

RENEWABLE ENERGY POTENTIAL IN THE ARAB REGION

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Summary

This chapter covers current status, key trends, and the potential of renewable energy in the Arab region. The Arab world extends for thousands of miles from the tip-east in the Arabian Gulf to the Atlantic Ocean in tip-west, and from the mountains of Syria and Lebanon until the tropical plateau of Somalia, an area of over 14.2 million km², accounting for about 10% of inhabited global land and home to more than three hundred million people, representing 5% of the world's population, with around 1472 billion dollars Gross National Product, GDP, representing 3.3% of global GDP.

Arab States have made great efforts to develop its energy sector to meet the continuous increase in the energy demand, as they are still at the stage of growth, expansion in infrastructure construction and industrial applications are still growing. Also, the region is characterized by special nature as it is rich with fossil fuel sources; oil and natural gas, in addition it has a huge potential of renewable energy resources; such as solar, wind and biomass energies. Currently, the main source of energy supplies are oil and natural gas which represents around 96% of electricity generated in year 2009 (Arab Union for Electricity, 2010). Meanwhile, renewable energy sources share with about 4% of electricity generation.

Current activities of renewable energy in the Arab region could be summarized in establishing around 1000 MW of wind energy farms already in operation, three solar thermal power plants are under construction in Algeria, Egypt, and Morocco. Also, biomass is used in traditional forms to meet a portion of energy requirements.

Moreover, eleven Arabian countries already announced their future targets of generating energy from renewable energy resources. According to these targets, it is expected to increase the share of renewable energy in the electricity portfolio to around 6% by the year 2020.

On the other hand, Arab countries electricity demand has increased rapidly, almost doubling in size in the last 20 years. It continues to increase by up to 7% yearly, which makes it one of the fastest growing power markets in the world. This growth mainly reflects rapid population and economic growth, as well as social development and urbanization.

Currently there is a clear political commitment towards a more sustainable energy sector and enhancing the sector's contribution to the achievements of sustainable development in the developing countries in general and in the Arab region also. This could be noticed in the steps taken on the national level.

According to the study, it has been found that, financing schemes applied for clean energy projects in the region had passed through three phases: the first one is the Grant Phase, which was applied in late eighties and early nineties, the second one is Self-

Finance/Grant Phase; and it has been practiced from the middle of nineties until the beginning of the Millennium, meanwhile the last one, Self-Finance Phase, has been applied during the last ten years. The source of the grant portion used in these phases was introduced from foreign agencies –in the form of- governmental agreements, most of which are from European partners. These phases helped in paving the road for wind and solar applications in the Arab region. It is expected that, without applying these schemes for future RE projects, doubts in revolutionizing energy sector in the Arab countries will increase to be more than realities, especially local loans are available on a commercial-basis; high interest rate and short repayment period, which in turn will affect the projects profitability.

In addition, this study proves that the potential of wind, solar, and biomass energy resources could be used in a commercial scale by building renewable power stations in order to meet a portion of the growing daily demand.

1. Introduction

Renewable Energy, RE, supplies around 19% of global final energy consumption, counting traditional biomass, large hydropower, and other renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels), as shown in Figure 1. Out of this 19%, traditional biomass, used primarily for cooking and heating, accounts for approximately 13% and is growing slowly or even declining in some regions as biomass is used more efficiently or is replaced by more modern energy forms. Meanwhile, hydropower represents 3.2% and is growing modestly but from a large base. Other renewables account for 2.6% and are growing very rapidly in developed and emerging countries rather than in developing countries (REN21, 2010).

Many of the current trends reflect the increasing significance of renewable energy. In a number of countries, renewables represent a certain share of total electricity supply. Changes in renewable energy markets, investments, industries, and policies have been so rapid in recent years that perceptions of the status of renewable energy can lag years behind the reality.

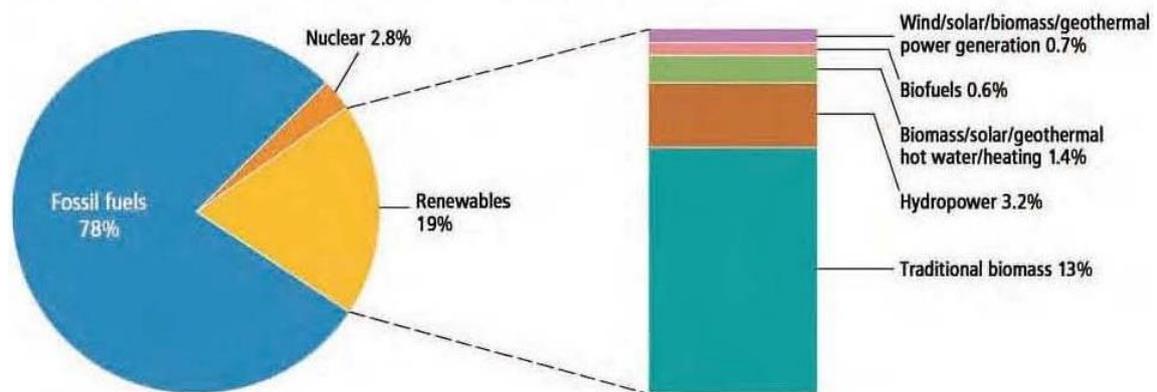


Figure 1. Renewable Energy Share of Global Final Energy Consumption, 2008.

The Arab States have made great efforts to develop its energy sector to meet the

continuous increase in the energy demand, as they are still at the stage of growth, expansion in infrastructure construction, industrial.. etc). Also, it is characterized with special nature, the region is rich with fossil fuel sources; oil and natural gas, in addition it has a huge potential of renewable energy resources; such as solar, wind and biomass energies. Currently, the main source of energy supplies are oil and natural gas which represents around 96% of electricity generated in the year 2009 (Arab Union for Electricity, 2010). Meanwhile, RE sources share with about 4% of electricity generation.

Work on energy security and caring of environmental basis require increasing the role of RE in the Arabian energy sector. Especially, most of these countries enjoy high radiation of solar energy and wind speed suitable to establish commercial power plants.

Current activities of RE in the Arab region could be summarized in establishing around 1000 MW of wind energy farms already in operation, three solar thermal power plants are under construction in Algeria, Egypt, and Morocco. Also, biomass is used in traditional forms to meet a portion of energy requirements.

Moreover, eleven Arabian countries already announced their future targets of generating energy from RE resources. According to these targets, it is expected to increase the share of RE in the electricity portfolio to around 6% by the year 2020.

1.1 Research Problem and Objectives

Renewable energy has a wider scope related to sustainable development; security of energy supply, reasonable cost, and saving environment. The challenge for countries is to allow a balanced growth while realizing sustainable development; this is the most important constraint of the 2010s not only for Arabian countries but also for most of the developing countries.

Examining the current situation and future perspectives for energy demand reveals that renewable energies and energy efficiency in the region are two of the most promising development paths in terms of electricity generation and domestic usages. Renewable energy and energy efficiency will relieve some of the economical burdens of oil-dependency through expanding the lifetime of existing fossil resources and/or reducing the need to import energy. Furthermore, they have an obvious effect on pollution reduction and mitigation of greenhouse gases, GHGs. Within the regional context; the existing potentials of RE resources can contribute in achieving sustainable energy aspects.

Also, it will add a new dimension for regional cooperation for the favor of all countries in the region. As oil prices rise, alternative-energy resources like hydrogen fuel cells, now much more expensive than fossil fuels, will become more cost effective. In addition, it can create opportunities for clean energy trade and greening the economy.

1.1.1. Research Problem

Arab region is distributed into two continents; Africa and Asia. The main use for RE

resources, mainly wind energy and hydropower applications, are located in the African part. The total installed capacities and the maximum demand in year 2009 have reached 171GW and 115GW, respectively. For the renewable portion, hydropower represents 3.4% of the electricity generation, meanwhile wind shares with 0.2%.

Globally, the share of the region's production in oil and gas fields is increasing continuously, and it is expected to reach 49% and 24% of both sources, respectively, in 2030.

The annual average growth rate of energy demand ranges from 6% to 7% for the last five years in the region, this means that there is a need to establish new capacities range from 10 to 12 GW yearly. Consequently, it is required to diversify the energy portfolio and convert it from fossil-fuel-oriented to fossil-fuel-and-RE-oriented.

Consequently, studying the potential of renewable energy in the Arab states and check its availability to work in commercial-basis is an urgent issue, which could be considered as one of the strategic components of each country and the region as well.

As a result, the current paper is focusing on defining the potential of RE in the Arab region, discussing the role of wind, solar, and biomass applications to secure certain amount of the future energy needs. Moreover, it concentrates on studying the role of both private and public sectors in promoting RE applications. Besides, it takes also the current incentives and the proposed mechanisms to enhance and accelerate the rate of using renewable energy applications, and the situation of localizing RE technologies.

1.2. Research Objectives

- Introduce a brief profile of the regional energy image.
- Define the potential of renewable energy resources.
- Illustrate regional strategies, policies, and laws adopted to promote RE technology
- Apply in the region
- Analyze financing schemes for RE projects
- Discuss options for greening economy in the region.

2. Energy Demand

In general, energy services stretching beyond the direct uses - which include heating, cooking and lighting - to the package of the fundamental pillars of development, as the electricity offer many services that can be obtained at any time, which is reflected in increasing working hours, productivity, and other energy images. The growth rate of energy consumption in the Arab states for the year 2008 could be classified into the following three categories:

- (1) More than 6%: it includes three countries, namely Libya 7.5%, Qatar 6.8%, and Kuwait 6.1%.
- (2) From 3% to 5%: includes six countries: Saudi Arabia 4.7%, Tunisia 4.5%, Syria 4.3%, United Arab Emirates 3.9%, Algeria 3.8%, and Iraq 3.7.
- (3) Less than 3%: Egypt 2.5% and Bahrain 2.2%.

The disparity in the rate of energy consumption between Arab countries back to the following main reasons:

- The achieved level of progress in both economic and social development,
- The population,
- Energy imports dependency level,
- The reserves of hydrocarbons, and
- The natural and climatic conditions.

Both industrial and transportation sectors are the major energy consumption sectors with 42.6% and 32.9%, respectively.

3. The Current Situation of Renewable Energy

Activities for renewable energy applications in the Arab region include hydropower, wind energy, solar energy, biomass, and geothermal energy. Hydropower represents the major share of these RE resources.

Country	Existing RE Capacities	
	Wind (MW)	Hydro (MW)
Algeria	0	228
Egypt	550	2800
Iraq	0	2513
Jordan	1.4	12
Kuwait	0	0
Lebanon	0	13
Libya	0	0
Morocco	255	1730
Sudan	0	1342
Syria	0	1151
Tunisia	160	66
United Arab Emirates	0	0
Total (MW)	966.4	9855

Table 1. Share of Electricity from Renewables and Existing In 2010

In the same context, Table 1 shows the share of RE sources of electricity in the Arab countries for the year 2010. As shown in this table, most of these countries have minor share of wind energy in producing electricity. Meanwhile, despite there are three solar thermal power plants are under construction in the region, solar energy still absent in the electricity portfolio until Oct. 2010. In addition Table 2 illustrates the details of RE applications in the region, including projects under construction.

Country	SOLAR				WIND		Biomass	Hydro
	DSWHs	SIPH	PV	EG	EG	Pumping		
Algeria	x		x	(x)				x
Bahrain			x					
Egypt	x	x	x	(x)	x	x	x	x
Iraq								x
Jordan	x		x		x	x	x	x
Kuwait			x					
Lebanon	x		x			x		x
Libya	x				(x)			
Morocco	x		x	(x)	x	x	x	x
Oman			x					
Qatar			x					
Saudi Arabia			x					
Sudan								x
Syria	x		x			x	x	x
Tunisia	x		x		x			x
United Arab Emirates	x		x				(x)	
Yemen			x					
Abbreviations								
DS WH	Domestic Solar Water-Heaters		EG	Energy Generation				
PV	Photovoltaic		SIPH	Solar Industrial Process Heat				
(x)	Under- construction project(s).							

Table 2. RE activities in the Arab countries

3.1. Hydropower

Hydropower relies on the water cycle, which is driven by the sun, thus its a renewable power source. So, it is a clean source of energy, it doesn't pollute the environment like thermal power plants that burn fossil fuels, such as coal or natural gas.

Most of hydropower potential in the Arab region has been exhausted and the total installed capacities of hydropower reached 9855 MW, as shown in Fig. (2), (Arab Union for Electricity 2010).

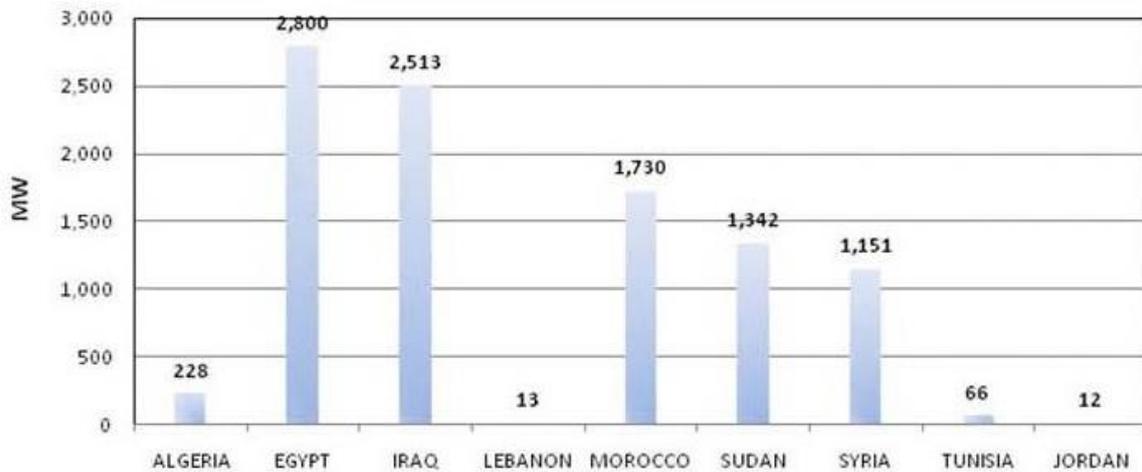


Figure 2. Hydropower in the Arab Countries

3.2. Wind Energy

Wind energy in the Arab region has reached 966 MW in Oct. 2010. Installed capacities are concentrated in Egypt, Morocco and Tunisia, as shown in Figure (3). The contribution of energy generated from wind power plants represents around 0.20% of the total electricity generated in the Arab nations. Wind energy projects are grid-connected.

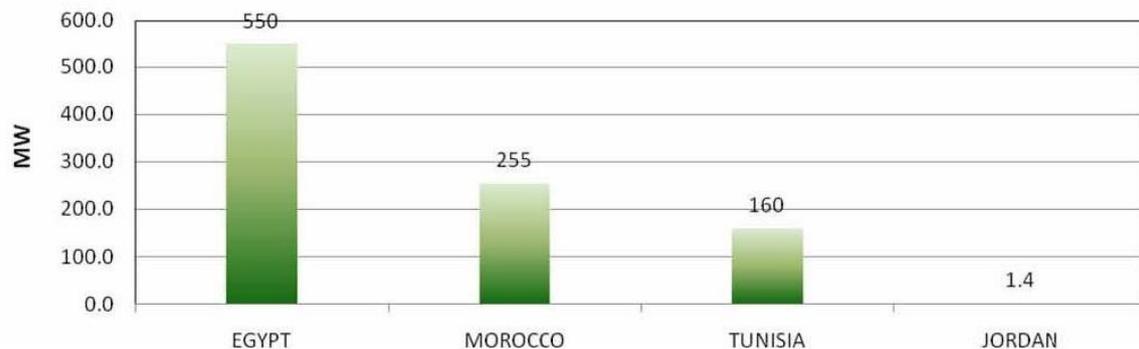


Figure 3. Wind Energy in the Arab Countries

3.3. Solar Energy

Since many years and based on the concept which says “Sun is available in large scale”, experts had expected that solar energy will remove oil as a main fuel, but results - until now - has been disappointing this expectation. Arab countries enjoy with total solar

radiation of between 4-8 kWh/m²/day, the direct solar radiation ranges between 1700 to 2800 kWh/m²/year, and the clouds ranging from 10% to 20% over the year. These ranges open the doors for the commercial applications.

Domestic Solar Water Heaters, DSWHs, were demonstrated in many Arab countries, such as Tunisia, Algeria, Palestine, and Jordan, with different penetration levels, types, capacities and fields of applications. The total capacities of DSWHs are not related to the huge solar potential available in the region. In order to get industry fully involved in the development of solar water heaters, national laws are needed to promote it.

Solar water heating systems and water desalination based on solar energy are used in some of the Arab countries, with different ratios, as in United Arab Emirates, Syria, Lebanon, Palestine, Jordan, and Egypt. Consequently, factories and workshops for manufacturing these systems are distributed in these countries. Furthermore, the most important development for the use of solar energy in the Arab states is login of electricity generating systems based on solar energy into practice. There are three solar thermal power stations are under construction in three Arab countries, Algeria, Egypt, and Morocco.

The most abundant and widely accessible, but least tapped form of energy on earth is solar radiation on deserts. The world's hot deserts cover around 36 Million km² (UNEP, 2006) of earth's land surface with 14 Million km² in the Arab region, around 39% of the global available hot desert. The solar radiation falling on Arab desert area is estimated at 88,219 TWh per day (assuming annual irradiation of 2300 kWh per m² per year) which is a vast amount. Therefore, from the theoretical point of view, the solar energy resource in the Arab region can supply not only the energy needs of the Arab people but also meet global energy needs to some extent. In other words: Any conceivable global demand for energy, today or in future, could be met from solar energy in deserts (Darwish Al-Gobaisi, (2010)).

The Average solar radiation potential (Equivalent Electric Energy = $2.35 \times 0.15 = 0.3525$ TWh/km²/year) for the desert surfaces in the Arab Region is around 0.3525 TWh/km²/year. Total Solar Thermal Energy (Total Solar Thermal Energy = $14 \times 10^6 \times 0.87 \times 2.35$ TWh/km²/year= 28.623 million TWh/year) falling on the Arab land is approximately 28.623 million TWh/year or 17889 billion barrels of oil equivalent (BOE) annually. This renewable annual amount is about 27 times the total existing Arab oil reserves, 650 billion barrels, which are non renewable, (Al Gobaisi et al 2010)

3.4. Biomass and Geothermal Energy

Biomass is a source of energy that is commonly used in past centuries, especially before the advent of oil. Biomass consists of local materials; such as crop residues, wood, animal dung ... etc. Despite the fact that many countries in the world has moved from the use of this source to fossil fuels, especially with oil production, biomass is still the only source of energy for more than 2 billion people, most of whom live in South Asia and Central Africa. The estimated yearly amounts of biomass is nearly 1110 million tons of oil equivalent, mote, constitutes about 10% of the primary sources of the global energy consumption, about 11500 mote.

Geothermal and biomass potentials are distributed very unevenly among Arab countries. Egypt was evaluated as having the largest potential in the range of 50 TWh/y, followed by Algeria, Morocco and Syria with significantly lower potentials. Yemen is in a favorable condition to use geothermal heat for power production in the range of 100 TWh/y, which is much more than current electricity consumption. Egypt and Morocco have some potential for geothermal power production (RCREEE 2010).

Until now there is no power stations based on either biomass or geothermal resources in the Arab countries.

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Bibliography

Arab Union for Electricity (2006)

http://www.auptde.org/NewSite/user/User_Def_Ar.aspx?PID=2014&ID=127

Arab Union for Electricity (2010)

http://www.auptde.org/NewSite/user/User_Def_Ar.aspx?PID=2014&ID=149.

Darwish Al Gobaisi, Omran Sultan M. Al Halami, Bushara M., Ali El Nashar, Woldai A. and Samir Damak (2010) *The Tragedy Of Energy Policy In the Arab Region-Solar Power Versus Nuclear Power - Options For The Arab World* International Conference on Alternative and Renewable Sources of Energy, Organized by Arab Academy of Sciences(AAS) Arab Forum for Sustainability Science (AFFSS) , Beirut, Lebanon 25-26 Nov.2010. [The paper discuss about Renewable Energy versus Nuclear Energy. It presents the issue of sustainability of future energy demand satisfaction, beyond conservation of energy resources, change in the life style and efficiency of usage.]

ESCWA (1999), Survey of Economic and Social Developments in the ESCWA region, ESCWA Dis General E/ESCWA/ED/1999/5, New York, United Nations Publications.

League of Arab States, LAS, Energy Department (10 May 2010), “Towards a Pan Arab Strategy for the Development of Renewable Energy”, 8th FEMIP Conference, Energy in the Mediterranean Region: The Challenges Ahead,

Valencia.Pamela Ann Smith (June 2010), Middle East and North Africa Promoting Renewable Energy, <http://www.energytribune.com/articles.cfm/4240/Middle-East-and-North-Africa-Promoting-Renewable-Energy>.

Regional Center for Renewable Energy and Energy Efficiency, RCREEE, (2010), Policies for Energy Efficiency and Renewable Energy in the RCREEE Group of Countries.

Renewable Energy Policy Network for the 21st Century, REN21, (2010), Renewables 2010 Global Status Report. World Wind Energy Association, WWEA, (2009), “Wind Energy International 2009/2010”, ISBN:978-3-940683-01-4

Biographical Sketch

Mohammed Mostafa El-Khayat, General Manager of Planning, New and Renewable Energy Authority, NREA, Cairo, Egypt, Guest Lecturer in Mansoura University, Faculty of Engineering, and Referee in the

USA-Egypt Joint Research Committee, from Year 2003 up till now.

Ph.D. of Fluid Mechanics, Faculty of Engineering, Mansoura University, June 2002. Recognition Award from Siemens South Africa, April 2010. First Prize for “The Best Research for the Academic Year 2003/2004”, Mansoura University, June 2004. Obtained Four Honoring Certificates from New and Renewable Energy Authority, NREA.

Main Achievements

- Member of Arab Experts who are preparing the Arab Strategy for using Renewable Energy, year 2009.
- Prepared the Outlines of the Arab Strategy for using Renewable Energy for League of Arab States, LAS, year 2008.
- Performed many due-diligence studies for LAS about renewable energy in Arab countries, 2006 – 2008.
- Carried out different due-diligence studies for ESCWA/UN about manufacturing renewable energy equipment in Egypt, 2007 - 2008.
- Performed a study titled: “Renewable Energies in the North Africa Region Potentials, Markets and Strategies”, as a due-diligence study for Deutsche Gesellschaft für Technische Zusammenarbeit, GTZ.
- Shared an economic team to design and implement a Model for calculating production cost from renewable energy projects, for NREA.
- Invited speaker/panelist in many national and international conferences.
- Two lectures under the title of “Renewable Energy: The Present and Future Trends”, for Hans Seidal Foundation (German Association), Egypt Office, Sept., 2007.
- Shared in implement a feasibility study for establishing two wind farms at Saudi Arabia, Jan. 2009.
- An advisor to the Syrian Government, Owner, to install a 5-MW Wind Farm Project, Nov. 2003.
- Shared in most of the feasibility studies implemented to NREA for renewable energy projects.
- Published more than 40 studies and article about energy and environment.
- Performed many studies for the Strategic Studies Centre at Al-Ahram.
- An Editor in El-Kahraba’e El-Arabia Magazine.
- Teaching in many courses related to Energy, energy economics, and energy policies for national and regional candidates.