transition process and facilitates the early development of policy strategies and policy instruments according to the requirements of the different phases that combine to form the overarching guiding vision.

In this study, the MENA phase model is applied to the case of Iraq. The current state of development in Iraq is assessed and analysed against the phase model. Expert interviews were conducted to gain insights to specify the previously defined abstract components of the model. As a result, further steps for the energy transition – based on the steps of the phase model – are proposed. This application is based on findings from previous studies and projects conducted in the MENA region, while case study specific data was collected for this study by the local partner Al-Bayan Center/ Qamar Energy.

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CONCEPTUAL MODEL

2.1 THE ORIGINAL PHASE MODELS[1]

The phase model for energy transitions towards renewables-based low-carbon energy systems in the MENA countries was developed by Fischedick et al. (2020). It builds on the phase models for the German energy system transformation by Fischedick et al. (2014) and Henning et al. (2015). The latter developed a four-phase model for transforming the German energy system towards a decarbonised energy system based on renewable energies. The four phases of the models correlate with the main assumptions deduced from the fundamental characteristics of renewable energy sources, labelled as follows: »Take-off Renewable Energies (RE)«, »System Integration«, »Power-to-Fuel/Gas (PtF/G)« and »Towards 100% Renewables«.

Energy scenario studies foresee that in the future most countries, including those in the MENA region, will generate electricity primarily from wind and solar sources. Other sources such as biomass and hydropower are expected to be limited due to natural conservation, lack of availability and competition with other uses (BP, 2018; IEA, 2017). Therefore, a basic assumption of the phase model is a significant increase of wind and solar power in the energy mix. This includes the direct utilisation of electricity in end-use sectors that currently rely mainly on fossil fuels and natural gas. E-mobility in the transport sector and heat pumps in the building sector are expected to play a crucial role. Sectors that are technologically difficult to decarbonise include aviation, marine, heavy-duty vehicles, and high-temperature heat for industry. In these sectors, hydrogen or hydrogen-based synthetic fuels and gases (PtF/G) can replace fossil fuels and natural gas. The required hydrogen can be gained from renewable electricity via electrolysis.

There should be a strong emphasis on adapting the electricity infrastructure because the feed-in and extraction of electricity (particularly from volatile renewables) must be balanced to maintain grid stability. Thus, power production and demand need to be synchronised, or storage options need to be implemented. Electricity storage is, however, challenging for most countries, and the potential remains limited due to geographic conditions. Accordingly, a mix of flexible options that matches the variable supply from wind and solar power plants with electricity demand must be achieved by extending grids, increasing the flexibility of the residual fossil-based power production, storage, or demand-side management. Furthermore, the development of information and communication technologies (ICT) can support flexibility management. By using PtF/G applications, different sectors can be more tightly coupled. This involves adapting regulations, the infrastructure, and accommodating a new market design. Due to the power demand being four or five times higher in a renewables-based low-carbon energy system, improving energy efficiency is a prerequisite for a successful energy transition. Following the »energy efficiency first« principle means treating energy efficiency as a key element in future energy infrastructure and, therefore, considering it alongside other options, such as renewables, security of supply, and interconnectivity (European Commission DG Energy, 2019).

The phase model outlines these socio-technical interdependencies of the described developments, which build on each other in a temporal order. The four phases are crucial to achieve a fully renewables-based energy system. In the first phase, renewable energy technologies are developed and introduced into the market. Cost reductions are achieved through research and development (R&D) programmes and first market introduction policies. In the second phase, dedicated measures for the integration of renewable electricity into the energy system are introduced. These include flexibility of the residual fossil power production, development and integration of storage, and activation of demand side flexibility. In the third phase, the long-term storage of renewable electricity to balance periods where supply exceeds demand is made essential. This further increases the share of renewables. PtF/G applications become integral parts of the energy system at this stage, and imports of renewables-based energy carriers gain importance. In the fourth phase, renewables fully replace fossil fuels in all sectors. All the phases must connect smoothly to achieve the target of a 100% renewables-based energy system. To describe the long-term changes in energy systems in these four phases, the phase model is supplemented by insights from the field of sustainability transition research. Such research is concerned with the dynamics of fundamental long-term change in societal subsystems, such as the energy system.

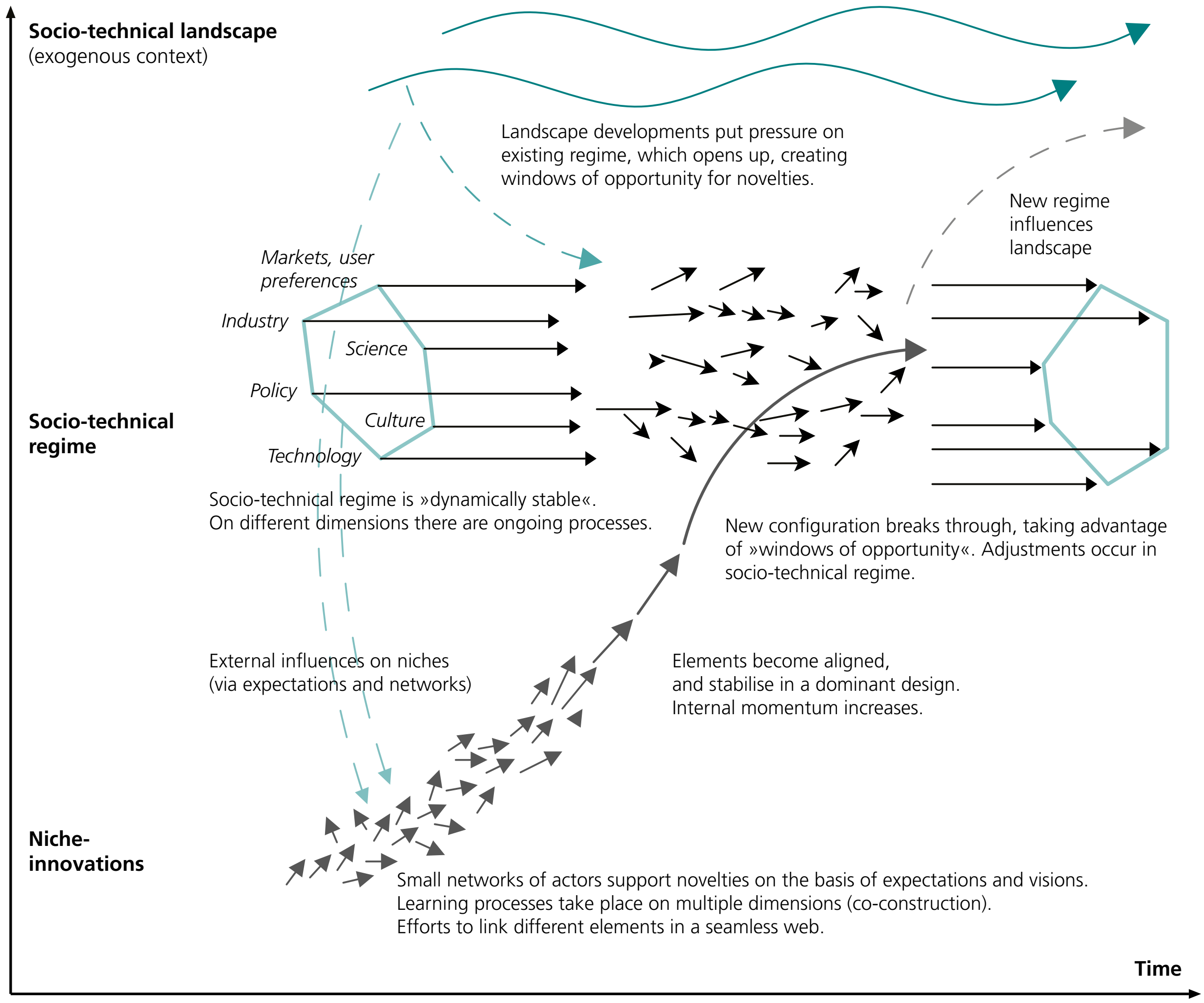
1 Text is based on Holtz et al. (2018).

2.2 THE MULTI-LEVEL PERSPECTIVE AND THE THREE STAGES OF TRANSITIONS

Energy transitions cannot be completely steered, nor are they totally predictable. The involvement of many actors and processes creates a high level of interdependency and uncertainty surrounding technological, economic, and socio-cultural developments. Due to the interlinkage of processes and dimensions, transition research typically applies interdisciplinary approaches. The multi-level perspective (MLP) is a prominent framework that facilitates the conceptualisation of transition dynamics and provides a basis for the development of governance measures (Fig. 2-1).

At »landscape« level, pervasive trends such as demographic shifts, climate change, and economic crises affect the »regime« and »niche« level. The »regime« level captures the socio-technical system that dominates the sector of interest. In this study, the regime 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 incremental because they provide the fundamental base for systemic change. Niches develop in protected spaces such as R&D labs and gain momentum when visions and expectations become more widely accepted. Therefore, actor-network structures that have the power to spread knowledge and change societal values are of key importance for the transition process (Geels, 2012) this paper introduces a socio-technical approach which goes beyond technology fix or behaviour change. Systemic transitions entail co-evolution and multi-dimensional interactions between industry, technology, markets, policy, culture and civil society. A multi-level perspective (MLP. The governance of transitions requires experimentation and learning, continuous monitoring, reflexivity, adaptability, and policy coordination across different levels and sectors (Hoogma et al., 2005; Loorbach, 2007; Voß et al., 2009; Weber and Rohracher, 2012). The development of niches in the framework of »strategic niche management« is an essential precondition for fundamental change. Within transition phases, three stages with associated policy approaches can be distinguished: »niche formation«, »breakthrough«, and

Figure 2-1
The Multi-Level Perspective



Source: Geels and Schot, 2007

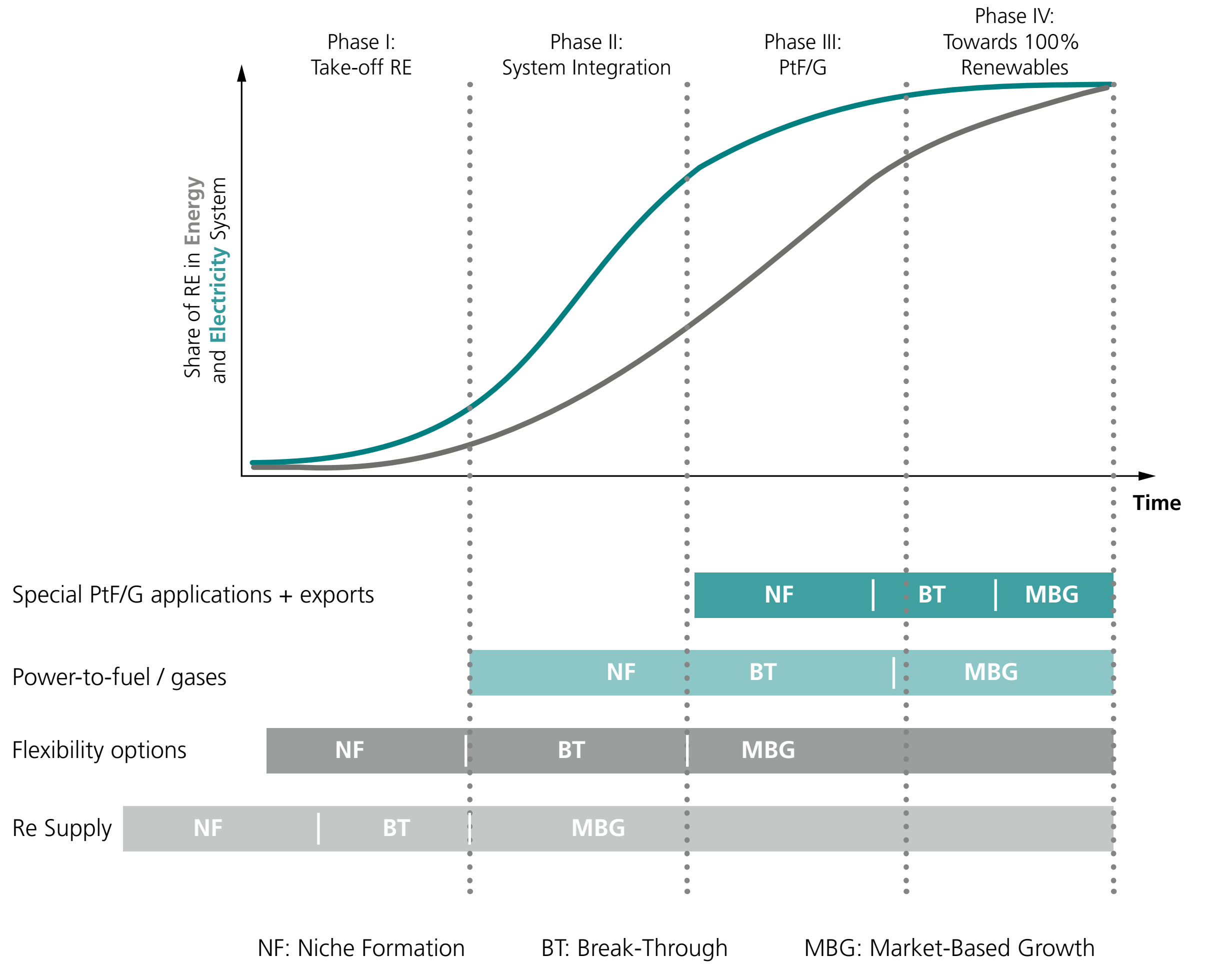
»market-based growth«. In the »niche formation« stage, a niche develops and matures, and it may offer solutions that can be absorbed by the regime. Within this stage, expectations and visions that provide direction to learning processes are essential. In addition, actor involvement and social networks can support the creation of the necessary value chains, and learning processes at different levels have the potential to advance the technology.

In the »breakthrough« stage, the niche innovation spreads by actors involved, market share, and replication in other locations. At this stage, improved price-performance is relevant, and access to necessary infrastructure and markets must be open. Amending rules and legislation as well as increasing societal awareness and acceptance, serve to reduce the barriers to deployment. When the niche innovation becomes fully price-competitive and specific supportive policy mechanisms are no longer needed, the »market-based growth« stage is achieved. Renewable energy technologies are, at this stage, fully integrated into the system.

2.3 ADDITIONS IN THE MENA PHASE MODEL

Assuming that the phase model for the German energy transition by Fischedick et al. (2014) and Henning et al. (2015) is relevant for the MENA countries, the four transition phases remain the same. The »system layer«, which was adopted from the original phase models, provides clear targets for the development of the system by orienting guidelines for decision-makers. Since niche formation processes are required for successfully upscaling niche innovations, a »niche« layer was added into the original phase model by Fischedick et al. (2020). A specific cluster of innovations was identified for each phase: renewable energy technologies (phase 1), flexibility options (phase 2), power-to-fuel/gas technologies (phase 3), and sectors such as heavy industry or aviation that are difficult to decarbonise (phase 4). In its breakthrough stage, each innovation cluster is dependent on the niche-formation process of the previous phase. Therefore, specific governance measures support the breakthrough and upscaling processes in the current phase. In later phases, the innovation clusters continue to spread through market-based growth (Fischedick et al., 2020). Consequently, the addition of the »niche

Figure 2-2
Transition Phase Model for the MENA Regio



Source: Holtz et al., 2018

layer« creates a stronger emphasis on the processes that must occur to achieve the system targets (Fig. 2-2).

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. Specific measures with a strong focus on building a renewables-based energy system are included in the phase model. Factors such as capacities, infrastructure, markets, and the destabilisation of the existing fossil fuel-based regime have also been added to the model. These aspects, however, serve as reflexivity about governance and need to be individually assessed and adapted for each MENA country.

This study pays particular attention to the »landscape« level and its role in pressurising existing regimes and creating opportunities for system change. Questions regarding the influence of international frameworks on climate change, global and regional conflicts, and the long-term impacts of the Coronavirus Disease 2019 Pandemic (COVID-19) on the transition processes are discussed in the individual country case studies. As well as focusing on the need to continuously improve energy efficiency through all the phases, the model is enlarged with resource efficiency. This assumes the continuing reduction of material intensity through efficiency measures and circular economy principles.

3

THE MENA PHASE MODEL

3.1 SPECIFIC CHARACTERISTICS OF THE MENA REGION

The original phase model was developed for the German context, meaning particular assumptions were made. As the MENA region context is different, the fundamental assumptions of the phase model were adapted to suit the characteristics of the MENA countries. Fischedick et al. (2020) outlined the differences and described the adaptations of the MENA phase model, which serves as a starting point for the individual country model transfer in this study.

One of the differences is the current energy situation in the MENA region, which varies from country to country. Several countries, including Iraq, are rich in fossil fuel resources. Others, such as Morocco, Tunisia, and Jordan, are highly dependent on energy imports. Furthermore, subsidised energy prices, as well as non-liberalised energy markets present further challenges for the energy transition in many MENA countries (IRENA, 2014).

Another fundamental difference to the German context is the growing trend in energy demand in the MENA region. According to BP (2019), the Middle East will face an annual increase in energy demand of around 2% until 2040. The power, transport, industrial, and non-combusted sectors are mainly responsible for the high increase in final energy consumption. An additional contributory factor is population growth, which is expected to further increase – particularly in Egypt and Iraq (Mirkin, 2010). In addition, energy-intensive industries, including steel, cement, and chemical, account for a substantial proportion of the energy demand. Energy demand is increasing due to the installation and expansion of seawater desalination capacities in most MENA countries: the electricity demand for seawater desalination is expected to triple by 2030 compared to the 2007 level in the MENA region (IEA-ETSAP and IRENA, 2012). Furthermore, the energy intensity in many MENA countries is high due to low insulation quality in buildings, technical inefficiencies of cooling and heating technologies, and distribution infrastructure. The electricity losses in distribution are between 11% and 15% in stable MENA countries compared to 4% in Germany (The World Bank, 2019).

Although the MENA region does benefit from significant renewable energy resources, much of the economic renewable energy potential remains untapped. By exploiting this potential, most of the countries could become self-sufficient in terms of energy, and they could eventually become net exporters of renewables-based energy. As energy and hydrogen imports become an important pillar of Europe's energy strategy (European Commission, 2020), the MENA countries could – in the future – benefit from emerging synthetic fuel markets and profit from energy carrier exports to neighbouring countries in Europe. In this regard, some MENA countries with infrastructure for oil and gas could build on their experience in handling gas and liquid fuels. With the support of power-to-X (PtX) technologies, these energy-exporting MENA countries could switch smoothly from a fossil fuel phase to a renewables-based energy system. However, to achieve this goal, the infrastructure would have to be retrofitted on a large-scale for transmission and storage. For other countries in the MENA region, harnessing their renewable energy potentials at a later transition phase to export PtX products could present new economic opportunities.

Yet a further difference is that the electricity grid in Germany is fully developed, whereas most of the MENA countries have grid systems that need to be expanded, developed nationally, and connected cross-border. Physical interconnections exist, but these are mainly in regional clusters (The World Bank, 2013). Therefore, the region lacks the necessary framework for electricity trade. In addition, technical grid codes would need to be developed to integrate renewable energy and balance its variability. Moreover, as there are few standards for PV and wind, clear regulations would need to be established to enable grid access.

The MENA countries could benefit considerably from global advances in renewable energy technologies. Global experience in the deployment of renewable energy technology adds to the learning curve, which has resulted in cost reductions. Against this backdrop, the costs of PV modules have fallen by around 80% since 2010, and wind turbine prices have dropped by 30% to 40% since 2009 (IRENA, 2019). While the phase model for the German context assumes that renewable energy technologies need time to mature, the phase model for the MENA context can include cost reductions. Additionally, there is already a wide actor network of companies that provide expertise in the field of renewable energy technologies.

The energy systems in the MENA region are in a developmental phase; renewable energies are attractive, seeing as they provide sustainability and energy security. Furthermore, they have the potential to stimulate economic prosperity. However, the conditions for developing renewable energy industries are weak due to a lack of supporting frameworks for entrepreneurship and technological innovation. While in Germany private actors play a major role in small-scale PV and wind power plants, state-owned companies in the MENA region are central to large-scale projects. The mobilisation of capital is an additional significant factor that would require dedicated strategies.

3.2 ADAPTATION OF MODEL ASSUMPTIONS ACCORDING TO THE CHARACTERISTICS OF THE MENA COUNTRIES

The phases of the original phase model must be adapted to correspond to the characteristics of the MENA region. Based on Fischedick et al. (2020), changes to the original model were made within the four phases and their temporal description. In addition, the »system layer« description is complemented by a stronger focus on the destabilisation of the regime, and the »niche layer« is highlighted in each phase to prepare for the subsequent phase.

In order to meet the expected increase in the overall energy demand, the volume of renewables in phases 1 and 2 rises considerably without undermining the existing business of industries that provide fossil fuel and natural gas. The grid in the MENA countries is limited in its ability to accommodate rising shares of renewables, which results in greater emphasis on grid retrofitting and expansion during phase 1. Moreover, phase 2 must start earlier than in the German case, and the development in some countries could include a stronger focus on solutions for off-grid applications and small isolated grids. The growing domestic demand for energy in the MENA countries could be satisfied by renewables-based energies and energy carriers, such as synthetic fuels and gases. While in Germany imports play a considerable role in the later phases (phase 3 in particular), excess energy in the MENA countries could be exported and offer potential economic opportunities in phase 4. The growing global competitiveness of renewable energies offers the opportunity to accelerate the niche formation stages in all phases of the transition. However, niche formation processes would have to be integrated into domestic strategies. Institutions to support niche developments would need to be established and adapted to the country context.

3.3 PHASES OF THE ENERGY TRANSITION IN MENA COUNTRIES

The Wuppertal Institute developed the phase model for the MENA countries based on the German phase model and the experience gained during the project *Development of a Phase Model for Categorizing and Supporting the Sustainable Transformation of Energy Systems in the MENA Region*, which was supported by the Friedrich-Ebert-Stiftung (Holtz et al., 2018; Fischedick et al., 2020). The phases for the MENA region are presented in detail in their dimensions, which are based on supply, demand, infrastructure, markets, and society. The multi-dimensional perspective of transitions research is reflected in these layers, highlighting the interrelation of these dimensions during the transition phases. Table 31 summarises the main developments in the »techno-economic« and »governance« layers, as well as on the »landscape«, »system«, and »niche« levels during the four phases.

The renewable electricity supply capacities are expanded throughout the phases to meet the increasing demand for energy from all sectors. A crucial assumption is the need for energy efficiency to be increased considerably in all phases. The developments in phases 3 and 4 are dependent on many technological, political, and societal developments and, therefore, have high uncertainties from today's perspective.

In addition, a more detailed analysis of the influence of the »landscape« level was conducted. The assumption is made that the following factors would impact on all phases: I) international frameworks on climate change; II) decarbonisation efforts of industrialised countries, including green recovery programmes after the COVID-19 pandemic; III) global and regional conflicts (affecting trade); IV) long-term impacts of the COVID-19 pandemic on the world economy; V) geographic conditions and natural resource distribution; and VI) demographic development.

Phase 1 – »Take-Off Renewable Energies (RE)«

Renewable electricity is already introduced into the electricity system before the first phase, »Take-off RE«, is reached. Developments at the »niche« level, such as assessing regional potential, local pilot projects, forming networks of actors, and sharing skills and knowledge about the domestic energy system, are initial indicators that diffusion is starting. During this pre-phase stage, visions and expectations for the expansion of RE-based energy generation are developed.

In the first phase, the characteristic development at the system level is the introduction and initial increase of renewable energy, particularly electricity generated by photovoltaic (PV) and wind plants. MENA countries could benefit considerably from the globally available technologies and the global price drops of renewable energies, which would facilitate the market introduction of PV and wind energy. As energy demand in the region is growing considerably, the share of renewable energy entering the system would not be capable of replacing fossil fuels at this stage. To accommodate variable levels of renewable energy, the grid must be extended and retrofitted. Laws and regulations come into effect, aiming to integrate renewables into the energy system and to enable renewables-based electricity to be fed into the grid. The introduction of price schemes as incentives for investors facilitates the large-scale deployment of RE and decentralised PV for households.

Developments occurring at the »niche« level pave the way for phase 2. The regional potential of different flexibility options is assessed (e.g. the possibilities for pump storage and demand-side management (DSM) in industry), and visions are developed that broach the issue of flexibility options. At this stage, the role of sector coupling (e.g. e-mobility, power-to-heat) is discussed, and business models are explored. Expected flexibility needs and sector coupling lay the ground for information and communication technology (ICT) start-ups and new digital business models.

Phase 2 – »System Integration«

In phase 2, the expansion of renewable energy continues at the »system« level, while growing markets still provide room for the co-existence of fossil fuel-based energy. The grid extension continues, and efforts to establish cross-border and transnational power lines are made to balance regional differences in wind and solar supply. At this stage, flexibility potentials (DSM, storage) are recognised, and the electricity market design is adapted to accommodate these options. The ICT infrastructure is fully integrated with the energy system (digitalisation). At the political level, regulations in the electricity, mobility, and heat sectors are aligned to provide a level playing field for different energy carriers. The direct electrification of applications in the mobility, industry, and heat sectors adds further flexibility to the system.

PtF/G applications are developed at the »niche« level to prepare the system for a breakthrough in phase 3. Pilot projects test the application of synthetic fuels and gases under local conditions. Green hydrogen is expected to replace fossil fuels in sectors such as chemical production. In the short to mid-term, the production of CO_2 from carbon capture in energy-intensive industries is acceptable. In the long term, however, the focus must shift to direct carbon capture from air or bioenergy to guarantee carbon neutrality. Actor networks create and share knowledge and skills in the field of PtF/G. Based on an assessment of the potentials for different PtF/G conversion routes, strategies and plans for infrastructure development are elaborated, and business models are explored.

The water-energy-nexus gains appropriate consideration in the framework of integrated approaches, as water is becoming even scarcer due to the consequences of climate change. This could result in shortages affecting the energy sector or competition from other uses, such as food production.

Phase 3 – »Power-to-Fuel/Gas (PtF/G)«

At the »system« level, the share of renewables increases in the electricity mix, leading to intensified competition between renewables and fossil fuels and – temporarily – to high, negative residual loads. Green hydrogen and synthetic fuel production become more competitive due to the availability of low-cost electricity. PtF/G, supported by regulations including pricing schemes, enter the market and absorb increasing shares of »surplus« renewables during times of high supply. The mobility and long-distance transport sectors, in particular, contribute to an increase in the application of PtF/G. This, in turn, enables the replacement of fossil fuels and natural gas. The development of hydrogen infrastructure and the retrofitting of existing oil and gas infrastructure for the use of synthetic fuels and gases create dedicated renewable supply facilities for international exports. Price reductions and the introduction of fees and taxes on fossil fuels not only have a negative influence on their market conditions, but they also initiate the phase-out of fossil fuels. These developments stimulate changes in the business models. As PtF/G solutions provide long-term storage, considerable export market structures can be established.

At the »niche« level, experiments with PtF/G applications play an essential role in sectors that are difficult to decarbonise, such as heavy industry (concrete, chemicals, steel), heavy transport, and shipping. In addition, the potential to export hydrogen as well as synthetic fuels and gases is explored and assessed. Actor networks are established, initial learning is gained, and business models are studied.

Phase 4 – »Towards 100% Renewables«

Renewable-based energy carriers gradually replace the residual fossil fuels. Fossil fuels are phased out, and PtF/G is fully developed in terms of infrastructure and business models. As support for renewables is no longer required, price supporting schemes are phased out. Export market structures are expanded and constitute a crucial sector of the economy.

3.4 TRANSFER OF THE PHASE MODEL TO THE COUNTRY CASE OF IRAQ

The MENA phase model was exploratively applied to the case of Jordan in 2018 (Holtz et al., 2018). The model was discussed with high-ranking policymakers, representatives from science, industry, and civil society from Jordan. It proved to be a helpful tool to support discussions about strategies and policymaking for the energy transition; a tool which would also be appropriate for other MENA countries. Consequently, necessary adaptations were made, and the MENA phase model was applied to the country case of Iraq. The results provide a structured overview of the ongoing developments in the Iraqi energy system and offer insights into the next steps necessary to transform it into a renewables-based system.

The »Vision Sustainability 2030« states that »Iraq is in a critical stage of building and strengthening the state after defeating the terrorist groups and restoration of the social peace« (Ministry of Planning, 2019). This statement illustrates the critical situation in which Iraq currently finds itself. It also raises the question of the transferability of the assumptions of the original German and the newly-developed MENA phase model. However, even though Iraq's energy system is in a difficult state – due to war and violence – there is an opportunity to rebuild it in preparation for the long-term future in which fossil fuels will become increasingly obsolete. Although the vision of an energy system based on renewables may seem far-fetched in light of today's realities in Iraq (with the dominance of fossil fuels and large reserves), it is important to take the first steps today to avoid the long-term effects of technological lock-in.

To reflect the specific challenges and opportunities for the energy transition faced by Iraq as a major oil and gas exporting country, some additions to the criteria set of the MENA phase model were made, and additional factors at landscape level were analysed. These include the effects of the COVID-19 pandemic and global decarbonisation efforts in light of the Paris Agreement that have already affected (or will affect) international oil and gas prices as well as the development of the sector. Furthermore, details of the dominant role of fossil fuels in the energy system and the connected challenges for the development of the renewables sector have been assessed. Table 31 depicts the developments during the transition phases.

3.5 DATA COLLECTION

Detailed information on the status and current developments of the various dimensions (supply, demand, infrastructure, actor network, and market development) was compiled in order to apply the phase model to individual country situations. In a first step, a comprehensive review of the relevant literature and available data was conducted. Based on the evaluation and analysis of the available data, information gaps were identified. The missing information was completed with the help of expert interviews and on-site research by local partner institutions. In addition, the local partner organisations helped to identify the country-specific challenges and barriers that could hinder the unlocking of the renewable energy potential in the country. The interviewees included relevant stakeholders with experience in the energy sector or related sectors from policy institutions, academia, and the private sector. The expert interviews were conducted according to guidelines for structured interviews. The quantitative data used is based on secondary sources, such as databases from the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), or was calculated using available data to identify the current status and future trends.

In the Iraqi case study, the local research was conducted by the partner institution Al-Bayan Center/Qamar Energy, based in Iraq.

Table 3-1
Developments During the Transition Phases

			Development before phase I	**Phase I: "Take-Off RE'**	**Phase II: "System Integration RE'**	**Phase III: "Power-to-Fuel/Gas (PtF/G)'**	**Phase IV: "Towards 100% RE'**
			* Niche formation RE	* Breakthrough RE * Niche formation flexibility option	* Market-based growth RE * Breakthrough flexibility option * Niche formation PtF/G	* Market-based growth flexibility option * Breakthrough PtF/G * Niche formation special PtF/G application and exports	* Market-based growth PtF/G * Breakthrough special PtF/G application and exports
Power Sector	**Landscape level**		* International frameworks on climate change * Decarbonisation efforts of industrialised countries (incl. green recovery programmes after COVID-19 pandemic) * Global and regional conflicts (affecting trade) * Long-term impacts of the COVID-19 pandemic on the world economy * Geographic conditions and natural resource distribution * Demographic development				
Power Sector	**System level**	**Techno-economic layer**		* RE share in energy system about 0%–20%	* RE share in energy system about 20%–50%	* RE share in energy system about 50%–80%	* RE share in energy system about 80%–100%
				* Market introduction of RE drawing on globally available technology and driven by global price drop	* Further grid extension (national and international)	* Extension of long-term storage (e.g. storage of synthetic gas)	* Large-scale construction of infrastructure for PtF/G exports
				* Extension and retrofitting of electricity grid	* ICT structures integrate with energy systems (e.g. introduction of smart meters)	* First PtF/G infrastructure is constructed (satisfying up-coming national/foreign demand)	* Phase-out of fossil fuel infrastructure and business models
				* Regulations and pricing schemes for RE	* System penetration of flexibility options (e.g. battery storage)	* Temporarily high negative residual loads due to high shares of RE	* Consolidation of RE-based export models
				* Developing and strengthening domestic supply chains for RE	* Direct electrification of applications in the buildings, mobility, and industry sectors; changing business models in those sectors (e.g. heat pumps, e-cars, smart-home systems, marketing of load shedding of industrial loads)	* Sales volumes of fossil fuels start to shrink	* Full replacement of fossil fuels by RE and RE-based fuels
				* No replacement of fossil fuels due to growing markets	* No replacement (or only limited replacement) of fossil fuels due to growing markets	* Existing fossil fuel-based business models start to change	* Stabilisation of PtF/G business models and production capacities (e.g. large-scale investments)
					* Development and extension of mini-grids as a solution for off-grid applications and remote locations	* Increasing volumes of PtF/G in transport, replacing fossil fuels and natural gas	
					* Progressing the energy transition in end-use sectors (transport, industry, and buildings)		
					* Progressing the energy transition in the industry sector, reducing the high carbon content of certain products and high emissions of certain processes		

			Development before phase I	Phase I: “Take-Off RE’	Phase II: “System Integration RE’	Phase III: “Power-to-Fuel/Gas (PtF/G)’	Phase IV: “Towards 100% RE’
			* Niche formation RE	* Breakthrough RE * Niche formation flexibility option	* Market-based growth RE * Breakthrough flexibility option * Niche formation PtF/G	* Market-based growth flexibility option * Breakthrough PtF/G * Niche formation special PtF/G application and exports	* Market-based growth PtF/G * Breakthrough special PtF/G application and exports
Power Sector	System level	Governance layer	* Fundamental recognition that energy efficiency is the second strategic pillar of the energy system transformation	* Support adoption of RE (e.g. feed-in tariffs), set up regulations and price schemes for RE	* Put pressure on fossil fuel-based electricity regime (e.g. reduction of subsidies, carbon pricing)	* Put pressure on system components that counteract flexibility (e.g. phase out base-load power plants)	* Put pressure on fossil fuels (e.g. phase out production)
				• Increasing participation of institutional investors (pension funds, insurance companies, endowments, and sovereign wealth funds) in the transition	* Withdraw support for RE (e.g. phase out feed-in tariffs)	* Withdraw support for flexibility options	* Withdraw support for PtF/G
				* Increasing awareness of environmental issues	* Measures to reduce unintended side-effects of RE (if any)	* Measures to reduce unintended side-effects of flexibility options (if any)	* Measures to reduce unintended side-effects of PtF/G (if any)
				* Provide access to infrastructure and markets for RE (e.g. set up regulations for grid access)	* Adaptation of market design to accommodate flexibility options	* Set up regulations and price schemes for PtF/G (e.g. transport, replace fossil fuels and natural gas)	* Access to infrastructure and markets (e.g. connect production sites to pipelines)
				* Moderate efforts to accelerate efficiency improvements	* Provide access to markets for flexibility options (e.g. adaptation of market design, alignment of electricity, mobility, and heat-related regulations)	* Reduce prices paid for fossil fuel-based electricity	* Support adoption (e.g. subsidies)
					* Support creation and activation of flexibility options (e.g. tariffs for bi-directional loading of e-cars)	* Provide access to infrastructure and markets for PtF/G (e.g. retrofit pipelines for transport of synthetic gases/fuels)	
					* Facilitate sector coupling between power and end-use sectors to support the integration of VRE in the power sector	* Support adoption of PtF/G (e.g. tax exemptions)	
					* Adaptation of market design to accommodate flexibility options		
					* Investments reallocated towards low-carbon solutions: high share of RE investments and reduce the risk of stranded assets		
					* Alignment of socio-economic structures and the financial system; broader sustainability and transition requirements		
					* Facilitate sector coupling between power and end-use sectors to facilitate the integration of VRE in the power sector		
					* Alignment of electricity, mobility, and heat-related regulations		

			Development before phase I	Phase I: "Take-Off RE'	Phase II: "System Integration RE'	Phase III: "Power-to-Fuel/Gas (PtF/G)'	Phase IV: "Towards 100% RE'
			* Niche formation RE	* Breakthrough RE * Niche formation flexibility option	* Market-based growth RE * Breakthrough flexibility option * Niche formation PtF/G	* Market-based growth flexibility option * Breakthrough PtF/G * Niche formation special PtF/G application and exports	* Market-based growth PtF/G * Breakthrough special PtF/G application and exports
Power Sector	Niche level	Techno-economic layer	* Assessment of RE potential	* Assessment of regional potential for different flexibility options	* Assessment of potential for different PtF/G conversion routes	* Experiment with PtF/G applications in sectors such as industry (e.g. steel, cement, and chemical sectors) and special transport (e.g. aviation, shipping)	
Power Sector	Niche level	Techno-economic layer	* Local pilot projects with RE	* Experiment with flexibility options	* Local pilot projects with PtF/G generation based on RE hydrogen and carbon capture (e.g. CCU/CCS)	* Invest in business models for PtF/G exports	
Power Sector	Niche level	Techno-economic layer		* Exploration of business models around flexibility options including ICT start-ups and new digital business models for sector coupling	* Exploration of PtF/G-based business models	* Pilot synthetic fuel exports	
Power Sector	Niche level	Techno-economic layer			• Exploration of new DSM potentials (e.g. smart charging and vehicle-to-grid for EV, flexible heat pump heating and cooling, thermal storage fed by electricity)		
Power Sector	Niche level	Techno-economic layer			* Tap into global experiences of PtF/G		
Power Sector	Niche level	Governance layer	* Development of shared visions and expectations for RE development	* Development of visions and expectations for flex-market and energy system integration (regional and transnational energy markets)	* Development of shared visions and expectations for PtF/G (e.g. strategy and plans for infrastructure development/adaptation)	* Development of shared visions and expectations for PtF/G exports (e.g. about target markets and locations for conversion steps)	
Power Sector	Niche level	Governance layer	* Support learning processes around RE (e.g. local projects)	* Support learning processes around flexibility (e.g. local projects)	* Support learning processes around PtF/G (e.g. local projects for PtF/G generation, tap global experiences of PtF/G, exploration of PtF/G-based business models)	* Support learning about PtF/G in sectors such as industry and special transport (e.g. experiments for using PtF/G products for glass smelting)	
Power Sector	Niche level	Governance layer	* Formation of RE-related actor networks (e.g. joint ventures)	* Formation of actor networks around flexibility across electricity, mobility, heat sectors (e.g. exploration of business models around flexibility including ICT start-ups and new digital business models for sector coupling)	* Formation of PtF/G-related actor network (national and international)	* Support learning around PtF/G exports (e.g. concerning market acceptance and trade regulations)	
Power Sector	Niche level	Governance layer	• Community-based engagement and involvement (e.g. citizen initiatives)	* Development of a shared knowledge base of integrated decarbonisation pathways to enable alignment and critical mass that can help shift the entire sector		* Formation of actor networks for creating large-scale synthetic fuel export structures (e.g. producers, trading associations, marketplaces)	
	* Continuing improvements in energy efficiency						
	* Continuing the reduction of material intensity through efficiency measures and circular economy principles						

Source: Own creation

4

APPLICATION OF THE MODEL TO IRAQ

Factsheet

Paris Agreement ratified	✗
Green growth strategy developed	✗
Renewable energy targets set	✔
Regulatory policies for renewable energy implementation established	✔
Energy efficiency strategy existing	✗
Power-to-X strategy	✗

4.1 CATEGORISATION OF THE ENERGY SYSTEM TRANSFORMATION IN IRAQ ACCORDING TO THE PHASE MODEL

Iraq's energy system is highly dependent on fossil fuel-based forms of energy, as the country is rich in fossil fuel resources. It is currently the third largest global oil exporter and is likely to remain one of the three largest oil exporters for the foreseeable future. Iraq is one of three of the 13 Organisation of the Petroleum Exporting Countries (OPEC) that did not ratify the Paris Agreement (Apparicio and Sauer, 2020). However, Iraq has formulated its own Nationally Determined Contributions (NDCs), and it aims to reduce its per capita carbon emissions by 6% by 2030 compared to 2010 levels (The University of Melbourne, 2020; UNDP, 2020). Iraq has recognised the potential for renewable energies and plans to increase its renewable energy share by 10% by 2030 (REN21, 2019). Nevertheless, regulations for renewable energy deployment are minimal, and reforms of the renewable energy framework, as well as energy efficiency measures, need to be considered as a priority.

On the one hand, the continual increase in energy demand challenges Iraq to extend and develop its domestic energy infrastructure to meet current and future demands. Political instability, stemming in part from the Islamic State of Iraq and the Levant (ISIL) war, have resulted in an extremely insecure energy supply and have complicated the retrofitting and expansion of the electricity network. On the other hand, Iraq faces a changing global energy system that could disrupt the fossil-fuel based economy and alter the future energy track of the country. Long-term decarbonisation efforts by the global community under the Paris Agreement framework could further encourage Iraq's plans to develop its energy system (IEA, 2019). As well as volatile global oil prices and changing energy markets (resulting in decreased revenue for the state), the Iraqi government faces the challenging question of how to meet the expectations of a young and growing population (ibid.).

Against this backdrop, the following sections will make a detailed assessment of the current status and development of Iraq's energy transition along the energy transition phase model.

4.1.1 Assessment of the Current State and Trends at the Landscape and System Levels

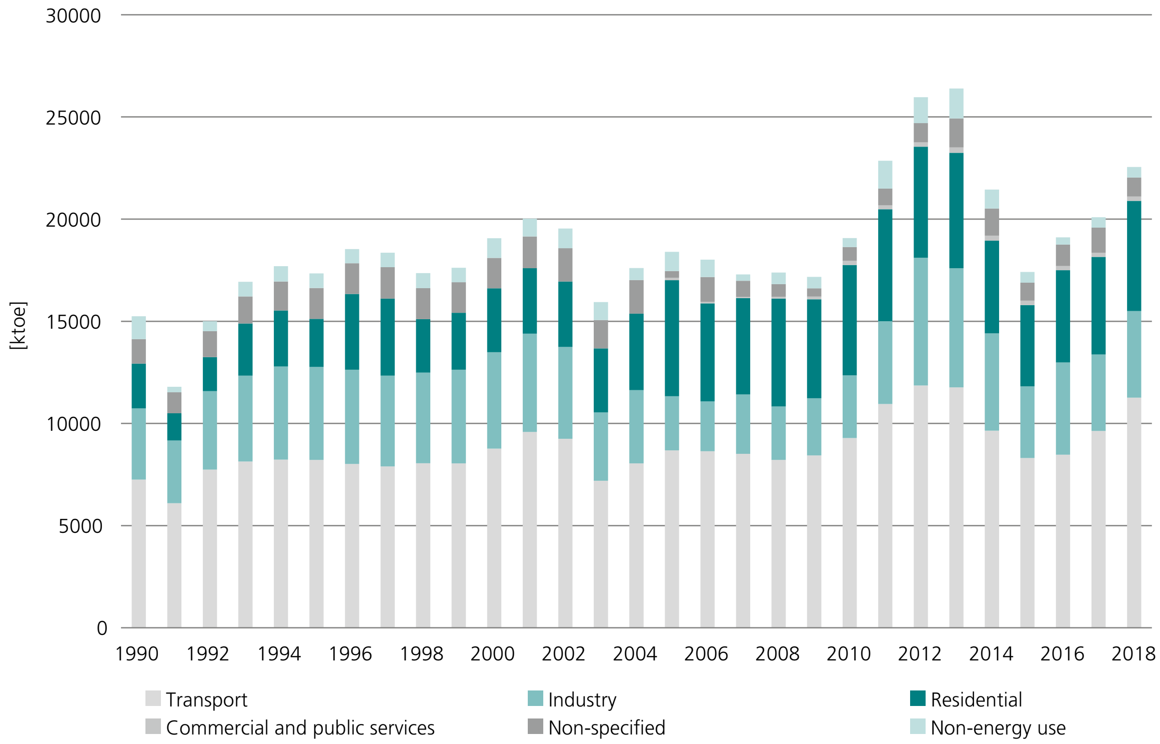
This section discusses the current state and trends of Iraq's energy system in terms of supply, demand, infrastructure, actor network, and market developments.

Energy Demand and Supply

The energy sector in Iraq has suffered in recent years, largely due to the war and acts of sabotage (Al-Khafaji, 2018; RCREEE, 2020). The energy demand has increased, and the generating capacity has not been able to meet this demand, resulting in serious power shortages (ibid.). The economic cost of these shortages was estimated to be more than 22 bn USD in 2013; a significant cost considering that Iraq lacks the finances to meet other basic needs such as education and healthcare (Istepanian, 2020b).

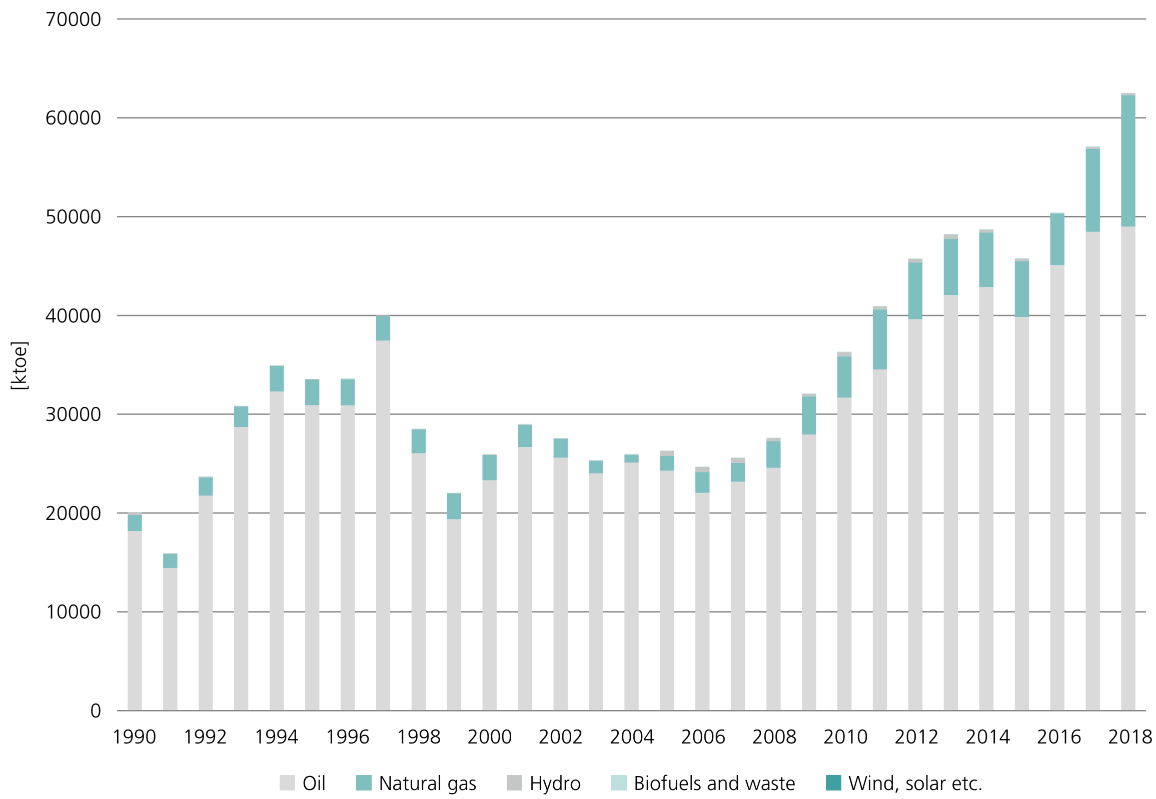
Iraq's total final energy consumption in 2018 was 22,552 ktoe (IEA, 2020a). Regarding the energy consumption by sector, the transport sector dominated accounting for 50%, followed by households (24%), industry (19%), and others (7%) (IEA, 2020a) (Fig. 4-1). The energy mix was predominantly made up of fossil fuels (Fig. 4-2). In 2018, oil held a 78% share of the energy mix, and natural gas accounted for 21%, while renewable energies held a negligible share of 0.3% (IEA, 2020a). The wasteful practice of gas flaring is also responsible for the increase in natural gas consumption (IEA, 2019).

Figure 4-1
Total Final Consumption by Sector (in ktoe), Iraq 1990–2018



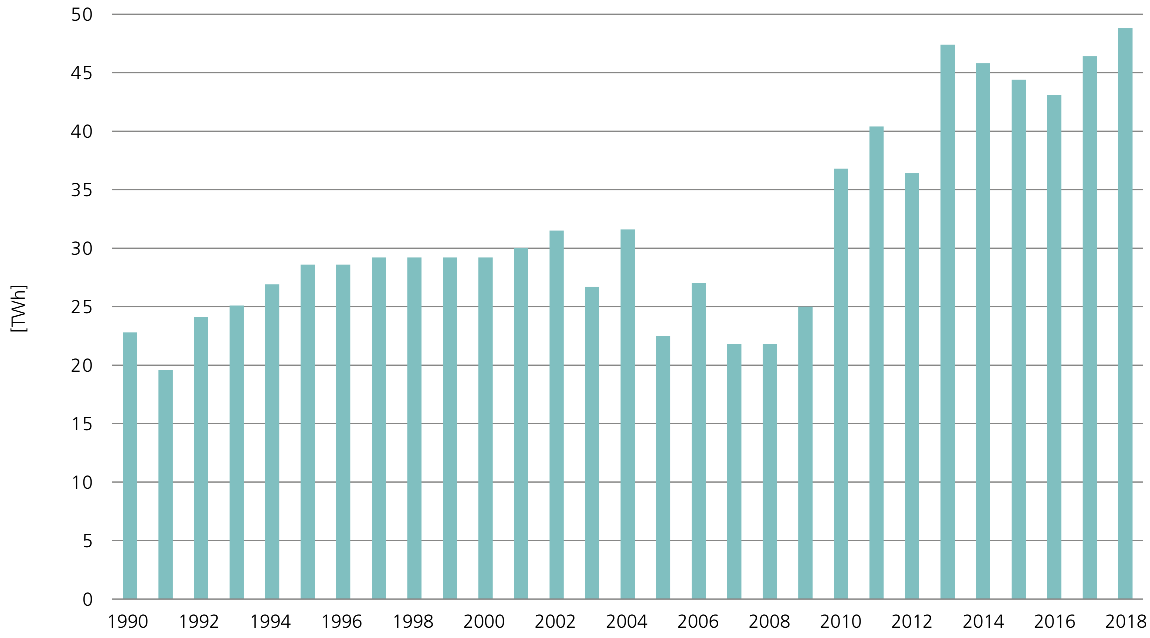
Source: data based on IEA, 2020a

Figure 4-2
Total Energy Supply by Source (in ktoe), Iraq 1990–2018



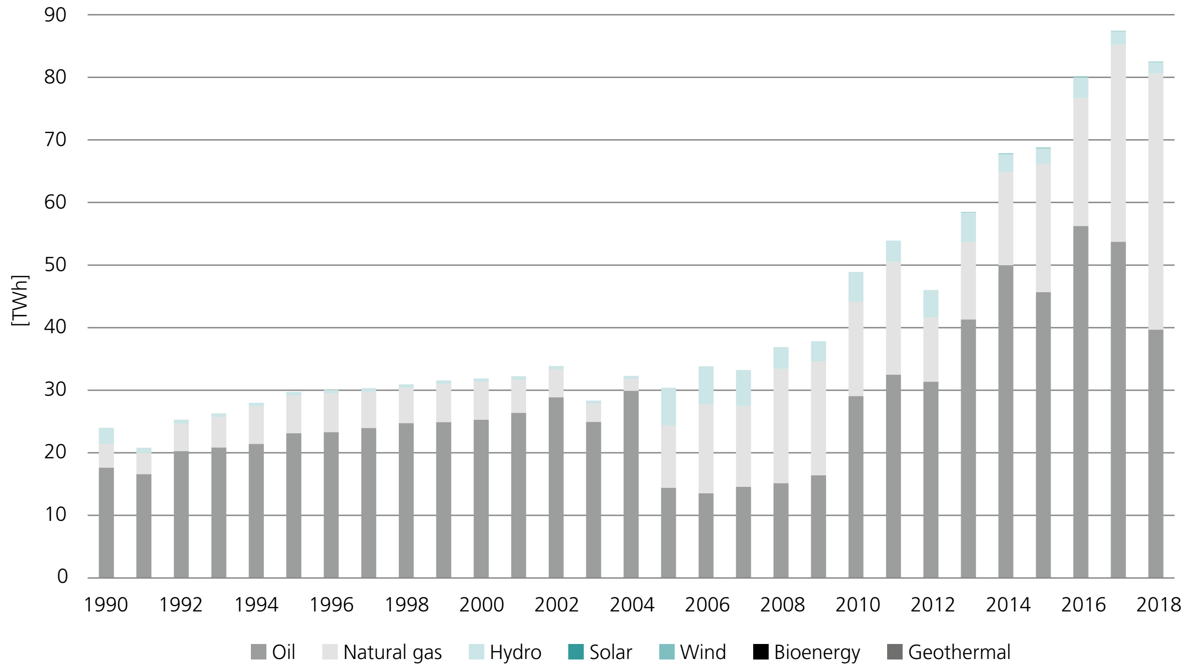
Source: data based on IEA, 2020a

Figure 4-3
Electricity Consumption (in TWh), Iraq 1990–2018



Source: based on data from IEA, 2020a

Figure 4-4
Electricity Generation (in TWh), Iraq 1990–2018



Source: based on data from IEA, 2020a

Iraq's electricity consumption had more than doubled since 1990, amounting to nearly 50 TWh by 2018 (Fig. 4-3). It is assumed that electricity demand will reach around 170 TWh by 2035 (Al-Khafaji, 2018).The current and future increasing demand for electricity is stimulated by population and economic growth driven by a surge in consumer purchases (ibid.). Additionally, old styles of equipment and appliances with high levels of energy consumption are widely used in the residential sector. In 2018, Iraq's operational capacity was between 14 GW and 15 GW, while the installed capacity was 26.2 GW with a peak demand of 25 GW spiking in summer (IEA, 2019; Al-Maleki et al., 2019). In the hot summer months, Iraq faces significant shortages because the summer peak can be 50% higher than average demand levels. These cannot be met from the supply side (Al Khalisi, 2015; Istepanian, 2020b). Even with the recent expansion of generation capacity, there is a huge gap between peak demand and grid supply. In 2013, the capacity reserve margin for Iraq was -17% (The World Bank, 2013). This has resulted in Iraqis privately acquiring diesel generators to fill the demand gap (Al-Kayiem and Mohammad, 2019; Istepanian, 2020b; TradeArabia, 2018). Iraq's electricity generating capacity is estimated to increase by 72% by 2025 compared to 2017 levels.

In general, the capacity factor of generation units in Iraq is low due to the age of the equipment, lack of fuel, breakdown, or need for routine maintenance (ibid.). Furthermore, decreasing water levels in the dams and hydropower stations result in huge unused potential capacity. The low water levels are partially a consequence of Turkey's recently constructed Ilisu dam, which reduces the water resources available to Iraq (Al-Maleki et al., 2019). Oil and natural gas generally dominate the electricity generation sector, and there is evidence of an increasing trend in generation over recent years (Fig. 4-4). The use of natural gas has been growing in recent decades and now equals oil use in power generation. Given the current inability of Iraq's power system to meet electricity demand, and thus the need for capacity expansion, Iraq can be classified according to the MENA phase model as being in the preliminary stage of the first phase.

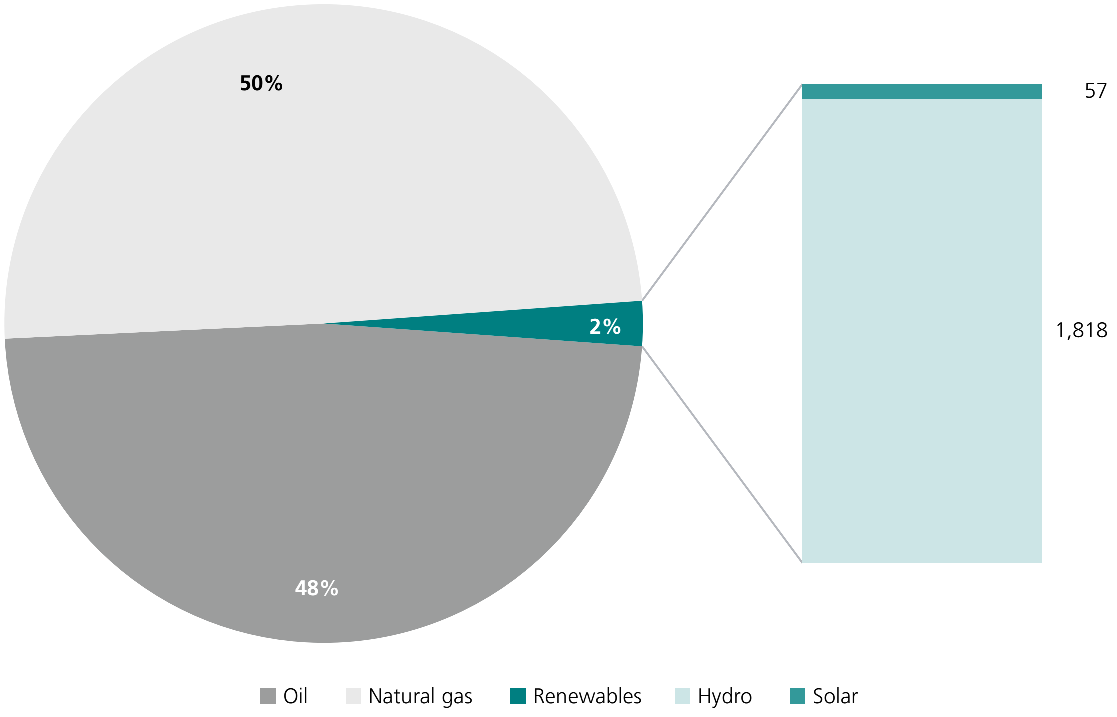
Renewable Energy

Hydropower is the main contributor to the renewables mix, but the overall renewables share is negligible. In 2018, around 1,875 GWh of electricity was generated by renewables; of this, hydropower contributed 1,818 GWh and solar power 57 GWh (Fig. 4-5).

Electricity generation from renewables experienced an increase in 2004 due to the repair of existing hydropower plants. However, the introduction of the Law on Protection and Improvement of the Environment in 2009, the Integrated National Energy Strategy of 2014, and renewable energy auctions in 2016 have so far had little impact on renewables-based electricity generation. In 2018, only 2% of the electricity generation mix came from renewables (Fig. 4-6). Iraq targets a renewable energy share of 10% in the electricity sector by 2030 (REN21, 2019) and a long-term target (time frame is not further defined) of 40% (Al-Maleki, 2020) to overcome the challenge of undersupply. It is estimated that solar PV will account for 42% of the total renewable energy mix by 2025. In the short term, renewable energy generation is expected to be used primarily for off-grid demand centres in remote areas, while in the medium to long term, solar and wind generation are also expected to feed into the grid (IEA, 2014). To date, sector coupling in the form of PtX, synthetic fuels, and hydrogen have not attracted attention at the political level. In 2016, the Ministry of Electricity of Iraq published its first renewable energy tender for a 50 MW solar PV project located in the Al-Salman District. In 2019, another tender was published, aiming to generate 755 MWp of solar energy. The investment will fall under the build, own and operate (BOO) scheme, and the investor will be granted a power purchase agreement (PPA) with the Ministry of Electricity for a period of 20 years (IEA, 2016).

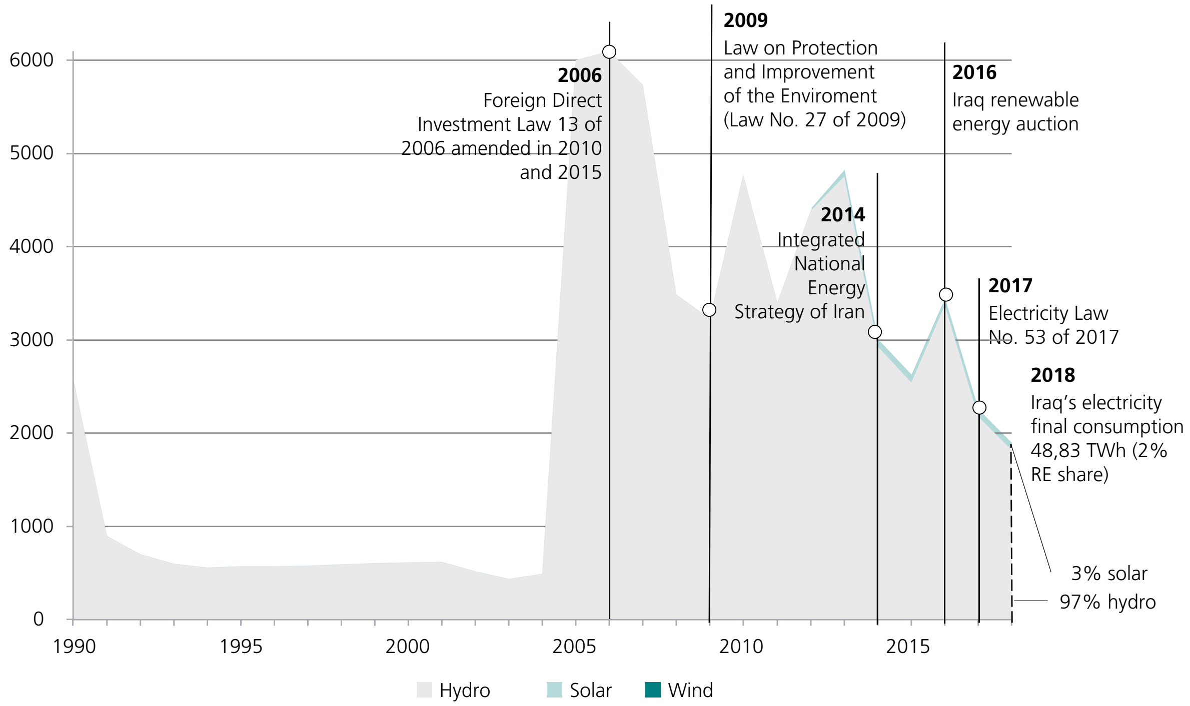
Despite its significant renewable energy potential, Iraq lags behind other countries in the region (Istepanian, 2018). The development of the renewable energy sector in Iraq faces multi-dimensional challenges. A lack of political measures, unattractive investment conditions, and non-existent financing mechanisms limit the expansion of renewable energy facilities. There are no official tax incentives from the government and no public funding to promote renewable energies. In particular, there is a lack of robust legal framework conditions to specifically promote the integration of renewable energies (IEA, 2019). In 2006, the Foreign Direct Investment Law 13 was introduced, which was amended to Law No. 2 of 2010 and, subsequently, to Law No. 50 of 2015. Under this legislation, a foreign investor or developer is entitled to make investments in Iraq without limitations. In 2009, the Law on Protection and Improvement of the Environment (Law No. 27 of 2009) was passed, focusing on monitoring pollution from all activities. In 2014, the Integrated National Energy Strategy of Iraq was developed as an attempt to create an energy vision; however, it did not take into account the reality of the challenges facing Iraq and was difficult to implement. The energy auction scheme was implemented in 2016, followed by the Electricity Law No. 53 of 2017; both were designed to accelerate the use of renewable energy. This legislation was Iraq's first endeavour to combine support for renewables, to increase energy efficiency, and to protect the environment. The National Development Plan from 2018 recognises that Iraq is one of the countries most affected by climate change and lists eight objectives for the electricity sector, which mainly target the security of electricity supply (Ministry of Planning, 2018). In 2019, the Ministry of Planning formulated »Vision Sustainability 2030«, which focuses on »empowered Iraqis in a safe country, a unified society with diversified economy, sustainable environment, justice and good governance« (Ministry of Planning, 2019). Still, neither the National Development Plan (2018) nor the Vision Sustainability 2030 outline a specific renewable energy development plan. Fig. 4-6 depicts the development of renewables-based electricity generation by source and the introduction of the most relevant energy policy measures in the period 1990–2018.

Figure 4-5
Electricity Generation Mix, Iraq 2018 (in %, GWh)



Source: data based on IEA, 2020a

Figure 4-6
Development of Renewables-Based Electricity Generation by Source (in GWh) and Introduction of Energy Policy Measures, Iraq 1990–2018



Source: data based on IEA, 2020a

Despite Iraq's minimal use of renewable energy, the country is endowed with rich renewable sources. According to studies, Iraq benefits from more than 3,000 hours of solar radiance per year, and the hourly solar intensity varies between 416 W/m^2 in January and 833 W/m^2 in June (Kazem and Chaichan, 2012). Although the overall regulatory framework is insufficient, the Ministry of Industry of Iraq has developed a directive to increase the use of solar energy. In the light of this mandate, applications such as domestic water heating, street lighting systems, and drip irrigation for agriculture will be actively promoted (Al-Kayiem and Mohammad, 2019). However, the importance, advantages, and potential of solar power are not sufficiently recognised by the government, which is a constraining factor for the sector's development (Istepanian, 2018). As stated in the literature, no private company has, to date, invested in renewable energy in Iraq, and all planned activities remain under the government's mandate (ibid.).

Studies into the potential of wind energy in Iraq are limited. Iraq can be divided into three different wind zones. The third zone, covering 8% of the country, has relatively high wind speeds of approximately 5.0 m/s with an energy density of 378 W/m^2 (Al-Kayiem and Mohammad, 2019). In the other two zones, the wind speed varies between 2.0 m/s and 4.9 m/s, resulting in energy densities of between 174-337 W/m^2 (ibid.). Iraq's first wind turbine was built in 2010 in Baghdad (Al-Jadiriyah), with a production capacity of 20 kW. Subsequently, the Ministry of Science and Technology installed a number of wind turbines in different parts of the country. This, however, did not improve the wind sector neither technically nor economically due to weak and variable wind activity as well as difficulty in connecting wind turbines to the national electrical network.

Although Iraq has some bioenergy potential, this sector has so far been neglected by the government (Kazem and Chaichan, 2012). A small number of studies have analysed the use of bio-ethanol and methanol in mixed internal combustion fuels, such as diesel and gasoline (Al-Kayiem and Mohammad, 2019). Yet, due to the minimal availability of water in Iraq, the use of biomass for energy generation is expected to remain limited.

Turning to hydropower, Iraq has two main rivers (the Euphrates and the Tigris). They both originate in Turkey and account for 98% of Iraq's water (Alwash et al., 2018), providing the supply for energy generation and irrigation in Iraq (Al-Kayiem and Mohammad, 2019). Hydropower is currently the renewable energy source with the highest share in renewable electricity generation in Iraq. Over 90% of Iraq's renewable power comes from hydropower (Fig. 4-5). However, the sector has faced several difficulties due to conflicts, resulting in damage to the infrastructure and electrical transfer lines. It has also been confronted with challenges from climate change to which hydropower generation is highly vulnerable (ESCWA, 2019). In 2012, the installed capacity of the hydropower stations was 1,864 MW, but their power generation potential could not be fully exploited (Al-Kayiem and Mohammad, 2019). Despite the limited water resources, the plan is to increase hydropower to 14 TWh by 2035 (ibid.). Compared to most other Arab countries, Iraq has the potential to use hydropower dams as pumped storage options (QAMAR Energy, 2018). Iraq's current operational and planned hydropower dams are listed in Table 4-1.

The water resources debate in Iraq is a crucial one. The water volumes in the Euphrates and the Tigris are predicted to decline by 50% and 25% respectively by 2025 (Tollast et al., 2019). Turkey started constructing dams as far back as the 1970s, and Syria built dams around the same period to better manage its own water resources. As a consequence, the water discharge to Iraq has been reduced. As the two rivers play a vital role in Iraq's power production, water supply may become a trigger point for future conflicts. While Iraq is accused of poor water management, neighbouring countries are blamed for pursuing one-sided water policies (Tollast et al., 2019).

Water resources are self-evidently an important topic for the energy sector in Iraq –both in terms of hydropower plants and for cooling purposes in conventional power plants – and should be the focus of integrated nexus planning (Al-Khafaji, 2018). The same holds true for energy use in the water sector, which is expected to significantly increase due to the expansion of desalination technologies.

Iraq's share of renewables is negligible in comparison to its significant potential. A weak legal framework and high unmet demand for energy have driven the Iraqi government to focus on simple and fast solutions; for example, the distribution of diesel generators (Istepanian, 2020b). These structural challenges further support the classification of Iraq as being in the pre-phase of the energy transition according to the phase model.

Table 4-1
Operational and Planned Hydropower Dams in Iraq

Operational hydropower dams								
Dams	Dokan	Derbedkhan	Mousil	Himreen	Haditha	Samara	A-hidya	Kuffa
Power (MW)	400	240	750	50	660	75	15	5
Planned hydropower dams								
Dams	Bakhma	Taktak	Al-Khazer Comel	Badosh	Al-Baghdadi	Mendawa	Al-Udym	Al-Fatha
Power (MW)	1,500	300	24	171	300	620	27	2,500

Source: based on Al-Douri and Abed, 2016)

The Oil and Gas Sector

As one of the world's largest oil exporters and a crucial player in global energy markets, Iraq exported 3,964,000 barrels of oil per day in 2019 (Statista, 2020). Fig. 4-7 shows that Iraq is a net energy exporter. The graph depicts a rise in exports in recent years, with the likelihood of Iraq becoming an increasingly important oil producer, seeing as it is the country with the largest proven petroleum reserves (RCREEE, 2020). Petroleum revenues account for almost 75% of the Iraqi Gross Domestic Product (GDP) and over 95% of government revenues (Latif, 2018; Wahab, 2014).

All developmental and strategic plans as well as government programmes depend on petroleum export revenues to finance the projects. Consequently, oil price fluctuation on the international market during the COVID-19 pandemic significantly affected the implementation of any such plans. Plans for reconstruction are currently either suspended or are frequently postponed.

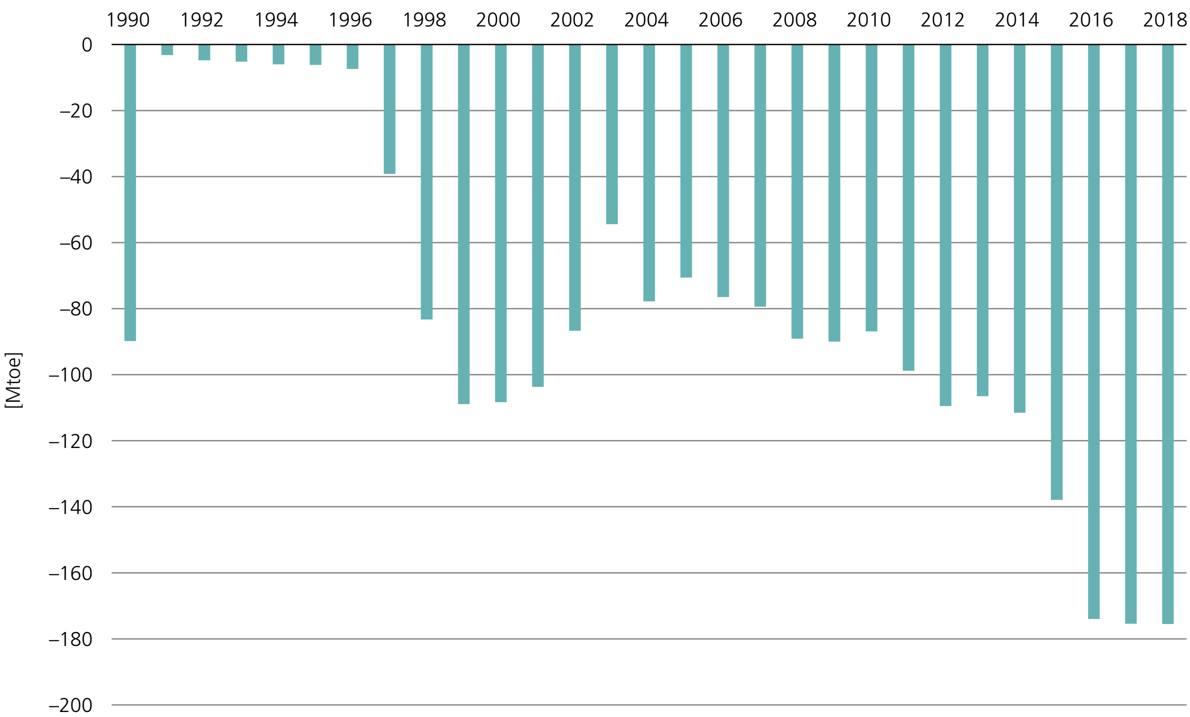
As it is a rentier economy, oil and gas play a pivotal role in Iraq. Most of Iraq's sectors depend on oil rents as the main driver of the economy's wheel. The government is heavily involved in the economy at the expense of market mechanisms and economic freedoms based on competition and comparative advantage. Due to expanding markets, the oil and gas sector may not be fully replaced by renewables in the short to mid-term. The time horizon for transitioning to a renewable energy-based energy system in the case of Iraq likely requires a prolonged period of time.

Institutions and Governance

Most policies and procedures in Iraq must be approved by the Ministry of Finance, after which the Central Bank finances the development measures. The Ministry allocates finance based on the requests of ministries concerned with energy projects.

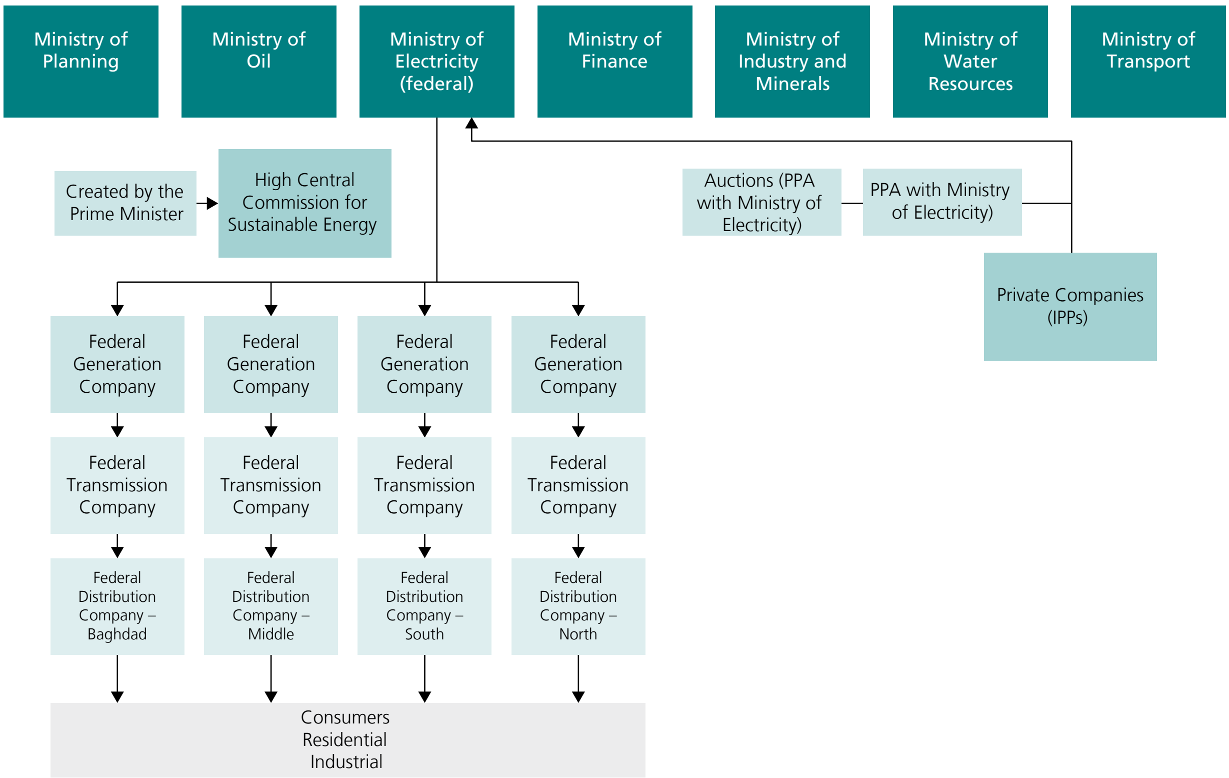
A number of ministries are involved in promoting and developing the renewable energy industry in Iraq, namely the Ministry of Oil and its affiliated departments and institutions; the Ministry of Electricity and its affiliated institutions; the Ministry of Industry and Minerals; the Ministry of Water Resources; and the Ministry of Transport. These ministries have financial allocations within the public budget, which can be used to invest in projects for renewable energy development in Iraq. The projects can be implemented through licensing rounds for specialised companies, especially those with significant experience in the field of renewable energy. The main actor in renewable energy in Iraq is the Ministry of Electricity. The federal Ministry of Electricity and the Ministry of Electricity in the Kurdistan region are separate entities. In the Kurdistan region, there are several active independent power producers (IPPs), including the Erbil, Sulaymaniyah, and Dohuk plants. At federal level, there are also a few IPPs, e.g. Maisan, Rumaila, and Bismaya Phase III. The tenders for the solar PV projects are open to IPPs. Under the Ministry of Electricity, four federal companies are responsible for generation and transmission. Similarly, four federal distribution companies – Baghdad, Middle, South, and North – are the entities responsible for electricity distribution.

Figure 4-7
Net Energy Imports (in Mtoe), Iraq 1990–2018



Source: data based on IEA, 2020a

Figure 4-8
Electricity Market Structure Showing Relevant Authorities and Companies



Source: own creation

The institutional framework for the electricity sector is characterised by vertical integration, while the governance framework for renewables in Iraq is weak. The process of corporatising the electricity sector has been delayed due to policy uncertainties and political sensitivities (Iraqi Economists, 2020). However, private and independent institutions could help to support the transition with different perspectives, which would enrich the transition pathways. As Iraq has neither an electricity regulator nor a wholesale market, and its electricity structure is inefficient and not liberalised, it is anticipated that (barring significant unforeseen changes) the transition of the energy system towards renewable energies will only be possible over a longer time horizon. This serves to reinforce classifying Iraq as being in the pre-stage of the first transition phase in the phase model.

CO_2 Emissions

Although annual electricity consumption per capita is estimated to be around 1,300 kWh, which is lower than neighbouring countries, the energy use per capita in Iraq amounts to around 1,437 kgoe, which is high in comparison to other countries in the region (Istepanian, 2018; The World Bank, 2014). By 2018, CO_2 emissions had increased by 69% compared to 2009 levels (Fig. 4-9), the year when the Law on Protection and Improvement of the Environment entered into force (IEA, 2020a). Electricity and heat producers generate the highest levels of emissions, followed by the transport sector and households.

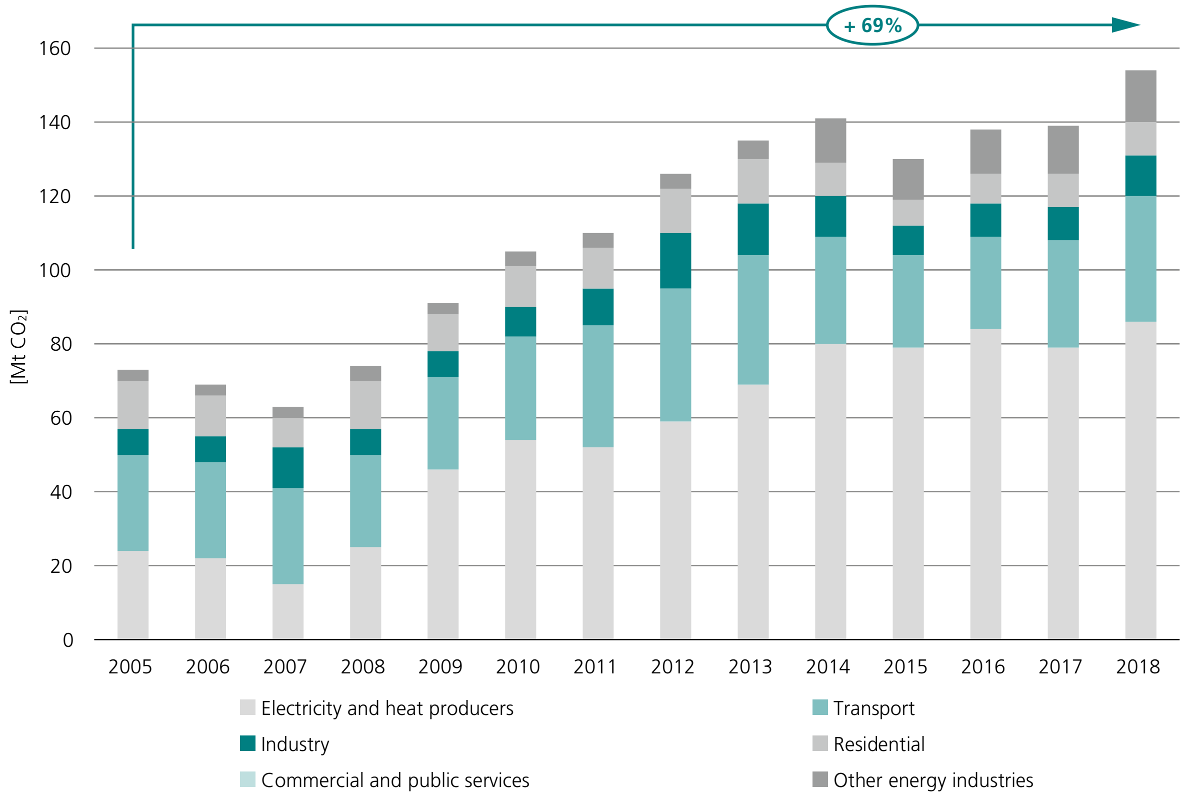
In 2018, a total of 85.9 Mt CO_2 was emitted from the electricity and heat generation sectors. The oil sector is the source of 73% of the emissions, while the natural gas sector accounts for the remainder (Fig. 4-10). Most of the air pollution is caused by the leakage of industrial waste and traffic fumes (Ministry of Planning, 2019). Iraq's emissions are also increasing due to changes in economic activities and consumer behaviour.

Owing to the absence of environmental policies, Iraq's environment is highly fragile. Iraq ranked 152 out of 180 countries in 2018 according to the Environmental Sustainability Index (Ministry of Planning, 2019). Moreover, the fact that Iraq has not ratified the Paris Agreement is a sign of the country's limited ambition on emissions reductions. This further supports classifying Iraq as being at the pre-stage level in the applied phase model.

Energy Efficiency

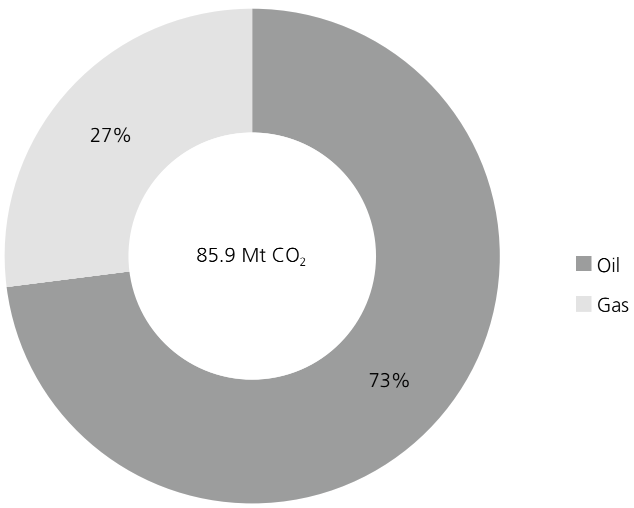
Energy efficiency strategies with concrete plans are limited and have not been a focus of the political debate in recent years (Istepanian, 2020c; RCREEE, 2020). However, with the establishment of the National Sustainable Development Plan 2018–2022, Iraq has concentrated on the overall improvement in efficiency of the energy system (ESCWA, 2019). As part of this plan, Iraq intends to rationalise electricity consumption for certain end users to achieve a 7% reduction in energy consumption by 2022 (ibid.). In its announced NDCs,

Figure 4-9
CO_2 Emissions by Sectors (in Mt CO_2), Iraq 1990–2018



Source: based on data from IEA (2020a)

Figure 4-10
CO_2 Emissions From Electricity and Heat Generation by Energy Source (in Mt CO_2), Iraq 2018



Source: based on data from IEA (2020a)

Iraq targets a reduction of per capita emissions of 6% compared to 2010 levels (The Universitiy of Melbourne, 2020).

One reason that energy efficiency plans in Iraq are hampered is the high energy subsidies. Under-pricing fails to incentivise the end consumer to adopt environmentally friendly behaviour or to implement energy saving measures. Iraq has the most regressive and one of the highest subsidies in the Arab region (Istepanian, 2020b). Low fossil fuel prices, which are subsidised at an average of 56%, largely distort the energy market. In 2019, fossil fuel subsidies accounted for 3.3% of the GDP (IEA, 2020b). The electricity tariff in Iraq is one of the lowest in the Arab region, at 1.2 US cents/kWh on average (The World Bank, 2013). Electricity subsidies drive up the national debt and reduce the country's budget (ibid.). Although electricity tariffs are very low when compared regionally, payments to distribution companies combined with payments for neighbourhood private generators mean that the end consumer's total costs for electricity are high despite the subsidies (generator costs are around 8.40 USD per 1 Amp per month (8 hours per day)) (ibid.). Fuel costs for private generators are 10 to 15 times higher than the electricity tariff. These generators also contribute to local air pollution (Al-Kayiem and Mohammad, 2019). Additionally, the high costs in the electricity sector are a result of the widespread use of oil fuel, which suffers from a high opportunity cost, technical inefficiency (thermal, gas turbine, and diesel generation power stations have 27.5% efficiency), the underutilisation of existing capacities, high aggregated technical and commercial losses (AT&C), and overstaffing (Istepanian, 2020b).

Thus far, the Ministry of Electricity, which largely owns and manages Iraq's electricity assets, has applied the »Increasing Block Tariff« scheme, which charges the customer a higher rate as the number of kWh increase (ibid.). Alternative schemes are under consideration, and a communication strategy to increase public awareness about the existing system's weakness is under development because Iraq fears that the abolition of subsidies might result in social unrest. It is crucial that the revised pricing scheme balances economic efficiency with social equity (ibid).

The Iraqi government is at an early stage of recognising energy efficiency efforts as an important pillar for energy transition. There are two fundamental requirements for achieving a smooth energy transition, namely the implementation of constantly updated energy efficiency measures and the phasing out of subsidies. Both are currently lacking in Iraq, showing that the country is in a pre-stage for these requirements.

Infrastructure

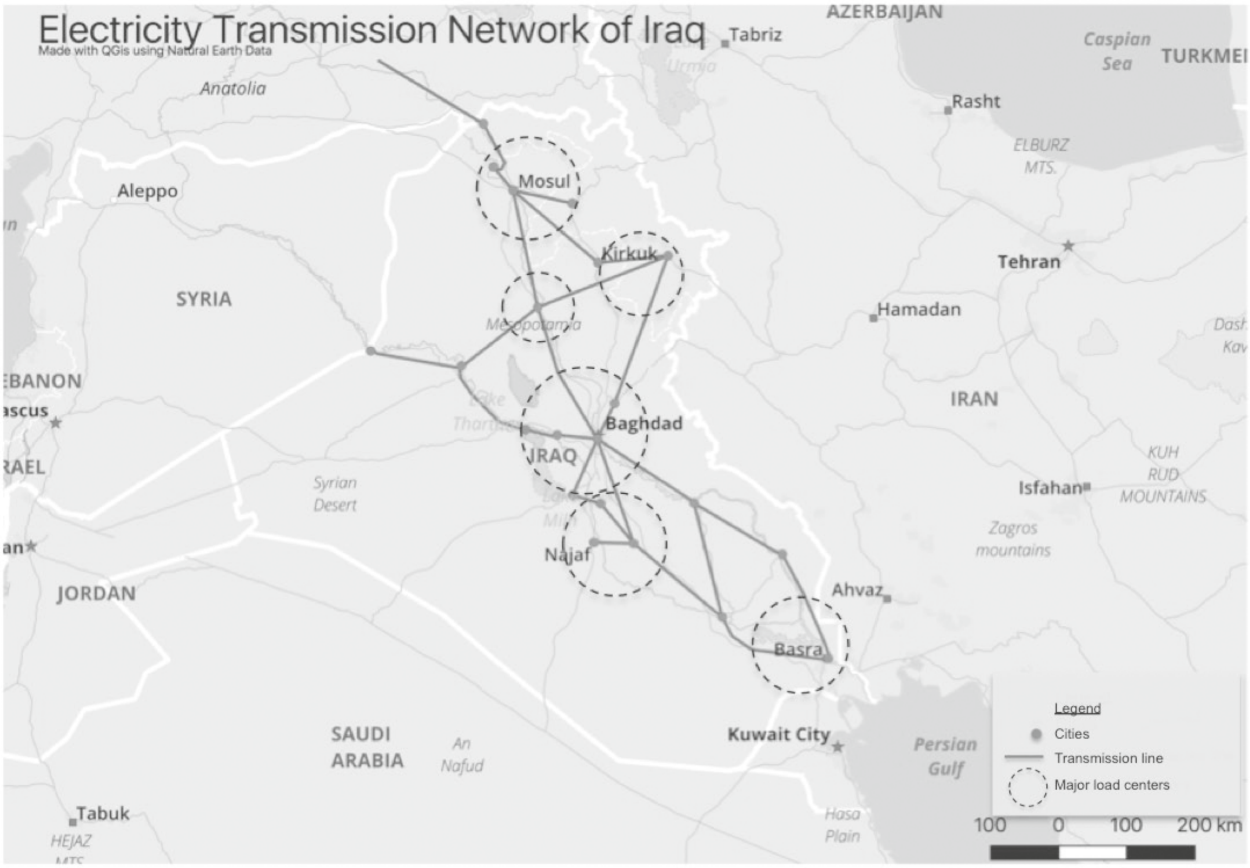
The Iraqi electricity grid is currently inadequate and, as previously mentioned, unable to cover peak demand – resulting in load shedding (Al-Khateeb and Istepanian, 2014). Due to old and inefficient grid structures, technical barriers, such as excessive losses during transmission and distribution, increase the challenges faced by the grid. In 2016, the losses amounted to more than 50% (ESCWA, 2019; Al-Maleki et al., 2019; Istepanian, 2020c). Technical and non-technical losses are a focus of the National Sustainable Development Plan 2018–2022, which recognises that critical efforts are needed to tackle this issue. There are multiple plans to expand the electricity transmission network, and concepts to interconnect the whole region are also being developed.

Interconnected grids have the advantage of offering system reliability, reducing reserve margins, supporting reactive power, better managing daily and seasonal demand diversity, and reducing operational costs (The World Bank, 2013). Interconnection can help to stabilise the grid in terms of managing the variable loads, which result from the potential increased injection of fluctuating renewables. In addition, interconnections between countries could support regional electricity trade. This, in turn, could increase the willingness of countries to cooperate in a regional electricity market (IRENA, 2014). Current interconnectivity projects include the Eight Country Interconnection Project (EIJLLPST), which involves Egypt, Iraq, Jordan, Syria, Turkey, Lebanon, Libya, and Palestine (The World Bank, 2013). The interconnection between Iraq and Syria under the EIJLLPST framework has been ready from Iraq's side since 2010, with a capacity of 400 kV. There is an existing 400 kV interconnection between Iraq and Iran, and a potential 400 kV interconnection between Iraq and Turkey to be implemented at a later date (IRENA, 2014). Under discussion is an interconnection from Iraq to Kuwait, and a plan to connect Iraq with the Jordanian grid was recently published. The agreement will provide Iraq with Jordanian electricity of up to 1,000 GWh per year (Ghafuri, 2020). The EIJLLPST framework has been effective since 1988 and aims to achieve grid stability and facilitate the trading of power. However, the EIJLLPST interconnection is currently suboptimal and not fully synchronised. Electricity trade between Arab countries has been hindered due to limited generation reserve margins and weak institutional and regulatory frameworks (The World Bank, 2013). Yet, the objective of interconnection and regional integration could support sustainability and help to secure energy supply across the region. The overall regional grid extension is, therefore, partly driven by the diversification of energy supply resources, particularly in terms of renewable energy extension and integration (ibid.). Nevertheless, the first priority for Iraq remains at this stage to improve its security of supply.

Iraq's transmission network faces serious reliability and security risks. The national grid infrastructure needs to undergo a major transformation to meet increasing demand and to integrate non-dispatchable renewable energy sources (Istepanian, 2020a). Fig. 4-11 depicts the Iraqi electricity transmission network. The data is based on the year 2017; thus, updated extensions could be missing. Nevertheless, the map shows the existing transmission network line (red line) with the major load centres across Iraq (Republic of Iraq, 2011).

The electricity sector is fully managed by the Ministry of Electricity (Energydata, 2017). The generated power is transmitted to more than 550 power substations across the country through a high-capacity grid transmission network (440 kV and 132 kV). The network is owned and operated by four companies owned by the Ministry of Electricity (Istepanian, 2020b). Through a lower-voltage network, the power is distributed to end consumers. The distribution companies enjoy a geographic monopoly (North, South, Middle, and Baghdad), and there is currently no retail sector in Iraq. Although, in recent years, the private sector has been increasingly involved in power generation via IPPs, its participation in electricity retail exists only in small-scale pilot projects: billing and revenue collection is limited to the four distribution companies. The importance of privatising the power sector has been emphasised in view of supply shortfalls. However, it is difficult for IPPs to enter into long-term PPAs.

Figure 4-11
Electricity Transmission Network of Iraq Showing Major Load Centres



Source: own creation data based on Energydata, 2017; Ministry of Electricity, 2010

The current electricity network is unstable, and the insufficient generation capacity reflects the outdated condition of the energy assets. It is necessary to rebuild and extend the network and to introduce smart grids, but Iraq still requires a lot of time before it can achieve these advanced systems. Due to its underdeveloped network, Iraq can be classified as being in the preliminary stage of the first energy transition phase.

Society

The public perception of the electricity sector is, in general, characterised by a lack of trust, as the government is unable to ensure a sustainable electricity supply (Istepanian, 2020b). Factors such as poor sector governance and the inability to provide electricity during peak times create a frustrated public that is intolerant of tariff increases (ibid.). There is also low regard and acceptance for renewable energy technologies by communities and citizens (Al-Kayiem and Mohammad, 2019; Istepanian, 2020a). People are not aware of their benefits due to a lack of awareness-raising programmes and limited financial information, which prevents the exploration of their implementation as an option (ibid.).

Summary of the Landscape and System Level Developments

On the landscape level, the COVID-19 pandemic is expected to affect the energy transition at least in the short term but potentially also in the long term. Delays to projects caused by the pandemic have led to increased costs. The tendered solar projects in particular, which represent a niche for Iraq, have been postponed until the country has recovered from the current crisis.

In addition to these pandemic effects, system-level barriers, such as the technical, financial, and regulatory framework, largely hinder the development of renewable energy. Although Iraq has published tenders for solar projects, there are almost no regulations to guarantee the dispatch and financial sustainability. As a typical rentier state, Iraq's energy system is based wholly on oil and gas, and the economy relies on hydrocarbon revenues. Under the Electricity Law No. 53 of 2017, Iraq officially declared its intention to support renewables, increase efficiency, and protect the environment. However, as the country suffers from an underdeveloped infrastructure as well as chronic power outages, Iraq's first priority is to improve the electricity supply before adding renewable energy to the grid. Given the political tensions that exist with neighbouring countries over water infrastructure and water supply for power generation (with the Euphrates and the Tigris rivers having played a central role since ancient times), Iraq is likely to continue to rely on diesel generators to offset the current unmet demand.

In summary, several factors can be identified at system level that currently limit Iraq's progress in the energy transition: the current pandemic, the sector's challenging institutional framework, and political instability. Iraq has a national energy strategy that lacks a clear vision and political commitment. As a result, renewable energy resources are a long way from replacing fossil fuels, such as oil and gas, in the energy mix. Accordingly, Iraq can be classified as being in the pre-phase of the energy transition model. Table 4-2 summarises important energy transition indicators in Iraq and compares them across several years.

4.1.2 Assessment of Trends and Developments at the Niche Level

Developments at the niche level during each phase are crucial for reaching the subsequent stages of the energy transition (see Table 3-1). From this perspective, Iraq displays very limited progress in almost all the relevant dimensions: supply, demand, infrastructure, markets/economy, and society.

Solar Energy

The Electricity Law No. 53 of 2017 states its objective of »supporting and encouraging the adoption of renewable energy, its activities and nationalisation«[2]. The law is currently in draft form. However, the Ministry of Electricity, which is both the regulator and the executive authority, has set the goal to implement 1,000 MWp of solar energy. As a pilot project, 8 MWp will be generated through rooftop solar projects at government buildings (Al-Maleki, 2020). In addition, a tender for 755 MWp of solar projects was published in 2019 (Table 4-3). The projects are planned to be implemented under an IPP scheme and should be operational by the end of 2021.

The drop in the cost of renewable energy technology has encouraged private companies to invest in Iraq (Istepanian, 2018). Although the initial investment cost in Iraq is about 5 to 7 times higher than in other MENA countries, ACWA Power[3] has expressed interest in establishing a large-scale PV power plant in the south of Iraq close to the Saudi border (Istepanian, 2020a). Siemens has also signed a contract to implement projects under a 14 bn USD roadmap, including the development of a wind atlas for Iraq (Al-Maleki, 2020).

Installations of solar flat collectors for water heating developed by foreign manufacturers are in the planning, and some smaller companies have recently started manufacturing solar cells (Al-Kayiem and Mohammad, 2019). Solar PV is used for lighting in several streets in cities. Despite Iraq's power sector challenges, schemes to foster the uptake of small-scale projects, such as rooftop PV systems, have not been introduced (ESCWA, 2019).

Since 2019, the Iraqi government has implemented mechanisms for citizens to access small loans to purchase and install rooftop solar systems. Through public and private banks, it is officially possible to install 3 kW to 10 kW solar systems in the residential sector. For large-scale projects above 10 MWp, the government recently introduced bidding rounds after abandoning the feed-in tariff. Future projects will, therefore, follow the BOO and IPP schemes (Al-Maleki, 2020).

Moreover, the huge budget deficit in Iraq's economy caused by the COVID-19 pandemic could help renewable energy to gain momentum. The significant decline in global oil prices provides the opportunity for Iraq's government to bolster the transition towards renewable energy supply; however, this depends heavily on political will. The introduction to market of renewables is an important step towards the »Take-Off Renewables« phase in Iraq.

4.1.3 Necessary Steps for Achieving the Next Phase

As previously mentioned, fossil fuels are the predominant source of energy in Iraq. Renewable energies still play a very minor role in the energy system. Legal and market regulations are limited, grid access for electricity from renewable sources is restricted, and there is little awareness about renewable energy among the population and the government. All these aspects hinder the expansion of renewable energy technologies. Although some aspects of the first transition phase of the phase model can already be observed in Iraq, the renewable energy share is negligible, and the grid expansion plans are currently hampered by the volatile political environment. Therefore, it is likely that without major efforts, Iraq will make slow progress toward a renewables-based energy system in the coming years. Nevertheless, Iraq can adopt certain measures that would propel the country into the next phase of the energy transition.

Institutions and Governance

To enter the first phase of the energy transition (»Take-Off Renewables«), efforts in the field of renewable energy implementation must be increased, and political will must be concretised into actions. Initially, this entails the fundamental requirement of establishing institutions to support the creation of a renewable energy sector on different levels (e.g. capacity building, financing, administration, and regulations). However, no such strategy exists in Iraq; the existing »Integrated National Energy Strategy« is outdated, is not reflective of Iraq's realities, and has not yet been replaced by a new strategy. Instead, a white paper was published in October 2020 to reform Iraq's economy in which the energy sector is a subject of considerable focus. Yet, according to experts, this white paper lacks a long-term vision on sustainable and socially just electricity supply (Iraqi Economists,

2 More information on: https://www.moj.gov.iq/upload/pdf/4443.pdf

3 ACWA Power is a developer, investor and operator of power generation, renewable energy and desalinated water production plants headquartered in Saudi Arabia.

Table 4-2
Current Trends and Goals of the Energy Transition

Category	Indicator	2005	2010	2015	2018	2020	2030	2050
Carbon Emissions (Compared to 1990)	CO_2 emissions per unit of GDP	+56%	+16%	+26%	N/A	N/A	–	–
	CO_2 emissions per capita	–10%	+17%	+23%	+33%	N/A	–6% (from 2010)	–
Renewable Energy	Installed and planned capacity (MW)	N/A	2,274	2,311	2,311	N/A	2 GW	–
	Share in final energy use	2%	1.2%	0.5%	0.3%	N/A	–	–
	Share in electricity mix (existing and planned)	19.7%	9.7%	3.7%	2.2%	N/A	10%	–
Efficiency (Compared to 1990)	Total primary energy supply (TPES) (compared to 1990)	+31.9%	+83.6%	+134%	+221.3%	–7% of energy consumption per capita by 2022	–	–
	Energy intensity of primary energy (compared to 1990)	–9.8%	–3.7%	–10.9%	N/A	N/A	–	–
	Total energy supply (TES) per capita (compared to 1990)	–16.7%	0%	+8.3%	+41.7%	N/A	–	–
	Electricity consumption per capita (compared to 1990)	–38.5%	–7.7%	0%	N/A	N/A	–	–
	Fossil fuel subsidies (% of GDP 2019)	N/A	N/A	N/A	3.3% of GDP: 5.9 bn USD (oil), 1.3 bn USD (electricity)		–	–
Buildings	Residential final electricity consumption (compared to 2005)	0%	+38.5%	+26%	+89.7%	N/A	–	–
Transport (Compared to 1990)	Total final energy consumption	+19.8%	+28.1%	+14.6%	+55.3%	N/A	–	–
	CO_2 emissions in transport sector	+18.2%	+27.3%	+13.6%	+54.5	N/A	–	–
Industry	Carbon intensity of industry consumption (compared to 1990)	+18.4%	+10.1%	+7.7%	+16.1%	N/A	–	–
	Value added (% of GDP)	63.6%	55.7%	41.9%	55.8% (2019)	37.4% (2019)	–	–
Supply Security	Natural gas imports (compared to 2017)	0	0	0	+181.3%	+243% (2019)	–	–
	Oil products imports (compared to 1990)	+134%	+643%	+1,118%	+1,162%	N/A	–	–
	Global crude oil exports (compared to 2012)	N/A	N/A	+27.2% (2017)	+59.4%	+63.6% (2019)	–	–
	Electricity imports (compared to 2005)	0%	+337%	+953%	+1,651%	N/A	–	–
	Electricity access by population proportion	97.6%	98.1%	99.3%	99.9%	N/A	–	–
	Oil reserves (compared to 1999)	N/A	+2.22%	N/A	+28.9%	+28.9%	–	–
	Gas reserves (compared to 1999)	N/A	–3.85 %	N/A	+13.5 %	+12.2 %	–	–
Investment (Compared to 2007)	Decarbonisation investments (millions USD)	0.0966 (2007)	158.20	250 (2016)	109 (2017)	N/A	–	–
Socio-economy	Population (2019)				39,309,783		–	
	Population growth	2.2%	3%	3%	2.3%	N/A	–	
	Urbanisation rate	68.7%	69.1%	69.9%	70.2% (2017)	N/A	–	–
	GDP growth	4.4%	6.4%	2.4%	–0.56%	N/A	–	–
	Oil rents (% of GDP)	63.8%	42.3%	34.7%	45.4%	N/A	–	–
Water	Level of water stress	79.6%	66.6%	49%	54% (2017)	N/A	–	–

Source: based on data from BP, 2020; FAO, 2020; IEA, 2020a; IRENA, 2020c; Statista, 2020; The World Bank, 2020

Table 4-3
Planned Large-Scale Solar Power Plants in Iraq

Planned solar power plants							
Project	Sawa-1	Sawa-2	Khidhir	Iskandariya	Jissan	Karbala	Diwania
Province	Muthana	Muthana	Muthana	Babil	Wassit	Karbala	Diwania
Installed Capacity (MWp)	30	50	50	225	50	300	50

2020). Iraq needs to develop an energy strategy that shares the values of diversification, sustainability, and social and economic development (Al-Khateeb and Istepanian, 2014). The principles of a circular economy must be understood by politicians in order to pave the way to a paradigm shift towards a clean and sustainable »green« economy. Furthermore, the strategy must include energy efficiency measures, indicators, and quantified targets. Initially, an inventory of the most energy-intensive applications in industry and households could be compiled. In addition, accountability for the implementation of efficiency measures needs to be created; this could be achieved, for instance, by monitoring developments on a regular basis and adapting the targets according to progress.

To make real progress in the development of a holistic energy strategy, the government must concretise the next steps instead of making vague statements about developing a strategy that moves towards a sustainable economy (Republic of Iraq, 2011). Concrete visions need to be developed and linked to specific Sustainable Development Goals (SDGs) and NDC targets and indicators. Another step would be to include cross-sectoral aspects in the future energy strategy, such as water demand for electricity production. In addition, closer cooperation between the sector stakeholders should be fostered to recognise the water-energy nexus and, by doing so, reduce trade-offs and achieve synergies. For example, joint exchange and capacity building workshops could be a starting point to manage the water-energy sector interfaces.

Electricity Sector

As well as lacking an overarching strategy, Iraq also lacks a clear and consistent policy plan for renewable energies. The entire electricity sector must be reframed to advance the development of renewable energies (Istepanian, 2020a). In particular, the government needs to pass new laws to support energy market liberalisation. Steps to unbundle the vertically integrated power sector are necessary to facilitate greater competition in the sector and increase transparency. At the same time, steps towards horizontal unbundling would allow for the entry of new players into the sector, which could support the necessary cost-savings and increased resilience that will be required if renewable energies are to play a greater role. Moreover, recent developments have exposed the vulnerability of Iraq to external shocks, which have affected the fossil fuel sector. Thus, expanding renewable energy capacities could improve the resilience of the Iraqi energy economy.

The Oil and Gas Sector

The effects of fluctuations in oil prices during the COVID-19 pandemic have highlighted the vulnerability of economies based on oil and gas exports, such as Iraq, to external shocks. In contrast, IEA has stated that renewables are the clear winner from the crisis, with record levels of electricity generation in the last year (IEA, 2020b). Consequently, the momentum for renewables has never been so buoyant, and Iraq could take advantage of this. As many governments have recognised the positive impact of renewables during the crisis, it is probable that the rapid expansion of solar PV and wind will continue, with potentially more ambitious targets, in countries such as Iraq that are currently lagging behind in renewable energy deployment. This development could be further expedited, as the currently reduced demand for oil and gas from industrialised countries is only the foretaste of long-term changes in demand resulting from decarbonisation efforts. To better predict the oil and gas demand and adapt national production accordingly, Iraq needs – in the short term – an institutional framework to be able to provide reliable forecasts (IMF, 2019a).

In the long term, a stabilisation fund (such as other oil exporting countries have established) could be considered. In common with other oil exporting countries which pursue procyclical fiscal policies, Iraq lacks effectiveness and is economically vulnerable because it has no fiscal buffers (IMF, 2019b). Fiscal buffers could help to reduce shocks and promote investment in the renewable energy sector, which would support Iraq to rebuild its national power sector in a sustainable manner. These funds could be managed, for example, through public investment facilities. The case of Norway, one of the largest oil exporting countries worldwide and a leader in the energy transition, shows how a sovereign wealth fund owned by the state can distribute benefits to the population and enable a socially just transition.

Infrastructure

At operational level, Iraq's electricity infrastructure requires significant investment to expand its overall capacity, retrofitting to improve efficiencies, and a focus on increasing renewables-based generation capacity (TradeArabia, 2018). The most pressing concern for Iraq's electricity sector is the need to secure a constant electricity supply. In this context, it is important to extend the transmission network to neighbouring countries. An example could be the agreement signed with Jordan in 2020 to connect the two countries« power grids. Energy partnerships with its regional peers could also be a possible first step to intensify the dialogue and elaborate the benefits of a shared vision of regional grid integration. This would also facilitate the next phases of the transition, which include the integration of flexibility options at a later stage.

Overall, for Iraq to move towards a renewables-based energy system, it must introduce regulations covering renewable energies, focus on market development, invest in grid retrofitting, and adopt energy efficiency measures, all of which are currently lacking in Iraq.

4.2 OUTLOOK FOR THE NEXT PHASES OF THE TRANSITION PROCESS

It is evident from the analysis that Iraq has huge potential for renewable energy but lags behind its regional peers in terms of renewable energy technology deployment. The Iraqi electricity sector has struggled to adequately exploit its renewables potential, with the war and violence creating extremely difficult conditions in comparison to some of the other MENA countries. The existing Integrated National Energy Strategy was an attempt at a short-term vision, but it needs to be revised with better focus on the given realities. Consequently, Iraq does not currently have a clear and specific strategy, and there is no straightforward approach to the shift toward renewable energy. Barriers such as the dominant role of fossil fuels for the economy and the state, insufficient legislation, lack of efficiency awareness among the population, and political factors all hinder Iraq's energy transition pathway.

Especially after the COVID-19 pandemic, an adapted or newly developed energy strategy must emphasise the value that renewable energy technologies and renewables should become part of short-term stimulus and recovery plans (IRENA, 2020a). The existing »Vision Sustainability 2030', which embraces »a new social contract between the state and its citizens to enhance their trust in the government and provide opportunities for self-development, work and generating income« (Ministry of Planning, 2019), represents a good starting point for an updated national energy strategy.

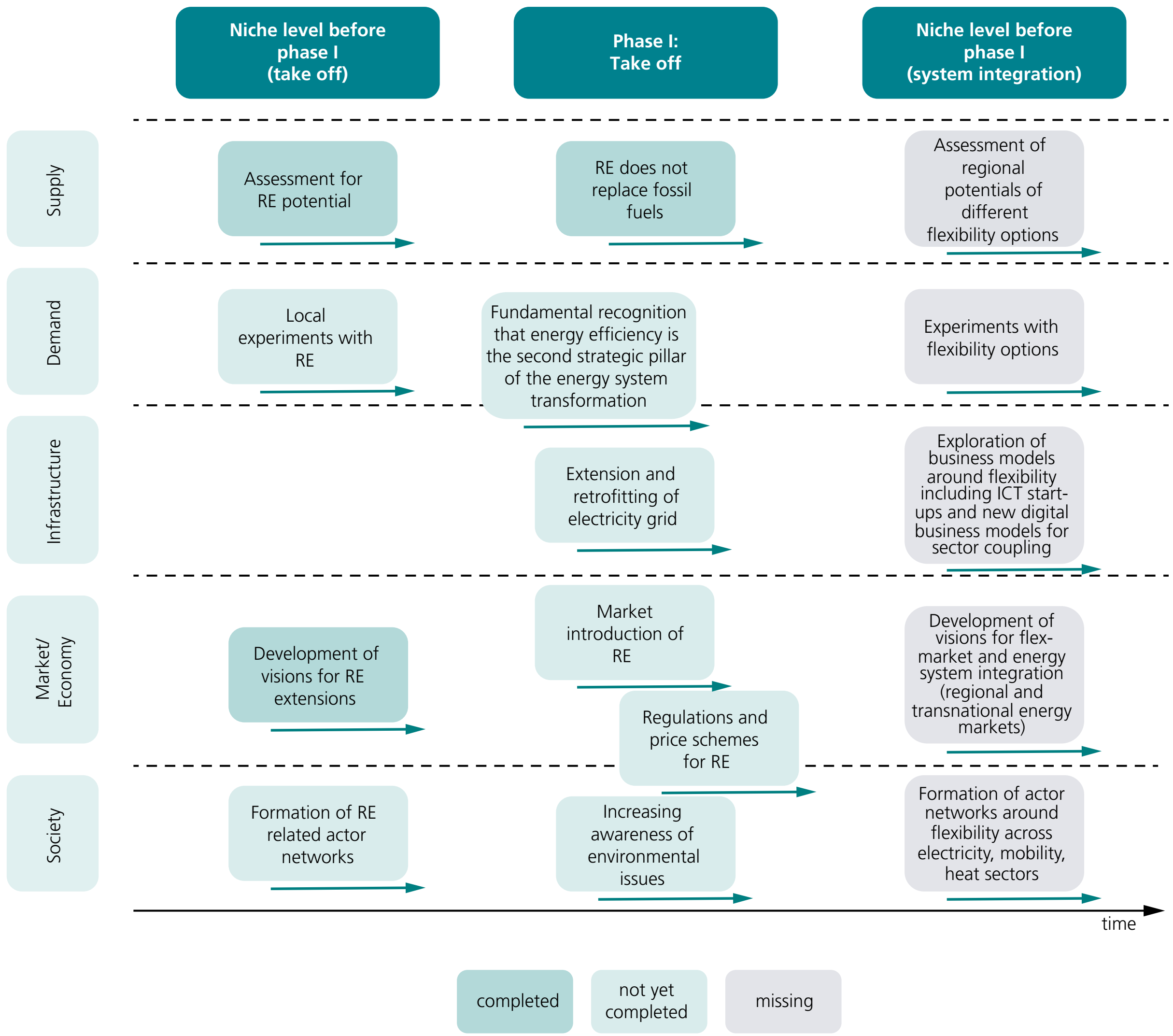
Building a long-term future energy vision necessitates understanding the nature of structural challenges and their interlinkages. Since energy security and stability of electricity are major concerns, harnessing the potential of renewable energy to contribute to these aspects would be an essential initial step. Policymakers and citizens need to understand the benefits that renewables can offer and recognise how global cost reductions make this technology an interesting alternative to diesel generators. Specific programmes can raise awareness and help to increase acceptance and participation from stakeholders and citizens.

While the need to secure the national energy supply could become a main driver for the greater deployment of renewables, environmental factors are currently not relevant driving forces in Iraq's energy transition. However, this could change in the long term, as Iraq will be affected by the increasing consequences of environmental concerns at the global level, namely the need to reduce greenhouse gas emissions. The decarbonisation efforts and resulting decrease in fossil fuel demand on the global market will, in the long-term, significantly affect the Iraqi oil and gas sector and therewith Iraq's economy. Therefore, a timely switch to producing fuels from renewable energy sources could offer new economic sector development and future export opportunities. This vision could encourage Iraq to adopt environmentally sound technologies now, particularly as the construction of new conventional power plants, production facilities, and transport infrastructure could create new path dependencies within the energy system. These dependencies could result in lock-in-effects, making the transition towards renewables in the future more difficult and potentially more costly. Priority should, therefore, be given to leapfrogging in the energy transition instead of to investments in carbon-intensive technologies. Though it will be a challenge to overcome political, institutional, and cultural resistance to renewable energy in Iraq, the transition to renewable energy could, however, have positive effects both economically and environmentally. For example, it could create jobs along the energy value chain, reduce air and environmental pollution thereby lowering health hazards, and increase energy security levels that are a prerequisite for economic growth (IRENA, 2018).

Several steps are required to advance the transition towards renewables. First, appropriate institutions and structures must be created. In addition, research and development is essential for the creation of local value chains, and this must be supported financially, possibly in the form of a tax levy on the oil sector to fund renewable energy research. Concrete measures for renewable energies in development plans are needed to create a realistic timeframe for the transition process. Moreover, the necessary infrastructure must be created. Society should be an integral part of the overall process, and an appropriate framework and legislative context must be created for consumers to adopt renewable energies or produce their own electricity. Furthermore, the introduction of better participatory tools and channels in the energy transformation process could foster acceptance and contribute to fair power dynamics and energy policies. This could be realised, for example, by establishing processes for stakeholders and citizens to jointly develop scenarios that subsequently attract broader support and acceptance. Another method would be designing awareness raising campaigns or projects that fit the local context (IRENA, 2020b).

Against this backdrop, a long-term and integrative approach taking into account the entire energy system and the long-term objectives of a transition towards a fully renewables-based energy system is needed. Policymakers need to understand that the early adoption of renewable energy systems can result in multiple benefits both in the short term (by increasing the security of supply) and in the long term (as an opportunity for economic development). Fig. 4-12 summarises Iraq's status in the energy system transition and provides an outlook for future steps.

Figure 4-12
Overview of Iraq's Status in the Energy System Transition Model



5

CONCLUSIONS AND OUTLOOK

A clear understanding and structured vision are prerequisites for fostering and steering a transition towards a fully renewables-based energy system. The MENA phase model was adapted to the country case of Iraq in order to provide information that would support the energy system's transition towards sustainability. The model, which built on the German context and was complemented by insights into transition governance, was adapted to capture differences between general underlying assumptions, the characteristics of the MENA region, and the specific Iraqi context.

The model, which includes four phases (»Take-off RE«, »System Integration«, »Power-to-Fuel/Gas«, and »Towards 100% Renewables«), was applied to analyse and determine where Iraq stands in terms of its energy transition towards renewables. The application of the model also provides a roadmap detailing the steps needed to proceed on this path. The drivers for Iraq to shift to a sustainable energy system are primarily the need to secure a reliable and affordable electricity supply, as well as potential cost savings and opportunities for long-term economic development. In the long term, other external imperatives such as structural changes due to global decarbonisation (expected to result in decreased demand for fossil fuels) could become even more important drivers for change. Despite the drop in renewable technology costs over the last decade and the increasing deployment of renewables in the MENA region, the current pathway towards renewable energies seems to be challenging for Iraq. This is due to the country's political instability and the dominant economic role played by the fossil fuel sector.

Yet, the need to rebuild the energy system after the war and the subsequent violent conflicts could offer an opportunity for a transition that would benefit Iraq in the short term and also provide a long-term sustainable perspective. To take advantage of this opportunity, Iraq needs to increase its ambition. The first step would be to improve the framework conditions for renewable energy and raise awareness about the benefits it offers. The government needs to invest in the development of a holistic energy sector strategy and a sound institutional framework to stimulate diversification and support the development of local value chains. The electricity sector must be unbundled to increase efficiency and allow for greater competition and increased transparency. At the same time, awareness among the population of the benefits of renewable energies needs to be raised, and capacities and expertise must be developed in the workforce to ensure that strategies can succeed on a broader level.

Therefore, while the transition towards renewable energies is still at the earliest stage in Iraq, and the scale up of renewables faces many challenges, the country would be well advised to establish a more sustainable energy system that will benefit the country in both the short term and the long term rather than investing in rebuilding the fossil-based energy supply structures. The results of the analysis along the transition phase model towards 100% renewables should stimulate and support the discussion about Iraq's future energy system by providing an overarching guiding vision for the energy transition and the development of appropriate policy strategies.

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LIST OF ABBREVIATIONS

AT&C losses	Aggregated Technical and Commercial Losses
bn	Billion
BOO	Build, own, and operate scheme
CCS	Carbon capture and storage
CCU	Carbon capture and use
COVID-19	Coronavirus disease 2019
DSM	Demand-side management
EIJLLPST	Eight Country Interconnection Project
GDP	Gross Domestic Product
GHG	Greenhouse gas
ICT	Information and communication technologies
IEA	International Energy Agency
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
ISIL	Islamic State of Iraq and the Levante
MENA	Middle East and North Africa
MLP	Multi-level perspective
NDC	Nationally Determined Contributions
OPEC	Organisation of the Petroleum Exporting Countries
PPA	Power Purchase Agreement
PtF	Power-to-fuel
PtG	Power-to-gas
PtX	Power-to-X
PV	Photovoltaic
RE	Renewable Energy
SDG	Sustainable Development Goals
USD	US Dollar

LIST OF UNITS AND SYMBOLS

%	Percent
CO_2	Carbon dioxide
GWh	Gigawatt hour
ktoe	Kilo tonnes of oil equivalent
kV	Kilo Volt
kW	Kilowatt
kWh	Kilowatt hour
m/s	Metre per second
Mtoe	Million tonnes of oil equivalent
MW	Megawatt
TWh	Terawatt hour
W/m^2	Watts per square metre

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ABOUT THE AUTHORS

Sibel Raquel Ersoy (M.Sc) works as a junior researcher in the research unit »International Energy Transitions« at the Wuppertal Institute since 2019. Her main research interests are transition pathways towards sustainable energy systems in the Global South and modelling the water-energy-nexus. She has a specific regional research focus on the Middle East and North Africa.

Dr. Julia Terrapon-Pfaff is a senior researcher at the Wuppertal Institute. Her primary research area is the sustainable energy system transition in developing and emerging countries, with a special focus on the Middle East and North Africa.

Partners consulted in Iraq:

Al-Bayan Center for Planning and Studies is a leading source of independent analysis and research in Iraq and the Middle East and North Africa region. The center aims to strengthen the capacity of educational institutions and civil society organizations to prepare future decision-makers and experts in the fields of politics, economy, energy, oil and gas, and international relations.

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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.

SUSTAINABLE TRANSFORMATION OF IRAQ'S ENERGY SYSTEM

Development of a Phase Model

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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 transition in MENA countries has been developed and applied to the country case of Iraq. It is designed to support the strategy development and governance of the energy transition and to serve as a guide for decision makers.

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The transition towards renewable energies is still at a very early stage in Iraq. Despite the drop in renewable technology costs over the last decade and the increasing deployment of renewables in the MENA region, the pathway towards renewable energies seems to be challenging for Iraq. This is attributable to the country's political instability and the dominant economic role played by the fossil fuel sector. The most pressing concern for Iraq's electricity sector is the need to secure a constant electricity supply. At operational level, Iraq's electricity infrastructure requires significant investment to rebuilt, retrofit and expand its overall capacity and to improve efficiencies.

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Yet, the need to rebuild the energy system after the war and the subsequent violent conflicts could offer an opportunity for a transition towards renewables that would benefit Iraq in the short term and also provide a long-term economic development perspective. To take advantage of this opportunity, Iraq needs to improve the framework conditions for renewable energies and raise awareness about the benefits it offers. Renewable energy regulations need to be introduced, market development supported, a realistic timeframe for the transition process established and an appropriate and reliable legal framework developed. The results of the analysis along the transition phase model towards %100 renewables are intended to stimulate and support the discussion about Iraq's future energy system by providing an overarching guiding vision for the energy transition and the development of appropriate policy strategies.

For further information on this topic:
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