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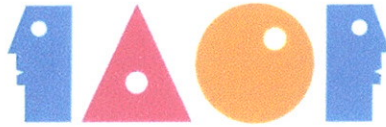
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SOLAR ENERGY FROM THE SAHARA SUN TO POWER EUROPE: THE DESERTEC PROJECT

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Abstract

This essay examines Concentrating Solar Power (CSP), which is a technology that is used to harness and convert solar energy to produce electricity, and its future use. CSP has the potential to be used to provide energy to a large portion of the world's population. Additionally, the paper discusses The Desertec project and how it intends to convert solar energy from the Sahara Desert to power Europe. The project envisages producing 15 percent of Europe's electricity by converting solar energy from the Sahara desert by 2050. This project could be the starting point of a much needed energy revolution.

Key Words: Concentration Solar Power, Solar and Desertec project

Introduction

The amount of energy the sun pours on the earth surface is more than what the world needs. Solar energy is inexhaustible and has remained untapped to meet human energy needs unit now. Prospects for harnessing solar energy have been changing over the years as growing energy costs and its associated

costs have forced countries to look for alternate sources of energy. Solar energy is the source of choice for many nations because it is inexhaustible, plenty and has fewer disadvantages. Rising global population coupled with an even rapidly growing demand for energy causing major pollution problems and changing climatic patterns that are placing the world in a dangerous situation. The ef-

fects of global warming (including more frequent and severe storms and droughts) are having devastating consequences on various parts of the globe. Consequently, the need for the discovery and development of new technologies that would convert renewable sources of energy to help mitigate the effects of climate change becomes inevitable. World-wide increased awareness of the perils that the use of fossil fuels presents to humanity along with falling prices of renewable sources of energy, brings hope to address the problem a change in energy consumption patterns. This paper discusses Concentrating Solar Power (CSP), which is a technology that is used to harness and convert solar energy to produce electricity, and how it is to be used in the near future. CSP has the potential to be used to provide energy to a large portion of the world's population. The paper will also examine The Desertec project and how it intends to convert solar energy from the Sahara Desert to power Europe. The project envisages producing 15 percent of Europe's electricity by converting solar energy from the Sahara desert by 2050. This project could be the starting point of a much needed energy revolution.

The Energy Dilemma

Some would argue that global energy consumption is rapidly reaching unsustainable levels and if left unchecked would be catastrophic to the globe. There is some truth to this observation considering that the world's energy consumption is growing at a geo-

metric rate while conventional sources of energy are growing at an arithmetic rate. If this trend goes unabated then energy consumption and its associated externalities pose a devastating danger to the human race. Increased global demand of and consumption of energy over the last 150 years has resulted in severe ecological imbalances thus resulting in rising atmospheric temperature (Roberts, 2008).

The United States Census Bureau, estimates that world population is expected to reach 9 billion by the year 2045 (US Census Bureau). Such a high increase in population would translate to a more drastic increasing demand for energy, 2009 consumption patterns are sustained. Estimates from the Energy Information Administration (EIA) show that the world's energy consumption will rise from 508 quadrillion British Thermal Units (BTU) in 2010, to 678 quadrillion BTU in 2030 (Energy Information Administration, 2009). According to the EIA, world energy consumption is expected to increase by 44 percent by the year 2030 (Energy Information Administration, 2009). This escalating demand for energy has already created a significant amount of stress for both, the environment and the relations between nations. Global warming, a phenomenon created by the excessive accumulation in the atmosphere of man created greenhouse gases (GHG) is expected to raise global temperature by the year 2100 between 1.4 to 5.8°C according to the Intergovernmental Panel on Climate Change (IPCC). (www.ipcc.ch). These

projections have a high probability of becoming a reality if current energy consumption patterns are sustained.

To cope with these unsettling state of affairs humanity must resort to ingenuity - - utilize of natural sources of energy including the sun and the wind - - to complement fossil fuel that are posing serious environmental threats and climatic changes. Newer technologies have given birth to exploration of new methods of tapping energy from renewable sources. Wind farms are now a reality in different parts of the world, and energy from the sun is captured by photovoltaic power stations in many countries including Portugal and Japan is a fact of life. According to the EIA, renewable sources of energy are expected to be the fastest growing energy types in the next 20 years according to the EIA (Energy Information Administration, 2009). Yet, all the progress that has been already made is not nearly enough to provide a long lasting solution to the energy related ailments afflicting. The rate at which humanity is changing its energy consumption patterns is still alarmingly slow. The EIA projects that coal and natural gas usage would contribute about 64 percent of the world's electricity supply by 2030. Such a high percentage translates to an increase for coal and natural gas exploration and usage in the electricity market when measured using 2009 market share (Energy Information Administration).

The transition from fossil fuel to renewable sources is so slow should not come as a surprise, since it took more

than half a century for the world to change from wood dependency to coal dependency, and another half a century to transition from coal to oil dependency (Aitkin, 2003). However, it is important to highlight that the world has evolve from what it was 100 or even 50 years ago; technology is evolving at increasingly faster rates as the world marches deep into the twenty first century. In fact, the technology capable of providing the world with electricity produced from renewable sources of energy already exists.

If we could be obtaining most of our energy from renewable sources, what is the rationale for relying on hydrocarbons? The answers to this question would include aversion to change that is endemic to many cultures and societies, fear of the unknown, denial of reality, the high cost associated with the harnessing of renewable energy, and lower cost of producing energy from fossil materials. In addition, the powerful vested interests that exist in the production and commercialization of highly profitable fossil fuels is resistant to change. Oil and gas companies together with their powerful lobbying exert unbearable powerful influence on governments around the world. For example, in the US, the Congress, legislation to limit CO2 emissions has not been ratified. The document presented by Senators John Kerry (D-Mass.), Lindsey Graham (R-S.C.) and Joe Lieberman (I-Conn.) aims to reduce CO2 emissions by 17 percent below 2005 levels in the near future, and by 80 percent by 2050. How-

ever, in order to obtain the 60 votes in the Senate that are needed to avoid a filibuster, decisive concessions are expected to be made, amongst which are the new incentives for offshore oil drilling (Bravender, 2009).

Fortunately, the times are changing. Today people all over the world, and especially in developed countries, are aware that a major change in the way we obtain everyday energy is an urgent matter. Furthermore, the cost to produce energy for renewable sources is falling as investments advance along the experience curve. Over time, more projects to produce energy from the sun or wind would generate diminishing costs for those industries. A World Bank report, "The Potential for Low-Cost Concentrating Solar Power Systems," expects future costs of renewable energy production to approach the costs of conventional fossil power (Price & el, 1999). Investors are conscious of this new trend and are responding accordingly. Only a few decades ago supplying an important amount of the world's energy needs using renewable sources of energy seemed impossible. Today, however, that occurrence has the potential to become a reality.

Of all the possible alternatives to produce energy from renewable sources, one has experienced an extraordinary leap in the past few years. Massive projects are on the pipeline or already functional. This new technology, which captures the sun's energy and transforms it into electricity, could cover 7 percent of

the world's energy needs by the year 2030 and one quarter by 2050 according to Greenpeace (Richter & el., 2009). The term for this technology is Concentrating Solar Power (CSP) and according to Joseph Romm, a senior fellow at the Center for American Progress who was named by Time Magazine as one of the "Heroes of the environment in 2009," CSP is the technology that could save humanity (Romm, 2008).

Concentrating Solar Power (CSP)

For centuries people have been using different devices to concentrate sunlight to produce energy. As far as seven centuries before Christ, magnifying glasses were used to make fire, and ancient Greek soldiers are believed to have used the sun's reflection in their bronze shields to set fire to Roman ships. Closer to our time, sixteenth century Swiss scientist, Horace de Saussure built the world's first solar collector, which was later used to cook food (United States Department of Energy). The technology to harness the power of the sun has significantly evolved since those early practices. CSP is the technology that has the largest potential to be used to produce an extensive percentage of the world's electricity in the coming decades.

CSP technologies use mirrors to reflect sunlight into receivers that collect energy and transform it into heat. That heat is, in turn, used to produce electricity using either a gas turbine or a Stirling engine (Richter & el. al., (2009). One important characteristic of CSP tech-

nologies is that they permit to store the heat captured during the day to transform it into electricity during the night. There are different possible systems devised to use CSP. The four main systems are: parabolic trough; solar tower; parabolic dish; and Linear Fresnel reflector. Even though these four systems work under the same principle, which is to concentrate sunlight in order to produce heat and to use that heat to make electricity, they have distinct characteristics.

Parabolic trough-shaped mirror reflectors work by concentrating sunlight on thermally efficient receiver tubes placed in the trough's focal line. Those tubes contain a thermal transfer unit that is heated to approximately 400°C by the sun's concentrated rays. The heated fluid is then pumped through a series of heat exchangers to produce steam, which in turn produces electricity using a steam turbine generator. Parabolic troughs have been commercially used for a hundred years. The first systems were installed in Egypt in 1912 with the purpose to generate steam for pumps used to deliver water for irrigation. Today the output of existing parabolic trough plants is over 500 Megawatts (MW) of electrical capacity. This type of CSP system can be used as a part of a hybrid operation called Integrated Solar Combined Cycle (ISCC), where the steam generated by solar energy is fed into a thermal plant that also uses fossil-fuel generated steam, commonly from natural gas. These kinds of plants are functioning in Algeria, Egypt and Morocco (Richter & el. al., 2009).

The solar tower system uses a vast amount of large mirrors with sun-tracking motion, resembling a sunflower field, to redirect sunlight to a central receiver mounted at the top of a tower. The concentrated sunlight is absorbed at the tower by a central receiver that turns collected sunlight into thermal energy, which is used to feed the electricity producing turbine. Solar tower systems have only recently been installed for commercial purposes, although very successful tests have been run since the 1980's. The largest solar power plant to date is located in Spain and it yields 11 MW of electrical capacity which is enough to provide electricity for almost 5,500 homes. The developer, Abengoa has constructed a similar plant next to the first one, which is twice as large and could more than double the existing electricity producing capacity. In the US, Brightsource Energy is planning to install a 400 MW solar tower plant in the Nevada desert, which would represent a huge step forward in the commercialization of this type of renewable energy (Richter & el. al., 2009).

In the case of the parabolic dish system, the parabolic dish-shaped mirrors concentrate sunlight on a receiver located at the focal point of the dish. The concentrated sunlight is absorbed into a receiver to heat fluid or gas at approximately 750°C. By means of a Stirling engine or micro turbine, the heated gas or liquid is used to produce electricity. Parabolic dishes are individual units that could have an enormous electricity generating capacity by combining large

quantities of dishes. There are a few large scale projects planned to start production in the near future. Amongst them, Parabolic Dish Systems have a power purchase agreement to install over 20,000 units in California's Mojave Desert (Richter & el. al., 2009).

Linear Fresnel reflectors use a group of nearly-flat reflectors to concentrate solar radiation onto elevated inverted linear receivers. Water flowing through these receivers is heated and converted into steam to power turbines to generate electricity. The Australian company, Ausra is planning to add to its existing Linear Fresnel plants one that could have the capacity to yield 177 MW of electricity in Carrizo Plains, west of Bakersfield (Richter & el. al., 2009).

The Future of CSP

Making predictions or forecasts on events that will take place decades into the future can be extremely complicated. This fact is especially true when the forecasts involve human behavior and scientific analysis. There are a number of variables that have to be taken into account and, moreover, different scenarios for the analysis of the same variables have to be considered (Webster & el. al., 2009). The Concentrating Solar Power Global Outlook 2009 establishes three different scenarios to evaluate the possible progression of the usage of CSP technology. The three scenarios study the potential of CSP development taking into consideration technical and economic factors. The time frame for the

study is presented in a two stage range: first, until the year 2020 and afterwards the scenarios cover the decades until 2050. The reference scenario, which predicts the lowest increase in CSP growth, is based on the projections made in the 2007 World Energy Outlook report by the International Energy Agency (IEA). It is based on policies already in place but it considers the possibility of electricity and gas market reform, and a more liberalized policy for inter-country energy trade. This scenario assumes a growth rate of 7 percent for 2011. By 2015 the expected growth rate is merely 1 percent, and this rate is expected to remain constant until the year 2040, after which no significant growth for CSP is expected. Under this scenario the expected participation in global electricity supply by CSP is extremely low. By the year 2020 CSP would supply between 0.12-0.14 percent of the world's electricity production, and by 2050 world electricity produced from CSP would amount to a meager 0.2 percent. (Richter & el. al., 2009).

To the contrary, a moderate scenario considers not only existing policies, but also all policy measures to support renewable energy which are either under way or planned around the world. It also assumes that countries would successfully reach the targets set for the development and implementation of renewable or CSP technologies. For countries to reach those goals, an increased investor confidence in the sector is assumed as well. Growth rates under the moderate scenario are expected to be significantly

higher than under the reference model. CSP growth rate is expected to start at 17 percent in 2011 and then jump to 27 percent in the period from 2015 to 2020, and in the following years it would steadily fall to reach 7 percent in 2030, 2 percent in 2040 and finally 1 percent in 2050. Following this scenario, CSP would satisfy 1.1 to 1.2 percent of the world's electricity demand by 2020 and between 8.5 to 11.8 percent by 2050 (Richter & el. al., 2009).

The advanced scenario is the most optimistic of the three; it evaluates CSP growth under conditions that would be optimal for that industry. Under this scenario, it is assumed that all of the industry's recommendations are translated into CSP promoting policies, and are carried out accordingly. It also assumes the creation of a large enough grid capacity to cope with the expanding supply of electricity from CSP plants. Under the advanced scenario the assumed growth rate starts at 24 percent in 2010, falls to 19 percent by 2015, then to 7 percent by 2030 and 5 percent by 2040. Subsequently, the growth rate will level out at around 3 percent annual increase. With these levels of growth, CSP could meet 1.5-1.7 percent of global electricity demand in 2020 and between 18.3-25.69 percent by 2050. Under ideal conditions, CSP could cover one quarter of the world's electricity demand in less than 50 years (Richter & el. al., 2009).

These three scenarios portray distinct futures for CSP. The fact that world leaders failed to produce a binding treaty

at the recent Climate Conference in Copenhagen could be an indication that achieving the conditions to develop the advanced scenario for the future of CSP, could be a far-fetched reality. However, the Copenhagen meetings produced an accord that represents a significant step towards an elaboration of a binding treaty for the future Climate Conferences. Even if the advanced scenario is discarded, the world is still capable of producing a treaty that could help promote the results expected under the moderate scenario.

Auspiciously, nations and private investors do not have to stand on the sidelines until all of the world's leaders finally produce a binding treaty on climate change. Renewable energy is already the fastest growing sector in the energy industry. Countries and private investors have noticed that there is much to be gained by expanding this energy sector. Several large scale projects are either underway or latent, waiting for the day to finally set their foundations. In the US, for example, BrightSource Energy and Pacific Gas & Electric will combine to produce up to 900MW of electricity from a CSP plant in the Mojave Desert in the year 2011 (www.brightsourceenergy.com). Abengoa has an 11MW CSP plant functioning in Seville, Spain and it could increase its yields to 300MW (Shukman, 2007). There is an immense project to produce electricity from CSP plants in the Middle East (ME) and North Africa (NA) regions called Desertec. This project could serve as an example of what needs to be

done to positively change the energy status quo.

The Desertec project

On 30 October 2009 a consortium of German companies (including energy utilities giants E.ON and RWE, the engineering firm Siemens, the finance house Deutsche Bank and the insurance company Munich Re) and the Desertec Foundation signed the articles of association for the Desertec industrial initiative (DII). This document represents an important step forward towards the realization of the Desertec project. The project envisages producing clean and cost efficient energy to power Europe, Middle East and North Africa (EU-MENA) regions. To achieve this goal the development would be based on economic cooperation between the countries in these three regions (www.desertec.org/concept/studies).

The DII has to establish a framework for investments to supply the EU-MENA region with power obtained from solar and wind energy sources. Ultimately, the aim of the project is to provide the MENA region with a considerable part of its energy needs and to satisfy 15 percent of Europe's electricity demand by 2050 (<http://www.desertec.org/en/press/press-releases/091030-01-formation-dii-gmbh>).

Given the scope of the project, which has been compared with the Apollo space program that landed Neil Armstrong and Buzz Aldrin on the moon,

the investments needed to execute it, are as impressive. Its estimated total cost would be about €400 billion. Of this amount, €350 billion would be used to construct the CSP plants and the remaining €50 billion would be used to create the widespread electricity grid network to transport electricity from North Africa to Europe (Kleinschmidt, 2009).

The Desertec project has many advantages that certainly make it a worthwhile undertaking. First the project's enormous potential to reduce aggregate CO₂ emissions levels make it extremely appealing for both policy makers and the general public. According to the Concentrating Solar Power Global Outlook 2009, if the moderate scenario is achieved, CO₂ savings would be 148 million tones of CO₂ annually in 2020, rising to 2.1 billion tones in 2050. The CO₂ savings under the moderate scenario would be comparable to 8 percent of today's global CO₂ emissions and Desertec would be a major contributor to that goal (Richter & el. al., 2009).

Second, the project has already secured the backing and support from several key stakeholders, including Angela Merkel, the German chancellor, Jose Manuel Barroso, the former president of the European Commission, and Prince Hassan bin Talal of Jordan. It also has the support of the twelve companies that signed the articles of association as well as of a number of North African countries. Furthermore, solar energy is increasingly viewed by leaders of the region as an efficient alternative to fossil

fuels. Saudi Arabia's oil minister, Ali Al-Naimi, said in September of 2009 that the country's intentions are to export as much solar energy in the future as it exports oil in the present (Alsharif, 2009).

As discussed above, this project requires a huge start-up investment to become functional. However, maintenance costs are not expected to be high; the life span of a conventional CSP plant is on average more than 40 years, and mirrors can be rotated to protective positions in case of storms or other natural threats (www.desertec.org/en/concept). Moreover, in the case of Desertec, one of the project's major strengths is that solar energy -- the resource used to produce electricity does not run out. The developers will never run out of raw materials. In other words the "well has dried up" as it is often happens with fossil fuel retrieving schemes. The sun will always shine on those areas and therefore, there would be no need to relocate in order to find the precious goods. The sun's energy will always be there. Gerhard Knies, the coordinator of the Trans-Mediterranean Renewable Energy Corporation, has stated this fact in a very simple, yet highly compelling way, saying that, "within 6 hours deserts receive more energy from the sun than human-kind consumes within a year." (www.desertec.org/en/news).

Implementing the Desertec project would have numerous benefits not only for the Europe and MENA regions but also for the world. These benefits repre-

sent a huge strength of this energy project. It would be very difficult for anybody to oppose the project once the expected benefits are included in the equation.

The MENA region would benefit from this project in various ways. Countries in the region abundantly exploit oil and gas resources to produce energy. However, these resources are finite and they will eventually come to their demise. It would be an intelligent long term economic strategy for MENA countries to diversify their energy exploitations and start transferring some economic resources from fossil fuel commercialization to the CSP industry. By doing so the countries would be able to take advantage of a limitless source of income while at the same time benefiting from technological advancements.

The MENA region suffers from extensive poverty and unemployment. In 2008, the International Labour Organization (ILO) published a paper that placed MENA amongst the regions with highest rates of unemployment (Messkoub, 2008). In 2003 unemployment rates averaged nearly 15 percent and to make matters worse the highest incidence in unemployment was found among the young adults group (aged 15-25). The Desertec project could help alleviate this affliction. The CSP Global Outlook 2009 report expects, considering the reference scenario, that for every MW of new capacity, the annual market for CSP would create 10 jobs through manufacture, component supply, solar farm develop-

ment, installation and indirect employment. This level of employment would slightly decrease as higher efficiency is achieved, but would still be high at 8 jobs per MW (Richter & el. al., 2009). If the CSP industry follows the moderate scenario of evolution, the amount of jobs created could be nearly 2 million, a significant fraction of which would be in MENA (Richter & el. al., 2009).

Another important factor to consider is that by the year 2050 MENA is expected to have the same power and drinking water requirements as Europe. This challenge could also be addressed by implementing the Desertec project. A 250 MW collector field (CSP plants in MENA are expected, at full capacity, to produce 470,000 MW by the year 2050) located near the sea shore to use saltwater for the cooling units, could produce 100,000 m³ of drinking water every day using the process of water desalination (www.desertec.org). That is more than 4 million liters of drinking water produced per hour.

Climate change is expected to have dire consequences for the whole world, and unfair as it is, the developing world's contribution to the increased atmospheric temperatures is minimal, but they are expected to suffer the most. Needless to say, MENA is not an exception. The World Bank expects the region to severely suffer the consequences of climate change.

Temperatures will rise up to 2 degrees in the next 15-20 years and over 4 degrees by the end of the century.

Higher temperatures accompanied by less precipitation have already increased the frequency of droughts, from one event every 10 years at the beginning of the 20th century to five or six events each decade (<http://beta.worldbank.org>). Rising sea levels could also have devastating effects for ports and coastal cities. For such reasons it is of the utmost importance that the Desertec project is implemented to help mitigate these effects by enabling European and MENA consumers to make a switch in their energy consumption patterns.

Europe could also enormously benefit from the implementation of the Desertec project. The benefits of having an atmosphere with acceptable levels of CO₂ have already been mentioned in this paper, and this view is shared by 97 percent of climate scientists (Doran & el. al., 2009). Desertec's positive impact on the climate change would not be limited to its own capabilities. This project could be a beacon for other endeavors to take place around the world. It could have the effect of inserting the world into a virtuous cycle of eco-friendly energy production patterns. Stopping climate change would be a colossal benefit on its own.

Europe has been a leader for years on matters regarding climate change prevention. The European CO₂ emissions targets are amongst the most ambitious. The EU agreed under the Kyoto protocol to cut down CO₂ emissions by 8 percent below 1990 levels by 2012 (www.pewclimate.org). Moreover, the

IPCC expects the EU to cut its emissions by 30% below 1990 levels by 2020 and that level should be reduced even further by 2050 (Hohne & el. al. , 2008). Through providing 15 percent of Europe's electricity by 2050, The Desertec project could certainly help Europe achieve its emissions targets.

Additionally, energy independence is matter of strategic priority to several European leaders because it will reduce Europe's dependency on Russian gas. For countries to deeply depend upon another to receive the energy needed to function normally proves to be dangerous. Almost 25 percent of the EU's gas supplies come from Russia, and around 80 percent of that is delivered through Ukraine. This arrangement of gas supply has already brought Europe serious problems when last year, in the coldest months of winter, Russian decided to cut off Europe's supplies of gas that run through Ukraine's pipelines. The decision by the Russian authorities was based on the belief that Ukraine was stealing vast amounts of gas aimed at European customers while it was transported through pipelines on Ukrainian territory (Walt, 2009). Regardless of the reasons that triggered this particular incident, heavy dependence on Russian energy could weaken European countries' bargaining position on every diplomatic issue that might arise between Europe and Russia.

The Desertec project could be an attractive alternative for Russian gas. Even if the eastern gas is replaced by yet

other foreign providers such as MENA countries, the difference lays in the fact that the electricity from CSP in MENA would be produced by a number of different countries through an extensive and interconnected grid and thus, the likelihood of occurrence of unexpected interruptions of energy supply services would be dramatically reduced.

Yet, the project has also some weaknesses. It is based on a multinational alliance between the public and private sectors of a wide array of nations. Reaching an extensive web of agreements could turn out to be extremely challenging. Without this alliance, the project could not be developed, or at least it could not be utilized at its full potential. Furthermore, on top of the agreements which have to be reached and maintained, the project requires extraordinary amounts of investment to become functional. The investment would come from private companies as well as governments. The world has recently experienced that even mammoths of the private sector can fail and thus, endangering each and every one of their investments.

Conclusion

When in 1949 Gunnar Jahn, the chairman of the Nobel Committee, introduced Sir John Boyd Orr who was awarded the Nobel Peace Prize for his scientific research on nutrition, he said, "...however great his scientific contributions may have been, they alone would not have earned him the Peace Prize, for scientific discoveries cannot, in them-

selves, create peace. It is only when they are employed to promote cooperation between nations that they become a valuable factor in the cause of peace” (Jahn, 1949). That statement is an accurate representation of the spirit behind the Desertec project. This project would bring together, through scientific development in the form of CSP, a wide variety of Nations that might otherwise not have many things in common.

Skeptics are concerned about the location of the CSP plants. They believe that the MENA region is not stable enough to entrust it with such a grand portion of Europe’s energy. What they fail to see is that a stable MENA could

be achieved through economic and social development. Desertec is a project that would bring energy and jobs to the region. It could also create millions of liters of drinking water each day in an extremely arid area. Furthermore, the project could help mitigate the devastating effects that global warming is expected to have on MENA and elsewhere. Desertec could act as a fraternizing bridge between the rich Europe and the poor Middle East and Northern Africa. This project has the potential to benefit countries on multiple levels and one can only hope that soon Desertec will become a reality.

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