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Electric Grid Interconnection and Gas Transmission Pipelines as an Entry to Achieving Maghreb Economic Integration

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Abstract:
Electric grid interconnection is an essential mechanism for optimizing electrical systems, representing a pivotal element of cooperation and fundamental integration across nations globally. Its primary objective is to diminish capital and operational expenditures associated with electricity production, thereby catering to specific demand levels while fostering savings in using primary energy sources.
This research paper endeavors to shed light on the electric grid interconnection initiatives among the Maghreb countries, elucidating the advantages and merits of electrical and natural gas interconnections. It delves into their pivotal role in facilitating the integration of the Maghreb region within the energy sector. The study deduces that electric grid interconnection significantly advances energy integration, effectively addressing any abrupt shortages in electricity supplies across the Maghreb countries. Moreover, it substantially enhances the reliability of these supplies, eliminating apprehensions regarding potential disruptions in the supply chain.

Keywords: Economic integration, Electric grid interconnection, Energy exchange.

Introduction:

Collective integration epitomizes a harmonious state of existence among nations, facilitated through economic endeavors rather than conflicts within a region of integration. This paradigm fosters unity among the consortium of countries, bestowing upon them an international stature capable of warding off potential hostilities, whether targeted at individual nations or the collective. The reciprocal provisioning of resources among countries engaged in the integration process cultivates a synergistic amalgamation within their economic frameworks, thereby establishing a common marketplace endowed with an expansive capacity for assimilation. Consequently, this engenders a vast economic conglomerate that accrues many benefits for all participating nations.
The Maghreb nations are endowed with the requisite attributes conducive to economic amalgamation. Notably, the Maghreb region commands a significant stance by virtue of the magnitude and caliber of its economic assets, prominently including energy resources alongside phosphates, iron, copper, and more. These resources are judiciously dispersed across the five Maghreb nations, facilitating their utilization in alignment with the aspirations of a substantially integrated Maghreb economic consortium.
The interconnection of electric grids emerges as a pivotal mechanism for optimizing electrical infrastructures, heralding a fundamental paradigm of collaboration among Arab and Maghreb countries. This initiative aims to diminish capital and operational expenditures associated with electricity production, thereby satisfying specific demand thresholds and catalyzing efficiency in the consumption of primary energy resources. A scrutiny of interconnection endeavors within the region's confines reveals electric grid interconnection projects as the quintessential exemplars of success, strategically leveraging the variances in energy sector capabilities across the nations.
Tunisia, Algeria, and Morocco have ratified energy exchange accords, delineating operational protocols for both standard and difficult scenarios and the economics of electricity trade. The fruition of these electric grid connections at 220 and 400 kilovolts between Tunisia, Algeria, and Morocco has culminated in many advantages, underscoring the

profound impact and utility of such collaborative ventures in the energy domain.

Problem Statement:

The problem this paper seeks to address is the following main question: How can electric grid interconnection contribute to embodying Maghreb's economic integration in the energy sector? And do the mutual supplies of electricity and gas through interconnection networks between the Maghreb countries contribute to achieving the productive and marketing integration of electricity?

Research Objectives:

This study aims to shed light on the role of electric grid and natural gas interconnection networks between the Maghreb countries in achieving integration and energy cooperation and the economic and technical advantages of exchanging electricity and gas. It also aims to identify the challenges faced in achieving electrical and gas network interconnection between the Maghreb countries.

Study Methodology:

To address this problem, we opted to use the descriptive analytical method to understand the concept of integration and its motives, the foundations of Maghreb economic integration, and to review the technical and economic advantages of electric grid interconnection and analyze the reality of electric grid interconnection and the obstacles to Arab and Maghreb integration in the field of electricity and gas.

First: The Theoretical Framework for Economic Integration

1. The Nature of Economic Integration:

We will review the definition of integration, its motivations, and its components.

1.1 Concept of Economic Integration:

The Political Encyclopedia defines economic integration as "the alignment between available elements at one of the integrated parties, such as human resources, skills, and a wide market, while the other party has capital, thus forming the integrated economic elements for the industrial and developmental process. It is the direction of economic projects towards enlarging their size to benefit from the advantages of large-scale production. [1]

Bela Balassa defines integration as follows: "Economic integration is represented in relations established between economic units (two or more countries) towards achieving their merger and eliminating the existing discriminatory practices among these units, forming a new and distinct economic entity.[2]

From the above, we deduce that economic integration means the gradual elimination of barriers between a number of countries, leading to the establishment of a homogeneous economic space that benefits all integrated parties. Integration has clear effects on production and consumption and impacts improving welfare and economic and social development.

1.2 Motivations for Economic Integration:

There are many motivations for countries to prefer regional economic integration, including:[3]

- The existence of strong historical links between the peoples of the group's countries, geographical proximity, and cultural similarity or convergence.
- The presence of a political motive.
- The desire for industrialization and marketing of industrial products in the common market of the integrated countries.

2. **Components of Maghreb Economic Integration:**

The Arab Maghreb countries possess many components that help them achieve economic integration, including:

2.1 Geographical Components:

The area of the five Maghreb countries totals about 6 million square kilometers, approximately 42% of

[1]Abdul Wahab Al-Kayyali, "The Political Encyclopedia," Vol. 1, Arab Institute for Studies and Publishing, Beirut, 1990, p. 214.

[2] Bela Balassa, "The Theory of Economic Integration" (translated by Rashid Al-Barawi), 1st edition, Dar Al-Nahda Al-Arabiya, Beirut, 1964, p. 10.

[3]Sabiha Bakhoush, "The Arab Maghreb Union: Between Motivations for Economic Integration and Political Obstacles," Dar Al-Hamed for Publishing and Distribution, Jordan, 2010, p. 57.

the total area of the Arab world, while the length of their coasts, extending from the north of the Mediterranean Sea to parts of the Atlantic Ocean, is about 6500 kilometers.

2.2 Human Resources and Demographic Aspects:
The population of the Maghreb countries is about 85 million people, approximately 27% of the Arab countries' population, with Algeria and Morocco's populations representing about 77% of the Maghreb population. The population density in the region is about 14 people per square kilometer, with an average population growth rate of 1.7% per year, the highest rate in Mauritania, close to 3%, while the lowest rate is in Tunisia, from 1 to 1.2% annually.
There is no significant structural imbalance or "large disparity" between the proportions of females and males in these countries. The population under 20 years of age represents about 50% of the total population of the Maghreb, indicating that these are youthful societies, and this will lead to an increase in the proportion of the productive workforce in the future, as well as an increase in the labor force and the necessity to address the needs of this segment with health, educational, and social facilities.
Literacy rates in the Maghreb countries have decreased over the last three decades, currently reaching less than 20% in Tunisia, Libya, and Algeria. However, the situation in Mauritania still approaches 40% of the population, with female illiteracy being more prevalent than male, as in other Arab countries.
The population of the Maghreb region is closer to homogeneity, with Arabic being the prevailing language and Sunni Islam being the predominant belief for about 99% of the population in all Maghreb countries. There are no natural geographical barriers between the countries of the region and also their recent history, as all of them were subjected to occupation by Spain, France, and Italy before gaining their independence during the 1950s.
The productive – capable and willing to work – workforce is estimated at about 32% of the population, approximately 27.2 million people, and as mentioned, this percentage is expected to rise due to the increasing participation of the population, especially the female element, in the labor market and the entry of those under 20 years into the labor market in the near future. While there are no precise statistics for unemployment rates, a general figure of 20% of the workforce is often mentioned, although it varies from one country to another.

The phenomenon of migration to major cities is widespread across all Maghreb countries, though it appears more significantly in some countries like Libya. However, there is a need to study this phenomenon across all Maghreb countries. Studies indicate that urban residents represent about 65% of the total population in all Maghreb countries.

3. Energy Potential and Mineral and Energy Resources:
The Maghreb region holds a significant position in terms of the size and quality of important economic resources that form the basis of various industries and energy sources for their economies. It has diverse resources distributed among the five Maghreb countries. The Arab Maghreb Union possesses a wealth of traditional energy sources such as oil, with reserves exceeding 5 billion tons (50.6 billion barrels as of 2005), and natural gas, more than 6100 billion m^3, in addition to renewable energy sources, as well as phosphates (44 billion tons), iron, primarily concentrated in Mauritania and Algeria, copper, and gold.

Second Axis: Electrical Connection and Natural Gas Connection Between Countries
The importance of interconnection between electric power systems has increased due to the global reliance on electricity and its ease of transmission across vast distances, in addition to its joint economic and technical benefit of stability in electric grids, continuity in supply, and cost savings. Undoubtedly, electric interconnection constitutes a scientific basis that must be considered and attempted to be applied to isolated integrated systems whenever appropriate.
Electric interconnection offers multiple advantages, including facing future loads and the exit of power-generating units from the system, reducing the likelihood of electrical outages and their impact and losses on consumers of various categories and their needs for electricity. It also forms a network for electric power transmission on a regional scale and reduces the installed reserve capacity in each network.

1. Benefits of Electrical Interconnection and Natural Gas Connection:
These advantages and benefits include the following:
(A) Technical Benefits

- Increased system availability and reliability and decreased probability or expectation of power supply loss.
- Mutual assistance in emergencies when a fault occurs.
- Increased dynamic stability as the integrated system is more capable of regaining its stability after disturbances or severe accidents, and improved frequency (oscillation) and voltage regulation.
- Opportunities for better preventive maintenance programs.
- Allows for the export or import of surplus energy depending on peak times in each country.

(B) Economic Benefits

- Direct savings result from delaying the need to establish new power stations, reducing both fixed and rotating reserves for each system separately by relying on the reserve of the unified system, and reducing operating and maintenance costs.
- Establishing production stations in locations where production costs reach a minimum.
- The possibility of supplying cheap electric power from its region to another more costly region.
- Financial revenues are obtained by transit countries.
- Reducing the cost of energy production positively reflects on the selling prices of electricity to consumers.
- Reduction of capital investments required to meet demand.

(C) Environmental Benefits

- Reducing emissions by using more efficient production.
- Using renewable energy sources.
- Increased opportunities to choose the best locations for establishing production stations.

(D) Social, Political, and Legal Benefits

- Exchange of visits and understanding of different cultures of countries, and forming social connections.
- Strengthening security between countries and political stability due to creating an atmosphere of cooperation and dialogue and the presence of shared economic interests.
- Increasing legal expertise and creating opportunities to make local laws compatible with international law.
- Working on the compatibility of regulatory rules for the connected countries' networks.[4]

2. Types of Electrical Connection Between Countries and Different Types of Exchange:

Different types of interconnection allow connected countries varying degrees of exchange and benefits, and they may also entail a number of issues. Generally, the types of connections can be categorized as follows:

(A) Open and Closed Connection:

Interconnection with low capacities suffers from transient instability problems; thus, the interconnection line is usually left open and is only closed in emergencies to supply the required electric power to the areas with a fault. This type of connection started between European countries, as well as between Tunisia and Algeria, and also between Syria and Lebanon, and Syria and Jordan.

(B) Synchronous and Asynchronous Connection:

Systems operating at the same frequency and the same frequency control systems usually prefer synchronous AC connection. However, if networks with different frequencies are connected, or there is a desire to maintain frequency independence in the connected networks due to differences in frequency stability regulation, the connection is made through direct current, making the connection asynchronous.

(C) Energy Exchange Connection and Capacity Exchange Connection:

The connection for energy exchange between two neighboring countries involves one country exporting cheaper electric energy to another neighboring country where electricity generation is more costly, according to a pre-determined time schedule between the two countries. Both countries benefit from this exchange as the exporting country sells electricity at a price higher than its production cost, while the buying country obtains energy at a price lower than its local cost.

[4]Walid Al-Deghaili, "Towards Integration of Electricity Interconnection Projects: Considerations and Possibilities," Workshop on "Impacts of Climate Change in the Arab Region: Towards Sustainable Energy - Sources, Opportunities, and Challenges," Manama – Bahrain, October 6-7, 2010, p. 15.

The difference in electricity costs between the two countries results in financial savings from the connection, usually distributed equally between the two countries. The exchange between the two countries can also evolve to include capacity exchange, where the programs for establishing new power stations in the two countries are integrated into a joint program. Some of the power stations required for one country are built in the second country due to the availability of a cheap energy source, such as natural gas or a water source in the second country.

3. Motivations for Electrical Connection Between Arab and Maghreb Countries:

Electricity is considered one of the vital necessities for countries in our present age, being the most important energy source in our lives. Thus, it is one of the indicators of economic growth. The demand for electricity is increasing for several reasons, including urban expansion, population growth, rising income levels, enhanced welfare standards, industrial development, etc.

Given that the Arab countries are among the fastest-growing regions in the world in terms of population, and due to the relatively modest levels of electricity consumption in many Arab countries currently, the future is expected to witness a huge demand for electricity supplies in these countries, facing bottlenecks in electricity supplies, especially during peak consumption times.

Advanced countries strive to ensure high-reliability levels of electricity supplies and ensure the stability of electric current. Since all countries, regardless of their level of advancement and their efforts to provide reserve generation capacity at their power stations, cannot guarantee the absence of any sudden power outage for any reason, they ensure to connect their electricity supply networks with those of other countries, allowing the exchange of generation surpluses between them and other countries.

For example, the electric supply networks in Europe are completely interconnected with each other, as well as the supply network in the United States is connected with Canada's network, and so on.

Fortunately, our Arab world possesses enormous capacities for generating electricity, having the largest stock of energy generation sources in the world, whether in terms of oil or gas. However, the distribution of these reserves is not uniform among the Arab countries. While oil is plentiful in the Gulf region, Iraq, and some North African countries like Libya and Algeria, there are countries with almost no oil at all. Similarly, there are vast reserves of gas in Qatar, Egypt, and Algeria, while these reserves are less in other countries in the region.

On the other hand, the significant difference in weather conditions between Arab countries leads to synchronized differences in peak electricity consumption times among them. While some countries may experience peak electricity consumption in summer, others have their peak in winter. While some countries may face peak electricity consumption during the day when temperatures soar, like Kuwait, others experience peak consumption at night, as is the case in Egypt.

The phenomenon of sudden electricity outages is widespread in Arab countries, even for those with large production capacities, causing numerous problems for residents and the business sector alike. Arab countries need to ensure the availability of electricity supplies in a way that guarantees the stability of these supplies and the appropriate voltage.

Often, electricity generation facilities are designed based on peak consumption plus a reserve capacity for emergencies, meaning the potential existence of significant surpluses in the electricity generated in some Arab countries while others suffer from a deficit in these supplies.

Hence, the importance of electrical connection projects between Arab countries becomes apparent, where the connection will enable electricity generation facilities in these countries to operate at their maximum capacity continuously and benefit from production surpluses through exchanging electricity surpluses throughout the day or across seasons between Arab countries with differing peak times and seasons, i.e., exporting these surpluses at their market prices to other countries facing a shortage in these supplies.

The clear differences in fuel sources between Arab countries lead to differences in their potential capacities for generating electricity and, consequently, relative differences in the cost of generating a unit of electricity in Arab countries, being high in some countries and low in others. These differences in relative advantages for generating electricity among Arab countries provide an important basis for electrical connection between them, allowing countries with abundant fuel sources

to optimally exploit these sources instead of exporting this fuel in its raw form.

Countries with fuel abundance can invest in massive production facilities, using what they need from their production, and the surplus can be transferred to the general network for electrical connection between Arab countries.

4. The Role of Electrical Connection Between Arab and Maghreb Countries in Achieving Economic Integration:

⇒ The electrical and natural gas connections between the Maghreb countries contribute to achieving energy economic integration as they realize the following:

⇒ Reduce the cost of generating a unit of electrical energy, as electricity will be generated where its production elements are available at a low cost. This enables planning for the construction of large-scale electric power generation stations to benefit from economies of scale and achieve the lowest possible average cost of generating a unit of electrical energy.

⇒ Allow any country with production facilities capable of generating electricity beyond its needs to dispose of this surplus at a profitable price, instead of wasting it in the networks or not using the production facilities for generation optimally.

⇒ Reduce the current trend in designing production facilities by adding high additional reserve facilities to face emergencies, leading to wide surpluses in production capacity at times of low consumption. This constitutes a waste in investment processes and poor utilization of resources, especially if this reserve generation capacity is not used.

⇒ Help reduce the number of capital investments required to meet the demand for electrical energy in Arab countries without affecting the reliability of electricity supply in the interconnected networks, as well as the possibility of postponing new generation station projects, which cost hundreds of millions of dollars, and rely on production surpluses in other Arab countries.

⇒ Enable countries that do not have sufficient production facilities for generating electricity and fall short of their actual needs to bridge this gap in supplies and ensure the stability of electricity supply operations by using the production surpluses achieved by other Maghreb countries.

⇒ Assist in extending the service of supplying electricity to all parts of the Arab Maghreb, especially to areas deprived of electricity supplies.

⇒ Help to address any sudden shortage in electricity supplies in the Maghreb countries and increase the reliability of supplies without fear of any disruptions in supply operations.

⇒ Strengthen the bonds of Maghreb economic cooperation, deepen the connection between neighboring Maghreb countries through increasing their mutual dependence in this field, and strengthen their common interests.

5. Maghreb Electrical Connection Networks:

Since its establishment in 1989, the Maghreb Electricity Committee (COMELEC) has played a significant role in enhancing energy cooperation between the Arab Maghreb countries. In recent decades, the committee has exchanged expertise in all areas related to electricity, renewable energies, smart systems, and the storage of electrical energy.

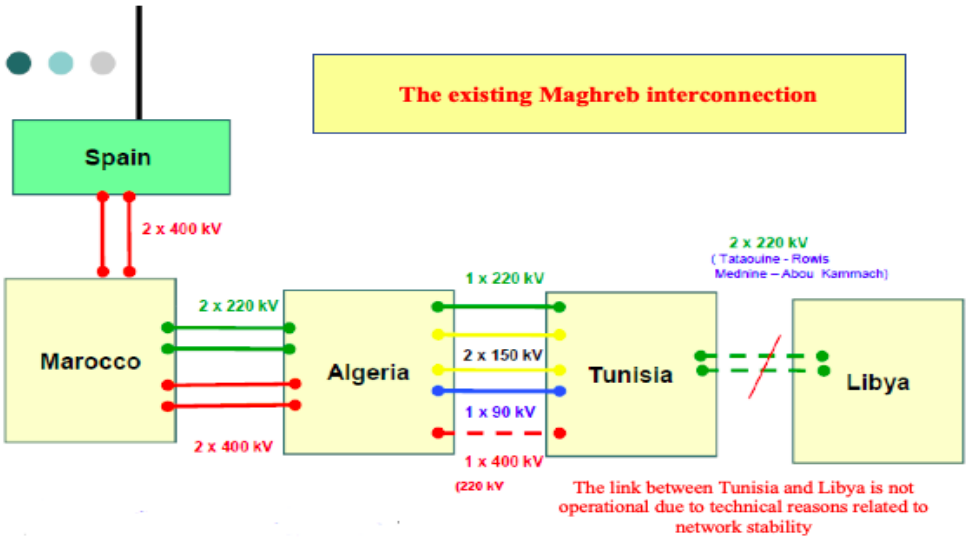
COMELEC significantly contributes to fostering a spirit of cooperation among the Arab Maghreb countries in the field of electrical energy through its committee activities, including the Maghreb interconnection committee and planning and studies.

Furthermore, cooperation between neighboring countries led to the agreement signed between Morocco and Algeria, which gives the latter the possibility to sell electricity to Spain through Morocco with a transit fee.

The Maghreb Electricity Committee has worked for 46 years to establish infrastructure in the field of electricity in the Arab Maghreb, especially the creation of four (4) high-pressure electrical interconnection lines between Morocco and Algeria at 625 kilovolts, along with five (5) interconnection lines between Tunisia and Algeria and the electrical connection between Tunisia and Libya.

COMELEC has called for the creation of an integrated and shared Maghreb market for electricity exchange among the five Arab Maghreb countries (100 million people and a concentrated electrical capacity of around 45,000 megawatts).

Figure 1: Completed Maghreb Electrical Interconnection Networks



Source: Lakhdar Chouireb, "Maghreb Electricity Connection," The Third General Conference of the Arab Union for Electricity Producers, Transporters, and Distributors, Tunis, December 14-15, 2009, p. 10.

Algeria is connected with Morocco and Tunisia through electrical interconnection networks as follows:

⇒ Algeria-Tunisia:

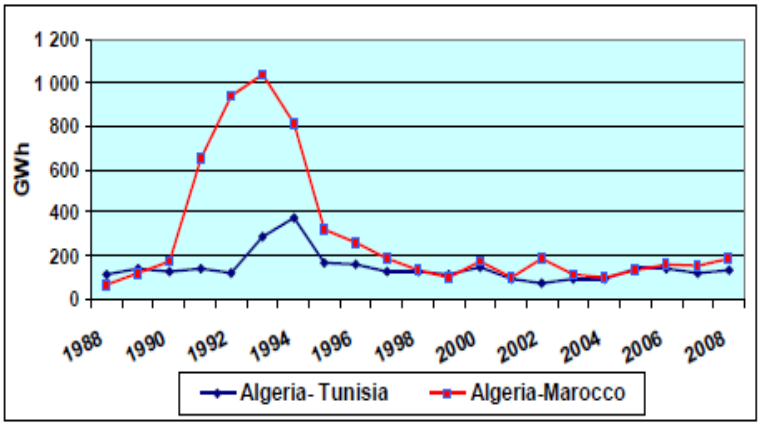
- El Aouinet-Tadjerouine en 90 kV (1952).
- El Kala-Fernana en 90 kV (1954).
- El Aouinet-Tadjerouine en 220 kV (1980).
- Djebel Onk-Metlaoui en 150 kV (1984).

⇒ Algeria-Morocco:

- Ghazaouet-Oujda en 220 kV (1988).
- Tlemcen-Oujda en 220 kV (1992).
- Hassi Ameur –Bourdim en 400 kV (2010).

The figure (2) shows the interconnection networks between the Arab Maghreb countries from Libya to Morocco at 220 kilovolts and 400 kilovolts.

Figure 2: Development of Maghreb energy exchange during the period (1988-2008)



Source: Electrical Interconnection, Arab Fund for Economic and Social Development, http://www.arabfund.org/default.aspx?pageId=467

5-1 Current Electrical Connection between Tunisia, Algeria, and Libya:

The existing electrical connection between Tunisia, Algeria, and Libya facilitates the exchange of electrical energy, especially during peak periods, as these times differ among the three countries. This temporarily enables a reduction in investment in setting up reserve production capacities. Table (1)

illustrates the volume of exchanges between the Maghreb countries during 2019.

Table 1: Volume of electricity exchanges during the year 2019.

2019	Capacity MW	Voltage kV	Line
Tunisia and Algeria			
Exchanges and purchases of 135 gigawatt-hours	76	90	Tajerouine-El Aouinet
	86	90	Fernana-El Kala
	178	150	Ataloui-Jebel Onk
	276	225	Tajerouine-El Aouinet
	1070	400	Jendouba-El Chaafia
Lybia and Algeria,	276	225	Medenine-Abu Kammash1
Exchanges and purchases of 294 gigawatt-hours	267	225	Medenine-Abu Kammash2
	267	225	Tataouine-Rouiss.

Source: The Ministry of Industry, Energy and Mines of the Tunisian Republic.

5-2 Development of Exchanged Energy among the Connected Maghreb Countries:

The exchange of energy among the Maghreb countries has seen significant development, as illustrated by Figure (3).

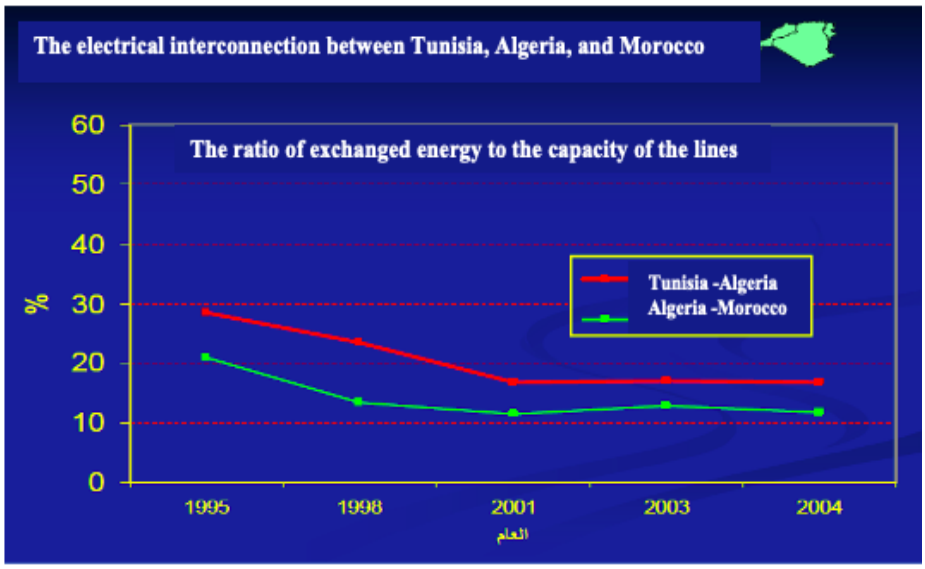
Figure 3: Development of Exchanged Energy between Connected Countries

Source: Arab Cooperation in the Field of Electrical Interconnection, The Tenth Arab Energy Conference, 2014, p. 39.

5-3 Benefits Achieved from the Maghreb Interconnection Project:

As a result of connecting the electricity networks in Tunisia, Algeria, and Morocco with the Spanish network, both Algeria and Tunisia have been able to improve the stability of their electricity networks' frequency by connecting them with Morocco and then Spain and the rest of the European network. The European network regulates the frequency in the Algerian and Tunisian networks when any issues arise by providing them with instantaneous power from an integrated electrical system with a total generation capacity of about 600 GW, which is about sixty times the total generation capacity of Tunisia and Algeria.

Figure 4: Exchanged Energy through the Tripartite Electrical Interconnection – Algeria, Tunisia, Morocco



Source: Arab Cooperation in the Field of Electrical Interconnection, The Tenth Arab Energy Conference, 2014, p. 44.

5-4 Obstacles Limiting the Optimal Exploitation of the Project:

The weakness of the internal networks in the three countries is the main obstacle to the optimal use of the project. For example, the maximum actual capacity that Algeria can draw from Tunisia is about 100 MW, and from Morocco, about 240 MW, representing about half of the actual capacities of the interconnection lines due to issues related to the internal networks in the three countries.

5-5 Efforts Made to Overcome These Obstacles:

Morocco and Algeria are strengthening their internal transmission networks and the interconnection lines between them in preparation for exporting electrical energy to Europe using Algeria's natural gas. Additionally, since 2010, Egypt, Libya, and Tunisia have started establishing interconnection lines between them at 400 kV tension (500 kV in Egypt).

5-6 Maximizing the Benefits of Current and Future Interconnection Projects:

To maximize the benefits from current and future interconnection projects, Arab and Maghreb countries may need to:

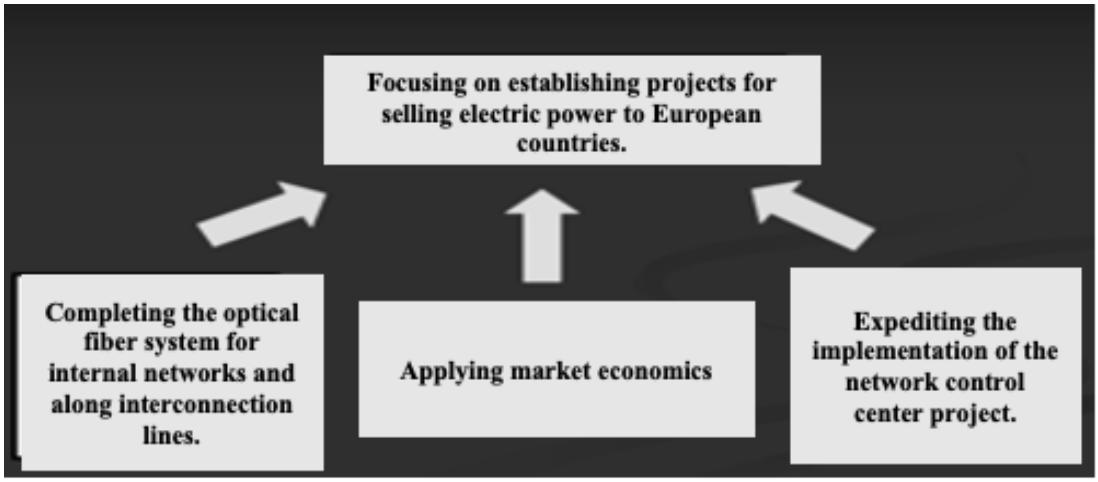
⇒ Complete the optical fiber system for internal networks and along interconnection lines for easy and fast data transfer between different control centers in Arab countries.

⇒ Expedite the implementation of the Coordination Control Center project involving nine Arab countries and Turkey to monitor the connected network and stimulate commercial exchange movement among those countries.

⇒ Focus on creating projects to sell electrical energy to European countries. Therefore, it is expected that the loading of submarine cable projects (Tunisia - Italy), (Algeria - Spain), and (Morocco - Spain) for exporting electricity to Europe will increase, as will the load on interconnection lines (Egypt - Libya - Tunisia) and (Algeria - Morocco) correspondingly.

⇒ Implement market economics in terms of selling and buying electricity and gas so that investors can enter the field of establishing new generation stations and sell their production to the global market via interconnection networks.

Figure 5: Requirements for Maghreb Electrical Connection



Source: Lakhdar Chouireb, Maghreb Electricity Connection, The Third General Conference of the Arab Union of Electricity Producers, Transporters, and Distributors, Tunis, December 14-15, 2009, p.18.

Figure (5) illustrates the requirements for electrical connection between the Maghreb countries, including the development of internal networks and the establishment of energy-selling projects to Europe, especially to Spain and Italy.

6- Arab Cooperation in the Field of Natural Gas:

In addition to existing and future electrical interconnection projects, there are a number of natural gas transportation networks between Arab countries and from Arab countries to European countries. Some of these are completed, while others are under construction. Examples include:

a. East Gas Pipeline:

Originating in Egypt, it used to supply Jordan, Syria, Lebanon, and Turkey. The first part of the project, which includes laying a gas pipeline from El Arish in Egypt to Aqaba in Jordan, has been completed. The work on the second part of the project, which includes laying a gas pipeline from Aqaba to the Jordanian-Syrian border, was expected to be completed in 2006.

b. Dolphin Project:

Starting from Ras Laffan in Qatar and used to supply the United Arab Emirates with Qatari natural gas. The contracts for this project have been signed, and it went into service in 2006.

c. Maghreb Gas Pipeline Project:

Beginning in Hassi R'mel in Algeria and used to supply Portugal and Spain with Algerian gas. This line has been in service since 1996, and its capacity is currently being doubled.

d. **Trans-Mediterranean Gas Pipeline Project:** Also, starting from Hassi R'mel in Algeria, this pipeline is used to supply Italy with Algerian gas. This line has been in service since 1995.

Additionally, studies are being conducted to extend a gas pipeline between Egypt and Libya and another gas pipeline between Libya and Tunisia.

Although gas pipelines can compete with electrical interconnection lines, there are two main differences between the two networks:

- ✓ Both gas and electricity networks are used for continuous energy supply, but electricity networks can also be used for immediate network relief, which cannot be achieved in gas transmission networks.
- ✓ There are other uses for energy sources, such as transportation and heating, where natural gas significantly outperforms electricity.

With these alternatives, along with others like liquefying natural gas and then exporting it, several questions arise. For example, for gas-rich countries, what is the optimal volume and price for exporting electricity and gas to maximize the benefits of energy sources? Similarly, for gas-poor countries, what is the optimal volume for importing electricity and gas to reduce total energy expenses?

To define a comprehensive strategy for Arab countries to maximize the benefits of electricity and gas networks, a study is needed to determine the best alternatives for each country and for the Arab

countries collectively. The terms of reference for this study are currently being prepared for its initiation.

Conclusion:

Electrical interconnection and the natural gas linkage among the Maghreb countries contribute to achieving energy economic integration because it realizes a set of benefits, the most important of which are:

⇒ Enabling countries that lack sufficient productive facilities for electricity generation and fall short of their actual needs to bridge this gap in supplies and ensure the stability of electricity supply operations through the use of production surpluses achieved by other Maghreb countries.

⇒ Extending the electric power supply service to all parts of the Maghreb, especially to areas deprived of electricity supplies.

⇒ Assisting in addressing any sudden shortage in electricity supplies in the Maghreb countries and enhancing the security of supplies without fear of any disruptions in the supply operations.

⇒ Strengthening the bonds of Maghreb economic cooperation, deepening the connection between neighboring Maghreb countries through increasing their mutual dependence in this field, and strengthening their common interests.

⇒ Reducing the current trend in designing production facilities by adding excessive additional backup facilities to face emergencies, which leads to significant surpluses in production capacity during times of decreased consumption, representing a waste in investment operations and poor resource utilization, especially if this backup generation capacity is not used.

⇒ Helping to reduce the volume of capital investments needed to meet the demand for electricity in the Arab countries in a manner that does not affect the reliability of electricity supplies in the interconnected networks, in addition to the possibility of postponing new generation plant projects, which cost hundreds of millions of dollars, and relying on production surpluses in other Arab countries.

On the Arab level, recent years have witnessed a significant boom in the implementation of electrical interconnection projects between Arab countries in terms of both the number of projects and exchange capacities between systems. The completed interconnection projects have contributed to varying degrees in improving the reliability of electricity networks and in reducing the investment costs for the participating countries, although the volume of energy exchange has not lived up to the expectations used in the feasibility studies for these projects. This is mainly due to some countries' delays in signing trade agreements that govern energy costs and mutual capacity and sometimes due to the limited capacity of the lines.

It is expected that the coming years will see a significant leap in the interconnection system in terms of the number of connected countries and exchange capacities between those countries as a result of the completion of several ongoing or planned projects. It is also expected that linking Arab countries with the European network and electricity networks in some African countries will create new opportunities for exporting large quantities of electric power to Europe.

The following recommendations can be offered:

1. Expedite the comprehensive Arab electrical interconnection study and the utilization of natural gas for electricity production and export.
2. Strengthen and modernize electrical transmission networks and ensure within each country, allowing the import of electrical energy from one country to another through any country whose geographical location permits it.
3. Develop and adopt policies to improve the performance of the electricity market in each country, reflecting the true cost and paving the way for creating an electricity market in the region, taking into account the social conditions in each country by adopting mechanisms to support the poor and needy.
4. Establish a coordination and monitoring center in one of the region's countries to undertake the tasks of coordination, monitoring, and commercial exchange between these countries and between them and neighboring regions, and establish a market for electricity trade.
5. Conduct feasibility studies on the integration of the region's network with networks of neighboring regions to take the necessary actions based on that.
6. Benefit from the expertise available in the neighboring European region in the field of electrical interconnection to assist in building technical capacities, transferring knowledge, policy making, and developing protection plans for networks.

7. Work on producing electric power from renewable energy sources (wind energy and solar energy) in large capacities and connecting it to the electricity network as part of a policy to reduce emissions and achieve environmental sustainability.
8. Encourage the private sector to contribute to investments, to secure the necessary financing on one hand, and to benefit from its flexibility and speed in project implementation.
9. Consider the economic factor and ensure speedy action, especially in project implementation and policy adoption, to avoid lagging behind global developments.
10. Encourage the signing of long-term contracts for the procurement of electric power through interconnection networks, allowing interested investors to invest in this sector after obtaining sufficient guarantees.
11. Begin restructuring electricity companies and institutions in the region and achieving harmony of institutional, regulatory, administrative, and technical frameworks.
12. Open networks for the passage of sold energy in a non-discriminatory manner.
13. Establish mechanisms for fair and transparent pricing to provide the necessary legal and regulatory frameworks and environments.
14. Establish a common electricity market (the integrated Maghreb electricity market is expected to come into effect by 2025, following its establishment announcement in Tunis, the capital, on the occasion of the annual meeting of the Maghreb Electricity Committee, attended by the CEOs of electricity companies in Tunisia, Algeria, Libya, Morocco, and Mauritania).

References:

[1] Ehab Salah El Din, "Energy and the Challenges of the Future," Academic Library, Cairo, 1994.
[2] Bela Balassa, "The Theory of Economic Integration" (translated by Rachid Al-Barawi), 1st edition, Dar Al-Nahda Al-Arabiya, Beirut, 1964.
[3] Sabiha Bakhoush, "The Arab Maghreb Union: Between Motivations for Economic Integration and Political Obstacles," Dar Al-Hamed for Publishing and Distribution, Jordan, 2010.
[4] Atef Naim Habib, "Electricity Interconnection Networks and Their Impact on the Arab Economy," Institute for Arab Research and Studies, Cairo, 2008.
[5] Abdul Wahab Al-Kayyali, "The Political Encyclopedia," Vol. 1, Arab Institute for Studies and Publishing, Beirut, 1990.
[6] Lakhdar Chouireb, "Maghreb Electricity Connection," The Third General Conference of the Arab Union for Electricity Producers, Transporters, and Distributors, Tunis, December 14-15, 2009.
[7] Walid Al-Deghaili, "Towards Integration of Electricity Interconnection Projects: Considerations and Possibilities," Workshop on "Impacts of Climate Change in the Arab Region: Towards Sustainable Energy - Sources, Opportunities, and Challenges," Manama – Bahrain, October 6-7, 2010.