Study

CLIMATE CHANGE, ENERGY AND ENVIRONMENT

SUSTAINABLE TRANSFORMATION OF PALESTINE'S ENERGY SYSTEM

DEVELOPMENT OF A PHASE MODEL

Sibel Raquel Ersoy, Julia Terrapon-Pfaff, Imad Brik
June 2022

→

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

→

A shift towards a sustainable energy system could support Palestine to secure a reliable and affordable electricity supply, achieve cost savings, and create long-term benefits for economic growth.

→

To what extent the renewable energy potential in Palestine can be exploited will depend heavily on political developments.

FRIEDRICH EBERT STIFTUNG

CLIMATE CHANGE, ENERGY AND ENVIRONMENT

SUSTAINABLE TRANSFORMATION OF PALESTINE'S ENERGY SYSTEM

DEVELOPMENT OF A PHASE MODEL

Sibel Raquel Ersoy, Julia Terrapon-Pfaff, Imad Brik
June 2022

Wuppertal Institut

Contents

1

INTRODUCTION

The Middle East and North Africa (MENA) region faces a wide array of challenges, including rapidly growing population, slowing economic growth, high rates of unemployment, and significant environmental pressures. These challenges are 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. 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 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. 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 CO2 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 Palestine. The current state of development in Palestine 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 local partners.

2

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'.

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. 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.

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

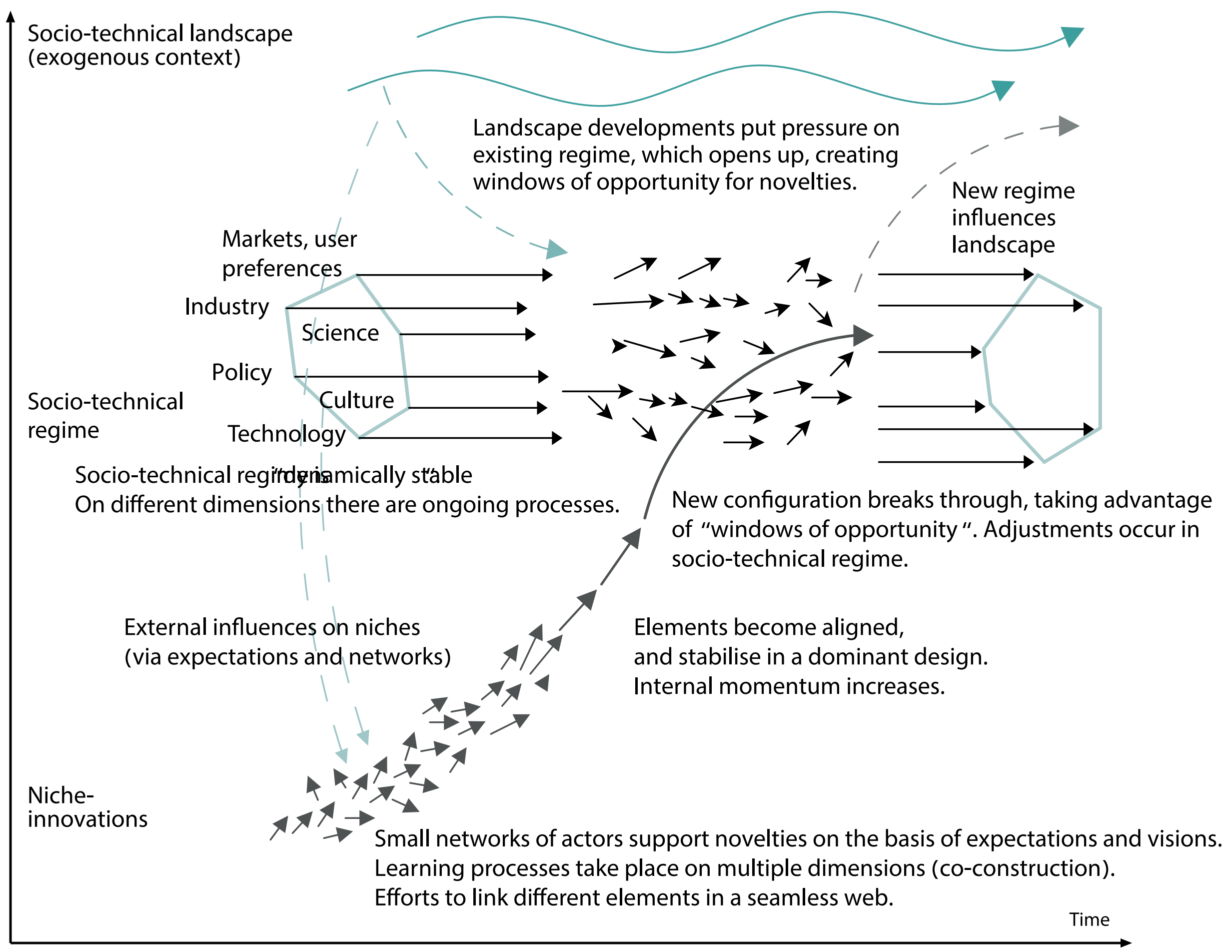
To describe the long-term changes in energy systems in these four phases, the phase model is supplemented by insights from the field of sustainability transition research. Energy transitions cannot be completely steered, nor are they totally predictable. The involvement of many actors and processes creates a high level of interdependency and uncertainty surrounding technological, economic, and socio-cultural developments. The multi-level perspective (MLP) is a prominent framework that facilitates the conceptualisation of transition dynamics (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, innovations at the 'niche' level are incremental because they provide the fundamental base for systemic change (Geels, 2012). Within the transition phases, three stages can be distinguished: 'niche formation',

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

Fig. 2-1

The Multi-Level Perspective



(Source: Geels and Schot, 2007)

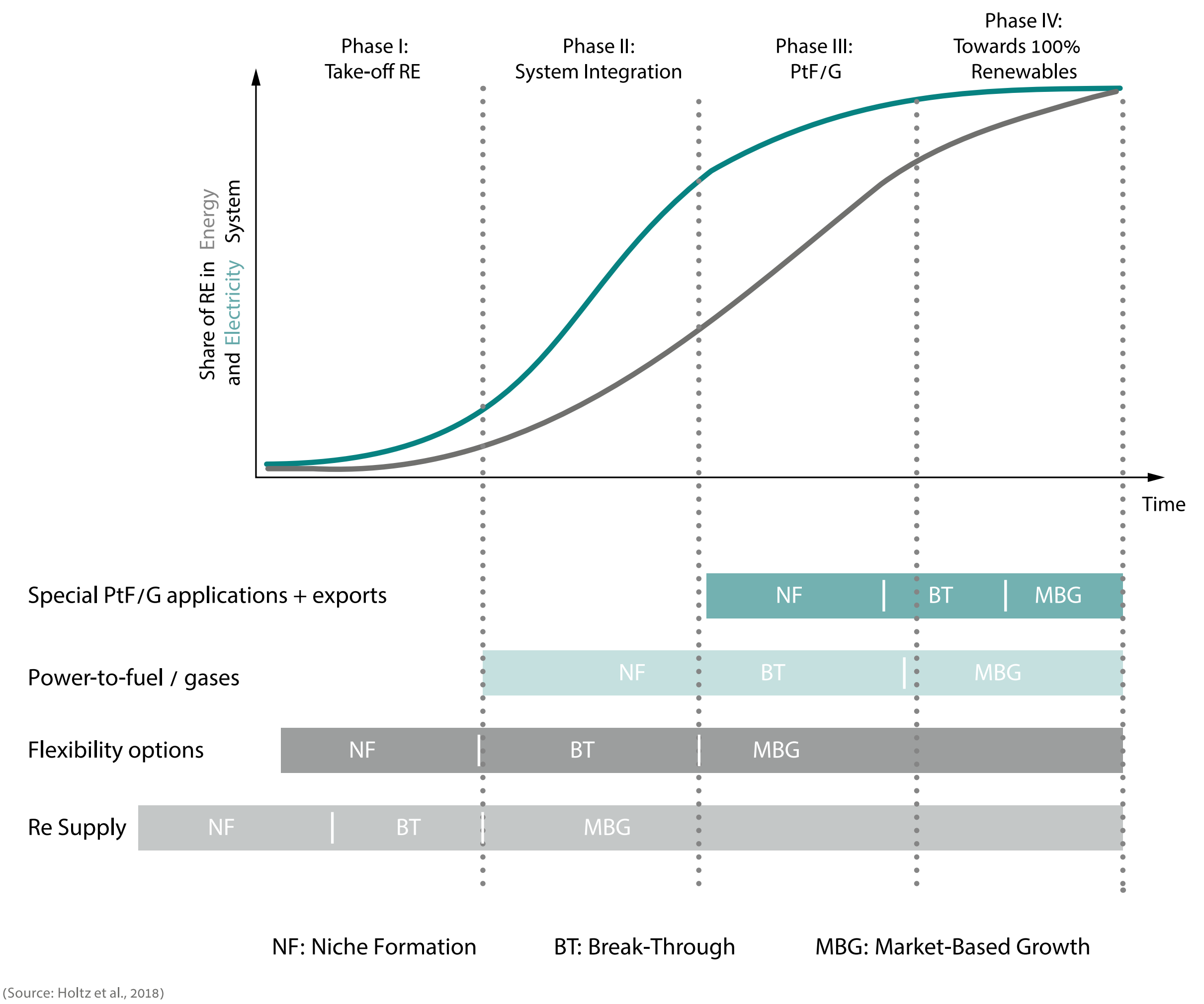
'breakthrough', and 'market-based growth'. In the 'niche formation' stage, a niche develops and matures. In the 'breakthrough' stage, the niche innovation spreads and when the niche innovation becomes fully price-competitive and specific supportive policy mechanisms are no longer needed, the 'market-based 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. 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. Consequently, the addition of the 'niche layer' creates a stronger emphasis on the processes that must occur to achieve the system targets (Fig. 2-2).

Fig. 2-2

Transition Phase Model for the MENA Region



(Source: Holtz et al., 2018)

3

THE MENA PHASE MODEL

3.1 SPECIFIC CHARACTERISTICS OF THE MENA REGION

One of the fundamental differences 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. 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.

Another 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.

The MENA countries could benefit considerably from global advances in renewable energy technologies. While the phase model for the German context assumed that renewable energy technologies need time to mature, the phase model for the MENA context can include cost reductions. 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 and large-scale projects take centre stage in most countries in the MENA region. 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 were adapted to correspond to the characteristics of the MENA region.

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. While in Germany imports play a considerable role in the later phases, 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

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. 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. 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.

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. 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.

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.

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.

Table 3-1 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.

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

The MENA phase model was exploratively applied to the Jordan case in 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 in regard to the energy transition that can also be applied to other MENA countries. Therefore, the MENA phase model was applied to the country case of Palestine after necessary adaptations were made to it. The results illustrate a structured overview of the continuous developments in Palestine's energy system. Furthermore, they provide insights into the next steps required to transform Palestine's energy system into a renewables-based system.

In order to reflect the specific challenges and opportunities for the energy transition in Palestine, some adaptations to the criteria set of the MENA phase model were made on the landscape level as well. These include factors such as the COVID-19 pandemic and global decarbonisation efforts in light of the Paris agreement. These aspects have either already affected or will affect the international oil and gas prices and the sector development. Furthermore, details about the dominant role of fossil fuels in the energy system and related challenges for the development of the renewable sector have been assessed. Table 3-1 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.

Expert interviews and demand forecast calculations were carried out in Palestine by Dr. Imad Brik to investigate the country-specific challenges and barriers that could hinder the unlocking of the renewable energy potential in the country. The main interview partners were relevant stakeholders with several years of experience in Palestine's energy sector from political institutions, academia, and the private sector. Additionally, a load forecast for the years 2020-2050 was calculated. For this, the period used as reference for the calculations associated to this forecast is 2015-2019. While the growth of consumption does not include the total electricity losses, they are included in the growth of supply. Energy efficiency measures have not been assumed for the load forecast, as they are only suggested for the private sector and their implementation will depend on the budget availability. The forecasts are based on the types of consumers that are: water pumping, industry, agriculture, residential, commercial and street lighting. Separate forecasts have been elaborated by the consultant for each of the types of consumers mentioned above. The load forecasts have been performed individually for each type of industry and cumulated further as total forecast for all electricity distribution companies and the local councils for the period 2020-2050. Moreover, a renewable energy capacity forecast has been calculated that is based on the two scenarios 1 and 2 until 2030. The expansion rate for renewables has been calculated by using the rates of the energy efficiency strategy forecast. Based on discussions with energy experts, they vary between 3-6%. In both scenarios, it is assumed that the total energy supply and the total electricity supply have the same growth rate.

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 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
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					
System level	Techno-economic layer		•RE share in energy system about 0%-20% •Market introduction of RE drawing on globally available technology and driven by global price drop •Extension and retrofitting of electricity grid •Regulations and pricing schemes for RE •Developing and strengthening domestic supply chains for RE •No replacement of fossil fuels due to growing markets	•RE share in energy system about 20%-50% •Further grid extension (national and international) •ICT structures integrate with energy systems (e.g. introduction of smart meters) •System penetration of flexibility options (e.g. battery storage) •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) •No replacement (or only limited replacement) of fossil fuels due to growing markets •Development and extension of mini-grids as a solution for off-grid applications and remote locations •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	•RE share in energy system about 50%-80% •Extension of long-term storage (e.g. storage of synthetic gas) •First PtF/G infrastructure is constructed (satisfying up-coming national/ foreign demand) •Temporarily high negative residual loads due to high shares of RE •Sales volumes of fossil fuels start to shrink •Existing fossil fuel-based business models start to change •Increasing volumes of PtF/G in transport, replacing fossil fuels and natural gas	•RE share in energy system about 80%-100% •Large-scale construction of infrastructure for PtF/G exports •Phase-out of fossil fuel infrastructure and business models •Consolidation of RE-based export models •Full replacement of fossil fuels by RE and RE-based fuels •Stabilisation of PtF/G business models and production capacities (e.g. large-scale investments)

		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'
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 •Increasing participation of institutional investors (pension funds, insurance companies, endowments, and sovereign wealth funds) in the transition •Increasing awareness of environmental issues •Provide access to infrastructure and markets for RE (e.g. set up regulations for grid access) •Moderate efforts to accelerate efficiency improvements	•Put pressure on fossil fuel-based electricity regime (e.g. reduction of subsidies, carbon pricing) •Withdraw support for RE (e.g. phase out feed-in tariffs) •Measures to reduce unintended side-effects of RE (if any) •Adaptation of market design to accommodate flexibility options •Provide access to markets for flexibility options (e.g. adaptation of market design, alignment of electricity, mobility, and heat-related regulations) •Support creation and activation of flexibility options (e.g. tariffs for bi-directional loading of e-cars) •Facilitate sector coupling between power and end-use sectors to support the integration of VRE in the power sector •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	•Put pressure on system components that counteract flexibility (e.g. phase out base-load power plants) •Withdraw support for flexibility options •Measures to reduce unintended side-effects of flexibility options (if any) •Set up regulations and price schemes for PtF/G (e.g. transport, replace fossil fuels and natural gas) •Reduce prices paid for fossil fuel-based electricity •Provide access to infrastructure and markets for PtF/G (e.g. retrofit pipelines for transport of synthetic gases/ fuels) •Support adoption of PtF/G (e.g. tax exemptions)	•Put pressure on fossil fuels (e.g. phase out production) •Withdraw support for PtF/G •Measures to reduce unintended side-effects of PtF/G (if any) •Access to infrastructure and markets (e.g. connect production sites to pipelines) •Support adoption (e.g. subsidies)

		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 level	Techno-economic layer	• Assessment of RE potential • Local pilot projects with RE	• Assessment of regional potential for different flexibility options • Experiment with flexibility options • Exploration of business models around flexibility options including ICT start-ups and new digital business models for sector coupling	• Assessment of potential for different PtF/G conversion routes • Local pilot projects with PtF/G generation based on RE hydrogen and carbon capture (e.g. CCU/CCS) • Exploration of PtF/G-based business models • 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) • Tap into global experiences of PtF/G	• Experiment with PtF/G applications in sectors such as industry (e.g. steel, cement and chemical sectors) and special transport (e.g. aviation, shipping) • Invest in business models for PtF/G exports • Pilot synthetic fuel exports	
	Governance layer	• Development of shared visions and expectations for RE development • Support learning processes around RE (e.g. local projects) • Formation of RE-related actor networks (e.g. joint ventures) • Community-based engagement and involvement (e.g. citizen initiatives	• Development of visions and expectations for flex-market and energy system integration (regional and transnational energy markets) • Support learning processes around flexibility (e.g. local projects) • 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) • Development of a shared knowledge base of integrated decarbonisation pathways to enable alignment and critical mass that can help shift the entire sector	• Development of shared visions and expectations for PtF/G (e.g. strategy and plans for infrastructure development/ adaptation) • 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) • Formation of PtF/G-related actor network (national and international)	• Development of shared visions and expectations for PtF/G exports (e.g. about target markets and locations for conversion steps) • Support learning about PtF/G in sectors such as industry and special transport (e.g. experiments for using PtF/G products for glass smelting) • Support learning around PtF/G exports (e.g. concerning market acceptance and trade regulations) • 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 PALESTINE

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

The Palestinian energy sector is a unique case compared to other MENA countries. There are many reasons for this: a lack of natural resources, an unstable political environment, the current economic crisis, and high population density (Juaidi et al., 2016). Moreover, Palestine is entirely dependent on imports of fossil fuel and electricity, mostly from neighbouring Israel. Physically divided into two geographical areas (the West Bank (including East Jerusalem) and the Gaza Strip), the energy sector faces many challenges, resulting in unstable and unreliable electricity supply with frequent disruptions affecting the daily life of the Palestinian population (Juaidi et al., 2016; Milhem, o. J.).

Palestine is endowed with a rich renewable energy potential and the Palestinian Energy and Natural Resources Authority (PENRA) has recognised renewables as an important option to contribute to meet Palestine's energy needs (PWC, 2012). However, the political instability has hindered development initiatives and hampered private investment into the large-scale deployment of renewables. Furthermore, the fragmented territorial conditions create challenges for the large-scale development of renewables and storage options.

This study aims to further the discussion about Palestine's future energy system by providing an overarching guiding vision for the transition to a renewables-based energy system. To support the development of appropriate policy strategies, the current status of Palestine's energy transition and potential developments are assessed in detail in accordance with the proposed phase model.

FACTSHEET

Paris Agreement ratified	(X)
Green growth strategy	(X)
Renewable energy targets set	(√)
Regulatory policies for renewable energy implementation established	(√)
Energy efficiency strategy existing	(√)
Power-to-X strategy	(X)

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 Palestine's energy system in terms of supply, demand, the oil and gas sector, renewable energy, infrastructure, actor network, and market development.

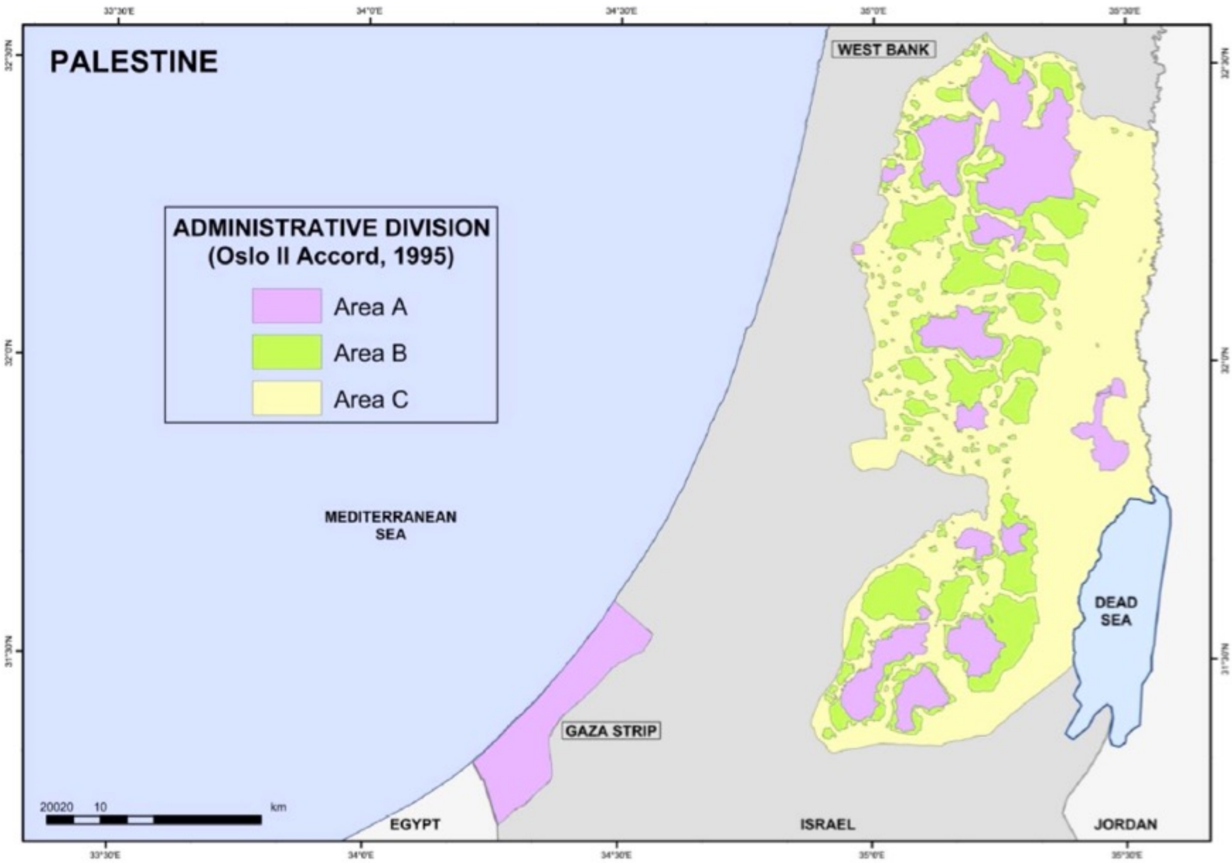
Energy Supply and Demand

To understand Palestine's energy sector, it is necessary to take into account the Israeli-Palestinian conflict as it significantly impacts on the energy situation of Palestine (Hamed and

Peric, 2020). The Palestinian Territories are since 1967 occupied by Israel and have since been divided into different administrative regions. According to the 1995 Oslo II Accord, the West Bank and Gaza have been divided into Areas A, B, and C (Fig. 4-1). In Area A, which constitute the highly populated areas, the Palestinian National Authority (PA) is fully responsible for the civil and security control; in Area B, the PA is responsible for the civil control but shares the security control with Israel; and in Area C, Israel is fully responsible for the civil and security control (Juaidi et al., 2016). This affects the potential to install renewable energy capacities. In the West Bank, Area A comprises 18% of the total land area, with Area B accounting for 22% and Area C for 60% (Hamed and Peric, 2020). Accordingly, Israel's partial/complete control of Areas B and C severely hinders the potential development of renewable and traditional energy infrastructure, as well as impeding development initiatives on a political and regulatory level (Juaidi et al., 2016). Additionally, population growth and the resulting expansion of the housing has effectively exhausted the land resources in Areas A and B: as a result, there is minimal land available for renewable energy projects (Hamed and Peric, 2020).

Today, the Palestinian electricity sector relies mainly on imported energy sources. There is only one domestic power plant, at Nusseirat in Gaza. It was built in 2002 and has a capacity of 140 MW but currently runs at only 50% capacity due to fuel price hikes and its partial destruction from Israeli bombardment (Hamed and Peric, 2020). In 2020, this Gaza power plant (GPP) provided enough power to supply 6% of the total electricity demand. While a share of 5% of the total electricity supply was imported from Jordan and Egypt (Fig. 4-2), the largest electricity supplier (accounting for 86%) was the Israeli Electricity Corporation (IEC). It provided 99% of

Fig. 4-1
Map of the Palestinian Territories



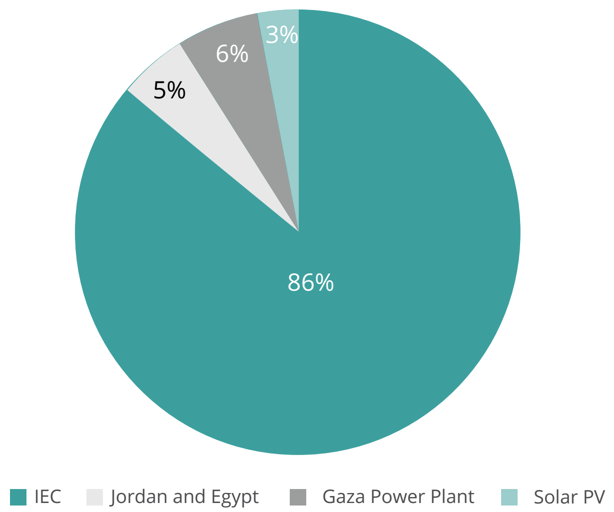
(Source: Hamed and Peric, 2020)

the total electricity supply in the West Bank and 64% in Gaza (Milhem, o. J.). Solar PV accounted for 3% of the electricity supply.

In 2018, Palestine's total final energy consumption was approximately 1,795.5 Kiloton/Watt. Electrical energy represents 31% of the total energy consumed. In terms of sectoral consumption in 2018, the domestic sector was the largest consumer of energy (45%), followed by the transport sector (38%), and the commercial and public services sector (10%). The industrial sector consumed 6% and the agricultural sector 1% (Fig. 4-3) (meetMED, 2020).

Fig. 4-2

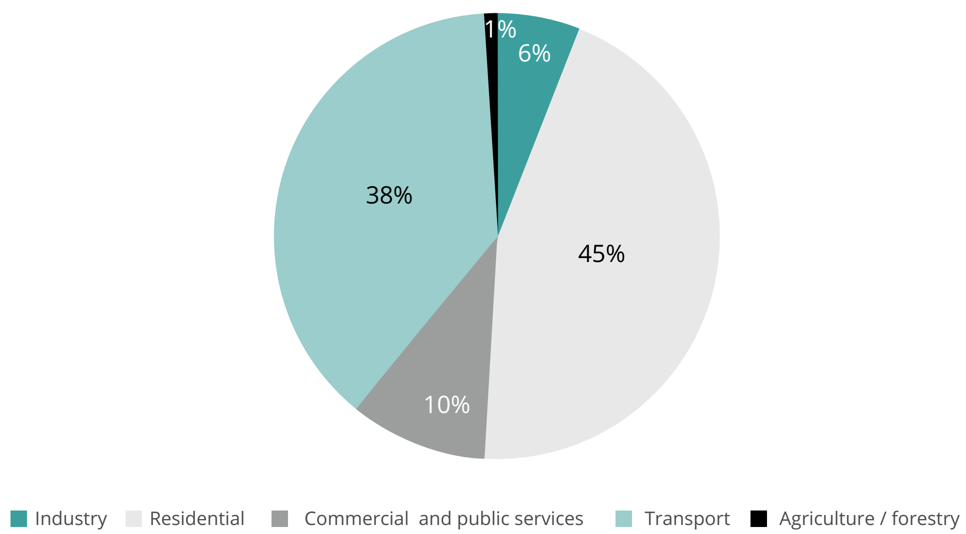
Electricity Sources in Palestine, 2020



(Source: data provided by Imad Brik)

Fig. 4-3

Final Energy Consumption in Palestinian Territories by sector, 2018



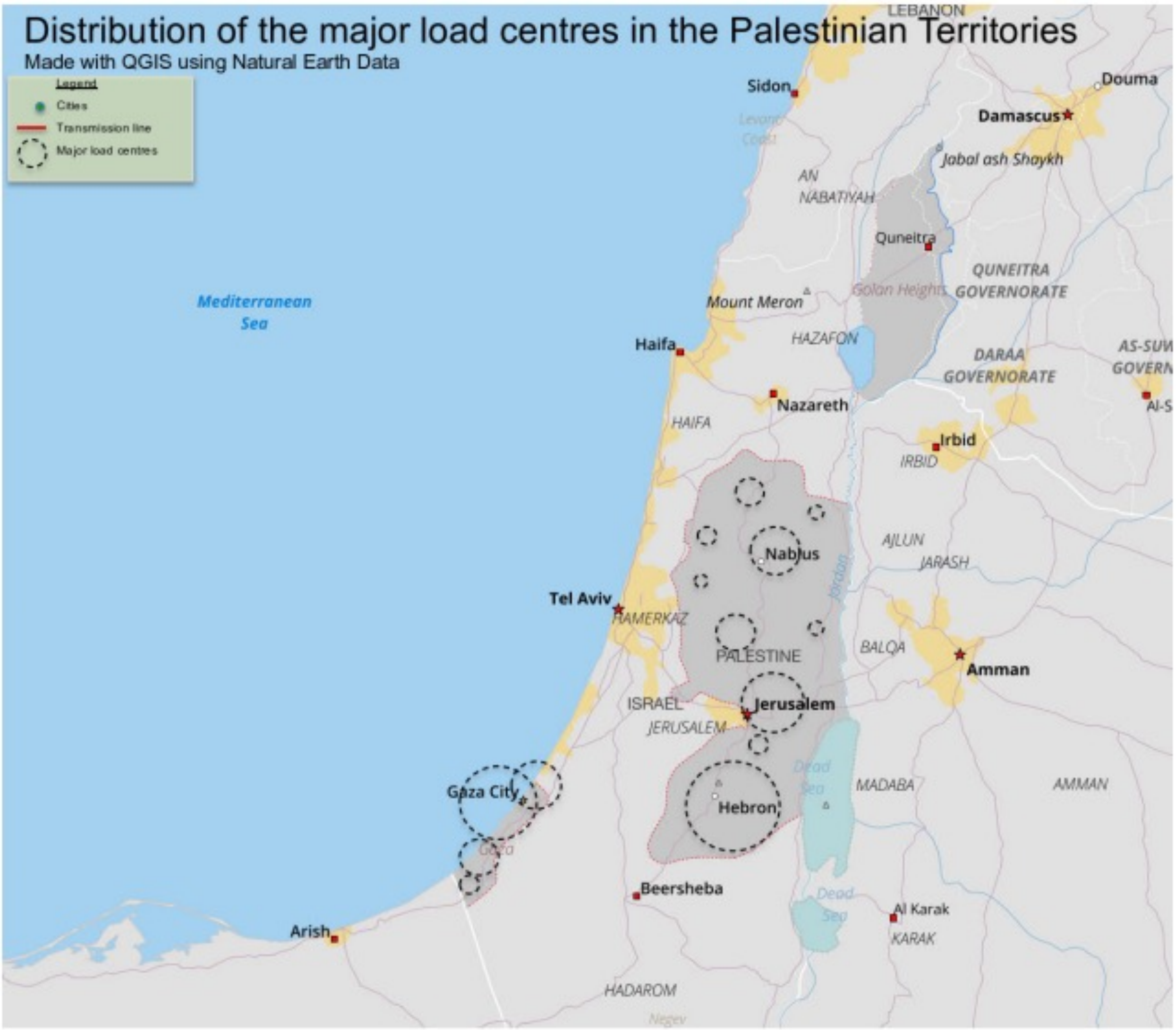
(Source: Palestinian Central Bureau of Statistics 2020, Energy Balance of Palestine, 2010-2019. Ramallah - Palestine.)

Household energy consumption, which represents the largest share, is made up of electricity, renewable energy (mostly thermal) and firewood, gasoline, diesel, kerosene, and LPG (Al Qadi et al., 2018). Although the Palestinian Territories have an electrification rate of 99%, some areas in the West Bank, in particular, have no access to electricity (AF-MERCADOS EMI, o. J.). Some villages there still use old kerosene lamps and gas for lighting and wood for cooking. For space heating, most Palestinians rely on a number of different types of heating systems (Al Qadi et al., 2018). Electric heaters are one of the dominant heating systems, which are also widely used in refugee camps. Another popular energy source for heating are LPG bottles; these have the advantage of being pre-paid, which makes costs easy to control (ibid.). The average annual electricity consumption for a typical household is relatively low in comparison to the MENA region average, at 3,672 kWh. The monthly average differs between the regions: average usage in the central region is 442 kWh[1], in the south region it is 294kWh, in the north region 272 kWh, and in Gaza 265 kWh (Monna et al., 2020). There is a clear increasing trend in household electricity consumption: in 2009 the average consumption was 275 kWh, while by 2015 it had reached 306 kWh (Hamed and Peric, 2020). Historical data shows an annual growth rate of electricity consumption during some periods of more than 6% (ibid.).

In 2020, the overall energy consumption (met by all the electricity distribution companies (DESCOs)) was reported to be 5,460 GWh. An additional 1,196.37 GWh came from the local council areas in the West Bank, amounting to total energy consumption of 6,656.37 GWh. The total peak demand was 1,877.70 MW. The Gaza Strip, for instance, requires around 690 MW electricity during peak seasons, while the total available capacity only amounts to 280 MW. IEC provides about 120 MW, the Gaza power plant about 130 MW capacity, and Egypt around 30 MW. Of these 280 MW capacity currently only about 210 MW are available. Most of this electricity is supplied by the IEC, while since 2018 no electricity has been supplied by Egypt. However, there is unmet demand of approximately 50% of the total required electricity, leading to daily electricity blackouts of between 8 and 16 hours in the Gaza Strip (Hamed and Peric, 2020; Khaldi and Sunikka-Blank, 2020; Monna et al., 2020). Usually, the peak demand occurs in winter for indoor heating. The summer period involves another peak, resulting from the need for air conditioning (Milhem, o. J.). The major load centres in the Palestinian Territories are Hebron, Gaza, Jerusalem, Nablus, and Ramallah. Fig. 4-4 shows the regional distribution of these major load centres: the larger the size of the circle, the greater the load.

[1] 1 1000 W = 1 KW
1000 KWH = 1 MW
1000 mw = 1 GW

Fig. 4-4
Distribution of major load centres in the Palestinian Territories

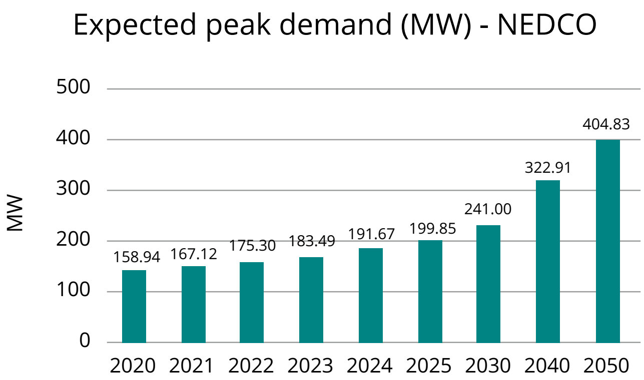


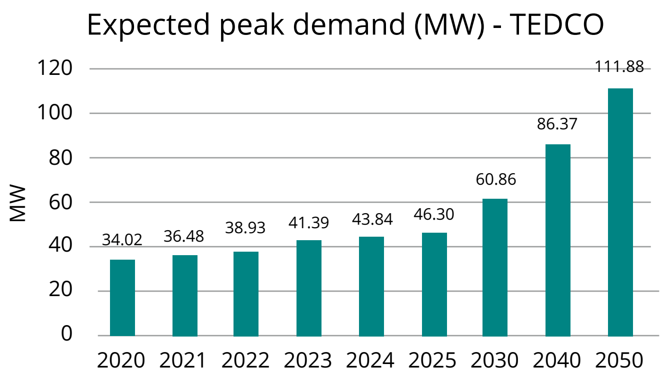
The global COVID-19 pandemic created new challenges for the energy sector. Overall consumption decreased by 12% due to the cessation of commercial and industrial activities. The imposed lockdown also hindered the implementation of certain projects relating to the development of the energy sector.

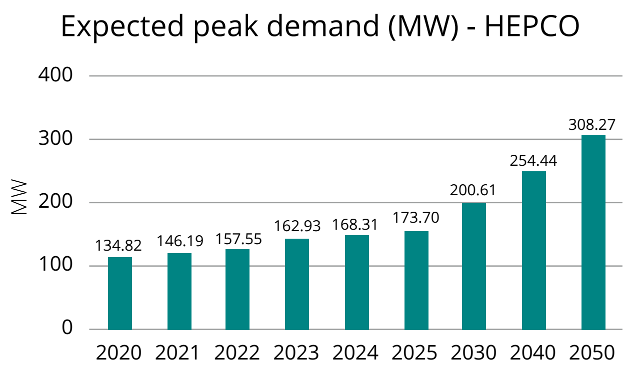
Own calculations conducted in frame of this project by the local partner Dr. Imad Brik show that the total electricity demand in Palestine will increase significantly by 2050 as a result of demographical change, industrial development, and increasing living standards. The modelling results show that by 2030 the electrical peak demand could reach 2,719 MW, increasing by 2050 to 4,620 MW (assuming an annual demand increase of about 6%). The future load forecast is shown in Fig. 4-5 for each DESCO that supplies the Palestinian Territories, as well as the local councils (Local Government Units – LGUs) involved in the distribution sector. The DESCOs are: Tubas District Electricity Company (TEDCO), Northern Electricity Distribution Company (NEDCO), Jerusalem District Electricity Company (JDECO), Hebron Electric Power Co. (HEPCO), Southern Electricity Co. (SELCO), and Gaza Electricity Distribution Company (GEDCO).

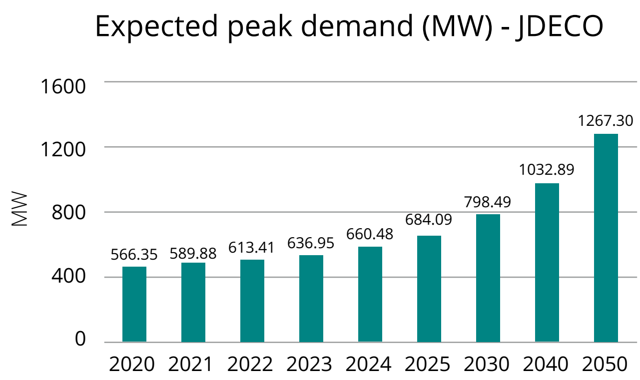
Fig. 4-5

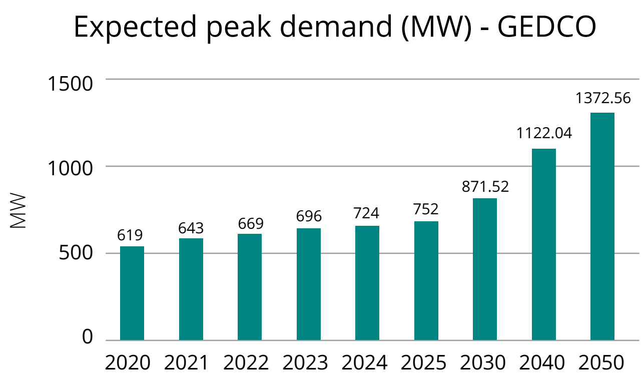
Expected Peak Load Demand for Different DESCOs and LGUs up to 2050

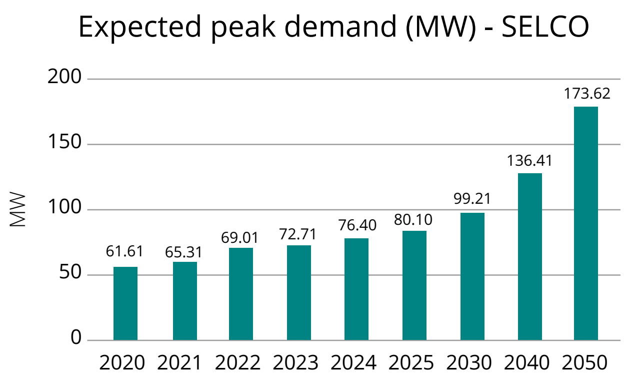


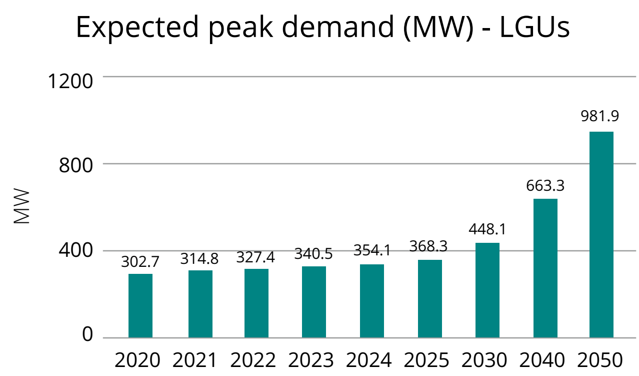












(Source: own calculation with contribution from Palestinian expert Imad Brik)

Next to electricity, future demand for energy in general is expected to increase considerably. The challenge stemming from the unpredictable power supply negatively affect the economy at local level. The COVID-19 pandemic has compounded the difficulties faced by the Palestinian energy sector, and Palestine is currently neither able to meet its own demand for energy nor to develop alternatives to fossil fuels to meet its growing energy needs. Hence, it seems appropriate to categorise Palestine as being at the pre-stage level of the described MENA phase model.

Renewable Energy

Renewable sources are estimated to account for around 18% of the total current energy consumption in Palestine, representing the equivalent of 2,287 GWh (as electrical energy) for thermal usage. This includes not only modern renewables like solar energy for water heating but also large shares of traditional biomass usage with the associated negative effects on health and environment. Within the electricity mix, renewables currently have a share of 3% (Fig. 4-2). According to a World Bank study, the renewable energy potential in Palestine amounts to about 4,246 MW (meetMED, 2020), from an estimated solar energy potential of 4,174 MW combined with a wind and biomass potential of 72 MW (meetMED, 2020). To exploit the renewable energy potential in Palestine will depend mainly on the availability and accessibility of land in areas B and C (Khaldi and Sunikka-Blank, 2020). Because most of the large-scale solar and wind energy potential is located in Area C, which is currently not accessible as it falls under Israel's control.

The most important renewable energy potential in Palestine is solar energy. The Palestinian Territories benefit from one of the highest levels of solar radiation in the MENA region, with a daily average of about 5.4 kWh/m2 (Hamed and Peric, 2020). In December, the daily solar radiation can reach 2.63 kWh/m2, while in June the radiation can be as high as 8.4 kWh/m2 (Juaidi et al., 2016). In total Gaza's rooftop solar energy potential is estimated at 163 MW, while the West Bank's potential amounts to 534 MW. These values indicate good potential for harvesting solar energy for use in applications such as water heating systems, drying systems, water desalination, and pumping (ibid.). However, to date, only small-scale solar PV and thermal systems have dominated the Palestinian market, while large-scale projects are missing. In 2015, around 57% of households used solar water heating systems (Hamed and Peric, 2020). However, in recent times the use of such systems has significantly decreased. The imposed blockade and import restrictions on technical equipment have hampered the use of the technology in the Gaza Strip, and in the West Bank the switch to electrical water heaters has resulted in lower demand for solar heating systems (ibid.).

Utility-scale solar systems are only possible in the West Bank, as Gaza's population density means there is insufficient land available there. In Areas A and B, the potential for large-scale solar amounts to 103 MW, while the most promising potential is for Area C, which could generate 3,374 MW.

Table 4-1

Solar Energy Potential in the West Bank and Gaza (MW)

Utility-scale PV or CSP				
	Areas A and B	**Area C**		**Total (MW)**
West Bank	103	3,374		3,477
Gaza				0
Combined				**3,477**
Rooftop solar				
	Residential	**Public**	**Commercial**	**Total (MW)**
West Bank	490	13	31	534
Gaza	136	8	19	163
Combined	626	21	50	**697**

(Source: data based on (Khaldi and Sunikka-Blank, 2020; meetMED, 2020))

Table 4-1 summarises the potential for solar energy in Palestine, which amounts to a total of 4,174 MW.

Table 4-2 summarises the installed, operational and contracted solar energy projects until April 2021 in Palestine, which have a combined total installed capacity of 202.797 MW. According to PENRA, the installed and operational projects reach 118.958 MW, while the contracted projects that are under development have a capacity of 83.839 MW.

Table 4-2

Installed, Operational and Contracted Solar Energy Projects in Palestine

Location	Installed/ Operational Projects (MW)	Contracted Projects (MW)	Total
JDECO	29.271	12.95	42.221
NEDCO	11.603	2.195	13.798
TEDCO	5.989	20.33	26.319
HEPCO	5.722	2.321	8.043
SELCO	3.196	4.25	7.446
Gaza Strip	12.992	15.676	28.668
LGUs	50.185	26.117	76.302
Total	**118.958**	**83.839**	**202.797**

(Source: data based on PENRA)

Next to solar, Palestine also has some potential for wind energy. However, there are no advanced wind speed measurements in Palestine to indicate the wind energy potential in detail (Hamed and Peric, 2020). Some meteorological stations have been destroyed by the Israeli army during invasions of the West Bank (AF-MERCADOS EMI, o. J.). Therefore, only theoretical estimations exist and these indicate that the hilly regions (mostly located in Area C) of Nablus, Ramallah, Jerusalem, and Hebron have an average annual wind speed of between 4 m/s and 8 m/s. This is considered to be moderate (Juaidi et al., 2016). The annual average wind potential in the Jordan Valley is around 150 kWh/m2, most of the West Bank records a potential of between 300-450 kWh/m2, and in some areas in the north and south the potential could reach 600 kWh/m2 (AF-MERCADOS EMI, o. J.). Area C, which covers over 60% of the Palestinian Territories, has some promising mountainous zones that are not densely populated where wind energy could potentially be harvested. However, these areas remain beyond the control of the Palestinian Authority, which is a major barrier. In contrast, Areas A and B are too densely populated, making them widely unsuitable for the development of wind energy. The coastal area of the Gaza Strip has wind speeds of around 2.5-3.5 m/s, which is considered to be too low for harnessing wind power (Juaidi et al., 2016). Overall, wind energy seems to have the most promising potential for small-scale off-grid applications, to charge batteries, for water pumping, and could be combined with diesel systems as a hybrid system. The Palestinian wind turbine manufacturer, Brothers Engineering Group, builds turbines of 200-2,000 W and cooperates with the Israeli company, Israel Wind Energy. Together they provide wind turbines of up to 50 kW that can be installed for factories, offices, or private homes (AF-MERCADOS EMI, o. J.).

Biomass already plays an important role for the energy supply. The most popular biofuel type is wood, which is used mainly for heating in winter, baking, cooking, and heating water (Hamed and Peric, 2020). In 2015, around 34% of households used biomass as fuel source (ibid.). Another prominent fuel type is olive cake, which is a by-product of olive pressing. This can be used for heating homes and heating water (ibid.). To date, no effective scientific study has been conducted to determine the potential of modern biomass use for example in form of biogas in Palestine.

To exploit the renewable energy potential in 2010, PENRA developed a strategic energy vision for the Palestinian energy sector. This vision focuses on renewable energies and includes the restructuring and development of the whole energy sector with legal, legislative, regulative, and institutional measures (meetMED, 2020). The Renewable Energy Strategy details two phases to meet the goal of 130 MW installed capacity of renewable energy by 2020. The first phase, from 2012-2015, set a target of 25 MW of renewable energy generation. As part of this first phase, PENRA launched the Palestinian Solar Initiative (PSI) with the target of installing 5 MW of small-scale solar PV systems. To better promote this technology, the PSI aimed to educate people and raise awareness about solar energy to encourage Palestinians to adopt renewable energies. Initially, there were plans to install small-scale, on-grid residential rooftop solar systems of 1-5 kWp PV on 1,000 houses. Households could apply for green loans to purchase solar systems from developers or installers, and a feed-in-tariff would be paid for energy sold to the grid at a rate of between 0.14-0.15 USD/kWh (Khatib et al., 2021; meetMED, 2020). However, due to budgetary restrictions, this initiative was downscaled: by 2016, PENRA’s goal was to install 300 systems of 5 kWp each (meetMED, 2020). The second phase of the strategy started in 2016 and ran until 2020. Its target was to reach a combined capacity of 130 MW from renewable energy systems by 2020. This goal equates to renewables generating 10% of electricity production (Milhem, o.J.). Table 4-3 shows the renewable energy targets by technology for the first and second phase of the energy strategy. In 2021, PENRA announced its Renewable Energy and Energy Efficiency Roadmap to 2030, which envisages an additional

500 MW to be installed by 2030, of which 80% will come from solar PV and CSP, 4% from wind energy and 16% from biogas/biomass.

Table 4-3
Renewable Energy Targets (MW)

		Phase 2012-2015	Phase 2016-2020	Roadmap to 2030
On ground PV		5	25	
PV small (total) Palestinian Solar Initiative		5	20	
	Northern West Bank (1.5)			
	Central West Bank (2)			
	Southern West Bank (1.5)			
CSP		5		
Solar total				400
Biogas landfill		6	18	
Biogas animal		0.5	3	
Biogas total				80
Small-scale wind		1	4	
Wind		2.5	40	20
Total		25	110	500

(Source: data based on PWC, 2012)

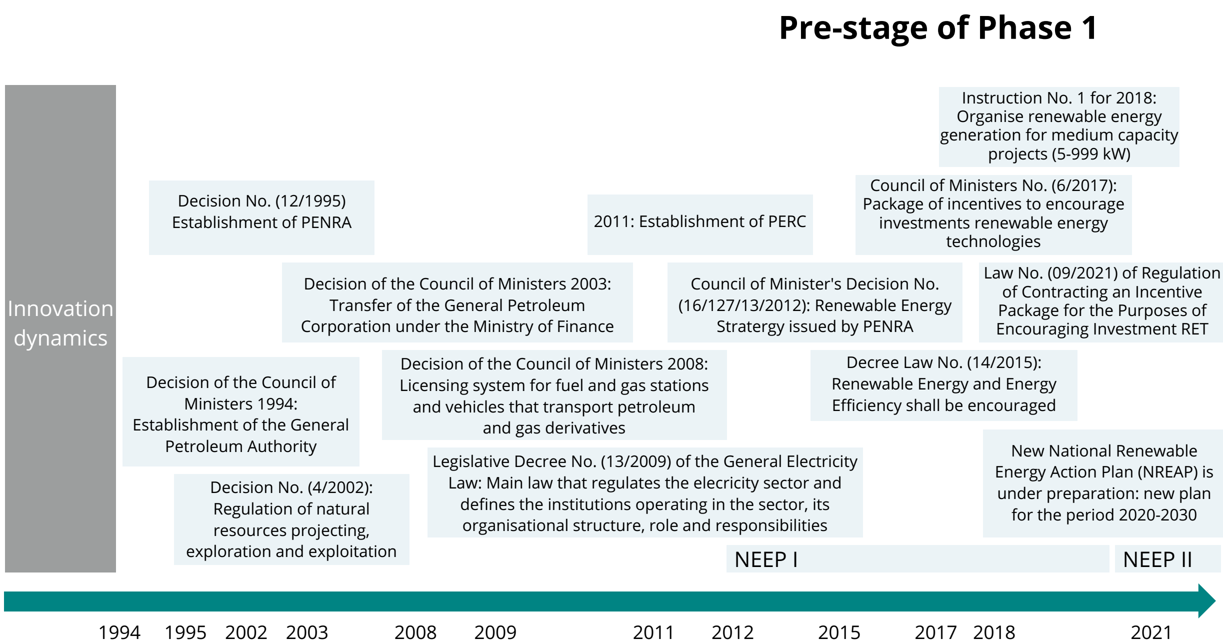
The renewable energy targets for 2020 have not been met, despite the introduction of several schemes to support the uptake of renewables in Palestine. The schemes include: a feed-in-tariff (FiT) scheme, a net metering scheme, a licensing scheme, and a tendering scheme (Milhem, o. J.). The FiT scheme applies to the residential sector for systems of up to 5 kW and guarantees a payoff during the system's lifetime (usually around 20 years) (meetMED, 2020). The net metering scheme applies to power systems between 5 kW and 999 kW in size (Khatib et al., 2021). This scheme forces DESCOs to buy excess electricity generated from PV systems. They provide credits to the consumer, who is only billed for their net electricity usage each month (ibid.). For large power plants (with a capacity over 1 MW), the Palestinian Electricity Transmission Company (PETL) signs a power purchase agreement (PPA) with the developer to buy the electricity generated (ibid.). In 2020, a law has been issued by the Council of Ministers to amend the purchase price of electrical energy so that it does not exceed 85% of the rate of purchasing electrical energy from traditional energy sources. The PETL acts as a single buyer in the market and guarantees the purchase. Power stations with a lower capacity (<1 MW) agree on a PPA directly with the DESCOs or the local councils, and with village councils (meetMED, 2020). Developers can apply for projects through a governmental bidding process for generation plants ranging in capacity between 1 MW and 5 MW. The winning bidder must offer the lowest purchase price, and this must not exceed 85% of the average purchase price. Utility-scale PV power plants (with a capacity exceeding 1 MWp) encourage private sector investment by offering the advantage of tax reductions (Khatib et al., 2021). The Palestine Investment Fund (PIF) offers a serious investment opportunity: it aims to secure 50 million USD for renewable energy projects, industrial infrastructure, and digital infrastructure (ibid.). The Gaza Solar Revolving Fund is another mechanism that aims to support the installation of rooftop solar energy in Gaza for residential, business, and public buildings (Hamed and Peric, 2020).

From a legal and regulatory perspective, the most relevant law that endorses the deployment of renewables is the Decree Law on renewable energy and energy efficiency issued in 2015. Its stated objective is for renewable energies to improve energy security and to address environmental protection. The law specifies the roles and responsibilities of institutions and bodies for monitoring, production, and distribution. Article 18 of the Decree Law encourages investment in the renewable energy production sector; however, Article 12 restricts production for commercial purposes for a limited time period which is regulated by a licence (Milhem, o. J.). The other relevant law for the sector is the Electricity Decree Law No. 13 from 2009 that aims to restructure the electricity sector. The law dictates the establishment of an electricity regulatory council and outlines a new structure for regulating the sector. The establishment of PETL was also reinforced by this law. Under this law, PETL allows generators and suppliers to use the national grid and authorises the purchase and sale of energy from other sources, including to DESCOs. In 2021, the law 07/2017 was amended by Law No. 09/21 on the Regulation of Contracting an Incentive Package for the Purposes of Encouraging Investment in the Use of Renewable Energy Technologies. This law aims to stimulate investment from the private sector, while regulating the electricity tariffs and the net metering scheme. Additionally, this law allows for the provision of income tax incentives and incentives for financing agencies to grant soft loans for small and medium-scale projects.

Other decisions and relevant regulations in the Palestinian energy policy are listed in Fig. 4-6.

Fig. 4-6

Development of the Laws and Regulations and Introduction of Energy Policy Measures, Palestine 1994-2021



(Source: own creation based on Khaldi and Sunikka-Blank, 2020)

In conclusion, Palestine's energy transition is driven by the need to enhance energy security, and to reduce Palestine's energy dependency on Israel. Although renewable energies can improve electricity provision for Palestine, technology applications have been limited to small-scale applications, as the most promising regions are located in the restricted Area C. Currently, only 3% of Palestine's electricity comes from local solar PV. The major share of electricity is provided by Israel, which is considered to have a conventional power system with limited renewable shares. Despite Palestine's efforts to develop its renewable energy sector, it still faces a long road ahead. According to the phase model described, Palestine can be classified as having achieved some of the required criteria for phase one, but it still lacks the larger implementation of renewables and potential assessment for relevant large-scale projects (such as wind energy). Therefore, the renewable energy sector in Palestine can be summarised as being in a niche and pre-stage level before phase I.

Energy Efficiency

PENRA launched the National Energy Efficiency Action Plan I (NEEAP I) in 2010. It aimed to achieve annual energy savings of approximately 384 GWh by 2020. This represents a reduction of around 1% per year compared to 2010 levels, and equates to at least 55 million USD in electricity cost savings and annual CO2 emissions reductions of 285,000 tons (meetMED, 2020). The pilot phase from 2010 to 2015 implemented the following: the provision of prepaid meters, the introduction of regulations for energy audits and their enforcement in industrial and commercial sectors, and the raising of public awareness. The action plan focused mainly on the electricity sector as this sector represents the largest share of Palestine's final energy consumption. Table 4-4 provides an overview of NEEAP I's energy saving targets by phase and sector.

Fig. 4-4

Energy saving targets of NEEAP I (GWh)

Sector	Targets (GWh)			
	Phase I (2012-2014)	Phase II (2015-2017)	Phase III (2018-2020)	2020
On ground PV	5	6	8	19
Buildings	38	130	195	363
Water Pumping		1	1	2
Total	**43**	**137**	**204**	**384**

(Source: data based on meetMED, 2020)

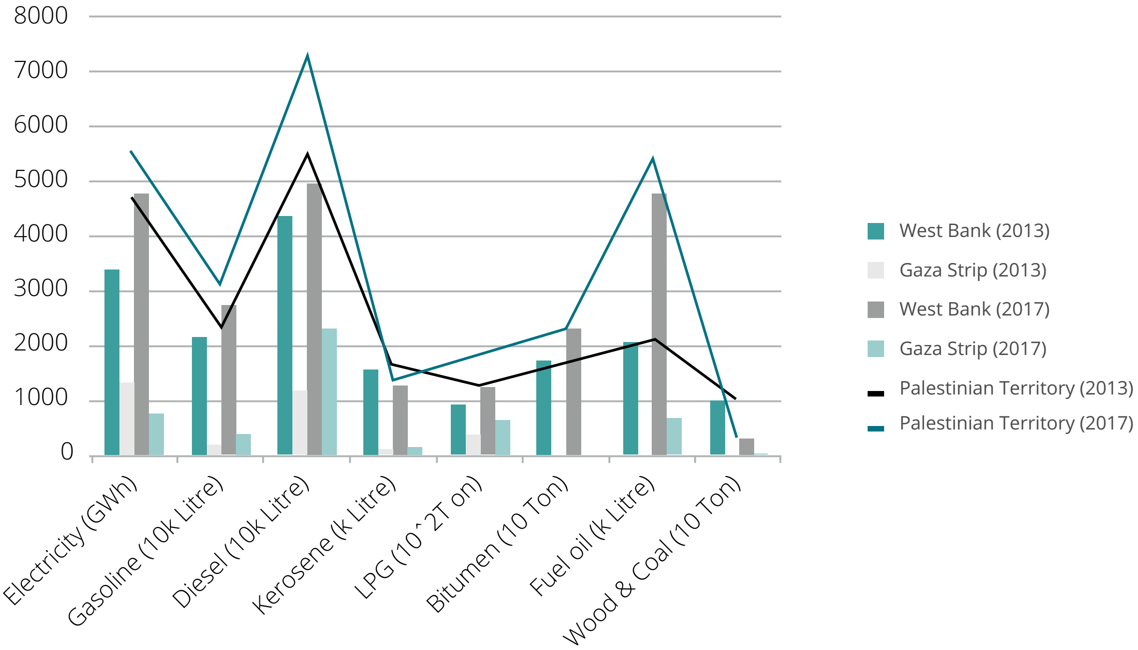
Phase I of NEEAP I has been successfully achieved, and Phase II was implemented satisfactorily (The World Bank, 2016). To achieve its goals, however, PENRA launched NEEAP II, which is a continuation of NEEAP I and is considered to be more ambitious. It will be discussed further in the chapter, "Assessment of Trends and Developments at the Niche".

Fossil Fuel Sector

Fossil fuels are imported 100% from Israel. Furthermore, 86% of Palestine's electricity also comes from Israel. Palestine spent over 4.95 billion USD in 2016 on imported energy from Israel. The fuel used by the GPP (Gaza power plant) comes mostly from Israel and sometimes from Egypt (Nassar and Yassin Alsadi, 2019). It is stored in two large tanks. Due to the high fuel prices, the GPP currently runs at only half capacity and its daily consumption amounts to 420,000 litres of diesel oil (ibid.). The costs of the generated electricity are high with about 0.29-0.46 USD per kWh. In light of growing demand, the domestic consumption of oil and gas is expected to further increase. According to available data, between the years 2013 and 2015 the average annual growth rate of oil and gas consumption was 5.7% (PENRA, 2016). Fig. 4-7 depicts the energy imports by energy type for the years 2013 and 2017, demonstrating the increase in energy imports.

Fig. 4-7

Energy Imports by Type, Palestine 2013-2017



(Source: data based on (Juaidi et al., 2016; meetMED, 2020)

In 1999, a natural gas field was discovered in the Gaza Sea. The British Gas Company was due to commence exploitation; however, political instabilities in the relation between Palestine and Israel prevented this project from launching (PENRA, 2016). Additionally, information about an oil field in the north-west of Ramallah, on the West Bank, was withheld by Israel. However, in 2016, the Palestinian Authority was granted a concession, financed by the PIF (ibid.), to develop this oil field.

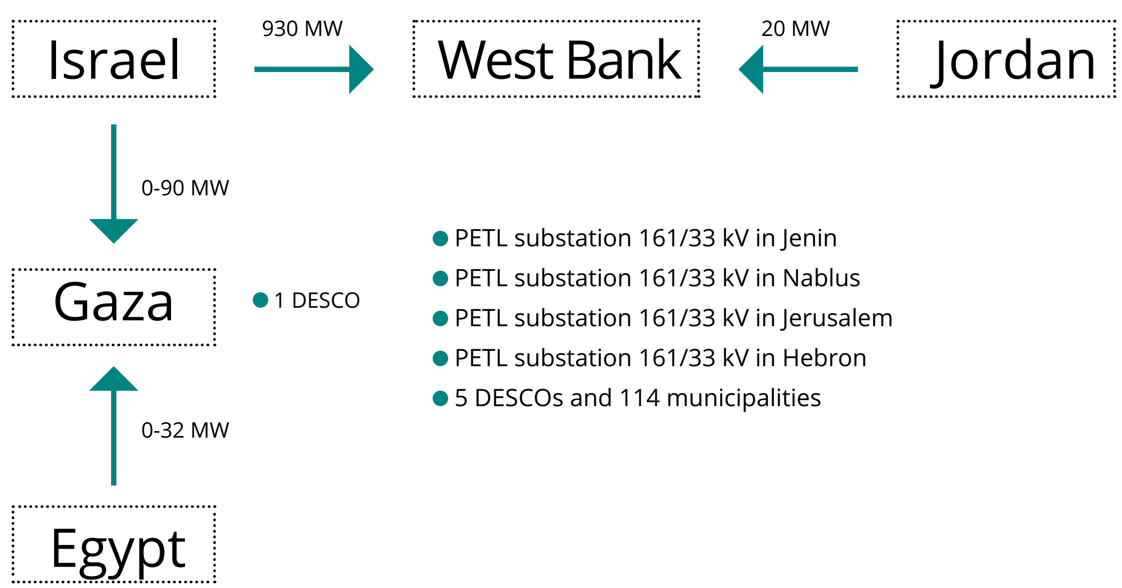
To sum up the oil and gas sector in Palestine is highly dependent on Israel. Due to the political instability between Palestine and Israel this dependency leads to a vulnerable and regularly unreliable energy supply. As the Palestinian domestic market is growing and its reliance on fossil fuels is increasing, decision-makers have realised that Palestine must broaden its sources of energy to meet domestic demand and increase the energy security. However, the road to achieving this outcome is long and is complicated because of the political situation. As a result, it is likely that the current energy supply structure will remain in place for years to come.

Infrastructure

The electrical infrastructure in Palestine is characterised by several fragmented systems that supply the West Bank and Gaza. The West Bank depends almost entirely on the IEC with four PETL substations located in Jenin, Nablus, Jerusalem, and Hebron (all in Area C). These substations transform the electric voltage arriving from Israel from 161 kV to 33kV or 22 kV (Khatib et al., 2021). Coupling points are placed at the Israeli side to control the flow of electricity into Palestine. The PETL has no control over the transmissions from Israel. Around 200 coupling points with caps on the electrical current are distributed across the West Bank and are controlled by the Israeli civil administration of the West Bank. The transmission capacity of the IEC to the West Bank totals 930 MW (Khaldi and Sunikka-Blank, 2020). Five DESCOs distribute the power via 33 kV and 11 kV distribution power lines. Operating DESCOs in the West Bank are HEPCO, NEDCO, SELCO, JDECO, and TEDCO, and the local councils are also responsible for the distribution of electricity. The IEC supplies up to 120 MW to the Gaza Strip, which also has the 140 MW GPP. The operating DESCO in Gaza is GDECO. As well as Israel, Jordan and Egypt also export electricity to Palestine. Jordan is connected to a 33 kV power line in Jericho and supplies around 20 MW. Rafah, in south Gaza, is connected to the Egyptian grid via a 260 kV power line which was discontinued since February 2018. Up to 32 MW can be supplied by the interconnections (Juaidi et al., 2016). These interconnections are usually not compatible with each other, and the voltage needs to be reduced via transformers when electricity is imported into Palestine. JDECO, which supplies mainly the central West Bank and distributes most of the power, has submitted a request to upgrade the power line to 132 kV which should then be compatible with the Jordanian grid (ibid.). Fig. 4-8 illustrates the structure of the electricity interconnections in Palestine.

Fig. 4-8

Structure of the Electricity Interconnections in Palestine



(Source: own creation based on Khaldi and Sunikka-Blank, 2020)

In some areas (mainly villages) private distribution network operators buy electricity directly from the IEC and provide it to customers (Khatib et al., 2021). The owners of these operators are the local councils. Some localities have no electricity network at all: notably regions in Tubas and Jericho, which are totally off-grid (Juaidi et al., 2016).

Electricity outages are frequent in Palestine and occur due to poor grid conditions and when the energy demand increases (AF-MERCADOS EMI, o. J.). When the grid is not able to meet the demand, diesel generators are used to cover the demand. However, other factors contribute to the weak performance of Palestine's electricity network: weak voltage stability, low ampacity, critical power stability and low power quality (Juaidi et al., 2016; Khatib et al., 2021). Electricity losses amount to 22% due to obsolete network conditions, and losses caused by thefts amount to 12%, especially in Area C which is difficult to monitor. These losses costs electricity companies a large sum: around 168 million USD annually. As it is old and inefficient, and lacks high voltage transmission lines, the grid network in its current state is not able to accommodate a large share of utility-scale renewable energy. Before licences are granted grid impact studies need to be conducted, to avoid negative impacts on the grid network (Khatib et al., 2021).

Overall, the Palestinian electrical distribution network is insufficient for meeting Palestine's high demand. Being highly dependent on the Israeli grid and the IEC – as a domestic high voltage grid network does not exist – Palestine's energy system is constrained. It faces various challenges on technical and structural levels. Moreover, in its current state, Palestine's transmission and distribution infrastructure is not prepared to accommodate large volumes of renewables. Accordingly, Palestine can be assessed as being in a pre-stage before phase I of a renewable energy transition according to the applied phase model.

Institutions and Governance

In 2016, the Palestinian and Israeli sides came to an agreement that settled the transfer of authority for the control of the electricity sector to the Palestinian Authority (PENRA, 2016). This agreement allows for the Palestinian Authority to develop an electrical transmission and distribution system, and to build a national electricity generation system to meet national demand. The Palestinian Energy and Natural Resources Authority (PENRA) heads up the electricity market structure in Palestine and has functions and responsibilities similar to an energy ministry. The Electricity Law issued in 2009 detailed PENRA's role and responsibilities, which include sectoral planning, policy making, regulating rules and laws for the electricity sector, issuing licences, and setting electricity tariffs. On an international level, PENRA pays Israel for the electricity it supplies to Palestine and manages all other international issues, including negotiations for electricity imports. PENRA is also responsible for implementing Palestine's renewable energy strategy (PWC, 2012).

Since 2011, the Palestinian Electricity Regulatory Council (PERC) has been the electricity regulatory council that monitors the Palestinian electricity market. The main task entrusted to PERC by law is to ensure the safe and continuous delivery of electricity. Moreover, PERC is responsible for competition in electricity generation and distribution activities. PERC also recommends the level of tariffs to be set by PENRA, and advises whether to accept, reject, renew, withdraw, or assign licenses to the generation and distribution companies. In addition, PERC issues the Feed-in-tariffs (FiT) for each type of renewable energy technology, which is then approved by the Cabinet. On a technical level, PERC issues network codes as well as distribution codes and ensures that third production parties are in compliance (PENRA, 2016).

The Palestinian Energy and Environment Research Centre (PEC) is a governmental institution belonging to PENRA (meetMED

2020). It oversees studies on the exploitation of renewables and is responsible for implementing the renewable energy strategy. It prepares studies on energy efficiency and implements energy auditing programmes and activities in public institutions.

Established in 2013, PETL is the Palestinian electricity transmission company that distributes the electricity purchased from the IEC and independent power producers (IPPs) to the consumers. PETL studies load expectations, and sets strategic plans to meet the expected loads by signing purchase and energy exchange agreements with IPPs for conventional and renewable energy. PETL is responsible for building new transformers for stepping the voltage up/down and for expanding the existing ones. It also manages the electrical connection points for local facilities not affiliated to the electricity distribution company.

The DESCOs and local councils are responsible for distributing electricity at local level. In the West Bank, six DESCOs distribute electricity: Jerusalem District Electricity Company (JDECO) provides electricity services in East Jerusalem and the central areas of the West Bank, and the Hebron Electricity Company (HEPCO) covers the Hebron area in the southern part of the West Bank. The South Electricity Company (SELCO) covers the remaining southern part of the West Bank, the North Electricity Distribution Company (NEDCO) serves areas of the northern West Bank (Nablus and Jenin), and the Tubas Governorate Electricity Company (TEDCO) covers the Tubas area. These five companies collectively serve approximately 70% of the population in the West Bank, while the electricity needs of the remaining residents of the West Bank are provided by the local councils. The Gaza Strip is served by the Gaza Electricity Distribution Company (GEDCO), which also has branches for electricity distribution in the North Governorate, Gaza Governorate, Al Wusta Governorate, Khan Yunis Governorate and Rafah Governorate. Thus, its services cover around 360 km2 and serve more than two million Palestinians in the governorates of Gaza.

IPPs (for both conventional or renewable energy projects) apply for a licence to the relevant DESCO, where they need to prove that they own the land or rooftop. The DESCO checks the applications and submits them to PEC to grant the licence. PEC is responsible for verifying the completeness, accuracy, and reliability of the application. Only then can a project be approved by PENRA and begin construction. After the infrastructure is built, the DESCO connects the facility to the power grid. A 20 year licence is granted for electricity production and delivery to the grid (PWC, 2012).

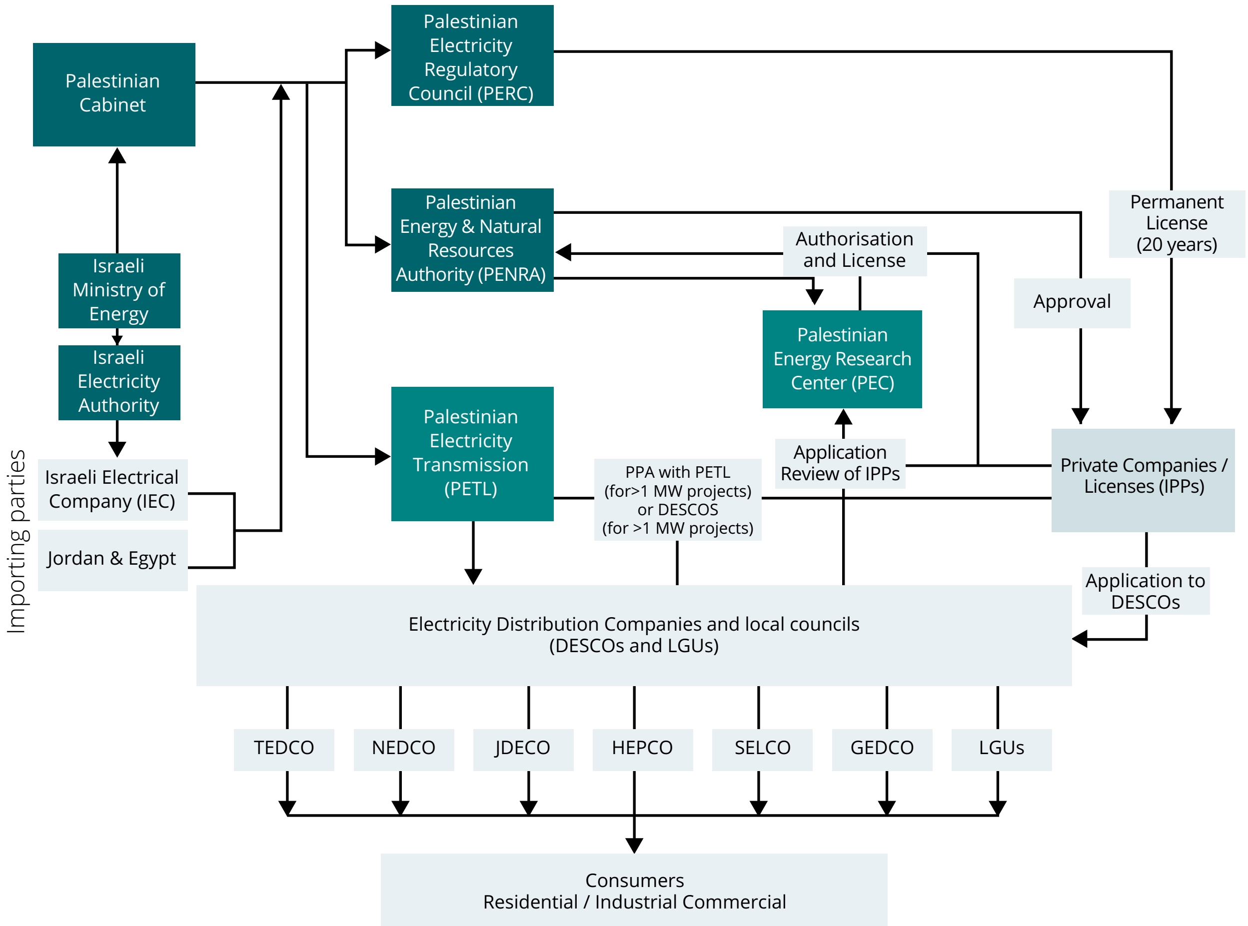
As the PETL distribution grid is connected to the IEC grid, which supplies the Palestinian grid with around 86% of its electricity, Israeli institutions remain involved in the Palestinian electricity sector. On the IEC side, the Israeli Ministry of Energy holds decision-making powers and is responsible for meeting the Israeli renewable energy targets. The share renewable sources in the grid electricity mix are, therefore, highly dependent on the extension of renewables in Israel. The cooperation between the Palestinian Authority and Israel is managed via a coordinating office.

Fig. 4-9 depicts the Palestinian institutional framework of the electricity market and the relevant steps required for granting licences to IPPs.

Palestine has a well-structured institutional setting. The introduction of the Electricity Law in 2009 defined and specified the roles and responsibilities of the public entities, which helped to restructure the whole sector. However, electricity service providers face the challenge of a fragmented distribution network and the dependence on external institutional settings due to the Israeli control, make the sector vulnerable and also inefficient in terms of decision-making. The current state of development and effectiveness of the institutional framework places Palestine at a pre-stage level of the first phase towards a renewables-based energy system according to the MENA phase model.

Fig. 4-9

Electricity Market Structure with Relevant Authorities and Companies



(Source: own creation based on (Khaldi and Sunikka-Blank, 2020; Khatib et al., 2021; meetMED, 2020))

Energy Market and Economy

While having the lowest energy consumption in the MENA region, Palestine has the highest energy costs (Hamed and Peric, 2020). On average, households spend around 8.5% of their income on energy, electricity, and liquid gas (Milhem, o. J.). As most of the energy is imported at high cost, this places a financial burden on people – especially the marginalised.

The residential electricity tariffs depend on the area and the DESCO involved, but they all have a linear structure. This means that the price remains stable for any consumption level (AF-MERCADOS EMI, o. J.). The price per kilowatt hour starts at 0.15 USD, while for electricity from diesel the unit tariff can be as high as 0.35 USD (Hamed and Peric, 2020). Clients from the residential and commercial sectors can choose between a pre-paid or a post-paid tariff (meetMED, 2020). While the pre-paid meter for commercial customers is advantageous, this scheme does not offer the same advantages to households. Other sectors, such as industry, agriculture, and public entities, are only offered a post-paid tariff. Moreover, the tariff adds a fixed charge that can vary between 0-37 USD per installed kilowatt depending on the sector (ibid.). Customers whose energy is supplied via the Jordanian grid usually pay less. The tariffs in Gaza are normally 0.03-0.04 USD per kWh lower than in the West Bank (Juaidi et al., 2016).

In terms of the cost of fuel, Palestine pays a higher consumption price compared to other MENA countries. In 2018, fuels such as gasoline, diesel, LPG, and kerosene cost between 1.57-1.97 USD per litre (Al Qadi et al., 2018). The Palestinian DESCOs usually purchase the power from the IEC at the tariff that applies to Israeli end consumers (meetMED, 2020). On-going negotiations are trying to reach a commercial agreement to lower the wholesale tariff.

The range of problems in the Palestinian energy system negatively affect the social and economic conditions in the territories (Milhem, o. J.). Households are vulnerable to the high price of imports, which limits their ability to afford energy for their daily needs. If the IEC bills are not paid – which often occurs because of the high prices – Israel can cut off the electricity service from its side (Hamed and Peric, 2020). PENRA often provides funds from other services or other local councils to settle household debts. However, this debt structure creates a vicious cycle that affects businesses and the population, as well as negatively impacting the Palestinian economy (ibid.). Palestine is classified at the market level as being in the pre-phase of the renewable energy transition according to the applied phase model.

CO2 Emissions

Rising energy consumption rates in Palestine have inevitably resulted in increased levels of CO2 emissions. In 2009, the CO2 assessment indicated that Palestine emitted approximately 3,500,000 tons of CO2 (PWC, 2012). Of Palestine's total emissions, around 49% came from the household sector. Households also had the largest share of CO2 emissions within the electricity sector, at 66% (Fig. 4-10).

Fig. 4-10

Share of household emissions: a) overall CO2 emissions, b) electricity sector, Palestine 2009

(Source: data based on (PWC, 2012))

The renewable energy strategy as well as the efficiency strategies, NEEAP I, and NEEAP II also all target emissions reduction. For households, in particular, the solar initiative (PSI) pledged to reduce CO2 emissions. The programme estimated that a reduction of 3.12% in CO2 emissions could be achieved if the PSI were successfully rolled out in the residential sector. However, the PSI did not reach the targeted number of households to install solar energy systems on their roofs.

The electricity sector is the main contributor to CO2 emissions in Palestine. The significant use of high-polluting diesel and other fossil fuel-based sources in the power sector are responsible for the electricity sector's large share of domestic CO2 emissions. Added to this, the electricity mix provided by the IEC (which serves most of Palestine's demand) is mainly fossil-fuel-based, with 64% of its energy generated from natural gas power plants (IEA, 2020). Although IEC shifted from other fossil energy sources to natural gas sources over the last decade, which has decreased emissions in the power sector, growing demand has the potential to reverse this effect. And also, the diesel-powered GPP located in Palestine is extremely polluting. This supports Palestine's classification as being in a pre-stage level before phase I in the applied energy transition phase model.

Society

Palestinians in general have a good awareness of solar energy, as it offers an alternative energy source to compensate for the frequent load shedding (Khatib et al., 2021). However, many solar systems were not installed properly. This has damaged the reputation of solar energy. According to Khatib et al. (2021), around 47% of the systems are incorrectly installed, which leads to regular systems failure. The DESCO workforce lacks technical training and standards, and PENRA and PETL lack technical expertise, which causes significant failures in the implementation of solar PV technologies. In the case of NEDCO, this lack of expertise within the institution has led to the rejection of PV projects. TEDCO, on the other hand, licenced too many PV projects; these ultimately had more capacity than the network itself, leading to serious grid instability (Khatib et al., 2021).

There is limited awareness of other renewable energy technologies. Day-to-day use of solar energy makes the technology visible, which has caused it to become accepted in Palestinian society. However, the population is not widely informed about renewable energy laws and regulations, as the information is not well disseminated via the media and is not easily accessible to the public (Assali et al., 2019). In general, environmental topics, global warming, and energy conservation are not part of the school curriculum.

The private sector on the other hand is a strong driver for the implementation of sustainable energies (Hamed and Peric, 2020). Due to the lack of public sector initiatives, the Palestinian Engineering Association, for instance, initiated a collaboration with the Italian Development Cooperation and the Palestinian Green Building Council. This is a good example of the emergence of grassroots movements when public initiatives fail or are simply absent. This is also the reason why the work of non-governmental organisations (NGOs) is crucial for the energy transition in Palestine (ibid.).

Overall, Palestinians have a good awareness of renewables, and they are often seen as the solution for gaining energy independence from Israel (Khatib et al., 2021). However, this knowledge is generally limited to solar energy because this technology is widely used around the West Bank and Gaza. Many initiatives happen at grassroots level in the absence of public initiatives. However, on a technical level, there is still much progress to make: there is a widespread lack of technical professionals and expertise, which creates significant risks and challenges when implementing distributed renewable energy systems. To sum up, Palestine can be classified as being in a pre-stage level in the society dimension of the phase model.

Summary of the Landscape and System Level Developments

The energy sector in Palestine faces many challenges that are driven by political, institutional, societal, and technical circumstances. On a landscape level, the Israeli control of areas in the West Bank prevents the construction of large-scale power facilities and also obstructs the efficient flow of energy across borders. Consequently, Palestine often lacks a reliable and adequate energy supply (Hamed and Peric, 2020) as a direct consequence of the political situation. Furthermore, high fuel prices force the only utility-scale power plant in Palestine, the GPP, to run only at half capacity. The need to import almost all fuel represents a high fiscal burden for local authorities and the high energy prices particularly hit the poorest in the population. Around 10% of household income is spent on electricity, which is one of the highest shares in the MENA region. Moreover, the consequences of the COVID-19 pandemic have negatively affected the Palestinian energy sector and are likely to continue to do so in at least the short term.

On a system level, the geographically fragmented regions of the West Bank and Gaza represent another challenge in terms of energy infrastructure, storage, and distribution that lead to high efficiency losses on both a technical and performance level. Network communications and distribution of loads between the regions is prevented, and necessary maintenance is limited. As a result, the network has high rates of electricity losses, including inefficiencies. Unpaid household bills become a burden for the Palestinian authorities, raising the debt. On an institutional level, the existence of multiple entities that manage and distribute the electricity makes it difficult to control and organise the sector. Many challenges are faced in terms of licensing, approvals, and technical expertise. On the one hand, the hierarchical structure aggravates this issue while, on the other hand, there is a lack of experienced staff with qualifications and expertise. Although most Palestinians are aware of solar energy, there are only limited incentives to strive towards a sustainable lifestyle.

To summarise, Palestine's energy situation can be described as complex and unique. The most relevant aspects are its high dependence on Israel and the associated political risks, the geographically fragmented territories of Gaza and the West Bank, low income levels, an unreliable grid, an array of inefficient institutions, and high electrical losses (meetMED, 2020). In its current state the energy system is lacking the most basic requirements to move towards a high share of renewable energy sources. According to the phase model; therefore, Palestine can be classified as being in a pre-stage level before the take-off phase of renewables.

4.1.2 ASSESSMENT OF TRENDS AND DEVELOPMENTS AT THE NICHE LEVEL

Developments at the niche level within each phase are crucial for reaching the subsequent stages of the energy transition (see Table 3-1). In the following the different activities at the niche level in Palestine are described. Overall, so far only limited progress is made in almost all relevant dimensions: supply, demand, infrastructure, markets and economy, and society.

Renewable Energy Scenarios

A new National Renewable Energy Action Plan (NREAP) until 2030 was prepared in 2021 by the Palestinian Energy together with the Palestinian Energy and Environmental Research Centre.

It will propose two scenarios with the following new renewable energy targets (Khaldi and Sunikka-Blank, 2020; Milhem, o. J.):

1. Scenario 1: 300 MW including only Areas A and B
2. Scenario 2: 500 MW including Areas A, B, and C

The renewable energy targets for 2030 are projected to be met with 80% solar PV, 10% wind energy, and 10% biogas/biomass for both scenarios (ibid.). Therefore, for scenario 2, the technology distribution is: solar PV 300 MW, CSP 100 MW, biogas 80 MW, wind 20 MW. Scenario 1 describes the current political and socio-economic situation of Palestine and assumes that it will remain constant in the future, while scenario 2 describes a future where Palestine is able to make more independent decisions in order to increase diversity in energy resources, suppliers, and routes. Many free surface areas, particularly in Area C of the West Bank, are still controlled by the Israeli authority, which hinders the development of large-scale renewable power utilities. As a result, a high penetration rate of renewables, such as solar PV, solar thermal, or wind energy, remains moderate in scenario 1. Scenario 2 represents a more optimistic situation, where renewables have a much higher penetration rate. Some mountainous zones in Area C are exploited for wind power, with flat zones in Area C used for PV farms. However, both scenarios still foresee a certain dependence on Israel in terms of energy supply and decision-making, meaning that renewable energy deployment and its share in the electricity mix remains dependent on the pace and ambitions of Israel in terms of the decarbonisation of the energy system.

Solar Energy

The most prominent programme under the PIF is the Noor Palestine Solar Programme, which comprises an investment portfolio of 200 million USD. The aim is to install a total of 200 MW PV, consisting of utility-scale PV power parks and rooftop PV power systems (particularly at schools) for grid-connected systems. In the southern West Bank, the Chinese government plans to build a 30 MW solar PV power plant consisting of 3 units, each with a capacity of 10 MW. This will be promoted by a competitive tender (meetMED, 2020). Table 4-5 summarises Palestine's solar energy projects (both proposed and under development).

Table 4-5
Planned Solar Energy Projects in Palestine

Under Development PV Projects	Capacity (MW)	Region
GIE/PADICO	7.3	Gaza
Noor Tubas, PIF	9	Tubas
Kafa'a Co. Solar Project	5	Tubas
Noor Jenin, PIF	3	Jenin
Bani Neim	30.5	Hebron
Askar	1	Nablus
Beit Forik	1	Nablus
Birzeit University	1	Ramallah
Schools Project	35	-
Total	**92.8 MW**	
Proposed PV Projects		
PALTEL	10	Jericho
Jericho development committee	10	Jericho
Czech project No. 1	2	Tubas
Czech project No. 2	2	Tubas
Total	**24 MWp**	

(Source: data based on Khatib et al., 2021)

Energy Efficiency

Similar to NEEAP I, NEEAP II which was announced in 2021 by the Palestinian Energy and Environment Research Centre of PENRA provides a roadmap until 2030 and focuses on energy efficiency in the electricity sector. This is because electricity constitutes the largest share of the final energy mix. NEEAP II focuses on the period between 2020 and 2030. By 2030, the target is to reduce energy consumption by a total of 5,000 GWh, which should result in an annual reduction in CO2 emissions of 3.5 million tons (The World Bank, 2016). In order to achieve this, NEEAP II is divided into three phases, each with a different focus (Khaldi and Sunikka-Blank, 2020; The World Bank, 2016):

1. Phase I (2020-2030): focus on energy savings in appliances, the residential sector, and smart metering;
2. Phase II (2024-2030): focus on energy efficiency in the energy market structure, demand side management, and energy conservation – all with the aim of reducing peak load (kW) and taking into account an increase of intermittent renewables in the energy system;
3. Phase III (2027-2030): focus on achieving energy savings by building smart homes, grid, cities, and optimising direct communications between generation and consumption.

The transformation of the Palestinian energy sector is based on a strategy of increasing the share of renewables in the system and applying energy efficiency measures, but also focuses on a fossil fuel-based infrastructure (Khaldi and Sunikka-Blank, 2020). In particular, natural gas is mentioned as a flexible response to intermittent solar and wind energy. The diversification of energy sources is triggered by the aim of decreasing Palestine's energy dependency on Israeli control and the associated restrictions (ibid.).

Grid Infrastructure

Palestine has signed a comprehensive interconnection agreement involving eight countries to introduce regional projects and initiatives to develop and cooperate in a joint energy market: the EIJLLPST (Egypt, Iraq, Jordan, Libya, Lebanon, Palestine, Syria, and Turkey) interconnection project (ESMAP, 2013). As part of these efforts, this collaboration aims to upgrade the electricity system in all countries involved, and later enable electricity trade between these countries.

PENRA's overall objective is to develop a system that includes power generation facilities in the northern and southern parts of the West Bank, and it is also studying the implementation of a connected transmission system.

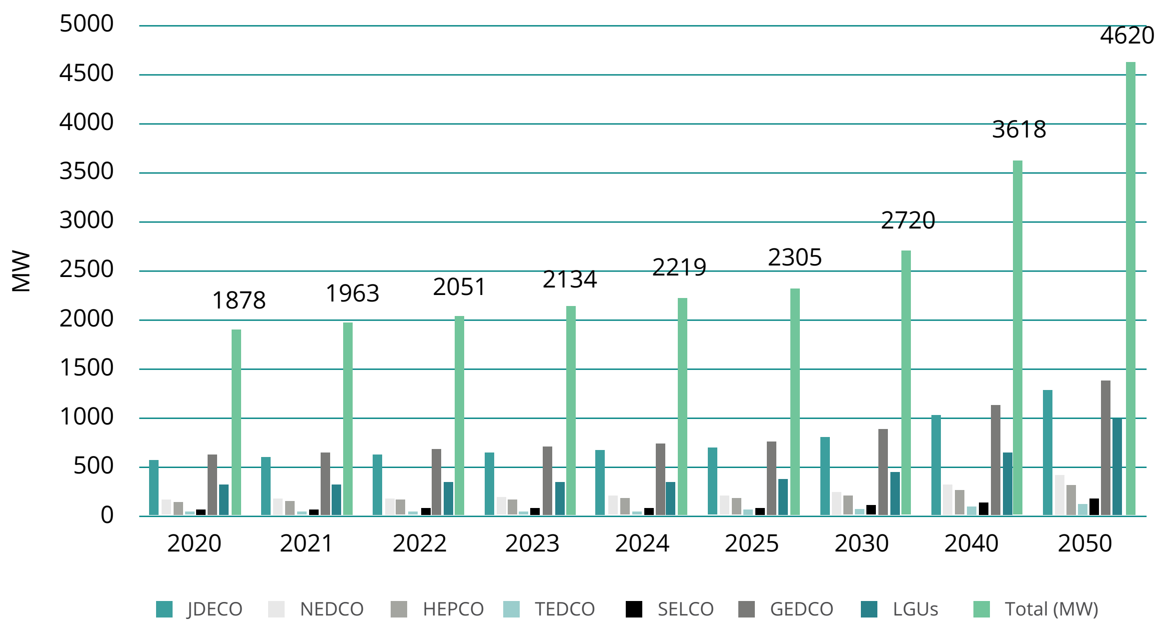
4.1.3 NECESSARY STEPS FOR ACHIEVING THE NEXT PHASE

The analysis shows that Palestine's energy system can be classified as a conventional power system mainly based on oil where the supply assets are used as the main source of flexibility, but it is unable to meet domestic demand. Energy security can therefore be a crucial driver for a transition towards renewables in Palestine (Khaldi and Sunikka-Blank, 2020). Yet, renewable energies still play a minor role in Palestine's energy sector and – according to the MENA phase model – the Palestinian territories still have a long road ahead in terms of transitioning to a renewables-based energy system. However, as preparations should be made long in advance to ensure a smooth transition, it is crucial that action is taken now.

The modelling of the future energy demand of Palestine in frame of this study, has shown that future energy demand will increase due to population growth, increase in industrial activities, and rising living standards. According to the modelling results the peak load demand is foreseen to reach approximately 4,620 MW by 2050 which can be translated to an energy demand of almost 20 TWh (Fig. 4-11 and Fig. 4-14). The required energy supply, hence, including reserves and losses, needs to be around 23 TWh with a required peak load supply of approximately 5,600 MW by 2050 (Fig. 4-12).

Fig. 4-11

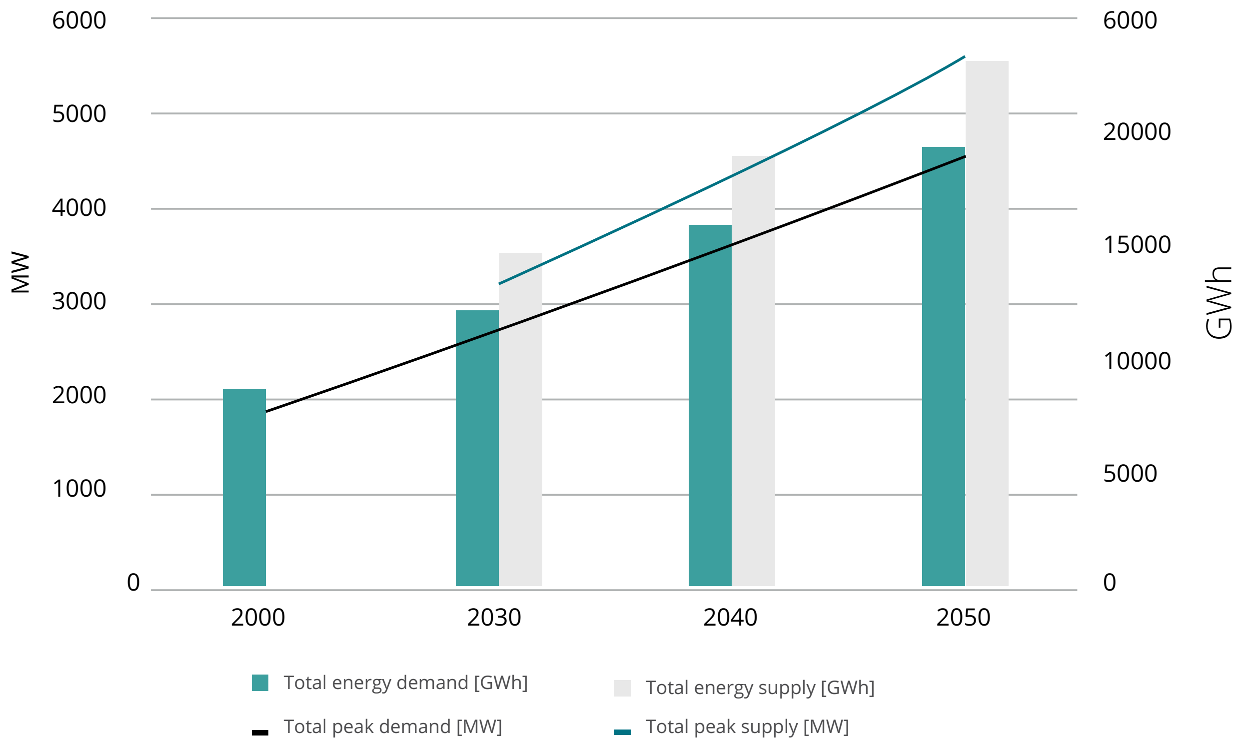
Modelled Expected Cumulated Peak Load Demand for Different DESCOs and LGUs up to 2050



(Source: own calculation with contribution by Palestinian expert Brik)

Fig. 4-12

Modelled Future Energy Supply and Peak Supply for 2030, 2040, 2050



(Source: own calculation with contribution by Palestinian expert Brik)

Developing a transmission grid and enhancing the current distribution network is critical to enable the integration of new capacities – in particular from renewables – and to guarantee the quality of the power supply (meetMED, 2020). The current lack of a proper transmission grid network prevents Palestine from delivering a secure energy supply and increases its dependence on foreign energy. The network needs to be built to allow the full exploration of local energy sources and the ability for regional exchange with neighbouring countries. Furthermore, the existing distribution network needs to be rehabilitated and upgraded to improve the quality of services. Renewables need to be centrally configured, scheduled, and dispatched to optimise the system operation; this falls under congestion management. Additionally, a reserve storage system will be needed to guarantee an uninterrupted peak supply.

To support renewables to take off in Palestine, it is fundamental to provide technical studies with reliable measurements. This includes, for instance, professional grid impact studies. Furthermore, potential assessments for the introduction of biomass energy and wind power are needed. A wind atlas with comprehensive data and measurements would for example allow to better assess the potential of wind energy. Solar energy, which is already widely implemented in Palestine on a small-scale level, will further benefit from the elaboration of technical standards and codes for PV installations. It is also essential to consider storage options to enable the renewables take off in the domestic energy market. Renewables should also be discussed as option to provide based load power, for example from power generation waste and other biomass, hybrid CSP plants with storage systems, or batteries. The potential of these options also needs to be studied. Furthermore, storage options need to be explored, especially against the background of the physically fragmented energy system in the West Bank and Gaza. Equally, small-scale distributed renewable energy systems must also be developed as these are more flexible than utility-scale projects and allow for citizens to participate in the energy transition. All these needed steps should be backed with concrete targets and tracked in order to measure their progress.

A robust regulatory framework is essential to support the upscaling of renewables. This includes policy and regulatory conditions to increase the financial viability of the Palestinian power market. To date, private developers, consumers, and financiers make most of the transition-related energy investments, while the institutions play a minor role. Developing competent and efficient institutions will enable the successful transition to a more open and competitive power market. The relatively high number of actors involved in the public power market in Palestine makes the market complex. The respective roles of the DESCOs and local councils are not clearly defined. To reduce inefficiencies, it is important that institutional responsibilities do not overlap and that each entity has a clearly defined role. The clear distribution of tasks will enhance the sector's performance, reduce losses, and improve the level of energy services provision. Furthermore, institutions need to provide clear and transparent procedures regarding project licensing and complaint procedures. On the implementational level offering capacity building activities and vocational training can help to upskill customer service staff working for the DESCOs and the local councils. Educational tools can be used to train technical staff with the goal of making large-scale renewables deployment possible (PWC, 2012). In addition, training for financiers in the banking sector will raise awareness about potential financing schemes, such as green loans for renewable facilities.

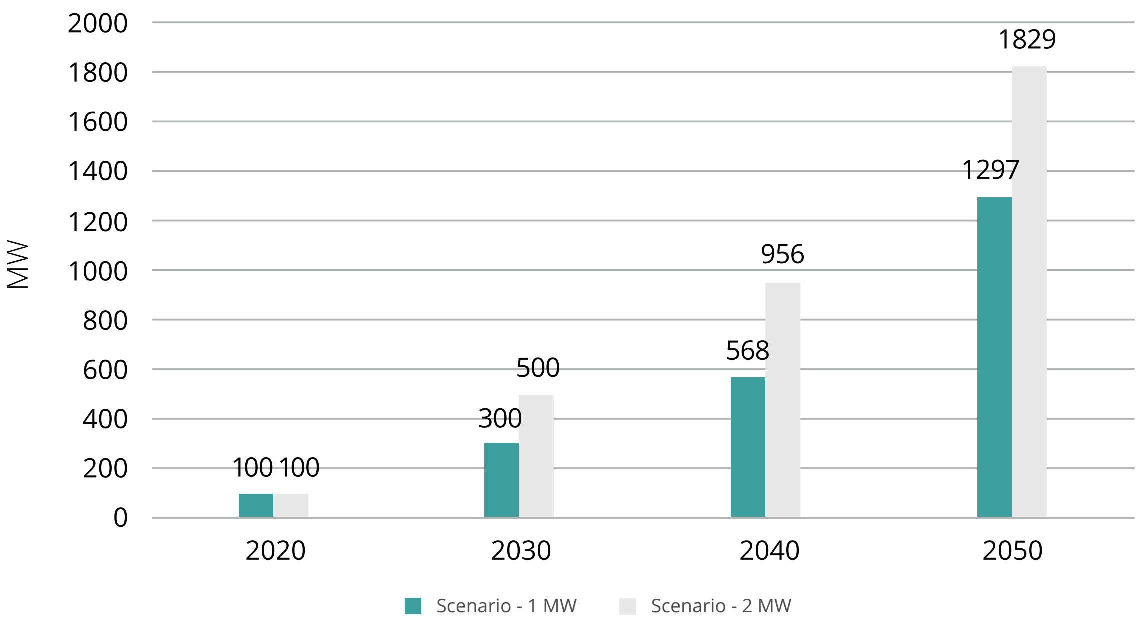
On a societal level, awareness about sustainable issues needs to be increased through workshops, information centres, and the use of mass media (meetMED, 2020). The school curriculum also needs to include topics on environmental issues and renewable energies in order to raise awareness from an early age.

Energy efficiency must remain as a main pillar in the Palestinian energy transition and should be given greater consideration in energy planning. The energy efficiency strategy should include measures with indicators and quantified targets that go beyond the electricity sector. Targets in the buildings, transportation, industrial, and agricultural sectors need to be set in order to achieve holistic efficiency planning.

Developing more ambitious scenarios for the extension of renewable energies could help the process to define concrete targets for renewables but also efficiency measures. The existing scenarios for 2030 in the new renewable energy strategy assume the scaling up of renewables at a gradual pace. This should, on the one hand, allow sufficient time to train technical experts (such experts are currently lacking in Palestine) and gain experience in the field (PWC, 2012). On the other hand, the gradual pace will not result in the full exploitation of Palestine's renewables potential and the associated benefits in terms of energy security for Palestine. Calculations made in the frame of this study, show that the continuation of the existing scenarios until 2050 would result in a renewables use in Palestine between 1.2 GW and 1.8 GW (depending on the option to implement projects in Area C - Scenario 1 without Area C and in Scenario 2 with Area C - and assuming the same growth rate of installed renewables capacity in the two scenarios) (Fig. 4-13). So, with the overall technical potential of renewables currently being estimated to be around 4.2 GW with Area C, the current scenarios are not overly ambitious. More ambitious scenarios – envisioning a situation where Palestine is able to make independent decisions, to increase the diversity of energy resources, suppliers, and routes – should be modelled and used to update the 2030 targets and set long-term targets for 2050. Furthermore, the modelling of scenarios should consider optimal import shares under different generation costs assumptions. This would allow to discuss the trade-offs between the energy security target and the cost of electricity supply. With more ambitious scenarios, important next steps, such as system integration, sector coupling, and the electrification of end-use sectors could also be elaborated in more detail.

Fig. 4-13

Renewable Energy Capacity Development Based on the Continuation of the Scenarios in Palestine's New Renewable Energy Strategy until 2050



(Source: own calculation with contribution by Palestinian expert Imad Brik)

It is essential for Palestine's sustainable energy development pathway to intensify and create new energy partnerships. Regional interconnection with neighbouring countries (Israel, Jordan, and Egypt) is key for enhancing the security of supply and for guaranteeing an uninterrupted energy supply. An ambitious energy diversification strategy can help to reduce the vulnerability of the Palestinian population to outside shocks. In an increasingly globalised world, it will also be vital to build energy partnerships that go beyond the regional scale. To achieve this, a peaceful regional and cooperative climate will be a precondition.

The ambitious deployment of renewable energies will help to increase Palestine's energy security. In terms of domestic politics in Palestine, stakeholders will have to increase their ambitions in terms of making the shift from a conventional power system to a renewables-based system. However, although if relevant stakeholders and the general public support the energy transition, the application of the recommendations will greatly depend on the cooperation with Israel.

4.2 OUTLOOK FOR THE NEXT PHASES OF THE TRANSITION PROCESS

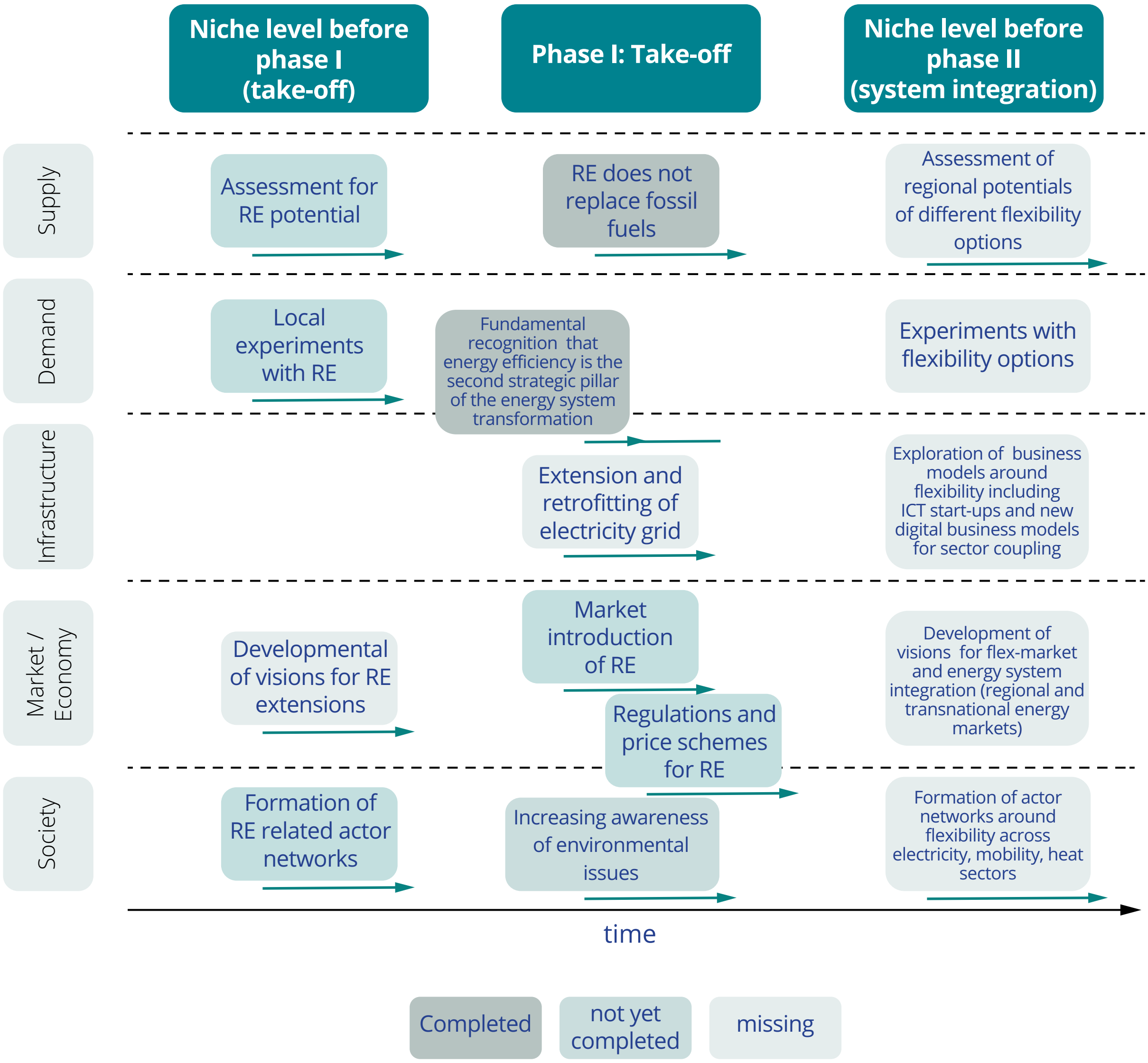
From the analysis, it is evident that access to sustainable renewable energy can be the cornerstone for development and economic growth in Palestine. In contrast to other countries in the MENA region, the value of the energy transition in Palestine goes even beyond economic development and technological change. According to Khaldi and Sunikka-Blank (2020) it represents a pathway for Palestine to become more independent. Solar energy is probably the most promising technology for Palestine. However, Palestine has not yet implemented large-scale PV due to the restricted access to Area C, as it is under Israeli control. To move forward with the energy transition, it will be vital that large-scale solar plants will be allowed to be constructed in Area C. Until this will become a possibility, Palestine should take an iterative approach to prepare the institutional and regulatory structures to facilitate the upscaling of solar energy. Starting with the implementation of measures to facilitate the implementation and maintenance of small-scale solar systems in Area A and B. But it is important to note that even if Palestine will be able to exploit all its renewables potential including area C, based on current potential assessments and demand scenarios it will still be unable to generate sufficient electricity to meet the entire domestic demand. Accordingly, Palestine will still be obliged to import energy. Therefore, Palestine is well advised to act now to strengthen existing and developing additional energy partnerships.

It is clear that the future development of the renewable energy sector in Palestine will be strongly linked to the development of the Palestinian-Israeli conflict as well as the political interference by external powers, and disagreements about the future shape of the Palestinian Territories. Next to the conflict in this resource-scarce region, the modern-day challenges of a growing young population will present further challenges for the energy sector. Renewable energy can help to address these challenges by providing clean and reliable electricity but also opportunities for economic development and job creation.

The phase model could be the starting point for the discussion and development of such a long-term strategy, taking into account the entire energy system and its transition to a fully renewable energy-based system. Fig. 4 -14 summarises Palestine's current status in the energy system transition and provides an outlook for the following steps.

Fig. 4-14

Overview of Palestine's Status in the Energy System Transition Model



5

CONCLUSIONS AND OUTLOOK

A clear understanding and a structured vision are prerequisites for fostering and steering the transition towards a fully renewables-based energy system. The MENA phase model was adapted to the country case of Palestine 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, characteristics of the MENA region, and the specific Palestine 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 Palestine 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 analysis has shown that the adoption of renewable energies, particularly solar energy, is driven by the need to enhance energy security. Palestine has set itself targets to increase its renewable energy share in the overall energy mix. Although Palestine has developed a comprehensive renewable energy and energy efficiency strategy, regulatory support for renewable energies and financial incentives have so far been somewhat limited and vague. Accordingly, fossil fuels, especially oil and diesel, continue to play the main role in Palestine's energy sector today. Thus, setting and implementing more ambitious targets is necessary to get the energy transition underway at all levels.

Converting Palestine's energy supply to a system based on 100% renewable energy offers a long-term opportunity for economic and social development, while reducing energy dependence on Israel and the fiscal burden of high-priced fossil fuel imports. Switching to renewable energy could therefore help ensure a cost-effective energy supply, avoid oil and gas price shocks and reduce imports. The successful transition will largely depend on available institutional funding, but also on private sector participation. However, a prerequisite for implementation is a supportive political climate between Palestine and Israel.

BIBLIOGRAPHY

AF-MERCADOS EMI. (o.J.). Task I Report: Assessment of Renewable Energy Sources Final Report.

Al Qadi, S., Sodagar, B., & Elnokaly, A. (2018). Estimating the heating energy consump-tion of the residential buildings in Hebron, Palestine. Journal of Cleaner Production, 196, 1292–1305. https://doi.org/10.1016/j.jclepro.2018.06.059

Assali, A., Khatib, T., & Najjar, A. (2019). Renewable energy awareness among future generation of Palestine. Renewable Energy, 136, 254–263. https://doi.org/10.1016/j.renene.2019.01.007

BP. (2019). BP Energy Outlook – 2019 edition. https://www.bp.com/energyoutlook

Energydata. (2017). Datasets—ENERGYDATA. INFO. https://energydata.info/dataset

ESMAP. (2013). Middle East and North Africa—Integration of Electricity Networks in the Arab World.

Fischedick, M., Holtz, G., Fink, T., Amroune, S., & Wehinger, F. (2020). A phase model for the low-carbon transformation of energy systems in the MENA region. Energy Transiti-ons. https://doi.org/10.1007/s41825-020-00027-w

Fischedick, M., Samadi, S., Hoffmann, C., Henning, H.-M., Pregger, T., Leprich, U., & Schmidt, M. (2014). Phasen der Energisystemtransformation (FVEE - Themen). FVEE.

Geels, F. W. (2012). A socio-technical analysis of low-carbon transitions: Introducing the multi-level perspective into transport studies. Journal of Transport Geography, 24, 471–482. https://doi.org/10.1016/j.jtrangeo.2012.01.021

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. Rese-arch Policy, 36(3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003

Hamed, T. A., & Peric, K. (2020). The role of renewable energy resources in alleviating energy poverty in Palestine. Renewable Energy Focus, 35, 97–107. https://doi.org/10.1016/j.ref.2020.09.006

Henning, H.-M., Palzer, A., Pape, C., Borggrefe, F., Jachmann, H., & Fischedick, M. (2015). Phasen der Transformation des Energiesystems. Energiewirtschaftliche Tages-fragen, 65(Heft 1/2).

Holtz, G., Fink, T., Amroune, S., & Fischedick, M. (2018). Development of a Phase Model for Categorizing and Supporting the Sustainable Transformation of Energy Systems in the MENA Region. Wuppertal Institut für Klima, Umwelt, Energie.

IEA. (2020). Data and statistics. https://www.iea.org/countries

Juaidi, A., Montoya, F. G., Ibrik, I. H., & Manzano-Agugliaro, F. (2016). An overview of renewable energy potential in Palestine. Renewable and Sustainable Energy Reviews, 65, 943–960. https://doi.org/10.1016/j.rser.2016.07.052

Khaldi, Y. M., & Sunikka-Blank, M. (2020). Governing renewable energy transition in con-flict contexts: Investigating the institutional context in Palestine. Energy Transitions, 4(1), 69–90. https://doi.org/10.1007/s41825-020-00024-z

Khatib, T., Bazyan, A., Assi, H., & Malhis, S. (2021). Palestine Energy Policy for Photo-voltaic Generation: Current Status and What Should Be Next? Sustainability, 13(5), 2996. https://doi.org/10.3390/su13052996

meetMED. (2020). Country Report on Energy Efficiency and Renewable Energy Invest-ment Climate - Palestinian Territories. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi5wJvzh73yAhVjh_0HHc9hCJgQFnoECAQQAQ&url=https%3A%2F%2Fwww.rcreee.org%2Fsites%2Fdefault%2Ffiles%2Fa31_palestineclimate_final.pdf&usg=AOvVaw0alXd7BB2jamtWykmbVnGG

Milhem, H. E. Z. (o. J.). Paving the Way for a Renewable Energy Future in Palestine. This Week in Palestine. Abgerufen 12. August 2021, von https://thisweekinpalestine.com/paving-the-way-for-a-renewable-energy-future-in-palestine/

Mohammed Bouznit, María del P. Pablo-Romero, & Antonio Sánchez-Braza. (2020). Measures to Promote Renewable Energy for Electricity Generation in Algeria. Sustainabi-lity, 12(4), 1468. https://doi.org/10.3390/su12041468

Monna, S., Juaidi, A., Abdallah, R., & Itma, M. (2020). A Comparative Assessment for the Potential Energy Production from PV Installation on Residential Buildings. Sustainability, 12(24), 10344. https://doi.org/10.3390/su122410344

Nassar, Y. F., & Yassin Alsadi, S. (2019). Assessment of solar energy potential in Gaza Strip-Palestine. Sustainable Energy Technologies and Assessments, 31, 318–328. https://doi.org/10.1016/j.seta.2018.12.010

PENRA. (2016). The Comprehensive National Strategy of Energy Sector in Palestine (2017-2022).

PWC. (2012). Palestine Solar Initiative.

The World Bank. (2013). Integration of Electricity Networks in the Arab World – Regio-nal Market Structure and Design (Report No: ACS7124). The World Bank. http://documents.worldbank.org/curated/en/415281468059650302/pdf/ACS7124 0ESW0WH0I0and0II000Final0PDF.pdf

The World Bank. (2016). West Bank & Gaza Energy Efficiency Action Plan 2020-2030. World Bank.

The World Bank. (2019). Electric power transmission and distribution losses (% of output). https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS

Weber, K. M., & Rohracher, H. (2012). Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive 'failures' framework. Research Policy, 41(6), 1037–1047.

LIST OF ABBREVIATIONS

CCS	Carbon capture and storage
CCU	Carbon capture and use
CNG	Compressed natural gas
COVID-19	Coronavirus disease 2019
CSP	Concentrated solar power
DESCO	Distributed Electricity Service Company
EIJLLPST	Egypt, Iraq, Jordan, Libya, Lebanon, Palestine, Syria, and Turkey interconnection project
EU	European Union
EV	Electrical vehicle
FiT	Feed-in tariff
GDP	Gross Domestic Product
GEDCO	Gaza Electricity Distribution Company
GHG	Greenhouse gas
GPP	Gaza Power Plant
HEDCO	Hebron Electric Power Co.
ICT	Information and communication technologies
IEC	Israeli Electricity Corporation
IPP	Independent Power Producer
JDECO	Jerusalem District Electricity Company
LGU	Local Government Units
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MENA	Middle East and North Africa
MLP	Multi-level perspective
MoU	Memorandum of Understanding
NDC	Nationally Determined Contributions
NEEAP	National Energy Efficiency Action Plan
NEDCO	Northern Electricity Distribution Company
NGO	Non-governmental organisation
NREAP	National Renewable Energy Action Plan
PA	Palestinian Authority
PEC	Palestinian Energy and Environment Research Centre
PENRA	Palestinian Energy and Natural Resources Authority
PERC	Palestinian Electricity Regulatory Council
PETL	Palestinian Electricity Transmission Company
PIF	Palestinian Investment Fund
PPA	Power Purchase Agreement
PSI	Palestinian Solar Initiative
PtF	Power-to-fuel
PtG	Power-to-gas
PtX	Power-to-X
PV	Photovoltaic
R&D	Research & Development
RE	Renewable Energy
RE	Renewable Energy
SELCO	Southern Electricity Co.
TEDCO	Tubas District Electricity Company
USD	US-Dollar

LIST OF UNITS AND SYMBOLS

%	Percent
CO2	Carbon dioxide
GW	Gigawatt
GWh	Gigawatt hour
kgoe	Kilogramme of oil equivalent
ktoe	Kilotonne of oil equivalent
kV	Kilo Volt
kW	Kilowatt
kWh	Kilowatt hour
m3	Cubic Metre
m/s	Metre per second
Mt	Megatonne
Mtoe	Millions of tonnes of oil equivalent
MVA	Megavolt-ampere
TW	Terrawatt

LIST OF TABLES

LIST OF FIGURES

ABOUT THE AUTHORS

Sibel Raquel Ersoy (MSc) has worked as a junior researcher in the "International Energy Transitions" research unit 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.

Experts consulted in Palestine:

Dr. Imad Brik has a doctorate degree of electrical engineering from Vinnitsa State Technical University in Ukraine, with a specialization in power system engineering and planning. Dr. Imad Ibrik is currently an associate professor at An-Najah National University in Nablus, Palestine, as well as a consultant. Dr. Imad Brik is an expert in the area of Energy Efficiency and Renewable Energy. He managed and conducted several projects in these fields, and conducted training programmes for the energy efficiency and renewable energy applications, and has over 20 years of experience in various areas of power system engineering and its subsectors: design of electrical part stations and substations, electrical installation, energy management, economics of energy, solar and wind sources and energy audits.

ABOUT THE STUDY

This study has been 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 the current state of the energy transition processes in the respective countries. It also offers key learning points for the whole region based on findings across the analysed countries. This aligns with FES's strategy of bringing together government representatives and 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.

IMPRINT

Friedrich-Ebert-Stiftung | Palestine Office
P.O. Box 25126 | Mount of Olives St. 27 | 91251 Jerusalem

https://palestine.fes.de/

To order publications: info@fespal.org

ISBN
978-965-598-084

9 789655 980844

SUSTAINABLE TRANSFORMATION OF PALESTINE'S ENERGY SYSTEM DEVELOPMENT OF A PHASE MODEL

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 case of Palestine. It is designed to support the strategy development and governance of the energy transition and to serve as a guide for decision-makers.

The transition towards renewable energies is still at a very early stage in Palestine. The long-standing political conflict between Palestine and Israel has prevented the large-scale deployment of renewable energy due to land restrictions. Palestine's political instability, its geographically fragmented territories, and its high dependence on Israel's imports are the most pressing concerns for Palestine's electricity sector. At the operational level, particularly the transmission and distribution infrastructure need to be better interconnected, renewed and expanded to accommodate larger volumes of renewable electricity and at the same time improve efficiency.

The modelled demand development shows that Palestine will most likely have to continue importing electricity even if the potential of renewable energy is fully exploited. This underlines the importance of sustainable energy partnerships for Palestine. The results of the analysis along the transition phase model towards 100% renewable energy are intended to stimulate and support the discussion on Palestine's future energy system by providing an overarching guiding vision for the energy transition and the development of appropriate policies.

FRIEDRICH EBERT STIFTUNG