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Advancing renewable energy in Arab Nations: A regional overview

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***Abstract*---**This study explores the status of renewable energy (RE) developments in Arab countries (AC), considering RE as a crucial element for sustainable economic growth in these nations, despite their rich oil and gas reserves. The Study begins by reviewing RE resources in AC and highlights several RE projects that either have been completed or are ongoing in the region. It also assesses the adequacy of the current national institutions responsible for RE development and evaluates the effectiveness of regional and international organizations supporting RE initiatives. Finally, the paper identifies significant obstacles that hinder the large-scale integration of RE into the energy markets of AC, offering recommendations for increasing RE contributions.

***Keywords*---**Renewable Energy, Arab Countries, Sustainable Growth, Energy Markets, Integration.

1. Introduction

Arab countries (AC) span a vast region, extending from West Asia to North Africa, with a population of approximately 270 million in 1999. Around 60% of this population resides in ESCWA countries, while the remaining 40% live in other

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Arab nations in Africa (excluding Egypt). Many AC still have substantial rural populations with limited access to essential services, including electricity. For example, only 15% of rural areas in Morocco have access to electricity, and sanitation in rural Jordan was accessible to only 2% of the population in 1995. These challenges highlight the critical need for renewable energy solutions to support sustainable development, particularly in rural areas.

In addition to rural development challenges, rapid population growth and increasing development pressures are exacerbating water scarcity in AC. With high demands for groundwater and surface water, which often exceed available supplies, water-related issues are expected to intensify in the future. This situation underscores the importance of renewable energy in supporting desalination efforts and addressing water resource needs.

Furthermore, although global environmental concerns like climate change are not a primary focus in AC, the impact of greenhouse gas (GHG) emissions from sectors such as power and transport is becoming increasingly significant. In 1999, CO2 emissions in AC totaled 986 million tons, with large variations between countries. For instance, Saudi Arabia emitted 271 million tons of CO2, while Somalia only emitted 0.6 million tons. The per capita CO2 emissions in AC ranged from 0.06 tons in Somalia to as high as 52 tons in Qatar; These figures emphasize the need for clean technologies utilizing renewable energy sources to help mitigate climate change and promote environmental sustainability in AC.

Problem Statement

Despite the abundant availability of renewable energy resources in Arab countries, such as solar, wind, and biomass, their integration into national energy strategies remains limited. This is evident in the underutilization of these resources, lack of advanced technologies, and slow adoption of renewable energy projects. While some Arab nations have initiated policies to promote renewable energy, challenges such as high costs, low public awareness, and inadequate infrastructure persist. Addressing these challenges is crucial to harness the potential of renewable energy and meet the growing energy demands sustainably.

Research Question

How can Arab countries effectively integrate renewable energy resources into their national energy strategies to achieve sustainable energy development?

2. RE development as part of national energy-planning

Energy (RE) resources, including hydro, solar, wind, and biomass. Despite the promising data presented in Tables 1–4 regarding solar and wind energy resources, biomass potential, and the status of hydropower stations in AC, RE has never been a priority for Arab governments. Over the past two decades, most RE activities in AC were mainly linked to the R&D efforts of academic communities and were not considered an integral element of national energy planning (ESCWA, 1999, pp. 45–47).

In all Arab countries, universities, research centers, and departments within relevant ministries such as energy, electricity, water, and environment mainly handle renewable energy development. A few countries, including Egypt, Jordan, Syria, Libya, Morocco, and Tunisia, have taken steps towards formulating policies and plans for RE development (Hegazi, 1999, p. 12).

In the early 1980s, the Egyptian government formulated a national strategy for the development of RE applications and energy conservation measures as an integral part of its national energy planning. The strategy has been periodically reviewed, and its current targets are: (1) to save 10% of the projected primary energy consumption by 2007 through energy conservation measures and efficiency improvements of existing facilities; and (2) to develop RE technologies to supply 3–5% of national primary energy needs by 2007, primarily from wind, solar, and biomass.

Similarly, Jordan's national strategy aims to: (1) develop local energy resources and technologies to supply 28% of national primary energy needs by 2010; and (2) improve energy efficiency and promote energy conservation. Likewise, Syria's national strategy aims to achieve 5% of the country's total energy consumption from solar and wind resources by around 2010.

In African Arab countries (excluding Egypt), even though countries like Libya have extensive oil reserves that could meet all energy needs, decision-makers have set higher goals by requiring that the share of renewable energy increase by 10% in the coming years. In Tunisia, the goal is to improve living conditions in rural areas by fully electrifying these areas by 2010, with 3% of the supply coming from solar photovoltaic (PV) systems. An extensive, decentralized rural electrification project has been underway since 1995, benefiting from both national and international financial support.

In Morocco, the government plans to raise the rural electrification rate from 21% in 1994 to 60% in 2003. To achieve this, the government plans to electrify 550,000 rural households, spending $153 million annually. The National Office of Electricity (ONE) is focusing on solar power and building wind farms throughout the country.

Table 1: Solar Energy Resources (kWh/m²/day)

COUNTRY	SOLAR ENERGY (KWH/M²/DAY)
ALGERIA	5–7
BAHRAIN	5–8
EGYPT	5–9
IRAQ	5–6
DJIBOUTI	4–6
JORDAN	5–7
KUWAIT	5–8
LEBANON	4–6
LIBYA	5–7
MAURITANIA	6
MOROCCO	5–7

COUNTRY	SOLAR ENERGY (KWH/M²/DAY)
PALESTINE	4–6
OMAN	5–6
QATAR	5–6
SAUDI ARABIA	6–8
SUDAN	5–8
SOMALIA	6–9
SYRIA	5–6
TUNISIA	5–7
UNITED ARAB EMIRATES	5–6
YEMEN	4–6

Source: (R. Chedid, F. Chaaban, 2003, p. 214)

This table highlights the solar energy potential across Arab countries, revealing significant variations in solar irradiation levels. The highest values are observed in Egypt (5–9 kWh/m²/day) and Somalia (6–9 kWh/m²/day), which demonstrate substantial potential for solar energy projects. Most countries exhibit ranges between 5–8 kWh/m²/day, indicating a strong capacity for leveraging solar energy to meet increasing energy demands. Lower ranges, such as in Djibouti (4–6 kWh/m²/day), suggest moderate solar potential that could still support small-scale or hybrid solar projects.

Table 2: Wind Energy Resources (m/s)

COUNTRY	WIND SPEED (M/S)
ALGERIA	2.8–4.1
BAHRAIN	5–6
EGYPT	4–10
IRAQ	-
DJIBOUTI	4–5
JORDAN	5.5–7.5
KUWAIT	5–6.5
LEBANON	3–5
LIBYA	3–6
MAURITANIA	6–7
MOROCCO	5–8
PALESTINE	3–5
OMAN	4–6
QATAR	5–7
SAUDI ARABIA	4.5–6.5
SUDAN	5–6.5
SOMALIA	5–7
SYRIA	4.5–11
TUNISIA	5–6
UNITED ARAB EMIRATES	3.5–4.5
YEMEN	4–6.6

Source: (R. Chedid, F. Chaaban, 2003, p. 214)

Wind energy potential is outlined, with notable differences between countries. Egypt and Syria show remarkable wind speeds, reaching up to 10 and 11 m/s, respectively, making them ideal for large-scale wind energy developments. Other countries, such as Mauritania and Morocco, demonstrate moderate potential (5–8 m/s), suitable for both onshore and offshore wind farms. Lower wind speeds, such as in Lebanon (3–5 m/s) and UAE (3.5–4.5 m/s), indicate limited wind energy viability, although small-scale solutions might still be feasible.

Table 3: Biomass Energy Resources (Mtoe/year)

COUNTRY	BIOMASS POTENTIAL (MTOE/YEAR)
ALGERIA	1.66
BAHRAIN	0.14
EGYPT	3.9
IRAQ	6.3
DJIBOUTI	-
JORDAN	0.74
KUWAIT	0.37
LEBANON	0.59
LIBYA	0.127
MAURITANIA	0.107
MOROCCO	4.8
PALESTINE	0.015
OMAN	0.47
QATAR	0.07
SAUDI ARABIA	3.0
SUDAN	3.9
SOMALIA	0.35
SYRIA	1.24
TUNISIA	0.18
UNITED ARAB EMIRATES	0.33
YEMEN	3.5

Source: (R. Chedid, F. Chaaban, 2003, p. 214)

This table presents biomass potential, with Egypt and Sudan (3.9 Mtoe/year) and Iraq (6.3 Mtoe/year) showing the highest capacity. These figures reflect the significant role agricultural residues and waste-to-energy projects could play in these countries. Conversely, nations like Palestine (0.015 Mtoe/year) and Libya (0.127 Mtoe/year) exhibit minimal biomass potential, limiting their reliance on biomass for energy production but suggesting opportunities for niche applications.

Table 4: Installed and Potential Hydropower in Selected Countries (MW)

COUNTRY	INSTALLED HYDROPOWER (MW)	POTENTIAL HYDROPOWER (MW)
EGYPT	2805	8520
IRAQ	2620	-
JORDAN	7	50
LEBANON	283.1	533

COUNTRY	INSTALLED HYDROPOWER (MW)	POTENTIAL HYDROPOWER (MW)
SYRIA	1505	1236
TUNISIA	66	-
MOROCCO	1205	-
ALGERIA	274	-
MAURITANIA	61	-
SUDAN	303	-

Source: (R. Chedid, F. Chaaban, 2003, p. 217)

Hydropower resources are assessed, highlighting a disparity between installed and potential capacities. Egypt leads with 2805 MW of installed capacity, with the potential to expand up to 8520 MW, displaying significant opportunities for scaling hydropower projects. Lebanon and Syria also exhibit notable potential increases. However, countries like Tunisia, Jordan, and Algeria report low installed capacities with limited data on potential, underscoring the need for further exploration and investment in hydropower infrastructure.

3. Renewable-Energy Activities

- RE Technology Demonstration

Various renewable energy (RE) technologies have been demonstrated in Arab Countries (ACs) through bilateral and multilateral cooperation programs. These include domestic solar water heaters (DSWH), solar industrial process heat (SIPH) systems, photovoltaic (PV) rural systems, and wind turbines. However, biomass resources remain underutilized, and advanced biomass technologies have not yet been developed in ACs. Hence, this section focuses on solar and wind energy technologies (Regional Renewable Energy Profile, 2001).

- Domestic Solar Water Heaters (DSWH)

Domestic Solar Water Heaters (DSWH) have been implemented in several ACs with varying levels of adoption. In Egypt, 200,000 units are operational, saving approximately 80,000 tons of oil equivalent (toe) annually (Egyptian Ministry of Electricity and Energy, 2003). In Syria and Jordan, the number of installed DSWH units is estimated at 15,000–20,000 and 200,000, respectively (MEER, 1996).

In Tunisia, hot water demand is expected to grow in both domestic and tertiary sectors by 2010, with a potential of 1.5 million m^2 of solar water heaters. To date, 32,000 m^2 of collectors have been installed, and Tunisia aims to reach 1 million m^2 of solar collectors by 2010, saving approximately 100,000 toe annually and preventing the release of 300,000 tons of carbon dioxide (MEER, 1996).

- Solar Thermal Electricity Generation

The most advanced solar thermal power plant in the region is located in Egypt, where a 150 MW integrated solar combined cycle system is under development. This system uses parabolic trough solar technology integrated with a conventional gas turbine cycle and is financially supported by the Global Environment Facility (World Bank, 2002). In Morocco, a proposed 50 MW solar power plant at Ouarzazate has been postponed, while a 180 MW solar thermal plant at Ain Beni Mathar is under planning (United Nations Environment Programme, 2001).

- PV Systems

Photovoltaic (PV) systems have seen limited adoption in ACs due to high initial costs and low public awareness. The total installed capacity across ACs is approximately 10 MW, distributed among countries such as Egypt, Jordan, Syria, Palestine, Saudi Arabia, Tunisia, Morocco, and Algeria. In Egypt, notable projects include over 10 water-pumping systems and rural electrification initiatives (Shalaby, 1999). Tunisia has implemented PV systems in 9,000 households and 200 schools, with panels rated at 100 watts, sufficient for basic energy needs (Jemal, 1997).

3.5 Wind-Energy Systems

Wind energy has made significant contributions to some ACs. In Egypt, projects such as the Ras Ghareb wind farm (400 kW) and the Hurghada wind farm (4.8 MW) demonstrate this potential (Aboel-Naga, 1998). Tunisia plans to connect 2,000 MW of wind farms to its national grid by 2010, with the Sidi Daoud wind farm (10 MW) being one example (MEER, 1996). Morocco has also prioritized wind energy, with the Koudia el Beida wind farm (50 MW) beginning operations in 2000 (World Bank, 2000). For further insights and data, see sources such as the Energy Information Administration (2001), Al-Khatib (1998), and ESCWA (2001).

Table 5: Renewable Energy (RE) Demonstration Activities in Selected Arab Countries (AC)

COUNTRY	TECHNOLOGY	TYPE OF DEMONSTRATION	INSTALLED CAPACITY	APPLICATIONS
EGYPT	Solar Water Heaters (DSWH)	Domestic, Industrial, and Commercial Use	200,000 units in operation	80,000 toe saved annually
SYRIA	Solar Water Heaters (DSWH)	Domestic and Industrial Use	15,000–20,000 units	-
JORDAN	Solar Water Heaters (DSWH)	Domestic and Industrial Use	200,000 units	-
SAUDI ARABIA	Solar Water Heaters (DSWH)	Domestic and Industrial Use	Various designs developed	-
TUNISIA	Solar Water Heaters (DSWH)	Domestic and Industrial Use	32,000 m² of captors installed	Estimated to reach 1 million m² by 2010, saving 100,000 toe annually
EGYPT	Solar Thermal Power	Integrated Solar Combined Cycle System (Parabolic Trough)	150 MW under implementation	Expected to start operation in early 2003
MOROCCO	Solar Thermal Power	Potential Solar Power Plant	50 MW (postponed)	Planning 180 MW solar thermal plant at Ain Beni

COUNTRY	TECHNOLOGY	TYPE OF DEMONSTRATION	INSTALLED CAPACITY	APPLICATIONS
				Mathar
EGYPT	Photovoltaic (PV) Systems	Water Pumping, Village Electrification	Total capacity: 2 MW	10 water-pumping projects, 200 kWp farm electrification
SYRIA	Photovoltaic (PV) Systems	Water Pumping, Pilot Projects for Desalination, Village Electricity	80 kWp	-
JORDAN	Photovoltaic (PV) Systems	Emergency Systems, Water Pumping, Rural Electrification	160 kWp	Emergency telephones, minimal energy supply for remote areas
TUNISIA	Photovoltaic (PV) Systems	Rural Electrification (Households and Schools)	9,000 households, 200 schools	PV solar panels with 100 W capacity for basic needs
MOROCCO	Photovoltaic (PV) Systems	Water Pumping, Rural Electrification, PV Production Line	5 MW	300 PV pumps installed, 11 million people electrified
SAUDI ARABIA	Photovoltaic (PV) Systems	Solar Village, Research and Development	Various applications	PV-based systems: pumping, desalination, telecommunication
EGYPT	Wind Energy	Water Pumping, Electricity Generation	400 kW (Ras Ghareb), 4.8 MW (Hurghada)	Hybrid wind/diesel systems for ice-making
JORDAN	Wind Energy	Water Pumping, Electricity Generation	1,620 kW total	Mechanical and electrical wind pumps, Danish wind plant
TUNISIA	Wind Energy	Wind Farms, National Grid Integration	10 MW (Sidi Daoud)	Wind farm projects aimed at 2,000 MW by 2010
MOROCCO	Wind Energy	Wind Farms, National Grid Integration	50 MW (Koudia el Beida)	Large-scale wind farms planned for Tangier and Tarfaya

Source: Prepared by the researcher

Solar Water Heaters (DSWH): Demonstrated in several countries such as Egypt, Syria, Jordan, and Tunisia, contributing significantly to reducing energy consumption. Egypt, for instance, has 200,000 units in operation, saving approximately 80,000 tons of oil equivalent (toe) annually.

Solar Thermal Power: Egypt has implemented a large-scale 150 MW solar thermal combined cycle system, while Morocco has planned several solar thermal power plants, though some projects have been postponed.
Photovoltaic (PV) Systems: PV systems have been demonstrated for rural electrification, water pumping, and emergency systems, with significant installations in Tunisia, Morocco, and Egypt.
Wind Energy: Wind energy projects, especially in Egypt, Jordan, and Tunisia, focus on water pumping and electricity generation. Tunisia aims for a total capacity of 2,000 MW from wind energy by 2010.
These demonstration activities highlight the progress made in harnessing renewable energy (RE) technologies, particularly in solar and wind energy, across various Arab countries.

Conclusion

Arab countries face significant challenges, including rural development gaps, water scarcity, and environmental pressures, that necessitate the integration of renewable energy (RE) solutions. Limited access to essential services like electricity in rural areas, coupled with the demands of rapid population growth and climate-related concerns, highlight the urgency of adopting sustainable energy strategies. Despite their reliance on fossil fuel resources, AC have substantial potential to harness RE technologies to support development, mitigate greenhouse gas emissions, and improve the quality of life for their populations. Based on the study, the researcher has reached several findings, including:

- A significant portion of rural populations in AC lack access to electricity and sanitation, underscoring the need for decentralized RE solutions.
- Increasing demand for water resources in AC, combined with limited supply, calls for innovative RE-based desalination and water management systems.
- The disparities in CO2 emissions across AC demonstrate the critical role of RE in reducing the environmental footprint of power and transport sectors.
- Despite existing challenges, AC possess untapped RE resources such as solar and wind energy, which, if utilized effectively, could drive sustainable development.

Accordingly, the researcher has proposed a set of recommendations, including

- Governments should prioritize the deployment of solar, wind, and biomass systems in rural areas to improve electricity access and support agricultural productivity.
- Integrating RE into desalination and irrigation projects could alleviate water scarcity issues and ensure sustainable resource use.
- To mitigate greenhouse gas emissions, AC should expand the use of RE technologies in the power and transport sectors while reducing dependency on fossil fuels.
- AC should strengthen partnerships with international and regional organizations to share expertise, attract funding, and facilitate large-scale RE projects.
- Public awareness campaigns and workforce training programs should be implemented to foster acceptance of RE technologies and enhance the local talent pool in the energy sector.

By addressing these key areas, AC can accelerate their transition to renewable energy systems, achieving both sustainable development goals and long-term energy security.

Reference

R. Chedid, F. Chaaban. (2003). Renewable-energy developments in Arab countries: a regional perspective. *Applied Energy*(07), 211-220.

ESCWA. (1999). *Survey of economic and social developments in the ESCWA region 1998–1999*. United Nations Publication.

Hegazi, A. (1999, February 16–18). Renewable energy: An option for sustainable development in the Arab states. Paper presented at the Middle East and North Africa International Energy Congress, Cairo.

ESCWA. (2001). *Regional renewable energy profile*. Energy Issues Section.

Al-Khatib, H. (1998). Renewable energy in the Arab world. *Oil and Arab Cooperation, 24*(85).

Energy Information Administration. (2001). *International energy database*.

Renewable Energy Focus. (2001). Renewable energy developments. Retrieved November 2001, from www.re-focus.net/wnov2001_3.html

Cité de l'Énergie. Renewable energy projects. Retrieved from www.citet.nat.tn/english/energies

Energy Information Administration. Morocco energy profile. Retrieved from www.eia.doe.gov/emu/cabs/morocco.html

GTZ. Wind energy projects in Morocco. Retrieved from www.gtz.de/wind/deutsch/projekte/morocco.htm

Climate Ark. (2000). Algeria renewable energy initiatives. Retrieved from www.climateark.org/articles/2000/1st/algforce.htm

Ministry of Energy and Mines, Algeria. Energy presentation. Retrieved from www.mem-algeris.org/energie/presentation.htm

Arabic News. (2001, November 9). Renewable energy projects in Arab countries. Retrieved from www.arabicnews.com/ansub/Daily/Day/011109/2001110921.html