TOWARDS A NATIONAL STRATEGY FOR PHOTOVOLTAIC INDUSTRIALIZATION

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ABSTRACT :. The utilization of photovoltaic energy requires a national plan in order to make it commercially attractive. Starting a local photovoltaic industry is a very good choice since it doesn't need advanced high technology as in microelectronics industry. Emphasis should be on local fabrication of low-cost solar cells, modules, and panels, using simple fabrication processes , such as screen-printing. A local silicon foundry is necessary for the production of the required silicon material. Low-cost techniques for the preparation of solar-grade (SOG) silicon, such as acid-treatment, and for production of silicon wafers for solar cells , such as ribbon , sheet growth, and casting should be used. At the same time, research towards reducing the cost and increasing the efficiency of single- and multicrystalline silicon solar cells, as well as examining other promising semiconductor materials for thin-film cells should be initiated. Collaborative efforts between state institutions and private sector are required.

1. INTRODUCTION

The Arab world enjoys an abundant incidence of solar radiation of 3,000 – 3,500 hours of sunshine per year, and receives more than 5.0 kW/m^2 of solar energy per day [1]. Solar energy technology may be divided into photovoltaics and solar thermal conversion. Each may be further divided into flat-plate collectors (One sun), which make use of the sun's incident radiation directly, and concentrating collectors, employing lenses or reflectors to concentrate the incident solar radiation. Solar energy may be used for domestic and industrial water heating, space heating, and industrial process heating. However, the use of solar cells enables the production of electricity directly from the incident solar radiation, which may be used directly, or it my be connected to the existing electricity grid, and therefore PV is attractive for use in remote areas. The use of photovoltaics for generating electricity is currently still limited, though, by the main disadvantage, which is the cost of the system. Photovoltaics is becoming more and more a favorite renewable energy choice because the PV generation is proven economically justifiable and reliable. PV system costs have been steadily reduced , and it continued demonstrating higher efficiencies and / or lower cost. Other reasons for the increased interest in PV is that fossil fuels are rapidly declining and will soon be depleted, and also due to increased environmental awareness

2. ENERGY AND DEVELOPMENT

Energy planning and management is a very strategic issue for any country. Research and development of renewable non-traditional sources of energy attract increased attention worldwide because of their promising features, such as being fuel free, pollution free and maintenance free, the accelerating depletion of fossil fuels, and also due to the high capital cost associated with nuclear energy.

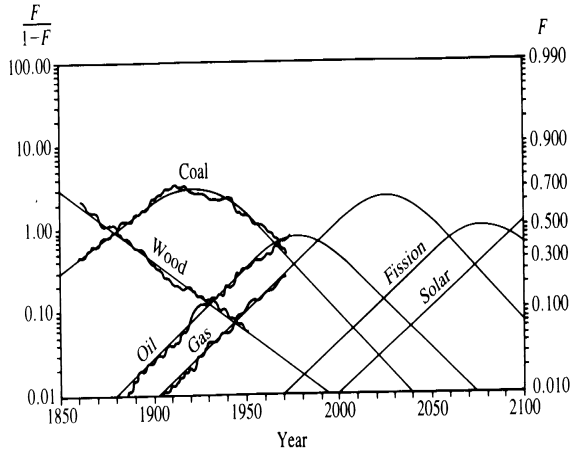

Figure 1 : History and projection of energy sources for the world versus year [1]

Several sources of renewable energy are being considered, such as solar (thermal and photovoltaic), wind, geothermal, biomass, oil shale, tidal, wave, and ocean thermal energies. Fig. (1) shows the total energy used in the United States , as supplied by various sources [1,2].

It is clear from the figure that the periods of rapid industrial growth in the United States can be identified with the large-scale availability of cheap fuels: first coal, then oil, and then natural gas. It is also clear that other sources of energy, such as hydroelectric and nuclear, started gaining a bigger share of the total energy market. Expanded use of renewable energy sources is already starting , and it is expected to increase further as their technologies develop further. Fig. (2) shows the expected estimates of maximum renewable energy sources contribution to the US energy supply in Quads (1 Quad = 1E15 BTU) of displaced fossil fuel per year [3].

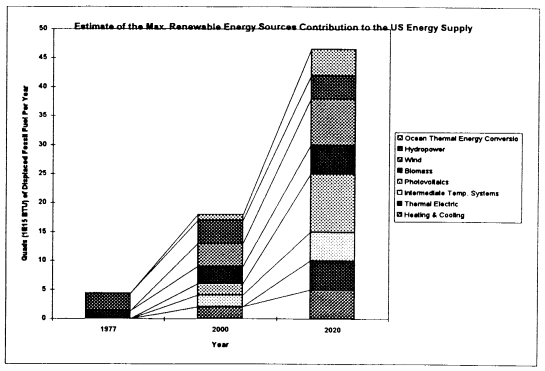

Figure 2 : Estimate of the maximum renewable energy sources contribution to the US energy supply [3]

3. PHOTOVOLTAIC ENERGY

A national strategy for the development and application of renewable energy in the Arab World has to be formulated. It is emphasized that the development of renewable energy technologies to supply five percent of the national primary energy by the year 2005, mainly from solar, wind, and biomass is an important requirement. [5]. Fig. (3) shows estimates of the worldwide photovoltaic market [6,7], demonstrating its predicted growth by the year 2000. Fig. (4) shows the photovoltaic module and system price goals (in \$ / W_p , dollars per peak-Watt, [1980 Dollars]) , set by the US Department of Energy in 1980 [7]. Photovoltaic energy has the advantages of being abundant, clean, with no wastes or pollution, maintenance-free, because of the absence of moving parts, requiring no fuel costs or running costs, and being suitable for remote and hard-to-access regions.

Photovoltaics is becoming more and more a favorite choice because the PV generation is proven economically justifiable and reliable. Its system costs have been steadily reduced , and it continued demonstrating higher efficiencies and / or lower cost. Other reasons for the increased interest in PV is that fossil fuels are rapidly declining and will soon be depleted, and also because of the increased environmental awareness [8].

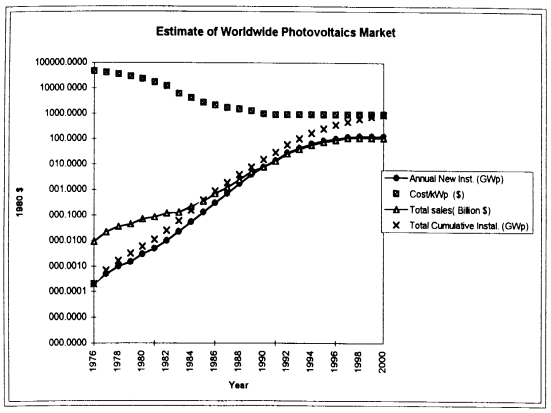

Figure 3 : Estimate of worldwide photovoltaic market [7]

Photovoltaics technology has improved very rapidly during the Eighties, and in the early Nineties PV was the energy source of choice for remote power requirements and for emergency power requirements, even when a grid power is available. It is expected that photovoltaics will become a utility option, initially for peaking power needs and later for intermediate base-loads needs [9].

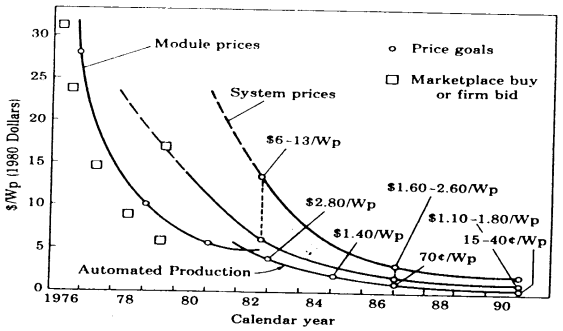

Figure 4 : Photovoltaic module and system price goals [7]

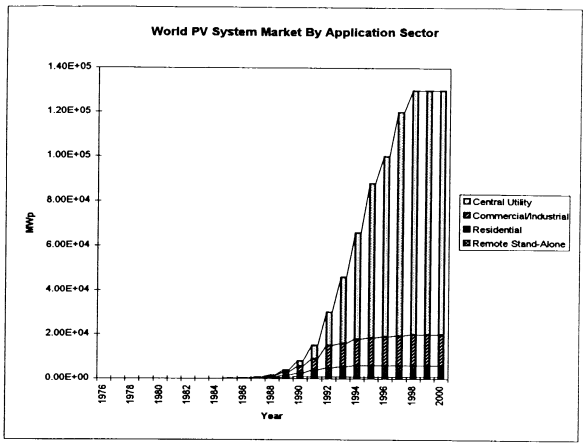

Figure 5 : Photovoltaic market by application sector [5]

Estimates of the World Photovoltaics market, by application sector, up to the year 2000 expect that while the largest PV application in the late Seventies was in remote stand-alone systems, it is expected to become in central utility by the year 2000 [5], as shown in fig. (5).

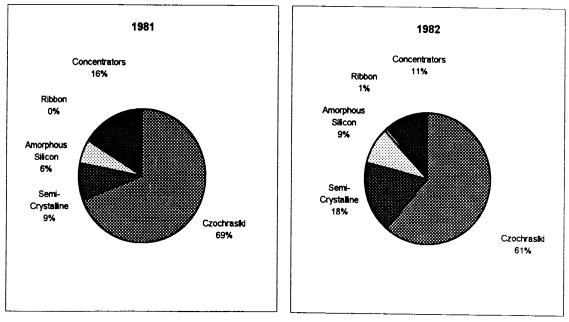

Figure 6 : Percent of PV market supplied by various silicon technologies [15]

4. LOCAL PV INDUSTRY

Some attempts have been reported which demonstrate the feasibility of local fabrication of silicon solar cells in developing countries like Egypt [11], India [12] and the People's Republic of China [13]. They stressed the urgent need to continue the development of single-crystalline silicon solar cells, as well as research into lower-cost and new solar cells, such as polysilicon and thin-film solar cells, through collaborative efforts between governmental and non-governmental institutions, as well as the private sector .

Based on cost analysis comparing single-crystalline silicon solar cells, amorphous silicon cells, and concentrator cells it is concluded that a reduction in the wafer cost and increase in the cell efficiency can significantly lower the cost of single-crystalline silicon solar cells, and that concentration seems to be a promising approach for the PV production of electricity at cost competitive for electricity mass production [14]. Figure (6) shows the percent of the photovoltaic market that was provided by the various silicon technologies during the years 1981 and 1982 [15].

Until recently, the PV industry has been almost totally dependent on silicon wafers supplied for integrated circuits, and prepared using the Czochralski method, which are very expensive to use, but now, and due to the strongly increased demand, the PV industry has started to produce its own ingots and wafers, having specifications suitable for PV purposes (large area, thin and rectangular wafers), produced from solar-grade (SOG) silicon , defined as shown in fig. (7), to have purity between that of metallurgical and that of semiconductor-grade silicon [16], and using new technology, such as ribbon and sheet growth, casting, and other techniques to achieve low cost and short energy pay-back time [17].

It is important that we start must be adopted, like that shown in fig. (8) for the automatic production of float glass and solar cells [18]. At the same time research must be carried out for reducing the cell cost and increasing its efficiency, using silicon, as well as other new and exotic materials.

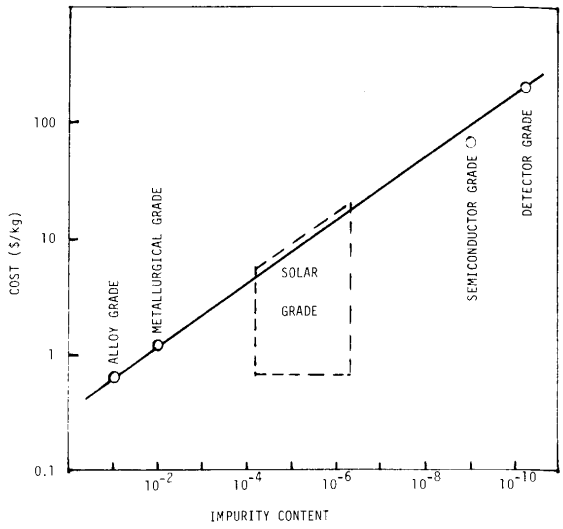

Figure (7) : Cost of silicon versus purity defining solar-grade silicon [16]

Photovoltaic industry is very suitable because it doesn't require sophisticated very advanced high technologies such as ribbon and sheet growth casting, and other techniques to achieve low cost

and short energy pay-back time [19]. It is important that we start a local photovoltaic industry as soon as possible.

5. CONCLUSIONS

A national plan is required for the efficient utilization of photovoltaic . Starting a local photovoltaic industry doesn't need advanced high technology as in microelectronics industry. Emphasis should be on local fabrication of low-cost solar cells, modules, and panels, using simple fabrication processes. A local silicon foundry is required for producing the required starting solar-grade silicon using low-cost techniques such as ribbon , sheet growth, and casting. Research towards reducing the cost and increasing the efficiency of single- and multicrystalline silicon solar cells, as well as examining other promising semiconductor materials for thin-film cells should be initiated.

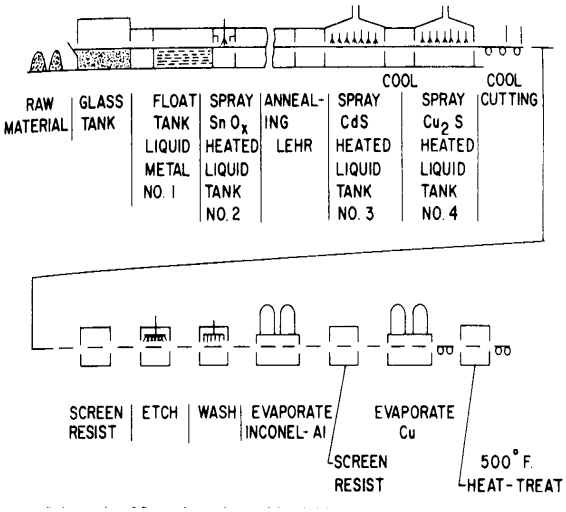

Figure (8) : Schematic of float glass plant producing solar cells [18]

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