المجلس الوطني للتطوير الاقتصادي و الاجتماعي

National Economic & Social Development Board

Executive Summary

The National Strategy of Sustainable Energy 2023- 2035

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This work aims to formulate the National Sustainable Energy Strategy until 2035 by analyzing and evaluating the expected trajectory of the energy system as part of the comprehensive development process of the Libyan state in accordance with the goals of the 2030 UN Sustainable Development Goals, particularly Goal 7 related to sustainability of energy systems. According to this methodology, achieving a sustainable energy strategy requires enabling everyone to have easy access to modern, reliable, and sustainable energy according to three goals, which include:

1. Easy and reliable access to modern energy services for all segments of society.
2. Increasing the contribution of renewable energy in the energy mix significantly.
3. Adopting effective measures to rationalize energy consumption and improve its efficiency.

This integrated view of sustainable development has positive implications in the economic, social, environmental, and institutional dimensions of the country. In the economic dimension, this development path will help stimulate economic growth in various productive sectors, particularly in industrial development, attracting investments, enhancing productivity, and creating new job opportunities, which will in turn alleviate poverty and improve housing facilities, and enhance access to desired social welfare. In the environmental dimension, it will effectively contribute to reducing the impacts of pollution resulting from the energy production and consumption chain and its direct effects on health and public facilities.

The large reserves of fossil and renewable energy owned by Libya represent an important support in achieving a balanced gradual transition in energy systems through conscious management of these resources, ensuring the continued contribution of the energy sector to supporting the state's economy. Additionally, the adoption of this strategy will enhance the concept of energy security both nationally and regionally by developing interconnected networks of electricity, natural gas, and hydrogen, both green and blue types, among Arab countries, gradually extending towards Europe and Africa. This expanding direction will contribute to supporting Libya's position in the future energy market due to its wealth in energy resources and possession of advanced infrastructure in the energy sector, which will have a decisive impact on supporting the future development of the national economy.

1) General Overview

The rapid economic and population growth in Libya has revitalized the energy market in recent years. With expectations of continued growth and expansion in investment in reconstruction, manufacturing, and rising living standards, the demand for energy is expected to continue to increase in the coming decades. Ensuring sufficient and affordable energy supply is pivotal in improving living standards, boosting the economy, and maintaining political stability in a region that is currently more fragile than it was in the past decade.

Providing energy to meet demand has become increasingly inadequate in Libya; there is an urgent need for planning for an advanced and efficient energy system capable of meeting increasing needs appropriately and accurately. However, the solution is neither direct nor easy; planning an energy system, given its complexity, is one of the most challenging issues facing the electricity industry today. Generally, power plants require long construction periods and have relatively long economic and technical lifecycles. Therefore, long-term planning at the national level is necessary to ensure a steady energy supply. Furthermore, the continuously increasing energy requirements, coupled with the limited availability of fossil fuels at times and their environmental impact due to carbon dioxide emissions, require new concepts for future energy planning systems. Integrating renewable energy sources and adopting energy efficiency policies in energy system planning leads to reducing the demand for fossil fuels and thus reducing costs and making the system environmentally friendly. The benefits already observed and the global cost reductions in renewable energy have prompted most countries worldwide to implement energy efficiency measures and integrate renewable energy sources into their energy mix. A hybrid energy system combining traditional and a significant portion of renewable energy technologies requires more complex planning and control methods.

It is evident that planning energy systems in developing countries poses a significant challenge due to the lack of various required data. Moreover, the inability to predict variables such as energy demand, fuel prices, and additional development

of renewable technology affects planning outcomes over a longer period. Therefore, all these aspects must be considered when preparing a long-term master plan for the energy system.

Over the next decade, every aspect of the national energy system will be affected by changes in climate and energy policy, financing, continuing technical advances, and shifts in energy supply and demand. The rapid decline in the costs of renewable energy technologies has opened up possibilities that were not previously available to all countries of the world, rich and poor. However, the energy transition needs to be significantly accelerated, initiated and scaled up to achieve SDG 7 and align with the goals of the Paris Agreement on climate change, while simultaneously achieving implementation of the 2030 Agenda for Sustainable Development.

The observed continuous and dramatic decline in the cost of electricity generated by ground-based solar PV plants is one of the most compelling factors in the development of the power generation sector over the past decade. Since 2010, the photovoltaic solar energy industry has witnessed various technological advancements that have contributed to improving the competitiveness of the technology. These developments have occurred along the entire photovoltaic solar energy value chain, with the costs of photovoltaic solar energy units and other device components decreasing rapidly, leading to the emergence of new photovoltaic solar energy markets worldwide. Between 2010 and 2021, the levelized cost of electricity generated from photovoltaic solar energy projects decreased from about 0.417 US dollars in 2010 to 0.048 US dollars in 2021.

Global attention to reducing greenhouse gas emissions, particularly carbon dioxide and methane emissions, is increasing, as evidenced by the unprecedented Paris Agreement in December 2015, ratified by 196 delegates from around the world, known as COP 21. The goal was to take measures to limit the average increase in Earth's temperature to no more than two degrees Celsius above pre-industrial levels, with the aim of striving for 1.5 degrees Celsius if possible.

Finally, energy transition can no longer be limited to gradual steps but must become a transformative effort, a systemic reform based on rapid advancement and the application of all available innovations in the future. This is the appropriate moment to reassess long-term assumptions, perceived barriers, and past decisions. The national economy must be strengthened for more sustainable growth. There is a need for ambitious and purposeful measures now and throughout the coming decades to achieve the seventh goal of the Sustainable Development Goals and achieve a decarbonized energy system by 2050, including, for example:

- The necessity of developing a national plan that comprehensively studies energy sources and their potential integration.
- The need to engage in alternative energy technologies as dictated by reality and to keep up with advanced technologies globally, which will become a reality and a necessity in the future, in addition to being environmentally friendly. This is one of the foundations upon which this energy is built, regardless of the cheapness of traditional energies that rely on fuel and gas. This energy is not an alternative to traditional energy, but supportive of it.
- Maximizing the use of energy efficiency systems, whether lighting systems or household electrical appliances.
- Establishing foundations to increase awareness of energy conservation in all government facilities.
- Energy consumption rationalization is one of the most important pillars for addressing the electricity crisis, and restructuring prices will achieve that.

A national strategy for renewable energies has been developed, including several axes outlined in the following sections.

2) Project Goals

The National Strategy for Sustainable Energy aims to review the available options for the future development of the electricity and renewable energy sectors, as well as energy efficiency, within a comprehensive view of the energy mix contributing to achieving sustainable development in its holistic concept. This includes:

preserving the status of Libya in the global energy market.

Integrating the two elements of renewable energy and energy effeciency in planning for the energy sector from an integrated prespective.

ensuring the continuity of contribution of the energy sector in the GDP through preserving resources and reserves and reducing the imports.

working to keep the energy sector a key provider of national encome rather than becoming an obstical and a consumer of other income resources.

increasing direct and indirect job oppertunities secured by sustainable energy sector.

increasing the contribution of national economy in facing the acute changes in the global energy map.

The strategy will be designed according to the following key principles:

1. Sustainability of the energy sector in Libya.
2. Renewable energy and energy efficiency are integral elements of a sustainable energy system.
3. Energy plays a pivotal role in achieving peace, economic development, and social welfare.
4. Ensuring continuous access to modern energy services for every citizen at affordable prices.

To achieve the above-mentioned principles, the National Strategy for Sustainable Energy explores the following axes:

1. Analyzing the energy sector from economic, social, and environmental perspectives and the importance of renewable energy and energy efficiency elements in the future energy mix, in line with the direction to establish a common Arab electricity market
2. Studying options and mechanisms to increase the share of renewable energy in the energy mix.
3. Enhancing energy efficiency in energy production, transmission, conversion, distribution, and consumption systems.
4. Working to reduce the growth intensity of electricity consumption.

Studying the economic, social, and environmental impacts of the energy sector's development trajectory and integrating renewable energy and energy efficiency, including reducing unemployment and increasing employment opportunities.

3) Project Partners

1. National Council for Economic and Social Development.
2. General Electricity Company.
3. Ministry of Planning.
4. Renewable Energy Authority.
5. Tripoli University.

4) Project Outputs

Most of the studies and reports prepared previously were collected, including those prepared by consulting companies and studies funded by regional and international institutions. The team focused on studying and analyzing this data during its regular meetings, drawing conclusions, and outlining strategies for each axis for the period (2023-2035). Additionally, proposals were made regarding institutional reform to support the effective management and regulation of maximizing the use of produced electricity and renewable energies, and localization of energy efficiency programs. The team also emphasized the importance of focusing on energy economics in all stages of strategy development, human development, and community awareness in these areas and their role in achieving the objectives of these strategies.

A unified report titled "National Strategy for Sustainable Energy 2035" was prepared, covering 177 pages, addressing the following main axes:

Electric power axis.

Renewable energy axis.

Energy efficiency axis.

Green hydrogen.

Arab electrical interconnection and the common Arab electricity market.

Laws and regulations.

The executive regulations for renewable energies (Renewable Energy Law) and the Public Utilities Regulatory Authority have also been prepared. It is a body concerned with regulating the electricity, renewable energy, gas, communications, information technology, digitization, water and sanitation sectors in Libya, and ensuring service provision with the best standards in terms of quality, efficiency and reliability. The Authority also works to protect these services from economic changes so that they always remain a foundation for the growth of the national economy.

5) The most important data/statistics

Since its assignment, the team has held periodic meetings, one meeting every week, where the work was divided into a number of stages, namely:

- The stage of collecting data from all relevant sectors
- The stage of preparing a report on the current status of the electric energy sector, renewable energies, energy efficiency, and electrical interconnection.
- The stage of analyzing data and preparing different strategies for different sectors.
- Preparing the final report.
- Preparing an executive summary of the final report.

The first phase of the team; Agreeing on the basic elements of the work, which were as follows:

• Electrical power axis.

• Renewable energy axis.

- Energy efficiency axis.
- Green hydrogen
- Arab electrical interconnection and the Arab common market for electricity.
- Rules and regulations.

Members of the team were tasked with gathering the necessary information and data for each axis to complete the work.
The following data is targeted for each axis:
Electricity Axis:
Information on the history of the energy sector in Libya.
Previous studies and energy demand statistics.
Vision of the General Electricity Company to meet energy needs.
Administrative structure of the electricity sector in Libya.
Renewable Energy Axis:
History of renewable energy activity in Libya and related studies.
Regional and global developments in the field.
Available potentials for this activity.
Administrative structure of renewable energy activity in Libya.
Energy Efficiency Axis:
Previous measures taken regarding energy efficiency.
Experiences of advanced countries in the field.
Role of the electricity production sector and other sectors.
Setting targets for energy efficiency programs, including awareness and training.
Green Hydrogen Axis.
Arab Electricity Interconnection and the Common Arab Electricity Marke
i. Study of expectations of demand for electrical energy:

Forecasting the demand for electrical energy and hence the total power generation capacity to be installed is a major problem, mainly due to two factors – Firstly, it is the responsibility of any government to provide sufficient energy to meet its requirements in order to stimulate the entire economic sector, where forecasting of demand for electrical energy helps In the long term, it will determine the capabilities needed to generate energy in the future, and secondly, because it is an area where many private sector developers, both local and international, are interested in making investments away from public sector investments, especially in the renewable energies sector.

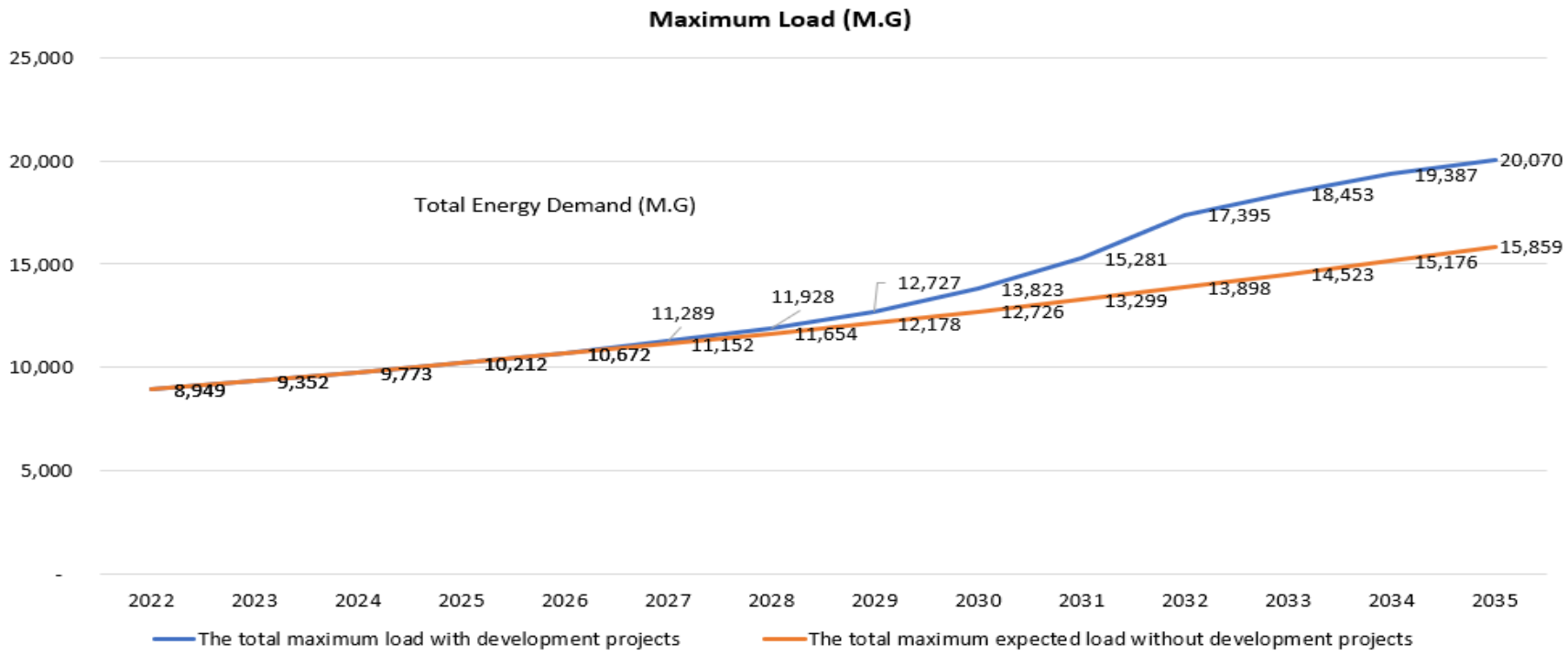
As demand for electricity increases, the associated uncertainties are also rising. Therefore, deeper insight into load forecasting techniques to anticipate future electricity demand becomes essential for electricity companies and policy makers. Electricity demand is subject to a set of different variables or “determinants of electricity demand.” These demand determinants depend on forecast horizons (long, medium and short term), level of load aggregation, climate, and social and economic activities. Therefore, forecasting electricity demand is a complex task that involves analyzing many system variables, which must be taken into account when making decisions to expand capacity. This analysis is performed using economic data with forecasts on demographic, economic and industrial development, so that forecasts on demand are more reliable. These expectations must also be based on historical data, including a review of all previous studies and knowledge of the foundations on which they were built, the levels of electricity supply, studies related to electricity generation, transmission and distribution systems, and the resources available for electricity generation. In this regard. The General Electricity Company is responsible for data collection, analysis, and future planning for the electric power sector in Libya, through the General Administration of Planning.

Total electricity demand in Libya was growing by 8% per year before 2011. After the revolution in 2011, the pace of demand growth slowed significantly. However, electricity demand continued to grow by about 4% per year, with a total of about 550 megawatts per year on average over the course of the last ten years.

After reviewing the available data, the year 2021/2022 was chosen as a base year to study the development of electricity demand in the medium to long term, where two scenarios were studied: business as usual with a growth rate of about 4% (in this study a growth rate is chosen based on growth rates in the past decade and anticipated future), and a high economic growth scenario. As mentioned earlier, the total population growth in the two cases was assumed to be the same. Additional analysis was conducted considering that there are a number of sustainable energy policies to be adopted such as renewable energy laws and energy efficiency measures; For example, considering replacing 60% of incandescent lamps with energy-saving LED lamps, replacing street lighting lamps with energy-efficient lamps by 2035, etc. A planning period of 13 years has been taken into account, giving electricity demand forecasts for the period 2023-2035.

The Strategy Preparation Committee worked on preparing a study of expectations for demand for electric power and future loads, and then studying the expansion of electric power generation projects and the expansion of conversion stations and transmission lines. Figure 1 shows electricity demand forecasts for the period 2023-2035.

Projections of energy demand growth and peak demand up to 2035 are prepared across two scenarios - the first scenario represents demand growth without large development projects, while the second scenario (high case) represents higher demand growth in a situation where political stability allows for the rapid development of large projects that will lead to Rapidly increasing demand for electricity. In the second scenario, it was assumed that large development and investment projects would begin in 2027. The demand for electrical energy would rise from 11,289 megawatts in 2027 to reach 20,070 in 2035.



According to the low forecast, electricity demand will reach 15,859 MW by 2035, while it will reach 20,070 MW under the high forecast. The demand for electricity is increasing more rapidly, so that the demand in 2035 will be approximately double the demand in 2025.

ii. Generation development plans in Libya

Based on a study and analysis of the current situation with regard to available generation capacities and daily consumption requirements, and based on a group of related studies that were previously conducted in particular in order to determine the features of the required future generation projects in order to achieve a balance between demand and availability, which are mainly represented in:

- Study of the development of demand for electrical energy for the period 2001-2010 and the period 2011-2022
- Study of load forecasts and expansion of production, prepared by the South Korea Electricity Corporation (KEPKO).
- World Bank study

Taking into account the following factors:

- Calculating the capacities required for programmed development projects.
- Considering an operational reserve of 20% to ensure operational safety and service stability.
- All high-voltage network equipment must be completed and in operation.
- Calculating the expected lifespan of each operating generating unit to determine when it will be out of service.

Estimates of the loads required to be available and the energy needed during the period between 2023-2035 have been determined by the committee and the General Electricity Company.

The expected capabilities of all currently existing units have been estimated (taking into account the impact of their lifespan on their availability and efficiency), with the need to note that the availability of these capabilities requires that they be subject to the required periodic maintenance procedures and proper operation.

In order to prepare a balance between demand and available capabilities, it was necessary to include the expected capabilities of the contracted projects, whether those that had begun to be implemented but were halted due to the circumstances the country is going through, or those that had not begun to be implemented to date. Table (1) shows a summary of the estimated total capacities that will be available after the completion of the new projects, with a statement

of the shortfall in meeting consumption requirements, while Table (2) shows a summary of the estimated total capacities of traditional and renewable energy plants.

Based on the data presented in the section on load forecasting data, Table 5.3 provides an overview of the generation status versus the forecast load. It is clear from Table No. (5.3) that the deficit in providing electrical energy requirements will continue to increase until it reaches about 13,000 megawatts in 2035, even if the implementation of the contracted projects is completed. Taking into account that the time frame required to implement generation projects (especially steam ones) is relatively long, it is necessary to begin putting the features of the plan into practice.

To help determine the financial estimates for implementing these projects, we relied on the cost of the company's previous projects and the currently prevailing global cost rates, as the estimated budget for these projects is estimated at $13 billion distributed over the coming years until 2035.

Figure (2) shows a comparison between the installed and available generation capacities and those planned to be installed to cover loads until the year 2035. The amount of new planned capacities is 19,110 megawatts, and the amount of out-of-service and unavailable capacities is 6,142 megawatts. Net capacity (final capacity 2035) is calculated as the difference between existing and new capacities taking into consideration decommissioned and unavailable capacities. On this basis, it is estimated that the total nominal capacity in 2035 will reach 26,227 megawatts.

iii. Institutional organization of the electricity sector in Libya

Many countries have begun implementing reforms in the electricity sector to achieve better performance. These reforms typically included institutionalization, where state-owned enterprises were re-established as commercial companies, and in some cases, these companies also underwent full or partial privatization, with ownership transferred from the government to the private sector, to increase access to finance and expertise, improve management and introduce business discipline.

As part of this wave of reforms, many governments have also begun to restructure the energy market, including unbundling vertically integrated utilities. Vertical unbundling can include allocating responsibilities for electricity generation, transmission and distribution to non-governmental entities that operate independently. Each sector of the value chain can also be subject to horizontal unbundling that leads to competition through the creation of multiple entities that may be responsible for providing services in the same sector. Vertical unbundling is the first degree of unbundling, horizontal unbundling is the second degree, followed finally by competition.

- The General Electricity Company has the main responsibility over the electricity sector in Libya. It supervises the entire electricity sector and is responsible for developing and implementing electrical energy policies and strategies and ensuring national electrical energy security. Due to increased awareness of the importance of renewable energy in Libya, the Executive Authority for Renewable Energy was established to promote the deployment of renewable energy in the country.
- The value chain of the electricity sector consists of three sectors: Generation consists of power plants, which are transmitted over long distances at high and medium voltages through the transmission network before entering the distribution system to deliver energy to consumers. As for the General Electricity Company, it is responsible for generation, transmission and distribution through one vertically integrated facility responsible for all sectors of the electricity value chain (Figure 3).
- The company is currently carrying out all operations; of producing, transmitting and distributing electricity through a huge and complex network, which requires advanced and specialized management, in addition to the fact that the size of the General Electricity Company has greatly increased over the past years, which has led to difficulties, leading to facing difficulties managing it according to the current government administrative system.
- The electricity sector in Libya is not yet subject to an electricity law since the establishment of the General Electricity Company under Law No. 17 of 1984, due to the fact that an electricity law has not been adopted until this moment. A draft electricity law was prepared by the Board of Directors of the General Electricity Company and reviewed by several committees and advisors. The proposed draft electricity law envisages the complete restructuring of the electricity sector over different time frames. The legal framework is generally open to private sector participation in the areas of generation and distribution and third party access to the transmission system. The law stipulates detailed provisions for how the private sector can participate in the electricity sector. For example, establishing clear procedures for independent power producers (IPPs) to obtain licenses and other sector-specific permits. The draft law also includes provisions related to renewable energy and energy efficiency and clarifies the role of the regulator in identifying the Public Utilities Regulatory Authority as the sector regulator. It also aims to provide greater openness to the private sector by allowing private investment in all types of stations and perhaps networks.

- The adoption of the draft electricity law will open horizons in the electricity sector in Libya and allow the private sector, municipalities and qualified individuals to generate and distribute electricity. In return, the bill gives legal support to renewable energy; So far, electricity has not been generated from renewable energies, according to data from the General Electricity Company. In addition, the adoption of the draft electricity law will revitalize the institutional framework for electricity supply industry reform which aims to strengthen policies and regulatory measures that will ensure the expansion of electricity transmission networks in order to address any imbalance in the existing transmission infrastructure. The new electricity draft law will also stimulate regulatory policies and procedures to expand the scope of efficient electricity generation, transmission and distribution capabilities in the sector.
- It is important to restructure the electricity sector and create new institutional arrangements that better meet the needs of consumers and continuously provide safe and reliable energy. In particular, policymakers may choose to serperate incumbent utilities—creating different companies from an existing vertical monopoly—to try to improve electricity service and reduce costs through improved management and competition. Market restructuring often involves, in addition to unbundling, the development of independent market operators to oversee power transmission, as well as independent market regulators to ensure that it is efficient and financially and technically accountable to consumers. There is significant accumulated experience on the outcomes of energy market restructuring and utility unbundling, based on collective experiences across developed and developing country markets over the past several decades.
- The common goal of the reforms is to restructure the General Electricity Company in Libya in line with international regulations and standards toreduce the financial burden on the state and raise the efficiency of the sector. This is done by distributing the work among several companies specialized in production, transportation and distribution, noting that the proposed organization is not new, but it is identical to successful regulations in many countries, whether at the regional or global level.

Restructuring the electricity sector

The process of restructuring the electricity sector will first take place by dissolving the General Electricity Company, forming the General Electricity Holding Company, and starting to establish new companies owned by the General Electricity Holding Company, which include:

- Establishing a public company or companies for electricity production: This company owns and operates existing generation stations and other generation stations that have not been completed.
- One transmission company called the General Electricity Transmission Company: It owns and operates high and ultra-high voltage transmission lines (400 KV, 220 KV) and its control centers, stations and facilities.
- Establishing an electricity distribution company or companies: to own and operate existing distribution networks, medium and low voltage (66 kV, 30 kV, 11 kV, 0.4 kV) for the purpose of supplying customers with electricity, later transforming into electricity distribution companies that rely on Self financing.
- The sole buyer system: The sole buyer system works by establishing an administrative unit in the General Electricity Transmission Company that is responsible for buying and selling electricity and implementing the powers and tasks assigned to it. It purchases the total output of electrical energy produced and supplied, pays the value of electricity bills to generation companies, and then sells to electricity distribution companies licensed to supply customers according to the tariff specified by the state.
- All assets owned by the General Electricity Company are transferred to the established companies: Figure No. (5) shows the general vision of the electricity sector restructuring program from the current situation until reaching the complete liberalization of the electricity market.

Both vertical and horizontal unbundling achieve distinct, but interrelated, results that should be reviewed when considering a market restructuring strategy.

The main benefits typically targeted through vertical unbundling and privatization include cost savings. By operating under market conditions, electricity companies must implement cost-effective measures to provide necessary services to end users, while generating sufficient income to cover operating costs.

Vertical unbundling alone may lead to gains in transparency and governance; Conversely, this model may reduce efficiency and economies of scale, as the three separate government-owned entities must now operate independently on corporate business functions (human resources, communications, etc.). In any case, focus should be placed on the generation sector in the dismantling process.

In many cases, unbundling is accompanied by privatization. Horizontal unbundling introduces competition into each sector, with private companies competing against each other and against former government entities. Horizontal disassembly can be applied individually for each sector, and overall competition is introduced for the first time in the

generation sector. The main benefits of horizontal unbundling and increased competition may include cost savings while providing higher quality services and value to end users.

Public Utilities Regulatory Authority

An authority concerned with regulating the electricity, renewable energy, gas, communications, information technology, digitization, water and sanitation sectors in Libya, and ensuring service provision with the best standards in terms of quality, efficiency and reliability. The Authority also works to protect these services from economic changes so that they always remain a foundation for the growth of the national economy.

The Authority's system includes the responsibilities entrusted to it by the state to enable it to achieve its goals. In particular, these responsibilities include the areas of consumer and service provider affairs, technical affairs, and administrative and organizational tasks.

The Authority is responsible for regulating public facilities in the country, and in particular has the following powers:

- Implementing legislation related to electricity services, renewable energy, gas, communications, information technology, digitization, water and sanitation, and proposing future strategies for this sector.
- Building a regulatory framework for carrying out activities in electricity services, renewable energies, gas, communications, information technology, digitization, water and sanitation, in accordance with state policies and leading to the provision of safe and reliable supplies and support for sustainable development.
- Supervising and monitoring the implementation of approved policies in the field of electricity services, renewable energy, communications, information technology, digitization, water and sanitation, and evaluating and addressing any deficiencies.
- Regulating the practice of activities related to providing electricity services, renewable energy, gas, communications, information technology, digitization, water and sanitation, and defining, classifying and updating the types of activities in order to achieve the best ways to establish the foundations of legitimate competition and limit monopoly.
- Proposing controls, specifications, and standards related to activating governance, performance rates, and tools for electricity services, renewable energy, gas, communications, information technology, and digitization, and submitting them to the competent authorities for approval.
- Proposing the regulations required by the nature of the Authority's work and the services it regulates, such as comprehensive licenses and permits, their fees, the basis for determining the tariff for the services it regulates, and the obligations and rules that define the relationship between licensees and consumers, submitting them to the competent authorities for approval, and following up on their implementation in coordination with the relevant authorities.
- Taking measures to monitor the performance of those licensed to work in the activities of electricity, renewable energy, gas, communications, information technology, and water and sanitation networks in terms of their commitment to applying the rules and standards of standard practice for performance regarding the services provided and their commitment to controls and standards of quality, reliability, and continuity of those services to achieve the requirements of the public interest, control violations, and take necessary action to address them.
- Enabling investors to achieve a profitable economic return through equal calculation and periodic review of costs, returns, and service tariffs according to economic and technical principles.
- Issuing the necessary licenses and permits for anyone who carries out any activity in the field of electricity services, renewable energy, gas, communications, information technology, digitization, water and sanitation, or intends to do so, and renewing and amending them.
- Encouraging the private sector to contribute, participate and invest in expanding and developing services related to electricity, renewable energies, gas, communications, information technology, digitization, water and sanitation in a fair competitive environment and at appropriate prices and tariffs.
- Ensuring the financial suitability and technical ability of licensees and determining their ability to self-finance their activities.
- Protecting the rights of beneficiaries of electricity supply services, renewable energy, gas, communications, information technology, digitization, and water and sanitation networks at fair competitive prices based on commercial foundations, with high reliability, and protecting the interests of limited-income beneficiaries (basic pension holders, people with special needs, people with chronic diseases, widows, and the like).
- Monitoring the implementation of regulations and rules related to management, accounting and investment for licensees and taking measures to ensure their compliance with the terms of the licenses and permits granted to them in a way that strengthens the foundations of legitimate competition and limits monopoly.

- Proposing the necessary development initiatives through the latest programs, technologies and tools used in the electricity, renewable energy, gas, communications, information technology, digitization, water and sanitation industries.
- Deciding on issues, issues and complaints related to activities and services that occur between consumers and those licensed to provide services, resolving disputes between competitors, and imposing penalties on violators subject to its supervision.
- Follow up on international developments and developments in the fields of electricity services, renewable energy, gas, communications, information technology, digitization, water and sanitation, and work to benefit from them in improving, developing and sustaining these services.
- Follow up on organizing and ensuring the availability of security and safety requirements in the field of electricity services, renewable energy, gas, communications, information technology, digitization, water and sanitation services in a way that preserves the interest of consumers and the public interest.
- Providing periodic reports to the concerned authorities on electricity services, renewable energy, gas, communications, information technology, digitization, water and sanitation, including achievements, obstacles and developments.
- Other tasks assigned to it in accordance with the law.

Organizational regulations for renewable energies

This document is called the Renewable Energy Regulations and aims to build and control the legal and legislative framework related to the implementation and operation of electrical energy production projects. Electricity is a source of renewable energy, and the goal of establishing legislation is to support and spread the use of renewable energy and encourage investment in it, whether the use is for the purpose of self-consumption, to meet the needs of local consumption, or for the purpose of export. This law also aims to define the responsibility of the relevant authorities in controlling and codifying work in this field and to specify details of obligations for the concerned parties and the technical and contractual requirements for implementing projects.

iv. National strategy for renewable energies 2035

The electric power industry is specifically known as one that can be used to reduce carbon emissions by increasing the proportion of electricity from renewable sources such as solar and wind energy. This will reduce dependence on fossil fuels, which in turn will ensure economic stability. Since the Libyan electric power generation system is currently based on hydrocarbon resources and is completely covered by the burning of depleted hydrocarbons, the share of renewable energies in the national energy mix is 0%.

The economically appropriate energy combination was found that is appropriate to the special situation of the Libyan state in terms of the fragile security situation, taking into account the reliance on fossil fuels as the sole source of generating electrical energy, in addition to support based on fuel and electrical energy in particular, based on a study of the current situation of the Libyan network in terms of generation and loading, the number of conversion stations, the voltages they are working on, the extension of the network and its branches, and its capacity to absorb, as well as the existing and potential maintenance on the generation stations, the types of stations, whether they are gas, steam, or dual, and their condition in terms of antiquity and modernity, and other data.

- The share of renewable energy in final energy consumption is defined as the ratio of energy obtained from renewable energy sources to final energy consumption, where:

- Energy from renewable sources is the sum of electricity produced from all renewable energy sources.
- Final energy consumption is the sum of final energy consumption in various sectors (residential sector, industry, commercial sector, service sector, and agricultural sector) + electricity loss in transmission and distribution + private consumption of the General Electricity Company.

- The strategy emphasizes the need to promote the use of renewable energy sources in a way that provides sustainable energy development. Specifically, for electricity generation, photovoltaic and wind will be the fastest growing technologies. **The share of renewable energies will be 11,000 GW. hour, meaning that its participation in the energy mix is 9% of the total energy generated in 2035.**
- Thus, the total installed energy from renewable energies until 2035 will be as follows:

- 3,600 megawatts of ground stations using photovoltaic technology.
- 500 megawatts of wind energy.
- 1000 megawatts of rooftop photovoltaic systems.
- 150 MW for concentrator solar thermal stations (CSP).

- The plan aimed to increase the contribution of the capacity of renewable energy sources in the energy supply system to the limits of 7% until the year 2025, 14% until the year 2028, 20% until the year 2031, and 25% until the year 2035 of the

total capacities required to be installed in the year 2035, in addition to ensuring the diversification of energy supply sources. electricity and contributing in supporting the national economy, as shown in Figures 6, 7, 8, and 9.

v. National Strategy for Electrical Energy Efficiency 2023-2035

The National Strategy for Electrical Energy Efficiency 2023-2035 aims to reach the general goal of saving 16,926 gigawatt hours, equivalent to 17.5% of the electrical energy consumed, by the year 2035.

The role of energy efficiency was identified, and then the National Sustainable Energy Strategy defined the goals of the energy efficiency pillar and the target to achieve energy savings, as well as the measures and procedures necessary to achieve the targeted savings (Figure 11).

The energy efficiency strategy or energy demand management is a key strategy to separate the impact of energy consumption from the path of economic growth in Libya (that is, the country's economic growth rate is not related to the rate of energy consumption). Improving energy efficiency in all economic sectors is a key element in the success and sustainability of any energy demand management program. Improving energy efficiency, through the implementation of appropriately designed programs, provides the fastest and most efficient way to reduce energy costs and carbon dioxide emissions, and to manage energy demand in the long term. In fact, the greatest benefits likely to be gained in the short and medium terms are achieved by implementing energy efficiency measures more extensively in appliances, equipment, buildings and facilities.

Energy Service Companies (ESCOS) play an important role in overcoming many of the challenges facing the implementation of energy efficiency programs within the framework of traditional market systems. Therefore, state institutions must focus on developing policies aimed at improving energy efficiency, evaluating technologies, and then these companies can implement them.

Improving energy efficiency is key to achieving carbon neutrality by 2050, and before that it is essential for energy security and affordability. Efficiency improvements reduce energy demand, thus contributing to combating the climate change crisis. Above all, energy efficiency contributes to reducing dependence on fuel imports, and thus reducing exposure to energy price fluctuations, as is now evident in light of fears of supply shortages amid the Ukrainian crisis.

Electricity sector indicators in Liby

Table 3 shows the main indicators for the electric power sector.

It can be noted that the per capita consumption of electrical energy is equivalent to what an individual consumes in some industrialized European countries. The reason for the high consumption is that a large portion of energy is wasted. We also find that the intensity of energy consumption in Libya is higher than the global average per unit of GDP by 50%, and this is due to several reasons: lack of awareness of the importance of energy conservation, inefficiency of devices and equipment used in lighting and heating systems and industries, and the absence of special building laws for Energy efficiency (building codes) and other energy efficiency regulations. It becomes clear thus that there is a very great opportunity to reduce consumption by applying energy efficiency measures.

Proposed framework for energy efficiency strategy

Electrical energy efficiency measures in various sectors consist of:

1. Improving the energy efficiency of lighting systems in buildings: a program to replace incandescent lamps with high-efficiency LED lamps
2. Program to replace traditional public lighting lamps with energy-saving LED lamps.
3. The energy efficiency specifications and energy efficiency labels program for electrical appliances, which includes:
   - A- Applying energy efficiency specifications for air conditioners.
   - B- Applying energy efficiency specifications for lighting lamps.
   - C- Applying energy efficiency specifications for refrigerators.
   - D- Applying energy efficiency specifications for electric water heaters.
4. Replacing regular electricity meters with prepaid meters.
5. Introduction of city gas service for water heating and cooking for the residential and industrial sectors.
6. Institutional development of energy efficiency programs and activities in order to supervise the implementation of energy efficiency initiatives in all energy producing and consuming sectors.

Supplementary energy efficiency measures

1. Energy management program in industrial facilities.
2. Establishing energy efficiency improvement units in various economic sectors.
3. Reforming electric energy prices.
4. Developing a program to establish energy service companies (ESCOS).

5. Program for implementing the energy efficiency code in buildings, especially new buildings (government projects).

The energy efficiency strategy aims to achieve energy savings of 17.5% of the expected energy consumption in 2035, equivalent to 4.15 million tons of oil equivalent.

By applying the previous six procedures and measures, the amounts of energy saved can be summarized in Table 3 and Table 4, where the total energy demand without applying energy efficiency measures and the amount of saving as a result of applying energy efficiency measures throughout the strategy period, and then the total energy required to be generated for each year. Figure 12 shows the contribution of each measure to energy savings in 2035, and shows the total amount of energy that will be saved as a result of implementing energy efficiency measures throughout the strategy period. Figure 13 also shows the annual saving rate of electrical energy for all applied measures.

iii. Arab electrical interconnection and supporting the transition to the Arab electricity market

Arab countries have paid great attention to the issue of electrical connection since the early seventies of the last century, based on their awareness of the vital role of the electricity sector in the process of economic and social development, and the economic and technical returns that benefits Arab countries through connecting their electrical networks. Electrical interconnection, in brief, is the process of linking existing electrical systems in two or more neighboring countries with each other through transmission lines so that the energy produced in one of them passes to consumers in the other and vice versa, allowing for easy exchange of energy. This is done with the aim of delivering electricity to the masses of consumers of different types in a manner Secure, lasting and reliable at the cheapest possible prices.

There were a number of factors that created the appropriate conditions for thinking about the necessity of connecting Arab electrical networks. In addition to the diversity of energy sources in the Arab world, such as oil, natural gas, and waterfalls, there is a daily and seasonal difference in the demand for energy between Arab countries due to different climatic conditions, in addition to The large discrepancy in times of electrical consumption peaks across Arab countries, due to the time differences resulting from the expansion of the Arab world, which may reach five hours between some countries. In general, it can be said that electrical interconnection achieves a set of goals that can be summarized as follows:

- Reducing the volume of investment in the electrical power generation sector as a result of reducing the reserves in each country's electrical generation stations.
- Taking advantage of the difference in peak times and timing differences, allowing for an increase in the capacity that can be exchanged between the linked networks.
- Electrical interconnection represents the main step towards establishing an Arab market for the commercial exchange of electrical energy.

Connecting electrical networks in the Arab countries began in the 1950s between the countries of the Maghreb, and in the 1970s between Syria and Jordan, Syria and Lebanon, at modest levels of electrical voltage. Studies of interconnection projects began to increase in intensity in the last two decades until the electrical connection between the networks of the Arab countries became what we see now through the octal connectivity projects (Jordan, Syria, Iraq, Lebanon, Egypt, Libya, Palestine, Turkey), the Gulf interconnection project (UAE, Bahrain, Saudi Arabia, Sultanate of Oman, Qatar, Kuwait) and the Maghreb interconnection project (Libya, Tunisia, Algeria, Morocco, Mauritania).

Electrical interconnection achieves a set of goals, such as reducing the volume of investment in the electric power generation sector; As a result of reducing the reserve in the electrical generation stations of each country, and taking advantage of the difference in peak times and timing differences, which allows for an increase in the capacity that can be exchanged between linked networks, as well as increasing the efficiency of electrical systems by providing support in emergency situations, with the possibility of exploiting electrical interconnection networks to transfer information between linked countries. All of the above is reflected in improving opportunities for better use of primary energy sources and reducing the negative environmental impacts of the expansion of traditional electricity plants. In fact, the electrical interconnection represents the main step towards establishing an Arab market for the commercial exchange of electrical energy.

At the regional level, there are five Arab connectivity projects, divided according to geographical regions into the following:

1. The Eight Electrical Interconnection Project: This project aims to connect the electrical networks of (Jordan, Syria, Iraq, Lebanon, Egypt, Libya, Palestine, Turkey) at a voltage of 400/500 kV.
2. Electrical interconnection project for the Arab Maghreb countries. This project aims to connect the electrical networks of (Libya, Tunisia, Algeria, Morocco, Mauritania) at a voltage of 400 and 220 kV.

3. Electrical interconnection project for the Gulf Cooperation Council countries: This project aims to connect the electrical networks of (the United Arab Emirates, the Kingdom of Bahrain, the Kingdom of Saudi Arabia, the Sultanate of Oman, the State of Qatar, and the State of Kuwait).
4. Egyptian-Saudi interconnection project (voltage 500 KV and exchange capacity 3000 MW)
5. The Egyptian-Sudanese electrical interconnection project with a capacity of 300 megawatts as a first phase, expandable to 3000 megawatts.

It is hoped that after completing the preparation and approval of the governance documents for the Arab Common Electricity Market, work will be done to form a team of Arab experts to review the position of all Arab countries in terms of preparing frameworks and guidance documents for the technical requirements for connecting renewable energy projects to public networks, and developing codes for transmission and distribution networks, so that they include: Small and large projects, and then work with relevant institutions in the states to ensure regional consistency in addressing interconnection issues, rates of participation in renewable energies, and opportunities for exchanging and trading produced energy through regional networks, as well as cooperation in technical documentation of the role of the interconnection network in dealing with load changes that will increase with increasing contribution of renewable energy in the future electricity production mix.

vii. National Hydrogen Strategy 2023-2035

The process of entering the low-carbon hydrogen industry needs to consider many factors; The first is to begin analyzing the current situation regarding the hydrogen market, whether in Libya or globally, and then, based on international best practices in enabling the expansion of low-carbon, renewable hydrogen according to the different stages of market maturity, we propose that a phased approach be followed to develop the hydrogen economy in The country.

This document targets Libyan government policymakers on the one hand and other experts interested in formulating or influencing green hydrogen policy and programs in the region. The primary objective of this document is to pave the way for the development of a green hydrogen strategy for Libya. The document thus identifies (1) the current framework conditions, policy objectives, and green hydrogen deployment plans, (2) the potential for production and application of green hydrogen and its derivatives, and (3) potential scenarios for the development of a green hydrogen economy in Libya. This analysis is complemented by recommendations for next steps in developing a green hydrogen strategy in the short, medium and long terms.

In this part of the report, a green hydrogen roadmap for Libya is presented. To reflect the assessment of industry maturity and the expected increasing penetration of green hydrogen, three development phases have been identified: pioneering phase (creation of pioneer experimental projects), demonstration phase (2023-2030), market creation and scale-up phase (2030-2040), and market/competition phase (2040-2050), the associated objectives, challenges and key requirements of which are described in Figure 14.

1) Conclusion

An assessment and analysis of the current situation was conducted through a comprehensive review of available documents on the electricity sector, renewable energies and energy efficiency in Libya, and consultation with stakeholders from the General Electricity Company, the Renewable Energy Agency and the Ministry of Planning. The activity included an analysis of the current situation, with basic data on the production, distribution and use of energy of all types, and included an evaluation of previous national initiatives in the fields of electricity, renewable energies, energy efficiency, and initiatives to increase the share of renewable energy in the national energy mix. The sector's strengths and weaknesses were also analyzed in specific areas relevant to the sector such as planning, institutions, legal and regulatory framework, financing, monitoring, capacities, and partnerships. After that, the National Strategy for Sustainable Energy in Libya was prepared, which included the following axes:

- Electrical power axis.
- Renewable energies axis.
- Energy efficiency axis.
- Green hydrogen.
- Arab electrical interconnection and the Arab common market for electricity.
- Rules and regulations.