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CONFERENCE PAPER

Harnessing Nigeria's abundant solar energy potential using the DESERTEC model

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Abstract
The DESERTEC project, a European Union (EU) initiative to harness solar energy by means of Concentrated Solar Power (CSP) from Africa for use in Europe, shows the enormous potential that exists in alternative energy sources for the sub-region once there is political will. The Trans-Mediterranean Renewable Energy Corporation (TREC), a network of scientists and politicians who have taken it upon themselves to solve Europe's energy problem using sun from Africa, conducted three studies which evaluated the potential of renewable energy resources in the Middle East and North Africa (MENA), the expected needs for water and power in EU-MENA between now and 2050 and issues relating to the construction of an electricity transmission grid connecting the EU and MENA (EU-MENA-Connection), with a formula to turn the North African desert sun into electricity and transport same to Europe. This paper harnesses the TREC fact-finding studies in order to estimate how much the same ideas can be applied in many other parts of the world, Nigeria in particular. Investigation reveals that this association exists with huge potentials for an energy-starved country like Nigeria in harnessing her abundant hot sun in the north, which could go a long way in meeting the energy needs in that part of the country and beyond. Other benefits include unlimited supplies of clean electricity, agricultural gains, and creation of new industries, new jobs and new sources of income.

Keywords: concentrated solar power, DESERTEC, Nigeria, solar energy

1. Introduction

Almost every other source of energy being exploited by man is directly or indirectly tapped from the sun's reservoir. In fact, it is proven that the sun has as much effect on the process of establishing non-renewable energy sources as it does to renewable sources. At present, the amount of energy radiated from the sun, that is wasted unutilised, is 10 000 times the amount of energy required to run human activities worldwide.

Recurrent overdependence on fossil fuels has, apart from not sustainably meeting energy demands, been bedevilled with such drawbacks like political instability, pollution and corruption, to mention a few. Consequently, Nigeria fits appropriately as a good case in this study when the backdrop of the oil resource-curse is revisited. The recent Niger-Delta unrest, the indiscriminate flaring of gas and oil-spillage by multi-national oil companies (MNOCs), as well as the gulf existing between demand and supply are daunting realities in the Nigerian energy polity (Malumfashi, 2007; Colwell and Greene, 2008).

European scientists have gone out of their way to research and develop better means of energy generation using the DESERTEC initiative to boost energy supply and reduce adverse environmental impacts. This initiative has been modelled to tap into the Middle East and North Africa's (MENA) cheap but unutilised deserts and seas in positioning a new brand of solar energy technology christened – Concentrated Solar Power (CSP). This technology will involve the construction of large solar plants that will drive power generating turbines to produce clean electricity for a greater percentage of

Europeans in a collaboration that will also benefit the MENA regions in electricity generation, job creation and fresh water supply.

Independent research has revealed that this technology can be replicated anywhere else in the world where similar potentials for operation exist; such that it could even be easier to implement in countries like Australia, China, India and the USA (Red Paper). In West Africa, the sub-region to which Nigeria belongs, the sun supplies 80 times more energy than is needed to run human activities every day with abundant opportunities for solar energy to be tapped in large quantities in Nigeria's north (Bala et al., 2000; Chineke and Igviro, 2008). The great potential for solar radiation in Nigeria is the primary drive of this research paper in contrast to MENA's initiative with the aim to model something similar for an energy starved country like Nigeria.

In order not to portray the DESERTEC initiative as seamless, it is noteworthy to establish that the few instances where drawbacks like initial high cost of generation have been identified and mentioned, it is still not enough to deny the benefits inherent in this project.

2. The conceptualization and branding of DESERTEC

DESERTEC is an ambitious contraction developed in North Africa by the DESERTEC Foundation and managed by the Club of Rome and Trans-Mediterranean Renewable Energy Cooperation (TREC) – an international network of scientists, politicians and other experts in the development and implementation of renewable forms of energy (Red Paper; Archibald, 2009; James, 2009).

The project founded in 2003, was officially launched by twelve European companies in a consortium led by Munich Re on 13 July 2009 (Red Paper). The consortium, which will be based in Munich, hopes to start supplying Europe with electricity by this year (2015) and aims to produce solar-generated electricity with a vast network of power plants and transmission grids across MENA regions.

The mandate of TREC among other things, includes to provide clean, cost efficient energy for EU-MENA as soon as possible and based on economic cooperation between the countries in the region, oversee the power from deserts as a supplement to European sources of renewable energy thereby speeding up the process of cutting European emissions of CO_2 and increasing the security of European energy supplies. In order to achieve this mandate, TREC embarked in the conduct of three preliminary studies which have evaluated the potential of renewable energy resources in MENA, the expected needs for water and power in EU-MENA between now and 2050 and issues relating to the construction of an electricity transmission grid connecting the EU and MENA (EU-MENA-Connection as in Figure 1).

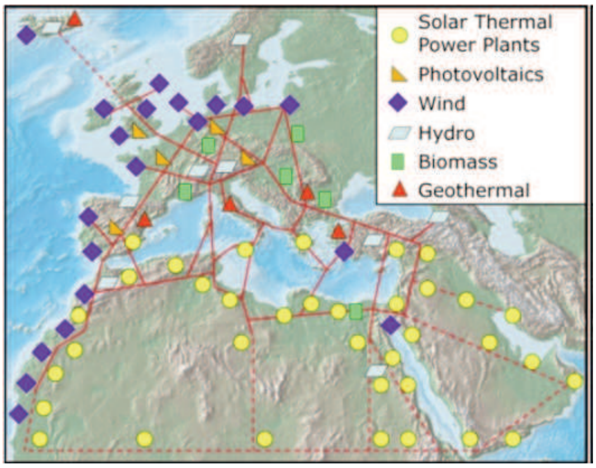

Figure 1: Euro-Super grid with a EU-MENA-Connection: Sketch of possible infrastructure for a sustainable supply of power to EU-MENA
Source: www.DESERTEC.org

The studies which were commissioned by the German Federal Ministry for the Environment, Nature Conversation and Nuclear Safety (BMU) with the German Aerospace Centre (DLR) taking the lead showed that, by using less than 0.3% of the entire desert area of the MENA region, enough electricity and desalinated seawater can be produced to meet the growing needs of these countries and of Europe (Red Paper). Power generation from wind energy is particularly attractive in Morocco and in areas around the Red Sea. Solar and wind power can be transmitted throughout the region via High Voltage Direct Current (HVDC) transmission lines, and to Europe with transmission losses up to 15%. Two of these studies, Concentrating Solar Power for the Mediterranean Region (MED-CSP) and Trans-Mediterranean Interconnection for Concentrating Solar Power (TRANS-CSP), which were conducted between 2004 and 2006, resulted to independent outcomes. The results of the MED-CSP and TRANS-CSP studies have been executively summarized (MED-CSP, 2005; TRANS-CSP, 2006).

Unlike the main results of the TRANS-CSP study, which analyses the renewable electricity potentials in Europe and their capability to provide firm power capacity on demand, the third study, Concentrating Solar Power for Sea Water Desalination (AQUA-CSP), covering aspects of solar desalination which was completed towards the end of 2007 highlighted several good reasons for the implementation of large-scale concentrating solar powered desalination systems for the provision of clean water for the parts of the MENA region. The main results identified within the AQUA-CSP study have also been summarized (AQUA-CSP, 2007).

3. Concentrating solar power and desalination of sea water: The TREC formula

The aims to harvest the sun's energy – using a method known as concentrating solar power (CSP), from the vast North African desert and deliver it as electricity via high-voltage transmission lines to markets in Europe is what the DESERTEC initiative is all about and so, an understanding how the basics of the system operates cannot be overstressed.

The technologies necessary to realize the DESERTEC concept have already been developed and some of them have been in use for decades (Red Paper; Trieb and Müller-Steinhagen, 2009). The fundamental principle behind the CSP is similar to every child who has ever burnt a hole in a sheet of paper with a magnifying glass. Curved mirrors known as 'parabolic trough collectors' are used to collect sunlight. The energy is used to heat water, producing steam, which then drives turbines and generates electricity.

A. Solar collectors

CSP entails focusing the sun's rays with a reflective surface and putting that energy to work in the form of electricity. Parabolic-trough systems (Figure 2) focus the sun's energy onto a tube running their length. Temperatures in the tube can reach 750 degrees F. A medium in the tube – sometimes synthetic oil that transfers its heat to water, sometimes water itself – collects heat to drive turbines. Large CSP projects – essentially expansive fields of solar collectors, or mirrors, that concentrate rays from the intense desert sun to heat water, generate steam, drive turbines and produce electricity – are not exactly new in Africa.

A wide range of concentrating technologies exists, including the parabolic trough; dish Stirling, concentrating linear Fresnel reflector, solar chimney and solar power tower. Each concentration method is capable of producing high temperatures and correspondingly high thermodynamic efficiencies, but they vary in the way that they track the sun and focus light.

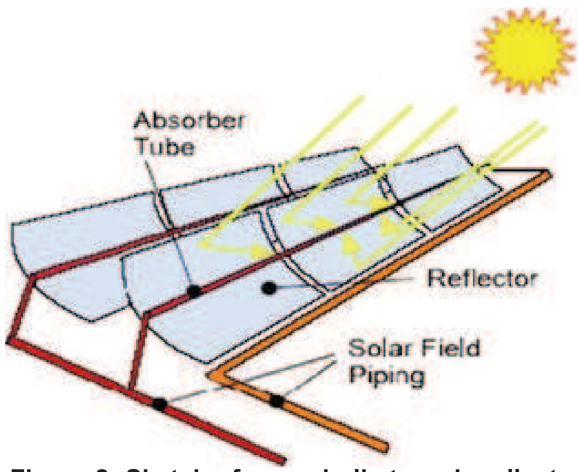

Figure 2: Sketch of a parabolic trough collector (A simplified alternative to a parabolic trough concentrator is the linear Fresnel mirror reflector)
Source: www.DESERTEC.org

However, the credit for favouring CSP over photovoltaic (PV) is supported in its ability to supply power on demand for 24 hours a day. Besides, PV is more expensive than CSP and needs expensive systems for storing electricity, such as pumped storage. The CSPs are known efficient fuel savers, which at the present produces heat at a cost-effective rate (MEDS-CSP, 2005; Pitz-Paal *et al*., 2005). Another feature that distinguishes CSP is the possibility of combined generation of electricity and heat to achieve the highest possible efficiencies for energy conversion (Trieb and Müller-Steinhagen, 2009).

B. Water tubes

The parabolic reflectors direct sunlight onto a tube suspended above their 200-foot lengths. Water inside the tubes boils and creates steam. The steam powers a 60–70 horsepower engine, which pumps 6,000 gallons of water per minute from the Nile River to nearby cotton fields. The system includes a number of technological improvements, including absorption plates with dual panes separated by a one-inch air space. The water can also be rechan-

Table 1: Capacity, costs and space: Development of the EU-MENA-Connection (marked 'HVDC') and Concentrating Solar Thermal Power (CSP) in the TRANS-CSP scenario between 2020 and 2050
Source: www.DESERTEC.org

	2020	2030	2040	2050
Transfer Capacity GW	2 x 5	8 x 5	14 x 5	20 x 5
Electricity Transfer TWh/y	60	230	470	700
Capacity Factor	0.06	0.67	0.75	0.80
Turnover Billion €/yr	3.8	12.5	24	35
Land Area km x km	15 x 15	30x30	40x40	50x50
CSP HVDC	3100x0.1	3600x0.4	3600x0.7	3600x0.1
Investment CSP	42	143	245	350
Billion € HVDC	5	20	31	45
Elec. Cost CSP	0.050	0.045	0.040	0.040
€/kWh HVDC	0.014	0.010	0.010	0.010

nelled to benefit agricultural demands.

C. Business advantages in solar power thermal plants

New solar thermal power plants with a total capacity of more than 2000 MW are at the planning stage, under construction, or already in operation. Favourable business conditions for CSP abound. For instance, where there is more sunshine, it is possible to realize cheaper feed-in tariffs, as for example, at good locations in Africa, America, China, India, Australia or MENA. In time to come, high initial investments will give room to long-term sustainable costs (Table 1). This is because the costs for raw materials for solar thermal power stations are rising more slowly than the price of fossil fuels. Therefore, CSP may become competitive earlier than previously expected (Red Paper).

D. High voltage direct current transmission lines

HVDC transmission has proved very reliable and much more efficient than the use of hydrogen as an energy vector. Using High Voltage Direct Current (HVDC) transmission lines, loss of power during transmission can be limited to only about 3% per 1000 km. Although there would be transmission losses up to 15% between MENA and Europe, they are more than offset by the fact that levels of solar radiation in MENA are about twice what they are in southern Europe. Furthermore, there is much less seasonal variation in levels of sunshine in MENA than there is in Europe.

E. Desalination of sea water – A by-product of the DESERTEC concept

The growing freshwater deficits in MENA will increasingly require seawater desalination which can be done using sustainable sources of energy. In brief, the DESERTEC initiative also enables the use of solar electricity for membrane desalination through combined solar heat and power for thermal seawater desalination to guarantee sustainability (Trieb and Müller-Steinhagen, 2009).

On the other hand, the considerable burden of desalination, though significantly reduced by the DESERTEC initiative, is not overlooked because the AQUA-CSP study analyses the environmental impact of a broad application of solar-powered seawater desalination to cover the expected freshwater deficits in MENA.

4. Harnessing DESERTEC concept for Nigeria and its comparative advantage

It is true that the advantages of DESERTEC for Europe look enormous; it frees the continent from dependence on Russian gas, rising oil prices, radioactive waste and CO_2-spewing coal power plants. Energy can be harnessed even at night such that excess heat produced during the day can be stored for several hours in tanks of molten salt. This way the turbines can produce electricity even when the sun is not shining. Moreover, the advantages for countries such as Libya, Morocco, Algeria, Sudan and especially Middle Eastern states, other than the solar power business triggering a truly sunny future, it would create jobs and build up a sustainable energy industry, which would translate to cash-inflow into these countries and an enabling infrastructure investment.

There is a similar advantage of DESERTEC for Nigeria's abundant solar reservoir. The annual average daily sunshine (measured with Campbell Stokes recorder) is 9 hours at the far northern boundary of Nigeria (Chineke and Igwiro, 2008)., this amounts to about 4.851x1012kWh of energy per day from the sun (Ojosu,(1990); Chineke, (2002).. Worth mentioning also is the fact that solar electric power could mean energy independence, economic value and environmental security. Above and beyond, it has the potential to supply a significant portion of the country's electric energy requirements, and lead to significant enhancements in living conditions, in sectors such as health services, communication, information and education. This form of electricity can also enhance the competitiveness of the country.

In the light of the present energy poverty in the country, production costs have been inflated leading to competition in the global market. Recent development have shown the preference of indigenous companies to relocate from Nigeria, where business has been qualified as being very expensive to sustain, to neighbouring West African countries where it is deemed cheaper. Indeed, access to electricity is a prerequisite for economic growth and sustainable livelihoods, and is thus a fundamental ingredient for the achievement of the United Nations Millennium Development Goals (Okoro *et al.,* 2006; Qurashi and Hussain, 2005; Modi et al., 2006).

There is no gainsaying that there is hope for Nigeria to turnaround its present deficiency in energy by implementing a national energy policy that substantially incorporates renewably energy which, no doubt, already exists on paper but lacks action as extensively reviewed in a recent research conducted by the authors Akuru, and Okoro (2010). This has been practised elsewhere and it is working.

Already, the DESERTEC concept which has been designed to insure the livelihood of mankind based on a lasting, developing, and peace supporting form of power production by bringing together political, economic, civil, and social interests can easily be duplicated in Nigeria with high probability of achieving the expected results. For example, other than an existing solar resource base, the fact that northern Nigeria is located inside Nigeria, technicalities for political, economic, and social furore are greatly reduced. The existing national supply grid can equally serve to support in the aspect of issues relating to the construction of an electricity transmission grid.

Whereas there has been extensive and on-going research as well as implementation of solar PVs and distillers for provision of clean water (Sambo, 2009); Committee on Creation of Science-based Industries in Developing Countries Development, Security, and Cooperation Policy and Global Affairs, 2008)], the possibilities for water desalination in Nigeria appear to be beyond the scope of this paper. However, it is hoped that with the prevailing pathetic situation of non-availability of clean and portable drinking water in northern Nigeria, research can be initiated to ascertain the prospects for exploiting it as an alternative to the provision of drinkable water. Similarly, the possibilities for wind power exists in the DESERTEC project as earlier mentioned and can be integrated into a concrete framework for Nigeria, who is equally endowed with abundant wind energy in the north.

It is equally certain that there will be creation of new jobs which will mean new sources of income for natives and nationals alike. Sharing or transfer of technologies is very possible in the long run for greater impact of results.

That the region in the north instead of the south would now be the hub of Nigeria's energy base is true to the fact, even if it may sound incongruous. This is because of the CSP plants can be used to meet both local and foreign energy demands which is expected to surpass whatever revenue that Nigeria gains from petroleum export at present.

5. Conclusion

The DESERTEC Concept has been termed sustainable, and it is so because according to its initiators, it meets all criteria for sustainability which is a necessary requirement for determined political support and action. The five focal points for national and international policy for all countries in EU-MENA support this claim (Trieb and Müller-Steinhagen, 2009).

1. Increase support for research, development and for the market introduction of measures for efficient supply, distribution and use of energy (efficiency focus).
2. Provide a reliable framework for the market introduction of existing renewable energy technologies, based on best practice experience and increase support for research and development for promising enhancements (renewable energy focus).
3. Initiate an EU-MENA-wide partnership for sustainable energy. Provide European support to accelerate renewable energy use in MENA (interregional cooperation focus).
4. Initiate planning and evaluation of an EU-MENA High Voltage Direct Current super-grid to combine the best renewable energy sources in this region and to increase diversity and redundancy of supply (interconnection focus).
5. Support research and development for shifting the use of fossil fuels from bulk electricity to balancing power production (balancing power focus).

Not only that, highpoints of opportunities for the MENA region has been brought to the fore and stressed in the light that duplicating it for any other scenario (available abundant solar), given the same conditions (congruent realizable framework), is very much possible. The basis for this hypothesis is that for countries like Nigeria where solar irradiation is high, similar or even better results can be obtained. Certain factors such as proximity of resource base, an existing electricity transmission backbone, and dwindling oil reserves due to overdependence and a non-renewability factor show that implementation in Nigeria can be achieved without difficulty. Clean water supply, jobs and income generation are other benefits that the DESERTEC initiative can lead Nigeria into if and when it is adopted.

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