The Solar Energy Potential of North Africa-Middle East vs. the Nuclear option

[i]

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I. Abstract

We know the world is headed for big changes in how to produce and distribute energy. We often talk about renewable energies as our future, but many nations will go through an intermediate stage before being totally "green," and this step is potentially that of nuclear generation.

We already know that our current energy system has come to its end. We are increasingly sensitive to the environment and the influence of our development on it. Therefore, it is urgent to consider the best overall solutions and be thoughtful so as to avoid making mistakes.

In certain regions of the world, the question of the transition needs to be asked. But in the case of the Middle East and North Africa countries, which are relatively free of infrastructure, it is possible to consider all options of development. The gigantic solar resource of the Sahara Desert is inexhaustible, freely accessible and will be more widely developed. We compare this to the nuclear reaction which needs uranium, is a non-renewable resource and will cost much more due to its scarcity.

The question addressed in this report is, *"what is most desirable for MENA countries today, development of nuclear power or installation of solar solutions?"*

II. Introduction

Today the world's population knows unprecedented growth. The daily energy needs of this growing population become increasingly more important, and we must find solutions to address them. In 2050, according to the medium variant, the world population is projected to reach 9.2 billion people. That's around 2.2 billion more than today.

"There are nearly 200,000 people born each day on the planet"[1]

« The world population is projected to reach 9.2 billion persons by 2050, that is, 2.5 billion more than in 2007, an increase equivalent to the combined populations of China and India.»[2]

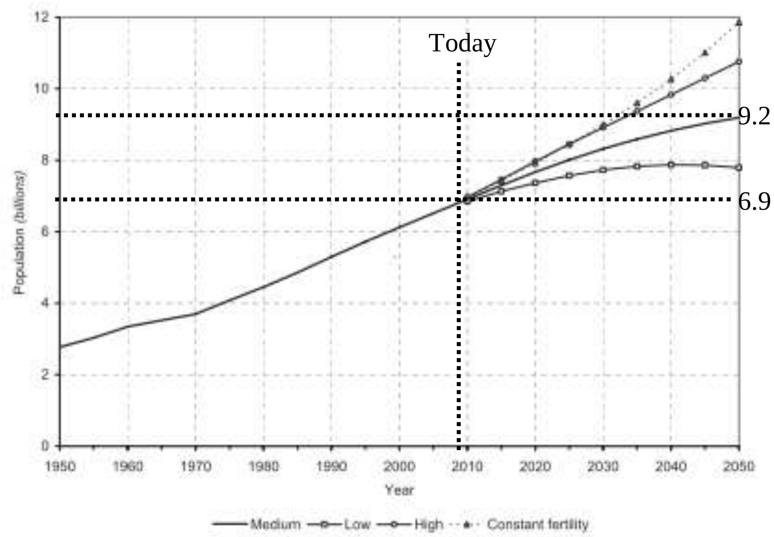


Figure 1: World Population, 1950-2050, according to different projection variants[3]

With some figures, we can see that "more developed regions" stay at about the same population level, but "less developed countries," even in the low variant growth, gain more than 1.2 million in their population.

[1] http://www.populationmondiale.com/
[2] Source : World Population http://www.un.org/esa/population/publications/wpp2006/WPP2006_Highlights_rev.pdf
[3] Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2007), World Population Prospects: The 2006 Revision, Highlights, New York: United Nations http://www.un.org/esa/population/publications/wpp2006/WPP2006_Highlights_rev.pdf

Major area	Population (millions) 1950	1975	2007	Population in 2050 (millions) Low	Medium	High
World	2 535	4 076	6 671	7 792	9 191	10 756
More developed regions	814	1 048	1 223	1 065	1 245	1 451
Less developed regions	1 722	3 028	5 448	6 727	7 946	9 306
Least developed countries	200	358	804	1 496	1 742	2 002
Other less developed countries	1 521	2 670	4 644	5 231	6 204	7 304
Africa	224	416	965	1 718	1 998	2 302
Asia	1 411	2 394	4 030	4 444	5 266	6 189
Europe	548	676	731	566	664	777
Latin America and the Caribbean	168	325	572	641	769	914
Northern America	172	243	339	382	445	517
Oceania	13	21	34	42	49	56

Figure 2: World Population, major development groups and major areas, 1950, 1975, 2007 and according to different variants[4]

Our society is now aware that we cannot consume without thinking about our future and our earth. Our resources are precious, as is preserving our environment. Developed nations now have better knowledge than others of this reality. In the past for their growth, these nations have used fossil fuels such as coal or oil, and now it is their obligation to help developing countries to avoid making the same mistakes.

In this report, we focus on the region of EUMENA - Europe, Middle East and North Africa. European countries will maintain their energy needs. On the other hand, we have the African continent, vast and rich in resources that is beginning to develop. For everyone, a good way will be for Europe to help Africa in its development.
For that, there are two main ways:

- Follow French energy plan with nuclear solutions, or
- Create a new production system with renewable energy

In this report we will compare nuclear and renewable solutions focusing on solar energy. As we can see, there is huge potential from the solar energy received by the earth compared to the world's electricity needs.

[4] Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2007), World Population Prospects: The 2006 Revision, Highlights, New York: United Nations

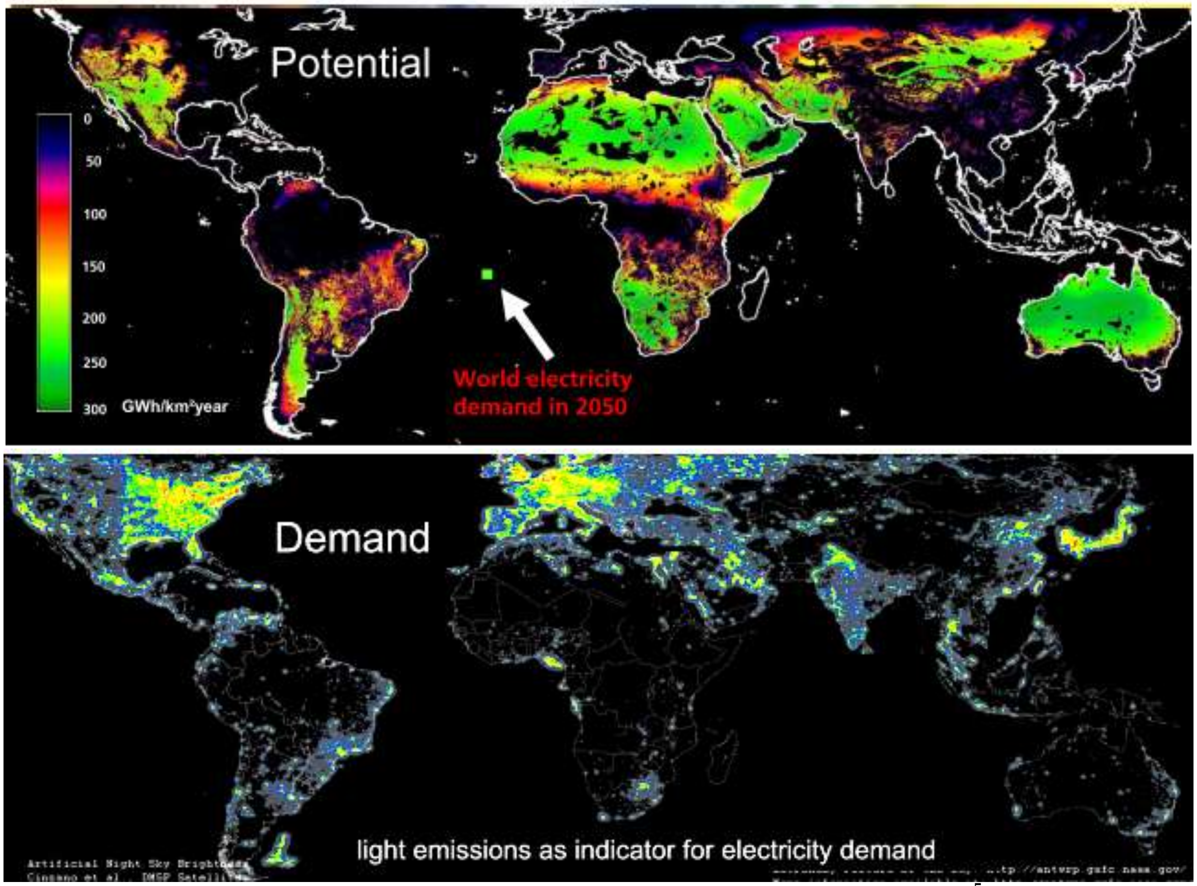


Figure 3: World solar energy potential & world electricity demand[5]

When we look at the energy demand, we understand that solar energy could supply all humankind's electricity needs, but we also see that those needs are not in areas with high production potential. This is why we must think about collaboration between regions to meet the needs of everyone.

From the diagram below, we know that the solar is the most important resource in MENA region's with the Sahara desert, so it is logical to exploit this potential.

[5] Solar Thermal Power Plants by Hans Müller-Steinhagen for DLR

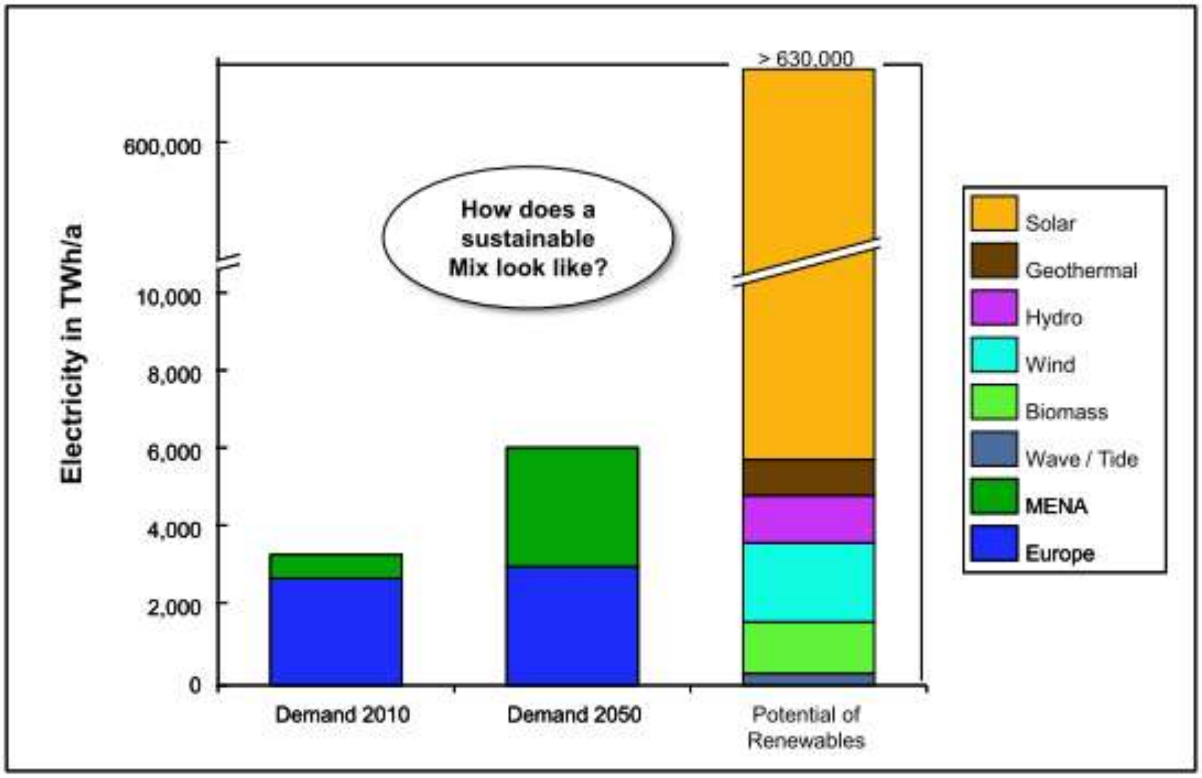


Figure 4: Electricity demand for EU-MENA in 2010, 2050 and Potential of Renewables[6]

[6] Source: German Aerospace Center (DLR)

III. DESERTEC

The **Desertec Foundation**[7] (DF), founded in 2008, includes politicians, academics and economists from Europe (EU), the Middle East (ME) and North Africa (NA) and members of the Club of Rome. The foundation, based in Berlin (Germany), is helping NGOs, firms and all international organizations, and it brings them together to accelerate the concept of high-voltage interconnection between Europe and Africa tapping solar and wind energies. There are, between the Desertec Foundation and universities or scientific institutions, associations to develop parts of projects in local areas.
Recently, on April 26, 2010, the foundation changed its leadership. Now, there are two new directors: Katrin-Susanne Richter and Dr. Thiemo Gropp.

Desertec was created by two organizations:

- The Club of Rome (German NGO/Non-profit) composed of scientists, economists, and industrialists of 53 countries. They wanted to study/resolve society's problems. They generated ideas on sustainable development and the ecological footprint.
  This group was founded in 1968 (8th April) in Rome (hence the club's name), and the first two leaders and creators were Aurelio Peccei (Italian) and Alexander King (Scottish).
  The club of Rome executive committee is composed by 13 members.
  Their first publication was in 1972 with The Limits To Growth (also known as the Meadows Report). In 1974, the second publication, Mankind At The Turning Point, they formed the outline of 10 areas in the world and defined all conditions and development problems.

- The Trans-Mediterranean Renewable Energy Cooperation (TREC) is also a German voluntary association formed as an initiative of the Club of Rome and the Hamburg Climate Protection Foundation in 2003. It collaborates with the German Aerospace Center (DLR).

All members are involved in the development of the Desertec concept.

The **DESERTEC Concept** describes the prospect of a sustainable supply of electricity for Europe (EU), the Middle East (ME) and North Africa (NA) up to the year 2050. The aim of the

7 Logo Desertec (http://www.desertec.org/en/foundation/)

concept is to make signficant changes in the world distribution of energy, water and to limit CO_2 emissions and mitigate climate change. It emphasizes transforming power production to renewable sources and in particular, harnessing the desert's solar resources. In fact, Desertec is a global concept that has studied many problems like energy, climate protection and drinking water in Asia as well.

The concept wants to develop, over the next two decades, a close cooperation between EU and MENA for market introduction of renewable energy and interconnection of electricity grids by high-voltage direct-current transmission.

Desertec project:

The Desertec project is a large-scale eco-energy project based on solar thermal energy and also, wind turbines in the deserts of MENA. The long-term objective is to cover a substantial part of the MENA electricity demand and 15% of the European demand by 2050.

Why choose solar energy? Because it generates clean electricity which can be exported with low loss to Europe (10-15%) via High Voltage Direct Current (HVDC or HVDC) transmission lines. Solar is inexhaustible and free. There is no owner for it, so everyone can exploit and use it. Studies conducted by German Aerospace Center (DLR) satellite have shown that by using less than 0.3% of the total area of deserts in the MENA region, we can produce enough electricity and fresh water to meet the growing needs these countries and Europe.

"Within 6 hours, deserts receive more energy from the sun than humankind consumes within a year."
Dr. Gerhard Knies from Desertec

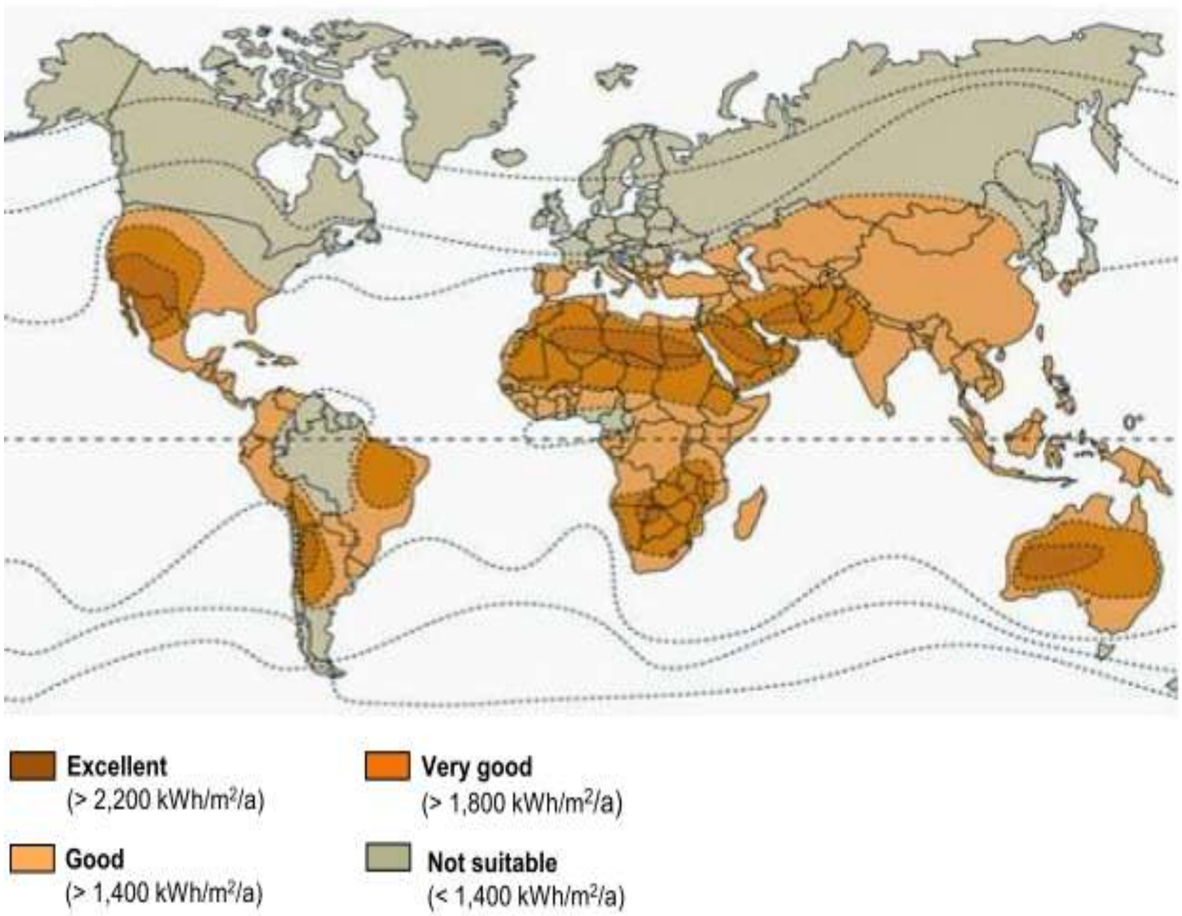


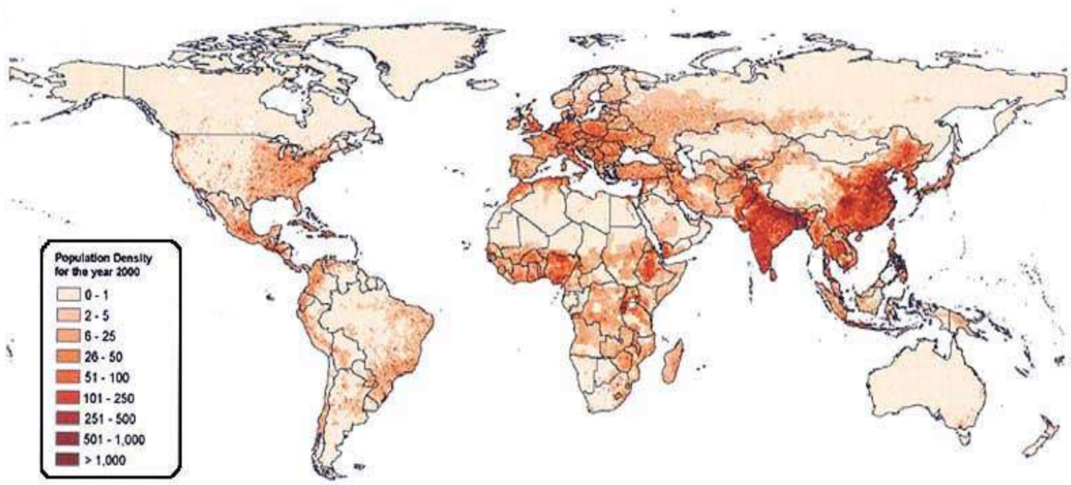
Figure 5: Solar irradiation globally[8]

Why choose deserts? For people in the Middle East and North Africa (MENA), this project will provide a large supply of clean energy, jobs, sources of economic income from improved facilities, opportunities for desalination of seawater, and many potential benefits (e.g. for agriculture) made by the shadow of solar collectors. For Europe, electricity from the deserts is a supplement to its own resources.
Satellite data obtained by German Aerospace Center (DLR) confirm the potential solar energy in the Sahara and decreased levels of oil and gas energy reserves. Volatility of the Climate conditions increase the urgency of applying this concept.

"Every year, each km² of desert receives solar energy equivalent to 1.5 million barrels of oil. The total area of deserts provide the entire planet several hundred times the energy currently used in the world."

Currently, more than 90% of the world's population are living in areas that are less than 3,000 km away from deserts and thus could be supplied with abundant solar power.

[8] *Source: Solar Millenium, iset, DWD, BMU, Solaraccess, BUND Naturschutz*



[9]

Figure 6: World population density in 2000

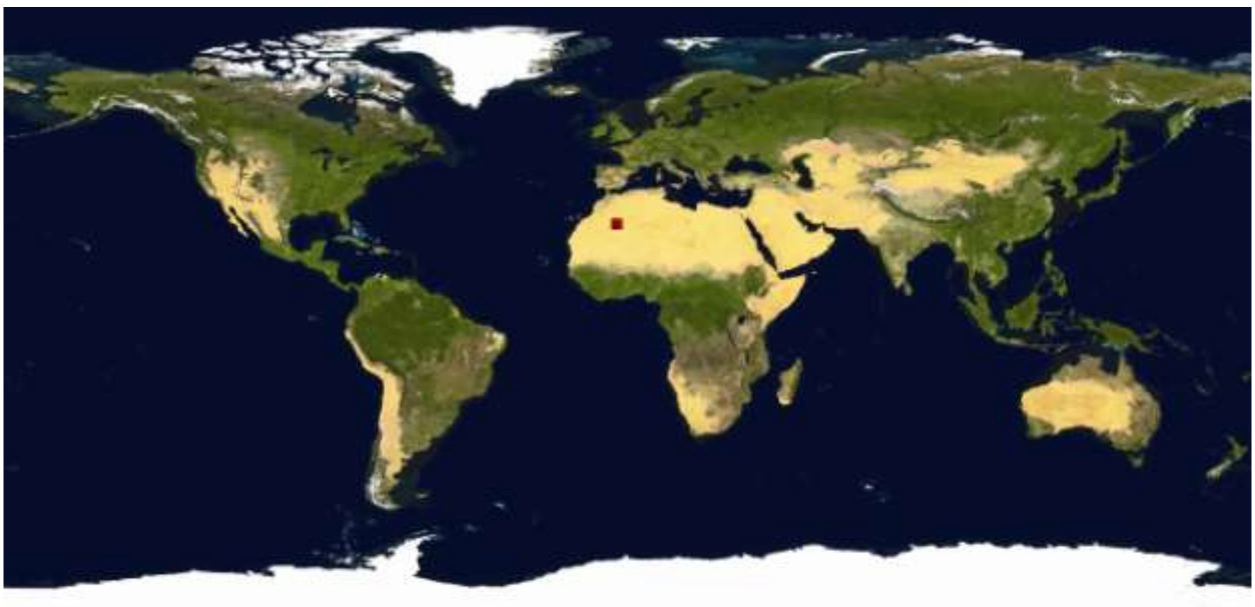


Figure 7: Desert area covered by solar plan to supply world energy needs[10]

"Covering 1% of deserts with solar panels would cover world energy needs! "
Desertec

[9] *Source:* Center for International Earth Science Information Network (CIESIN), Columbia University and Centro Internacional de Agricultura Tropical (CIAT)

[10] Desertec foundation
http://www.desertec.org/en/foundation/

IV. Solar energy available in MENA

A. Types of solar energy

Currently in MENA, there are two kinds of solar technologies that could be used on a large scale. The first is Concentrating Solar Power (CSP) and the second is the Photovoltaic Power (PV). To understand the major differences between these two technologies, you just need to know that one uses the heat of the sun while the second uses its light.

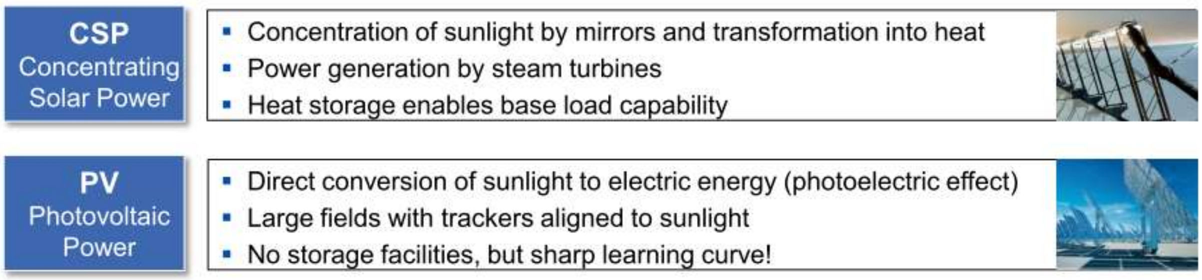


Figure 8: Difference between CSP & PV systems[11]

[11] *Source : Dii – Desertec Industrial Initiative*

1. Concentrating Solar Power

a) Parabolic Trough

The Parabolic Trough System is the most commonly sold and used, since it has a high output for a low cost.

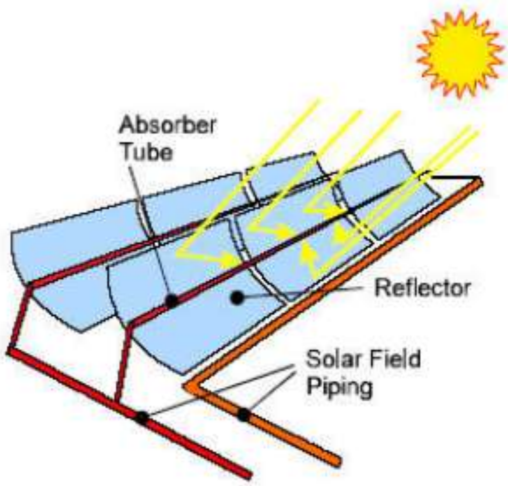


Figure 9: Schematic of Parabolic Trough Reflectors[12]

This system uses a parabolic shaped mirror angled just right to focus the incident solar radiation onto a pipe along the focal line of the collector. Each mirror can rotate throughout the day to follow the sun. A hot transfer fluid flows through this tube, and when the sun's light is focused on this tube, it heats up quickly, thanks to the reflective material. The temperature can easily top 700ºF.

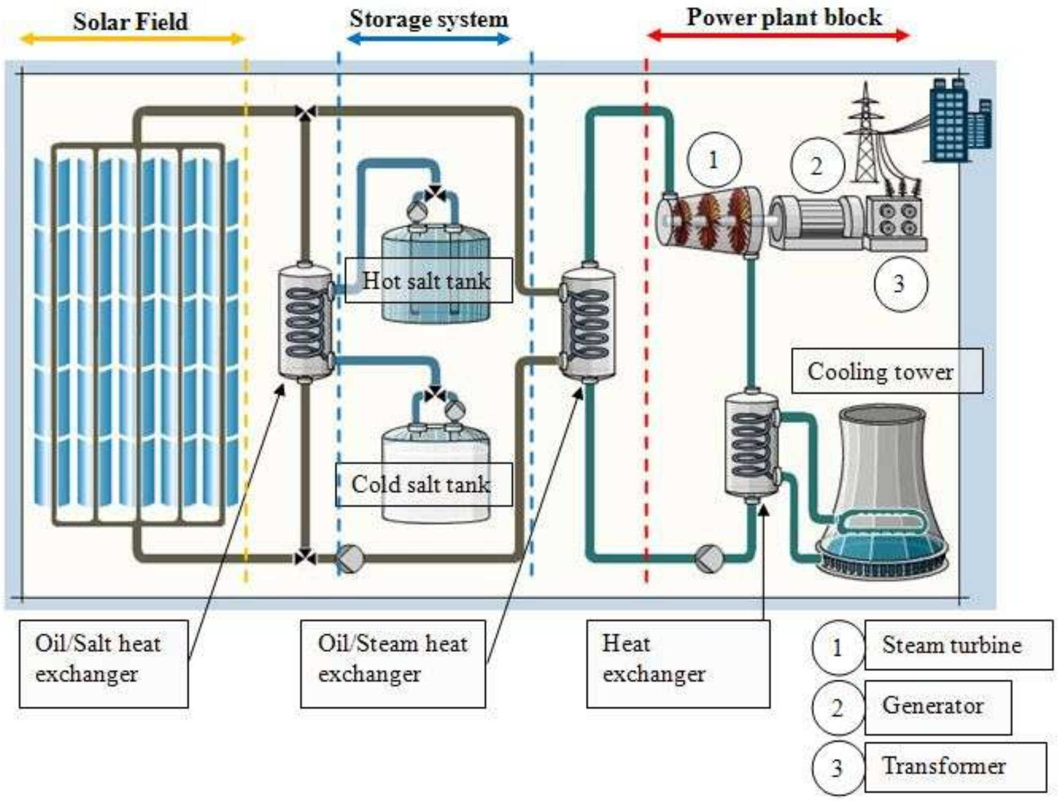


Figure 10: Parabolic Trough Power Plants[12]

As with conventional power plants, the heat generates steam in the power block via heat exchangers. Then the steam is utilized in a turbine to create electricity. Through the integration of thermal storage, this power can then be supplied on demand. It is also able to generate electricity after sunset or for peak consumption times, because the hot transfer fluid can continue to supply the turbine with steam. With this kind of installation, a small area can produce a large output of electricity throughout a sunny day and into the second peak demand of the evening.

[12] http://www.solarmillennium.de/upload/Animationen/andasol_blue_engl.swf

Summary of Advantages/Disadvantages:

Advantages	Disadvantages
Well known technology, more developed and sold than other CSP systems	Compared to oil/gas turbines, the fluid doesn't reach very high heat (700°F), which makes its efficiency for electricity production lower
Could be hybridized with: - Fossil fuel to produce electricity during nights and cloudy days - An Integrated Solar Combined Cycle System (ISCCS) with potential to reduce the cost and increase the overall solar-to-electric efficiency	Consumes water in the turbine, because it is based on the heat transfer fluid.

Figure 11: Advantages & Disadvantages of Parabolic Troughs

b) Concentrating Linear Fresnel Reflector

A Linear Solar Fresnel solar plant uses the similar system than Solar Parabolic Trough in a). The difference is in the mirrors; in this case, they are flat, and in the trough, they are curved.

Figure 12: Linear Fresnel Reflector[13]

The Compact Linear Fresnel solar power system uses array of single axis solar mirrors to reflect sunlight onto a receiver tube. The system uses many flat mirrors, each rotating to follow the sun.

[13] Source: Photo credit : Ausra in Energy Facts : Compact Linear Fresnel Reflector (CLFR) Solar

Figure 13: Linear Fresnel Reflector Plant[14]

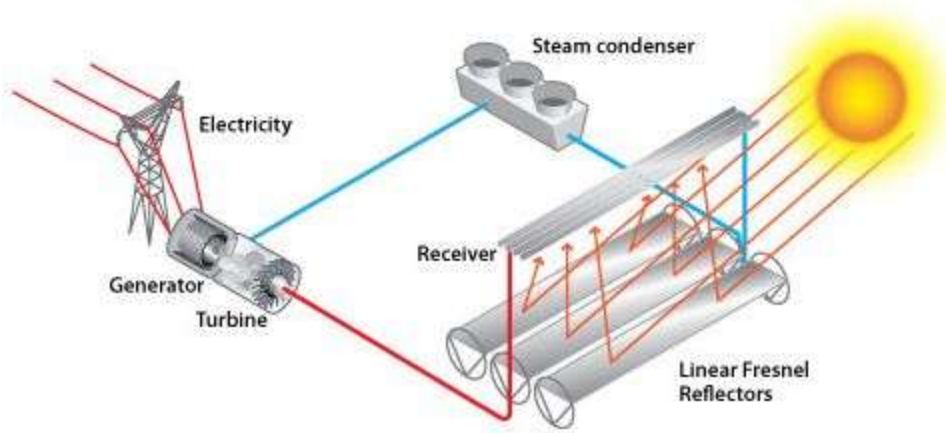


Figure 14: Linear Fresnel Reflector Power Plant[15]

Currently, the Linear Solar Fresnel system produces steam at 545°F in the absorber tubes. In distinction to the Parabolic Trough, the steam is used directly to drive a turbine to produce electricity, avoiding the need for a heat exchanger to produce steam from some other high temperature fluid.

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[14] Idem
http://www.energy.ca.gov/reti/steering/2008-06-18_meeting/SOLAR_FS-Compact_Linear_Fresnel_Reflector.pdf

[15] Source: U.S. Department of Energy - Energy Efficiency and Renewable Energy
http://www1.eere.energy.gov/solar/printable_versions/linear_concentrators.html

Summary of Advantages/Disadvantages:

Advantages	Disadvantages
Less expansive than Parabolic Trough system or Stirling dish: - Flats mirrors are easier to produce - Receiver is simpler too, because there is only one, and there aren't any couplings	Fluid doesn't reach very high heat (545°F), which makes its efficiency for electricity production lower
Flat Solar Fresnel Reflectors have a structure simpler than the Parabolic Trough and Parabolic Dish systems	Consumes water in turbine
Could be hybridized with fossil fuel to produce electricity during nights and non-sunny days	Needs maintenance by regular cleaning of all mirrors

Figure 15: Advantages & Disadvantages of Linear Fresnel Reflector

c) Stirling dish

An individual Solar Parabolic Dish - Stirling Engine unit consists of a dish-shaped array of mirrors focusing solar energy onto a receiver, which harnesses the solar heat energy. It is constitute of two axis-tracking, parabolic dish reflectors that focus incoming sunlight onto a Stirling Cycle Engine/Generator.

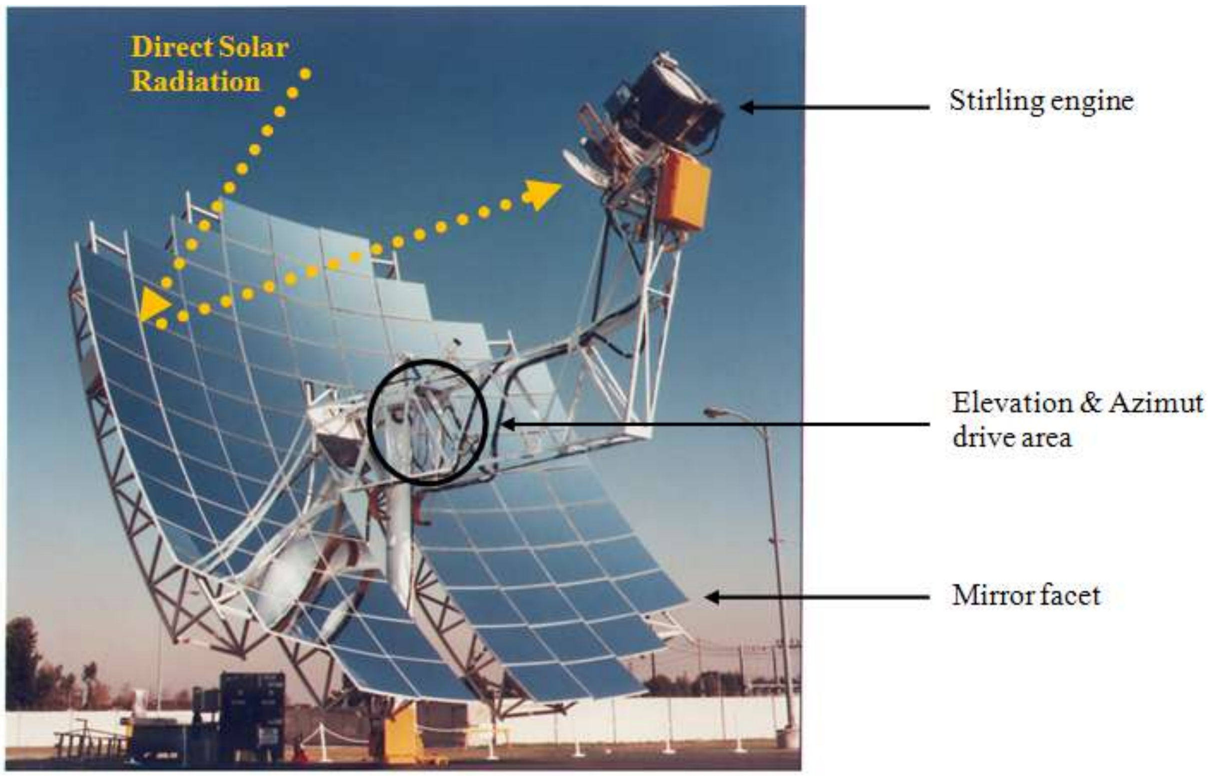


Figure 16: Stirling Dish description[16]

The engine uses the Stirling thermodynamic cycle to produce electricity without producing steam as an intermediate step. The Parabolic Dish Reflector moves continuously to face the sun producing a high temperature (~1452^{o}F) in the fluid receiver. This system, unlike the previous, doesn't use a heat transfer fluid, just air.

Figure 17: Stirling Dish plant[17]

[16] http://www.thegreentechnologyblog.com/wp-content/uploads/Solar-thermal-Sterling-dish1.jpg

[17]Left: http://blog.vadaenergy.com/wp-content/uploads/2009/03/stirling_dish_engine_500.jpg,
Right: http://www.dlr.de/en/Portaldata/1/Resources/portal_news/newsarchiv2008_5/DishStirling.jpg

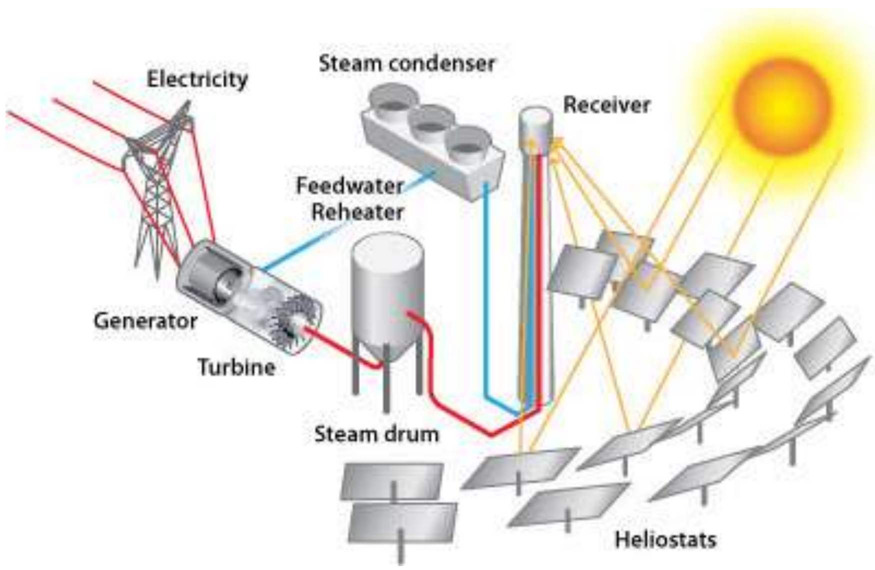
Summary of Advantages/Disadvantages:

Advantages	Disadvantages
Reaches the highest fluid temperature (1452°F) of solar power technologies, so has the best conversion efficiency (around 30%)	It can't be used for thermal energy storage, so it can't generate electricity when the sun isn't shining.
Could be installed as a single unit or as an array, depending on necessity; both are efficient	Needs maintenance by a regular cleaning of all mirrors and mechanical revision
Does not use water to produce electricity	

Figure 18: Advantages & Disadvantages of Stirling Dish

d) Solar Power Tower

As we see previously, all CSP technologies focus concentrated solar energy onto a fluid-containing receiver and thus heat the fluid to a high temperature. This fluid is then used for conversion of solar power to electricity; the higher the fluid temperature and more efficient the conversion is.



[18]

Figure 19: Solar Power Tower operation

[18] http://www1.eere.energy.gov/solar/printable_versions/power_towers.html

In the case of Solar Tower system, all mirrors are angled on a Solar Tower placed in the middle of the area. Light that hits the mirrors target the top of the solar tower where there is the heat transfer fluid contained in the receiver. This installation could be coupled with a molten salt storage system and can be heated over 1000°F. With storage system coupling, it can produce electricity continuously day and night. This system then uses the heat from the fluids to generate steam, which turns a turbine and generator to create electricity.

Figure 20: Solar Power Tower[19]

Summary of Advantages/Disadvantages:

Advantages	Disadvantages
More commercially developed than the Stirling dish and Linear Fresnel systems	Fluid reaches high heat (1000°F), but not as high as the Stirling Dish system, so its efficiency for electricity production is lower than the Stirling Dish.
Could be hybridized with fossil fuel to produce electricity during nights and non-sunny days	Needs maintenance by a regular cleaning of all mirrors and mechanical maintenance

Figure 21: Advantages & Disadvantages of Solar Power Tower

[19] http://climatelab.org/@api/deki/files/522/=PS10_solar_power_tower.jpg

2. Photovoltaic

Currently, when we speak about solar technologies many people think about Photovoltaic systems. Nearly everyone has seen large rooftop area filled completely with photovoltaic solar panels.

These systems harvest solar energy and convert it to energy. This electricity is then transmitted moved through a distribution station, and the power is added to the grid. Photovoltaic fields work similarly to the solar panels you can install on your roof, but on a much larger scale.

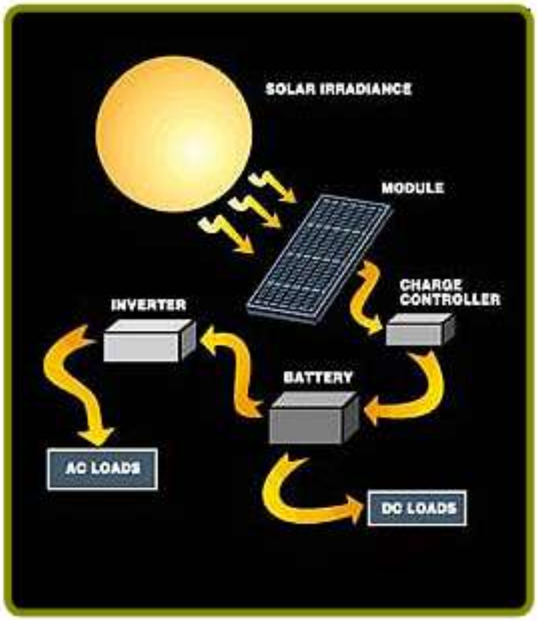


Figure 22: Photovoltaic operation[20]

Summary of Advantages/Disadvantages:

Advantages	Disadvantages
Well known technology, good development and sold all around the world	It is expensive to produce Photovoltaic technology and requires electricity storage systems which are relatively expensive
Easy to install	Low efficiency transformation (~ 20%)
Doesn't need many maintenance	Cannot produce electricity when there isn't any sun

Figure 23: Advantages & Disadvantages of Photovoltaic Power

[20] http://www.windandsolarpower.biz/how-do-solar-panels-work

Figure 24: Photovoltaic field[21]

[21] http://www.aw-solution.com/blog/wp-content/uploads/2009/12/giant_photovoltaic_array.jpg

B. Projects

In this table is a non-exhaustive list of CSP plans available or under construction in MENA region.

Country		Project/Location	Concentrated Solar Power	Power	Cost (in $)	Sart operating	Remarks
Egypt		ISCC Al Kuraymat/Al Kurayamat	Integrated Solar Combined Cycle (ISCC) with Parabolic Trough	**140 MW**	*190million*	2010	Owner: Solar Millennium A.G.
Tunisian	>> 40 projects planned				*9billion*	2010-2016	-
Morocco	>> 5 projects throughout country				*NC*	NC	-
	1	Abi Ben Mathar: One	Parabolic Trough	**20MW**	*NC*	2010	Owner: Abengoa Solar S.A.
	2	Morocco ISCC plant/At Ain Beni Mathar	ISCC with Parabolic Trough	**470MW**	*520million*	2010	Owner: Office of National Electricity; Society : Abengoa Solar
Jordan		JOAN1 / Ma'an	Parabolic Trough	**100MW**	*425million*	2013	Will be the largest in the world using direct solar steam generation
Saudi Arabia		NC	NC	NC	*NC*	2015-2020	
Unated Arab Emirates	>> Projects throughout country			**1500 -2000MW**	*NC*	2020	City of Abu Dhabi and Masdar (futur energy company); Abu dhabi invest $2billion in photovolataic manufacturing
	1	Shams-1 /Madinat Zayed	Fresnel & Parabolic Trough	**100MW**	*600million*	2011	Owner: Masdar; Society : Abengoa Solar, Total
Algeria	>> 10% of the energy demand with RE				*NC*	2025	-
	1	ISCC Argelia/Hassi R'mel	ISCC - Parabolic Trough	**150MW-400MW**	*410million*	2010-2015	Owner : Sonatrach Society : Abengoa Solar The innovation of this project is electrical exploitation of the heat generated in the same steam turbine that captures the residual heat from the gas turbine.
	2	ISCC Plant 2	ISCC with Parabolic Trough	**70 MW**	*NC*	2015	Owner: Algerisol
Iran		?	ISCC with Parabolic trough	**450MW**	*322million*	NC	
		Yazd Plant	ISCC, technology unknown	**67MW**	*NC*	NC	
Kuwait		?	Parabolic Trough	**100MW**	*NC*	NC	
Israel		Ashalim / Negev Desert	Parabolic Trough	**250MW**	*650 million*	2014	

Figure 25: CSP plans available or under construction in MENA region

V. Solar vs. Nuclear

C. Nuclear

Today, on our earth, nuclear energy provides between 11% and 18% of world electricity needs with 440 operating nuclear power plant. With the map below, we can see that the majority of the world does not use nuclear energy to produce electricity. There is only a small "club" of nations that actually use nuclear power. Europe has many operating reactors and wants to build new ones. In MENA, there aren't any operating reactors yet today, but some of these countries want to develop this technology to become more competitive.

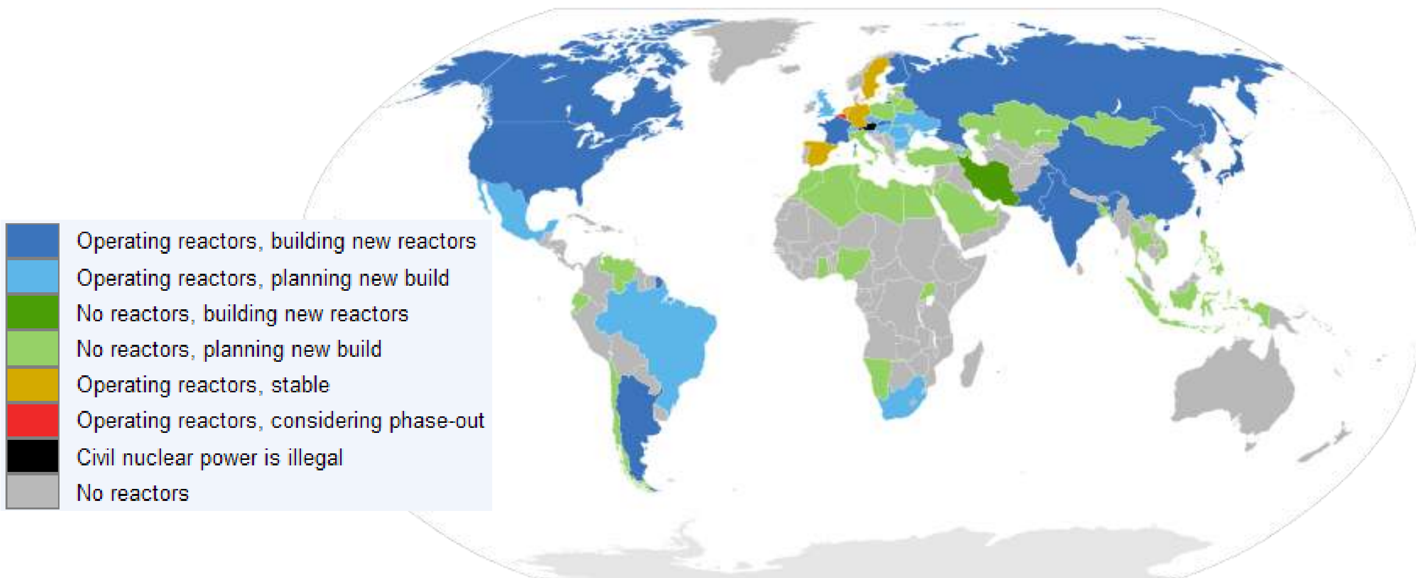


Figure 26: Commercial nuclear power plants in the world[22]

For example, in 2006 the world's nuclear electricity production was 2,625GKWh, with 1,173GKWh, or half of world's production produced in Europe. Africa, except for South Africa, doesn't produce any electricity from nuclear systems.

[22] Wikipedia http://en.wikipedia.org/wiki/Main_Page search nuclear power

Country	%	Nuclear electricity production in 2006 (GKWh)
Germany	27%	159
Belgium	55%	44
Bulgaria	42%	18
Spain	20%	57
Finland	28%	22
France	79%	428
Hungary	38%	13
Fed. Czech	32%	25
UK	19%	72
Russia	15%	144
Slovakia	54%	17
Suede	45%	63
Switzerland	43%	26
Ukraine	47%	85
	Sub Total Europe	**1173**
U.S.	19%	787
Japan	28%	288
South Korea	37%	141
Canada	16%	93
China	2%	55
Taiwan	18%	38
India	2%	16
Brazil	3%	14
South Africa	4%	10
Mexico	4%	10
	Total World	**2625**

Figure 27: Nuclear electricity generation and its share in national production of electricity in major countries[23]

[23] http://www.planete-energies.com/contenu/nucleaire/production-consommation.html
http://www.naturestudy.org/pdf/SolarNuclearWindPower.pdf
http://www.maghrebemergent.com/economie/72-maghreb/876-nucleaire-vs-solaire-une-bataille-franco-allemande-qui-a-des-echos-au-maghreb.html

Location	Production in 2006 (GKWh)	% of nuclear electricity in electricity production
North of America	891	18%
South and central america	21	2%
Europe	**967**	**27%**
CEI	232	17%
Middle-East	0	0%
Africa	**10**	**2%**
Asia	540	9%
Total World	2 660	15%

Figure 28: The production of nuclear electricity in the world by geographical area[24]

[24] http://www.planete-energies.com/contenu/nucleaire/production-consommation.html
http://www.naturestudy.org/pdf/SolarNuclearWindPower.pdf
http://www.maghrebemergent.com/economie/72-maghreb/876-nucleaire-vs-solaire-une-bataille-franco-allemande-qui-a-des-echos-au-maghreb.html

D. Comparison

	Nuclear Power Plan	Solar Plan		Remarks
		Photovoltaic	CSP	
Electricity cost:	$0,12 to $0,20 per kWh	$0,15 to $0,22 per kWh	$0,12 to $0,20 per kWh	
Exploitation time:	Around 40-50 years	Around 20-25 years	Around 20-30years	Solar Plan are used during twice less time in comparion with nuclear plan but, in fact, to be viable, a nuclear power plant must be exploited during 50 years. In fact, for nuclear systems engineers must build a long-term explotation business plan.
Construction cost:	Very expansive to schedule and build power plant	Materials (essentially panels) are very expensive		
After use:	Decommisioned or refitting of generator is very expansive ($200 to 500million) but necessary to profitable use of nuclear	We often could recycle panels at 80% and all tubes could be reused in buildings industry The field area never received chemicals or polluant products so it could be use for anything else (culture, construction...)		
	Dismanstling is the higgest cost of nuclear industry because you need to decontaminate all aera and tools use during operating			
Security system:	Need a huge security system: - to be sure there isn't faillure - against terrorism attack - against risk of military weapons proliferation	Need security for the plan because energy is one of the foundations of the economy and is consistent with a sensing		Nuclear is very risky and need many security system. In an other way, solar plan need security too because if there is problem in a power plan (terrorism, accident or incident...) it could be block all economy system of a region. With security, Solar plan are more interesting than nuclear because a solar plan can be divide in many part in different area. Like that it become more difficult to destroy all energy production. It's important to clarify that security cost for nucler are very more expensive than solar security cost
Environmental facts:	No production of CO2 in using	No production of CO2 in using		Each technology claim to be "green" because in using they don't produce CO2. But to be fair we need to put in perspective all the chain. To obtain Uranium many engines and trucks are use; produce solar plan use many energy with a important temperature control for cooling cristals all this produce CO2! For each systems, there is a big consumtion
	CO2 and greenhouse or/and chimical products emissions during stages of: - uranium mining - processing - transport	Chimicals products and greenhouse emission are used during manufacturing and for transportation of materials on plan	Essentially greenhouse emission during manufacturing and for transportation of materials on plan	
	Nuclear pollution is a risk with radiation	Don't noisy, some people think that plan are visual		

	Nuclear Power Plan	Solar Plan		Remarks
		Photovoltaic	CSP	
Health risks:	Radiation create cancer, pregnancy with problems...	NA		
Public opinion:	Very mixed all around the world because of nuclear weapons and accidents like the Chernobyl disaster	There is few people against this renewables energy because they think it can't be a global answer but only a		For each of these, this kind of plant create employment and skilled and technical jobs
Raw material:	Uranium is a scarce resource, its supply is estimated to last only for the next 30 to 60 years depending on the actual demand	Solar is inexhaustible source of energy		
	Uranium cost will increase	Today, it's free and we can't imagine that one day we'll		
	Uranium is the most concentrated energy source so needs a little storage aera	Storage of solar is imposible		
Plan:	Big production of energy in a little explotation area	The land of a solar power plant is 30 to 160 km2 by		
	Only could be used as Power plant	Could be use at diferent scale (house, fields...) it		
	Produce more than conventional (coal, oil) thermal power plant; it is more efficient	Need a huge area to produce the same quantity of eletricity than a nuclear plant		
Waste:	Duriong operationg it produce a lost of waste more or less irradiated We don't know how we can treate all of this so we creat very long-term storage (10 000 to more 100000 years) on or into the floor A thimbles of uranium used per year per capita	During operating, it produce waste with replacement of planels or with thermal fluid		
Future:	Waiting for a new generation of generator (2035-2050). It will reduce waste and increase efficiency	Research continue on each technologie to improve their efficiency and decrease cost materials		

Figure 29: Nuclear vs. Solar Power Generation Comparison

VI. Conclusion

In conclusion, we can see that today and for again many years, access to electricity will be uneven between developed and developing societies. European countries and other developed countries already have their distribution network and large generating stations in operation. In MENA countries everything has to be done, and we can expect that they are able to do better, more sustainable, environmentally friendly and less fuel-hungry systems. However, for this the developed nations must help them.

In the current political and economic system in such countries, we can’t imagine that rich countries will allow the production of nuclear electricity. Moreover, in view of the current price of construction, problems of site location, industrial safety, and treatment of waste, it is an industry that makes it totally dependent on technology and these countries cannot get financing to equip themselves to be autonomous.

From this point of view, the solar industry, for its financial and ethical aspects, could be the energy of the future for MENA region. It is a renewable energy that is abundant and free in these regions, unlike uranium, which will suffer from cost increases if nuclear power becomes more widely used. Solar technology works, and now, with all new storage systems, it can be efficient all day. Also we can provide more than enough energy to MENA’s population, even to produce desalinated water from the ocean. But in this case, there is also the financial problem of who could or wants to pay for Middle East and North Africa.

To conclude, MENA countries need Europe’s help to develop their network of production and distribution of electricity, and also, we know that Europe is not self-sufficient in her production of electricity. Therefore, if MENA can share a part of energy produced in Africa, Europe will be necessarily more prone to provide the financing. Furthermore, it’s important to repeat Europe’s signed agreement to use 21% of renewable energy by 2020.

As the project DESERTEC points out, we are faced with a situation that can, if properly managed be "win-win." Currently, much work remains to be done, because we must show politicians and financiers that this project is viable and even desirable for our sustainable development.

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