Renewable energy and resource curse on the possible consequences of solar energy in North Africa

Bae, Y.J.

Author: Bae, Yuh Jin

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Chapter 3. Renewable Energy

3.1 Realization of the Importance of the Renewable Energy

The world's heavy dependence on fossil-fuels, such as coal, oil and natural gas, is a well-known fact. Today, for example, fossil-fuels still dominate energy consumption which accounts for 87 percent of market share (BP statistical Review of World Energy June 2012 Report, p.1). However, the long-term excessive reliance on fossil-fuel poses great threats such as climate change. There are many organizations and initiatives which are concerned with climate changes and aim to reduce Greenhouse gases (GHG). For example, the Kyoto Protocol to the United Nations Framework Convention on Climate Change is an international treaty that sets binding obligations on industrialized countries to reduce emissions of GHG. This was adopted at the third session of the Conference of the Parties in Kyoto in December 1997 which was open for signature from 16 March 1998 to 15 March 1999 at United Nations Headquarters, New York. By that date, the Protocol had received 84 signatures. Currently, there are 192 parties including all members of the European Union (United Nations Framework Convention on Climate Change)[4]. Many developed countries have agreed to legally binding limitations or reductions in their GHG in two commitment periods. The first commitment period applied to emissions between 2008 and 2012, and the second commitment period applies to emission between 2013-2020. For example, during the first commitment period, 37 industrialized countries and the European community committed to reduce GHG emissions to an average of 5 percent against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020 (United Nations Framework Convention on Climate Change)[5]. Furthermore, the Europe 2020 strategy, what is often referred to as 20/20/20 climate/energy target, also shows Europe's concern with the emissions of GHG as it involves 20 percent reduction in greenhouse gas emissions compared to 1990 levels (or by 30 percent if the conditions are right), increase the share of renewable energy sources in final energy consumption to 20 percent, and a 20 percent increase in energy efficiency (COM/2010/2020/FINAL, p. 11).

Another threat, or the inevitable truth, is that fossil-fuels will eventually run out because they are not renewable resources. In other words, there is a limited time for the world to rely on fossil-fuels as the dominant energy sources. For example, Campbell & Laherrère (1998) published an important article named "The End of Cheap Oil" which questions the future oil supply and predicts

[4] http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php (accessed: 23.05.2013)
[5] http://unfccc.int/kyoto_protocol/items/2830.php (accessed: 23.05.2013)

that global oil production is to reach a peak level and start to decline. Their consideration and prediction became the foundation of a new theory called the "peak oil theory" which was later coined by Collin Campbell in 2001. He defines peak oil as "the maximum rate of the production of oil in any area under consideration, recognizing that it is a finite natural resource, subject to depletion." (Robelius 2007, p. 58). It is not difficult to find supporters of the peak oil theory.

Schindler et al. (2008) illustrate a number of evidences for peak oil such as no large oil field (such as Ghawar field in Saudi Arabia) discoveries in recent years; decline in oil exploration expenses and increase in expenses for maintaining oil production from major oil companies; and decline in oil production in Saudi Arabia which is considered as one of the major oil producers in the world.

Chefurka (2007) argues that oil production already peaked in May 2005. He follows the approach of the Energy Watch Group to create decline model for the world's oil production. Although, the world total oil production has been increasing (BP Statistical Review of World Energy June 2012 Report, p. 8), his model projects 1 percent per year in decline rate in 2010 to a constant rate of 5 percent per year after 2025 which will result in an average of 4 percent decline rate per year until 2050. According to Chefurka (2007), in 2050, oil production will be only 18 percent of what it is today. Furthermore, In December 2009, Mr. Gabrielli, the CEO of Petrobras, gave a presentation on oil capacity, including biofuels, and projected that oil production is to peak in 2010 because the oil capacity additions from new projects are unable to offset the declining rates of world oil (Eriksen, 2010).

Of course, peak oil is different from running out of oil. There is still a vast amount of oil and other fossil-fuels which can be extracted, and there may be new fields discoveries in the future. Furthermore, the recent improvement of fossil-fuels exploration and extraction technologies may have already begun to postpone such a peak of fossil-fuels. For example, a new technique such as Hydraulic Fracturing (often called "Fracking") is used to free natural gas that is trapped in shale rock formations which is often referred to as "shale gas". More specifically, a mixture of water and sand is injected into the rock at very high pressure which creates fractures within the rock that provide the natural gas a path to flow to the wellhead. The fracking fluid mix also helps in keeping the formation more porous (NaturalGas.org)[6]. This recent improvement and development in shale gas production begun in the United States and is often referred to as 'Shale Gas Revolution' (Stevens, 2010). According to Stevens (2010, p.14), shale provided 1 percent of US gas supply in 2000 but increased to 20 percent in 2009. Furthermore, it is projected to account for 46 percent of US gas supply by 2035 (Stevens 2012, p.2). The increase in shale production has also been observed in Canada and some

[6] http://www.naturalgas.org/environment/technology.asp#advances (accessed: 28.05.2013)

analysts such as Krauss (2009) argue that shale gas will help in expanding the worldwide energy supply.[7]

Despite the peak oil theory or new technology development which may help in prolonging the time for 'a fossil fuel peak', it nevertheless remains an inevitable truth that oil and other fossil-fuels are non-renewable energies and will eventually run out.

Due to the mentioned threat and inevitable truth, there has been growing interest in renewable energy which can be the alternative energy source to replace the use of the fossil-fuels. Renewable energy is also derived from natural resources such as sunlight, wind, rain, tides, and geothermal heat which are renewable and, unlike fossil-fuels, can be naturally replenished easily. The focus on renewable energy is rapidly growing all over the world, and this can be seen by world's policy changes and growth of global renewable energy capacity.

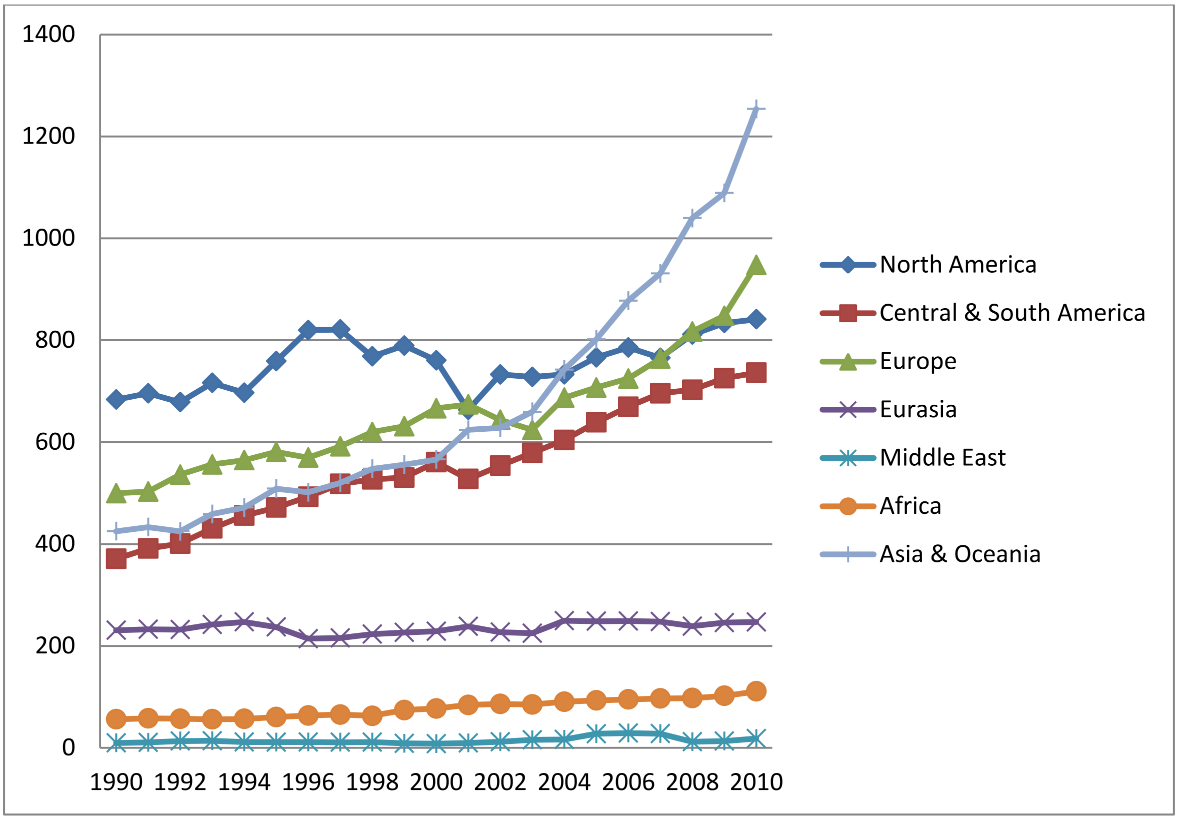
3.1.1 Changes in Policies towards Renewable Energy

In the 1980s and 1990s there were not many countries supporting the idea of renewable energy and had policies to promote it. However, more countries, states, provinces, and cities have begun to change their policies to promote renewable energy, and this can be witnessed especially during the period of 2005-2011. For example, the number of countries promoting some form of renewable energy policies doubled during the period of 2005-2011 from an estimated 55 countries to 118 countries by early 2011 (REN21 2011, p. 49). There are at least 118 countries, including all 27 European Union member states, which have policy targets for renewable energy and more than half of these countries are developing countries. For example, there were 22 developing countries with targets for renewable energy and the figure expanded to 45 by early 2010 (REN 21 2010, p.35). Furthermore, most countries with renewable electricity targets aim for an average annual share increase of 0.2-1.4 percent. There are also other targets such as renewable energy shares of primary or final energy supply and the installation of the electric capacities of specific technologies (REN21 2012, p. 65).

Figure 1 and 2 present the total renewable electricity net generation by regions and the world total renewable electricity net generation during the period of 1990-2010. As can be observed from these two figures, most regions have been experiencing an increase in the total renewable electricity net generation, and consequently, there has been a steady increase in the world total renewable electricity net generation.

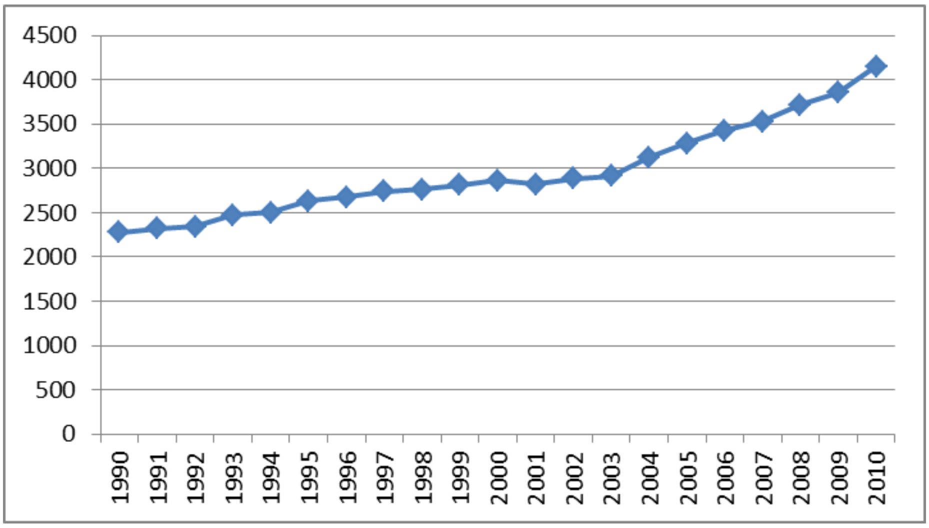
[7] It must be mentioned that there are growing opposition to shale gas driven by concerns over the environmental impact of hydraulic fracturing and the impact on greenhouse gas emissions (Stevens 2012, p. 1).

Figure 1: Total Renewable Electricity Net Generation by Regions 1990-2010 (Billion kWh)



Source: U.S. Energy Information Administration (EIA)
http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=6&pid=29&aid=12&cid=regions&syid=1990&eyid=2011&unit=BKWH
(accessed: 16.11.2012)

Figure 2: The World Total Renewable Electricity Net Generation 1990-2010 (Billion kWh)



Source: U.S. Energy Information Administration (EIA)
http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=6&pid=29&aid=12&cid=regions&syid=1990&eyid=2011&unit=BKWH
(accessed: 16.11.2012)

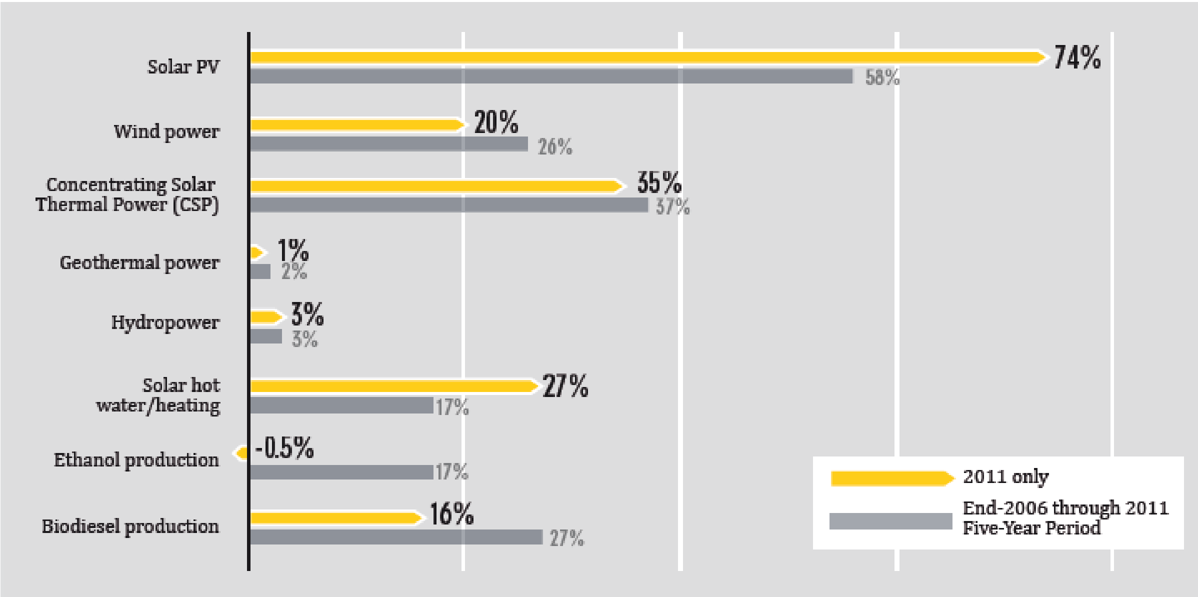
There have been many targets to promote renewable energy aimed for the 2010-2012 timeframe. However, in recent years, there has been growing number of targets aiming for 2020 or even beyond. All 27 EU countries mentioned earlier have confirmed national targets for 2020 in 2008, following a 2007 EU-wide target of 20 percent of final energy by 2020 (REN21, 2010, p. 35). The plans of developing countries also show increasing ambition in the targeted amount. For example, China, the investment leader in renewable energy capacity with Germany in 2009, aims for 15 percent of final energy consumption from renewable energy by 2020. Their recent draft development plan targets 300 Gigawatt (GW) of hydro, 150 GW of wind, 30 GW of biomass, and 20 GW of solar Photovoltaics (PVs) by 2020 (REN21, 2010, p. 35). There were new policy targets introduced in 2011 by nine countries. For example, Lebanon aims to include in its final energy production a 12 percent share from renewable sources by 2020. In order to achieve this they propose the installation of an additional 190,000 square meter (m^2) of solar thermal collectors, to be completed by 2014 (REN21, 2012, p. 65).

3.1.2 Growth of Renewable Energy Capacity

It is estimated that, in 2010, about 16.7 percent of global final energy consumption was supplied by renewable energy. Within the energy consumption supplied by renewable energy about 8.2 percent came from modern renewable energy sources including hydropower, wind, solar, geothermal, biofuels and modern biomass. Here, traditional biomass accounted for around 8.5 percent of total final energy. Hydropower supplied around 3.3 percent of global final energy consumption, and its capacity is growing steadily from a large base. Furthermore, all other modern renewable energy sources provided around 4.9 percent of final energy consumption in 2010 (REN21, 2012, p. 21). These renewable energies have been growing rapidly in both developed and developing countries as it can be seen from the policy changes towards renewable energy from section 3.1.1.

According to REN21 (2012, p.21), modern renewable energy can replace fossil-fuels in four distinct markets: power generation, heating and cooling, transport fuels, and rural/off-grid energy services. Between end-2006 and 2011, there has been a rapid growth of total global installed capacity of renewable energy technologies. As can be seen from figure 3, the fastest growing renewable technology during the period was PV with operating capacity increasing an average of 58 percent annually. It was followed by the concentrating solar thermal power (CSP) with an average of 37 percent annual growth, and wind power with 26 percent annual growth. Furthermore, there has also been an increase in demand for solar thermal heat system, geothermal ground-source heat pumps, and some biomass fuels. Hydropower and geothermal power, according to REN21 (2012, p.13), are growing at rates of 2-3 percent per year globally.

Figure 3: Average Annual Growth Rates of Renewable Energy Capacity and Biofuels Production, 2006-2011



Source: REN21 (2012, p.22)

During 2011, more mature renewable energies, such as solar PV and onshore wind power, experienced a drop in price because of declining costs due to economies of scale, technology development, and other factors, but also reductions or uncertainties in policy support contributed to price reduction.

It must be noted that, at the same time, some renewable industries, such as Solar PV manufacturing, has been challenged by declining prices and policy support, and the international financial crisis. According to REN21 (2012, p.22), due to the continuous economic challenges and changes in policy environments in many countries, there have been some uncertainties and negative outlooks in some industries. Despite some challenges, it is still certain that renewable energy industries have been growing, and there has been a growing realization of the importance of the use of renewable energy for future consumption. Though the global renewable energy capacity grew rapidly for many technologies, solar energy technologies have been achieving the most outstanding development and growth. Here, the growth of solar energy technology and its capacity have particular relations to North Africa and the Sahara desert. Due to its high potential to produce large amounts of electricity via solar energy, North Africa has received a lot of attention recently. The reason why North Africa is receiving special attention is not only because it can help in meeting their own electricity demand but also can help in meeting Europe's electricity demands in the future.

Therefore, the following section will be focusing on the solar energy and its potential in relations to North Africa in more detail.

3.2 The Potential of Solar Energy in North Africa

Due to the continuous growing demand for electricity, it has been a crucial task to find and support new sources and possibilities for electricity generation. The huge potential of solar energy is no longer a new idea, and it has been discussed by various organizations and studies. For example, according to the DESERTEC concept, with high Direct Normal Irradiance (DNI), "within six hours, deserts receive more energy from the sun than humankind consumes within a year." (DESERTEC Foundation: Concept). In other words, solar energy can play a major role in generating electricity.

Solar power can be described as the conversion of sunlight into electricity. The conversion of sunlight into electricity is usually materialized in two ways, known as PVs and CSP.

PVs are most well-known arrays of solar cells that generate electrical power by converting solar radiation into direct current electricity with the photovoltaic effects. More specifically, PVs convert solar energy into energy forms by "directly absorbing solar photons-particles of light that act as individual units of energy-and either converting part of the energy to electricity (as in a photovoltaic (PV) cell) or storing part of the energy in a chemical reaction (as in the conversion of water to hydrogen and oxygen)." (Solar Energy Development Programmatic EIS: Solar Energy).

As mentioned earlier, PV was the fastest growing technology during the period, end-2006 to 2011. The European Union currently dominates the PV market which accounts for almost three-quarter of the world's total installed solar PV capacity. Germany and Italy, for example, accounted for 57 percent of new operating capacity in 2011. Besides Europe, there are also large PV markets in China, the United States, Japan, and Australia (REN21, 2012, p. 47).

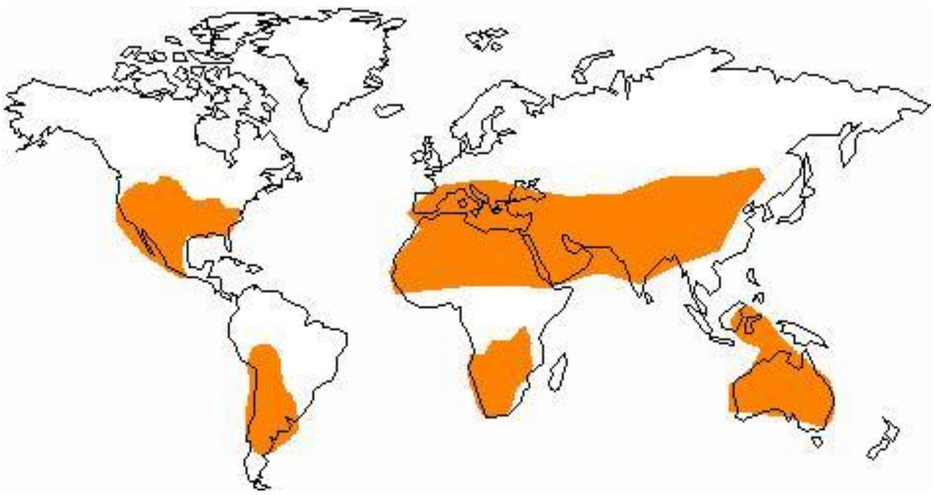
CSP power plants utilize focused sunlight. They generate electric power by using mirrors to concentrate the direct sun light and convert it into high-temperature heat. This heat is used to produce steam which drives steam turbines and electricity generators. Heat storage tanks, which are usually molten salt tanks or concrete blocks, are then used to store heat during the day which would power steam turbines during the night or when high demand occurs. Also, the turbines can be powered by oil, natural gas or biofuels, when there are overcast periods or bad weather, in order to ensure uninterrupted service. The CSP power plants have the ability to supply power on demand for 24 hours a day (GREEN ASSEMBLY ASIA ENVIRONMENT: CLIMATE CHANGE Definitions).

Commercial-scale CSP plants resumed in 2005 after the experience of a stagnant market beyond the early 1990s. Between 2005 and 2009 the global capacity of CSP plants -all located in the US and

Spain- increased to about 70 percent (REN21, 2010, p. 20). The CSP market was down in 2011, relative to 2010, but significant capacity was under construction at the end of 2011. As mentioned earlier, during the period of 2006-2011, total global capacity of CSP grew at an average annual rate of 37 percent. The CSP market is dominated by parabolic trough plants, about 90 percent of newly built plants and most of operating plants, but there is growing investment in other technologies. Furthermore, Spain is known to have most of the world's CSP capacity (REN21, 2012, p. 51).

In general, deserts have been perceived as, or regarded, "wastelands". However, this way of thinking has been changing rapidly due to the development of solar energy technology. Instead of being considered as "wastelands", they are beginning to be viewed as the basis of the future electricity provider. For example, according to Desertec-AFRICA, each square kilometer of the desert receives solar energy equivalent to 1.5 million barrels of oil per year. In other words, if one is to multiply this by the deserts in the world, deserts have the potentials to provide several hundred times more energy than the whole energy the world uses in one year.

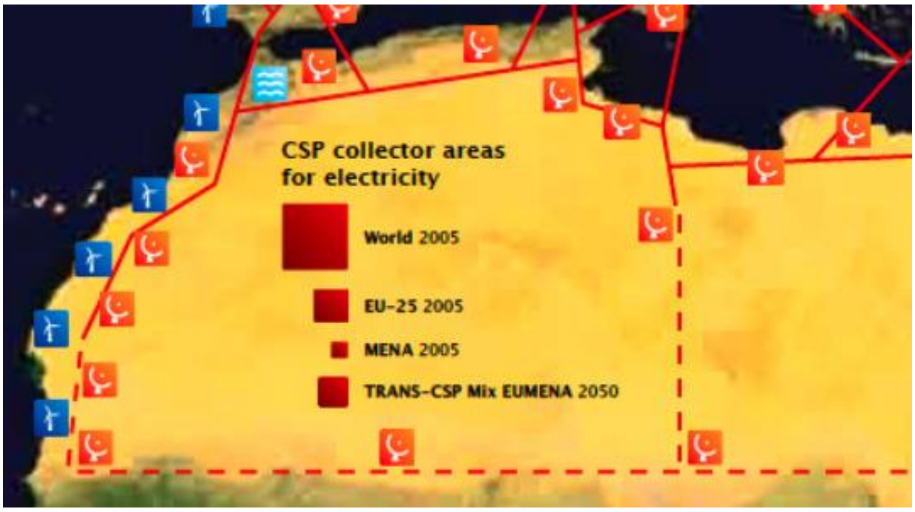
Figure 4: High Solar Insolation Regions in the World



Source: Desertec-Africa http://www.desertec-africa.org/ (accessed: 16.11.2012)

Figure 4 presents the areas in the world which receive high solar insolation. Data above indicates that, the Sahara, Kalahari and Namib deserts in Africa fall in the category of the lands which receive high solar insolation. The Sahara desert, especially, is regarded as an ideal location to develop solar energy. For example, at the Euroscience Open Forum in Barcelona in 2008, Arnulf Jaeger-Waldau, the European commission's institute for Energy, said that it only requires the capture of 0.3 percent of the light falling on the Sahara and Middle East deserts to meet the European energy demand. Furthermore, he accentuates the CSP plants by saying "compared to the size of the countries on the continent, the area needed for a CSP plant large enough to power Europe is tiny- roughly the size of Wales.” (Amstell 2009). Figure 5 is provided by the DESERTEC Foundation and helps to understand and seeing how much land is needed to provide enough energy for the world. The red squares represent the sufficient land size for CSP to generate electricity for the world, Europe, and MENA in 2005. The last square, TRANS-CSP Mix EUMENA 2050, represents the land necessary for EUMENA in 2050. As can be observed, the Sahara desert has high potential to become an important energy source.

Figure 5: The Potential of the Sahara Desert to Provide Electricity for the World



Source: DESERTEC Foundation
http://www.desertec.org/fileadmin/downloads/media/pictures/DESERTEC_EU-MENA_map.jpg (accessed: 19.11.2012)

According to Desertec-AFRICA, if deserts in Africa can be utilized to their full potential, this could mean that countries, such as Algeria, Angola, Libya, and Nigeria, would have the potential to become solar-rich instead of oil-rich nations. As they are currently oil-rich nations, their oil export revenues could be directed to invest in solar energy technologies, such as CSP, to harness energy from the sunlight in the Sahara, Kalahari and Namib deserts. If solar energy technology is successfully established in the continent, for example in Nigeria, the northern part of the country can become the energy power source instead of the southern Niger delta region. This is because the electricity produced via CSP plants –located in parts of the North which lies in the arid Sahel zone- can be sold locally and exported to Europe, which may generate more revenue compared to the current revenue made from export of petroleum. DESERTEC and Desertec-AFRICA strongly believe that the CSP technology is the most suitable solar based technology that could utilize the full advantage of the high solar irradiation from deserts.

In order to understand why the CSP technology is regarded as suitable for deserts, it is necessary to see the amount of solar heat that is required. For example, when using coal, dependent on the capacity of the power plant, 400-700°C could be generated to produce enough steam to drive the coal-fired power plant. In the case of solar heat, a mega sized mirror or a large collection of mirrors (about the size of a football field) are required to concentrate sunlight to generate heat of 400-700°C (Desertec-AFRICA). As one can assume, large deserts can be places that can meet the above requirement. Also, when it comes to the CSP technology, they can be operated by only the use of DNI. For example, a region, or a site, is considered suitable if it receives more than 2,000 kWh of sunlight radiation per square meter per year, and considered best if it receives more than 2,800kWh/m² per year (Desertec-AFRICA). The Sahara desert is one of the few sites in the world that meet these requirements, large fields and high DNI, and it is, of course, considered as an ideal site for CSP installations. Furthermore, according to Desertec-AFRICA, apart from the deserts, Sahel Stepes and Savanna Grassland are also considered to be suitable sites for solar thermal installations. In other words, Africa is a continent with many suitable sites for the installation of the CSP system, and these factors could make the African continent an important energy provider in the future.

As can be seen above, the Sahara desert as well as other African sites have huge potentials to become future solar energy providers. In other words, the geography and the weather, which often have been perceived as obstacles for their development and growth, may be the essential elements that may lead the continent to be the leading electricity producer in the future. The potential of solar energy, especially in the MENA region, has been exemplified by many energy companies and organizations, and the idea is in the process of being materialized.

3.3 DESERTEC Foundation & Desertec Industrial Initiative (DII) and Current Development in North Africa

3.3.1 DESERTEC & Desertec Industrial Initiative (DII)

As mentioned earlier, there are many energy companies and organizations which are interested, and also work on materializing the potentials for solar energy. When it comes to solar energy in North Africa, also in the Middle East region, the DESERTEC foundation has been one of the leading organizations which have been working on utilizing the potential of solar energy. Therefore, it is worth looking at its concepts and ideas.

The DESERTEC Foundation was established on 20 January 2009 as a non-profit foundation. DESERTEC demonstrates a way to “provide climate protection, energy security and development by generating sustainable power from the sites where renewable sources of energy are at their most abundant" (DESERTEC Foundation: Concept) and implement the global DESERTEC Concept "Clean Power from Desert" all over the world (DESERTEC MILESTONES). More specifically, its concept describes the prospects of providing Europe and MENA with a sustainable supply of renewable energy, electricity, by the year 2050. Furthermore, the DESERTEC Foundation does not only work on materializing their concept in the MENA region, but also in other parts of the world. The DESERTEC Foundation now works together with Japan Renewable Energy Foundation (JREF) to boost Japan's transition to clean, affordable and reliable sources of clean power from nuclear power. Furthermore, The Japanese Softbank Corp., let by JREF founder Masayoshi Son, works on the implementation of the so-called "Asian Super Grid". The "Asian Super Grid" is to transport renewable energy, such as from the Gobi deserts, via interlinking national electricity grid from Japan, Korea, China, Mongolia and Russia (DESERTEC Foundation Press release, October 24, 2012).

The DESERTEC Foundation was developed by the Trans-Mediterranean Renewable Energy Cooperation network which is a voluntary organization founded in 2003. The driving pillars behind the formation and development of such network are Physicist Dr. Gerhard Knies and HRH Prince Hassan bin Talal of Jordan who was the president and founder of the Club of Rome. Furthermore, the research institutes for renewable sources of the governments of Algeria (NEAL), Egypt (NREA), Jordan (NERC), Libya (CSES), Morocco (CDER), Yemen (Universities of Sana'a and Aden), and German Aerospace Center (DLR) contributed in the development of the DESERTEC Concept. The DLR scientist Dr. Franz Trieb provided the basic studies related to DESERTEC which were financed by the German Ministry of the Environment (BMU) (DESERTEC MILESTONES).

On 13 July 2009, in Munich, 12 companies[8] signed a Memorandum of Understanding to establish the Desertec Industrial Initiative (DII). The objective of DII is to "analyse and develop the technical, economic, political, social and ecological framework for carbon-free power generation in the deserts of North Africa" (Munich RE Press release, July 13, 2009) and, of course, to accelerate implementation of the DESERTEC Concept in EUMENA. Furthermore, their long-term aim is to "produce sufficient power to meet around 15% of Europe's electricity requirements and a substantial portion of the power needs of the producer countries." (Munich RE Press Release, July 13, 2009). The DII has been expanding since its establishment and currently consist of more than 55 countries and institutions as shareholders or associated partners. The idea of implementing solar energy in the MENA region has been receiving vast amounts of supports. Their growing status could be seen in the 3rd DII conference in 2012, in Berlin. A number of quotes taken from the 3rd DII conference in Berlin are presented below.

[8] ABB, ABENGOA Solar, Cevital, Deursche Bank, E.ON, HSH Nordbank, MAN Solar Millennium, Münchener Rück, M+W Zander, RWE, SCHOTT Solar, SIEMENS.

Mr. Padmanathan, the CEO of ACWA Power said;

"The only way we can survive is to deliver energy to the lowest possible price. We in Saudi Arabia have significant renewable resources both wind and solar and they are already on a good way. We are with DII to make that development faster."

Christian Ruck, member of the German Bundestag, CDU/CSU said;

"I am a big supporter of the DESERTEC vision. This idea is on the edge of becoming reality. We have to start concretely and as early as possible. We can reduce the cost of renewable, their volatile and the cost of co2 emissions."

Hans-Josef Fell, Member of the German Parliament, Spokesman on Energy for the Alliance 90/The Greens Parliamentary Group said;

"When we organize an export from North Africa to Europe, money and know-how flow back to North Africa and there would be a great need for these counties that this happens."

Accordingly, the DESERTEC Foundation and DII received a lot of supports from both European and the MENA region. In North Africa, not only due to the DESERTEC Foundation and DII, there has been substantial growth in solar energy and other renewable energy development. Therefore, the next section will illustrate the current development of solar energy in North Africa which will enable one to understand where the North African countries stand with the potential of solar energy.

3.3.2 Current Development in North Africa

There has been specific focus in Morocco as regards to DII's reference project. Morocco can be considered as a natural choice for the reference project as there is an existing power grid connection between Morocco and Spain, and it was here that the first DII project was demonstrated. In 2010, the government of Morocco announced the implementation of 2,000 megawatt (MW) solar program by 2020, for which MASEN was founded (Dii Newsletter, March 2011).

In May 2011, DII and MASEN signed a Memorandum of Understanding in Morocco regarding a large cooperative solar project in Morocco. The aim of this DII's first reference project is to demonstrate the export feasibility of electricity generated by solar energy in the deserts to Europe by using the existing line between Spain and Morocco. Here, DII acts as an enabler, which provides the expertise in developing a feasible business case for the planned solar project. MASEN, on the other hand, acts as project developer and manages the overall process in the country (Dii Newsletter, July 2011).

The location of this reference project is in Ouarzazate, it has a total capacity of 500 MW, combination of CSP (400 MW) and PV (100 MW), and its estimated cost is approximately €2 billion. The project's first phase is to be 150 MW pilot plant which is expected to be a CSP with an estimate cost of €600 million (Dii Newsletter, February 2012). The second phase, with the combination of wind and PV (100 MW), has already been defined. It is projected that the first electricity provided by the joint DII/MASEN project could be transferred into the grids between Morocco and Spain around 2014-2016 (Dii Country Focus: Morocco). This reference project has been under discussion for the past two years, and on 19 November 2012, a financial commitment of €300 million was signed in Marrakech by the European Investment Bank, the Development Agency for France, KfW Entwicklungsbank and MASEN (European Investment Bank, November 19, 2012).

Morocco is not the only country that is involved with the DESERTEC Foundation and DII. Following the development of reference project in Morocco, in April, 2011, Paul van Son, CEO of DII, met with four members, Ministers Abdelaziz Rassaa (Industry & Energy), Riffat Chaabouni (Education & Research), Abderrazak Zouari (Regional Development & Business) and Abdelhamid Triki (Planning & International Relations), of the interim Tunisian government and agreed on further steps in implementing the DESERTEC vision in Tunisia. The main focus of the meeting was creating/developing jobs and establishment of knowledge transfer for the next generation (Dii Newsletter, July 2011).

DII and STEG Energies Renouvables, shareholder in DII since October 2010, initiated a feasibility study of solar and wind energy projects in Tunisia. Currently, they are working on a pre-feasibility study, which includes reviews of technical and regulatory prerequisites and the capacity of the electricity network to integrate desert power, within the framework of cooperation agreement signed by DII and Tunisian authorities in 2011. Furthermore, the study focuses on identifying reference projects, including PV, CSP, CSP Hybrid, with a total volume of 1 GW, particularly on the transmission link between Tunisia and Italy (Dii Country Focus: Tunisia).

In December 2011, DII and Sonelgaz (the Algerian governmental National Society for Electricity and Gas) signed a Memorandum of Understanding for their future cooperation in Brussels. The aim of this cooperation was to support renewable energy strategy in Algeria and also to enable cooperation with Europe in reference project in the form of export agreements. Furthermore, the cooperation between DII and Sonelgaz focuses on identifying reference projects. The reference project consists of a total capacity of 1 GW, and, of the 1 GW, 90 percent is to be for export purposes and 10 percent for local consumption. Algeria already has an operating solar-combined cycle hybrid power plant near Hassi R'Mel which generates electricity via parabolic trough solar field (25 MW), and gas fired facility (125 MW) (Dii Country Focus: Algeria).

Another African country also moving towards renewable energy is Egypt. In December, 2010, Egypt's first solar thermal plant went into operation in Kuraymat. Flagsol GmbH, a subsidiary of Solar millennium and Ferrostaal, provided the solar technology for this reference project. It is a hybrid power plant which uses solar energy and natural gas, and it has a capacity of 150 MW. Dr. Christoph Wolff, the CEO of Solar Millennium AG, explains that the successful operation of the plant is proof that the Desertec vision can be realized, and it can create jobs in clean energy generation (Solar Millennium Press Release September 22, 2011). Similarly, Oliver Blameberger, a member of the Executive Board of Solar Millennium, finds this project as an important step towards the realization of DESERTEC vision, and there could be the successful European-African cooperation in the field of renewable energy (Solar Millennium Press Release December 23, 2010).

Libya is probably the slowest country that is promoting the renewable energy. Unlike other North African countries, in 2010, Libya did not produce any electricity via renewable energy. Also, at the 3rd DII Conference in Berlin, it was possible to see that there was little interests, in comparison to the other North African countries, from international companies and organizations as there was lack of discussion regarding renewable energy in Libya. Nevertheless, according to REN21 (2012, p.105), Libya has targets to expand the use of renewable energy in the future. Table 4 presents the share of primary and final energy from renewable energy, existing share in 2009/2010 and the future targets of North African counties.

Table 4: Share of Primary and Final Energy from Renewables, Existing in 2009/2010 and Targets

Country	Primary Energy		Final Energy	
	Share (2009/2010)	Target	Share (2009/2010)	Target
Algeria	-	-	-	40% by 2030
Egypt	-	-	-	20% by 2020
Libya	-	10% by 2020	-	-
Morocco	-	8% by 2012 10-12% by 2020 15-20% by 2030	-	10% by 2012
Tunisia	-		-	-

Source: REN21 (2012 pp. 105-106)

As can be seen from this chapter, the world has been realizing the importance of the renewable energy. Although there have been policies to promote renewable energy since the 1980s, it is only the recent period that has seen the rapid growth in policies promoting renewable energy, especially for the electricity generation. Despite the types of renewable energies, their capacities have also been growing rapidly throughout time. Here, the solar energy technologies have been experiencing substantial growth. Indeed, solar energy appears to have great potential in meeting the future electricity demand. As for North Africa, the Sahara desert has been identified as the place where once can produce enormous amount of electricity by erecting solar power plants. International companies and organizations, such as DESERTEC Foundation and DII, have already begun their process in planting reference projects in the North African countries, and the idea of renewable energy is spreading in the continent.