United Nations
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Office for North Africa

The Renewable Energy Sector in North Africa

«Current Situation and Prospect»

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Current Situation and Prospects

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This publication, published by the Sub-regional North Africa Office of the United Nations Economic Commission for Africa (UNECA) aims to give an overview of the situation and prospects for development of renewable energies in North Africa. It underlines the great potential of the region and current and future efforts to significantly increase the share of renewable energies in the energy mix and so strengthen energy security. The publication reviews policies in place and the various institutional, legislative and financial instruments set up. It proposes to analyze also the synergies and opportunities for cooperation in the region. It identifies the main barriers to the development of renewable energy and proposes ways round these obstacles.

This publication was produced by Ms Marieme Bekaye, Economist in charge of Sustainable Development, under the direction of Ms Karima Bounemra Ben Soltane, Director of the Office. This report has had the benefit of technical contributions from Mr. Smail Khennas, Energy expert, and Mr. Ramzi Abbes, student intern. The publication also took into account the comments and recommendations of the meeting of experts in Rabat (Morocco) on 12 and 13 January 2012.

The final version of this publication was revised with the help of Ms Houda Mejri, Information Manager. Editing was by Mr. Mohammed Mosseddek, Research Assistant.

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ACRONYMS AND ABBREVIATIONS

ADER	Agence pour le Développement de l'Electrification Rurale (Mauritanie)
ADEREE	Agence nationale de Développement des Energies Renouvelables et de l'Efficacité Energétique (Maroc)
AFD	Agence Française de Développement
BAD	Banque Africaine de Développement
AIE	Agence Internationale de l'Energie
ANADER	Agence Nationale de Développement des Energies Renouvelables (Mauritanie)
ANER	Agence Nationale des Energies Renouvelables (Tunisie)
ANME	Agence Nationale pour la Maîtrise de l'Energie (Tunisie)
APAUS	Agence de Promotion de l'Accès Universel aux Services de Base (Mauritanie)
APRUE	Agence pour la Promotion et la Rationalisation de l'Utilisation de l'Energie (Algérie)
BEI	Banque Européenne d'Investissement
BOOT	Build, Own, Operate and Transfer
BT	Basse Tension
CDER	Centre de Développement des Energies Renouvelables (Algérie)
CDER	Centre de Développement des Energies Renouvelables (Maroc) devenu ADEREE
CES	Chauffe-Eau Solaire
CO2	Dioxyde de Carbone
COMELEC	Comité Maghrébin de l'Electricité
CSLP	Cadre Stratégique de Lutte conte la Pauvreté
CSP	Concentrated Solar Power
CTF	Clean Technology Fund
DII	Desertec Industrial Initiative
DNI	Direct Normal Irradiance
EAPP	East Africa Power Pool
EE	Efficacité Energétique
ER	Energie Renouvelable
EREE	Energie Renouvelable et Efficacité Energétique
FNME	Fonds de l'Environnement Mondial
FNME	Fonds National de Maîtrise de l'Energie (Algérie)
FOGEER	Fonds de Garantie pour l'Efficacité Energétique et les Energies Renouvelables (Maroc)
GES	Gaz à Effet de Serre
GNL	Gaz Naturel Liquéfié
GPL	Gaz de Pétrole Liquéfié
IFI	International Financial Institution
IPCC	Intergovernmental Panel on Climate Change
IRESEN	Institut de Recherche en Energie Solaire et en Energies Nouvelles (Maroc)
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt fur Wiederaufbau
LBC	Lampes Basse Consommation

MASEN	Moroccan Agency for Solar Energy
MEDEREC	Mediterranean Renewable Energy Center
MENA	Middle East and North Africa
MHETHIC	Ministère de l'Hydraulique de l'Energie et des Technologies de l'Information et de la Communication (Mauritanie)
LOEE	Ministère de l'Energie et de l'Electricité (Egypte)
MT	Moyenne Tension
NEA	New Energy Algeria
NEC	National Electricity Corporation (Soudan)
NIF	Neighbourhood Investment Facility
NOx	Oxyde Nitreux
NREA	New and Renewable Energy Authority (Egypte)
OMS	Organisation Mondiale de la Santé
ONE	Office National de l'Électricité (Maroc)
ONEP	Office National de l'Eau Potable (Maroc)
PIB	Produit Intérieur Brut
PNME	Programme National de Maîtrise de l'Energie (Algérie)
PNUD	Programme des Nations Unies pour le Développement
PPA	Parité de Pouvoir d'Achat
PPP	Partenariat Public Privé
PSM	Plan Solaire Méditerranéen
PST	Plan Solaire Tunisien
PV	Photovoltaïque
PWMSP	Paving the Way for the Mediterranean Solar Plan Project
R&D	Recherche et Développement
RCREEE	Regional Center for Renewable Energy and Energy Efficiency
REAOL	Renewable Energy Authority of Libya
RIM	République Islamique de Mauritanie
SIE	Société d'Investissements Energétiques (Maroc)
SNIM	Société Nationale Industrielle et Minière (Mauritanie)
SO2	Dioxyde de Soufre
SMELEC	Société Mauritanienne de l'Electricité
SONELGAS	Société Nationale de l'Electricité et du Gaz (Algérie)
SPC	Solar Power Company
SSDSB	Sudanese Social Development and Savings Bank
STEG	Société Tunisienne de l'Electricité et du Gaz
UDST	Unité de Développement pour la Technologie Silicium
UE	Union Européenne
UMA	Union du Maghreb Arabe
UNECA	United Nations Economic Commission for Africa
UNEP/PNUE	United Nations Environment Program, Programme des Nations Unies pour l'Environnement
UNESCO	United Nations Educational, Scientific and Cultural Organization
WB	World Bank

Units of measurement

GW GigaWatt
GWh Gigawatt-hour
ktpe Thousand tons of petroleum equivalent
kWp kilowatt-peak
kWh KWh kilowatt hour
m^2 Square metre
Mm^3 Millions of cubic metres
Mtpe Millions of tonnes petroleum equivalent
MW MegaWatt
T Tonnes
tpe tonnes petroleum equivalent
TWh terawatt-hour

Currencies

DA Algerian Dinar
DH Moroccan Dirham
DT Tunisian Dinar
UM Mauritania Ouguiya
€ Euros
$ USD

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PREFACE

Access to energy is a strategic priority in all regions of the world. Even today, nearly 1.6 billion people do not have access to modern energy and three billion people depend on "traditional biomass" and coal as their main source of fuel. Lack of access to clean, affordable and reliable energy (the energy sector is responsible for two thirds of greenhouse gas emissions), is a brake on human and economic development; it is a major obstacle to achieving the Millennium Development Goals.

Recognizing the importance of energy for sustainable development and the fight against poverty, the General Assembly of the United Nations proclaimed 2012 as the International Year of Sustainable Energy for All in Resolution 65/151. The UN "Sustainable Energy for All" initiative set three main goals for 2030:

- Universal access to modern energy services;
- A 40% reduction in world energy intensity;
- A 30% increase in use of renewable energy in the world.

Achieving these objectives is all the more urgent as today there are 7 billion people on our planet and by 2050 world population should rise to 9.5 billion inhabitants, leading to an explosion in energy needs.

The United Nations "Rio +20" Conference on Sustainable Development held in Brazil in June 2012 reaffirmed the need to promote access for all and the poor in particular to modern and sustainable energy services. It urged greater use of renewable energy sources and other low carbon emitting technologies, more rational energy use, greater use of advanced energy technologies, including clean technologies for use of fossil fuels. To achieve these objectives, developing countries will have to mobilize sufficient financial resources, in a reliable, affordable, economically viable and acceptable way on a social and environmental level. They must create the necessary conditions for the public and private sectors to invest in less polluting and more sustainable energy technologies.

In its report on energy prospects in the Mediterranean (MEP, 2011), the OME forecasts a 40% increase in global energy demand and CO_2 emissions by 2030, while in the countries south of the Mediterranean, these increases should double by 2030 and demand for electricity will triple.

North Africa, with its rapid growth is facing an ever-increasing energy demand (of the order of 6-7% per year), in particular for electricity needs. Energy production has in this way become a major issue for the region. Given that most of the electric power stations use fossil fuels, and taking account of very high volatility of oil and gas prices, countries have had to review their energy policies and diversify the energy mix giving greater importance to renewable energies and energy efficiency, even if it is known that fossil fuel is likely to continue to dominate the energy mix (70%) with a larger share for natural gas.

On the basis of the their solar and wind capacities, the countries of North Africa have set themselves ambitious strategic objectives and launched large-scale integrated programmes which have expected benefits that involve reduction of greenhouse gas emissions, economic diversification, direct and indirect job creation, local industrial development and the improvement of human capital. Renewable energies also offer the opportunity to serve isolated regions remote from the national electricity grid and so improve access to energy for the populations, particularly the poorest.

Important reforms in the institutional, regulatory and financial frameworks have been carried out, so as to promote greater participation by the private sector and an increased level of investment. It is clear that the vital contribution of the private sector will only be possible if governments adopt robust and transparent frameworks of governance and regulation and invest in research and strengthening of capacities, to produce a leverage effect on private investment.

To complement the efforts at national level and remove obstacles associated with weak institutional, technical and financial capacities as well as with there being a limited market, it is important to strengthen partnerships between countries and specialized national businesses while taking international experience and knowhow as a basis. The ninth session of the Ministers of Energy and Mines of the AMU (Rabat, November 2010) stressed the need for countries to converge toward a common vision and strengthen cooperation, particularly with regard to the creation of an electricity market in North Africa.

A number of current initiatives such as the Mediterranean Solar Plan (MSP)[1], the Euro-Mediterranean partnership, the agreements that exist between the EU and some countries of North Africa, the DESERTEC project or the initiatives running under the AMU (COMELEC, North African platform for scientific and university research in the field of renewable energies) and the Arab League, are all forums for consultation and joint action, that may improve technical and financial cooperation for effective development of renewable energies. These partnerships offer definite prospects of increasing investments and developing projects to produce and distribute renewable energies, strengthen interconnections and create an expanding regional market for electricity.

Karima Bounemra Ben Soltane

Director of the Office

[1] The Mediterranean Solar Plan (MSP) plans 20 GW production from solar energy in North Africa by 2020 and development of the Mediterranean interconnection network which should, in the longer term, be the basis of establishing a Euro-Mediterranean network.

INTRODUCTION

Scope of the study and assumptions

This publication was produced as part of a project on innovative finance mechanisms for renewable energies, carried out by the Sub-regional North Africa Office of the United Nations Economic Commission for Africa (UNECA).

This two-year project is part of the action undertaken by the member countries to strengthen energy security, improve socio-economic conditions, promote local development and combat climate change. It has the more specific aim of promoting development of renewable energies in North Africa through the establishment of a knowledge base on innovative and sustainable finance mechanisms and strengthening of regional cooperation.

The publication gives an overview of the current situation and of development prospects for renewable energies in North Africa. It is an in-depth analysis of policies and programmes and of the institutional, legal and financial instruments put in place to support the various technologies. Stress is laid on synergies and partnership opportunities in the region, as well as in a cooperation framework with the European Union. Recommendations are made for lowering barriers to the development of renewable energies and for improving energy efficiency.

A specific chapter is devoted to the cross-cutting challenge of energy efficiency. In a context of global efforts to combat climate change and reduce their energy dependency in the face of volatile fossil fuel prices, the countries of the region must face up to the twin challenges of diversifying their energy mix and reducing their energy use.

There is real energy efficiency potential as a 10% gain in the region's energy consumption could be made via improved energy efficiency measures by 2030 (MEP, 2011). Energy efficiency policies must therefore involve and cover all sectors where there is potential for energy saving.

The report will review the situation of the various forms of renewable energy, but with a focus on solar and wind. With the exception of Sudan[2], hydro-electric potential has been to a great extent been brought into play in North Africa. Hydro-electricity is moreover a mature technology where long-term development costs will remain relatively stable, in contrast to other renewables where the potential is still poorly exploited and there is the real prospect of costs coming down and consequently of a contribution to the energy balance of the countries in the region. Biomass can only be regarded as renewable if the harvesting rate does not exceed the natural regeneration rate. Wood fuel (firewood and charcoal) plays only a marginal role in Algeria, Egypt and Libya, but is significant in the energy balance and economies of Sudan and Mauritania.

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[2] This study concerns both Sudan and newly independent South Sudan. Lack of statistics with regard to each country meant that the two countries could not be treated separately.

This study is founded on two basic assumptions:

- The increasingly fast downward trend of the price of renewables will favour the medium and long term economic and financial viability of most renewable energies compared to the services provided by fossil fuels.
- The countries of the North Africa zone along with the developed countries will continue to provide support at a political institutional and financial level for the large-scale expansion of renewables and energy efficiency (EE) measures. The analysis will provide evidence for these two assumptions.

The study comprises seven chapters:

- . The first chapter deals with the major global trends in the main renewable energy technologies, in particular the economic and technological dynamic. This part is vital for an understanding of the issues and policies in the North African region.
- The second chapter identifies the main RE development issues, and reviews the energy situation of the countries of the region and the place of renewable energies. A second section deals with potential so as to show the gap between the current situation and prospects for use of RE, even if there is only partial use of this potential.
- The third chapter is devoted to RE development strategies, and highlights development plans in this field.
- The fourth chapter deals with instruments and mechanisms for promoting RE. It analyzes the legal, regulatory and financial frameworks as the institutional dimension and finance mechanisms are vital decisive factors for large-scale development of RE. A second section looks at research and development (R&D) which is a fundamental tool for sustainable endogenous development of RE.
- The fifth chapter focuses on synergies and intra-regional partnerships, as well as those between the countries of the region and partners in the North who can offer opportunities at this stage of RE deployment for technology transfer and mobilization of financial resources.
- The sixth chapter deals with the question of energy efficiency which is a fundamental aspect of economically viable energy growth which minimizes greenhouse gas emissions. Energy efficiency is without doubt the most viable investment in demand control policies. The seventh and final chapter looks at barriers and makes recommendations for faster development of renewable energies and energy efficiency in North Africa.

The conclusion is a recapitulation of the current situation as regards renewable energies in North Africa, as well as the future of these clean energies within the region. It highlights opportunities and major advances, along with needs in terms of development strategy, legislation and financial and cooperation mechanisms.

Chapter 1
RECENT SIGNIFICANT GLOBAL TRENDS

The history of the political economy of energy shows that since hydrocarbons were discovered in 1859, the world energy scene has been marked by fuel transitions and consequently by fuel substitutions, with a movement to energy sources with lower marginal costs and/or offering more diversified services and greater user convenience. This is the explanation for the move from coal, a solid fuel, to liquid and gas hydrocarbons for many uses. It should however be noted that coal is still important in the energy balance of a number of countries especially in Asia, in particular for electricity generation on account of the very large proven reserves[3] and relatively low production costs if the environmental impact is disregarded. According to the economist Jeremy Rifkin, after steam in the 19th century, the combustion engine and electronic data transmission in the 21st century, the third industrial revolution, now under way in this author's view, will be based on the combination of renewable energies and online communication networks[4].

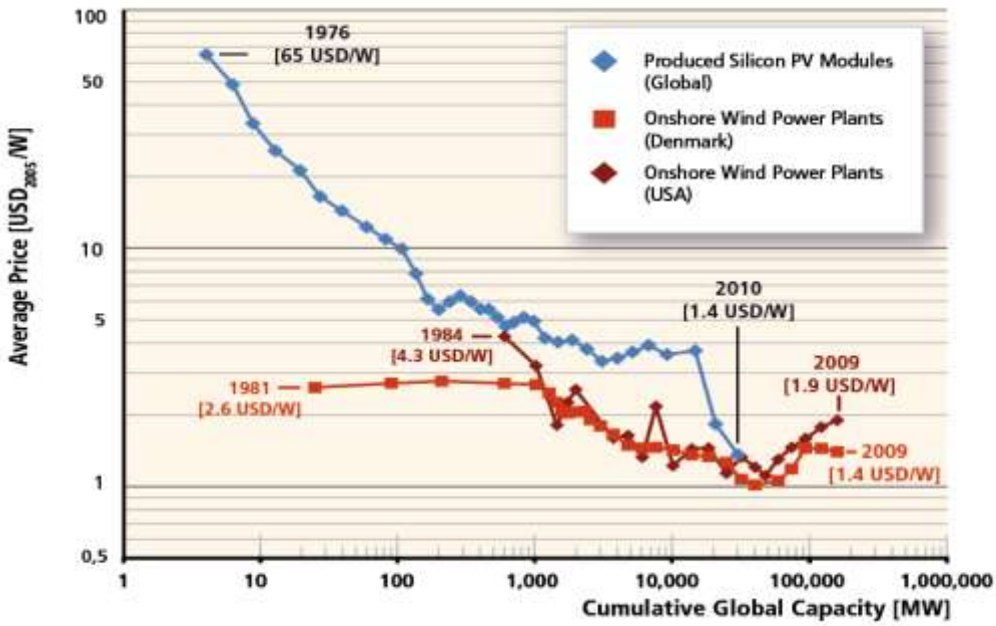
Besides the fact that they are non-renewable, fossil resources, and more particularly coal, have a greater impact on global warming than do REs. Sustainable energy development requires use of forms of renewable energy with low greenhouse gas emissions. This historic trend could be speeded up on account of the fundamental change, starting in the 1970s, of the balance of power between producer countries and the big multinational oil companies. One important factor was the considerable rise in the nominal price of crude oil as well as a fall in the reserves-production ratio, for crude oil at least, on account of the non-renewal on a like-for-like basis of world reserves. This trend along with uncertainties over nuclear electricity and the impact on climate change strongly favoured development of renewable energies. These continue to experience considerable growth in some areas and a significant price drop which moreover is connected to the growth in demand. This dynamic has opened up new prospects.

Production costs and photo-voltaic market prices have fallen greatly over the last 5 years and are now close to a breakeven point, compared to fossil fuels, for decentralized applications and for centralized applications to a lesser extent (figure 1).

[3] China and India possess respectively 13.3% and 7% of proven world coal reserves and their reserves/production ratios are 35 and 106 years. British Petroleum Statistical Review of World Energy, June 2011

[4] Rifkin, J. The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy, and the World, Palgrave Macmillan, 2011.

Figure 1: Trends in PV and wind prices and in production capacities 1976-2009[5]



Between 1976 and 2010, the average world price of a photo-voltaic Watt fell from 65 to 1.4 USD, a factor in excess of 46, while that of onshore wind in Denmark fell from 2.6 USD in 1981 to 1.4 USD in 2009, a factor of 1.85.

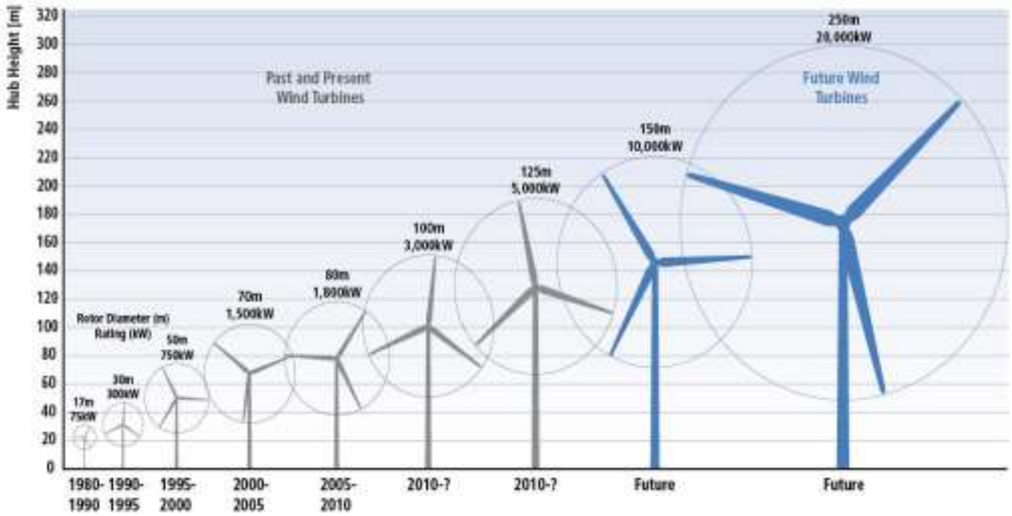
Government policies have greatly contributed to the results achieved by this technology in a number of European Union countries (especially in Germany and Italy). In this way with a total installed capacity of 51 GW by the end of 2012, the EU accounts for nearly three quarters of the world's installed PV capacity, and has enough operating solar photo-voltaic energy to meet the electricity demand of over 15 million European households. China leapt from 8th to 6th place in the world with a market which nearly quadrupled in 2011, taking its capacity to 3.1 GW.[6]

Thanks to feed-in tariff policies, there has been a significant penetration rate of wind energy in the energy balance of European Union countries. It accounts for 24% of the total electric capacity from renewable energies which is of the order of 174 GW (excluding hydro-electricity). At present China has, at world level, the largest installed base of renewable energies with 70 GW (if hydro-electricity and biomass are excluded), followed closely by the United States (68 GW) and Germany (61 GW).[7]

[5] IPCC: Intergovernmental Panel on Climate Change, Renewable Energy Sources and Climate Change Mitigation, Special Report of the IPCC, Cambridge University Press, 2011.
[6] REN21, Renewables 2012 Global Status Report, 2012, p47
[7] REN21, Renewables 2012 Global Status Report, P24-25, 2012

2011 saw an important historic milestone for Spain whose production of electricity from wind for March reached 4,738 GW, exceeding that generated from fossil fuels. Moreover the feed-in tariff is being revised as the expected results have been achieved earlier than planned. This remarkable advance of wind power is explained by the availability of very favourable sites in the countries of the North and technological progress allowing for economies of scale from the size of the units available on the market. Average capacity of a wind unit went up from 750 kW between 1995 and 2000 to 1800 kW between 2005 and 2010 (figure 2). In the near future plants of over 5000 kW are planned.

Figure 2: Change in average unit size of wind plants[8]



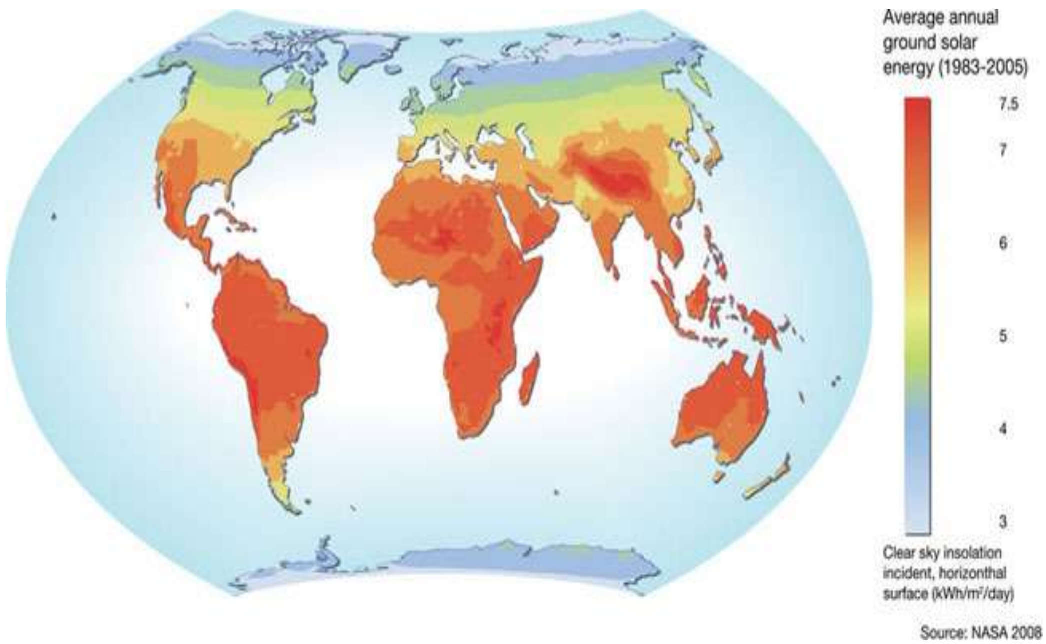
Solar technologies: a comparative analysis

Up to the early 2000s, the solar market for electricity production was dominated by photo-voltaic. Recent research by foundations or the private sector agrees in showing that concentrated solar power stations (CSP) have a comparative long-term advantage for large-scale electricity production even if current production costs are still fairly high.

CSP is undeniably being strategically positioned by the big industrial companies of the North, on account of the prospects and market development indicators in the North Africa region where there is a large potential (figure 3), regional demand showing sharp growth and the proximity of the Mediterranean countries of southern Europe with which there is already an electricity link running between Morocco and Spain. A number of North African countries have either already carried out pilot high power CSP projects like the Hassi R'mel plant in Algeria or that in Ouarzazate in Morocco (in progress), or planned studies where feasibility is far advanced.

Figure 3: World map of solar potential

[8] IPCC: Intergovernmental Panel on Climate Change, Renewable Energy Sources and Climate Change Mitigation, Special Report of the IPCC, Cambridge University Press, 2011.

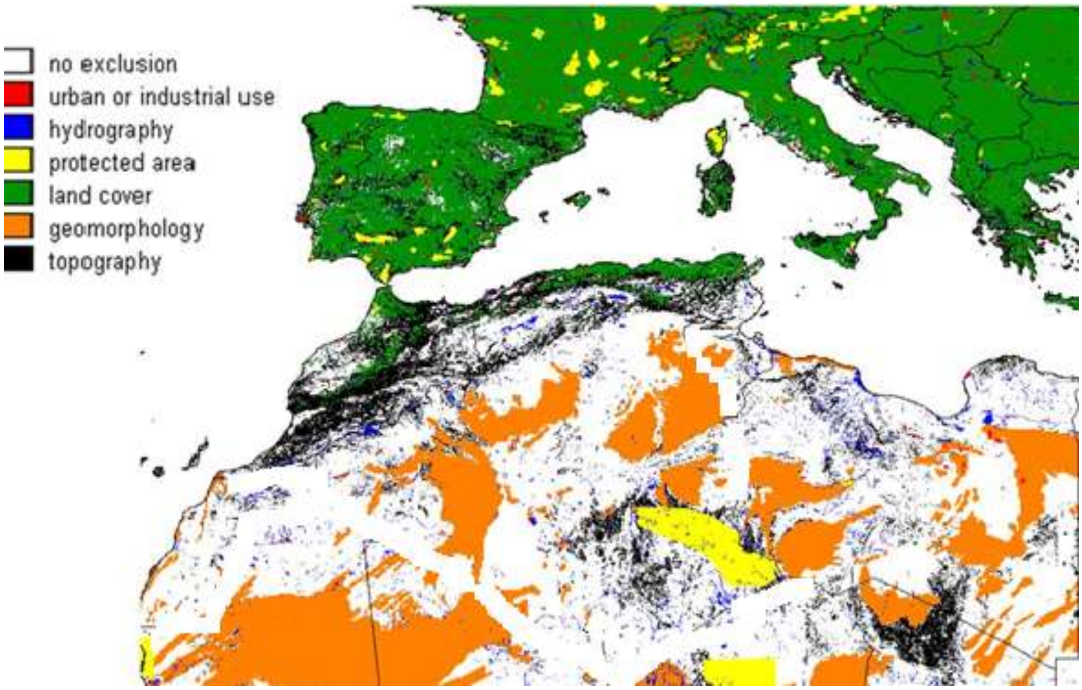


There are a number of reasons for this interest in CSP as against other power technologies. It is an attractive solution for large power plants (around several hundred MW); and one single site is able to contribute significantly to satisfying a large part of demand for electricity. Photo-voltaic (PV) appears to be more viable for decentralized applications especially for rural electrification where transaction costs are relatively high. Besides this, rural electrification is virtually complete in all countries of the region apart from Mauritania and Sudan, which might limit the growth of the PV market. These latter two countries, given the great disparity between urban and rural electrification, could combine different forms of renewable energy such as wind, especially in the case of Mauritania, PV and agricultural waste in Sudan, to meet centralized and decentralized demand for electricity in rural areas over the next two decades. For the five other countries of the region, PV, on account of the rapidly falling costs and prices, will occupy niches for low power and decentralized applications such as pumping and telecommunications, especially for sites remote from the grid. In urban areas, there is considerable potential for incorporation of PV in buildings, but this presupposes financial incentives and an electricity tariff policy restricting subsidies especially in Algeria (35% of the electricity price is subsidized by the Algerian state), in Egypt and in Libya (where in 2000 State subsidies for electricity rose to 94%[9]). For large-scale electricity production PV will remain marginal, over the next decade at least, taking account of projects completed and those under way. However, in the longer term, it is important to keep up with the technological and economic developments in centralized PV which could be a second route for large-scale electricity production, the more so as PV production costs and at the same time sale prices have fallen considerably over the past five years. So the two technologies (CSP and PV) will have different market segments.

[9] The Libyan Economy, Wannis Otman and Erling Karlberg, p.346, 2007

The other renewable energies, in particular wind, certainly have great potential - especially in Morocco, Egypt and Mauritania - but this will be limited in the long term if account is taken of trends in the demand for electricity[10]. By way of example, the potential of Morocco is of the order of 7,000 MW, around the current total installed capacity, which is considerable in 2011 but relatively low three decades from now even if offshore is taken into consideration. Wind may be put in the same category as hydraulic power. It is a fuel which at present is quite definitely the most viable and already making a contribution to satisfying a part of electricity demand. However once wind farms are commissioned the prospects for expansion[11] will become very limited, which was the case for hydro-electricity where only a few niches remain such as pumping plants or micro hydro-electric plants. By contrast, this type of constraint does not put a brake on CSP which has remarkable comparative advantages in terms of land use, being located in desert and/or semi desert areas (figure 4), and in terms of energy availability (a less intermittent, and therefore more reliable, energy source, as opposed to wind power). Admittedly, in countries with high wind potential (Egypt, Morocco, Tunisia, Mauritania, and to a lesser extent Algeria), RE development strategies should as a priority incorporate onshore wind development on account of its commercial maturity, as compared with other forms of renewable energy.

Figure 4: Land use map for North African countries



[10] It is very probable that over the next two decades, most wind sites with high potential will be commissioned on account of their economic and financial viability.
[11] Unlike solar power wind resources are relatively limited.

Chapter 2
NORTH AFRICA'S ENERGY SITUATION AND RE POTENTIAL

This chapter presents the energy situation of the countries and reports the state of the existing regional infrastructures, in particular the electric and gas interconnections. It analyzes the RE potential by country and by source, as well as the place of renewable energies in the energy mix. It also highlights the growing trend of energy demand, especially for electricity which should see a strong rise between 2011 and 2020.

2.1 Energy situation and place of renewable energies: *by country*

Disparities in terms of energy resources

The North Africa region comprises 7 countries, of which 5 (Algeria, Libya, Morocco, Mauritania and Tunisia) belong to the Union du Maghreb Arabe (UMA, AMU) and the Comité Maghrébin de l'Electricité (COMELEC). At an institutional level, Egypt and Sudan belong neither to the UMA nor to COMELEC. Egypt is a member of the East African Power Pool (EAPP)[12]. The region has 5 net hydrocarbon exporting countries (Algeria, Libya, Egypt, Sudan and, in more recent times, Mauritania). These 5 countries are dependent on hydrocarbon exports, a particularly high dependence in the cases of Libya, Algeria and Sudan. Within the region, the energy balances of Mauritania and Sudan show traditional biomass as having a large share in spite of their being net hydrocarbon exporters.

Algeria has large reserves of oil and natural gas and greatly depends on these resources to generate export earnings. The oil and gas sector accounts for 45.9% of Algerian GDP. Total oil and gas exports accounted for nearly 98% of the total volume of exports for 2007. With an export turnover of nearly 56.1 billion USD in 2010 realized by the Sonatrach company, Algeria was the fourth largest exporter of liquefied natural gas (LNG) in the world, the third largest exporter of liquefied petroleum gas (LPG) and the fifth largest exporter of natural gas.[13]

Tunisia exports crude oil (3.5 Mtpe/year in 2008); however all its oil products are imported. The trend is of a net exporting country becoming a net importer if no major hydrocarbon finds are made.

In Sudan, in 2008, exports reached 19.5 million tonnes petroleum equivalent (Mtpe[14]) and accounted for 95% of total exports and 60% of state revenues[15]. The structure of Sudan's energy balance shows that out of a final consumption of 9.6 Mtpe in 2008, biomass accounted for 6.3 Mtpe or 65% of total final consumption.

[12] EAPP is an intergovernmental body (9 countries) with the aim of pooling electrical energy resources to supply affordable, sustainable and reliable energy in the East Africa region.
[13] http://www.sonatrach-dz.com/sonatrach-en-bref.html
[14] World Energy Outlook, Source Bilans énergétiques, IEA, 2011
[15] Reegle, 2011. Sudan. http://www.reegle.info/countries/SD (IMF Data)

In Egypt, given the size of the domestic market, net exports of crude oil are not very large (4.5 Mtpe in 2008). Gas exports are larger with over 14.4 Mtpe exported in 2008 (International Energy Agency, IEA)[16]. This fossil fuel dominates electricity production in Egypt, accounting for around 87.6% of total electricity production in 2009[17].

Libya, the Libyan economy also remains highly dependent on hydrocarbon exports (with oil reserves estimated at 40 billion barrels and 1,300 billion m3 of natural gas reserves[18]). In 2050, the price of a barrel of oil is likely to reach an average of 200 dollars and Libya will need around 70 million barrels of oil per year to meet the country's electricity demand, a cost of around 14 billion per year[19].

Morocco is heavily dependent on oil imports and imports 96% of its fossil fuel needs. It is also the only country in the region with coal-fired power plants. In 2009 out of a total fuel consumption of 3.6 Mtpe, coal accounted for 2.7 Mtpe, nearly 75% of total consumption. This is on account of the relatively lower production costs per kWh from coal as against other energy sources. However, CO_2 emissions are in comparison far higher. This is, to a great extent, explains why the country has set up a large renewable energy development programme particularly in wind and solar.

In Mauritania, the energy balance of the country is consists in excess of 80% in fuels from forest sources accounting for 87% of final residential sector energy consumption, as against 9% for butane gas, 3.4% for electricity, 0.4% for kerosene and a negligible proportion for renewable energies. Over the last ten years, Mauritania has made a number of discoveries of fossil resources in particular in the Chinguitti (oil, 2001) and Banda (gas, 2003) fields. Of all these finds, only the Chinguitti field is actually in production at present. Mauritania plans to set up a natural gas-fired electric power station using the large reserves of the Banda field. The plant with a capacity of 350MW should be commissioned in 2014. The total cost is estimated at around 700 million dollars. The electricity will be used for mining production and for domestic consumption and any surplus might be exported to neighbouring countries, Senegal and Mali for example.

Marginal energy flows

Energy swaps within the region are marginal in comparison with the potential. Electricity and gas links do exist inside virtually all the countries of the region (except for Mauritania) but in the case of natural gas flows from Algeria are for the EU market, while as regards electricity swaps are still relatively limited with the aim of a balance of imports and exports. Without conditions promoting the development of a competitive market, regional cooperation on energy will remain marginal. Electricity and more particularly gas flows are for the most part meant for final consumers outside North Africa. (Figure 5)

[16] World Energy Outlook, 2011
[17] Egyptian Electric Holding Company (EEHC), 2009
[18] Prospects of Renewable Energy in Libya, Ibrahim Saleh, 2006 p.154
[19] Prospects of Renewable Energy in Libya, Ibrahim Saleh, 2006 p.154

Figure 5: Gas links between North Africa and the European Union

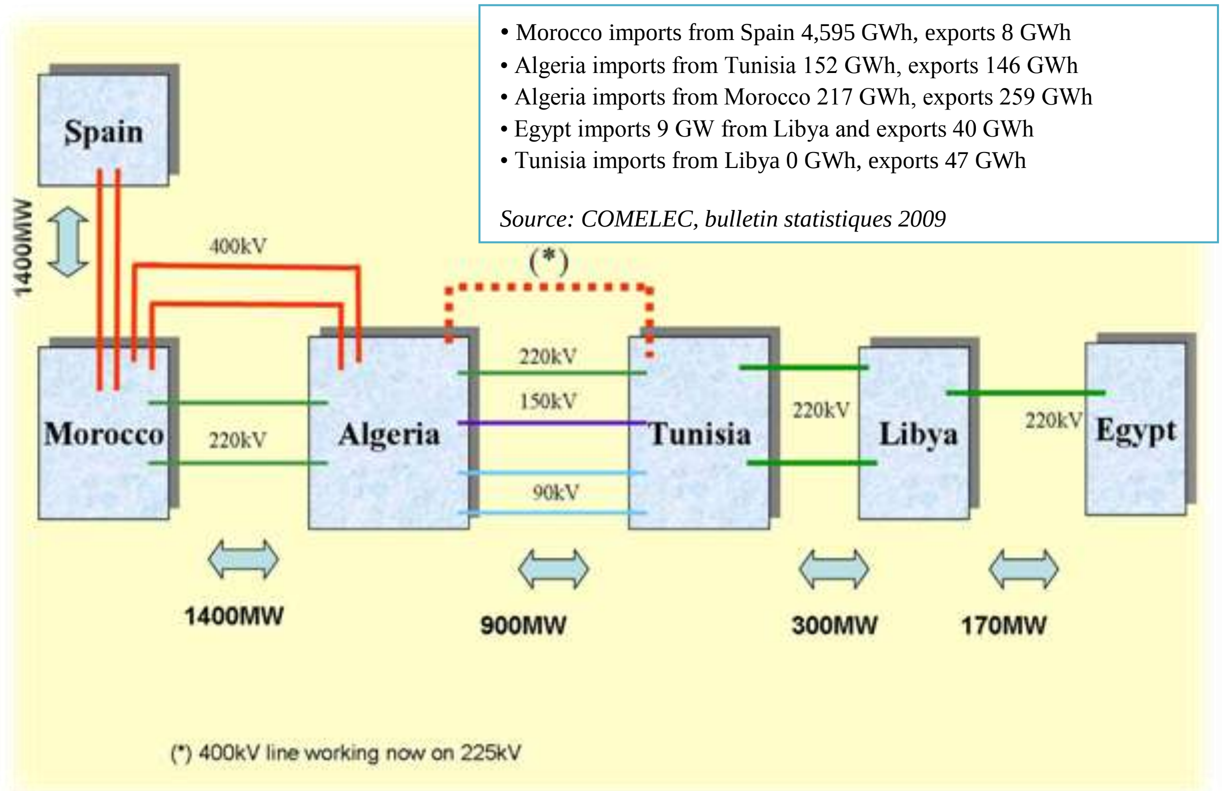
There exist some bilateral gas contracts but their share in total flows is still marginal. By way of example under a commercial agreement signed in August 2011 in Algiers by Sonatrach, the Algerian public sector group, and the Office National de l'Electricité marocain (ONE), Algeria will supply 640 million m^3 of gas per year to Morocco over 10 years. The gas is to supply two ONE power plants (Ain Beni Mathar: 470 MW and Tahaddart: 385 MW). It will be brought via the Maghreb-Europe gas pipeline, also known as the GPDF (gazoduc Pedro Duran Farell) linking Algeria to Spain via Morocco[20]. Morocco already had gas supplies of a value equivalent to the cost of royalties for the pipeline crossing its territory.

The situation is hardly any different in the field of electricity where, despite electricity links, swaps between the North African countries are very rare. The main electricity flows are between Morocco and Spain.

[20] Marchés tropicaux et méditerranéens, http://www.mtm-news.com/article/3526/accord-commercial.

The diagram below shows the various links and swaps operating in the North Africa region.

Figure 6: Interconnection of networks in the countries of the region and regional electricity swaps



Place of renewable energies

At present the share of renewable energies in final consumption, excluding hydro-electricity and traditional biomass, is marginal even if there have been significant developments over the past five years.

An analysis of the installed electricity capacities, excluding hydro-electricity, in the region shows that the contribution from renewable energies comes essentially from wind farms, connected to the network, installed in Egypt, Morocco and Tunisia (Table 1). Account should also be taken of decentralized, (more particularly photo-voltaic, facilities, for the needs of households, (telecommunications, education etc.) which, while they are only a small part of total renewable energy capacity, are still a crucial contribution to the quality of life in rural areas. Given the remoteness of these areas from the fossil fuel transport and supply network and the low population density in the countryside, decentralized renewable energy options are at an advantage in comparison with other forms of rural electrification including diesel.

The following table gives the quantitative make-up of the power generation stock of each country in the study and includes the percentage of renewable energies used for electricity production (2009).

Table 1: Structure of power generation stock and renewable energy share in 2009 (MW)

	Algeria	Egypt	Libya	Morocco	Mauritania	Tunisia	Sudan
Power plants	11,099	21,435	6,273	4,166	104	3,359	919
Hydraulic power	228	2,800	-	1748	3,022	66	1,590
%	2%	11.3%	-	28.5%	4%	1.9%	63%
Other renewable	-	490	-	222	-	55	-
energy (wind)	-	1.9%	(0.21)	(3.6%)	-	(1.6%)	-
Total	11,325	24,726	6,273	6,135	134	3,480	2,509
% RENEWABLE ENERGY	2%	13.2%	<0.2%	32.1%	22.4%	3.5%	

Sources: COMELEC, bulletin statistique 2009 pour les pays de l'UMA, Egyptian Electricity Holding Company, Arab Union of Electricity (Sudan).

The share of hydro-electricity will only see a small increase in that the main sites have already been commissioned, apart from in Sudan where the considerable potential is only exploited to a small extent. For the other countries, there is a potential for small hydro-electric plants (micro and mini plants) in Morocco in particular[21] which will certainly contribute to better coverage of the energy needs of rural populations but which will only have marginal impact in quantitative terms. In contrast, the other renewable energies, particularly wind and solar power, including CSP (Concentrated Solar Power) plants, will see a notable progression over the next two decades. This has already been evidenced by the recent commissioning of large pilot natural gas-solar hybrid plants in Algeria, Egypt and Morocco and a considerable increase in wind farms in Egypt and Morocco.

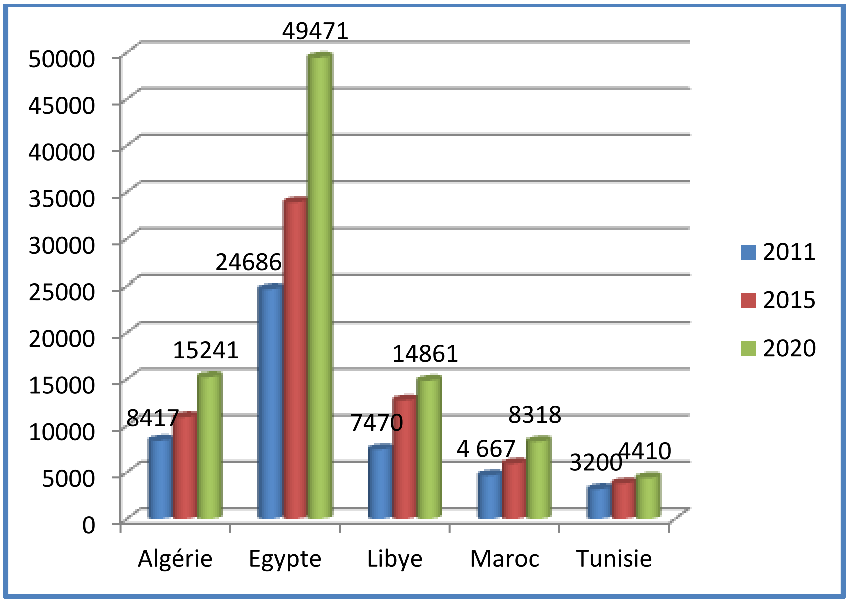
Mauritania and Sudan have energy balances where the share of traditional biomass (firewood, charcoal, agricultural waste) is relatively large. However, the energy efficiency at the various stages (production, conversion and consumption) is very low resulting in high CO_2 emissions per unit. Stress is also to be laid on the impact of interior pollution from cooking and the effects on the health of women and children. The World Health Organization (WHO) and the United Nations Development Programme (UNDP) estimates that around 1.6 million women and children in particular die each year from the effects of interior air pollution[22].

[21] It should be noted that Morocco has significant potential for hybrid pumping plants (hydro-electricity-wind).
[22] WHO-UNDP, indoor air-pollution, the killer in the kitchen.
http://www.who.int/mediacentre/news/statements/2004/statement5/en/index.html

An increased forecast demand

All countries in the region will see a considerable increase in energy consumption and more particularly electricity demand by 2020 (figure 7). According to the forecasts of the Arab Union of Electricity, the maximum electricity demand[23] will grow in all countries in the region between 2011 and 2020. Demand for electrical energy in Egypt, which already has the largest installed capacities of the region, should double over this period. In Algeria, the level of national natural gas market needs are said to be of the order of 45 billion m3 in 2020 and 55 billion m3 in 2030. In addition to these needs are the volumes destined for export the revenue from which contributes to financing the national economy. In Morocco, development has led to a sustained growth of primary energy demand of the order of 5% per year on average and 6.5% for electricity. Primary energy demand is expected to double by 2020 and triple by 2030 and electricity demand quadruple by 2030.

Figure 7: Changes in the demand for electricity in the countries of the region 2011-2020[24]



Mauritania and Sudan will also experience high rates of growth heading towards 2020 as their capacity is currently weak and because of these two countries' status as net exporter of hydrocarbons. In Mauritania, it will be necessary to strengthen the power station so that it can cope with 175MW if it is to satisfy future demand as we head towards 2020.

[23] These statistics concern demand and not installed capacities which exceed demand.
[24] Source Arab Union of Electricity, http://auptde.org

2.2 Capacity in Renewable Energy: the situation by subsidiary and by country

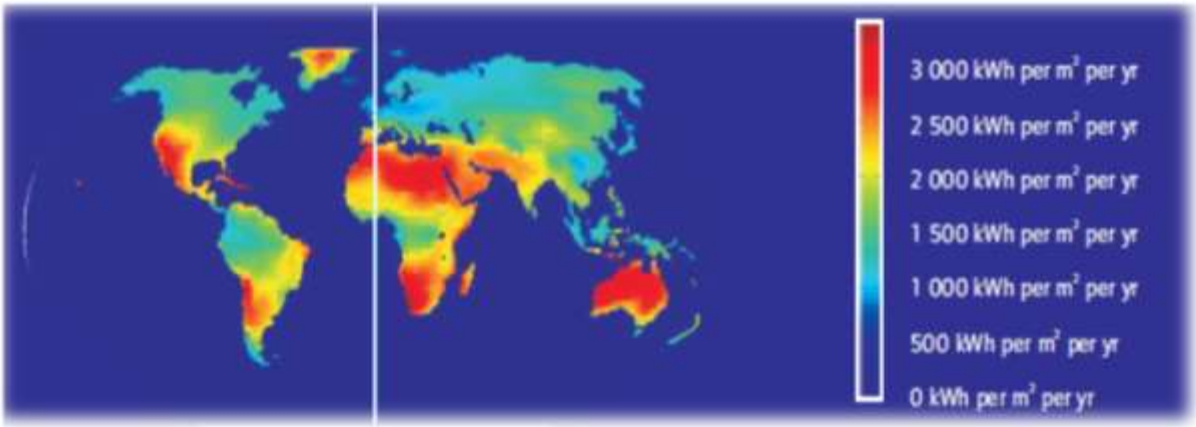
All the countries in the region have a sufficient ER capacity to cover almost all the needs of current and long-term provisional demand, specifically the different services provided by electricity (lighting, air conditioning, heating, telecommunications, transport, electric railways, etc). Solar power is the largest natural source. In the very long term, this form of energy will become dominant as an energy supply in the North African region and most probably in most other regions of the African continent. This is reinforced by the comparative capacity of the different sources, technological developments and achievements, projects and programmes currently in progress.

The level of the capacity of RE that can be mobilised, together with that already mobilised will vary from country to country. In this way, a large proportion of hydro-electric capacity is already being exploited in Algeria, Egypt, Morocco and Tunisia, while Sudan still has a very large capacity. In Mauritania, hydroelectric power will contribute 13% to the energy mix by 13% in 2015[25]. In all the countries in the region, the contribution of solar and wind turbine resources as energy supplies is marginal, whereas Egypt, Morocco, and, to a lesser extent, Tunisia and Egypt, have put in place large scale development programmes for these two forms of primary energy.

2.2.1 Solar capacity

Every country in the region is blessed with considerable solar capacity, as indicated in the following map (figure 8), large enough for low temperature applications (solar water heating), drying, photovoltaics, and also in order to be able implement CSP which, in order to be profitable, requires significant irradiation over a long period of time. The higher significantly higher yield in the Sahara, the size of the area and the almost total lack of competition with current usages, specifically with agriculture, explains the interest in exploiting the Saharan capacity on a grand scale, on a national and international scale, with a view to export.

Figure 8: Scale of solar capacity in North Africa and in the world.. Direct irradiation DNI)[26]



[25] Round table for Mauritania, Plans for and capacity of the Electric Sector, Brussels, 22-23 June 2010
[26] IEA, technology road map, concentrating solar power, 2010

In **Algeria**, average annual sunshine is evaluated at 2,000 hours, with average sunshine of 6.57 kWh/m^2/day. With a territory made up of 86% of the Sahara Desert, and because of its geographical positioning, Algeria is area with the most sunshine in the world.[27]. If we compare sun to natural gas, the energy capacity of Algerian sun is equivalent to a volume of 37,000 billion cubic metres, 8 times the natural gas reserves in the country, with the difference that solar capacity is renewable, as opposed to natural gas.[28]

The following table gives the capacity energy from the sun in Algeria in figures and broken down by locality.

Table 2: Algerian sun capacity in terms of sunshine hours and energy received (average)

	Coastal regions	Tablelands	Sahara
Area (%)	4	10	86
Average sunshine hours (hrs/year)	2650	3000	3500
Average energy received (kWh/m^2/year)	1700	1900	2650

Source: NEAL[29]

In **Egypt,** the solar atlas published in 1991 indicated a solar irradiation level of 2000 to 3200 kWh/m^2/year from north to south with average sunshine of 9 to 11 hours a day and very few clouds[30]. Egypt has the highest economic capacity for solar energy in North Africa and in 2005, it had the 4th largest capacity for CSP in the Mediterranean[31].

In **Libya**[32]**,** the solar capacity stands at 7.5 kWh/m^2 /day in the most favoured areas, with 3000 à 3500 of sun per year. The mobilisation of this capacity should not pose any issues concerning the use of land, since the desert represents around 80% of the country.

In **Morocco,** the capacity is also considerable, with a capacity 20,000 MW, with more than 3000 hrs/year of sunshine[33], which is an irradiation de ~ 5 kWh/m2/day.

Mauritania has some of the sunniest conditions on the planet. It receives more than 3,000 hours of sunshine per year. Direct solar rays for the entire country are estimated at 78%. However, it is the North East region of the country and the costal region that the share of direct sunshine is highest, that is at around 90% (particularly in the areas on the plateau of Adrar, Tagant and Hodhs). Capacity is estimated at 4-6.5 k Wh/m2/day with average sunshine of 8 hours per day. Extremes of 9.3 kWh/m2/day in the North (Bir Moghrein) and 7.9 kWh/m2/day in the south (Rosso) have been recorded.

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[27] PWMSP, Country Report Algeria, p.13, 30 November 2011
[28] Belgian Embassy, Economic Mission" The basis of economic activity in Algeria, p.4, 2010
[29] http://www.neal-dz.net/index.php?option=com_content&view=article&id=150&Itemid=132&lang=fr
[30] New and Renewable Energy Authority, annual report 2008-09
[31] PWMSP, Benchmarking, County Report Egypt p.16, November 2011
[32] REEGLE database, http://www.reegle.info/countries, (United Nations, World Bank)
[33] Source: MASEN. This is a capacity, as elsewhere in other countries, which can vary according to the technological networks used (PV, CSP) and the degree of technical progress made

In **Sudan,** the average sunshine is of the order of 6.1 kWh/month^2/day,which indicates an increased capacity for the use of solar energy.

Tunisia has increased solar source particularly in the zones of the south with a direct irradiation index which varies on average from 2 kWh/m^2/day in the extreme north, to 6 kWh/m^2/day in the areas of the extreme south.

2.2.2 Wind power capacity.

Although all the countries have a non-negotiable capacity, the most interesting sites and the largest ones are in Egypt, Morocco and Mauritania.

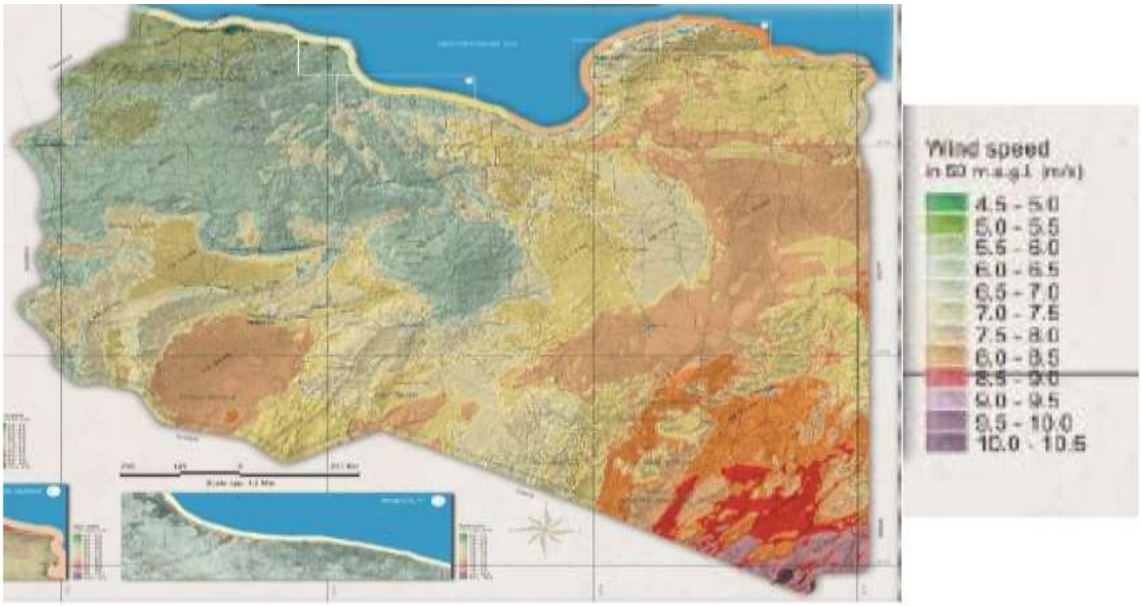
In **Algeria,** wind capacity is relatively moderate, with speeds varying between2 et 6 m/s. This energy capacity is ideal for pumping water to the Tablelands, but is marginal for large commercial projects. The most promising sites are situated in the region of Adrar in the south, in the north west of Oran, the region stretching from the Meghres at Biskra in the East and from El Kheiter at Tiaret in the West. A number of sites along the coast have average wind speeds higher than 5 m/s, increasing to more than 8.5 m/s at 80m.

In **Egypt**, two Atlases on wind energy covering all of the Gulf States were published in 1993 and 2003 before a wind energy atlas of Egypt was published in 2005. Several regions which are conducive to high power wind plants, were identified, specifically those of the Gulf and Suez, and some areas up and down the Nile, and also Sinai[34]. In this way,Egypt is able to have 20 000 MW of capacity within wind farms[35], this is not far short of the electric capacity already in place (24 726 MW in 2010).[36]According to the Egyptian electric company[37], some 7200 MW will be able to be mobilised between now and 2020.

En **Libye,** the wind power atlas put together in 2004 (figure 9)[38], indicates wind speeds of between 6 et 7,5 m/s which is sufficiently high to run high power units. There are several interesting sites along the coast, such as Dernah, with average wind speeds of around 7.5m/s.

[34] Egypt, New and Renewable Energy Authority, annual report 2008-09
[35] UbiFrance, summary sheet "Renewable Energy Sector in Egypt", 2009
[36] PWMSP, Country Report Egypt, November, 2011
[37] Egyptian Electricity Holding Cy, annual report 2009/10
[38] Communication from Ekhlat, M.A, REOAL, Renewable Energy in Libya, meeting of experts, UNECA, Renewable energy sector in North Africa: current position, and prospects, Rabat, Rabat, 12-13 January 2012

Figure 9: Wind power atlas of Libya



Morocco has a capacity estimated at around **25000 MW** across its whole territory, and around 6000 MW[39]on the sites studied, particularly along costal areas. For the most conducive sites, average wind speeds are higher than 6 m/s. At 40 metres above sea level in certain regions (such as Tangiers, Essaouira and Tetouan), average wind speeds vary from 95 to 11 m/s.

Mauritania is one of 15 countries identifies by Hélimax[40] as being one of the best wind power resources in Africa, with winds of 5-6 m/s for most of the regions, with less strong winds of 4-5 m/s in the North East and parts of the south, and there is a good source of 6-7m/s on the West coast of the Atlantic. Other than the feasibility of plans connected to the network for isolated zones, generally some distance from the network, constitutes a real interest given the weak rate of rural electrification (in the order of 3-4%).

In the **Sudan,** the average wind speeds are estimated at 3-6 m/s and higher speeds are recorded along the coasts of the Red Sea. In Sudan, wind power is currently used to pump water which comes up from deep wells, and not so deep wells, in order to provide drinking water, and to provide irrigation.

In **Tunisia**, a very detailed wind power atlas was published in 2009, which, for a year, required the installation of wind measuring instruments at 20 and 40 metres above sea level, in 17 different sites in the country, except for the use of statistics collected by the National Institute of Meteorology in this field.

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[39] Source Ministry of Energy, Morocco.
[40] Canadian research office specialising in wind energy.

Figure 10: capacity for wind power in Tunisia[41]

- Good winds (speeds > 7m/s at 60m above sea level): north and north east coast sectors: Bizerte and Nabeul: central area of the country: Kasserine, south east: Medenine, Gabes.
- Very good sites (speed > 8m/s at 60m) can be located within the sectors above.
- Interesting sites (speed >6.5 m/s at 60m): eastern sectors of Tozeur, Kebile and Tataoline, eastern coast of Medenine, region of Monastir.

2.2.3 Hydro-electric capacity

The highest capacity can be found in Sudan, Egypt and to a lesser degree Morocco; but in these two latter countries, together with the three other countries in north Africa (Algeria, Mauritania and Tunisia), the capacity has already been, to a greater or lesser extent, met. Only Sudan has a large capacity which can contribute to increasing the share of RE in the country's electric consumption in the medium term.

In **Algeria, Mauritania** and **Tunisia,** the unused capacity is limited. Nevertheless, there is a modest capacity which could be developed.

Algeria has several wind barriers on Algeria rivers but they are essentially used in irrigation and drinking water, the production of electricity is limited. The share of hydraulic capacity in electric production is 5% or 286 MW.

Since 2002, 15% of energy produced in **Mauritania** is produced by the hydro-electric power station at the Manantali barrier, built on the River Senegal (power installed at 200MW and an average annual production of 800 GWh). This plant was built as part of the Energy project run by the Senegal River Basin Development Authority (OMVS).

[41] Nafaa Baccari, ANME, Opportunities for development of wind powered electricity connected to the Tunisan network. Wind power capacity in Tunisia and the national programme of electrical production using wind energy , plant at Tunis, 17 and 18 May 2011.

In **Morocco**, the contribution of conventional hydroelectricity is significant with 26 plants in total giving power of 1,265 MW in 2007[42]. This contribution was able to be enhanced thanks to the building of pumping stations the capacity capacity of which is still available from hybrid stations. There is also capacity to develop hydroelectric micro plants, some 200 sites have already been identified and thus will be able to contribute to the energy needs of isolated zones. However, at a quantitative level, even if all the micro plants are developed, their share in overall electrical supply will remain marginal.

Egypt has at its disposal a large hydroelectric capacity, but most of this has already been exploited. In fact, hydroelectricity represents 2,800 MW out of a total of 24,726 MW[43] , thus 11.3% of the total capacity in operation in 2010. The trend of the relative share of hydroelectricity must therefore be downwards as one takes into consideration the increase in capacity as a result of fossil energy, and other renewable energy.

In **Sudan,** the hydroelectric capacity is estimated at 4,920 MW; this represents about double the total electrical capacity in operation in 2009. Only 10% of hydroelectric power is currently used. More than 200 sites conducive to hydroelectric power have been listed along the Blue Nile and the main Nile. The total capacity of mini-plants in the southern region is estimated at 67 GWh/year.

The Merowe barrier or the "Merowe Multi-Purpose Hydro Project", with a capacity of 1,250 MW is the largest contemporary hydroelectric project in Africa. Situated in the town of Merowe, in the north of Sudan, its main objective is to provide electricity to the growing population of the country with an annual production which could grow to 6,000 GWh. The barrier was constructed in the fourth cascade of the Nile between 2003 and 2009, by Lahmeyer International, a German engineering consultancy; two Chinese companies, China International Water and Electric Corp, and Harbin Power Engineering Co; together with the French energy company, Alstom. It was financed by the Sudanese Government, China Import Export Bank and the Arab development banks and organisations, for a cost of 2 billion dollars.

In relation to its North African neighbours, **Libya** has a very under-developed hydroelectric sector. This is mainly due to the absence of available resources in the country for the development of this source of energy. Currently, there is no plan to exploit hydroelectric power. Plans to develop a hydroelectric installation on the large, artificial river came to nothing[44].

2.2.4 Biomass capacity

The proportion of biomass of total energy in Algeria, Egypt and Libya is negligible. In Mauritania, although biomass occupies an important place in energy use in the economy of the country, its productivity is decreasing given the over exploitation of forestry resources.

Only Sudan has a high capacity for the production of biomass energy, including vegetable residues which, thanks to cogeneration, represent the largest renewable electric capacities beyond

[42] Source: Energy Ministry, Morocco
[43] Egyptian Electricity Holding Cy, annual report 2009/10
[44] http://www.reegle.info/countries/libya-energy-profile/LY

hydroelectricity. They are estimated at 55.5 MW[45] and concern the sugar industry's own production. Moreover, it is envisaged that there will be growth in production capacity from this subsidiary. Besides the forestry biomass, we should also stress the importance of non-forestry biomasses, such as biomass from municipal waste, agricultural biomass and industrial biomass which can represent an undreamed of capacity for energy production as is shown in table 3.

Table 3: Non-forest biomass[46] in Sudan

Residues	Quantities Millions of tonnes	% energy
Agriculture		
Cotton	292	8
Dura	6838	3
Millet	2381	2.5
Peanut shells	2230	6
Animal residues		
Cows	224.5	22.5
Sheep and goats	60.4	6
Camels	16.4	

In **Tunisia,** there is a relatively high capacity which can be mobilised to develop vegetable and animal for electricity production, even if, up until now, the amounts mobilised and the plans have been modest (table 9).

Table 18: Development of residues in Tunisia: cost and environmental outcome

Sector	capacity	Estimated cost in TND	Economies tep/year	CO2 avoided tCO2/year	Status
Development of organic waste	1 MW	9	1570	3690	Brought into production
Development of waste gases	10MW	20	15,700	36,880	In progress
Processing of poultry droppings	14.5MW	47	22,800	53,560	Promoter's research

[45] www.ssafta.org_wp-content_uploads_2011_05_Sudan-Energy-Profile1

[46] The Panel of The United Nations Commission on Science and Technology for Development 9-11 November 2009.

Morocco still depends on biomass energy for certain uses in urban areas (hammams or public baths), and also in rural areas. According to the National Agency for the Development of Renewable Energy and Energy Efficiency (ADEREE), residues from farming, agricultural industry and urban waste (solid municipal waste and residual waters) could represent 515 ktep/year if they were treated by methane fermentation (biogas), most of which comes from solid municipal waste.

The following table provides information on the capacity production of biogaz in Morocco, by type of residue.

Table 4: Capacity production of biogas in Morocco[47]

Type of residue	Capacity production of biogaz (1000 m^3/year)	Equivalent in ktep/year	%
Hot manure	320,250	165	32
Solid municipal waste	584,000	300	50
Sewage	100,000	50	10
Total	1,004,250	515	

In Algeria, forest areas cover about 250 million hectares, that is less than 10% of the total area of the country. Theoretically, the total capacity of biomass is estimated at 37 mtep, of which around 10% could be recovered. 5 million tonnes of urban and agricultural waste are produced annually. The theoretical capacity of energy is close to 1.33 million tep/year.

2.2.5 Geothermic capacity

In Africa, the largest geothermic capacity can be found in Eastern Africa. In Northern Africa, there is a limited capacity, particularly in Algeria and Sudan.

Algeria has a large geothermic capacity, estimated in terms of electricity production, at 700MW. More than 200 heat sources have been identified to the north of the country, of which almost 1/3 (33%) have a temperature higher than 45 ° C. Some sources have temperatures which can reach 96 ° C at Hamman Meskoutine. Further south, the country possesses a vast geothermic reservoir which extends across several thousand km2. This reservoir is known as the "Albian Water Table" and has an average temperature of 57°C.

The geothermic capacity of **Sudan** is estimated at 400MW. Sources have been identified close to the Jabel Marr volcano, the Tagbo and Meidob, the volcanic domain of Bayud and the coasts of the Red Sea.

Libya has a geothermic capacity but this has not been studied much at this time.

[47] UNEP, financing the development of renewable energy in the Mediterranean region, baseline study for Morocco, by F. Senhadji, May 2003. See also National Plan for Biomass Energy, CDER, December 1998.

Table 18: Development of residues in Tunisia: environmental cost and outcome

Sector	capacity	Estimated cost in TND	Economies tep/year	CO2 avoided tCO2/year	Status
Processing of organic waste	1 MW	9	1570	3690	Achieved
Processing of waste gas	10 MW	20	15,700	36,880	In progress
Processing of poultry droppings	14.5 MW	47	22,800	53,560	Research by developer

2.3 Access to energy and disparities in type

Energy policies do not take sufficiently into account disparities in type when it comes to access to modern energy services. Although decision makers can visualise their choices linked to energy as being neutral in relation to type, men and women are affected differently by energy policies where their roles are in the home, at work or in a different community. Energy programmes often place stress on an increase in supply of fuel or electricity, in particular for industrial and urban uses, with little attention being paid to the characteristics of the demand for energy by women, in particular in poorly served rural zones. Energy needs in rural areas, for domestic, agricultural use, and, on a smaller scale, for informal production activities, where women predominate, are insufficiently taken into consideration.

Women experience much more difficulty than men in accessing energy for several reasons:

- They have no control over land and property, which limits their ability to take advantage of access to renewable energy, such as solar systems, wind power and biofuels which require ownership of land.
- The absence of income which constitutes a barrier to investing in a technology;
- Limited access to credit which decreases their ability to pay the initial costs of energy technology or the costs of linking up to an electric supply.
- Limited access to education which reduces their opportunity to become users of renewable energy and to earn an income.

Different development organisations, such as FAO, have demonstrated that RE systems on a small scale can enable the supply of electricity to deprived groups such as women (Lambrou and Piana 2006). For example, these systems can supply energy for the water pumps and the windmills used to grind grain in areas not covered by the network, and promote productivity and income generating activity (Panchauri and Spreng 2003, ENERGIA 2007, Aguilar 2009). Despite the small size of these projects, the socio-economic impact on the lives of women is large as is shown in a number of studies[48]. They allow :

- An improvement in health, for example, by reducing the risk of problems linked to smoke coming from the use of biomass in badly adapted plants;
- An economy significant of time and effort thanks to the supply of renewable energy in rural areas;
- An extension of the day thanks to lighting which adds flexibility and sometimes income, but this does not necessary lead to an increase in free time for women.

Full participation of women in this sector is crucial in all aspects leading to the identification of energy projects, design, implementation and evaluation. Energy bodies have a tendency to be dominated by men, accordingly, problems identified and solutions proposed can have a male bias. The growing involvement of women in the energy sector helps bring in the perspectives of the genre into policies and energy practices. Today, there are no precise data broken down by gender which demonstrated the place of women in the renewable energy sector in North Africa, but there is evidence that women are not sufficiently involved in this sector. However, there is some progress to note, in Algeria for example, where, at the time, the Centre of Renewable Energy Development (CDER)counted 52 womenout of 126 researchers, that is more than 40% of women ; and the Centre of Development of Modern Technologies, for its own part, had 56 women researchers[49].

[48] Panjwani 2005, Cecelski and CRGGE 2006, Tully 2006, Modi et al 2007, Practical Action 2010, Clancy et al 2011, Kohlin et al 2011, UN 2011.

[49] http://portail.cder.dz/spip.php?article2060

Chapter 3

STRATEGIES AND PROGRAMMES FOR RENEWABLE ENERGY

All the countries in the region have set out different levels of programmes for developing RE on a grand scale. Although the objectives are quite similar, the technologies, the unit sizes and the strategies for implementation are different. Egypt, Morocco and Tunisia favour wind power and CSP. Wind power in Egypt, Morocco and Tunisia represent 95% of the total capacity in operation in the continent (World Report on Wind Power, 2009). Algeria gives priority to the CSP sector with the installation of a first hybrid electric plant (Natural gas and solar), with a total capacity of 150MW, of which 30MW comes from solar. Egypt and Morocco, with the cooperation of the World Bank, have implemented projects which use a hybrid technology based on concentrated solar power (CSP). Sudan also envisages the development of CSP on a grand scale. Mauritania could develop plants of a more modest size starting with the thermal solar sector (1 to 10 MW), but only after 2015, taking into account the size of wind power capacity, which is favoured, and priorities in the area of decentralised rural energy.

In all countries in North Africa, there are photovoltaic installations on a small scale, for isolated areas, and for different uses, specifically rural electrification, telecommunications and water pumping. All these installations currently contribute to an improvement in the quality of life of deprived populations; but at a quantitative level, the relative share of photovoltaic of the total electric capacity installed, and as a proportion of total national energy remains marginal. However, the considerable reduction in the price of solar panels over the past five years opens up new prospects for a change in the scale of photovoltaic as much for the countries where the rate of rural electrification is low (Mauritania, Sudan), as for the five other countries in North Africa, specifically from centralised photovoltaic.

On the subject of low temperature applications, especially solar water heating, the level of equipment in several Mediterranean countries is very high. In North Africa, only Tunisia, whose energy management policy has been in place since the 1980s, has a solar water heating park of any significant size. Therefore, there is a potentially large market in North Africa. This industry, with relatively lower technological and financial entry barriers, and which is, additionally, a creator of jobs, can take advantage of a much greater level of support from the public authorities.

Regional initiatives such as the Mediterranean Solar Plan (MSP) and Desertec Industrial Initiative (DII) contribute to the dynamism of a development of renewable energy on a grand scale, particularly in Morocco, Egypt Tunisia and Algeria. These countries have also signed bilateral cooperation agreements with the countries of the North (USA, France, Germany, Spain…), and the emerging countries (Brazil, China). These partnerships offer prospects for the growth of investment, promote a technology transfer, reinforce interconnections and create a Maghreb electricity market. Additionally, in order to be effective, and have a real economic, social and environmental impact, these prospects are going to need the adoption of a coordinated and harmonised regional approach.

3.1 The Algerian Case

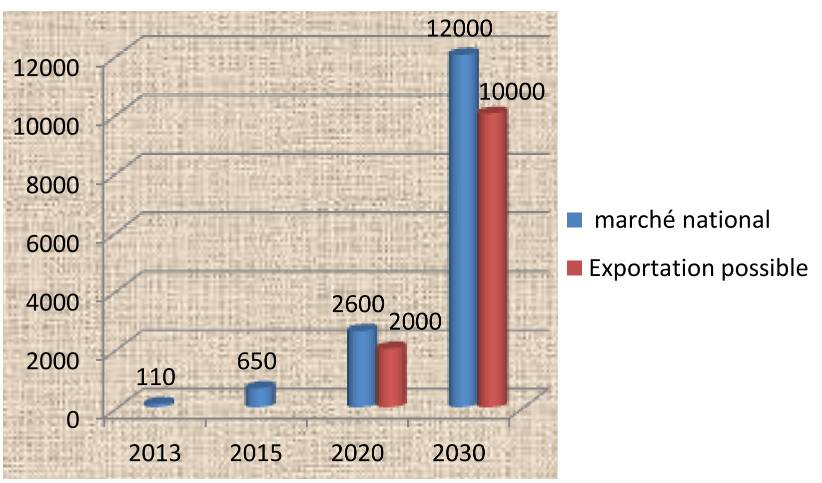
In 2011, Algeria adopted a strategy whose objective between now and 2030 was to produce 40% of electricity from renewable resources. This strategy moreover aims to develop a real solar industry associated with a training and capitalisation programme, which, in time will allow a good knowledge to develop, specifically in the area of engineering and project management.

A long-term plan for renewable energy and energy efficiency was adopted with the aim to have in place 22,000MW of capacity between 2011 and 2030, 12,000 MW of which would cover national demand, and 10,000 of which could be exported if there were long her guarantees of purchase, and if external financing could be secured. This programme includes the building of around sixty photovoltaic solar and thermal solar plants, wind farms and hybrid plants between now and 2020. Its implementation, placed under the aegis of the Ministry of Energy and Mines, is open to public and private operators.

Solar power can make up more than 37% of national electricity production between now and 2030. Despite a quite small capacity, the programme does not exclude wind power which makes up the second wave of development and whose share could be around 3% of electricity production by 2030. Algeria also envisages the installation of some units of an experimental size so as to test the different technologies in the area of biomass, geothermal power and desalination of salt water by the different sectors of renewable energy.

The first stage of the programme (2011-2013) will be mainly devoted to the completion of pilot projects which will test the different technological sectors. The main developments in the area of installed capacity are set out in the following figure:

Figure 11: Evolution of total installed capacity RE 2013-2030 (MW)



Exports remain conditioned by an institutional framework which will guaranteed a price which will allow profit against investment. Moreover, this also supposes that there will be transit agreement with neighbouring countries (Morocco and Tunisia), in the likely event that there will be export to these countries.

3.1.1 Solar Energy

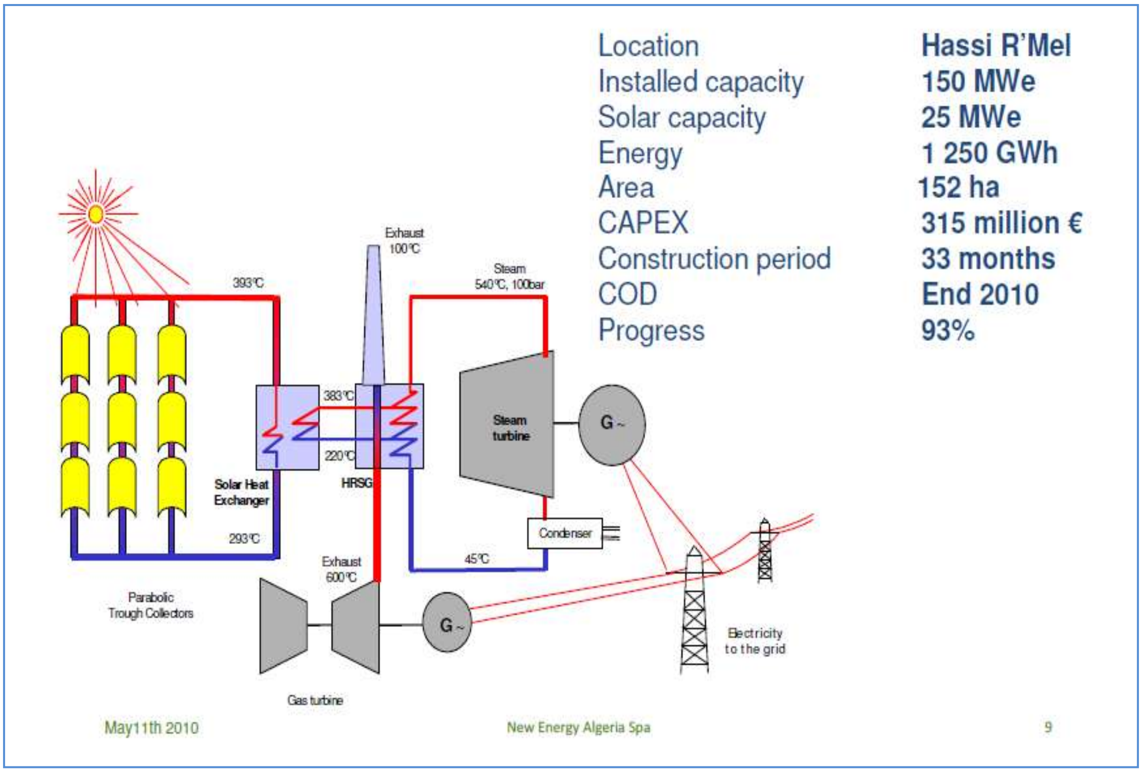
As the national capacity for renewable energy is strongly dominated by solar power, Algeria considers this form of energy as an opportunity and a lever for economic and social development, specifically throughout the implantation of industries which create wealth and jobs.

The strategy adopted by the Algerian Government partly rests on prioritising the development of the CSP sector, even if the other technological sectors cannot be removed. The priority given to CSP can be justified by a limited wind power capacity and the need for greater technological and commercial maturity on the part of the centralised PV sector. The objective sought is to produce 7,200 MW from the CSP sector. Two pilot projects for concentrated thermal plants with stock, each with a total power of around 150MW, shall be launched between 2001 and 2013. Over the period 2016 to 2020, there is a plan to build four thermal plants with the ability to stock a total power of 1,200MW then the introduction of 500MW per annum until 2023 and 600MW per annum until 2030.

These projects have just completed the programme of solar energy which started with the installation of the first hybrid plant - natural gas-solar - built at Hassi R'mei in July 2011 (see plan below). This plant, built by NEAL in partnership with the Spanish company ABENER[50], brings together combined cycle technology with that of cylinder-parabolic solar concentrators. This is the first combined cycle deployed far from the coast, thanks to a technology of refreezing vapour with aerocondensors. The market to build the plant has been attributed to ABENER which is in charge of Engineering Procurement Construction (EPC) and maintenance operations. The capital structure of this pilot unit is divided between NEAL: 20%, SONATRACH: 14%, ABENER: 51% and COFIDES[51]: 15%. The cost is estimated at 315 million Euros, €252 million of which (80%) was provided by a consortium of Algerian banks (Banque Extérieure d'Algérie, Banque Nationale d'Algérie & Crédit Populaire d'Algérie), and 20% (€63 million) through its own funds [52].

[50] Abener is a Spanish company which operates in the field of engineering and construction in order to secure durable development.
[51] Financial cooperative for the development of a Joint North/South economy.
[52] A. Sokhal, NEAL, Entrepreneur in technologies linked to new and renewable energy sources. Presentation from the first solar/gas plant at Hassi R'Mel, Meeting of Experts UNECA, Rabat, 12-13 January 2012.

Simplified plan of the natural gas/solar hybrid plant a Hassi R'Mel



The project has been completed according to the formula "Build, own, operate and Transfer" (BOOT). The existence of a client, like SONATRACH, which will purchase electricity for the needs of its activities in the south, guarantees the investor a competitive price, higher than the price operated by the publicly run network. All the same, this model will be difficult to replicate as current clients, in this case SONATRACH, or capacity ones, shall have recourse to other options to access electricity at considerably more advantageous rates. The development of the market will happen via the setting up of an attractive institutional framework attractive to all operators. This supposes incentivising financial mechanisms, such as, for example, the repurchase rate, a light tax burden, preferential loans, etc.

In the matter of contributing to the national value added, the supply of equipment and services by Algerian operators is very small. This can be explained by recent developments in this technology. Parabolic panel blocks were assembled in a factory on site, by an Algerian sub-contractor, partner of the Spanish company ABENER. However when they were deployed in the solar area, some difficulties were incurred as the Ouargla factory in Algeria, whose job it was to provide industrial gas, argon, had difficulties in respecting the required standard and the import of argon would have given rise to a delay of 18 to 20 weeks.

The following table presents the other large CSP plans in Algeria:

Table 5: Project for four hybrid solar power plants in Algeria

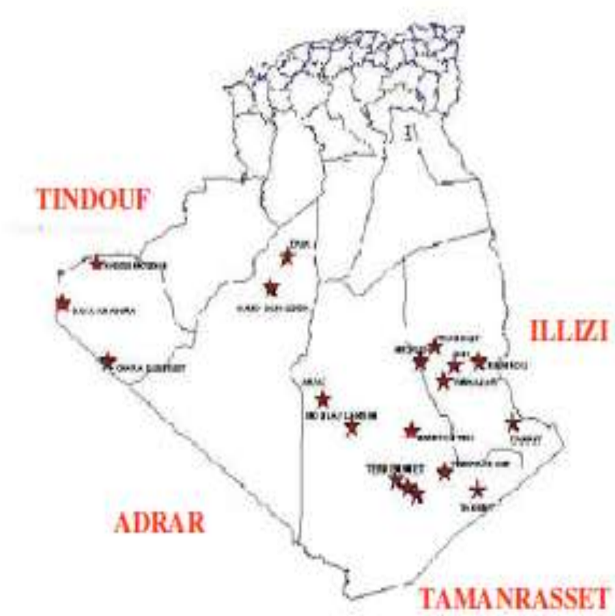
Hybrid solar station	Location	Installed capacity CSP/MW	Year
SPP I Solar Power Plant One	Hassi R'Mel	25 (total capacity is 150 MW)	2011 **(June)**
SPP II Solar Power Plant Two*	Meghaïr	470 of which 70 solar	2014
SPP III Solar Power Plant Three	Naâma	70 solar	2016
SPP IV Solar Power Plant Four	Hassi R'Mel	70 solar	2018

*Feasibility study launched in 2010. Source New Energy Algeria

In addition to these projects developed by NEAL, the SONELGAZ group is preparing the launch of a call to tender for a solar thermal power plant of over 150 MW, at El Oued, in South-East Algeria[53].

Several PV projects of a capacity totalling 800 MWc are planned between now and 2020. Other smaller scale projects have been completed, especially by SONELGAZ. Thus, between 1992 and 2005, 18 villages in the South of Algeria, i.e. around 1000 households, benefited from PV installations to meet basic electricity needs (lighting, refrigeration, television, ventilation) (see figure 12).

Figure 12: Electrification Programme for 18 villages in Southern Algeria 1992-2005[54]



[53] According to the CEO of SONELGAZ group, this plant could be in service in 2016 or 2017

Other programmes are ongoing, such as the complementary programme of growth support with a view to the electrification of 16 villages in the South of Algeria and that of the development of high plateaus involving around 60 localities in steppe zones. Furthermore, the *Centre de Développement des Energies Renouvelables algérien* (Algerian Centre for Renewable Energies Development - CDER), within the framework of an Algeria-Spain co-operation, operates a plant of 2.5 kW nominal power connected to the network[55], with the objective of research and development. The CDER has also installed a number of systems of several kW in different areas of the country, as shown in the table below:

Table 6: Principal achievements of the CDER within the PV sector[56]

Region	Usage	Power installed et systems
Batna (East Algeria)	Electrification of housing for teachers	10 kWc
	Study and installation of mini plants for various uses	One 5 kWc plant and three 2.5 kW plants
	Rural health	5 medical storage units (60 litres of unit capacity)
Oum El Bouaghi	Pumping	5 systems at different sites of the region
Tiaret	Lighting, pumping, health	Several systems
Centre	Rural tele-communications	8 relays of 160 W
Various regions	Aerial beaconing and signalisation	15 radio beacons in several airports
South	Supply to electromagnetic relays	Ten 2 kWc systems

BP's (British Petroleum) recent involvement in solar should also be noted, BP being a major player in the hydrocarbon field in Algeria. For BP this partnership in PV is an operation with a social dimension, as well as for company brand image promotion.

In the centralised PV sector, SONELGAZ is going to complete a 900 kWp plant in the South of Algeria (M'Zab Valley, Oued Nechou). This will be the first large-scale unit within this field. This project should provide information on the economic viability of PV, which will then be rolled out on a large scale[57] In order to have a full picture of PV in Algeria, account must also be taken of systems for telecommunications, public lighting, pumping water, cathodic protection and supply to telemetry systems for hydrocarbon deposits.

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[54] A. Khelif, Expérience, potentiel et marché photovoltaïque algérien (Algerian PV experience, potential and market), New Energy Algeria, no date

[55] Source CDER

[56] Compiled according to CDER data

[57] Source Sonelgaz, Echos no 3, May 2011

Despite the number of projects, the contribution of PV to rural energy on a quantitative scale (domestic usage, pumping, telecommunications) remains marginal. These needs are still essentially covered by diesel. This situation may change if the economic viability of the centralised PV plant is confirmed technically and economically.

3.1.2 Wind power

Compared with Morocco, Tunisia and Egypt, Algeria possesses a rather weak potential for wind power. Despite this, it is not excluding wind power, which constitutes its second axis of development (after solar) with a pilot project on the horizon for 2012-2013, having an investment of €30 million[58] for building the first wind farm with a capacity of 10 MW (10 tranches) in Adrar, in the South-east of the country.Between 2014 and 2015, two other wind farms of 20 MW each should be completed. Studies shall be carried out in order to identify the preferred locations in order to complete other projects over the period 2016-2030 for power of around 1 700 MW.

Between now and 2013, the launching of studies for the implementation of the wind power industry is envisaged. Over the period 2014-2020, the aim is to reach a 50% integration rate. This rate should reach to over 80% over the period 2021-2030, thanks to the expansion of capacity for mast and rotor blade production, and to the development of a national subcontracting network for the production of equipment in this fledgling field.[59]

3.2 The case of Egypt

Egypt became endowed with an energy strategy adopted by the Supreme Court for Energy[60] in February 2008. This fixed to 20% the rate of RE (including hydroelectricity), in the total production of electricity by 2020[61].

Given the importance of wind power potential, Egypt has given priority to developing this resource which has seen strong growth in installed capacities. A contribution of 12% (7200 MW) from wind power interconnected with the network is thus planned through this strategic objective. However other technologies are also seeing new facilities set up, but with far less investment. As of late 2009, installed wind power capacity reached 430 MW, for a production of 948 GWh. Such production has made possible a saving of 205 000 tonnes of fossil fuels (oil products or natural gas), a reduction of 521 000 tonnes of CO_2.

[58] Ministère de l'Energie, Energie et mines, no 12, November 2010
[59] MEM, Programme des énergies renouvelables et de l'efficacité énergétique (Renewable Energy and Energy Efficiency Programme), p.22
[60] Created at the end of 2006, it is an inter-ministerial committee assembling the Ministries of Industry, Petroleum and Electricity and presided over by the Prime Minister, ensuring coordination of between agents of the sector and projects put in place.
[61] New Renewable Energy Authority, annual report 2009-2010.

3.2.1 Solar Energy

Solar is the second technology in terms of importance and involves both low temperature applications (solar water heater: SWH) and electricity production by CSP, which is also one of the most promising large-scale applications.

The first hybrid project (natural gas-CSP) in this field is that at Kuraimat, brought into service in July 2011, with a capacity of 140MW, of which 20 MW is solar. The total cost of this project is 340 million dollars, an investment approximately comparable with the CSP plant completed in Algeria. Financing sources are from NREA (100 million USD), the GEF (50 million USD) and a low-interest loan (0.75% repayable over 40 years, with 10 year grace period) and Japanese cooperation. This plant should allow an annual saving of around 10,000 tonnes of fossil resources and a 20 000 tonne reduction in CO_2[62]emissions.

There is no clear plan in existence for the expansion of CSP technology. At present only one study on feasibility has been carried out for the installation of a CSP of 100 MW capacity in the South of Egypt, on top of two 20 MW PV installations.[63]

Photo-voltaic (PV) and solar-thermal are being developed. Several small and medium-sized Egyptian enterprises produce and assemble panels in partnership with German, Danish, Spanish and Japanese companies. These small size panels are sold in order to supply isolated sites or rural areas. Installed capacity is estimated at 10 MW particularly for lighting, refrigeration, pumping, telecommunications, and advertising along highways. A few small-scale projects are under way for the electrification of isolated sites.

As regards SWHs, in the early 1980s, the Ministry of Electricity and Energy had imported 1000 units of various capacities that were installed in a number of regions so as to promote the market. Alongside this process there was the creation of the first Egyptian companies producing SWHs. At present there are around ten companies and the number of SWHs is estimated at 400 000 units at end 2009. Current projects, in collaboration with UNEP, for installation of SWHs in the Sinai and Red Sea regions at a total cost of 0.5 million dollars. The project subsidizes 25% of the cost and handles maintenance for 4 years.

Despite all of these factors, the development of solar energy remains embryonic, perhaps because conventional electricity remains heavily subsidised.

[62] Source NREA, annual report, 2009-10
[63] PWMSP, Benchmarking, Country Report Egypt p.16

3.2.2 Wind power

The real effect of wind power production began to appear once the wind farms in Hurghada were connected to the network at the end of the 90s. Throughout this period, the production of electricity grew very rapidly, moving from a growth of 368 GWh in 2003 to one of 1133 GWh in 2009. The following figures show the evolution of installed wind power capacity and the reduction of greenhouse gases.

Figure 13: Installed wind power capacity (MW)

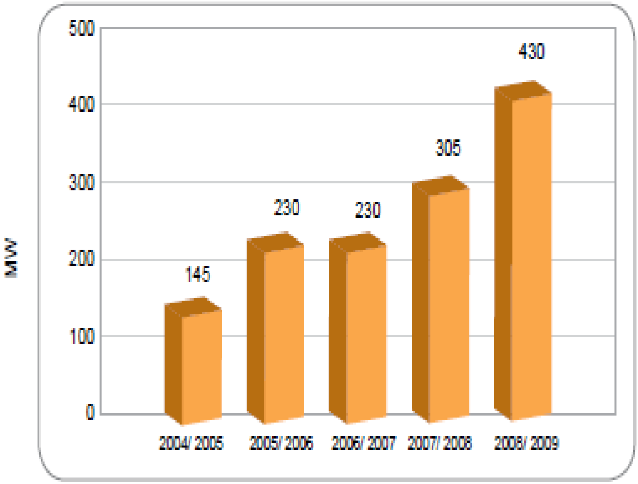
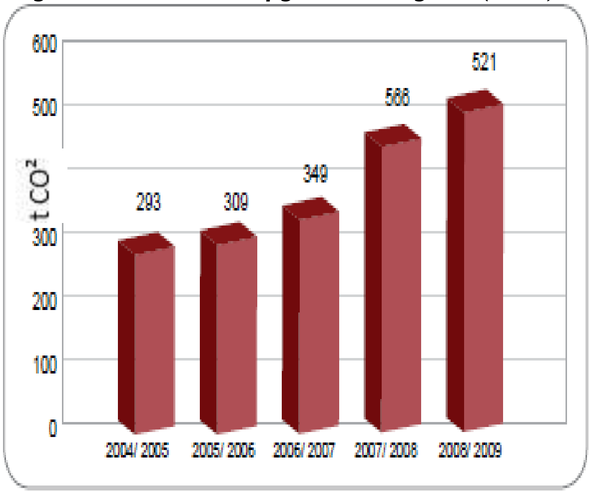


Figure 14: Reduction of greenhouse gases (t CO²)



Installed wind power capacity comprises two sites, Hurghada and Zafrana. The first site may be regarded as the first pilot experiment. The following table provides information on the capacity and characteristics of the two sites.

Table 7: Capacities and characteristics of the Hurghada and Zafarana sites

Sites	Capacity in MW	Year of commissioning	Characteristics
Hurghada	5	1993	42 turbines with different technologies (1, 2 and 3 blades), and German, Danish and American partners. Manufacture of local equipment is estimated at 40% (blades, towers, mechanical and electrical work).
Zafarana	517	Several tranches as of 2001	Partnership with Germany, Denmark, Spain and Japan.

A number of projects are in the course of realization or at the planning stage, including 120 MW additional capacity at the Zafarana site. Other projects are programmed from 2013, which is notably the case for the Gulf El Zayt and Gulf of Suez sites. *(Table 8)*

Table 8: Wind power projects on different sites whose commissioning is forecast as of 2013

Sites	**Capacity in MW**	**Possible year of commissioning**	**Comments**
Site TBC	200	2013	Partnership with Germany, the EU and the EIB. Agreement with Egypt and Germany, and the EU, ratified by the Egyptian assembly
Gulf El Zayt	220	2014	Cooperation with Japan International Cooperation Agency (JICA). 2005 feasibility study by a Japanese consultant. Agreement over a loan from Japan in March 2010, ratified by the assembly in June 2010.
Gulf of Suez	120	2013	Spain should provide €120 million according to the protocol signed in 1998

Three other projects, for which financing research is under way, totalling a capacity of 580 MW, are planned (Table 9).

Table 9: Wind power projects in Egypt for which the financing in progress

Sites	Capacity in MW	Possible year of commissioning	Comments
Gulf of Suez	140+40	Not available	140 MW: financing by Spain and reserved for Spanish companies. A donation shall be made for the financing of the preparation for studies into feasibility. 40 MW: not linked to the Spanish market
Site TBC	200	2014	In cooperation with Masder Company, property of Abu Dhabi. Framework for cooperation signed in 2010 with this company.
Gulf of Suez	200	2013	Cooperation with KfW Germany, AFD France, the EIB and the EU.

Other projects in the region West of the Nile totalling a capacity of 700 MW are planned over a longer term and should be completed in several stages. Alongside these projects initiated by NREA, the Egyptian private sector disposes of a consequent portfolio of a total capacity of 1370 MW, of which the state of progress is variable according to each project. *(Tableau 10)*

Table 10: Private sector wind power projects in Egypt

Sites	Capacity in MW	Possible year of commissioning	Comments
Wind farm for Suez Cement Company	120	Not available	Cooperation with Italgen 'company', environmental study completed in 2010 and approved by the environmental agency
Gulf of Suez	250	Not available	Build, Own, Operate Formula. 34 companies have submitted offers. Selection of offers with support from the World Bank.
Gulf of Suez	1000	Not available	Build, Own, Operate. In preparation.
Total	1370		

Source NREA, annual report 2009-2010.

3.3 The case of Libya

In order to reduce its dependence of on fossil fuels (oil and gas) and to promote renewables, in 2007 Libya created the Renewable Energy Authority of Libya (REAOL). More recently, a Ministry of Electricity and Renewable Energies was put in place. The strategy (looking to 2030) of development of renewable energies forecasts reaching a 30% share of electricity production of renewable origin between now and 2030. In order to achieve this, Libya set itself intermediary objectives which aim at 20% of total electricity production from renewables in 2020 and 25% in 2025.

REAOL had initially prepared a medium term plan (2008-2012) including local manufacture of goods for solar and wind projects.

3.3.1 Solar Energy

Photovoltaic installations began in 2003. The total number of photovoltaic systems installed by the GECOL (General Electric Company of Libya) is 340, for a total capacity of 240 kWp (kilowatts-peak). Solar PV comprises centralised and decentralised branches. Within centralised PV, three large plants connected to the network are envisaged (Aljofra, Green Mountain, Sabha), of which the project for a first plant is heavily advanced. Within decentralised PV, 2 MW in isolated areas and 500 solar PV roofs for residential areas are planned.

The thermal branch began in 1983 with a first pilot project which included 10 CES systems. Today it comprises a feasibility study for a 100 MW CSP, though without a site having been identified, as well as the usage in the first stage of 10 000 solar water-heaters. The production of energy from solar water-heaters is around 12% of national electricity production, but its usage has not spread across the whole country, due to a lack of information being given to the population and to the poor rate of electricity in Libya.

Negotiations are in progress for local production in partnership with national and foreign investors, specifically:

- Development of a joint venture with local and foreign investors for the manufacture of solar water heaters (40 000 units/year), for local and export markets;
- Development of a joint venture with national and foreign investors for the assembly of photovoltaic systems (50 MW).

However, these objectives need to be refined as part of a detailed strategy and feasibility study in consultation with the main interested parties in the sector in Libya.

3.3.2 Wind power

The utilisation of wind power has not been greatly developed, outside of use for the pumping of water in several oases, since wind power requires periodic maintenance. In 2000, a German-Danish consortium was contracted by the national electricity company to conceive of and construct a 25 MW wind farm. Several appropriate sites were identified and masts were installed in order to conduct a survey of wind conditions over the course of a year. Technical specifications for all components of the pilot wind farm and the call to tender documentation were prepared, but the project did not come to anything. The 2008-2012 development plan for renewables envisages the installation of several wind farms, with a capacity in the region of 1000 MW, of which:

- Dernah: phase 1 (60 MW) is under construction
- Al Maqrun: the contract for phase 1 (120 MW) is currently being awarded
- Al Maqrun (120 MW): the contract for phase 2 under negotiation
- Western region: Meslata, Tarhunah and Asabap (250 MW): projected
- Southern region: several possible sites Gallo, Almasarra, Alkofra, Tazrbo Aliofra, Sabha, and Gatt, Ashwairef: 250 MW projected[64].

3.4 The case of Morocco

Morocco has established a strategy for the development of renewable energies, particularly from wind and solar CSP, aiming for an installed capacity of 6000 MW (including hydro-electricity), or 42% of capacity by 2020, according to the national energy strategy. The implementation of this strategy shall pass through a programme which should permit substantial modification of electrical power generation, scheduled to reach 14 580 MW in 2020, or 2 to 3 times the capacity installed in 2010[65]. The detailed programme figures in the table below:

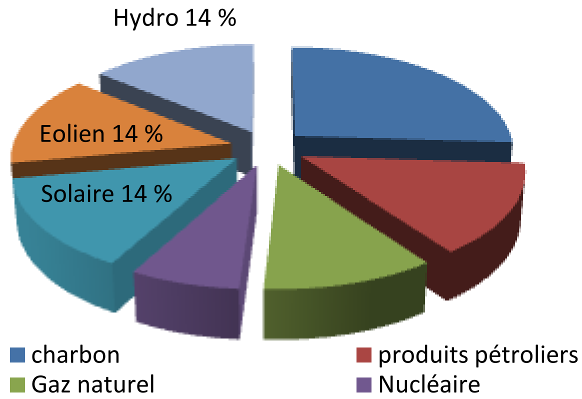
Table 11: Contribution of renewables and placing of actors by 2020 in Morocco

Technological Branch	Principal actors	Capacity in MW
Wind power	ONE (integrated national programme: 1000 MW Private Sector: 1000 MW	2000
Solar power	MASEN	2000
Hydraulic power	ONE	2000

[64] Communication from M.A Ekhlat, Renewable Energy Authority of Libya, Renewable Energy in Libya, Meeting of experts, UNECA, Rabat, 12th-13th January 2012.
[65] The installed capacity of Morocco in 2010 was 6343.7 MW (source: ONE, official site, one.org.ma)

The following diagram shows the composition in energy sources of Moroccan electrical power generation in 2020.

Figure 15: Structure of installed electrical power generation in Morocco in 2020 according to technological branch



Renewables will represent 42% of the total installed capacity in 2020. The relative ratio of carbon will diminish but will nonetheless represent 26% of the total installed capacity, or a reduction of 8% compared to 2008. Nuclear energy should represent 7% of this capacity. It seems unlikely that such electro-nuclear capacities be realised within this time frame, given the technological complexity of this branch and the level of financing required.

3.4.1 Solar Energy

The implementation of the solar programme aiming to restructure Moroccan electrical power generation by 2020 is in progress; its total cost is estimated at around $US 9 billion. The programme should provide a saving of 1 million (in toe) per year, at a value of $US 500 million; and also to reduce CO^2 emissions by close to 3.7 million tonnes per year[66]. This programme includes the first pilot solar-natural gas hybrid plant on a combined cycle, with a capacity of 470 MW, of which 20 MW are solar and an average annual productivity of around 3500 GWh. The completion of this plant, in operation since May 2010 and installed at Ain Beni Mathar (figure 16), required a total investment of €400 million, thanks to two loans from the African Development Bank totalling €287.85 million, granted in 2005 (€136.45 million) and 2007 (€151.40 million), a gift of $US 43.20 million from the Global Environment Facility (GEF), and a loan of €43 million from the Spanish development fund and by the *Office National de l'Electricité* (ONE)[67].

[66] PWMSP, Benchmarking Country Report Morocco
[67] http://www.afdb.org/fr/news-and-events/article/morocco-inauguration-of-the-ain-beni-mathar-thermo-solar-power-project-6720/

Figure 16: Ain Beni Mathar, Morocco: hybrid solar (CSP)-natural gas plant

On an environmental level[68], its commissioning has allowed a fossil fuel saving of 12 000 tonnes per year and an emissions reduction of 33 500 tonnes of CO_2. In addition, dry cooling technology (air coolers) reduced water consumption from 5.4 million m^3 to 850 000 m^3 per year, a saving of 80%[69]. From a socio-economic perspective, this achievement forms part of the integrated development programme of the Oriental region, and contributes to the opening up of Ain Béni Mathar by the building of an access road to the plant and the neighbouring towns, job creation during the implementation and operation phases (360 000 work days) and the development of small and medium sized local businesses. The infrastructures of the town of Béni Mathar have been improved through the construction of two bridges over the Charef and Tabouda Oueds, and drilling for water in the adjacent locations.

The Moroccan solar energy programme aims at a capacity of 2000 MW, spread over five sites, including Ouarzazate, already identified, with a capacity of 500 MW for a production of 1150 GWh/year. The Ouarzazate solar plant currently in the process of being realised has benefited from the support of international financial institutions and from the Facility for Euro-Mediterranean Investment and Partnership (FEMIP), alongside a sizeable commitment from several European Union member states. It has also benefited from grants and loans from the German Financial Cooperation Bank (KfW) and from the French Development Agency (AFD), via Clean Technology Fund (CTF) managed by the World Bank. This is the first proposal under the investment plan for CSP in the MENA (Middle East and North Africa) region to be approved by the Fund (CTF).

As for PV, currently over 250 000 rural households are fitted with photovoltaic systems. Around 170 000 PV domestic PV systems were installed, giving capacity of the order of 3 MW[70].

[68] ONE, Planned Ain Beni Mathar thermo-solar power plant, environmental specifications
[69] http://www.afdb.org/fr/news-and-events/article/morocco-inauguration-of-the-ain-beni-mathar-thermo-solar-power-project-6720/
[70] ONE

3.4.2 Wind power

This technology is the second important aspect of the renewable energy development programme. The 2020 aim for wind power is to reach a capacity of 2000 MW, producing around 6600 GWh. The cost of the investment is estimated at $US 3.5 billion. This project should provide an annual saving of 1 million (in toe) and a reduction in CO² emissions of 5.6 million tonnes.[71]

Morocco already possesses significant installed wind power capacity, totalling 290 MW, as shown in the table below.

Table 12: Wind farms in Morocco: end of 2011

Sites	Ownership	Capacity	Year of Commissioning
Abdelkhalek Torrés Tetouan	ONE	50 MW	2000
Lafarge-Tetouan	Lafarge	30 MW	2006
Amogdoul-Essaouira	ONE	60 MW	2007
Tangiers 1	ONE	140 MW	2009
Tantan (South)	ONEP	10 MW	2008
Total		290 MW	

Furthermore, wind power installations totalling 850 MW, financed by private producers, are planned at 5 sites, having an significant potential, of which Tangiers 2 (150 MW) and Jbel Lahdid (200 MW) in the Essaouira.

For the completion of the wind farm, ONE aimed at issuing a pre-qualification folder in January 2012, in advance of a call to tender, which was issued during the second quarter of 2012. This programme shall be implemented according to the Build, Own, Operate and Transfer formula, within the framework of a public-private partnership involving ONE, the SIE and the Hassan II fund on the Moroccan side, which shall be retained following the call to tender. For the implementation of this programme, ONE has solicited a loan from the African Development Bank.

3.5 The case of Mauritania

The development of renewable energy is an objective in the Strategic Framework to Combat Poverty (SFCP) and a strategic line of action of the Government's energy policy. The latter's aim is to improve the population's access to electricity and to promote new energies and renewables. A plan is in place to bring the rate of renewable energies within the total national energy balance up to 15% by 2015 and 20% in 2020[72]. This objective should contribute to growth in the rate of electrification (estimated at 23.8% on a national level), especially in rural and semi-rural areas, where it is very weak (3-5%). A national strategy for development of renewable energies is currently in the process of being prepared. Up till now, the main projects realized have been decentralized small-scale off-grid projects. It is very

[71] PWMSP, Benchmarking, Country Report Morocco, 2011
[72] Islamic Republic of Mauritania, Perspectives and Potential for the Electricity Sector, round table for Mauritania, Brussels, 22nd-23rd June 2010

likely that this tendency will be maintained over the next decade, notwithstanding the implementation of plants of small and medium power interconnected to the network, especially within wind power, of which the costs are comparatively lower than other types of renewables, and for which Mauritania possesses a very strong source. However large-scale integration of renewables in the Mauritanian energy system[73] remains limited by current installed capacity and the high number of isolated grids.

The most important advances have been obtained in decentralised solar and wind projects and programs, most often with technical support from partners in the North. Furthermore it should be noted that even if the cost access to energy services from renewable energy remains high, this option is still more viable if not less expensive, in the long term, on account of the remoteness of electrical grids and difficulties in obtaining fossil fuels.

3.5.1 Solar Energy

The total installed solar capacity remains low, in spite of the social and economic impact, which can be very significant in very poor locations. In 2001 total installed PV power was estimated at 950 kWp spread between pumping (19%), and lighting and refrigeration (81%). A number of other projects have been realized between 2000-2010, in particular:

- In 2005, the completion of the project to electrify 208 locations (villages and administrative towns etc. in the wilaya of Adrar, Dakhlet Nouadhibou and Trarza) through photovoltaic solar systems called project 3000 Kits. Besides lighting, the main uses are pumping water and storage of medicine, which have improved living conditions in isolated villages.
- Several thousand other homes were electrified within the framework of similar operations, in particular in rural areas of the centre and east of Mauritania (wilayas of Hodh, Echargui, Hodh el Gharbi, Assaba, Tagant and Brakna[74]).

Other projects within solar energy are programmed (over the course of the next two decades), such as thermo-solar pilot plants connected to the network (1 to 10 MW) in interior wilayas (Assaba and Hodhs), and pilot PV plants connected to the Nouakchott network (500 kWc to 1 MWc)

3.5.2 Wind power

Wind power is the other technology which saw development start in the early 1990s. This consisted in low-powered turbines mainly for pumping water. As part of the trade wind project[75], 101 pumping turbines were installed in the Trarza regions in southern Mauritania. These installations enabled the provision of a drinking water supply for over 20 000 people. It is important to underline the strong involvement at local and regional levels of the villagers who contributed to around 15% of the

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[73] IPCC: Intergovernmental Panel on Climate Change, Renewable Energy Sources and Climate Change Mitigation, Special Report of the IPCC, chap 8, Integration of renewable energy into energy systems, Cambridge University Press, 2011

[74] Ministère de l'Hydraulique de l'Energie et des Technologies de l'Information et de la Communication (MHETIC - Ministry of Hydraulics and Energy, Information Technology and Communication). Expérience mauritanienne dans l'électrification rurale (Rural electrification, the Mauritanian experience), Marrakesh, 19th to 29th November 2007

[75] www.alizes-eole.com/mauritanie/historic/.htm

investment. Maintenance of the installations is currently ensured through a mutual association ("NASSIM")[76]. The other important factor is the local manufacture of the equipment by the DEYLOUL Company thanks to a technology transfer with ECOLAB, the French manufacturer of the OASIS turbine. This experiment has made it possible to extend services of electricity through the introduction of energy-generating turbines which are a totally different technology from pumping turbines[77]. A few were installed in the Trarza region, providing basic services to 980 families and bringing electricity to six clinics.

- 1 x 2.5 kW: Tighent local grid, LMW windmill (now FORTIS)
- 17 x 1 kW: individual battery recharges, LMW windmills
- 20 x 70 W: individual photovoltaic installations and Marlec turbines in certain cases

These installations were carried out by the Mauritanian DEYLOUL and BTI companies, in association with the Dutch supplier LMW (now FORTIS) in the AFRIVENT consortium, which handled the installation and maintenance of the equipment. This is a 2.2 million USD project financed by the GEF and implemented by UNDP. Generally the entrance fee for the beneficiary is set at 10% of the investment and the service cost invoiced[78]. Compared with the needs of the country, the impact of these projects remains limited and their implementation is highly dependent on outside subsidies, which are not easy to obtain.

In future, numerous other wind power projects will be added to those already completed or in the process of being completed, as shown in the following table:

Tableau 13 : Wind power projects connected to the network in Mauritania[79]

Wind power
• 4.4 MW Wind plant (SNIM). • 7-15 MW Wind farm in the Nouadhibou region. • 18-25 MW Wind farm, possibly linked to a desalination unit in Nouakchott (SOMELEC)[80] • 50 to 100 MW Wind farm in the mining corridor.

[76] NASSIM is a federation of cooperatives; its members are the village cooperatives set up in each village to manage the turbine. 54 villages are members of NASSIM as of late 2001.
[77] Khennas S, Dunnet S and Piggott H, Small Wind Energy for Rural Services, ITDG Publishing, London 2003
[78] Individual 70 W Module: 1600 UM, 1000 W Turbine (1 village): 12 000 UM, 2500 W Turbine (1 village): 24 000 UM, energy kit (individual battery): 400 UM, source http://www.alizes-eole.com/
[79] Ministry of Energy and Petroleum, Perspectives on Renewable energies in Mauritania, Financing of Development in North Africa, Meeting of Experts, Rabat, 19th-21st October 2010.
[80] Cheikh Ould El Moctar, The renewable energy sector in North Africa: current situation and prospects. The case of Mauritania, Meeting of UNECA Experts, Rabat 12th-13th January 2012.

The SNIM (National Industrial and Mining Company) project is very advanced, with the signature of a contract with the French group Vergnet, for the completion of 16 wind turbines on the site of Nouadhibou, with a unitary power of 275 kW[81]. The study was completed by a Moroccan company, SOR Energy. The cost is estimated at €1.7 million/MW or around €0.10/kWh. These costs, if confirmed during completion and operations, may justify a large-scale development over a medium-term (5 to 10 years) in wind power in Mauritania. Furthermore, SOMELEC should also launch the completion of a wind farm of 30 to 40 MW in Nouakchott.

Compared with the other countries of the region, these projects may seem small, but are actually very significant in relation to the installed capacity in Mauritania in 2011. Given the low rate of rural electrification, decentralized projects are an important line of action in strategies to combat poverty.

The following table presents the planned wind-powered projects which may help to increase the rate of rural electrification and, as a consequence, fight against the poverty which is especially rife amongst rural communities. Nonetheless, detailed feasibility studies are still to be carried out, added to the mobilisation of finances.

Tableau 14 : Wind power projects for rural electrification in Mauritania

Wind power
• North Coast Project: hybrid wind/diesel electrification of 13 locations between Nouakchott and Nouadhibou (UNDP /GEF – RIM). • Wind farms in the South-eastern regions • Small isolated turbine for locations along the line of the Aftout Es-sahéli (Southern coast).

3.6 The case of Sudan

In the long term, Sudan is planning to reinforce the contribution of renewables to the energy balance of the country. At the current stage, these consist of projects for which complete feasibility studies and mobilization of finance are required. According to the renewable energy directive drawn up in 2005, around 20 000 megawatts will be achieved over the next 20 years. Hydroelectric plants may contribute a proportionate maximum of 20-25%, the rest coming from other renewable energies, such as biofuels[82] and solar.

[81] http://www.boursorama.com/forum-vergnet-16-eoliennes-mp-pour-la-mauritanie-405570515-1

[82] The question of biofuels shall not be addressed in this study. This question should be addressed whilst taking food security into consideration. A United Nations study completed by the FAO is dedicated to biofuels, "The State of Food and Agriculture 2008. Biofuels: prospects, risks and opportunities", 2008.

3.6.1 Solar Energy

Given the slow pace of electrification and low population density, solar PV is a very attractive technology - both for rural electrification, and for pumping water, in particular for the thousands of farming plots along the course of the Nile. With this in mind, the Global Environment Facility (GEF) launched a project in 2000 aiming to support market penetration of photovoltaic solar power through technical, institutional and financial backing, so as to meet social demand from the education and health sectors. As finance is the main constraint, the project has developed, along with the Sudanese Social Development and Savings Bank: SSDSB), a guarantee mechanism, which came into operation in 2003. By late 2003, around 80% of the capital supplied had been used as leverage for solar systems, mainly for homes. The recovery rate was of the order of 87-92%. On account of the success of this program, the Agricultural Bank of Sudan agreed in 2004 to grant credit in five further towns where the SSDSB did not have branches.

Another project financed by the UNDP has allowed the installation of photovoltaic panels to electrify 13 rural and suburban communities, reaching 45 000 homes[83].

Sudan also envisages large-scale development of the solar sector. In this context, the French Solar Euromed Company recently signed an agreement with Sudan to build and run solar plants over the next decade.

3.6.2 Wind power

Wind power is mainly limited to water pumping from wells of various depths for the supply of services to agriculture (irrigation) and drinking water for the population. During the 1960s, pumping turbines were relatively widespread in the centre of Sudan, since over the course of the 1950s, thanks to support from the Australian government, around 250 pumping turbines were installed within the framework of the “El Gezira Agriculture Scheme”[84]. Lack of maintenance and especially that of spare parts led to their disappearance despite the efforts made from the late 1990s. Pumping turbines are now in use in the North, Khartoum, central Butana and the Nile States. Such wind technology is relatively simple; and equipment can be made entirely from available local materials. In terms of large-scale electricity production, the Sudanese electricity company, the National Electricity Corporation (NEC), has signed an agreement protocol with the OMENE Energy Africa group[85], based in the United Arab Emirates, for the construction and operation of wind farms in Red Sea coastal sites, with a 500 MW capacity, to be completed in stages of 100 MW. The formula retained for this large-scale wind power programme is that of Independent Power Producer.

[83] Renewable energy and energy efficiency partnership, Sudan (2010)

[84] A. M. Omer, Sudan energy background; an overview, Renewable Energy Journal, Vol.14, Nos (1-4), p.467-472, Elsevier Science Ltd, UK, 1998. See also: A. M. Omer Wind energy activities in Sudan, Nottingham, United Kingdom, www.ewec2007proceedings.info/allfiles2/55_Ewec2007fullpaper.pdf

[85] http://www.omeneholdings.com/

3.7 The case of Tunisia

The Tunisian Solar Plan (Plan Solaire Tunisien - PST), published in 2009 and updated in July 2011, contains the principal objectives and projects in terms of renewables, including the promotion of agro-industrial refuse and energy efficiency. It envisages the completion of 40 projects in the wind and solar power sectors during the period 2010-2016. All of these projects shall contribute to reaching objectives set by the PST, which aims at 16% of electricity production coming from renewable energies in 2016 (or 1000 MW) and 40% in 2030 (or 4700 MW). In terms of energy efficiency, the Tunisian government hopes to reduce demand by 40% in 2030.[86]

The PST envisages the completion of the following projects, according to type:

- Solar power:
  - 6 thermal application projects: Water heating (residential, individual and collective - tertiary - industry)/Solar cooling/Solar drying;
  - 5 decentralised urban and rural PV projects;
  - 5 centralised PV and CSP projects;
  - 1 PV production unit.
- Wind power:
  - 3 projects: wind farms totalling 350 MW by the STEG, the private sector and self-producers
- Energy efficiency:
  - 7 projects

Once all of these projects have been implemented, the expected impact of the plan is to reduce the consumption of fossil fuels by 600 ktoe per year, equivalent to 22% of the national energy consumption in 2016. In terms of environmental impact, the PST will enable the reduction of greenhouse gas emissions by over 1.3 million tonnes of CO^2 each year.[87]

It is estimated that the cost of this plan will reach 3369 MDT (Million Tunisian Dinar), of which the financing from public and private sectors is envisaged in the following way:

- 256 MDT towards energy efficiency, coming from the FNME (National Energy Control Fund - NECF);
- 596 MDT from the public sector, mainly from the STEG;

[86] Conference on « L'économie verte, solution à la crise » ("The green economy, solution to the crisis"), Tunis, 2012 (powerpoint)
[87] PWMSP, Benchmarking, Country Report Tunisia, p.4

- 2479 MDT from the private sector, of which 1074 MDT is set aside for exports projects to Europe, and
- 38 MDT of the technical cooperation.

3.7.1 Solar Energy

Tunisia should in the short term possess a 50 MW pilot CSP unit, under the auspices of the STEG, which should be in service by 2015. Several other CSP units are planned, as described in the following table:

Tableau 15 : CSP unit projects in partnership with the private sector

Site/operator	Capacity	Comments
El Borma	Between 40 and 50 MW Hybrid solar gas, of which 5 MW solar	(Financing: Japanese gift, Studies launched)
ELMED Project	100 MW of renewables toward 2016	Link with Italy
Private Sector	75 MW	Regulatory and tariff framework in preparation. Promoter being sought

The El-Borma plant will be built in partnership with Japanese companies and financing from this country. Indeed, Mitsui Engineering & Shipbuilding[88] Co. plans to build a solar plant in Tunisia so as to be present in a developing market, currently dominated by European companies and initiatives. This plant should have a capacity of 5 MW and will be linked to a 39 MW combined cycle gas station, pairing gas and steam turbines to produce energy more efficiently.

As for PV, there will still be a very significant number of installations on account of the small unit size of the units, generally in the tens or hundreds of Watts. STEG's photovoltaic strategy aims towards both decentralized applications in construction and photovoltaic power plants[89].

The solar roof programme for homes, which would allow, admittedly in a small way at the outset, a reduction in the recourse towards fossil fuels. So household electricity bills will fall considerably through resale of home production to the electricity company.

With regards centralized PV, a feasibility study, by a German consultancy, is currently under way for the completion of a plant with a 10 MW capacity by 2014. Estimated costs, energy savings and emissions prevented through the solar-thermal programme are set out in the following table:

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[88] African Manager, 10/12/2010. http://193.95.93.174/detail_article.php?art_id=130741
[89] ANME, rencontres du solaire thermodynamique, Développement de la Production de l'Electricité par l'Energie Solaire Thermodynamique dans le cadre du PST en Tunisie, Kawther LIHIDHEB, Paris 7th July 2011

Tableau 16 : Project for two CSP plants, one public, the other private.

Type	Capacity	Cost in MDT	Savings toe/year	CO2 emissions avoided tonnes CO2/year
STEG CSP plant	50 MW	355	16 500	38 760
Private CSP plant	75 MW	450	49 500	116 280

3.7.2 Wind power

In terms of large developments, the first experiment in wind production of electricity dates from over ten years ago, with the 10.56 MW pilot wind plant, installed at Sidi Daoud and in operation since the start of 2000[90], thanks to financing from the Spanish MADE Company, which has representatives in Tunisia. Two extensions to capacity were achieved in 2003 and 2007, of 8.72 MW and 34.32 MW respectively, a total capacity of around 54 MW. Operation of the farm is handled directly by the STEG.

In environmental terms, for a production estimated at 150GWh/year[91], 33 000 toe of fuel is saved and around 93 000 tonnes of CO_2 emissions prevented[92]. One should also take into account the savings of water (11,000 m^3) and of other particularly dangerous emissions: NOx (174 tonnes), SOx (190 tonnes), particles (9 tonnes).

STEG's wind farm reached around 244 MW in 2011, with the building of the Metlin Kchabta plant (120 MW) and its 70MW extension. Wind power programme costs, energy savings and CO_2 emissions prevented, current and short-term (2017) are set out in the following table:

Tableau 17 : Wind power programme described through costs, energy savings and CO² avoided by 2017

Site	Capacity in MW	Cost in MDT	Savings toe/year	CO_2 emissions prevented tonnes CO_2/year	Status
Bizerte Wind Farm	190	570	142 500	334 000	Planned for 2011
EGCE self-production	60	180	50 000	117 450	Feasibility study
IPP Wind Farm	100	300	75 000	176 180	

Source: Tunisian Solar Plan

[90] UNIDO, unité pour la promotion des investissments, Tunisie, le secteur des ER en Tunisie, April 2002
[91] STEG http://www.steg.com.tn/dwl/02_experience_energies_nouvelles_renouvelables.pdf
[92] STEG

Chapter 4
TOOLS FOR THE PROMOTION OF RENEWABLE ENERGIES.

4.1 Legislative, regulatory and financial frameworks

In the majority of North African countries, significant reforms of institutional, legislative and regulatory frameworks (laws, decrees and orders) have been carried out over the past few years with a view to promoting renewable energies and energy efficiency. Thus, specific institutions have been created and regulations reviewed in order to favour, to varying degrees, a greater opening up of the renewable energy market. In terms of financing, funds have been established and financing mechanisms put into place.

4.1.1 Algeria

The institutional framework of the energy sector includes an agency for the promotion and rationalisation of energy use (APRUE) and a specialised agency for the development of new and renewable energies (NEAL). The development of renewable energies is framed through a set of legislative texts:

Law n° 99-09 of 28th July 1999, on the control of energy, bringing about the National Energy Management Program (PNME - Programme National de Maîtrise de l'Energie). This enshrines the promotion and utilisation of renewables. Action and projects under the PNME are carried out through contributions from the National Energy Management Fund (FNME - Fond National de Maitrise de l'Energie) which aims to promote both the national energy control market and renewable energy projects. Under this law a strategy and institutional mechanism have been put in place, based around:

- the National Agency for the promotion and rationalisation of energy use (APRUE), tasked with driving and leading the implementation process for programmes and actions in energy management;
- the setting up of an Intersector Energy Management Council (CIME - Conseil Intersectoriel de la Maîtrise de l'Energie), which will serve as a forum for coordination and consultation between the various interests involved in the field.

Law n°02-01 of 5th February 2002, relating to electricity and public distribution of gas through pipelines, ensures the purchase of energy originating from renewables and the taking on of related extra costs. This law also enshrines a special scheme for electricity production from renewables, as separate from the standard scheme. Applying the provisions of this law, in particular Article 26, Decree n° 04-92 on diversification costs of electricity production (feed-in tariffs), which envisages the granting of preferential tariffs for electricity produced from renewables, the payment for connection of installations and the granting of a green premium varies between 100% and 300% of the kWh cost.

Law n°04-09 of 14th August 2004, relating to the promotion of renewable energies as part of sustainable development, sets up a national promotion programme for renewables and the tools for achieving this. It should also be noted that this law provides for the creation of a national monitoring body tasked with the promotion and development of renewable energy use, the "Observatoire National de Promotion des Energies Renouvelables" (National Observatory for the Promotion of Renewable Energies).

In 2004, a decree on the diversification of electricity production (executive decree n°04-92 of 25th March 2004) was enacted by the Algerian government. The aim of the decree is to create incentives for sources of electricity production outside of more traditional models. At the time of publication of this work, the decree was unique in Africa: for the first time on the continent, a system of remuneration has been precisely defined for renewable electricity.

In detail the decree defines the payment that the producer of electricity will receive per kWh of renewable energy injected into the network. In a more detailed way, the decree envisages the following payments, which are made above the market price of electricity.

1. For electricity sourced from wind power, the payment is of 300% (of the price per kWh of electricity, as outlined by the market operator, defined by law n°02-01 of 22nd Dhou El Kaada, 1422 (corresponding to 5th February 2002)).
2. For electricity sourced from solar power alone, the payment is of 300%.
3. For electricity produced from installations using solar-thermal energy through hybrid solar-gas systems:
   - for a solar contribution of 20-25%: the payment is of 180%
   - for a solar contribution of 15-20%: the payment is of 160%
   - for a solar contribution of 10-15%: the payment is of 140%
   - for a solar contribution of 5-10%: the payment is of 100%
   - for a solar contribution of 0-5%: the payment is nil.
4. For hydroelectricity, the payment is of 100%.
5. For co-generation installations, the payment is of 160%.
6. For refuser incineration installations, the payment is of 200%.

The inter-ministerial order of 19th April 2008, bringing about the adoption of the technical regulation of the photovoltaic module "PV", defines the technical, regulatory and administrative requirements to which the commercialisation of crystalline silicon photovoltaic modules (PV), for land use is compelled to adhere.

Following the enactment of the law on electricity which authorises competition, 35% of the production of electricity is now handled by plants owned by private foreign companies. The electricity produced is sold to SONELGAZ, which is the sole buyer, as well as the distributor. In terms of renewable energies, the incentivising measures implemented are insufficient for the stimulation of private investments. A reformulation of the law on renewable energy is currently under discussion.

In terms of financing, the finance laws set up financing mechanisms specific to renewables. Thus, according to the additional finance law (LFC) for 2011 published in late July, the percentage of petroleum royalties devoted to funding action and projects within the framework for the promotion of renewable energies and co-generation, was raised from 0.5% to 1%. The 2011 LFC forecasts that revenues from oil taxation will come to 1529.4 billion dinars. A national fund for renewable energies was established by the 2010 finance law. Article 63 of the law states that an account for this fund is open in the Treasury accounts and with 0.5% of deposits coming from oil taxation. Given that finance laws are being passed each year, this in no way guarantees ongoing and predictable means of financing.

4.1.2 Egypt

Despite the existence of a specialised agency for renewables (NREA: New and Renewable Energy Authority), there is no specific law within this sector. Certain provisions of the law on electricity define the procedures for the construction of installations connecting generators sourced from renewable energies to the network and for the compensation of the EETC (Egyptian Electricity Technology Company) for the purchase of energy at prices higher than those for other sources. Economic and financial incentives have been put in place so as to speed up the development of renewable energy and energy efficiency in Egypt. Article 45 of the law establishes the process for the acquisition of electricity production centres utilising renewable energies. It envisages several options combining a competitive call to tender system and a feed-in tariff.[93]

The projected law on electricity "still under ratification" envisages three production mechanisms on the basis of renewable sources (wind farms). These three mechanisms are:

1. Installation built by NREA (2200 MW);
2. Installation built through a call to tender (2500 MW);
3. Installations built through the feed-in tariff (2500 MW).

Article 47-50 envisages the creation of funds named "Funds for the Development of Electricity Production from Renewable Energies" created by the Council of Ministers. This fund aims to compensate the EETC[94] for the purchase of electrical energy sourced from renewable energy generators. The fund shall be mainly financed through State public budget credits. The status of funds and their governance shall be fixed by decree.

4.1.3 Libya

Although there is a specialised agency (REAOL: Renewable Energy Authority of Libya) for the promotion of renewable energies, the development of tools and mechanisms to promote RE is very low. Indeed, in legislative terms, there is no law to cover or regulate RE, nor even its funding. Opportunities for the possible involvement of private investors are thus reduced.

A bill on electricity could contain measures for the promotion and financing of RE and EE, but no specific measures are currently in place.

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[93] PWMSP-Benchmarking, Country Report Egypt, p.22
[94] Egyptian Electricity Technology Company

4.1.4 Morocco

The institutional and regulatory frameworks have undergone significant progress during the years 2009 and 2010 with Law No. 13-09 on the development of RE, Law No. 16-09 on the creation of the National Agency for Development Renewable Energy and Energy Efficiency (ADEREE), Law No. 57-09 on the creation of the MASEN and Finance Law 40-08 establishing the Energy Development Fund and the creation of the Energy Investment Company (SIE)[95].

The main achievements are:

- The introduction of competition to the production of electricity from renewable sources;
- Access to the national grid in medium, high and very high voltage for any producer of electricity from renewable sources;
- The ability to export electricity from renewable sources by the use of the national network and interconnections and;
- The ability for a developer to build a direct transmission line if the national transmission and interconnection grid is insufficient.

Creating ADEREE (which replaced CDER) helped integrate energy efficiency in the functions of the Agency. It aims to contribute to the implementation of government policy on renewable energy and energy efficiency[96]. It will thus have a broad competence in proposing to the administration a national and sectoral and regional plans for the development of RE and EE. The ADEREE also has the ability to design and implement development programmes in the areas of renewable energy and energy efficiency (Article 3, Law 16/09).

The MASEN was created to ensure the implementation of the Moroccan solar programme. It is a public limited company owned equally by the Moroccan State, the Hassan II Fund for Economic and Social Development, and the ONE Energy Investment Company (SIE). The MASEN aims to achieve, within the framework of an agreement with the state, the development of integrated production of electricity from solar energy, with a minimum total capacity of MW 2,000. Although it is specified that the production will be allocated by priority to national needs, some of the electricity could be exported[97]. The law does not specify which solar technology sectors should be developed by priority. It is only stated that the combined power of a project must be greater than or equal to 2 MW. The current technological trends and the scale of the Moroccan solar programme (2,000 MW) suggest that the CSP sector will be prioritised.

[95] Moroccan Agency for Solar Energy
[96] Ministry of Energy, Mines, Water and Environment, Law No. 16-09 on the National Agency for the development of renewable energy and energy efficiency
[97] Article 3 Law 57-09, June 2010

On the financial side, the Finance Law 2009 established the fund to promote energy development in the energy sector, in order to finance renewable energy and energy efficiency. This fund has an initial amount of USD 1 billion provided by Saudi Arabia (USD 500 million), the UAE (USD 300 million) and the Hassan II Fund to the tune of USD 200 million. The SIE, which was established in February 2010, is an investment fund for renewable energy and energy efficiency. It operates by taking active minority stakes in companies with specific, profitable projects, for which industrial feasibility has been demonstrated. It also seeks to maximise synergies and complementarities with its institutional partners the ADEREE, ONE and the MASEN. Thus, the SIE will give priority to renewable energy, especially solar energy (apart from solar centres to be developed by the MASEN[98]), wind, biomass and hydro.

In addition, two other funds, respectively for RE and EE are being created. The main features of the future RE fund are summarised in the following table:

Table 19: Properties of the two funds being created for RE and EE

Size and duration	1-2 billion DH of which 50% from Moroccan investors and 50% from international investors Duration: 7 to 10 years
Participation of SIE	The SIE invests 20% for Morocco. Financial contribution identical to the Moroccan element for international investors (one to one matching)
Management	The Management Company is controlled by La Compagnie Benjamin de Rothschild and Ascent Capital Partners, based in Casablanca

The FOGEER[99], created in 2007 from a partnership between the ADEREE and DAR ADDAMANE[100], is a fund to guarantee investment loans made by credit institutions to Moroccan companies and operators wishing to invest in renewable energy and energy efficiency. The fund is structured by sector (solar water heating, wind, energy efficiency...) and allows a guarantee of 70% of the investment with a direct subsidy of 10% of the total cost and a reduction of about 1.5% in the interest rates applicable.

To encourage people to adopt solar panels on the roofs of their homes, the ONE offers incentives based on three options:

- Direct action: the ONE buys and installs the PV kit with assistance from the CDER and provides its maintenance and after-sales service.
- Service provision: the ONE commissions a private company closer to the beneficiaries to install the PV system and provides after sales service and debt collection.

[98] According to the law of 11-02-2010 establishing the MASEN, the latter is responsible for research, design and development of integrated solar projects. However, the EIS has taken a 25% stake in the MASEN

[99] Guarantee Fund for Energy Efficiency and Renewable Energy

[100] DAR Addamane is a financial institution that was founded in 1997 by Bank Al Maghrib and is intended to facilitate SMEs in particular, to ensure access to finance by guaranteeing investment loans and the operating credits needed to finance the operation cycle.

- Partnership action: the ONE provides solar panels and batteries for the selected companies through tenders, which are then responsible for the installation of the equipment and accessories at their own expense and also equipment warranties, maintenance and after-sales service.[101]

Another interesting programme "Energipro" was developed by the NEB in late 2006. It offers "Key Accounts" of the ONE an opportunity to generate electricity to meet their energy needs. The NEB is committed to transporting the energy produced from the production site to the consumption site, buying any excess energy not consumed. The conditions of participation are:

- Production of electricity from renewable energy;
- Production must be designed for the needs of the autoproducer;
- Compliance with the conditions for connection to the grid.

4.1.5 Mauritania

Since the early 2000s Mauritania has had an Agency for the Promotion of Universal Access to Basic Services (APAUS)[102] for energy, primarily electricity, water and telecommunications. This mission is part of the Strategic Framework for the Fight against Poverty (CSLP) and the achievement of the Millennium Development. The scope of intervention by the APAUS is open, but it is by no means specified that the provision of energy services must derive from renewable energy sources.

On the other hand, the mandate of the Agency for the Development of Rural Electrification (ADER), founded in February 2000, is confined to rural energy. The mission of the ADER is coordination and facilitation of the process of decentralised rural electrification. The government delegates to the ADER the project management of the national electrification programme. The ADER is not required to rely exclusively on RE; it can use low-voltage/medium voltage (LV/MV) networks either isolated or connected to the grid, and individual solar kits. The rates differ depending on the option chosen (solar or network) and the level of consumption[103].

Mauritania created in October 2010 a national development agency for renewable energy (ANADER). This agency is intended to be a strategic tool for the design, research and implementation of projects in the renewable energy sector. It also aims to create favourable conditions for the development and use of national expertise, in order to give the people quick and transparent access to functional energy systems, especially in rural areas. Law No. 2001-19 on the electricity code opens the electricity market to the private sector. In financial terms, the mechanisms used are: the EU Energy Facility, the IDB's concessional loans, funding from the UNDP and the MOUs with mining companies.

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[101] PWMSP, Benchmarking Country Report Morocco
[102] Law of 2001-06 establishing the APAUS revised 2005-31
[103] ADER, A. Ould Mohamed Mahmoud, The development of hybrid industry nationally and future prospects, Workshop on Applied hybrid solutions for rural electrification, Bamako 18-22-07-2011

4.1.6 Sudan

At the legislative level, energy legislation is very limited. However, the 2000 Law on Electricity provides the opportunity for the private sector to invest in power generation, transmission or distribution. Thanks to the investment law of 2001, private and foreign investment has been encouraged, which has led to the construction of new power plants. However, there is little competition in the electricity sector because the National Electricity Corporation (NEC) has control of all activities in the sector, although there are some private diesel generators that provide electricity in some regions which are outside the national grid coverage.

The "National Strategic Plan for Sudan", which is the first since the signature of the Peace Agreement, includes the construction of distribution networks for electricity and rural electrification projects promoting sustainable economic development.

Another plan written slightly earlier in 2005, the "Sudan Renewable Energy Master Plan", aims to promote the use of renewable energies including priority projects such as installations of solar panels and biomass cogeneration, so to avoid energy or technology dependence related to the petroleum sector.

There is no agency specifically dedicated to RE. For example, the Forest Research Institute (Forestry Research Institute) is responsible for energy technologies in biomass. The Energy Research Institute (ERI) undertakes research on RE and development programmes and the Ministry of Science and Technology is involved in research to promote sustainable economic development in the country.

Sudan has not yet developed tools and financing mechanisms for renewable energy, but the Sudanese authorities have benefitted from a loan of 93 million dollars (US) from the Saudi Development Fund for the project "Benefit of the Nile" and the raising of the Roseires dam to double its hydropower generating capacity. At the same time, the Kuwait Fund for Arab Economic Development has agreed to lend 52 million dollars (US) for the same project.

4.1.7 Tunisia

Since the early 1980s, Tunisia has progressively put in place the institutional and regulatory instruments for the promotion of RE. At the institutional level, the ANME is now the main tool for the design and implementation of RE and EE policy**.** The Agency is under the Ministry of Industry and Technology.

In 1985 and 1986, outlines of the regulatory framework that is to evolve gradually were defined by the enactment of several laws and decrees[104], including Decree Law No. 85-8 of 14 September 1985 on energy saving, ratified by Law No. 85-92 of 22 November 1985. This statute created the Energy Management Agency (AME), which went on to become the ANER and currently the ANME.

[104] Law No. 85-48 of 25 April 1985 on the promotion of research, production and marketing of RE; Decree Law No. 85-8 of 14 September 1985 on energy saving, ratified by Law No. 85-92 of 22 November 1985. This is the statute that created the AME; Decree No. 87-50 and 87-51 of 13 January 1987 on the establishment of mandatory energy audits and the obligation of prior consultation with the AME on projects for large energy consumers

The implementation of the regulatory framework on renewable energy in Tunisia was covered by the Law of 2 August 2004 as amended by the Law of 9 February 2009. This new law stipulates that:

Any establishment or group of establishments engaged in the industrial, agricultural and tertiary sectors is allowed to produce energy for its own consumption and has the right to:

- Transport electricity from the national grid to the points of consumption.
- Sell surplus exclusively to the STEG[105] (according to a standard contract approved by the energy regulator)

The conditions for transport, sale of surplus and upper limits are set by decree.[106]

According to Article 14 Ter of Law No. 2009-7, individuals and persons connected to the low voltage network are allowed to produce electricity for their own consumption. The limit of the capacity will be fixed by decree.

Decree No. 2009-2773 of 28/09/2009, in turn, sets the conditions for transmission of electricity produced from renewable energy and the sale of its surplus to the STEG.

- The exclusive sale of surplus electricity to the STEG must remain within 30% of the electricity produced annually;
- This limit may be exceeded for production projects from biomass, but without exceeding 15 MW;
- The installed capacity for electricity generation equipment must be less than the low-voltage electrical capacity purchased from the producer with STEG.

Since the mid-1980s, the Finance Law 1985 has established in Article 79 a special fund for oil and control of Energy funded by a tax on oil. This special Treasury fund was created to promote advances in the field of renewable energies and energy saving. This fund only operated for a very short time. It was closed down in 1987. Although it is difficult to assess the impact of this fund, it provided the benefit of laying the groundwork for future funding mechanisms essential to the development of RE. In funding from domestic sources, the law of 15 August 2005 established the National Fund for Energy Conservation, while the decree of 22 August 2005 defines the amounts and procedures for subsidies[107].

An incentive framework for the control of energy has been established by the Government of Tunisia. Decree No. 2009-362 of 09/02/2009 fixed the rates and amounts of premiums relating to actions covered by the plan for the control of energy and the terms and conditions of their allocation as follows:

- Rural illumination and water pumping project by solar and wind power for farms and rural projects: a premium of 40% and a ceiling of 20,000 TD (Tunisian Dinar);

[105] Tunisian Company of Electricity and Gas

[106] Conference on "Green Economy in Crisis", Tunis, 2012

[107] Law No. 2005-82 of 15 August 2005 and Decree No. 2005-2234 of 22 August 2005.

- Grid-connected photovoltaic systems: a premium of 30% with a ceiling of 15,000 DT;
- Biogas production: a premium of 40% with a ceiling of 20,000 DT;
- Biogas plants in order to produce electricity: a premium of 20% and a ceiling of 100,000 DT;
- Solar water heating
  - Residential and small businesses:
    DT 200 for systems where the sensor surface is between 1 and 3 m^2;
    DT 400 for systems where the sensor surface is between 3 and 7 m^2;
  - Industry and tertiary sectors: 30% of the investment.

In addition, the raw materials, semi-finished products and equipment used in the energy management benefit from tax incentives such as the suspension of VAT and a 10% reduction of customs duties.[108]

4.2 Development of industrial capacity

Strengthening the industrial base is a fundamental part of the development strategies in RE. Algeria, for example, expects to achieve an integration rate of 80% for industrial capacity in solar photovoltaic and 50% in solar thermal and wind, over the period 2014-2020.

In most countries of North Africa there are already companies involved in the production of goods and services in the field of RE and EE and major projects are currently underway. The following table provides an overview of production capacity by sector.

[108] Conference on "Green Economy in Crisis", Tunis, 2012

Table 22: Industrial capacity by sector

Sector	Field of intervention
Energy efficiency	Proven experience in energy audits in several countries in the region (Algeria, Tunisia, Morocco, Egypt)
	Production of energy-saving lamps in Tunisia
Solar water heaters	Dealer-installers in all countries
	- Large-scale manufacturing in Egypt and Tunisia. In the latter country SOFTEN (partnership with Giordano), a leader in the Tunisian market, has a production capacity of 35,000 CES/year[109]. - At least 10 producers in Egypt
Photovoltaic	Proven experience in design and installation in all countries
	Manufacture of electronic and electrical components in several countries (regulators, batteries)
	- Encapsulation units in Algeria, Algerian PV company in Tlemcen since April 2011, capacity 12 MW. Projects for the manufacture of components (inverters) - EDIELEC (Algerian private company): capacity 12 MW (50,000 panels/year capacity 80 Wp, 160 and 260 Wp. Hybrid panel planned (electricity and water heating). € 1.5 million investment. Unit operational before the end of the first half of 2012[110]. Fairly high integration rate. Flat glass and aluminium provided by local private companies (Mediterranean Float Glass, a subsidiary of CEVITAL for glass and Satal+ for aluminium). Solar cells imported from Europe. Possible supply from the unit of the Engineering Company of Electricity and Gas (CEEG) when it is put into service. - Production unit for building PV panels of 116 MWp/year in Rouiba by the Engineering Company of Electricity and Gas (CEEG), a subsidiary of Sonelgaz. Partnership with the German company Centrotherm/Kinetics. Entry into service likely in 2013-2014. - Sonelgaz tender: expressions of interest for a unit of silicon.
Wind	Capacity in Egypt for some components such as towers, blades, mechanical and electrical work.

The development of concentrating solar power plants requires major productive capacity in several industries, including the glass sector for mirrors, steel for steel structures and other equipment and the electrical and electronics industries. The countries in the region have some experience and production capacity for most components of CSP. The companies concerned generally work with foreign partners. For the glass sector, there is substantial capacity in Egypt and Algeria with the company CEVITAL, a

[109] SOFTEN (Société franco-tunisienne d'Energie Nouvelle). http://www.giordano.fr/soften-societe-franco-tunisienne-d-energie-nouvelle
[110] Maghreb Emergent, 2-12-2011.

member of the consortium Desertec Industrial Initiative (DII). The quality of the glass[111], which depends on the method used, is a fundamental criterion for the manufacture of mirrors for CSP. The following table summarises the production capacity in mirror glass for CSP in North Africa.

Table 23: Production capacity in mirror glass for CSP in North Africa [112]

Company	Country	Use	Capacity
Egyptian Glass Company	Egypt	Construction mirrors, automotive	1 furnace with 160,000 tonnes/year
Sphinx Glass Co.	Egypt	Different thicknesses but not suitable for CSP	1 furnace with 200,000 tonnes/year (in 2011)
Saint-Gobain	Egypt	Float glass	1 furnace 160,000 tonnes/year
Mediterranean Float glass/CEVITAL	Algeria	Float glass	3 lines of 600, 700 and 900 t/day

"Float" glass production in the two countries (Algeria and Egypt) is currently used for other purposes (building, food processing, automotive industry). Given the level of domestic demand, this requires the development of float glass production capacity in the countries of the region and investments to the extent that a modern unit with a capacity of 600 t/d requires an investment of the order of 160 to 180 million[113]. Current strategies for the development of solar thermal power plants, the high capital intensity of the industry and the lack of financial resources provide opportunities for regional projects within the framework of a regional security and energy independence strategy.

In four countries of North Africa (Algeria, Egypt, Morocco and Tunisia), there is steel production capacity, but the demand is fairly high. Beyond the availability of steel, it assumes the existence of companies able to produce goods to order with high standards. Recent experiments performed by three CSP in North Africa show that most of the equipment was imported in the cases of Algeria and Morocco. The integration rate is higher in Egypt with about 60% of the value added being generated locally, thanks to civil engineering (Orascom) and local subcontracting for structures and other metal equipment[114].

[111] There are several processes for the production of glass. Only "float" glass or floated glass meets certain criteria (thickness etc.) Based on the float process it is possible to agree on the manufacture of mirrors used in CSP.
[112] ESMAP, chapt 2 review of manufacturing capabilities and potential in MENA countries, see in particular 2.1 review of the main CSP-related industrial sectors and companies in the MENA Region.
[113] World Bank, ESMAP, review of manufacturing capabilities and potential in MENA countries.
[114] World Bank/ESMAP, Middle East and North Africa Region Assessment of the Local Manufacturing Potential for Concentrated Solar Power (CSP) Projects, January 2011.

Libya plans to expand its local production capacity by establishing joint venture companies in the following areas:

- Systems of heating with a thermal capacity of 40,000 units
- PV systems with a capacity of 50 MW

A regional market would allow companies to benefit from economies of scale and therefore reduce costs, thereby increasing corporate profitability and promoting the emergence of regional industrial clusters.

4.3 Research and development and the need for critical mass

Research and development (R&D) is an important component for long-term mastery of technologies, the development of know-how and the improvement of energy performance.

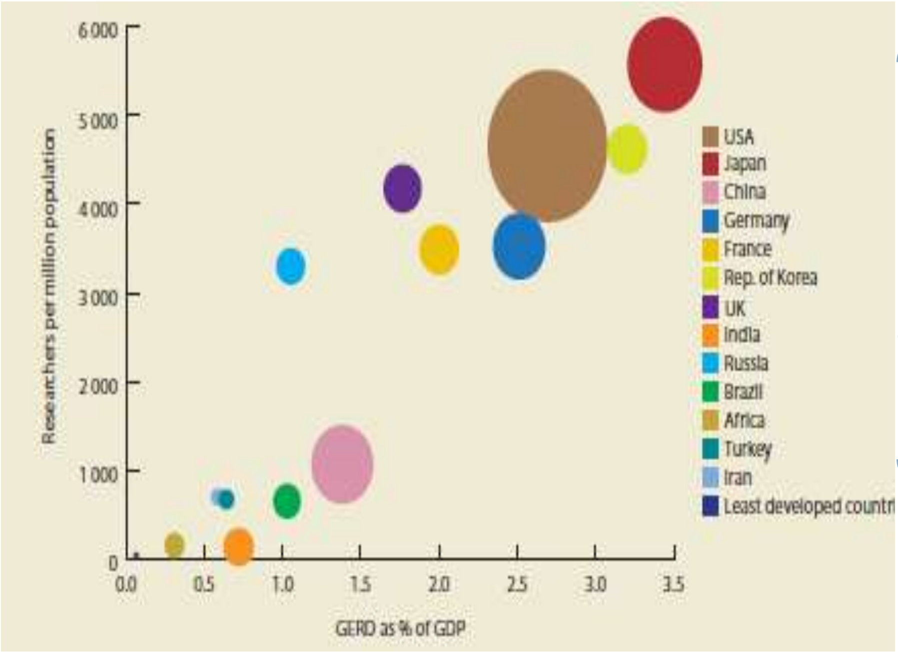
Unlike fossil fuels, renewable energy is still likely to experience significant technological developments in most sectors, including wind power, whose costs have fallen considerably over the past decade. This downward trend in prices also applies to other RE. Less energy dependence and above all the creation of added value from the development of sustainable RE programmes in the North African zone requires a critical mass of R&D and linking between the major operators (utilities, industries) and research centres. The objective of this section is to:

- Analyse the role of the region in terms of R&D relative to the rest of the world,
- Identify regional structures involved in training and R&D on RE in the region.

4.3.1 The place of Research and Development in Africa

Spending on research and development (R&D) is a good indicator of the efforts of the countries or regions in this field. Certainly, in the context of a more comprehensive study, other indicators should also be considered, such as the production of patents and synergies between R&D and industry. Recent data from UNESCO show the weakness of investment spending on R&D in Africa. Regardless of industries, these costs are a necessary investment for favourable positioning in the global trade in goods and services with high added value. *(Figure 17)*

Figure 17: Investment in R&D globally in absolute and relative terms in 2007 [115]



The data in the abscissae represent investment expenditure as a % of GDP.

The size of the discs represents the scale of R&D expenditure for each country or group of countries.

These aggregated data for Africa can only partially show the place of the countries of North Africa. However, these statistics at the continental level are sufficiently indicative of the need for a substantial increase in R&D in the region. This is also confirmed by the indicator of the intensity of R&D in the Arab States in Africa, which is more representative of the countries of the North African region. *(Table 20).*

Table 20: Comparative intensity of research and development in 2007[116]

	Researchers	% world	Per million inhabitants	Expenditure per researcher (USD)
European Union	1,448,300	20	2936	182,900
South Africa	19,300	0.3	393	225,600
African Arab States	98,400	1.4	477	33,300

Spending power parity (PPP); with rounding

[115] Report of the UNESCO Science Report 2010, Executive Summary.
[116] UNESCO report, op cit.

4.3.2 Overview of regional training and R&D structures in renewable energy in North Africa

In the various countries of the region, especially in Algeria, Morocco and Tunisia, there have been research and development structures since the early 1980s in most sectors of renewable energy. However, there are very few synergies with industry, which is a major constraint on the evolution of research and development and the creation of new products with high added value.

More recently, some countries such as Algeria, Morocco and Tunisia have established new R&D structures and are encouraging exchanges between businesses, research centres and various specialised networks in renewable energy.

In Morocco the Research Institute of Solar Energy and New Energy (IRESEN[117]) was established in February 2011 to support the national strategy and translate it into R&D projects. The IRESEN has already launched two calls for projects to promote solar thermal (InnoTherm I & InnoTherm II)[118].

In Algeria, an Institute of Renewable Energy and Energy Efficiency (IAER) [119] was created with the objectives of the promotion of applied research, the development of research results and implementation of pilot demonstration facilities in renewable energy and energy efficiency. The institute will provide training in the fields of engineering, safety and security, energy audits and project management.

There is also a Development Unit for Silicon Technology (UDTS) within the Ministry of Scientific Research which undertakes research and postgraduate training in the field of the science and technology of semiconductor materials and devices for applications in several areas including photovoltaics[120]. A Pan-African University specialised in RE and research on climate change should be operational in late 2012.

In Tunisia, the Solar Plan provides for the establishment of an International Centre for Higher Education in RE and EE and an International Laboratory of Solar Energy Technologies.

Mauritania has recently put in place a Master in Renewable Energy at the Faculty of Sciences and Technologies.

The development and adoption of a regional strategy would allow the optimisation of resources in the region, which would better meet the challenge of developing relatively endogenous RE, taking into account the economic and social specificities of the countries of the region. Such a strategy would allow specialisation by sector in order to reach a critical mass to sustain increased and institutionalised scientific exchanges among researchers in the region but also with partners in the North.

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[117] These tenders relate on the one hand to simulation and modelling (InnoTherm I) and on the other to storage, network, desalination, cold, solar oven (InnoTherm II). See www.iresen.org
[118] For more details, see www.iresen.org
[119] Decree of 27-01-2011 establishing the Algerian Institute of Renewable Energy.
[120] MEM, Renewable Energy Program

Beyond the national R&D structures in the region[121], there are some specialised regional bodies/networks working for capacity development and regional cooperation (eg: RCREEE, MEDREC, MEDENER). None of these structures includes all the countries in North Africa. *(Table 21)*

Table 21: Regional structures operating in capacity development

Structure and location[122]	Objectives and themes	Countries in the region	Main activities related to capacity building and R&D
RCREEE[123]	Policies and strategies, R&D Capacity	All except Mauritania	Training in wind energy (design, operation and maintenance, software) Financing RE including tariffs, energy audits, labelling, network codes (grid codes) Grants for young researchers (internship)
MEDREC	Training and dissemination of information; development of pilot projects	All except Mauritania and Sudan	Study on the identification of capacity building needs in RE in North Africa (2009-01-10) Training courses on the CES Programme of capacity building on CDM
MEDENER	Strengthening the interregional partnership: know-how and "best practices"	Algeria, Morocco, Tunisia	Events on RE for the Mediterranean countries and the development of joint proposals to be submitted to international bodies. Marginal activities in R&D and capacity building

These networks are largely financed by foreign sources. For example, Denmark, Germany and the EU provide substantial financial resources, which is why some activities are more in the short or long term interests of the donor. This trend reinforces the need for reflection on the establishment of a regional R&D structure for the countries in the region. Indeed, for almost all countries in the region, RE and EE are now a priority with strategies and indicators to measure objectives. R&D is also an important component of these strategies.

[121] These include Algeria, CDER, Unit Technology Development of Silicon, Tunisia, Centre for Energy Research and Technology, Morocco, ADEREE and more recently the Institute of Energy Research and New Solar Energies (IRESEN) in Morocco etc..

[122] RCREEE: Regional Centre for Renewable Energy and Energy Efficiency, MEDENER: Mediterranean Association of National Agencies for Energy Management, MEDREC: Mediterranean Renewable Energy Centre

[123] For more information, see RCREEE, A. Bida, Renewable Energy and Energy efficiency capacity building in RCREEE Member states, UNECA Expert Meeting, Rabat, 12-13 January 2012.

Chapter 5
THE CHALLENGES OF REGIONAL COOPERATION

The countries of North Africa are facing similar challenges in terms of energy security, even if they do not have the same resources. They have to respond to a significant growth in energy demand, at present mostly covered by subsidised fossil. This has resulted in more or less marked policies to significantly increase the share of RE in the energy mix (less than 3% of the capacity for electricity generation). Significant investments have been made since 2009. However, many challenges remain in terms of funding to achieve the required investments, training, research and development and industrial integration, which remains hampered by the limited size of the markets.

The solutions to these challenges can be only achieved in the context of a genuine regional cooperation strategy that takes advantage of the opportunities and complementarities and establishes common rules for the creation of an integrated market for electricity and the creation of innovative partnerships, particularly in terms of capacity building, exchange of experiences and the transfer of technology. Thus, efforts could be directed in particular to:

- promoting the transfer of technology by strengthening networks for the exchange of knowledge and experience, as well as partnerships between countries for the implementation of specific projects;
- the development of a structured industrial approach;
- The optimisation of cross-border interconnection infrastructure which is currently underutilised and strengthening.

Today, the region is considered to be the least integrated of the world, although it has significant advantages: potential in terms of a young workforce, proven experience in the field of solar water heaters, PV and wind technology and the presence of several centres of expertise and networks (eg: RCREEE, MASTAR Institute of Egypt). Cooperative efforts could also form part of the implementation of the Pan Arab RE strategy (2010-2030).

Cooperation with the countries of the North is being strengthened in the context of bilateral partnerships and regional initiatives such as the Mediterranean Solar Plan (MSP) and Desertec. Indeed, funding and the relatively complex technology required, particularly with regard to the approach taken by countries to develop CSP, can only be mobilised in the context of a partnership with institutions and countries of the North.

In this context, the European Union plays a key role. A study on the progressive integration of the electricity market in Algeria, Morocco and Tunisia into the market of the European Union has been produced by the Delegation of the European Union in Algeria. The overall objective of this study was to harmonise the legislative and regulatory framework, as well as the industrial structure of the recipient countries, in order to create a national and regional electricity market and, as a second step, make these instruments compatible with the European standards in order to integrate these markets into the European Union.

The DII initiative aims to create a long-term EU-MENA market by facilitating the integration of local markets into the European electricity system. The initiative is currently working with Algeria, Tunisia and Morocco. A first CSP project has been realised with the MASEN in Morocco. Other projects, known as benchmarks, are planned in Algeria[124], Egypt and Tunisia.

The Mediterranean Solar Plan (MSP) aims to support the implementation of large-scale projects based on renewable energy, interconnection and energy efficiency. Detailed studies along the lines of integration between the southern Mediterranean countries and the EU have already been carried out. The pilot projects currently ongoing in Morocco, Egypt and Tunisia fall within the context of the PSM.

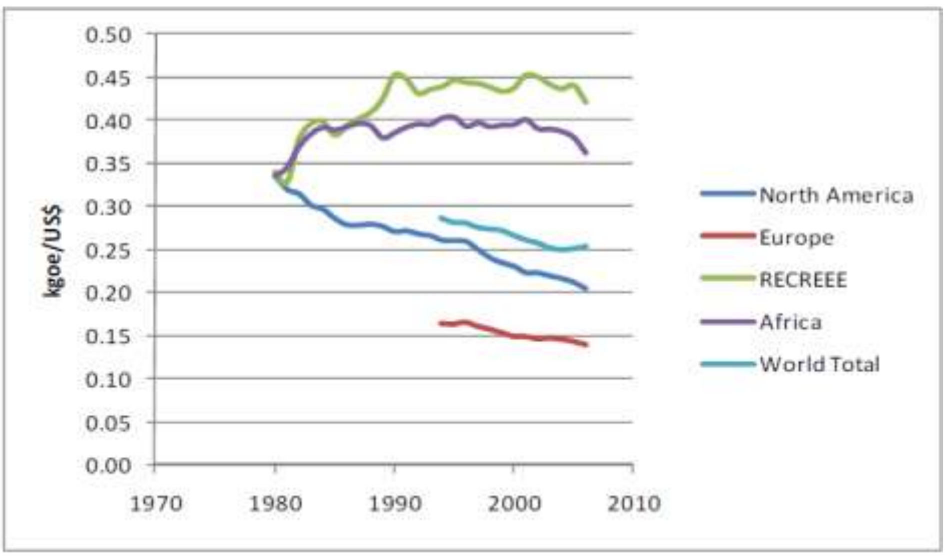
The project "Paving the Way for the Mediterranean Solar Plan Project (PWMSP)" funded by the EU aims to facilitate integration between the two shores of the Mediterranean through support for the implementation of sustainable energy policies and development capacity. Only four Mediterranean countries of the region (Algeria, Egypt, Morocco, and Tunisia) are stakeholders in the project.

[124] Sonelgaz signed a partnership agreement with DII in Brussels in December 2011.

Chapter 6
ENERGY EFFICIENCY POLICIES

The objective of energy efficiency policies is to maintain the same quality of service with less power consumption. Energy efficiency is, in many cases, the cheapest reserve for the development of energy services while minimising GHG emissions. Energy intensity is certainly the most relevant indicator for measuring the performance of economic agents in this area. A comparative analysis of global energy intensities shows that they are relatively high in North Africa and in the African continent as a whole (Figure 18). This alarming finding also means that the scope for energy saving is considerable. In a context of scarcity of financial resources, EE should be included among the priorities of sustainable energy and economic development, given its low environmental impact and good return on investment. Most often, the capital recovery period is very short, as for example in the case of low consumption lamps. It is also expected that incandescent lamps will no longer be marketed within the territory of the EU from 2012.

Figure 18: Regional comparison of energy intensities (kgoe/USD at market prices 2005)[125]



The analysis of the graph shows that energy intensity in Europe, although relatively low, has still significantly decreased, while that in North Africa and Africa as a whole remains very high and the trend is not downwards. Faced with this situation, all the countries of North Africa have developed

[125] Recreated Policies for Energy Efficiency and Renewable Energy in the RCREEE Group of Countries December 2009, revised April 2010.

strategies for rational management of demand, especially for households, which consume a large part of the electricity consumption. The actions taken include the introduction of energy-saving lamps, energy awareness campaigns and financial incentives.

These measures require only small investments, and in some cases the investment is negligible, if any, to the extent that a simple change of the behaviour of economic agents (households, industry and government) can lead to substantial savings. However, these gains are not automatic and are the result either of economic pressures or awareness raising accompanied by financial incentives. For example, considerable gains were made in the North during the adjustment in world oil prices (the first oil shock) during the first half of the 1970s. This was achieved by a reduction in energy intensity and decoupling the growth rate of the economy expressed in monetary units with that of energy consumption in physical units.

The integration of EE in energy policy is taken into account in most countries. Specific institutions have sometimes been created and incentives developed to promote energy efficiency. Tunisia, Egypt and Algeria have prepared their national EE action plan with support from the RCREEE.

6.1 The Algerian case

In **Algeria**, the Agency for Promotion and Rationalisation of Energy Use (APRUE) was created in 1985 with the status of a public industrial institution. Within the framework of Law No. 99-09 of 28 July 1999 on the control of Energy, the agency is responsible in particular for:

- The implementation and monitoring of the National Energy Management Programme (PNME);
- Awareness raising on the dissemination of information on energy efficiency;
- Assembly programmes and sectoral projects in partnership with the relevant sectors (industry, construction, transport, etc.).

The financing of energy efficiency is covered by the National Fund for Energy Conservation (FNME) introduced by the Finance Law 2000. A ministerial decree sets the fields eligible for the FNME. The Finance Law 2000 had set the taxes to support the FNME[126].

In February 2011, the Council of Ministers adopted the three-year plan for RE and EE[127]. Regarding EE, this programme comprises eight components:

- The thermal insulation of buildings;
- The development of solar water heaters;
- The widespread use of energy-saving lamps;
- The introduction of energy efficiency in public lighting;
- Support for the introduction of energy efficiency in the industrial sector and energy-intensive facilities by conducting audits and providing assistance for energy-saving projects;

[126] 0.0015 DA/therm for natural gas high and medium pressure) - 0.02 DA/kWh for electricity HV and MV).
[127] Department of Energy, Renewable Energy Program and Energy Efficiency, March 2011.

- Conversion to combined cycle power plants where possible;
- The implementation of pilot projects for solar air-conditioning.
- The increase in market share of LPG/C (Liquefied Petroleum Gas/Fuel) and the promotion of CNG (Compressed Natural Gas Fuel);

Thus, in 2020, it is planned to increase the market share of liquefied petroleum gas (LPG/C) in the fleet up to 20%. In this context, APRUE has developed a three-year energy efficiency plan for the period 2011-2013. It should be noted that this programme includes actions in the field of alternative fuel use, by promoting natural gas and LPG/fuel in the transport sector. In addition, the State undertakes to provide direct financial assistance to beneficiaries who wish to convert their vehicles to LPG/C[128].

APRUE with the OPGI (Offices for Property Promotion and Management) developed a project entitled ECOBAT which from 2011 is committed to the production of 600 high energy performance units. The objectives of these programmes are broadly similar and include:

- The improvement of thermal comfort in homes and the reduction of energy consumption for heating and air conditioning;
- The mobilisation of players in construction around the issue of energy efficiency;
- The holding of demonstrations across the country, to show the feasibility of high-performance energy projects;
- The start of a domino effect of practices of including aspects of energy efficiency in building design.[129]

Another feature is solar air-conditioning which is an application to be promoted in particular in the south by 2013. Studies will be launched to acquire and master the technologies of solar ventilation. And finally, the energy management plan for local authorities is intended to replace all mercury lamps which are energy-intensive by sodium lamps that are much more economical.

6.2 The Egyptian case

In **Egypt**, the government has developed a national plan for the conservation of energy and has set up a coordination group for the promotion of energy efficiency. Actions affect both demand and supply. From the point of view of demand, the focus is on the distribution of energy-saving lamps, lighting, building and dissemination of CES. From the point of view of supply, combined cycle gas turbines are an area which is being prioritised.

In a first phase, about 6.2 million LBCs were sold by electricity companies. In a second phase, launched in 2010, 3 million lamps were distributed through financial measures including substantial discounts on the purchase price (-50%), instalments over 12 months and 18 month guarantees from the date of purchase.

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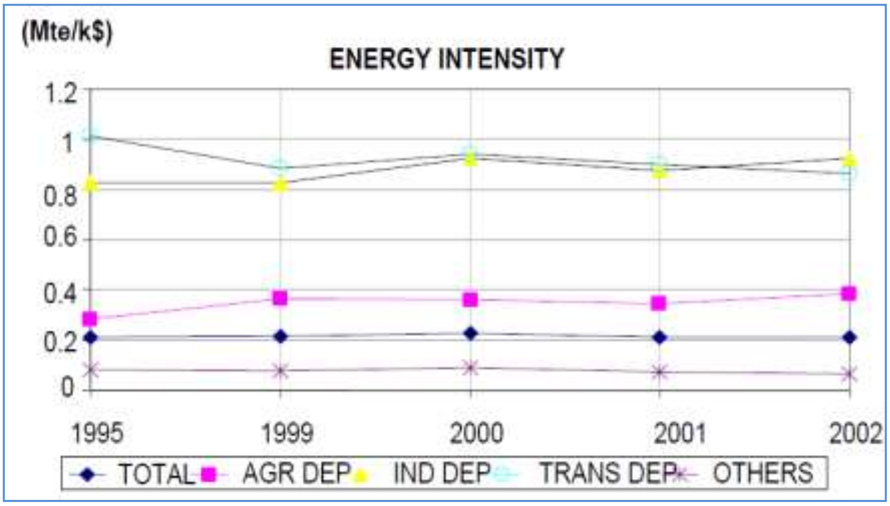
[128] MEM Programme for the development of renewable energies p.15
[129] Energy Efficiency in the southern and eastern Mediterranean, p22, MEDENER

6.3 The Libyan case

In **Libya**, at the institutional level, there is no institution responsible for energy management. This can be explained by the availability of abundant and inexpensive energy. Moreover, energy intensity[130] has varied little over the period 1995-2002 despite the technological progress. The analysis could be further refined to show that there has in fact been a deterioration, since GDP is expressed in monetary units. Energy intensity (Figure 19) would probably be increased if it were expressed in physical units to the extent that the value of the gross domestic product (GDP) largely depends on the hydrocarbon sector, whose prices have risen over the period. It is, of course, also necessary to take into account the increase in input prices. This approach would pose complex methodological problems, which makes it difficult to have an indicator on a regular basis[131].

Figure 19: Energy intensity by sector in Libya



Given the low efficiency of the energy system of Libya and the importance of consumption, the rational use of energy is a major opportunity. It is thus estimated that about 50 million barrels (Mbl) and 2,160 MW of installed capacity could be saved through rational management and use of energy in 2020[132].

[130] GECOL Ekhlat Mohamed Ibrahim M. Salah &. Nurredin M. Kreama, "Energy Efficiency and Renewable Energy Libya - National Study, Plan Bleu 2007".
[131] For more information on the concept see eg a) OECD statistical overview of 2011, b) Kammoun, N., Analysis of energy intensity in manufacturing in four provinces from 1976 to 2006, Master of Arts dissertation, Laval University, Québec 2011
[132]Ballut Abdullah Mohamed Ekhlat "The Potential Impact Of Improved Energy Utilization Efficiency On The Future Energy Demand In Libya Up To The Year 2020" 17th World Energy Congress, USA 1998. Quoted by GECOL.

6.4 The Moroccan case

In **Morocco**, the national energy efficiency strategy launched by the government in 2009 envisages a saving of nearly 12% of electricity by 2020 and 15% by 2030. The National Energy Efficiency Programme focuses on three sectors (construction, transport and industry) that offer potential for significant energy savings due to their low energy efficiency and the scale of their consumption. Globally, the potential energy saving is more than 15% (17% in the industrial sector with a payback period of 18 months). The following table shows the key measures by sector.

Commercial and residential	Industry	Transport
Implementation of the energy efficiency Code in construction Generalization of low consumption lamps: 4.6 million AML implemented and 10 million being distributed Use of insulation materials Use of double glazing Installation of low temperature solar thermal (1,360,000 m² by 2020) Installation of PV kits and solar pumps	Widespread industrial audits Use of speed and frequency adjusters Hot and cold storage optimisation Use of energy-saving lamps	Rejuvenation of the fleet Organisation of urban transport (traffic, public transport...) Enforcement of energy efficiency on vehicles

The "Wood Energy" plan prepared by the Centre for Development of Renewable Energies (CDER) and implemented in partnership with associations of owners of hammams in cities and associations for local rural development is intended to increase the energy efficiency of steam and commercial profitability, improved working conditions and the protection of forests. It is estimated that Morocco has about 5,000 hammams with annual steam consumption of 1.25 million tonnes of wood, valued at 800 million dirhams[133]. The evaluation of this programme shows that significant results have been achieved in terms of energy efficiency (192 t/year for an improved boiler instead of 358 t/year for a conventional boiler) and corporate profitability with a payback period on the investment[134] in the order of 10 months.

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[133] Source CDER-AFD, Energy Efficiency Programme in the field of steam ovens and bakeries, Morocco, plate, Morocco fuelwood, July 2008

[134] 192t/year for improved boilers instead of 358 t/year for the traditional boiler) with a payback period of the investment in the order of 10 months.

Law 47-09 on energy efficiency sets clear objectives and lays the foundation for future Moroccan thermal regulation (RTBM). It makes mandatory energy audits for companies and institutions in the production, transmission and distribution of energy, as well as the performance of an energy impact study for new construction and urban projects. Appliances and electrical equipment sold on the Moroccan market must meet the criteria of "minimum energy performance". This defines the role of energy services and facilities and establishes technical control.

On household consumption, an action relating to the strengthening of demand management was put in place through social tariffs and incentives of the type "20-20" (20% discount in the event of a reduction of 20 % of consumption), which represents a saving of 1,474 GWh.

6.5 The Mauritanian and Sudanese cases

Unlike other countries in North Africa, **Mauritania** and **Sudan** are characterised by a high demand for biomass - to meet domestic requirements, especially cooking and heating - putting heavy pressure on forestry as a resource. At the institutional level, in both countries, there are no independent institutions in charge of energy management, but in the case of Mauritania there is a National Unit of Energy Management in the Ministry of Energy and Petroleum.

The greatest potential in energy efficiency lies in improving yields in various segments of the industry, mainly charcoal (wood processing charcoal) and cooking equipment. Policies of demand management are much more profitable than those relating to supply. Indeed, policies to increase supply by planting or by substituting gas are expensive and require heavy subsidies. However, interventions to achieve a more rational use of the primary resource (carbonisation) and final consumption at user level are much less expensive. Moreover, in the case of Sudan, plant and animal residues represent an important potential which could be enhanced to cover a portion of the demand from households and industry, particularly cogeneration from bagasse[135].

In Mauritania, the initiatives for rationalisation of the use of wood and charcoal have focused on the promotion of improved stoves in rural and semi-urban environments. Although positive results have been obtained in terms of saving time and energy for women, the main beneficiaries, there are still challenges in terms of the ownership, control and dissemination of this technology. In addition, efforts to distribute butane in the rural environment, as a substitute for natural resources, have been reduced by the high cost and supply problems.

Apart from biomass and mass distribution of improved islands and mills for these two countries, the promotion of the use of LBC and efficient household appliances is to be generalised.

[135] Residues from the sugarcane industry. Obtained after grinding, the bagasse is used as fuel.

6.6 The Tunisian case

Tunisia is probably the most advanced country in the region in terms of energy efficiency. However, the increase in per capita consumption of households (0.31 toe in 1990 and 0.41 toe in 2006) and the increase in the relative demand for heating and air conditioning (20% in 1989 and 26% in 2004) pose new challenges to the implementation of energy efficiency policies. Construction therefore remains one of the sectors where energy efficiency policies will have the greatest impact.

The Tunisian energy efficiency policy in the construction industry is probably the most elaborate of the Southern and Eastern Mediterranean Countries (SEMC). It relies on an evolving regulatory framework that has been developed since 2004 (Article No. 10 of Law No 2004-72 of 2 August 2004 relating to energy conservation as amended by Law No. 2009 - 7 of 9 February 2009). In 2008, the implementing decree for the type of buildings to be used for offices was enacted, followed in 2009 by the one for residential buildings and in 2012 those relating to buildings for health and tourism.

The Tunisian programme on the Thermal and Energy Regulation of New Buildings in Tunisia (RTEBNT) managed by the ANME (National Agency for Energy Management) and supported by the GEF (Global Environment Facility) through the UNDP (United Nations Development Programme) and FGEF (French Global Environment Facility) through the AFD (French Development Agency), has achieved 40 pilot projects (33 in residential and 7 in the tertiary sector), thus fostering sustainable practices for energy efficiency in building design. Particular attention has been given, in the realisation of these projects, to interventions generating a maximum additional cost of 10% of the initial construction. This programme has enabled the development of climate zoning in Tunisia as well as technical tools for industry professionals.

Over time, the RTEBNT programme will target several objectives:

- improving the capacity of various stakeholders in the field of construction (administration, building owners, designers, directors);
- training and awareness raising of various stakeholders in construction to the thermal regulations for new buildings and energy;
- demonstration of operational evaluation;
- implementation of energy efficiency standards in building and
- the implementation of an interface structure between research and development and the various players in construction.

Tunisia is also to focus on the most efficient equipment in terms of energy consumption. At the regulatory level, a system has been developed in the framework of Law 2004-72 on energy management in the form of the mandatory energy labelling of household appliances and the phasing out of equipment with low energy efficiency, for example the ban on marketing inefficient fridges. In this perspective, the

Technical Centre for the Mechanical and Electrical Industries (CETIME[136]) is equipped with a laboratory for testing the energy efficiency of refrigerators.

The low consumption lamps (LBC) are to be generalised. To achieve this goal, progressive taxes on incandescent lamps have been introduced with a view to their gradual and total replacement[137]. These tax measures are accompanied by distribution of low consumption lamps[138] and interventions to stop the manufacture of incandescent lamps. Of the two companies concerned, "Global Lighting" stopped production in 2009. As to the second company, FAWANIS, which has been making light bulbs since 1991, it is expected to stop their manufacture. It should be noted that the company has 3 production lines for incandescent lamps and another for LBC[139].

In terms of funding from national resources, the Finance Law No. 2005-106 established the National Fund for Energy Conservation (FNME) which establishes financial incentives for the development of effective energy. It has thus been given a 20% subsidy for all energy efficiency investments made by companies, 50% on the cost of energy audits, 50% as a subsidy on investments related to demonstration projects in the areas of rational use energy. The main sectors (industry, transport, residential and tertiary) are being developed within the Tunisian solar plan with indicators for each sector in 2016 and 2030. For both targets, economies are envisaged for all sectors of 3 Mtoe in 2016 to 10 Mtoe in 2030, respectively 24% and 40% of primary energy demand. This objective implies a decrease in primary energy intensity from 0.28 toe/1000 DT in 2016 to 0.20 toe/1000 DT in 2030.

[136] The CETIME is placed under the guardianship of the Ministry of Industry and Technology.
[137] Tax of 10% from November 2007, 30% from November 2008.
[138] Distribution by STEG of 1 million LBC in 2010 for low-income households (3 LBC per household and recovery of incandescent bulbs).
[139] www.fanis.com.tn

Chapter 7

MAIN BARRIERS TO RE AND EE DEVELOPMENT

This section summarises the obstacles that are hindering efforts to develop renewable energy and energy efficiency and provides guidance for improving the overall investment in renewable energy.

❖ *The Regional Market*

The North African area is not yet a homogenous market because the production and movement of energy commodities, the implementation of energy infrastructure (power lines) and the manufacturing of equipment (PV, LBC, wind turbine components) do not follow the criteria of economic efficiency at the regional level. Electricity flows in North Africa (Algeria, Egypt, Libya, Morocco and Tunisia) are insignificant physical flows compared to the installed capacity and production of these countries. Electricity trading is the most important form of trading between Morocco and Spain. Electrical interconnection networks of the five countries allow various operators to make savings, but these savings are limited by the lack of a regional market. This requires mechanisms at the regional level, with technical (setting up a system operator) and economic regulation (market operator).

Regional gas interconnections (the Algeria-Morocco-Algeria-Tunisia and Spain-Italy gas pipelines) are primarily intended to supply Western Europe. For this reason, the consumption of natural gas is very uneven in the area of North Africa. In fact Morocco and Tunisia are transit countries for Algerian natural gas. There is no regional gas policy, which would make it possible to increase the use of gas resources in the North African area. Intercontinental gas interconnections (North Africa-Western Europe) have enabled Morocco and Tunisia to significantly increase domestic consumption of natural gas, but well below the proven gas reserves in the region. However, natural gas is a competitive energy and the emissions of greenhouse gases emissions are lower compared to other fossil fuels.

The development of renewable energy sectors (wind and CSP in particular) does not form part of an integrated regional development approach. However, the objectives, technological choices and institutional and private partners are often the same. CSP requires the development of a highly qualified body of personnel, which is currently lacking in the specialised industries and industries of solar grade glass, electronics and electromechanical. Indeed, unlike fossil fuels, energy security lies not in control of the raw material, but in the development of regional expertise and an industrial infrastructure able to meet a large part of the demand equipment, as well as trained personnel for the development of renewable energy technologies.

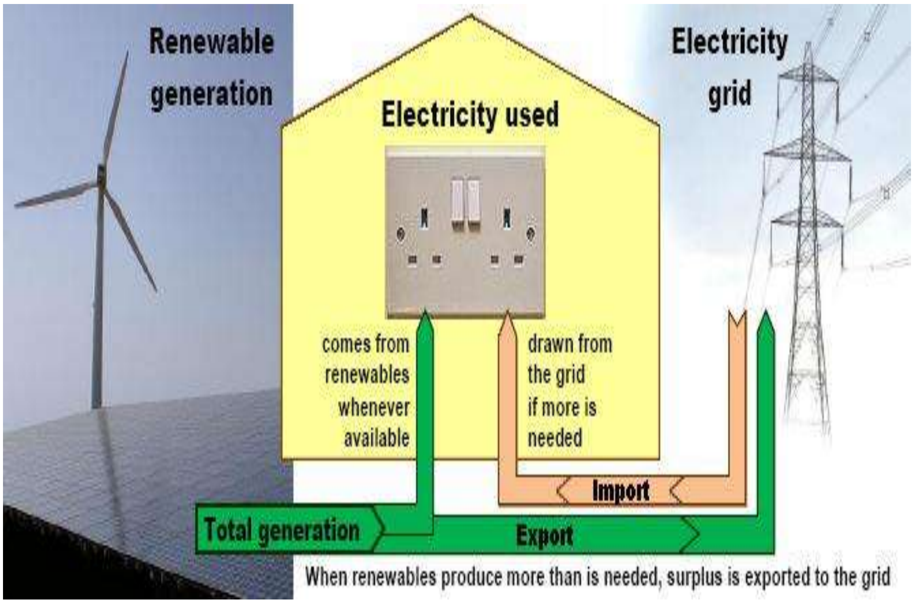
It is necessary for the establishment of a regional market to develop:

- a common and integrated vision of renewable energy;
- harmonised policies and legal frameworks;
- strengthening of the interconnections

❖ *Funding*

The scale of the capital cost of RE, the still comparatively high prices of the services provided by these energies and the subsidies to fossil fuel derivatives are major constraints on the expansion of RE. Large-scale development, renewable energy sources and energy efficiency in all countries of North Africa work through preferential mechanisms and innovative financing and tax incentives to promote the development of national and regional companies. Feed-in tariffs (feed in tariffs) are just one example of a funding mechanism. They have also been used primarily to ensure a long-term redemption price for companies producing renewable electricity, but they can also be applied to users, as shown in the following example implemented on a large scale in the UK and which could be extrapolated to countries in North Africa.

Figure 20: Feed-in tariffs for users [140]



The government grants a guaranteed fixed price for the entire RE output. Rates depend on the sectors. In addition, a bonus is awarded for the surplus exported to the grid. Rates too low can be offset in the state budget.

[140] Source: Department for International Development (DFID).

The following table gives a range of possible financial mechanisms for the change of scale in the production of renewable energy[141].

Table 24: Examples of mechanisms for financing RE

Such mechanisms	Terms
Capital grants	Direct financial subsidies to reduce the cost of capital and return on the initial investment
Tax credits	Allows the deduction (partial or total) of expenditure related to a PV facility from the taxable revenue stream
Preferential loans	Loans under much more favourable terms than those prevailing in the financial markets. These loans are granted by multilateral institutions such as the African Development Bank In the IMF mechanisms a grant element accompanies the concessional loan. These loans are usually sovereign debt
Tariffs for businesses and users	Guaranteed prices per kWh in the long term are granted to producers of RE. These rates are based on the commercial maturity of the technological processes and strategies of the countries. Generally higher prices are given to solar channels. These mechanisms largely explain the development of wind. This mechanism is generally financed by government
Projects or renewable green electricity	Enables consumers to buy green electricity from energy in general at a higher price than the average
RE purchase commitments	A requirement that a portion of production is met by renewable electricity supply
Green certificate	Document certifying the origin of green electricity. Control bodies responsible for issuing the certificate of guarantee of origin for renewable energy facilities
Net metering	Electricity taken from the grid and that fed into the grid from RE are monitored separately. Electricity fed into the grid is valued at a higher price to that coming from the network to encourage the production of RE

In some countries in the region, especially Libya, Mauritania and Sudan, there is almost no or no money at all depending on the country or incentives or mechanisms dedicated to the promotion of renewable energies and energy efficiency.

The removal of financial constraints can be achieved through:

- The adoption of incentives, including appropriate systems of energy pricing and the phasing out of subsidies for fossil fuels;
- The mobilisation of financial resources and the creation of sustainable innovative financing mechanisms tailored to the requirements, especially those of small and medium projects;
- The creation of specific national funds (in countries that do not have them) which are strong political signals and allow countries to mobilise international (financial and technical) resources;
- Strengthening the role of the private sector and public-private partnerships;
- Developing regional projects.

[141] A detailed study conducted by UNECA on innovative financing mechanisms for RE.

❖ *Technological choices*

Renewables (excluding hydropower) are sectors that have experienced substantial technological progress but have not yet, in most cases, reached commercial maturity except for the sector of wind power.

The solar sectors (CSP and PV) have substantial comparative advantages (high potential land use with little binding, etc.). Technological advances in thermal have opened new opportunities for CSPs and large-scale applications, such as solar power plants connected to the grid. Hybrid plants (CSP-natural gas) are already in service in three countries of the region and major projects are underway. This progress should not obscure the following uncertainties and constraints of the CSP sector:

- The use of scarce natural resources like water is in competition with other domestic, industrial and agricultural uses;
- The level of technological maturity, in particular for solar (for example heliostats), is still evolving. It is obvious that CSP will be much more expensive because of the high cost of components and also the learning curve, which will result in additional costs compared to the operation of a conventional power plant;
- Operating conditions in a difficult environment, especially sand storms that can damage the heliostats and frequent dusting of heliostat that could cause water consumption greater than that which was originally scheduled.

The significant decline in the price of PV during the past six years in itself offers new niches for centralised applications in this sector, which should operate at the regional level.

The following measures could be taken to contribute to the expansion of the most appropriate technological processes in the context of the region:

- Facilitate access to all the information on the state-of-the-art regarding the Technologies and their development prospects (cost, technical requirements, competitiveness, risk);
- Enhance and capitalise on successful technology gains in the region;
- Establish specialised training (engineers, technicians) on renewable energy, particularly solar and wind; and combine the efforts of countries in a regional partnership.

❖ *Integration of energy efficiency measures in the areas of housing, transport and electrical equipment*

In most countries of North Africa, energy consumption for heating and air conditioning has increased dramatically over the last decade. This increase is not only due to climate change, but also and especially to construction practices with little respect for environmental standards and also to the increase in purchasing power in a context where domestic energy prices have remained relatively low, particularly in the oil producing countries of the region.

The following table summarises the current situation, the main constraints and the possible solutions in energy efficiency.

Table 25: Current situation and solutions for energy efficiency

	Current situation	Impact	Options
Construction	Inefficient use of materials Low insulation Architectural design is not suitable	Increase in energy consumption for heating and air conditioning Lighting	Construction Standards Grants for insulation
Equipment and household appliances	Low performance Predominance of incandescent lamps	Overconsumption of devices	Labelling, differential taxation, Ban on inefficient equipment
Transport	Predominance of road transport Fleet obsolete in most countries. Urban traffic plans inefficient	Higher average unit consumption.	Development of rail and river transport Maritime haulage Urban traffic plans

For the least economically developed countries of the region (Mauritania and Sudan) which are also characterised by still low electrification rates, the low incomes of a large proportion of the population, especially in rural areas, limit the adoption of energy efficient equipment. Innovative financial mechanisms adapted to the purchasing power of the population and seasonal income are needed to expand access to energy services from RE, and promote the choice of energy efficient equipment.

Rationalising the use of energy requires coordination between the different sectors, which is far from being systematic in most countries. In addition, communication and awareness campaigns for better use of energy are crucial, since the behaviour of economic players greatly affects energy consumption. Indeed, in the event that standards and legislation exist (labelling of appliances, for example), the use of energy-efficient products is not clear, either through lack of financial incentives and/or lack of information on the micro-economic benefits for the household or business and macro-economic benefits at the national level. This applies to all forms of energy including biomass, particularly in Mauritania and Sudan, whose sustainable energy development involves measures for production, processing (carbonisation) and final use by the distribution of improved stoves.

Promoting energy efficiency in North Africa requires:

- The establishment of a fund for energy efficiency;
- Capacity building for the implementation of safety standards, and construction standards for appliances;
- Improving energy efficiency in public buildings;
- Launching an information campaign on energy efficiency;

❖ *Capacity development and R&D*

At the regional level there is no critical mass of researchers in almost all sectors, working in synergy with the industry to achieve the objectives of integration of RE in the energy mix over the next few decades. The few existing regional centres do not have an infrastructure for sustained high-level R&D which meets the specific needs of the region. The newly created R&D structures in the countries of the region are part of national thinking, while technological, economic and social progress at the global level involve a regional response. The financial and human resources needed can only be met within the framework of a regional strategy for R&D, in partnership with similar structures in the North.

As such, some recommendations could be issued to assist in the development of research and development in the field of renewable energy:

- Initiate research programmes on RE and its uses involving industrialists, commercial players and universities and research centres;
- Establish a network for interconnecting the centres of studies and research on RE in the region and ensure a technological advantage for the commercial players;
- Strengthen exchanges on learning between countries of the region in renewable energy and energy efficiency;
- Encourage the transfer of expertise and experience between countries.

CONCLUSION

The rich countries were able to develop thanks to the massive use of fossil fuels and thermal. Today, however, at a time when the world population has reached seven billion people and is expected to be around nine billion by 2050, the energy transition has become essential to meet the growing energy needs and mitigate the risks of volatility of oil prices and the trend to declining reserves of fossil fuels that is affecting markets and reducing emissions of greenhouse gases.

Globally, investment in renewable energy (excluding hydropower) is continuing to grow despite a difficult economic and financial context. Reports on the global situation of RE in 2011 and 2012 published by the Renewable Energy Network REN21[142], indicate that these investments in 2010 reached a record level of USD 211 billion, or one third more than in 2009 (160 billion) and 5 times more than in 2004. In 2011, they are estimated at USD 257 billion. The drivers of this growth are China, the USA, Germany, Italy and India. Today, China is the world's leading investor in the renewable energy sector. Thus, the installed capacity in wind energy has experienced significant growth in recent years (with a total installed capacity at the end of 2011 that can meet 2-3% of global electricity consumption). In addition, the year 2011 was marked by a strong performance of solar energy (PV and CSP). Renewables accounted for more than 25% of global electricity production capacity and provided approximately 20.3% of global electricity.

These investments were largely driven by policy incentives and lower equipment costs, particularly with respect to wind and photovoltaic (PV). But despite the progress, the production cost of renewable energy remains high, especially in the solar thermodynamics segment, because of its complexity. Unlike fossil fuels, renewable energy has a cost structure in which the initial investment is very high, while the operating costs are very low.

In North Africa, the analysis of the energy sector reveals disparities between the countries, but also similarities which are opportunities to promote regional integration. The region (Algeria, Libya and Egypt) has only 4.6% of the world's proven reserves of oil and natural gas; and energy supply is dominated by fossil fuels (over 90%). Although demand for energy continues to grow (6-8% per year), especially electricity, the potential for energy efficiency (EE) and renewable energy (RE) is still largely under-exploited.

[142] REN21: Renewable 2011 Global Status Report, July 2011.

The sector is characterised by:

- ✓ inequitable distribution of energy resources at the regional level;
- ✓ strong growth in energy demand and dependence on fossil fuels;
- ✓ small contribution of renewables to the energy mix, despite the existence of significant potential;
- ✓ underdeveloped infrastructure for transport, transmission and distribution of oil, gas and electricity;
- ✓ low private sector investment;
- ✓ national electrification rates that vary between 97 and 99% depending on the country, except for Mauritania and Sudan, but still limited access to energy in rural areas;
- ✓ non-rational use of energy,
- ✓ limited specialist capabilities (training, applied research, exchange of information on technological innovations) and
- ✓ very low cooperation and trade in energy in relation to the energy possibilities and potential in the region.

Renewable energy is an alternative to fossil fuels. It can help meet current and future energy needs in order to support sustainable economic growth and the fight against poverty. In North Africa, however, its contribution to the energy mix is still quite marginal since it represented only 7% of the energy mix in 2006 (solar, wind, hydro, biomass), the rest being composed of gas (67%), oil (19%) and coal (6%) [143].

Nevertheless, all the countries have a potential to cover almost all the needs of their current and projected domestic demand in the long term, especially for the various services provided by electricity such as lighting, air conditioning, heating, telecommunications and rail transport.

Wind, which has benefited from lower global cost, is booming with power plants connected to the network already installed in Egypt, Morocco and Tunisia (these countries provide 95% of the total installed capacity of wind power in Africa) and significant ongoing projects. The solar field is the largest, but it is still largely untapped because of its cost. Decentralised photovoltaic systems exist in all the countries (<0.5% of the national energy balance) and lower prices for solar panels are offering new perspectives for changing the scale of PV. Centralised PV projects are being considered in several countries (Algeria, Morocco, Libya, Tunisia).

In this situation, and given the magnitude of the issue and the impact on economic and social development, virtually all countries in the region have developed strategies and programmes for the development of renewable energy and energy efficiency. If strategic priorities overlap, technological choices may differ. Countries such as Egypt, Morocco and Tunisia have favoured wind and CSP, while Algeria is oriented mainly to the development of the CSP industry because of its limited wind potential, even if it is not ruling out the latter. Solar (centralised PV and CSP) and wind sectors are also envisaged in Libya.

[143] 100% renewable electricity, A roadmap to 2050 for Europe and North Africa, p18, 2010

In Mauritania and Sudan, the achievements focus mainly on decentralised small-scale, off-grid projects to meet the needs of rural electrification. However, projects are under consideration for the introduction of average power plants connected to the grid in the sectors of solar PV, thermal and wind. The first wind power plant of 4.5 MW has been built by SNIM; another is planned.

Sudan also plans to develop large-scale CSP in the country and could turn to hydropower as it is the only country in the region to benefit from huge hydroelectric potential largely untapped so far.

It appears that the RE sector in North Africa is progressing at two speeds, with on the one hand Algeria, Egypt, Morocco and Tunisia, which have developed their regulatory framework with laws encouraging investment, creating specialised institutions and research centres and setting up financial mechanisms, and on the other Libya, Mauritania and Sudan, which therefore lagging in this area.

Energy efficiency remains a challenge for North Africa due to several constraints. In oil-exporting countries such as Algeria, Egypt and Libya, energy prices are significantly lower than the retail cost and do not encourage energy saving. Tunisia and Morocco have developed EE programmes in the fields of construction, transport and industry.

Barriers related to the high cost of RE in competition with subsidies to fossil fuels, the small size of the local market and the absence of a regional market, the lack of mastery of the technology and the weak capacity of local production of goods and services could be removed through enhanced regional cooperation. At present, however, the lack of coordination of policies and actions at the regional level makes it impossible to take advantage of opportunities for cooperation. The achievements so far in energy cooperation remain limited in scope compared to the potential and needs of the region. Energy flows between countries in the region are low, despite the existence of networks of electrical interconnections between Algeria, Tunisia and Morocco, between Libya and Tunisia and between Libya and Egypt. The majority of the interconnection projects currently under consideration are for south-north trade (mostly to Europe).

At the first Ministerial Council of the Energy UMA-EU devoted to the project for the integration of the electricity markets of Algeria, Tunisia and Morocco within the EU, the ministers undertook to pursue actions aimed at harmonisation of the legal and regulatory frameworks for the creation of a viable market for electricity (Algiers Declaration, June 2010). The ninth session of the Ministers of Energy and Mines of the AMU (Rabat, November 2010) also stressed the need for countries to converge towards a common vision and strengthen cooperation, especially with regard to the creation of a Maghreb electricity market.

Broader partnerships are currently under construction in the context of the Mediterranean Solar Plan and Desertec project supported by the DESERTEC Industrial Initiative created in 2009 (DII). These partnerships offer opportunities to increase investment and develop projects for the production and distribution of renewable energy, strengthen interconnections and create a regional carrier market for electricity.

GLOSSARY

Renewable energy: Sources of natural and inexhaustible energy. The first of these is solar radiation and the others derive more or less directly from it (wind, water cycle and tides, biomass production and other energy from the incineration of household and industrial waste).

Energy efficiency: Energy efficiency is the ratio of the energy produced by a system for a particular purpose with respect to the energy consumed. For example, an incandescent lamp has an efficiency of 5%, as only 5% of the electrical energy is actually converted into light, the rest is lost.

Energy intensity: Energy intensity is the ratio of primary energy consumption and gross domestic product generally in constant US dollars, measured in purchasing power parity. Energy prices and the structure of the economy according to the activities have a direct impact on energy intensity: a more industrial country will, all other things being equal, have higher energy intensity.

Photovoltaic panel (or module): assembly of photovoltaic cells electrically interconnected in series or in parallel.

Peak power: Maximum or optimal (in Wp) issued by the photovoltaic cell under ideal conditions under illumination of 1 kW/m^2 and a junction temperature of 25° C.

Silicon: Basic element composing the photovoltaic cell (existing as monocrystalline (single crystal), polycrystalline (several crystals) or amorphous (non-crystalline thin). Silicon, the main component of sand, is the second most common element in the earth's crust.

Feed-in tariff (feed in tariff): Policy that sets a guaranteed price at which power producers can sell renewable energy to the grid.

Watt (W): A unit of power which can be either electrical, mechanical or thermal. The Watt is the product of the voltage and current (amperage).

Watt hours (Wh) and multiples: A unit of energy equal to the product of the power (W) by time (h).

Watt-peak (Wp): Maximum power (called peak power) that a solar cell can deliver under optimal conditions (Irradiance 1000W/m^2, temperature 25° C).

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Agency for the development of renewable energy and energy efficiency (ADEREE, Morocco): www.aderee.ma

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ANME: National Agency for Energy Management (ANME, Tunisia): www.anme.nat.tn

Centre for Development of Renewable Energies (CDER, Algeria): www.cder.dz

Maghreb Electricity Committee (COMELEC Maghreb-UMA): COMELEC-net.org

Egyptian Electricity Holding Company: www.egelec.com

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