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Utilization of Solar Radiation in High Energy Intensive of the World by PV System

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Abstract: Solar energy can be converted directly into electricity by means of solar cells. Solar cells currently cost around \$3.50 per watt for crystalline cells and \$2 per watt for thin-film wafers, which are less efficient but can be integrated into building materials. Industry analysts note that between 2000 and 2005, each doubling of cumulative production resulted in a price drop of 20%. Some maintain that prices may fall even more dramatically in the future. Meanwhile the conversion efficiency has been increased more than expected. Furthermore improvements and cost reductions are expected, not only of cells but also of the solar cell modules and solar cell systems. In the development of PV much attention is given to however, the present market which is still dominated by crystalline silicon. The market might grow until multi-thousand MW a year in the next century. PV module can be a return by the same cost after five year installed the high energy consumption rate per m^2 and the intensive utilization of Arab World. Assessment studies indicate that on houses and building (roofs, walls) it might be possible to install a PV generating capacity of 50,000 Megawatt, assuming a conversion efficiency of the system of 14.7%. Such a system might be able to produce 50 Terra-watt, hour per year, about 70% of the electricity consumption we are facing today.

Key words: PV market-arab world- silicon raw material, photovoltaic

INTRODUCTION

The current development of photovoltaic production capacity increased together with intensive efforts towards the low-cost availability of the processed feedstock for the exclusive use of the PV manufacturing. Typical examples are quite encouraging in the USA, Japan, Europe, India and others. In the United States, Hemlock Semiconductor Corporation conducted an economic analysis on silicon photovoltaic production with a projected silicon price \$20/kg for a production rate of 1000 Tones per annum[1]. In Japan, the cost target in the new Sunshine Project predicted a considerable decrease in Silicon Photovoltaic cost to about \$2/Wp (based on PV modules)[2]. Thin film solar cell technologies are continually growing and in 1997 10 MWp of thin film modules were produced, representing a market share of 10%. There are mainly three options for thin film modules: devices based on amorphous silicon and polycrystalline materials based on the semiconductor compounds CdTe or Cu (In, Ga) Se_2. Amorphous silicon devices have reached an unutilized cell efficiency of 13.1%, while CdTe devices have realized a maximum cell efficiency of 16.2%[3]. Cu(In, Ga)Se_2 thin film solar cells have been fabricated by several groups at over 15% efficiency, with a world record cell efficiency of 18.8% and a record mini-module efficiency of 14.7%[4]. When comparing the three different thin film technologies Cu (In, Ga) Se_2 based solar cells have the best performance. Cu (In, Ga) Se_2 modules have also shown good long-term stability.

More details on thin film approaches can be found in the papers presented at the recent NCPV Program Review. Two billion people in the world have no access to electricity. For most of them, solar photovoltaics would be their cheapest electricity source, but they cannot afford it[5].

Why PV in the Arab world?

- In general, each square meter in the Arab world receives nearly 640 W/h. If we assume that the Arab world requires continuous electric power of 100 GW, this could be met easily by installing photovoltaic system with efficiency of 10% covering an area of 1.56×10^9 m^2 (1560 km^2), which represents only 0.011% of total area of the Arab world (147 million km^2)[6].
- Many study procedures in the Arab world especially in Egypt at PV solar energy applications denote that; the potential for PV solar energy applications in Egypt is enormous. For example: one part of this study used two commercially Photovoltaic panels which were tested during the course of the

measurements in the outdoor conditions. The first panel was a flat plate solar panel containing three squared amorphous silicon solar cell 30×30 cm with η = 6.91% produced by Chronar, UK. The second panel was a polycrystalline solar cell as a panel (3 modules) 37.5 cm^2 with η = 14.45% produced by PJ2, Japan. Cell temperatures were measured using thermocouple, which was laminated on the back surface of the PV modules using a conductive paste to ensure good thermal contact. Daily records of measurements studies for efficiencies for different types of solar cells were found to give that the mono-Si (η = 9.5%) and amorphous η = 6.5% and for poly η = 14.45%[6].

- The application of photovoltaic systems must take into account regional conditions, i.e., the resources available, the efficient energy use and demand management and system optimization to ensure that cost-effective systems are developed. The knowledge of the components market is also a critical parameter in establishing sustainable industrial applications on different activity sectors. Spectral and chemical analyses of the local raw materials in the Sinai, Egypt and Riyadh, Saudi regions show that the average silicon oxide content in the white rock/sand has the highest ratio 99.5% compared with those obtained from red sand 86.7% and limestone 13.5% as a raw materials in the Riyadh, Saudi region and Sinai, Egypt indicates that the white rock/sand is suitable for further development and particularly for use in photovoltaic manufacturing[7].
- The population of Arab world is nearly 400 million and most of their citizens are in rural area and nearly 100 million have no access to electricity and a similar number have a modest supply of electricity (100Wh per person). The electricity consumption per capital in Sudan is 26 kWh, in Yemen it is 110 kWh while in Norway its 44000 kWh and in USA it is 12000kWh[7].
- Life cycle greenhouse gas emissions are now in the range of 25-32 g/kWh and this could decrease to 15 g/kWh in the future. For comparison, a combined cycle gas-fired power plant emits some 400 g/kWh and a coal-fired power plant with Carbon capture and storage some 200 g/kWh. Only wind power is better with a mere 11 g/kWh. Every technology causes some amount of harm to the environment. Unlike fossil fuel based technologies, solar power does not lead to any harmful emissions during operation, but the production of the panels leads to some amount of pollution.

PV POWER COSTS

Crystalline Silicon cell technology forms about 90% of solar cell demand. The balance comes from thin film technologies. Approximately 45% of the cost of a silicon cell solar module is driven by the cost of the silicon wafer, a further 35% is driven by the materials required to assemble the solar module. The international attention on the climate and environmental issues has supported the photovoltaic market and gradual growth for the industry can be anticipated. Japan, Europe and the United States are three main centers that dominate the PV production as shown in Fig. 1. Third world countries such as, India, Indonesia and others have started PV manufacturing in an optimistic shape. The world PV shipment was estimated to be 80-90 MW in the year 1996 with about 70% crystalline silicon, 15% amorphous-silicon and the rest as thin-film CdTe and CulnSe2. Cumulative solar cell or photovoltaic (PV) capacity now exceeds 1,840 MW. This market growth would be very satisfying for any conventional product but in the case of photovoltaic, it is insufficient if we consider the goals. The top five producers in 2001 were Sharp, BP Solar, Kyocera, Siemens Solar and Astro Power, accounting for 64% of global output [R1]. Both Japan and the United States were net exporters of solar cells. Almost two thirds of U.S. output was exported, while Japan exported 42% of its total. The cost of electricity from solar cells remains higher than that from wind or coal-fired power plants for grid-connected customers, but it is falling fast due to economies of scale as rising demand drives industry expansion. Solar cells currently cost around $3.50 per watt for crystalline cells and $2 per watt for thin-film wafers, which are less efficient but can be integrated into building materials. Some maintain that prices may fall even more dramatically in the future. The

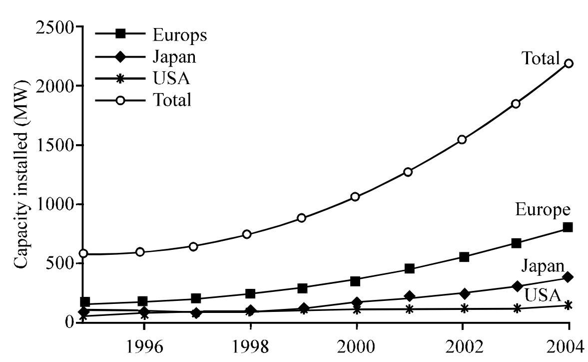

Fig. 1: World PV production[5]

Table 1: The total cost in US cents per kWh of electricity generated by a photovoltaic system

The annual energy output in kWh expected from 20 years each installed kW_p (kWh/kW_p y)									
2400	2200	2000	1800	1600	1400	1200	1000	800	$\$/kW_p$
0.8	0.9	1	1.1	1.3	1.4	1.7	2	2.5	200
2.5	2.7	3	3.3	3.8	4.3	5	6	7.5	600
4.2	4.5	5	5.6	6.3	7.1	8.3	10	13	1000
5.8	6.4	7	7.8	8.8	10	12	14	18	1400
7.5	8.2	9	10	11	13	15	18	23	1800
9.2	10	11	12	14	16	18	22	28	2200
11	12	13	14	16	19	22	26	33	2600
13	14	15	17	19	21	25	30	38	3000
14	16	17	19	21	24	28	34	43	3400
16	17	19	21	24	27	32	38	48	3800
18	19	21	23	26	30	35	42	53	4200
19	21	23	26	29	33	38	46	58	4600
21	23	25	28	31	36	42	50	63	5000

Kilowatt-hours per peak kilowatts per year at various locations[R2]

European Photovoltaic Industry Association suggests that grid-connected rooftop solar systems could account for 16% of electricity consumption in the 30 members of the Organization for Economic Co-operation and Development by 2010. If costs of rooftop PV systems fall to $3 per watt by the middle of this decade, as projections suggest, the market for residential rooftop solar systems will expand.

For the industry as a whole, output is expected to increase at 40-50% annually over the next few years, bringing the solar age ever closer[R1].

The Table 1 below shows the total cost in US cents per kWh of electricity generated by a photovoltaic system. The row headings on the left show the total cost, per peak kilowatt (kW_p), of a photovoltaic installation. The column headings across the top refer to the annual energy output in kWh expected from each installed kW_p. The calculated values in the Table 1 reflect the total cost in cents per kWh produced. They assume a 10% total capital cost (for instance 4% interest rate, 1% operating and maintenance cost and depreciation of the capital outlay over 20 years). PV installations World-wide increased by 57% in 2004. Terrestrial photovoltaic shipments continue to grow at the rate of 20% per year, but total shipments were still only 152 MW per year corresponding to a value of about 0.7-1 billion US $. From these studies one might expect a shipment of 1000 MW/year at a cost of $ 2-3 per watt and as much as 20,000MW year at a cost of $ 1-2 per watt [8,9].

PRODUCTION AND TRADE IN PV CELLS AND MODULES

Solar cell energy conversion efficiencies for commercially available mono-crystilline Si solar cells

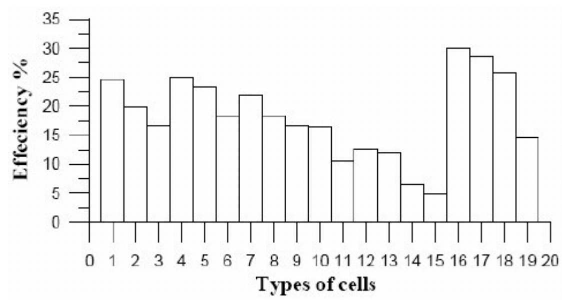

Fig. 2: The development of solar cell efficiencies

(M-Si) are around 14-16%. Amorphous silicon cells (A-Si) accounted for nearly 40% of the modules shipped to 37% of the total shipments. Polycrystalline silicon cells (P-Si) stayed at a level of 22%[10]. Worldwide more than 60 industrial companies produce solar cells and modules. In 1988 the largest share in the module shipments has been delivered by ARCO solar (5.5 MW), followed by Sanyo (4.8 MW), Solarex (3.2 MW) and Chronar (2.9 MW)[10]. Adding the expenditures of the industry, the yearly total investment in PV R and D can be estimated to be 500 million dollars. Several studies have been made to estimate the market potential of PV as a function of cost which are estimated deployment studies for 2010, for example refs.[11], [12] and [R2]. Fig. 2 shows the development of solar cell efficiencies obtained in laboratory situation of the different types of solar cells, classified and clear in Table 2.

Around 50% of the world's solar cell production was manufactured in Japan in 2003. United States accounted for 12%. On the supply side, the amount of product manufactured by PV cell manufacturers worldwide reached 742 Megawatts in 2003. Japan has taken over from the United States as the largest net exporter of PV

Table 2: Confirmed terrestrial cell and sub module efficiencies measured under the global AM 1.5 spectrum (1000 W m^{-2}) at 25°C

Code	Classification	Cells types
1	M-Si Crystalline	
2	P-Si polycrystalline	Silicon cells
3	Si Supported film	
4	GaAs Crystalline	
5	GaAs thin film	III-V cells
6	GaAs polycrystalline	
7	Inp Crystalline	
8	CIGS Cell	
9	CIGS Sub module	Polycrystalline
10	Cd Te cell	thin film
11	Cd Te sub module	
12	A-Si cell	Amorphous
13	A-Si cell sub module	
14	Nan crystalline dye	Photochemical
15	Nan crystalline dye	
16	GaLnP/GaAs	
17	GaLnP/GaAs/Ge	Multi-junction
18	GaAs/CIS thin film	cells
19	A-Si/CIGS thin film	

cells and modules. Four Companies account for over 50% of solar cell production: Sharp, Kyocera, BP Solar and Shell Solar. Among the top five manufacturers, Sharp remains the largest and has shown the fastest growth over the last five years. Sanyo, fifth largest, has shown the second highest rate of growth over the same period. M-Si and P-Si has a 15% efficiency has a cost around $ 5/Wp and Thin film cells CdTe, CuInSe2 gives 10-15% efficiency and has a cost around $(3-4)/Wp [13]. Equipment prices; P-Si modules (manufacturing costs): has a cost around \$2,000/kW_p, P-Si modules (commercial prices Installation: from \$600 up to \$2,000/kW_p (self-construction: from \$100 up to \$400/kW_p) and Inverter for grid feed-in: has a cost around \$400 /kW_p [R3].

NSTALLED PHOTOVOLTAIC TOTALS

Total peak power of installed solar panels is around 5,300 MW as of the end of 2005. (IEA statistics appear to be under-reported: they report 2,600 MW as of 2004, which with 1,700 installed in 2005 would be a cumulative total of 4,300 for 2005). The three leading countries (Japan, Germany and the USA) represent 90% of the total worldwide PV installations Equipment prices; P-Si (manufacturing costs): has a cost around \$2,000/kW_p, P-Si modules (commercial prices): from \$3,490 up to \$5,100/kW_p per m², Installation: from \$600 up to \$2,000/kW_p (self-construction: from \$100 up to \$400/kW_p) and Inverter for grid feed-in: has a cost around \$400/kW_p [R3]. Deployment of solar power depends largely upon local conditions and requirements. But as all industrialised nations share a need for electricity, it is clear that solar power will increasingly be used to supply a cheap, reliable electricity supply; a view of the deployments of solar power of all types is given at Deployment of solar power to energy grids. In 2004 the worldwide production of solar cells increased by 60% but silicon shortages reduced growth afterwards. For comparison, the largest non-photovoltaic solar plant, the solar project trough-based SEGS in California produces 350 MW and the largest nuclear reactors generate more than 1,000 MW. A plant in Australia, which will not come into service until 2008, is expected to be 154 MW when it is completed by 2013[R4,R5].

ARAB WORLD PV APPLICATIONS

Most of the Arab countries use the electricity mainly for air conditioning and water production to overcome the harsh environment. This is made by burning natural gas and light hydrocarbon fuel, which are exhaustible (non sustainable) and polluting. The demand on energy is expected to grow substantially due to the growing investment, especially in building and construction sector (sky scrapers and artificial tourist islands). The data for nearly 280 stations from 19 Arab world cover latitudes from 0° (Mogadishu, Somalia) to 37° N (Aleppo, Syria) and longitudes 15°W (Nouakchott, Mauritania) to nearly 60°E (Salalah, Oman) with different elevations from the sea level[14] and Atlas of the Arab World, including the most famous persons for 16 Arab states including 207 cities[15]. To estimate the practical price to get at one watt from the global solar radiation incident at Arab world using Photovoltaic module were tested. The Arab countries are characterized and blessed with abundant global solar radiation, i.e., ranging from 5.1 kWh/m^2/day (Iraq) to 6.7 kWh/m^2/day (Mauritania). Even more, the maximum recorded annual mean sunshine duration ranges from 7.5 h (Tunis), to 10.7 h (Egypt).These data are much larger by, at least, 3 times compared to European countries. Using the data base for the Solar Radiation Atlas for the Arab World[14], Polycrystalline modules are worked in standard condition solar irradiance (SI = 1000 W m^{-2}), solar reference spectrum AM 1.5, cell temperature 25°C, 14.6% efficient (η), 10×10 cm square. Voc = 0.617V, I_{sc} = 3.07A and P_{max} = 1.46W. The common price for this module around P = \$9.50 USD each from[R6]. From the data describe before can be estimated according to:

Table 3: The monthly recorded mean of the Price USD $ (W h/m^2 per day) in most Arab world

Code	Country	City	Dec.	Nov.	Oct.	Sep.	Aug.	Jul.	Jun.	May.	Apr.	Mar.	Feb.	Jan.
1	Sudan	Juba	11.5	9.8	8.9	7.1	8.5	6.9	8.9	7.8	7.5	8.1	10.1	10.6
2	Mauritania	Nouak chati	10.5	10.1	9.2	8.3	8.1	8.0	7.8	8.3	8.2	8.6	11.2	9.4
3	Oman	Salalah	14.9	13.8	7.3	2.0	3.1	3.4	8.2	11.7	11.5	9.9	10.3	13.4
4	Saudi	El-Medina	12.0	11.2	10.3	8.7	8.4	8.3	8.5	8.8	9.0	9.5	9.7	10.5
5	Algiers	Tamanraset	11.7	11.3	11.8	8.5	8.6	8.6	7.7	8.0	8.5	8.1	10.4	11.6
6	Philistine	Jerusalem	12.9	13.3	11.6	9.9	9.2	8.9	7.8	7.9	8.7	9.7	11.4	13.1
7	Sudan	Khartoum	11.9	12.0	10.9	9.6	9.6	9.0	9.3	11.5	9.6	8.6	12.5	12.0
8	Egypt	Cairo	7.8	15.0	13.1	11.2	10.6	10.2	9.9	9.8	9.8	8.9	12.8	8.0
9	Tunis	Tunis	11.7	12.4	10.6	10.5	10.3	10.0	9.2	8.9	8.5	10.0	12.5	13.1
10	Egypt	Aswan	13.5	11.8	9.9	9.5	9.3	8.9	10.2	10.2	10.3	9.9	11.3	14.1
11	Morocco	Marrakech	14.5	12.9	11.1	10.1	9.7	9.6	9.4	9.1	9.2	10.1	11.5	13.7
12	Jordon	Aquabaa	13.1	13.3	12.2	10.6	10.0	9.9	9.4	8.8	8.7	9.0	11.3	15.7
13	Abu Dhabi	Abu Dhabi	13.6	13.5	11.7	10.6	10.1	9.8	9.4	9.6	9.6	9.9	11.4	13.0
14	Algiers	Oran	15.8	13.8	12.1	10.4	9.9	9.6	9.0	9.0	8.9	10.0	11.7	14.0
15	Egypt	Hyrghada	14.8	12.3	10.1	9.5	9.0	9.6	9.8	9.8	10.2	12.1	14.6	16.0
16	Bahrain	Bahrain	15.9	14.6	13.1	11.7	11.1	10.0	10.0	9.4	9.1	10.5	10.8	13.3
17	Jordon	Amman	15.0	14.2	13.0	11.3	10.7	10.3	10.0	9.2	9.1	10.4	12.4	15.3
18	Saudi	Riyadh	13.6	12.0	11.5	11.7	11.8	11.6	11.7	11.0	8.8	10.7	12.2	14.8
19	Libya	Tripoli	17.1	13.7	13.1	11.7	13.2	10.9	10.1	10.3	7.3	10.5	12.0	14.0
20	Libya	Sert	15.1	15.2	13.6	11.5	11.9	12.4	10.8	9.8	8.8	10.5	12.2	13.7
21	Algiers	Alger	16.4	13.6	13.5	11.2	10.6	10.4	10.7	9.9	10.3	10.7	12.9	15.5
22	Morocco	Casablanca	15.8	15.3	12.9	11.7	10.7	10.2	11.3	9.8	10.7	10.9	13.1	13.8
23	Qatar	Doha	14.4	14.9	13.5	12.2	12.1	11.5	11.6	11.1	9.2	10.4	12.1	14.2
24	Iraq	Baghdad	14.8	14.5	13.4	12.4	11.4	10.9	11.0	11.6	10.1	10.8	12.8	14.0
25	Syria	Damas	20.6	20.6	16.3	12.1	11.0	10.1	10.0	13.0	6.9	11.7	12.2	17.0
26	Yemen	Sana	16.1	17.7	17.4	12.0	10.8	10.9	11.9	11.8	11.5	11.5	14.3	17.0
27	Iraq	Mosil	14.3	17.9	15.9	14.5	13.9	13.1	12.8	12.0	11.6	10.4	13.6	15.4

$$C = \frac{P}{G \times \eta / S}$$

Where:

G = The incident of global solar radiation at any city.
S = The measurements of sunshine duration (h).
C = The price of one watt equal.

Table 3 shows the monthly cost for one watt in different cities in Arab world where standard result corresponds to the previous practical result[15].

Fig. 3 describes the annual result to degradation of one watt cost. There are several technological approaches for solar cells manufacturing. Producing commercial solar cells requires: (a) availability of raw material, (b) adoption of a suitable process for mass production of Photovoltaics and (c) a demand for Photovoltaic. In Saudi Arabia, there are already several private companies involved in the PV industry. Most of their PV modules are assembled locally with an estimated unit price $5-6/Wp. The photovoltaic market at national/international levels will be discussed next (Al-Gazira Co. and BP Solar Arabia Ltd, 1997). It is clear that the total cost, per peak watt/h (Wh m^{-2}), of a photovoltaic installation. This varies by geographic region because the average insulation depends on the average cloudiness and the thickness of atmosphere traversed by the sunlight. It also depends on the path of the sun relative to the panel and the horizon. This implies that the orientation of the panel should be optimized for the latitude at which it is used. (In theory the orientation can be changed from hour to hour or, more practically, from month to month, but this is rarely done). The calculated values in the Fig. 4 reflect the total cost in per kWh/y by $USD at one, five and ten years produced.

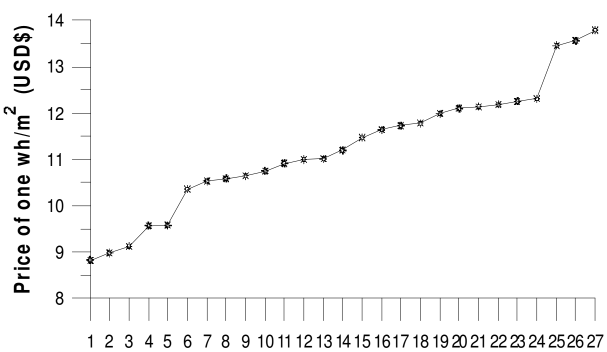

Fig. 3: Annual mean recorded of one W h/m^2 USD $ for Arab world Coded in Table 3

Arab world is characterized by the high sunshine duration per year around 300 sunny days. Normally, photovoltaic modules have 25 years' warranty, but they should be fully functional even after 30-40 years). It is clear from the curves that; the decrease in the cost of one Watt per hour

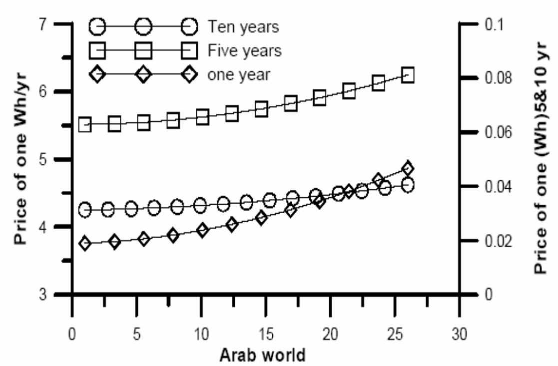

Fig. 4: The total cost $USD at one, five and ten years produced in Arab world

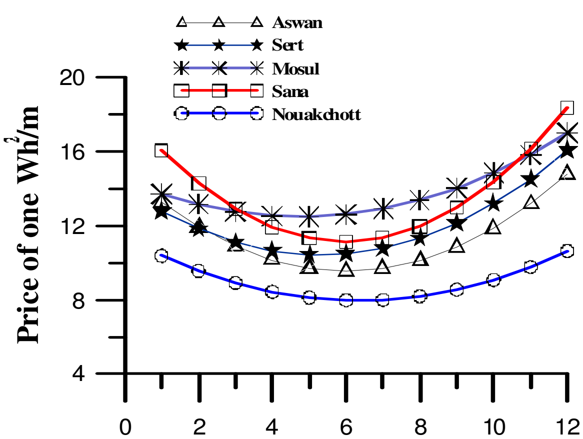

Fig. 5: The cost of one watt/h/m^2 production of Arab world countries by $USD at different latitude

at long times that make the economic return is very beneficial from many sides: economy and limits from the energy problem. PV module can be a return by the same cost after five years due to the high intensity of global solar energy rate per m^2.

Fig. 5 shows the cost of one Wh/m^2 production of Arab world by $USD covering different latitudes. It is clear that; the general curves at the same symmetry except at Sane, Yemen that return to the effect of insulation cloud covered at the summer months (June, July, August) which due to effect at decrease at sunshine duration. Hence, related to decrease the cumulative of income global solar radiation. But the minimum prices are coming from the Nouakchott (Mauritania), Aswan (Egypt), Sert (Libya), Mosul (Iraq) and Sane (Yemen).

Fig. 6 shows that the PV-market in Saudi Arabia is still small, but it is expected to increase in the coming years to meet the increased electrical energy demand at

Table 6: The annual mean of the global solar radiation in the Arab World Kw

A	City	A	City	A	City
5.9	Aquaba	5.1	Baghdad	3.5	Bahrain
6	Abu Dhabi	5.1	Doha	4.1	Mosul
6.2	Khartoum	5.1	Oran	4.4	Alger
6.3	Aswan	5.1	Riyadh	4.6	Sane
6.4	El-Medina	5.3	Jerusalem	4.8	Salalah
6.6	Tamanraset	5.4	Cairo	4.8	Tunis
6.7	Nouakchott	5.4	Marrakech	4.9	Damask
		5.5	Juba	5	Seart
		5.6	Amman	5	Tripoli

A: Annual

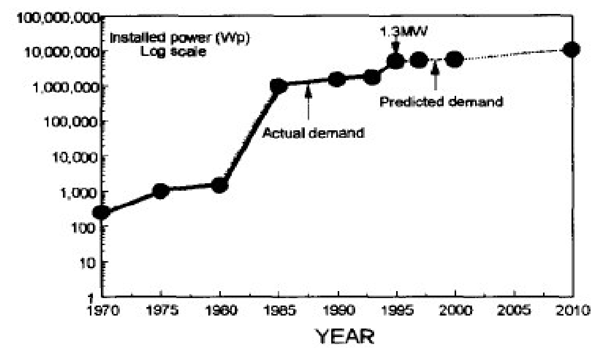

Fig. 6: The photovoltaic market in Saudi Arabia (1970-2010)[7]

both national and international levels. Consequently, the silicon raw material for photovoltaic should be considered seriously for further investigation towards silicon solar cells manufacturing. In Saudi Arabia, the photovoltaic market is still small and the accumulated installed capacity is about 1.3 MWp according to the available data. It is expected that PV-demand will increase gradually in the coming years, since the government is considering new measures for energy conservation and special attention will be given to remote regions. It is expected that the installed PV capacity will be about 0.8 MWp/year. The estimated PV demand urges the energy decision-makers to take action concerning the PV-manufacturing in Saudi Arabia[7]. Table 6 shows the annual mean of the global solar radiation in the Arab World kW h/m^2/day; The maximum annual mean average global solar radiation on a horizontal surface reaches about 6.7 kWh m^{-2} per day in Nouakchott, Aswan and El-Medina and the minimum about 3.5-4.5 kWh m^{-2} per day in Bahrain, Mosil and Alger. Egypt had installed generating capacity of 17.7 Giga-watts (GW) as of 2001, with plans to add 4.5 GW of additional generating capacity by 2007. Around 84% of Egypt's electric generating capacity is thermal (natural gas), with the remaining 16% hydroelectric, mostly from the Aswan High Dam. All oil-fired plants have been converted to run on natural gas as their primary fuel. With electricity demand growing, Egypt is building several power plants and is considering limited privatization of the electric power sector. Work has been completed on the interconnection of Egypt's electric transmission grid with other countries in the region. The Five Country inter-connection of Egypt's system with those of Jordan, Syria and Turkey was completed by 2002. Egypt also activated a link to Libya's electric grid in December 1999 [R7].

PROMOTING OF SOLAR PHOTOVOLTAIC SYSTEMS IN THE ARAB WORLD

A private company in Saudi Arabia is planning to start manufacturing multi-crystalline solar cells (4 and 5 inch wafers Efficiency after conversion to solar cells 15%, Resistively 1-3 ohm cm. Thickness 270-300 micron or 330-370 micron) by early 2005 and possibly begin production of its own modules at a factory it owns in Morocco. The Al-Afandi Solar Wafers and Cells Factory in Jeddah is in the process of commissioning a 1 MW cell production line. Al-Afandi began manufacturing and slicing wafers from ingots a year ago. The entire annual production of 500,000 wafers is being sold to two German PV companies, RWE Schott Solar GmbH and Sunways AG, he says, adding that Sunways has rated the cells from Al-Afandi 5 inch wafers at an efficiency of 15%. Plans call for the addition of a second HEM furnace as wafer production is increased to 2 million annually with six months to a year. Al-Afandi is also starting to produce 6 inch wafers, sliced at thicknesses ranging from 330 to 270 μm[R8]. Tenth of Ramadan Trade Point factory, 10th of Ramadan City, Egypt cumulated all ranges of PV modules, PV modules mounting structures, charge regulators and controllers, PV lighting fixtures, intelligent chargers and monitoring equipment[9]. In the annual 2004 the Sudanese government is development budget, the parliament passed a resolution exempting PV-system components from import duties and the value added tax. The government has further decided to invest in a joint venture with China for a module assembly line. It is expected that the combined effects of tax reduction and local assembly will reduce PV costs by 30-40% [R10].

CONCLUSION

It is concluded that Arab world solar PV can be a substantial source of energy;

- The major drawback at the moment is the high costs of PV if compared to conventional power production. When grid-connected PV systems have been implemented substantially, a further expansion of PV power requires the availability of cheap energy storage systems.
- In sunny regions the mean values of irradiated solar energy on the earth's surface amounts to 4-6 kwh/m^2/day. On an inclined surface, this value can be higher, up to- in the Egypt-20% at an inclination of 30° to the south. Energy will continue to play an important role in Arab world's economy in coming years.
- PV module can be a return by the same cost after five year installed the high energy consumption rate per m^2 and the intensive utilization of land. Assessment studies indicate that on houses and building (roofs, walls) it might be possible to install a PV generating capacity of 50,000 Megawatt, assuming a conversion efficiency of the system of 14.7%. Such a system might be able to produce 50 Terra-watt, hour per year, about 70% of the electricity consumption we are facing today.
- Recommended the PV Market is available in the Arab world in two countries; one in Egypt due to the over raw material in Sinai, Egypt, experience, scientific studies, accumulated wafer factory in Tenth of Ramadan City and high incident global radiation at Aswan, Egypt around 6.3 Kwh/m^2/day that make this industry available building. Second in Saudi Arabia which has; Raw material in Riyadh, Al-Afandi Solar Wafers and Cells Factory in Jeddah produce the wafer of multicrystalline solar cells which has the base in solar module, high incident global radiation at El-Medina, Egypt around 6.4 Kwh/m^2/day, scientific studies, support price to establish complete PV system.

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