بسم الله الرحمن الرحيم

Evaluating the Central Electricity Grid System in Comparison with Decentralized Solar Panels for Residential Power Supply in Egypt

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Abstract:

The rapid population growth in Egypt has resulted in a large escalation of demand for new settlements out of the old valley. The main obstacle in establishing new settlements is the absence of infrastructure. Installing the traditional central electricity grid systems demands huge capitals and investments which exceed the abilities of the Egyptian economy. Electricity is also a problem in existing populated areas which suffer either the expensiveness or the cutoffs of electricity, especially in hot summer months. This paper suggests that decentralized, self installed solar power supply can help providing cheap, clean and sustainable power resources for both populated and isolated areas. It is found that decentralized solar energy system is cheaper, more sustainable than centralized systems. This can help improving the quality of life in Egyptian cities and help expanding into new communities in the Egyptian desert.

1. Introduction :

Electricity is the main key for any desired social or economical development. Recently it became a problematic issue in Egypt because of the shortage of fuel required for its generation. Electricity expensiveness and recurrent cutoffs are also a problem which affected Egypt's social, economical and even political life. The centralized traditional electricity grid is unable to expand to every house in Egypt and is also expensive and polluting the environment. So, we study the feasibility of using decentralized solar power systems in the Egyptian urban, rural and desert regions to supply clean energy for Egyptian household.

Key words: Egypt, electricity, decentralization, solar energy.

A- Evaluating Central electrical grid system:

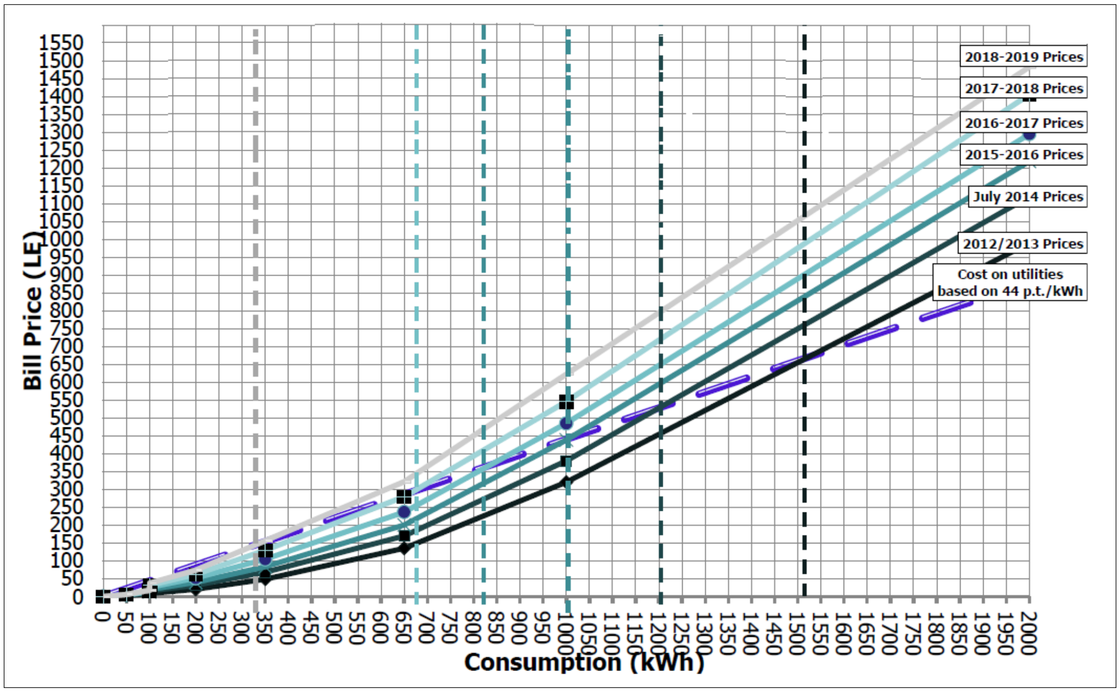
We'll evaluate the central electricity grid system using five criterions: Feasibility, Efficiency, Sustainability, Equality of distribution, and Impact on land use & urban planning.

1- Economical Aspect:

(1-1) Feasibility to the consumer:

An ordinary Egyptian family pays (20 – 950) LE monthly for residential electrical consumption, which forms 2.5 – 3 % of household expenditure, and 0.5 – 0.7 % of the family total income **(1)**.

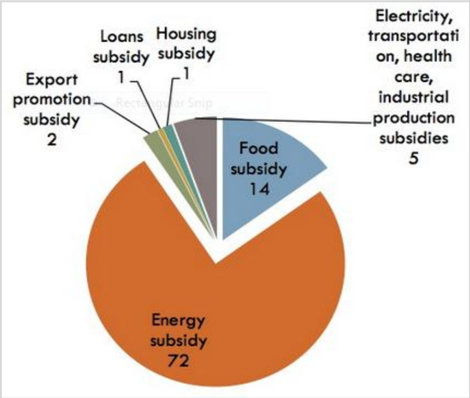
After the submission of privatization policy in 1997, electricity sector was reformed to be a holding company targeting for profit. Since then; electricity tariff has been inclining regularly. Due to energy crisis and economical pressure, the subsidies supplied to the sector are planned to be totally deleted by 2018 **(2)**. See Fig(1).



Fig(1): Electricity tariff and bill prices in Egypt 2012/2018- Source: (Environics SAE)

(1-2) Feasibility to the Government:

Providing basic facilities like water and electricity has always been an evaluation meter for the governmental performance. For a long time, the Egyptian governments have been responsible for offering great subsidies for electricity sector. Energy and electricity sectors consume more than 72 % of total governmental subsidies, see fig (2).



Fig(2) : Subsidies structure in 2011/2012 budget- Source: Egyptian Center for Economic Studies.

Electricity subsidies are structured in a way that offers biggest support to poorest population. As seen in table(1), subsidies are inversely proportioned with consumption. This structure aims to support the poor, but in fact it benefits the rich, because the higher income part of the population consumes more of the energy products that are subsidized by the government. The analysis of Egypt's household surveys indicate that the top 40% of the population enjoy about 60% of the energy subsidies while the bottom 40% receive about 25% of these subsidies. (3)

Category of Consumption (KWh)	Number of Families Million Families	Amount of Subsidies Million LE
0-50	4.19	273.02
50-100	3.48	375.42
100-150	3.44	518.48
150-200	2.23	431.37
200-250	1.44	287.51
250-300	0.82	184.5
300-350	0.48	120.11
350-400	0.39	97.58
400-450	0.25	61.59
450-500	0.176	43.04
500-550	0.055	13.27
550-600	0.043	10.21
600-650	0.033	7.7
650-1000	0.169	11.78
1000-2000	0.083	-
Total	17.27	2435.57

Table(1): Electricity subsidies for Egyptian families in fiscal year 2005/2006- www.CAPMAS.com

But although they benefit the rich disproportionately, removal of these subsidies will have significant adverse impact on the poor (4). The elimination of energy subsidies, without any offsetting policy actions, would reduce the GDP growth rate and the household welfare at all levels of income distribution.(5).

Paying 2.5 billion L.E. annually to cover subsidies is a heavy burden on the governments' shoulders', especially with a high budget deficit and an external debt of $45 billion and internal debt of $ 243 billion.(6). So, the government is under pressure to cut energy subsidies, which weigh heavily on its fiscal position. (7).

Another economical aspect is the **initial cost investment**. New plants and expansions require huge investments that the government usually takes responsibility for as a part of developmental strategy. About 16.9 billion pounds were invested in electricity sector in fiscal year 2010/2011 as seen in fig(3). Electricity projects and maintenance usually consume **15** to **18%** of total investments done by Egyptian governorates annually, as seen in fig(4).

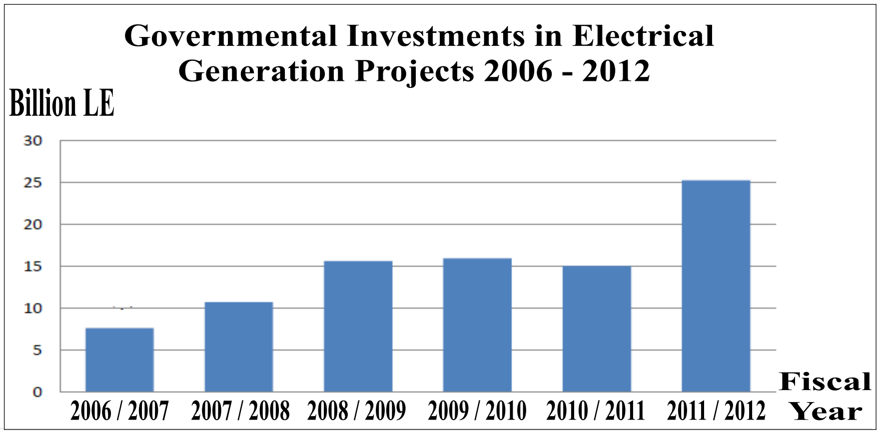


Fig (3): Governmenatl Annual Investments in Electricity Sector
Source: Parameters of Economic and Social Performance in Egypt- CAPMAS annual report, Feb, 2012

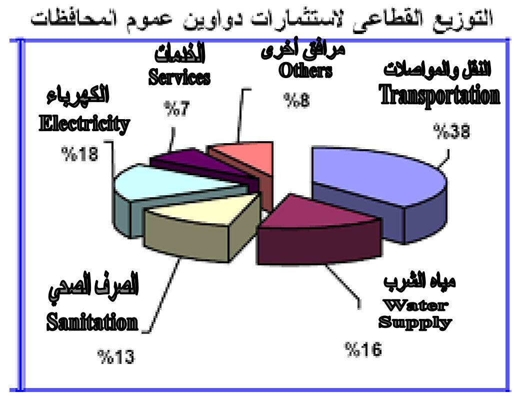


Fig 4 : Distribution of Investments done in Egyptian Governorates during 2006/2007

(1-3) Feasibility to the supplier:

Despite the governmental subsidies, the electricity supplying companies suffer great losses annually. The cost recovery percentage for production, transmission and distribution companies is less than **43%** for residential consumption, which forms **41%** of total electricity purchased **(2)**, see fig(5).

These losses are caused by many factors, like illegal connections, fuel shortages, power cuts, inefficient transmittance and payment delays of governmental entities.

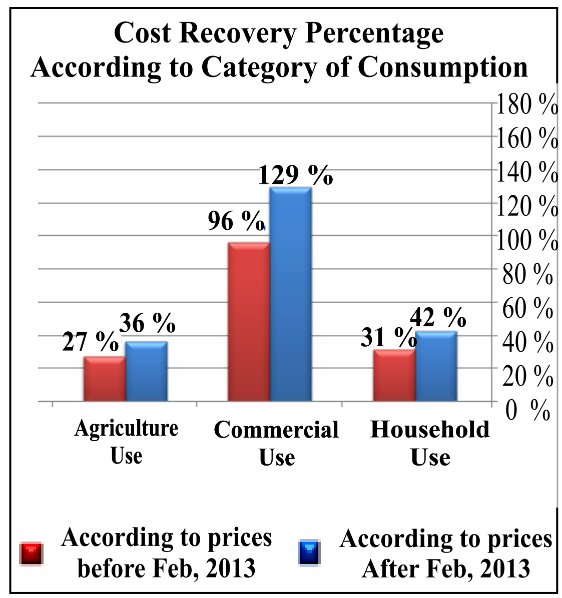


Fig (5) : Cost Recovery Percentage For Electricity Sector in Egypt- Source: ERWA Annual Financial Report, March 2012-http://egyptera.org

As a response to their commercial losses, the distribution companies were allowed to install **coded revenue meters** at unauthorized buildings and customers with illegal connections, to allow the metering of their consumption. But this allowance was shortly cancelled in Feb.2014 because it exacerbated the illegal buildings' problem, especially with the weak surveillance by the authorities and the political unrest. This cancellation caused inclining in losses for the supplier companies again **(2)**.

2- Efficiency Aspect:

(2-1) Efficiency in distribution and transmission: Due to their losses, electrical suppliers don't offer adequate budget for repair and maintenance. The outdated grid lines, shown in fig(6), cause a gap between generated and purchased electricity in Egypt. With bad quality of distribution and transmission line system, a massive leak of electrical current takes place during transmission. The deterioration of cables and transformers between supplier and consumers causes losses estimated by 8.2% to 24% of total electricity produced. More than 20 Billion KWh of power was lost in 2010/2011 alone, and an accumulated leak of 122 billion (KWh) had been lost from our power grid in last 7 years **(8)**, see fig(7).

Fig(6) : Left: Deteriorated conductors and un-insulated cables in residential destricts in Kerdasa and Bahteem. Right: Electrical Tower falling by storm in Alwadi-Algedid governorate, March.2014 - http://al-mashhad.com/News

In comparison with oil-rich countries like Kuwait and United Arab Emirates, Egypt's lost electricity due to bad transmission lines are far greater than these countries as shown in fig(8) **(9)** .

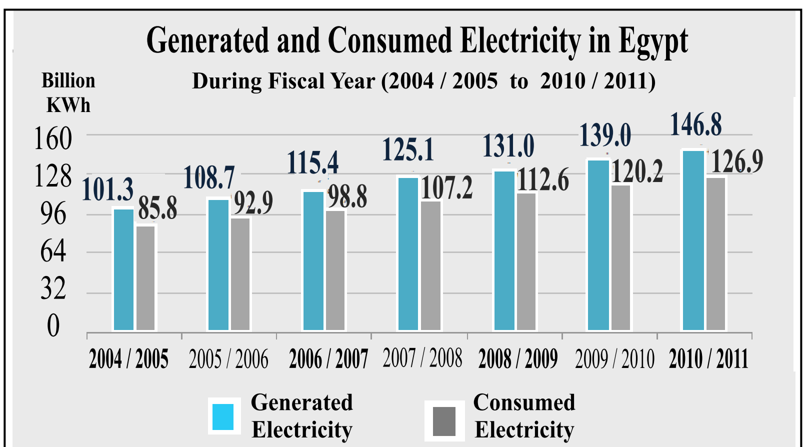
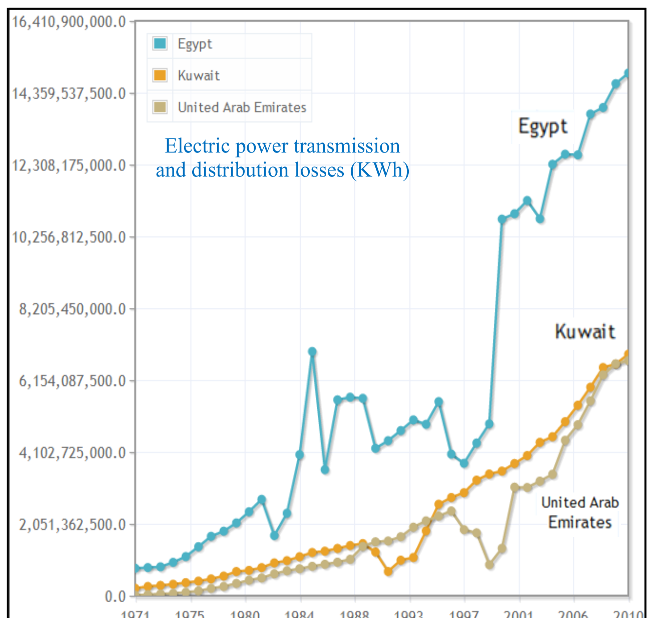


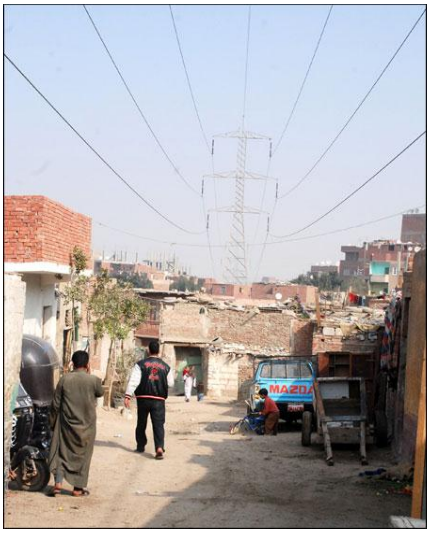
Fig (7): The Gap between generation and consumption of electricity in Egypt- Source: Parameters of Social and Economical Performance in Egypt, CAPMAS Annual Report, Feb, 2012



Fig(8) : Electric power transmission and distribution losses in Egypt and Arab world (1971-2010)- www.indexmundi.com/facts/indicators/EG.E

(2-2) Fire threats and electric shocks: As **75**% of the total low-voltage network in Egypt is non-insulated **(2)**, cables and conductors are serious threat to inhabitants. Many accidents took place due to the falling down of bare cables penetrating residential quarters, causing injury or death. See fig (9).

(2-3) Power cut-offs: As a result for their economical losses, electricity suppliers became unable to provide fuel needed for power generation plants, which resulted in frequent power-cuts all over the country. Power cuts have become one of the biggest problems facing economical development in Egypt. These almost daily cutoffs have economical, social and even political impacts, see fig (10) and (11).



Fig(9): High voltage cables penetrating a village in Geiza, Egypt -www.masress.com

Fig(10) : Strikes and standups because of power cuts-source:www.Egyptendipendent.org

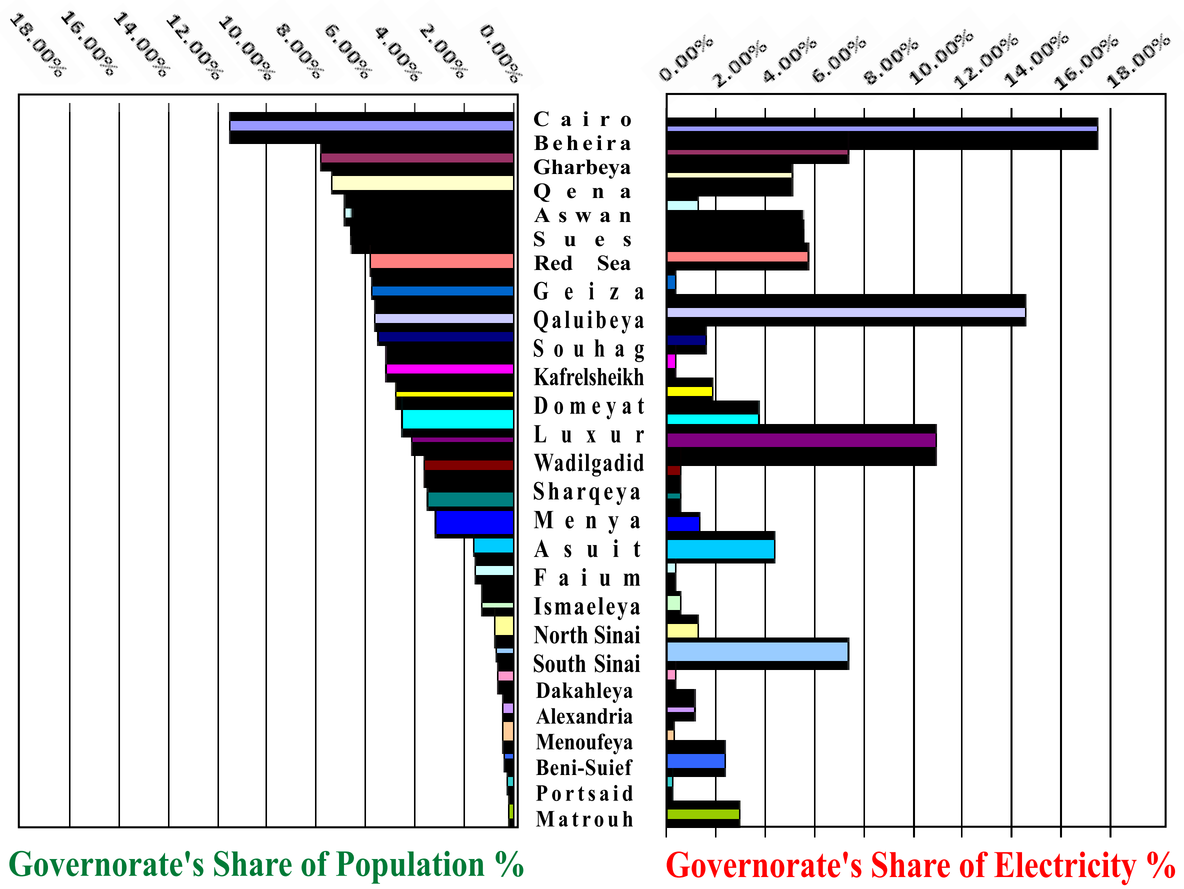
Fig(11) : Power cuts affecting politics Alyoum Alsabe3 newspaper 31/5/2013

3- Availability and Equality of distribution:

The improving of living standards and prolongation of human life itself depends, nearly, on the energy consumption per person **(10)**. Unfortunately, not all Egyptians enjoy the same share of electrical supply around Egypt. By comparing each governorate's share of population with its share of provided electricity, we find that an Egyptian citizen in Cairo enjoys more than **1890 %** of electricity than his peer in Almenya, and **2150 %** of electricity more than his peer in Suhag, see fig (12).

This unfair distribution is due to many factors. For the rural areas and remote settlements, the centralized energy expansion is heavily expensive due to the dispersed nature of both bedwin and rural communities, in addition to their low demand and scattered population.

Due to heavy population density, citizens in major cities enjoy bigger share of electricity and less installment prices which gives their children better chances in education thus better future jobs.



Fig(12): Comparing share of population to share of electricity for each Egyptian Governorate in year 2010 / 2011 -Source:www.ECOM.com

Ease of access:

Supplying electricity to any building requires many procedure, documents, inspections and approvals from municipalities and distribution companies. Many buildings may be deprived from electricity due to restrictions imposed by laws like the restricted heights imposed by civil aviation, building on agriculture lands and under high voltage transmission lines **(11).**

Due to judicial disputes or bureaucratic procedures, some owners who cannot install electricity in a legal way, try to install illegal connections to have a source of power supply till they can compromise their situation with the authorities, this action leads to more commercial losses for supplier companies **(11).**

4-Sustainability of Central Electricity sector:

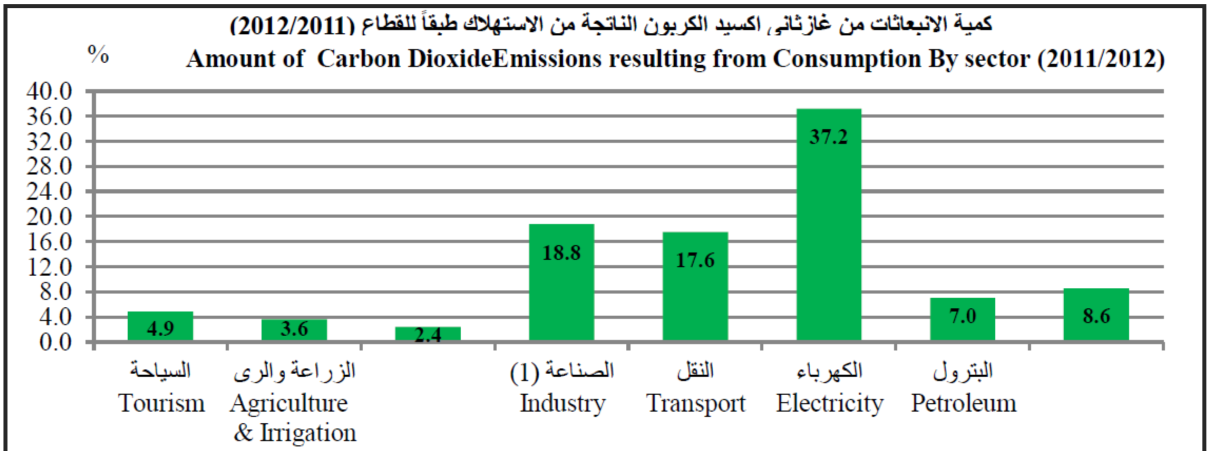
(4-1) Greenhouse effect:

Electricity sector is the biggest source of greenhouse gas emissions globally, according to the U.S. Environmental Protection Agency (EPA) **(12).**

Carbon dioxide (CO_2) makes up the vast majority of greenhouse gas emissions from the sector, but smaller amounts of methane (CH_4) and nitrous oxide (N_2O) are also emitted. These gases are released as a result for two factors:

- The combustion of fossil fuels, such as coal, oil, and natural gas, to produce electricity.
- The usage of sulfur hexafluoride (SF_6), in insulating electricity transmission and distribution equipment **(13).**

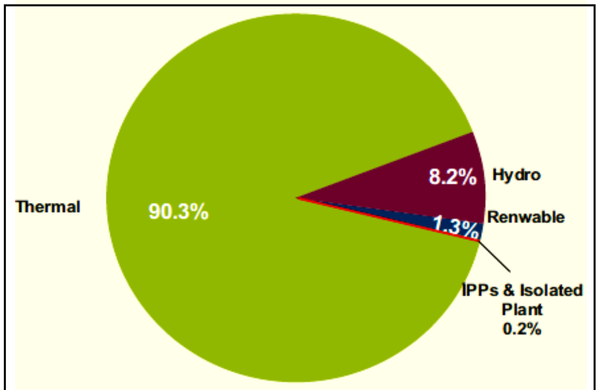
In Egypt, electricity sector is responsible for even more damage, in year 2011/2012; this sector was responsible for 37.2% of Co2 emissions. Next to it was the industry sector with 18.8% (about half of electricity share), and then the transportation, then Petroleum, see fig (12).



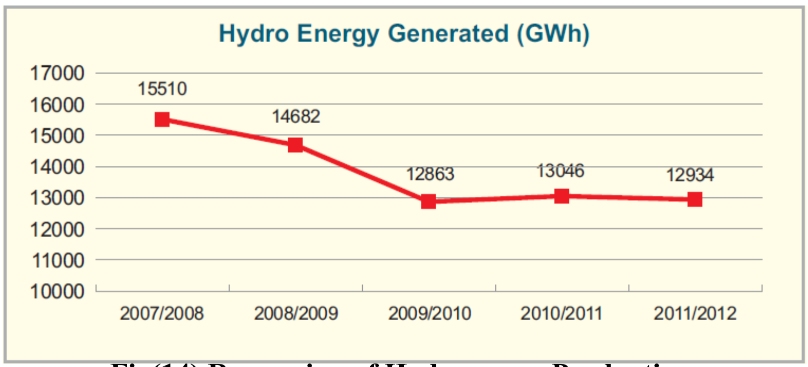
Fig(12) : Co2 Emmission percentage in Egypt by sector- Source: www.capmas.org.eg

(4-2) Hydropower regression effect:

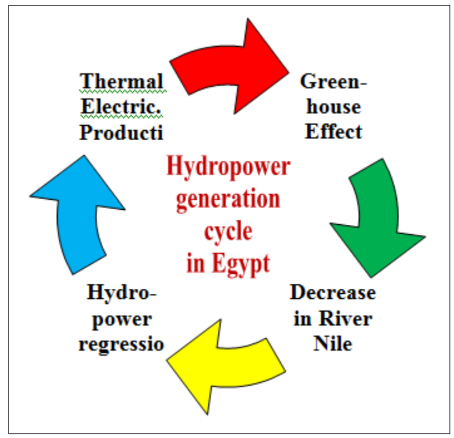
After 50 years of building the High Dam in Aswan, Egyptian electricity sector still depends mainly on thermal technology to generate electricity. The hydropower from the dam contributed only with **8.2%** in 2011/2012, while thermal sources contributed with **90.3%** of total generation, see fig (13). Hydro power in Egypt is declining because of the decrease of water levels in the River Nile due to draughts and climatic changes.As shown in fig (14), hydropower has a decrease of 16% in five years duration. The less hydropower generated, the more fuel burnt to generate thermal power. So, it is a closed circle: The electricity sector causes the greenhouse effect, which by turn helps in decreasing the level of River Nile, this causes the regression of hydropower generation, so, more thermal technology is used for electricity production and the green house effect is getting worse, and so on. See fig (15).



Fig(13) Energy Generated and Purchased by Type and Technology- Egyptian Electricity Holding Company annual report 2011/2012



Fig(14) Regression of Hydropower Production- Egyptian Electricity Holding Company annual report 2011/2012



Fig(15): Hydropower generation cycle in Egypt

The problem is expected to exacerbate after the completion of Al-Nahda Dam in Ethiopia, which will greatly affect the flow of River Nile and decrease the hydropower generation as well.

Fuels used for production:

Electricity sector in Egypt depends on fossil fuel for generating power. As seen in table (2), about 5000 kilo tons of Heavy Fuel Oil (H.F.O) are consumed annually to generate electricity.

Fuel Consumption (by Type)*

Item		10/11	11/12	Variance %
H.F.O	Ktons	5302	4605	(13.1)
N.G	Million m³	25894	29210	12.8
L.F.O	Ktons	3.3	3.5	6.1
Special L.F.O	Ktons	81.7	59.2	(27.5)
Total	Ktoe	27430	29728	8.4

Table(2) : Fuel Consumption in Electricity Production in 2010/2012- Egyptian Electricity Holding company Annual Report 2011/2012

Heavy fuel oil (HFO), or "residual fuel oil" is based on the high viscosity, tar-like mass which remains after crude oil has been cracked to produce lighter hydrocarbon products such as methane, hydrogen, petrol (gasoline), distillate diesel fuels and heating oils or feedstocks for lubricants.

Fig(16) : Heavy Fuel Oil used in electricity production- www.epa.org

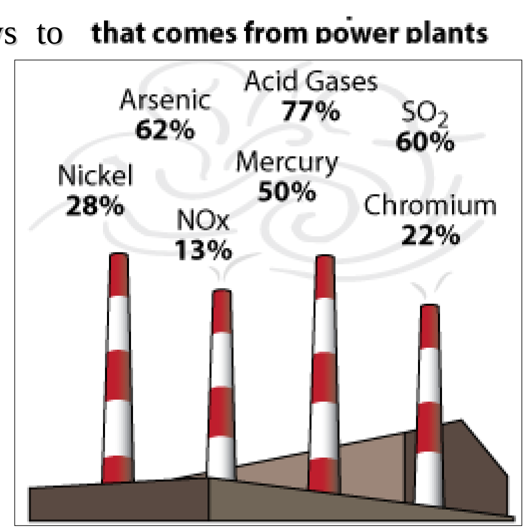
As a residual product, HFO is a relatively inexpensive fuel – typically its costs around 30% less than distillate fuels. It thus became the standard fuel for large marine diesel engines. Its use required extensive adaptation of the injection system and other components of low and medium speed engines - which are still the only engines capable of running on HFO **(14)** .

The use of HFOs has raised concerns over their environmental impacts and, in particular, their contribution to anthropogenic (human-induced) climate change caused by the greenhouse gases emitted by the burning of HFOs to generate power. The ("HFO") emissions can adversely affect human health. These emissions are nitrous oxides, sulfur oxides and particulate matter. **(14).**

Light Fuel Oil and Special Light Fuel Oil are slightly used for generating. The main fuel used is Natural Gas as the less environmentally damaging fossil fuel available in Egypt.

Environmental Impacts of H.F.O and L.F.O usage in generating electricity:

Although power plants are regulated by national laws to protect human health and the environment, there is a wide variation of environmental impacts associated with power generation technologies. There is specific air, water, and solid waste releases impacts associated with oil-fired electricity generation.



Fig(17) : Percentage of toxic emissions generated from electricity generation plants- www.EPA.gov.

Air Emissions:

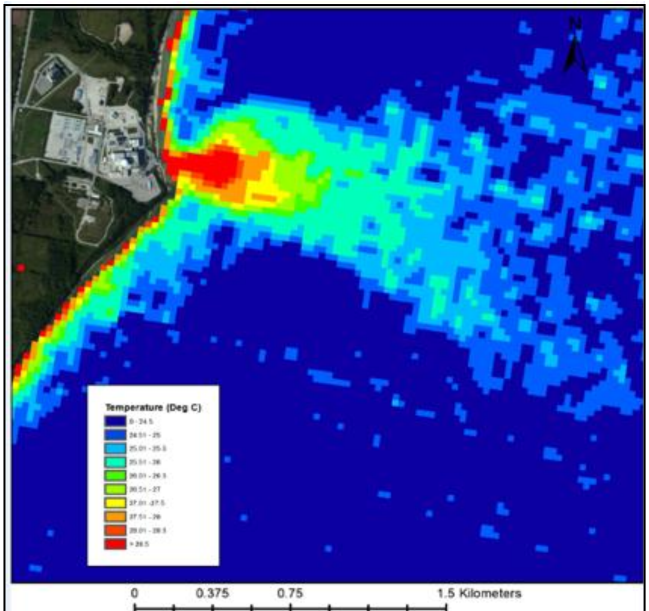
Burning oil at power plants produces nitrogen oxides, sulfur dioxide, carbon dioxide, methane, and mercury compounds. The amount of sulfur dioxide and mercury compounds can vary greatly depending on the sulfur and mercury content of the oil that is burned.

The average emissions rates from oil-fired generation are: 1672 lbs/MWh of carbon dioxide, 12 lbs/MWh of sulfur dioxide, and 4 lbs/MWh of nitrogen oxides **(14).**

In addition, oil wells and oil collection equipment are a source of emissions of methane, a potent greenhouse gas. The large engines that are used in the oil drilling, production, and transportation processes burn natural gas or diesel that also produce emissions.

Water Resource Use:

Thermal power plants use large quantities of water for steam production and cooling. Thermal release in water bodies may raise temperature up to 19 degrees at field of hundred miles, see fig (18). This action increases the temperature of the water and thus many kinds of fish and aquatic lives may be killed. This damage also affects people who depend on these aquatic resources as a source of living. **(14)**



Fig(18): Power plant discharging hot water into the ocean during the cooling process in Florida, USA- http://www.bluewatersatellite.com/

Solid Waste Generation:

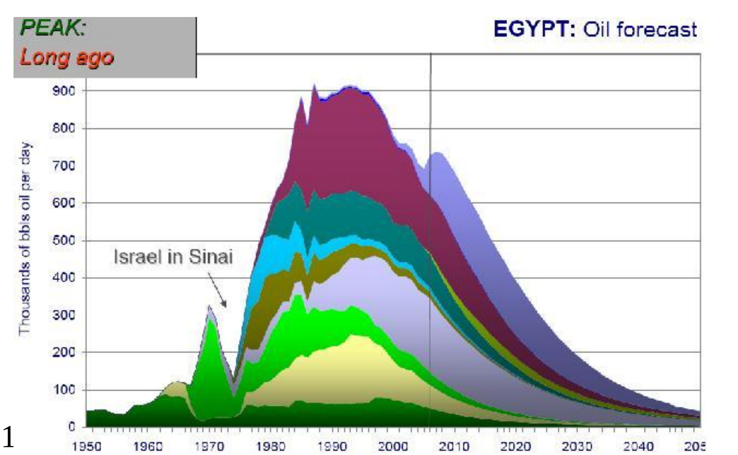
When oil is burned at power plants, residues that are not completely burned can accumulate, forming a source of solid waste that must be disposed **(14).**

Land Resource Use:

The construction of large power plants can destroy habitats for animals and plants. Waste products from power plants (such as wastewater sludge and residues) can cause land contamination if not properly disposed. In addition, when oil spills occur on land, soils are degraded **(15)** .

Reserves:

Egypt oil reserves are not well estimated due to shortage of funds needed for exploration and extraction. Oil production in Egypt started to decline 20 years ago, while consumption is inclining regularly.



Fig(19) : Egypt oil production forecast in the coming 30 years- http://www.crudeoilpeak.com/

The government compensates this gap by importing crude oil products.

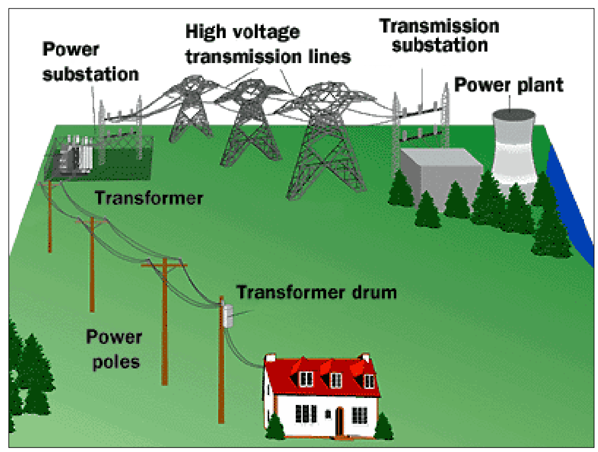
In general, electricity production sector has the lion share in CO_2 and SO_2 emissions. This sector causes **76%** of total **CO_2** global emission, and **57.4%** of **SO_2** global emission which makes this sector number one in air pollution and greenhouse effect worldwide **(16)**.

5- Land use and Impact on Urban Planning:

Central electricity grid requires certain conditions for production, transmission and distribution process. Streets are preferred to be gridiron or radial, Entangled or free form streets may affect the quality of the system.

Fig(20): Street forms that suit central electricity grid system

Land is required for towers and cabinets. Columns are installed in the streets to carry transmitting cables which affect the shape and area of the street and thus the urban form of city.



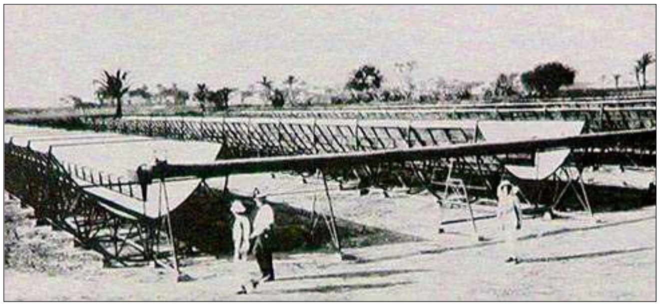
Fig(21): Land requirements for central electricity grid system

B- Decentralized Solar Systems:

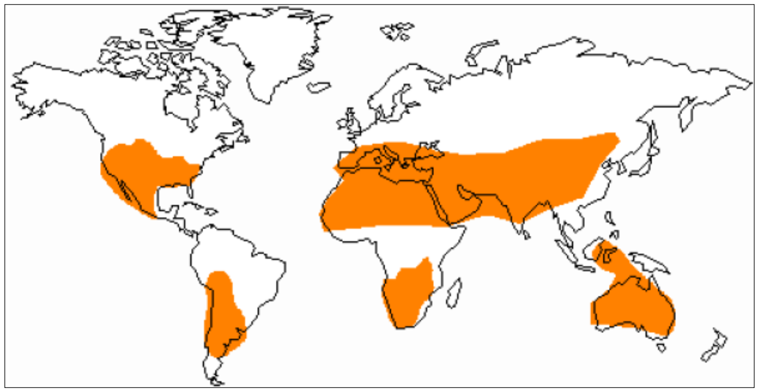
There are many systems that serve local decentralized power generation. We mention solar cells:

Egypt is in advantageous position with solar energy. It belongs to the global sun-belt, Fig. 2. In 1991 solar atlas for Egypt was issued indicating that the country enjoys 2900-3200 hours of sunshine annually with annual direct normal energy density 1970- 3200 kWh/m2 and technical solar-thermal electricity generating potential of 73.6 Petawatt.hour (PWh) **(17).**

. Egypt was among the first countries to utilize solar energy. In 1910, American engineer F. Shuman built a practical industrial scale solar system engine at Maadi south to Cairo using solar thermal parabolic collectors, Fig. 3. The engine was used to produce steam which drove a series of large water pumps for irrigation **(10)**



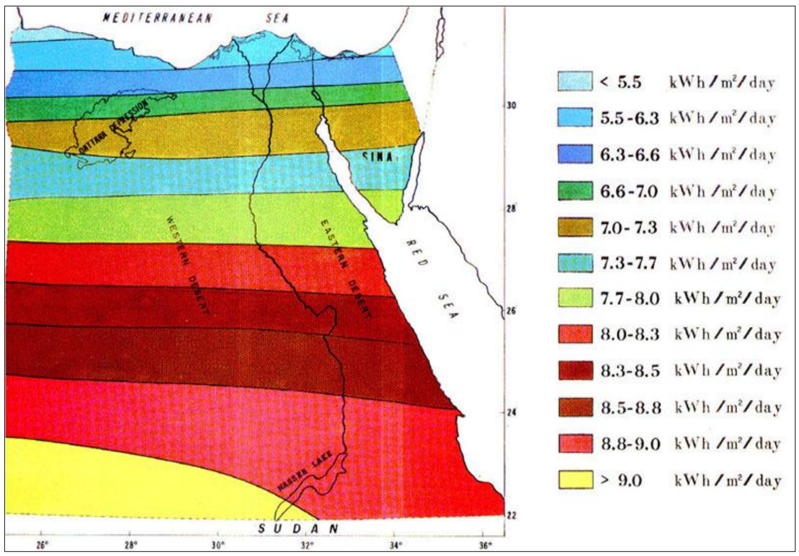
Fig(22): Frank Shuman parabolic solar collectors, Maadi 1912



Fig(23): Egypt as part of solar belt - Source: Comsan, 2010

Solar Energy Potentials in Egypt :

Solar energy utilization includes use of photovoltaic cells, solar water heating and solar thermal power. In Egypt PV systems are considered one of the most appropriate applications for remote areas away from national grid. According to NREA photovoltaic technologies are in use for lighting, commercial advertisements, wireless communications and cell phone networks, in water pumping for irrigation in newly reclaimed lands, in rural electrification, refrigeration, etc. It is estimated that present Egypt's PV systems installed capacity is close to 5 MW peak **(18).**



Fig(24) :Annual Direct Normal Irradiation zones in Egypt (Source NREA)

As an estimate with solar power parameters for Egypt, a 1 km2 of desert equipped with modern trough or Fresnel flat mirror technology can produce 300 GWh/year of solar electricity **(19).**

1-Feasibility:

A recent study shows that the cost of generating electricity by solar cells in Egypt costs 0.05 U.S. dollar (0.35 LE) / 1 kWh of generation. This cost is constant and not ascending by different consumption categories like the central grid. The same study is expecting future cost reduction due to many factors like future mass use, development in technology and climatic changes which are expected to increase solar radiation density **(20) .**

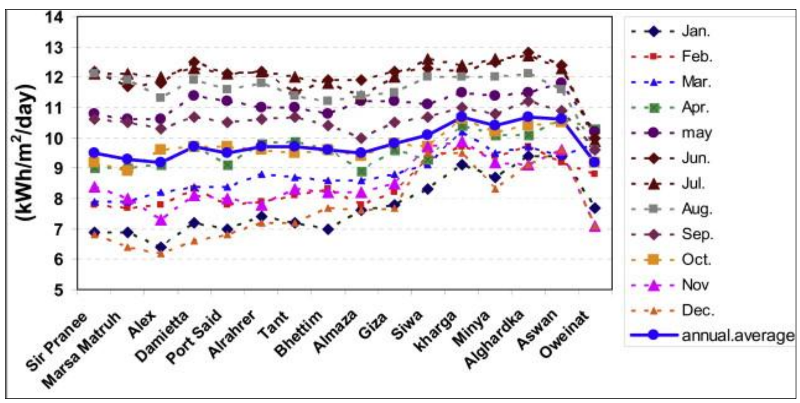
Solar electricity is also economical in long run. After the initial investment has been recovered, the energy from the sun is practically free.
Solar power directly offsets the need for building large power plants and upgrading the existing grid structure because the bulk of your electricity requirement is generated on site. The grid remains in place but does not require expensive alterations to be able to transmit increasing amounts of power from distant sources.

2-Efficiency :

Solar Energy systems are virtually maintenance free and can last for decades. It's not affected by the supply and demand of fuel and is therefore not subjected to the ever-increasing price of fossil fuel.

3-Equality of Distribution and ease of access:

Solar panels depend basically on sun exposure. Not all Egyptian cities enjoy the same density, but there are similarities in most major cities. Fig(25) shows that 16 cities are enjoying nearly the same average of solar radiation density, which is **9** to **10.8** kWh/m^2/day.



Fig(25): Solar radiation intensity map for Egyptian cities- source: (Solar atlas for Egypt).

Solar panels do not require special education. In a country like India, solar panels are installed even in the poor slums and rural areas. With little guidance, people can easily adapt with it and their children will gain new experience, see fig (26).

Fig(26) : Applied solar panels in rural Indian house- www.greenenergy.com

4- Sustainability:

Environmentally, Solar power is the most Clean and Green energy. It causes no pollution during the process of generating electricity. Solar Energy is clean, renewable (unlike gas, oil and coal) and sustainable, helping to protect our environment. Solar energy does not require any fuel. It does not pollute our air by releasing carbon dioxide, nitrogen oxide, sulfur dioxide or mercury into the atmosphere like many traditional forms of electrical generation does. Therefore Solar Energy does not contribute to global warming, acid rain or smog. It actively contributes to the decrease of harmful green house gas emission

The sun provides a tremendous resource for generating clean and sustainable electricity without toxic pollution or global warming emissions.

The potential environmental impacts associated with solar power — land use and habitat loss, water use, and the use of hazardous materials in manufacturing — can vary greatly depending on the technology, which includes two broad categories: photovoltaic (PV) solar cells or concentrating solar thermal plants (CSP).

The scale of the system — ranging from small, distributed rooftop PV arrays to large utility-scale PV and CSP projects — also plays a significant role in the level of environmental impact **(22) .**

Water Use:

Solar PV cells do not use water for generating electricity. However, as in all manufacturing processes, some water is used to manufacture solar PV components.

Concentrating solar thermal plants (CSP), like all thermal electric plants, require water for cooling. Water use depends on the plant design, plant location, and the type of cooling system.

CSP plants that use wet-recirculating technology with cooling towers withdraw between 600 and 650 gallons of water per megawatt-hour of electricity produced. CSP plants with once-through cooling technology have higher levels of water withdrawal, but lower total water consumption (because water is not lost as steam). Dry-cooling technology can reduce water use at CSP plants by approximately 90 percent **(22) .** However, the tradeoffs to these water savings are higher costs and lower efficiencies. In addition, dry-cooling technology is significantly less effective at temperatures above 100 degrees Fahrenheit.

Many of the regions in the United States that have the highest potential for solar energy also tend to be those with the driest climates, so careful consideration of these water tradeoffs is essential.

Hazardous Materials

The PV cell manufacturing process includes a number of hazardous materials, most of which are used to clean and purify the semiconductor surface. These chemicals, similar to those used in the general semiconductor industry, include hydrochloric acid, sulfuric acid, nitric acid, hydrogen fluoride, 1,1,1-trichloroethane, and acetone. The amount and type of chemicals used depends on the type of cell, the amount of cleaning that is needed, and the size of silicon wafer **(22) .** Workers also face risks associated with inhaling silicon dust. Thus, PV manufactures must follow U.S. laws to ensure that workers are not harmed by exposure to these chemicals and that manufacturing waste products are disposed of properly.

Thin-film PV cells contain a number of more toxic materials than those used in traditional silicon photovoltaic cells, including gallium arsenide, copper-indium-gallium-diselenide, and cadmium-telluride **(22) .** If not handled and disposed of properly, these materials could pose serious environmental or public health threats. However, manufacturers have a strong financial incentive to ensure that these highly valuable and often rare materials are recycled rather than thrown away.

Life-Cycle Global Warming Emissions

While there are no global warming emissions associated with generating electricity from solar energy, there are emissions associated with other stages of the solar life-cycle, including manufacturing, materials transportation, installation, maintenance, and decommissioning and dismantlement. Most estimates of life-cycle emissions for photovoltaic systems are between 0.07 and 0.18 pounds of carbon dioxide equivalent per kilowatt-hour.

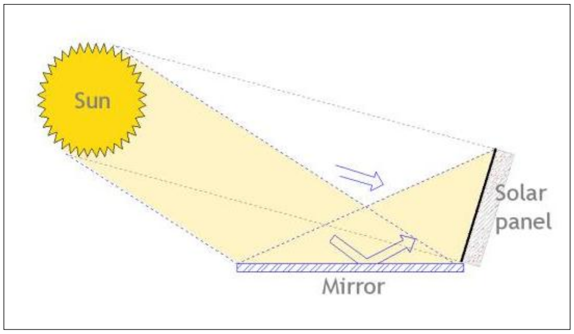
Most estimates for concentrating solar power range from 0.08 to 0.2 pounds of carbon dioxide equivalent per kilowatt-hour. In both cases, this is far less than the lifecycle emission rates for natural gas (0.6-2 lbs of CO2E/kWh) and coal (1.4-3.6 lbs of CO2E/kWh **(22) .**

5- Impact on Urban Planning and Land Use:

Land Use:

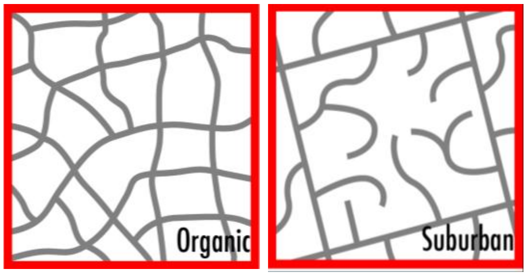
Fig(27): Solar farm land use in Berlin,Germany 2010

If applying in mass city-scale plants, depending on their location, large utility-scale solar facilities can raise concerns about land degradation and habitat loss. Total land area requirements vary depending on the technology, the topography of the site, and the intensity of the solar resource. Estimates for utility-scale PV systems range from 3.5 to 10 acres per megawatt, while estimates for CSP facilities are between 4 and 16.5 acres per megawatt.



Unlike wind facilities, there is less opportunity for solar projects to share land with agricultural uses. However, land impacts from utility-scale solar systems can be minimized by setting them at lower-quality locations such as brown-fields, abandoned mining land, or existing transportation and transmission corridors (22). Smaller scale solar PV arrays, which can be built on homes or commercial buildings, also have minimal land use impact.

If applying in residential scale, solar technology can simply be applied over the roof of any building without any special planning requirements. There is no land acquired for generation or transmission. The street form may be straight, organic or even random slums. However, some considered factors may affect this process like shading factor and the building's orientation. For the shading factor, high buildings may deprive neighbors from having adequate solar radiation necessary for generation. This problem can be solved by renting the highest roof in the street and installing solar cells for neighbors on it. For the direction problem, the solar rays may be trapped by installing reflecting mirrors which will reflect opposite directed sun rays and point them into solar cells direction.



Fig(28): Decentralized solar electricity system suit all street forms including organic and suburban

As the shading factor increases, the need for cooling in summer will decrease, which will positively affect the need for electricity as well.

1 klm2 is required to produce 300 GWh/y solar electricity. This means that the average consumption of a single Egyptian family which is 300 kwh/monthly requires 12 m2 to generate its average electricity consumption.

Fig(29) : Two young men standing beside an installed solar collector above their roof- Photo courtesy : T.H.Culhane-http://news.nationalgeographic.com/

Disadvantages :

The main disadvantage of solar energy is the initial cost. Air pollution and weather can also have a large effect on the efficiency of the cells. The silicon used is also very expensive and the problem of nocturnal down times means solar cells can only ever generate during the daytime. Solar energy is currently thought to cost about twice as much as traditional sources (coal, oil etc). Obviously, as fossil fuel reserves become depleted, their cost will rise until a point is reached where solar cells become an economically viable source of energy. When this occurs, massive investment will be able to further increase their efficiency and lower their cost.

Conclusions:

- Centralized electricity system in Egypt is facing many problems; economically, technically, socially and environmentally.
- Egypt has good potentials in solar power generation which may solve the electricity problem for generations.
- Solar electricity is sustainable, efficient and needs minimum public space for generation.
- The decentralization of power generation may solve the problem of remote rural and Bedouin areas were expanding electricity grid needs huge investments.
- There are some disadvantages of solar technology which can be resolved in the future especially with mass use and technology development.

The decentralized small scale solar system, is suitable for Egypt because it :

- Suits isolated houses and desert areas with small population where it is unworthy to establish central electrical grid.
- Suits sites with challenging conditions (e.g., mountains with steep slopes, or slums with entangled streets where utilities face gravity problems or too many bending.
- Strengthens neighborhood relations because many clusters may share the same solar system.
- Encourages innovators and young scientists to improve technologies and performance their community can appropriately adopt.
- Enhances self dependence and positive thinking.
- Creates new green jobs.

Recommendations

The Egyptian government can't offer subsidies to solar projects, but it can offer other kinds of support and incentives. New policies supporting renewable energy projects are required. Such support can play an important role in solar energy cost reduction and competitiveness. If subsidies are not available, other incentives can be offered like flexible debt conditions, low or zero interest rate loans with long maturities for solar energy domestic units. It is also recommended that new legislations are implemented by the government (represented in the **New and Renewable Energy Authority of Egypt**), to promote the adoption of solar energy technologies. Media campaigns and social leaders can also contribute in promoting sustainable solar systems in residential scale.

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