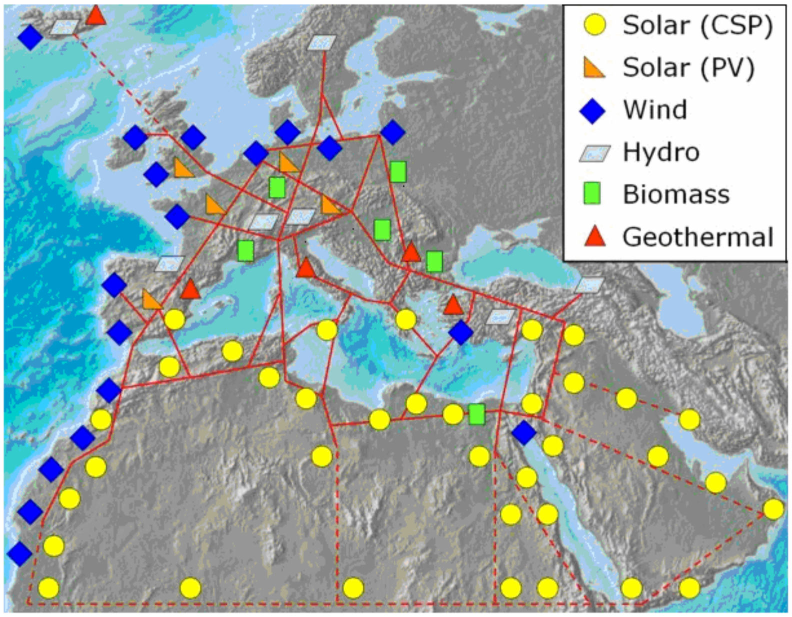
Renewable Energy Potential of the Middle East, North Africa
vs.
The Nuclear Development Option



or

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Abstract

Solar energy has the potential to equip the Middle East with centuries of sustainable, clean electricity. A solar power plant the size of Lake Nasser has the capacity of supplying the electricity needs of the entire region.[1]

Traditional sources of power do not meet the demands of an environmentally sensitive future. As the costs of fossil fuels continue to rise, the price of electricity and government subsidies will continue to cut into socio-economic growth, widening the gap between those who can afford electricity and those who cannot. Carbon emissions increase as demand grows, and the costs of carbon sequestration are not monetarily efficient to be the only mitigation technique when there are better options available.

Renewable energy will stabilize electricity costs, as it is not dependent upon depleting resources. Photovoltaic systems will also increase access to electricity in rural areas without the need of complex policy decision-making, thus balancing the socioeconomic infrastructure of the region. Solar power will be especially useful for heating and cooling systems and water desalinization. Renewable energy is not difficult to implement - Iran, Egypt, the UAE, and Algeria are all currently planning concentrated solar power plants - and once it is more established, it will also be useful for cooperation and peace negotiations to share this energy.

Recently, nuclear power has been sought as an alternative to fossil fuels in the Middle East. This interest has perhaps been spurred by the pressure of keeping up with Iran's nuclear program.[2] However, the waste produced by nuclear power is immense, and the costs of developing a comprehensive nuclear program, including all the up and downstream requirements, such as the development of a waste disposal program, are great. Nuclear power production also relies on a depleting, nonrenewable source - uranium, which will suffer from cost increases if nuclear power becomes more widely used. An attack on a nuclear power plant, whether intentional or accidental, would be disastrous, spreading radiation for miles; thus, the presence of nuclear power facilities in politically instable areas is not safe.

Thus, when considering these energy options on a larger scale, renewable energy is the most efficient choice in the long-run. The vast solar potential of the Middle East is waiting to be tapped.

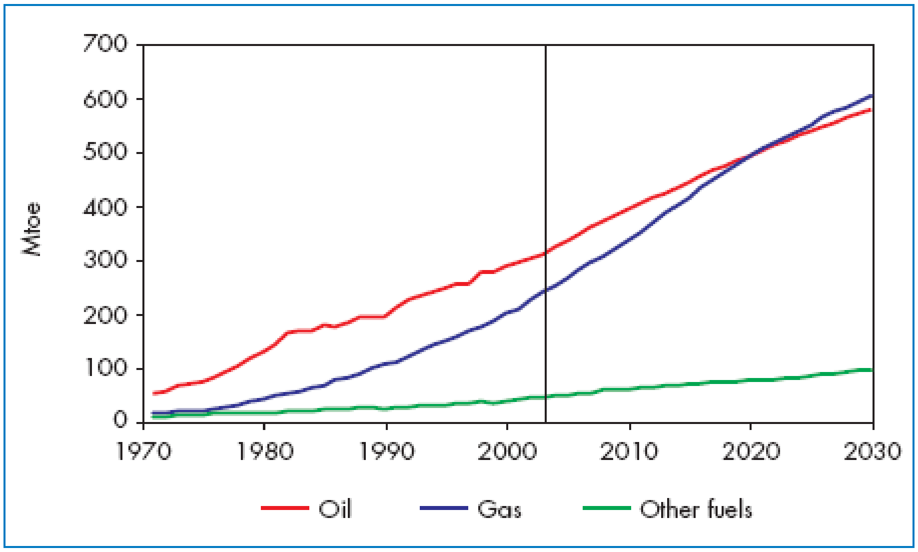
[1] http://www.middleeastelectricity.com/

[2] More Mideast states eyeing nuclear power
http://www.iht.com/articles/ap/2007/04/16/africa/ME-GEN-Mideast-Nuclear.php

1. Energy Trends in the Middle East

Power demand is experiencing strong growth in the Middle East while natural resources are depleting. Oil consumption in the Middle East **rose by 5.4 per cent in 2006**, faster than in any other region of the world, except China.[3]

Figure 3.1: MENA Primary Energy Demand by Fuel



If we look two or three or four decades into the future, we know that hydrocarbons alone will not meet the needs of a growing world economy. Even with all the technical expertise the world could offer and all the political will it could muster, eventually, we will run out of oil. And, even before then, the price of a dwindling supply will be prohibitive. At present, our world is overly focused on, and overly dependent upon, one source of energy. . . and that path is unsustainable.

Samuel Bodman,
US Energy Secretary
Middle East Institute's 60th Anniversary Conference[4]

If energy production and use continues at the current pace, the economy is headed down a very counter-productive path. As fossil fuels become more scarce, prices will increase causing more conflict and insecurity. And with the affects of climate change - desertification, loss of arable land, and rare but extreme flooding - the region will become increasingly reliant on food imports.[5]

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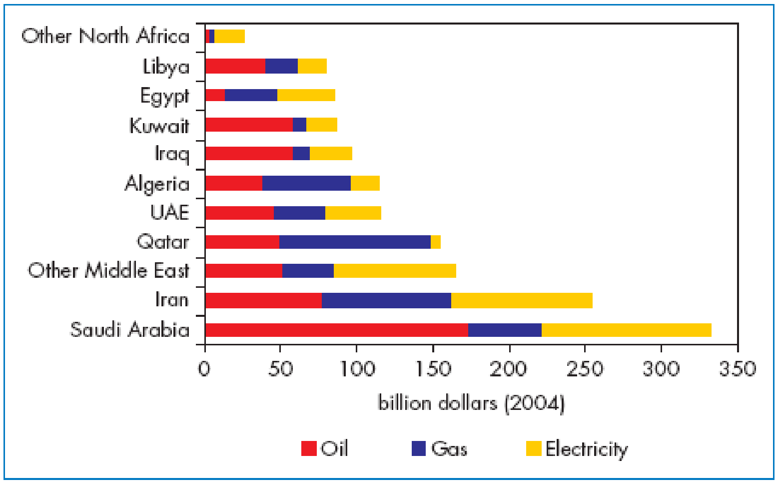
[3] Data taken from Economist Intelligence Unit, published at: http://archive.gulfnews.com/articles/07/03/31/10114773.html

[4] Bodman's Remarks at Middle East Institute's 60th Anniversary Conference. http://www.energy.gov/print/4477.htm

[5] Concentrating Solar Power for the Mediterranean Region: http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573/

According to the Reference Scenario referred to in *World Energy Outlook 2005,* this increase in energy supply calls for a cumulative infrastructure investment of about **$1.5 trillion** over the period of 2004-2030, or **$56 billion per year** in the Middle East and North African Region (MENA). [6]

Figure 3.4: **Cumulative MENA Energy Investment, 2004-2030**



In countries where oil is plentiful, such as Iran, the government is also **heavily subsidizing** electric energy production. In Iran, **1.2 million barrels** of oil are consumed domestically at much lower prices than the rest of the world, while **2.3 million barrels** of oil are exported.[7]

Costs are also great for countries with few of their own indigenous energy resources, such as Jordan. Energy imports account for as much as **10% of GDP**, and will continue to rise 50% in the next 20 years, according to the Ministry of Energy and Mineral Resources.[8]

Furthermore, MENA energy-related carbon-dioxide emissions will **double by 2030**, primarily from power generation and water desalination, if the business-as-usual case continues.[9]

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[6] World Energy Outlook (2005)
http://miranda.sourceoecd.org/vl=1131950/cl=12/nw=1/rpsv/~6673/v2005n26/s1/p1l

[7] Wind and Solar Energy Developments in Iran
http://www.itee.uq.edu.au/~aupec/aupec02/Final-Papers/H-Kazemi1.pdf

[8] Data from the MEMR, published at:
http://pepei.pennnet.com/display_article/288632/89/ARTCL/none/none/Country-Focus:-At-the-crossroads/

[9] World Energy Outlook (2005)
http://miranda.sourceoecd.org/vl=1131950/cl=12/nw=1/rpsv/~6673/v2005n26/s1/p1l

Table 3.3: **MENA Energy-Related CO_2 Emissions** (million tonnes)

	Middle East		North Africa		MENA	
	2003	**2030**	**2003**	**2030**	**2003**	**2030**
Power sector	383	800	98	200	481	1000
Industry	232	459	54	90	286	549
Transport	239	507	66	163	305	670
Other*	248	425	77	151	325	576
Total	**1 102**	**2 191**	**295**	**604**	**1 397**	**2 795**

*Includes other transformation, residential and services and non-energy use. [10]

As a response to these trends, there is a growing global interest in alternative forms of energy production. If fossil fuels are replaced by more future-adept technologies, it is possible to mitigate their detrimental trends, **reduce carbon emissions**, **conserve and avoid the cost hikes of nonrenewable natural resources**, **reduce dependence on imported energy resources** such as uranium, natural gas, and oil, and **increase energy resource exports**, to benefit the region economically and socio-politically for years to come. At the same time, mitigating the increase in carbon emissions will have a significant impact on moderating global warming.

[10] World Energy Outlook (2005) http://miranda.sourceoecd.org/vl=1131950/cl=12/nw=1/rpsv/~6673/v2005n26/s1/p1l

2. Renewable Energy as an Alternative

Unlike hydrocarbon energies, renewable energy is developed from resources which are constantly replenished and will never run out.

· **Solar Power** utilizes the energy from sunlight either indirectly or directly. It can be used for heating and cooling, generating electricity, lighting, water desalination, and many other commercial and industrial uses.

· **Wind Power** captures the energy of the wind through wind turbines.

· **Biomass Energy** uses the energy from plants and plant-derived materials, such as wood, food crops, grassy and woody plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes.

· **Geothermal Energy** utilizes the heat from the earth, drawn from hot water or steam reservoirs in the earth's mantle located near the earth's surface.

· **Ocean Energy** traps thermal energy from the sun's heat and mechanical energy from the tides, underwater currents and waves.

· **Hydropower** captures the energy from flowing water to power machinery and produce electricity.[11]

Renewable Energy has the capability of meeting all world energy demands if utilized properly:

Renewable energy can be used on its own or as a supplementary power source in developing countries… It can provide clean energy that protects the local environment and reduces greenhouse gas emissions [while reducing] dependence on foreign sources of energy. [12]

Eric Martinot
Manager of Global Environment Facility

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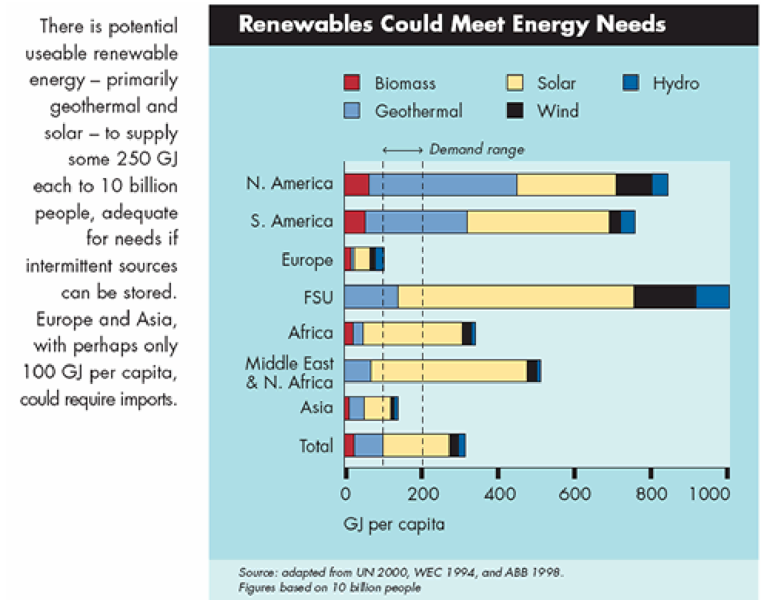
[11] Data taken from http://www.nrel.gov/learning
[12] Renewable Energy: Empowering the Developing World
http://links.jstor.org/sici?sici=0091-6765%28200201%29110%3A1%3CA30%3AREETDW%3E2.0.CO%3B2-D

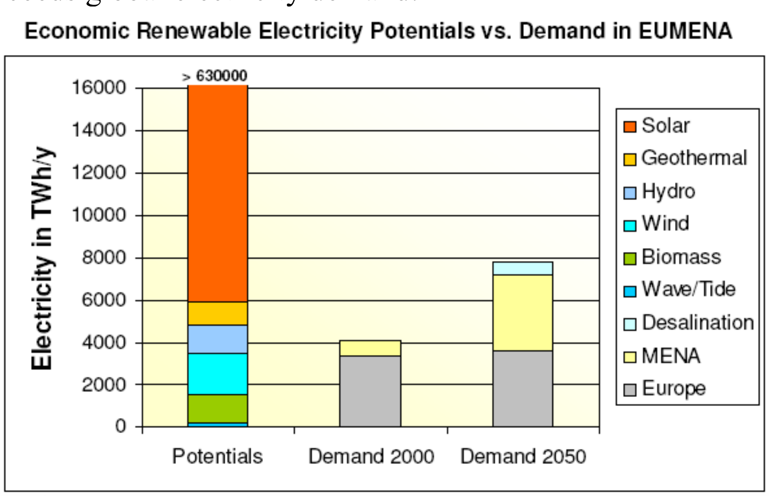


[13]

The world market is also becoming more favorable to renewables. According to statistics defined at *Middle East Electricity*, over the past 10 years, electricity generated by renewable energy has been developing at the highest rate in the world's energy and electricity market. The increased rate of solar power generation is as high as **30.9 percent**, followed by 30.7 percent for wind power generation.[14]

2.1 Renewable Potential in the Middle East

There is a large potential for renewable resources in the Middle East which, up to this point, have remained largely untapped. This is especially true of solar power; its potential in the MENA region alone far exceeds global electricity demand.[15]



[16]

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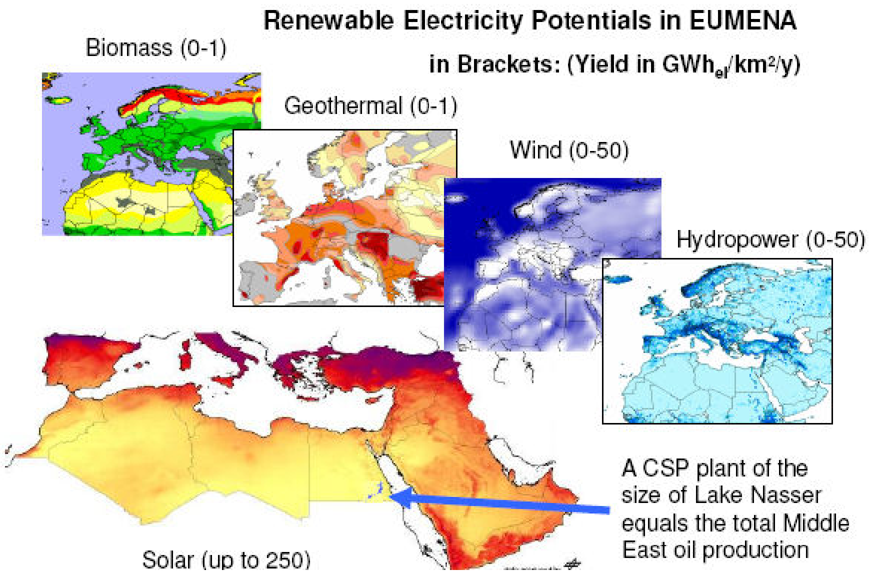
[13] Image from http://cleanpeace.org
[14] http://www.middleeastelectricity.com/Renewable/New-and-RenewableEnergy.html
[15] Concentrating Solar Power in the Mediterranean Region http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573/

As seen in the image below, a concentrated solar plant the size of Lake Nasser would have the production capacity **equivalent of all of the Middle East's oil production**:



[17]

The earth receives an incredible supply of solar energy – the sun provides enough energy in one minute to supply the world's energy needs for a full year. In one day it provides more energy than our current population would consume in 27 years.

From *Middle East Electricity*[18]

According to a report by the Electrical Engineering Department at King Saud University, the Middle East receives 3,000 - 3,500 hours of sunshine per year, with more than **5.0 kW/m^2 of solar energy per day**.[19] In Iran, average solar radiation is about **19.23 Mega joules per square meter**. The potential of wind and solar energy in Iran is about **6500 MW**.[20]

Conclusion: By applying renewable sources to energy production in the Middle East, the life of fossil fuels will be expanded for future generations, decreasing carbon emissions, and encouraging socio-economic development for sustainable wealth.[21]

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[16] Concentrating Solar Power for Europe, Middle East and North Africa – A Roadmap to 2050 http://www.german-renewable-energy.com/Renewables/Redaktion/PDF/en/en-Hannover-Messe-Energy-2007-Trieb,property=pdf,bereich=renewables,sprache=en,rwb=true.pdf

[17] Concentrating Solar Power for Europe, Middle East and North Africa – A Roadmap to 2050 http://www.german-renewable-energy.com/Renewables/Redaktion/PDF/en/en-Hannover-Messe-Energy-2007-Trieb,property=pdf,bereich=renewables,sprache=en,rwb=true.pdf

[18] http://www.middleeastelectricity.com/

[19] Potential for economic solar desalination in the Middle East http://www.sciencedirect.com/science/article/B6V4S-3TK6GM5-1T/2/0d6d01afd4d4696a232e21f2faf6ebc1

[20] Wind and Solar Energy Developments in Iran http://www.itee.uq.edu.au/~aupec/aupec02/Final-Papers/H-Kazemi1.pdf

[21] Concentrating Solar Power in the Mediterranean Region http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573/

3. Solar Power, the Untapped Resource

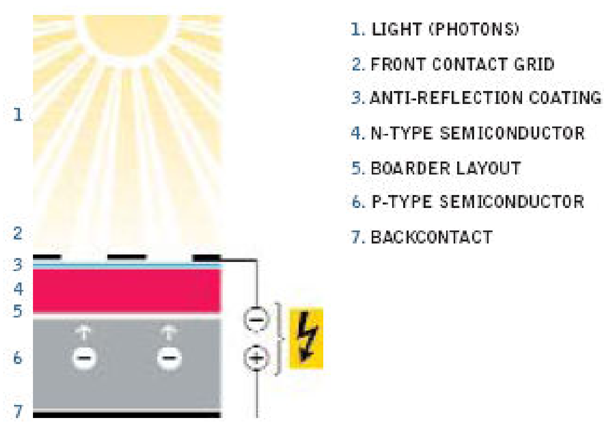
3.1 Solar technologies and applications

The energy from the sun's heat may be obtained by one of two means: from distributed photovoltaic systems or from large central solar thermal power stations. Solar power alone can provide electricity to a variety of locations and various situations: photovoltaic systems do not require a grid, and thus may be employed to serve rural demand, while solar thermal power stations are best suited for high demand urban areas.

3.1.1 Photovoltaic (PV) systems

Description by Greenpeace:

> Photovoltaic (PV) technology involves the generation of electricity from light. The secret to this process is the use of a **semiconductor material which can be adapted to release electrons**, the negatively charged particles that form the basis of electricity. The most common semiconductor material used in photovoltaic cells is silicon, an element most commonly found in sand. All PV cells have at least two layers of such semiconductors, one positively charged and one negatively charged. When light shines on the semiconductor, the electric field across the junction between these two layers causes electricity to flow. **The greater the intensity of the light, the greater the flow of electricity**. A photovoltaic system does not, therefore, need bright sunlight in order to operate, and can **generate electricity even on cloudy days.** When a PV installation is described as having a capacity of 3 kWp (peak), this refers to the output of the system under standard testing conditions, allowing comparison between different modules. In central Europe, a 3 kWp rated solar electricity system, with a surface area of approximately 27 square metres, would **produce enough power to meet the electricity demand of an energy conscious household**.[22]



[22] Image and information from: A pathway to a sustainable and clean energy future for the Middle East http://www.greenpeace.org/international/press/reports/energyrevolutionreport

There are four types of solar PV systems employable to best suit the region where it is installed:

· **Grid connected:** Connection to the local electricity network allows any excess power produced to be sold to the utility. Electricity is then imported from the network outside daylight hours. An inverter is used to convert the DC power produced by the system to AC power for running normal electrical equipment.

· **Grid support:** A system can be connected to the local electricity network as well as a back-up battery. Any excess solar electricity produced after the battery has been charged is then sold to the network. This system is ideal for use in areas of unreliable power supply.

· **Off-grid:** Completely independent of the grid, the system is connected to a battery via a charge controller, which stores the electricity generated and acts as the main power supply. An inverter can be used to provide AC power, enabling the use of normal appliances. Typical off-grid applications are repeater stations for mobile phones or rural electrification.

· **Hybrid system:** A solar system can be combined with another source of power – a biomass generator, a wind turbine or diesel generator – to ensure a consistent supply of electricity. A hybrid system can be grid connected, stand alone or grid support.[23]

Due to its higher start-up cost, solar photovoltaic technology is considered more of a long-term option when compared to other renewable technologies. But, considering its enormous flexibility, simplicity, high reliability, low maintenance costs, and technical potential for rural electrification to those who have no other access to electricity, the returns of this investment are immense both socio-politically and economically.[24]

3.1.2 Solar Thermal

Solar thermal technologies concentrate energy by heating up water in a dark vessel. The heat is then transferred to operate a conventional power cycle. The heat may be preserved to be utilized at night by storing it in liquid or solid media such as molten salts, ceramics, concrete, or newly developed salt mixtures.[25] Concentrating Solar Power can either focus sunlight directly onto solar cells or generate electricity through an intermediate, such as heating water to drive steam turbines.[26] It may be used for domestic water heating, space heating in residential and commercial buildings, swimming pool heating, solar-assisted cooling, industrial process heat and the desalination of drinking water.[27]

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[23] Information taken directly from: A pathway to a sustainable and clean energy future for the Middle East http://www.greenpeace.org/international/press/reports/energyrevolutionreport
[24] Photovoltaics in 2010: Rest of the World, Chapter 5 http://www.agores.org/Publications/PV2010.htm
[25] Concentrated Solar Thermal Power-Now! http://www.greenpeace.org/international/press/reports/Concentrated-Solar-Thermal-Power
[26] Egypt tries Concentrating Solar Power http://www.metimes.com/storyview.php?StoryID=20070220-044724-3240r
[27] A pathway to a sustainable and clean energy future for the Middle East http://www.greenpeace.org/international/press/reports/energyrevolutionreport

There are three systems which utilize solar thermal technology:

· **Parabolic trough systems:** Parabolic trough-shaped mirror reflectors are used to concentrate sunlight on to thermally efficient receiver tubes placed in the trough's focal line. A thermal transfer fluid, such as synthetic thermal oil, is circulated in these tubes. Heated to approximately 400°C by the concentrated sun's rays, this oil is then pumped through a series of heat exchangers to produce superheated steam. The steam is converted to electrical energy in a conventional steam turbine generator, which can either be part of a conventional steam cycle or integrated into a combined steam and gas turbine cycle. [28]

· **Central Receiver (Solar Towers) Systems:** A circular array of heliostats (large individually tracking mirrors) is used to concentrate sunlight on to a central receiver mounted at the top of a tower. A heat-transfer medium in this central receiver absorbs the highly concentrated radiation reflected by the heliostats and converts it into thermal energy to be used for the subsequent generation of superheated steam for turbine operation. To date, the heat transfer media demonstrated include water/steam, molten salts, liquid sodium and air. If pressurized gas or air is used at very high temperatures of about 1,000°C or more as the heat transfer medium, it can even be used to directly replace natural gas in a gas turbine, thus making use of the excellent efficiencies (60% and more) of modern gas and steam combined cycles.[29]

· **Parabolic dish systems:** A parabolic dish-shaped reflector is used to concentrate sunlight on to a receiver located at the focal point of the dish. The concentrated beam radiation is absorbed into the receiver to heat a fluid or gas (air) to approximately 750°C. This fluid or gas is then used to generate electricity in a small piston or Stirling engine or a micro turbine, attached to the receiver.[30]

[28] Information taken directly from "Concentrated Solar Thermal Power-Now!" http://www.greenpeace.org/international/press/reports/Concentrated-Solar-Thermal-Power
[29] Information taken directly from "Concentrated Solar Thermal Power-Now!" http://www.greenpeace.org/international/press/reports/Concentrated-Solar-Thermal-Power
[30] Information taken directly from "Concentrated Solar Thermal Power-Now!" http://www.greenpeace.org/international/press/reports/Concentrated-Solar-Thermal-Power

The following image compares these three solar thermal technologies:

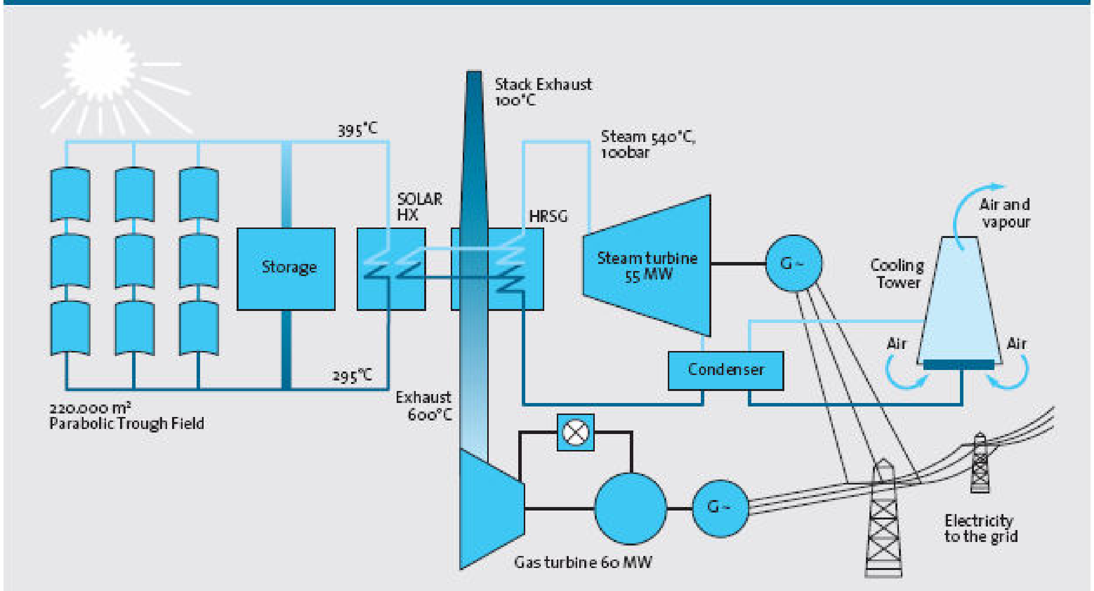
Table 2.1: Comparison of solar thermal power technologies			
	Parabolic Trough	Central Receiver	Parabolic Dish
Applications	Grid-connected plants, mid- to high-process heat (Highest single unit solar capacity to date: 80 MWe.) Total capacity built: 354 MW	Grid-connected plants, high temperature process heat (Highest single unit solar capacity to date: 10 MWe, with another 10 MW currently under construction.)	Stand-alone, small off-grid power systems or clustered to larger grid-connected dish parks (Highest single unit solar capacity to date: 25 kWe; recent designs have about 10 kW unit size.)
Advantages	• Commercially available – over 12 billion kWh of operational experience; operating temperature potential up to 500°C (400°C commercially proven) • Commercially proven annual net plant efficiency of 14% (solar radiation to net electric output) • Commercially proven investment and operating costs • Modularity • Best land-use factor of all solar technologies • Lowest materials demand • Hybrid concept proven • Storage capability	• Good mid-term prospects for high conversion efficiencies, operating temperature potential beyond 1,000°C (565°C proven at 10 MW scale) • Storage at high temperatures • Hybrid operation possible	• Very high conversion efficiencies – peak solar to net electric conversion over 30% • Modularity • Hybrid operation possible • Operational experience of first demonstration projects
Disadvantages	• The use of oil-based heat transfer media restricts operating temperatures today to 400°C, resulting in only moderate steam qualities	• Projected annual performance values, investment and operating costs still need to be proven in commercial operation	• Reliability needs to be improved • Projected cost goals of mass production still need to be achieved

[31]

[31] Concentrated Solar Thermal Power-Now! Sept. 2005
http://www.greenpeace.org/international/press/reports/Concentrated-Solar-Thermal-Power

The following image illustrates how solar thermal technologies tap into electric power grids:

Figure 2.6: Integrated Solar/Combined Cycle system (ISCC)



[32]

3.2 Potential for Water Desalinization

Around the world, water demand is increasing, while supply is rapidly decreasing. The water demand of MENA countries will **increase from today's 300 billion cubic meters per year to over 500 billion m³/y in 2050**, but current water supply is already exploited beyond its yield.[33] Solar energy is a clean and low-maintenance means of water desalinization and is much safer to use near water than nuclear energy. Water is desalinized by solar energy through low temperature seawater evaporation and condensation cycles similar to a normal multi-stage flash distillation (MSD) and multiple effect distillation (MED). It operates twenty-four hours a day with energy storage and hybrid operation.[34] According to the German Aerospace Center, energy from solar thermal power plants will become one of the least cost options for desalted water in MENA within a decade.[35]

As an example, solar powered water desalination is already utilized in Bahrain. The Al Hidd independent water and power plant (IWPP**)**, once complete, **will triple Al Hidd IWPP's current desalination capacity from 136 million litres per day (MLD) to 409 MLD**.[36] They

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[32] Information taken directly from "Concentrated Solar Thermal Power-Now!"
http://www.greenpeace.org/international/press/reports/Concentrated-Solar-Thermal-Power
[33] Concentrating Solar Power for the Mediterranean Region
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573/
[34] Potential for economic solar desalination in the Middle East
http://www.sciencedirect.com/science/article/B6V4S-3TK6GM5-1T/2/0d6d01afd4d4696a232e21f2faf6ebc1
[35] Concentrating Solar Power for Seawater Desalination
http://www.dlr.de/tt/desktopdefault.aspx/tabid-3525/5497_read-6611/
[36] Independent Power & Water Plants: Serving up success

have the potential of being expanded to very large units, producing up to **100,000 m³/day of desalted water.** [37]

3.3 Emissions and Downstream Waste of Solar Technologies

The life cycle of solar electric-energy generation includes material production (mining, smelting, refining, purification), solar cell - and PV module - production, balance of system production (inverters, transformers, wiring, structural supports), system operation and maintenance, system decommissioning, and disposal or recycling.[38] The emissions from solar electricity production are much less than that of fossil fuels. According to the German Aerospace Center, by applying solar energy technologies, emissions may be **reduced to 475 million** tons per year in 2050 **from a projected 2000 million**, with per capita emissions of 0.58 tons/cap/y in the power sector. Therefore, **28 billion tons of carbon dioxide may be avoided by 2050**, equal to the present annual emissions **world wide**.[39] In a second study from the United States, renewable energy has the capacity of reducing carbon emissions by 60-80 percent by 2030, as seen in the image below.

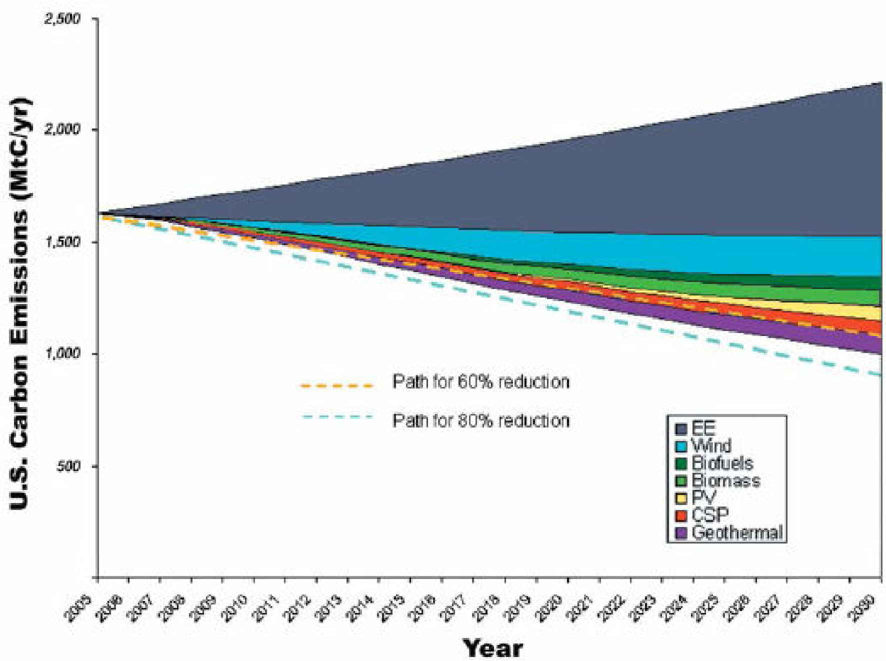


Figure 2. Potential carbon reductions in 2030 from energy efficiency and renewable technologies and paths to achieve reductions of 60% and 80% below today's emissions value by 2050.

[40]

http://pepei.pennnet.com/display_article/288635/89/ARTCL/none/none/Independent-Power-&-Water-Plants:-Serving-up-success/

[37] Concentrating Solar Power for Seawater Desalination http://www.dlr.de/tt/desktopdefault.aspx/tabid-3525/5497_read-6611/

[38] Greenhouse-gas emissions from solar electric- and nuclear power: A life-cycle study http://www.sciencedirect.com/science/article/B6V2W-4MBCBR8-1/2/1a51cd422851f2d0f6dc8ca4fd1a2129

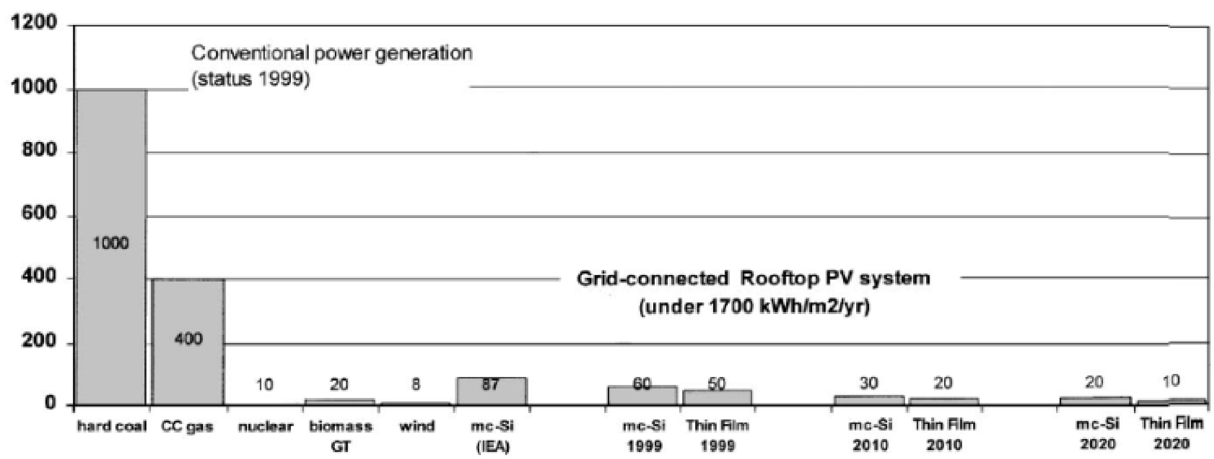
[39] Statistics and image taken from Concentrating Solar Power for the Mediterranean Region http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573/

[40] Tackling Climate Change in the U.S.: Potential U.S. Carbon Emissions Reductions from Renewable Energy and Energy Efficiency by 2030

Solar power plants also reduce negative environmental effects. At the Egyptian solar power plant in Kuraymat, the World Bank reports that "no significant adverse environmental impacts are predicted to occur with this system compared to potential localized environmental changes associated with heliostat fields…accidental spills or potential leakages of the thermal fluid are manageable…and water use for mirror washing and cleaning is very limited and the resulting water drains are controllable."[41] This is opposed to nuclear and fossil fuel producing plants where an accidental spillage is actively detrimental to the surrounding environment. With photovoltaics, pollution is minimized, and the uncontrolled disposal of throwaway batteries (toxic waste) is avoided.[42]

Emissions also decrease as technology continues to improve. Examples include the fluidized bed reactor (FBR) for producing solar-grade Si which may cut electricity consumption in Si-purification by up to 90%. Also, thinner thin-films, dye-sensitized cells, and organic cells promise lower production costs in the coming decade, with lower greenhouse emissions.[43]

CO_2 emissions for grid-connected roof-top PV systems [g/kWh]



[44]

3.4 Costs of Implementing Solar Technology

3.4.1 Land:

Solar power technologies use the **least amount of land** as compared to all of the other electricity generating technologies. This is because they do not require the additional infrastructure for

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http://www.ases.org/climatechange/
[41] Egypt - Solar Thermal Hybrid Project : environmental impact assessment
http://go.worldbank.org/01PP8UUYG0
[42] Photovoltaics in 2010: Rest of the World, Chapter 5
http://www.agores.org/Publications/PV2010.htm
[43] Greenhouse-gas emissions from solar electric- and nuclear power: A life-cycle study
http://www.sciencedirect.com/science/article/B6V2W-4MBCBR8-1/2/1a51cd422851f2d0f6dc8ca4fd1a2129
[44] Source: Alsema E.A., Nieuwlaar E (2000). Energy viability of photovoltaic systems. Energy Policy 28, 999-1010

mining, transport, and disposal that nuclear and fossil-fuel powered technologies necessitate.[45] In addition, the land which is developed for solar power plants is often un-used and infertile.[46] Due to the fact that these technologies do not pose a threat to the surrounding environment, solar collector fields may also be used for agriculture and for the shade they provide. Also, PV systems can easily be affixed to commercial and residential roofs in rural and rural areas.[47]

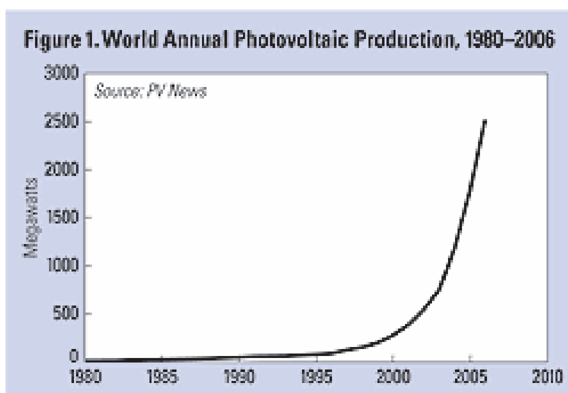
3.4.2 Start-up Costs and Investment:

***The costs of new nuclear plants and coal gasification plants with carbon capture and storage will likely be sufficiently high that renewables will be very competitive economically*.**

The American Solar Energy Society
Tackling Climate Change in the U.S.: Potential U.S. Carbon Emissions Reductions from Renewable Energy and Energy Efficiency by 2030[48]

The life cycle of solar-electric energy generation requires material production (mining, smelting, refining, purification), solar cell - and PV module - production, balance of system production (inverters, transformers, wiring, structural supports), system operation and maintenance, system decommissioning, and disposal or recycling.[49]

Although the initial costs of implementing solar technologies require significant investment, in the long-run, renewable technologies are becoming economically viable. These initial costs are also now decreasing due to newer, more efficient technologies and the rising availability of PV materials (as with the emergence of China as a low-cost producer).



[50]

[45] Concentrating Solar Power in the Mediterranean Region
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573/
[46] Egypt - Solar Thermal Hybrid Project : environmental impact assessment
http://go.worldbank.org/01PP8UUYG0
[47] Concentrating Solar Power in the Mediterranean Region
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573
[48] Tackling Climate Change in the U.S.: Potential U.S. Carbon Emissions Reductions from Renewable Energy and Energy Efficiency by 2030
http://www.ases.org/climatechange/
[49] Greenhouse-gas emissions from solar electric- and nuclear power: A life-cycle study
http://www.sciencedirect.com/science/article/B6V2W-4MBCBR8-1/2/1a51cd422851f2d0f6dc8ca4fd1a2129
[50] As reported by Janet Sawin of World Watch Institute. Published at: http://www.worldwatch.org/node/5086

Renewable energy technologies are seeing costs reductions while fossil fuel prices and costs of CO_2-sequestration are continuing to rise. The additional infrastructures of fossil fuel energies are not required (i.e. coal being distributed long distances and natural gas pipelines). Renewable energy production also does not require the long-term subsidies seen with fossil fuels and nuclear power; rather, it acts to lower and stabilize energy costs over the long run. **Renewable energies will thus foster economic growth instead of burdening it.**[51] For example, in Germany, it would cost as much as $75 billion to make renewable energy break even with fossil fuels before 2020. However, after this point, **a shift to renewables would save Germany US$ 250 billion**, equaling to a net savings of **US$ 175 billion.**[52]

3.4.3 Projected Costs of Photovoltaic Electricity Generation:

According to a study by Greenpeace:

> The learning factor for PV modules has been fairly constant over a period of 30 years at around 0.8, indicating a continuously high rate of technical learning and cost reduction. Assuming a globally installed capacity of **2,000 GW in 2050**, and a decrease in the learning rate after 2030, we can expect that electricity generation costs of around **5-9 cents/kWh will be possible by 2030**.[53]

The costs of PV are also offset because its electricity can be utilized from the point of production, which has a competitive advantage over power transmitted over long distances which often is not distributed properly.[54] This is shown in the following image:

figure 6: centralised energy infrastructures waste more than two thirds of their energy

[55]

[51] Concentrating Solar Power in the Mediterranean Region
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573/

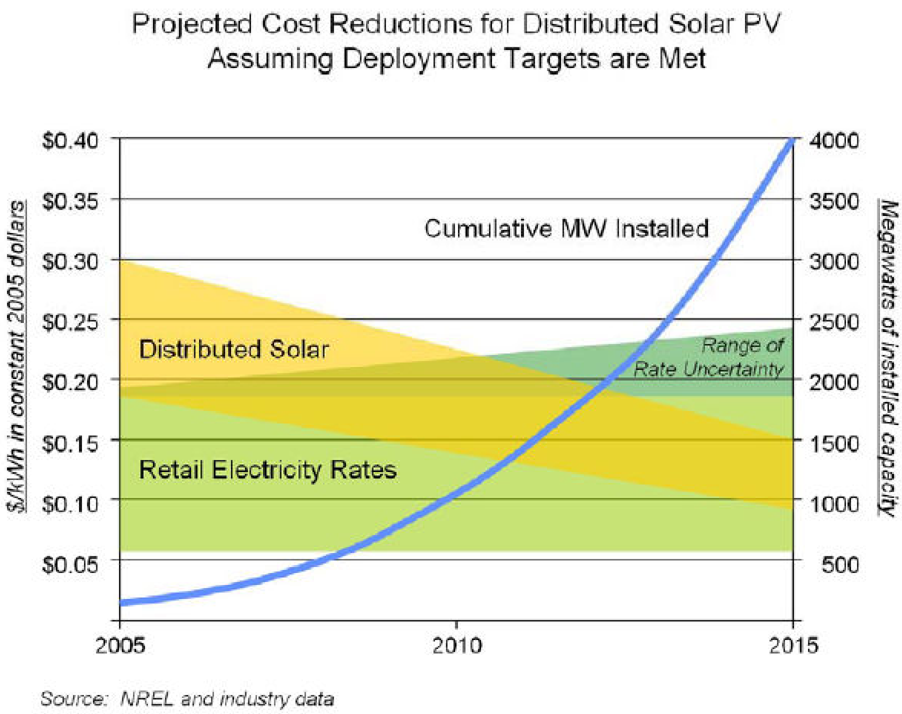
[52] How the Middle East Could Save the Climate
http://www.spinwatch.org/content/view/196/8/

[53] A pathway to a sustainable and clean energy future for the Middle East
http://www.greenpeace.org/international/press/reports/energyrevolutionreport

[54] Carbon emission and mitigation cost comparisons between fossil fuel, nuclear and renewable energy resources for electricity generation
http://www.sciencedirect.com/science/article/B6V2W-472S0YT-3/2/05686ec482c21dbae7445380462470e5

[55] A pathway to a sustainable and clean energy future for the Middle East

Furthermore, the cost of solar power is currently less expensive in areas where the solar resource is plentiful and where the market is open to solar technologies. For example, in the UAE, it only costs about **5 cents** (20 fils) to generate one unit of solar power from building-affixed PV systems, whereas in the United States it costs between 25 and 50 cents.[56]



57

3.4.4 Projected Costs of Solar Thermal Generation:

According to a study by Greenpeace:

> Crucial factors for market launch will be low storage costs and an adequate, usable heat yield. Data for the European collector market show a learning factor of nearly 0.90 for solar collectors, which indicate a relatively well developed system from a technological point of view. By contrast, the construction of seasonal heat reservoirs is expected to show a **long term cost reduction of over 70%**. Depending on the configuration of the system, it will be possible in the long term to achieve solar thermal costs of **between 4 and 7 cents/kWh thermal**. [58]

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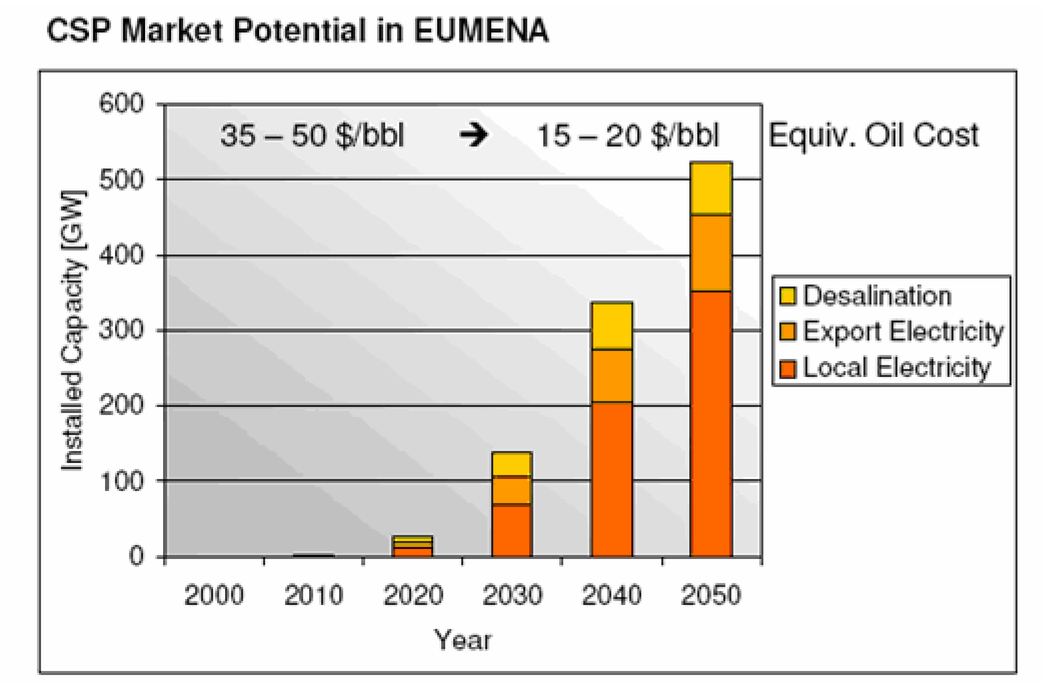
http://www.greenpeace.org/international/press/reports/energyrevolutionreport
[56] Domestic sector yet to tap Gulf's solar power potential
http://archive.gulfnews.com/articles/06/01/14/10011505.html
[57] Western Governors' Association Clean and Diversified Energy Initiative: Solar Task Force
http://www.westgov.org/wga/initiatives/cdeac/solar.htm
[58] A pathway to a sustainable and clean energy future for the Middle East
http://www.greenpeace.org/international/press/reports/energyrevolutionreport



[59]

Conclusion: With its stabilizing economic effects, low emissions, and potential for water desalinization, solar technology would be a great asset to the Middle East's energy production, which would free up more natural resources for export instead of consumption.

[59] Potential of Solar Thermal technologies: Concentrating Solar Power for Europe, Middle East and North Africa – A Roadmap to 2050 http://www.german-renewable-energy.com/Renewables/Redaktion/PDF/en/en-Hannover-Messe-Energy-2007-Trieb,property=pdf,bereich=renewables,sprache=en,rwb=true.pdf

4. Applications and Future Implementations of Solar Technology

4.1 Creation of Jobs and Economic Benefits

The development of solar technologies is very beneficial to the economy due to the influx of high quality jobs it requires. These jobs include systems manufactures, suppliers, developers and planners, system operators, maintenance and construction workers, financers, insurers, and retailers. Construction generates demand for local labor and services. Also, with the gradual introduction of photovoltaics, there will be a continuity of local employment over the years.

A study from the United States indicates a renewable program would add over **15,000 high-quality jobs and contribute up to 6 million megawatt-hours of electricity annually to the region by 2015** (the equivalent of the electricity consumed during peak hours by Portland, Seattle and Denver each year combined).[60] In Germany, 150,000 jobs have already been created.[61] By 2020, the number of available jobs could increase **to over 300,000 (gross employment)**.[62]

The introduction of solar technologies will have numerous other socio-economic benefits. According to Egypt's solar plant plan by the World Bank:

> No resettlement is foreseen and no adverse social impacts are expected. The project may, on the contrary, **impact poverty positively by adding to the power capacity of Egypt.** This is needed given the very low reserve margin that the system is currently operating on. The Global Environmental Facility component will ensure that the poor are not adversely affected, as the project will not impact on the current tariff levels in place.[63]

The improvement of the living conditions in rural areas may also **reduce the migration pressure to urban areas**, improving the overall social, demographic and economic balance of the nation.[64]

4.2 Current Applications of Solar Power

- **Israel:** Over 700,000 households in Israel have solar water heaters.[65]
- **UAE:** Forecasts suggest that by 2050, up to half of the UAE's required energy will come from renewable sources, of which solar is expected to make up a large percentage.[66] Solar

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[60] Western Governors' Association Clean and Diversified Energy Initiative: Solar Task Force http://www.westgov.org/wga/initiatives/cdeac/solar.htm
[61] Trans-Mediterranean Interconnection for Concentrating Solar Power http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6588/
[62] Renewable Energy Employment Effects: Germany http://www.bmu.de/english/renewable_energy/downloads/doc/38515.php
[63] Egypt - Solar Thermal Project by the World Bank http://go.worldbank.org/R980JKEVO0
[64] Photovoltaics in 2010: Rest of the World, Chapter 5 http://www.agores.org/Publications/PV2010.htm
[65] http://www3.iptv.org/exploremore/energy/profiles/solar.cfm
[66] http://www.middleeastelectricity.com/Renewable/New-and-RenewableEnergy.html

energy is currently being used to power **parking meters, offshore buoys, and water heating in hotels.** It has recently been developed to cool a 100-flat apartment complex in Dubai, which has **cut utility bills by a third**. It powers the hot water system at another hotel in Dubai, which more than meets their daily requirement, **saving them nearly 100% on their energy costs.** The first solar-cell production line has recently been opened in the Fujairah Free Zone, UAE.[67]

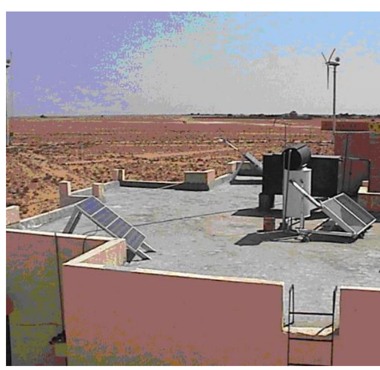
- **Iran:** Solar energy is being used for lighting public parks and streets and is also being used to power a water pump providing water to a remote village.[68]

4.3 Installed Photovoltaic systems

- **Morocco:** Morocco has launched a solar home systems program to electrify over 150,000 households in isolated, off-grid locations. A market for PV operators, distributors and installers was established with this program, with an estimated market size of over US$80 million.[69]

- **Jordan:** The photovoltaic cell systems for lighting in remote villages has been implemented under the Jordanian Badia project for lighting Rawdat Al-Bindan in Ruwaished district in cooperation with the Rural Electrification Project & the National Energy Research Center. The project was commissioned in October, 2002, as a pilot project in the development of rural areas. The total cost of the project reached J.D. (45.000). Efforts are also underway to implement a similar one at Thaghrat Aljob Village in Ma'an governorate and Al-Faida village in Ruwaished district.[70]

- **Egypt:** A 2.7 PV system is being used to light one of NREA' remote sites at the Matrouh Governorate. The total capacity **of 2 PV systems** is **424 watt peak for 9 × 11 W (DC)** efficient lamps, and a TV set of **60 W (AC)**


[71]

4.4 Concentrated Solar Power Plants

[67] Renewable Energy Regional News http://www.middleeastelectricity.com/Renewable/NewandRenewableEnergyRegionalNews.html
[68] http://middleeastelectricity.com/Renewable/NewandRenewableEnergyRegionalNews.html
[69] Prospects for Renewable Energy Technologies in the Middle East and North Africa Region http://www.menarec.com/docs/Yemen_RET_UNEP-Background-Paper_16Apr2004_1_.pdf
[70] Policy Instruments for the Renewable Energy in Jordan http://www.menarec.com/docs/Policy_Instruments_for_the_Renewable_Energy_in_Jordan_02.pdf
[71] NREA Annual Report 2006 http://www.nrea.gov.eg/english1.html

· **Iran** will complete a solar thermal electric power plant in Yazd in 2010. It will ensure uninterrupted power during peak demand periods, cloudy days or early evenings with the aid of an auxiliary natural gas-fired heater which will operate to supplement sources of power, but is limited to 25% of the total effective energy input a year[72]. Iran is also developing capacity for solar-thermal plants with a **250 kW plant in Shiraz** for which parts of the civil works, including landscaping, buildings and relevant accessories, as well as purchasing the mechanical equipment, have been completed.[73]

· **Egypt** will soon develop a hybrid parabolic-trough concentrating solar power plant in Kuraymat. According to the NREA, it will **reduce carbon dioxide emissions by 38,000 tons per year**.[74] Refer to the report by the World Bank for more details.[75]

· In the **UAE,** Abu Dhabi will build a 500 megawatt **$350m solar power plant** which also may be used for water desalination. Construction will begin in 2009.[76]

· **Algeria** is also currently developing a solar power plant so as to be competitive with the energy produced in other regions of the world. The hybrid is expected to reach 5% of national generating capacity by 2015, and the country already has opportunities available to export this energy to Italy and other European countries. According to Energy and Mines Minister Chakib Khelil, "Algeria has a huge sunny area with big potential to be exploited. It has also financial and human resources. It lacks nothing. We can compete with other countries."[77]

4.5 Hybridization

Because solar is intermittent, in order to ensure the continuous supply of electricity, a back-up of another power source must be available for peaking demand. This will be done with natural gas or fossil fuels. A hybrid with nuclear power falls short because **nuclear plants can only operate economically if they run at constant power.**[78]

This back-up source is already available. According to the German Aerospace Center:

> No extra capacities are needed as long as the fluctuating renewable energy share is smaller than the existing peaking capacity, which is the case in our scenario. Wind and

[72] Iran's first solar power plant to become operational in 2010
http://pro.energycentral.com/professional/news/power/news_share_article.cfm?id=8131834
[73] Iran Power sector note:
http://go.worldbank.org/ULEO2OGRH0
[74] Egypt tries Concentrating Solar Power
http://www.metimes.com/storyview.php?StoryID=20070220-044724-3240r
[75] Egypt - Solar Thermal Project by the World Bank
http://go.worldbank.org/R980JKEVO0
[76] Renewable Energy Regional News
http://www.middleeastelectricity.com/Renewable/NewandRenewableEnergyRegionalNews.html
[77] Algeria plans to develop solar power for export
http://africa.reuters.com/business/news/usnBAN923494.html
[78] Trans-Mediterranean Interconnection for Concentrating Solar Power
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6588/

> PV plants cannot considerably reduce the required installed capacity of conventional power plants, but they will reduce their consumption of fossil fuels. Establishing a well balanced mix of technologies and sources, fossil peaking capacities will remain, while fossil and nuclear base load plants will be subsequently replaced.[79]

There can also be limits to energy generated by the hybrid source to prevent excess utilization. By 2050, fossil fired plants will become more environmentally compatible, reduced to their key function of peaking demand. The availability of resources will be prolonged for centuries, and the expensive and energy consuming carbon dioxide sequestration will no longer be needed.[80]

Conclusion: These examples demonstrate that solar power is definitely technically viable in the Middle East and will achieve its desired impact over the next couple of decades when implemented.

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[79] Trans-Mediterranean Interconnection for Concentrating Solar Power
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6588/

[80] Concentrating Solar Power for the Mediterranean Region
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573/

5. Concentrating Renewable Resources: Transmission Grids for a Global Impact

Electricity from renewable energy may be grid connected in order to **reduce costs**, **increase reliability and security**, and to **encourage cooperation within the Middle East and with Europe**. Transnational power lines are in the process of being developed, which renewable energies may easily tap into. There is also political support for extensive renewable energy development:

If I where you, I would stop trying to make Saudi Arabia the oil capital of the world and make Saudi Arabia the energy capital of the world. You should take your cash right now and go out and buy half the solar capacity in the whole world and you should start at the equator. All the way around the equator and go north and south until you put solar power everywhere the weather will tolerate it. You will save the planet and get richer.

Bill Clinton,
speech in Saudi Arabia in January 2006
to 400 business people from the Persian Gulf

5.1 Grids within the Middle East

· By 2010, the multibillion-dollar **Gulf States Cooperation Council (GCC) power grid project** will create an integrated electricity network in the Middle East. This network will create **100,000 MW of additional power over the next 10 years to meet demand** for an estimated $100 billion dollars. The states involved are Saudi Arabia, Qatar, Bahrain, Kuwait, Oman and the United Arab Emirates. Thirteen contracts will be awarded in the first phase, worth $1.25 billion to link Saudi Arabia with Kuwait, Bahrain and Qatar.[81]

· The **Seven Countries Interconnection Project (SCIP)**, which interconnects the grids of Libya, Egypt, Jordan, Syria, Iraq, Turkey and Lebanon, was launched at the beginning of the last decade. It will save costs by avoiding the construction of larger generating units. In the future, this grid will be interconnected to include Europe via Turkey and Morocco. Syria is connected to Iraq by a single AC circuit 400 kV overhead line, operational in 2002. An Egypt-Jordan interconnection cable will be rated to 550 MW. Furthermore, cooperation between Egypt, Libya, Tunisia, Algeria, and Morocco may have an increased interconnection voltage of 400-500 kV in order to increase the capacity transferred to those countries, which is currently limited to the existing interconnection voltage of 220 kV. The path of interconnection is shown on the image below:[82]

[81] http://www.middleeastelectricity.com/Power/PowerGenerationRegionalNews.html
[82] Information and image from the article: Transmission Grid Network: The seven wonders of interconnection http://pepei.pennnet.com/display_article/288634/89/ARTCL/none/none/Transmission-Grid-Network:-The-seven-wonders-of-interconnection/

5.2 Grids with other regions, the European Union

The sun-belt and the technology belt can become very powerful when they begin to understand themselves as a community: a community of energy, water and climate security; a community for their common future.

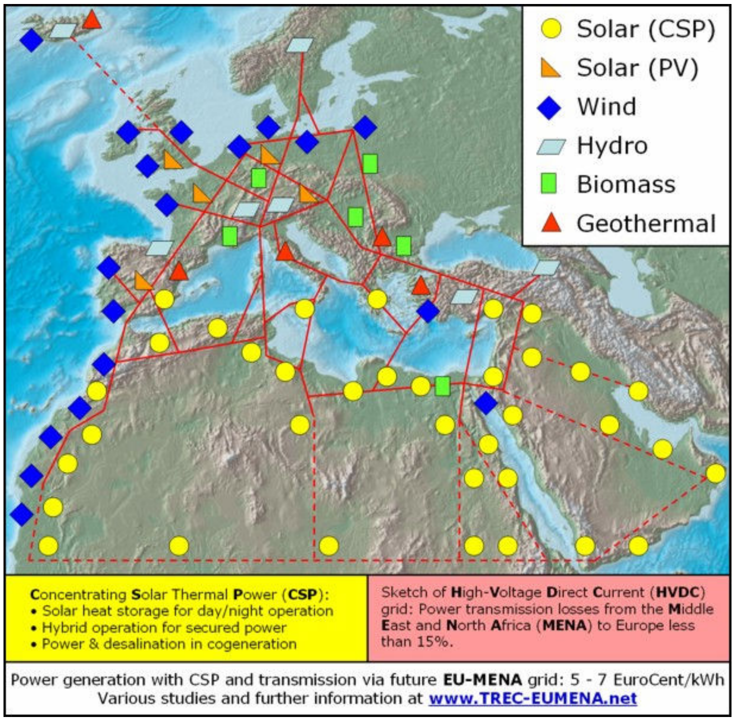
H.R.H. Prince El Hassan Bin Talal,
President of the Club of Rome
Address for World Energy Dialogue,
Hannover Messe, April 2006

A partnership between the EU and MENA will greatly benefit both sides: MENA may utilize and export their vast solar resource for economic growth while the EU can provide the technologies and the capital to activate these potentials.[83]

Grid infrastructure is not dependent on renewable development alone. According to the German Aerospace Center**, "its construction will probably take place anyway, with the purpose to stabilize the growing Pan-European grid, to provide higher security of supply, and to foster competition."[84]**

The following image indicates the proposed transmission grid:

[83] Concentrating Solar Power in the Mediterranean Region
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573/
[84] Trans-Mediterranean Interconnection for Concentrating Solar Power
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6588/



North Africa alone could provide the EU with **700,000 GW-hours per year of electricity by 2050** through an interconnected electric grid, according to the European Commission's Directorate-General for Energy and Transportation.[85] By **2050, twenty power lines with 5000 MW capacity** could be developed, each providing about 15 % of the European electricity demand by solar imports.[86]

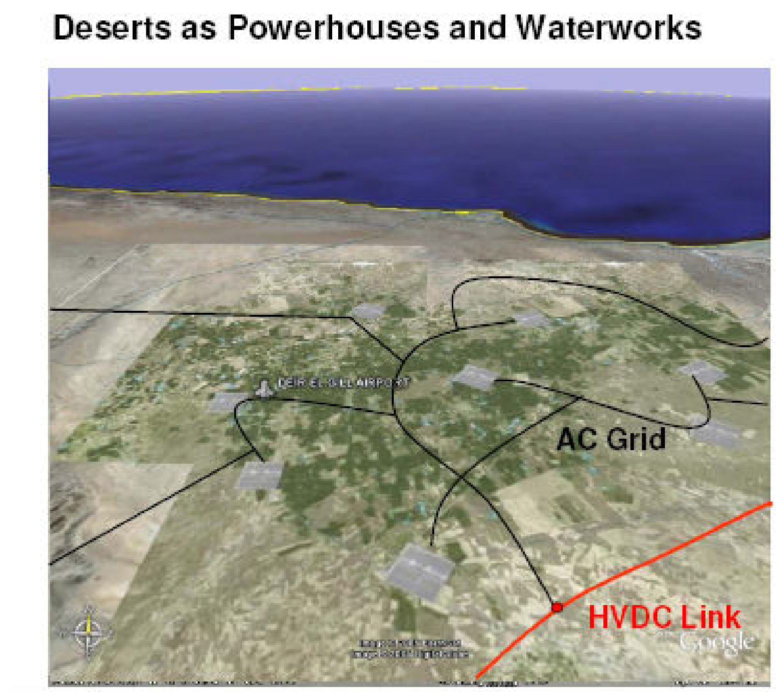
5.2.1 Technical issues

Conventional Alternating Current (AC) energy grids are not capable of transferring electricity such long distances. Thus, a combination of AC grids and High Voltage Direct Current (HVDC) transmission technology will be used in a Trans-European electricity grid.[87]

According to the German Aerospace center, HVDC systems are necessary:

> A future **HVDC grid** will have a **low number of inlets and outlets** to the conventional AC system as it will primarily serve **long distance transfer**, while the **AC grid** will have a **function analogous to country roads and city streets**...
> HVDC over long distances contributes considerably to **increase the compensational effects** between distant and local energy sources and **allows system operators to compensate for outages** of large power stations through distant backup capacity.[88]

[85] Egypt tries Concentrating Solar Power
http://www.metimes.com/storyview.php?StoryID=20070220-044724-3240r
[86] Trans-Mediterranean Interconnection for Concentrating Solar Power
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6588/
[87] Trans-Mediterranean Interconnection for Concentrating Solar Power
http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6588/



[89]

Only 10 % of the generated electricity will be lost by HVDC transmission from MENA to Europe over 3000 km distance. [90]

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[88] Trans-Mediterranean Interconnection for Concentrating Solar Power http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6588/

[89] Concentrating Solar Power for Europe, Middle East and North Africa – A Roadmap to 2050 http://www.german-renewable-energy.com/Renewables/Redaktion/PDF/en/en-Hannover-Messe-Energy-2007-Trieb,property=pdf,bereich=renewables,sprache=en,rwb=true.pdf

[90] Trans-Mediterranean Interconnection for Concentrating Solar Power http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6588

6. The Nuclear Resurgence

Many countries consider nuclear power to be the best alternative to costly fossil fuel technologies. Governments of the Middle East are attracted to its perceived benefits: lower carbon emissions, lower relative start-up costs, freeing up more natural resources for export. However, in the long-run, the costs of nuclear power continue adding up over time, and in the end result, **its disadvantages outweigh its benefits.**[91]

6.1 The costs associated with developing a comprehensive nuclear program

There are numerous costs involved in the up and down-stream stages of nuclear energy production:

· **Uranium mining:** Uranium is extracted from mines in Canada, Australia, Russia, and Nigeria and thus must be imported to the Middle East.

· **Uranium enrichment:** Natural uranium contains only 0.7% of fissionable uranium. It must be enriched to 3-5%. 80% ends up as waste product. Presently, this process can only be carried out in sixteen facilities throughout the world.

· **Fuel rod production:** Enriched material is converted into uranium dioxide and compressed into pellets in fuel rod production facilities. There are 29 of these globally.

· **Power plant operation:** Uranium nuclei are split in a nuclear reactor, releasing energy which heats up water. This is converted in a turbine generator into electricity. This creates more than 100 radioactive products. Of these, plutonium is the most toxic and long-lasting, with a half-life of 25,000 years.

· **Reprocessing:** The contaminated uranium and plutonium must be extracted from used reactor fuel rods. There are currently over 230,000 kilograms of plutonium stockpiled globally. This process requires the transport of radioactive material and nuclear waste around the world.

· **Waste Storage:** Lastly, this waste must be stored. Currently there is not a single final storage facility available anywhere in the world, and this technology is waiting to be developed.[92]

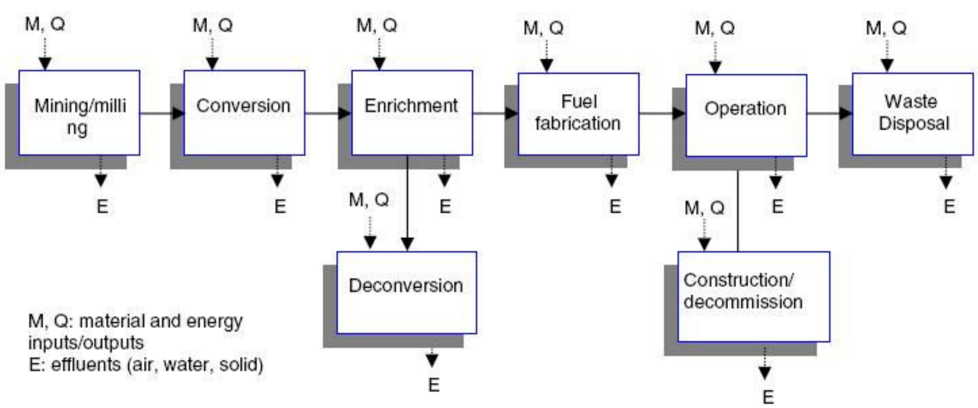

Fig. 3. The nuclear fuel life cycle (without reprocessing).

93

91 More Mideast states eyeing nuclear power http://www.iht.com/articles/ap/2007/04/16/africa/ME-GEN-Mideast-Nuclear.php

92 A pathway to a sustainable and clean energy future for the Middle East http://www.greenpeace.org/international/press/reports/energyrevolutionreport

According to Michael Sailer, of Germany's Institute of Applied Ecology (Öko-Institut), the dependence on imports creates two bottlenecks:

- Because natural deposits of uranium are not equally distributed around the globe, the few corporations that operate mines divide up the market among themselves.
- The countries with the most enrichment capacity often are those with nuclear weapons. Other countries that wish to set up their own enrichment capacity either have also tried to use this capacity for military purposes (i.e. South Africa, Brazil) or may be planning to do so (Iran).[94]

The nuclear waste programs implemented today are **extremely long-term and some of the largest construction projects ever undertaken**. By observing the large payments associated with the treatment and disposal of nuclear waste from spent nuclear fuel and the requirements connected with decommissioning nuclear power plants decades after they have been taken out of production, researchers in Sweden have concluded that **nuclear power has the largest negative salvage value of any other energy system.**[95]

The costs of developing permanent nuclear waste storage programs will heavily loom over economies in the future if they are not implemented soon. The **US Yucca Mountain project**, has already suffered from a **very large cost escalation**. The cost of **site characterization** was estimated in **1981 to be $60–80 million per site.** After being postponed for several years, the cost has risen to an estimated **$6.3 billion in 2001**.[96]

6.2 Emissions, Downstream Waste

Although the emissions of nuclear power plants are reported as essentially carbon-free, waste is produced both upstream and downstream. Steel, concrete, and other materials are necessary for the construction of nuclear power plants, which will largely use fossil energy. Thus, additional greenhouse-gas emissions occur from chemical reactions during material processing.[97]

During **uranium mining**, huge quantities of mining debris is generated. In **uranium enrichment**, 80% of the total volume of uranium ends up as a waste product. Depleted uranium may be used for weapons and thus must be handled carefully. During **power plant operation**, over 100 products are produced, including plutonium. Workers are exposed to a great deal of radiological hazards. During **reprocessing**, plutonium must be stockpiled, and the volume of

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[93] Greenhouse-gas emissions from solar electric- and nuclear power: A life-cycle study: http://www.sciencedirect.com/science/article/B6V2W-4MBCBR8-1/2/1a51cd422851f2d0f6dc8ca4fd1a2129

[94] Lecture by Sailer in 2004 at the Asian regional conference: "Nuclear Energy, Renewable Energy and Peace" http://www.oeko.de/publications/reports_studies/dok/659.php?id=&anzeige=det&ITitel1=&IAutor1=&ISchlagw1=&sortieren=&dokid=229

[95] Costs of the Swedish Waste Nuclear Program http://www.sciencedirect.com/science/article/B6V3X-4HDX6VN-2/2/e30527026f404ad550131978db130b8b

[96] Costs of the Swedish Waste Nuclear Program http://www.sciencedirect.com/science/article/B6V3X-4HDX6VN-2/2/e30527026f404ad550131978db130b8b

[97] Comparison of Greenhouse-Gas Emissions and Abatement Cost of Nuclear and Alternative Energy Options from a Life-Cycle Perspective http://oeko.de/publications/reports_studies/dok/659.php?id=&anzeige=det&ITitel1=&IAutor1=&ISchlagw1=&sortieren=&dokid=315

waste increases many tens of times after being reprocessed, discharged daily into the sea and air. The life of plutonium waste is 25000 years. [98]

6.3 Safety Concerns

The presence of nuclear power plants does little to aid transnational peace negotiations; rather, to the contrary, issues of national security become foremost. And this is not only because of the threat of an arms race. Any attack (even accidental) to a nuclear power plant would be disastrous, causing tremendous amounts of radiation. In comparison, since renewable plants do not operate with a large amount of contaminants, an attack would have little impact on the surrounding environment and humans. Also, an attack on one renewable energy unit would not do enough damage to detrimentally affect national energy supply greatly.[99]

Running a nuclear power facility requires a great deal of safety requirements. However, even when these are in place, a number of things can go wrong. For example, over recent years in the United States, radioactive spent fuel rods have been missing or misplaced from at least 3 nuclear power plants: the Millstone I nuclear reactor in Waterford, CT, the Vermont Yankee reactor in Vernon, VT and the Humboldt Bay Power reactor near Eureka, CA. These missing rods and other radioactive wastes could be seriously misused if they came into the wrong hands.[100]

Countries with less organized and accountable governments, nuclear energy develops into even a greater security issue:

My worries are how to fit this sophisticated industry in an undisciplined society such as Egypt. Our experience in many industries has shown problems. We can't even run the railway system.

Salah E. Ibrahim
Former member of the Egyptian delegation to the IAEA[101]

Conclusion: In the end , the costs, emissions, and safety hazards of nuclear power greatly outweigh its perceived benefits, especially in conflicted, unstable, developing regions.

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[98] A pathway to a sustainable and clean energy future for the Middle East
http://www.greenpeace.org/international/press/reports/energyrevolutionreport

[99] Lecture by Sailer in 2004 at the Asian regional conference: "Nuclear Energy, Renewable Energy and Peace"
http://www.oeko.de/publications/reports_studies/dok/659.php?id=&anzeige=det&ITitel1=&IAutor1=&ISchlagw1=&sortieren=&dokid=229

[100] Energy bill speeds up nuclear proliferation, stifles competition from renewable energy, threatens national Security
http://www.world-wire.com/news/0809050002.html

[101] Power to the People
http://www.egypttoday.com/article.aspx?ArticleID=7036

7. Build-out Plan

In order for renewable energy to be adopted with the best results, grids must be utilized, fossil fuel subsidies must be lowered, and there must be communication and involvement among all sectors.

Specific measures will allow a more cost-effective introduction of renewable energies, offsetting start-up costs. For example, in China, renewable energy will contribute 5 % of national production by 2010, and in Tunisia 25 % of energy production will be available by renewable energy by 2010.[102] Taxes on the detrimental impact of emissions from fossil fuels, such as a CO_2 tax, could also be initiated. For example, in the Dominican Republic, revenues from a tax on fossil fuel consumption go to a fund for the promotion of renewable energy. If affordable, tax relief, concessionary grants and subsidies are also important success conditions. An abolition of import duties of renewable supplies will also make them more cost-competitive.[103]

After this point, the renewable energy produced by the Middle East would be more attractive to foreign and private investment, which will tremendously aid development. According to the World Bank:

> It is beyond any doubt that developing countries would attract more domestic and foreign investment to renewable energy projects if the necessary legal and financial frameworks were in place, and appropriate financial incentives were provided to the private sector to ensure adequate financial returns and offset high risk perceptions.[104]

After this initial start-up, planning is implemented and as renewable energy develops into a common energy source, little else is required in the long run as solar energy is modular and will never deplete.

[102] Energy for all: Obstacles and Success Conditions for RE in Developing Countries http://www.re-focus.net/articles/solarpass/features/energy.html

[103] Energy for all: Obstacles and Success Conditions for RE in Developing Countries http://www.re-focus.net/articles/solarpass/features/energy.html

[104] http://www.worldenergy.org/wec-geis/wec_info/work_programme2007/tech/renew/renewables.asp

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