A Study on the Present Environmental Scenario due to Pollution by Conventional Energy Sources—and Remedies:

Solar Cell with Nanotechnology

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ABSTRACT

At present, pollution is a matter of grave concern; it is occurring due to the abundant burning of fossil fuels. Among the reasons for environmental pollution, one is the conventional method of power generation to produce electricity. If a portrait of the world's pollution is taken, the countries that use non-conventional power make many times less pollution than those with conventional power usage. As a result of massive pollution, climates all over the world have been changed, and people are facing lots of problems. To remedy this vital concern, the one and only way is to adopt the habit of utilizing renewable energy sources. Among all renewable energy sources, solar energy is the only major, environmentally independent source of energy that is sustainable and can produce a good amount of energy. The basic problem of solar cell is its high cost and poor efficiency. But new technology (nanotechnology) has been discovered that will reduce the cost of solar cell, with improved efficiency.

INTRODUCTION

Power generation in the world, especially in India, depends upon thermal power stations, whereas a very little amount of power is generated from solar, wind, hydro, geothermal heat, biomass, etc. In the thermal power stations, due to the burning of fossil fuel, a huge amount of CO_2 is discharged and added to the atmosphere. Consequential increase of CO_2 raises the temperature of the atmosphere, which creates extreme draught, augments sea level, creates floods, etc. Another important aspect is that fossil fuel is a non-renewable resource. So, a better choice is renewable resources, which are enormous in quantity and put less pollution into the atmosphere.

The world community has achieved a broad consensus that the atmospheric concentration of CO_2 is increasing due to the random combustion of fossil fuel. According to the Mauna Loa Observatory in Hawaii, virtually continuous records show a rise of CO_2 from an average of 316.0 ppm in 1959 to 369.4 ppm in 2000; about 114×10^9 metric tons of carbon was added to the atmosphere in the form of CO_2 [1]. On Lampedusa Island, an Italian monitoring site like Sicily shows an increase from 360.8 ppm in 1993 to 371.3 ppm in 2000. The recorded data of CDEIAC are collected from over 50 different sampling sites [2]. The atmospheric concentration of CO_2 is increasing day by day, which has not been experienced for perhaps 20 million years (IPCC, 2001) [13]. In the advent of the 20^{th} century, the approximate CO_2 emission from fossil fuel was 0.5×10^9 ton C. From the time when energy consumption activities took place, developed areas like North America and Western Europe contributed 38% of the total in 1998; total CO_2 emission from fossil fuel combustion for 1998 has been estimated at 6.4×10^9 metric tons carbon, with another 0.2×10^9 tons to make cement.

Table 1. CO_2 emission by Sector (1998) (in percent; data from Industrial Energy Agency, 2000). [14]

Emission data from four countries (USA, Italy, Norway and China):

	Pollution due to	*Italy*	*USA*	*Norway*	*China*
1	Electric Power generation	31	44	1	40
2	Other energy industry	5	5	38	5
3	Manufacturing/Construction	19	10	21	33
4	Transport	26	30	36	8
5	Residential	16	6	3	7
6	Others	3	4	1	7

The emission of CO_2 depends upon the economy of different countries. According to the data, it is clear that the CO_2 emission per capita of the USA is nearly three times that of two European countries and nine times that of China. It is noticeable that emission occurring (via electric power section) in Norway is less than that of three other countries, as most of the electric power in Norway comes from non-fossil sources. The cumulative total of CO_2 emission from fossil fuel amounts to 270 × 10^9 tC. Although there is a carbon cycle, over the decade of 1990s the annual increase in the atmospheric concentration has ranged from 0.6 to 2.6 ppm. The vast and increasing anthropogenic release of carbon to the atmosphere is a relatively recent phenomenon. The anthropogenic emission is about 45% of the pre-industrial atmospheric stock of CO_2, and that period represents about 42% of fossil fuel emissions. This pollution makes changes in ocean uptake and biological responses, as well as in all portions of the global carbon cycle.

Due to random emission of CO_2 in the atmosphere, the temperature of every region has already been changed, and it has become hotter. Not only has the average temperature of the equatorial region increased, but also the temperature of cool climate countries has increased. In the

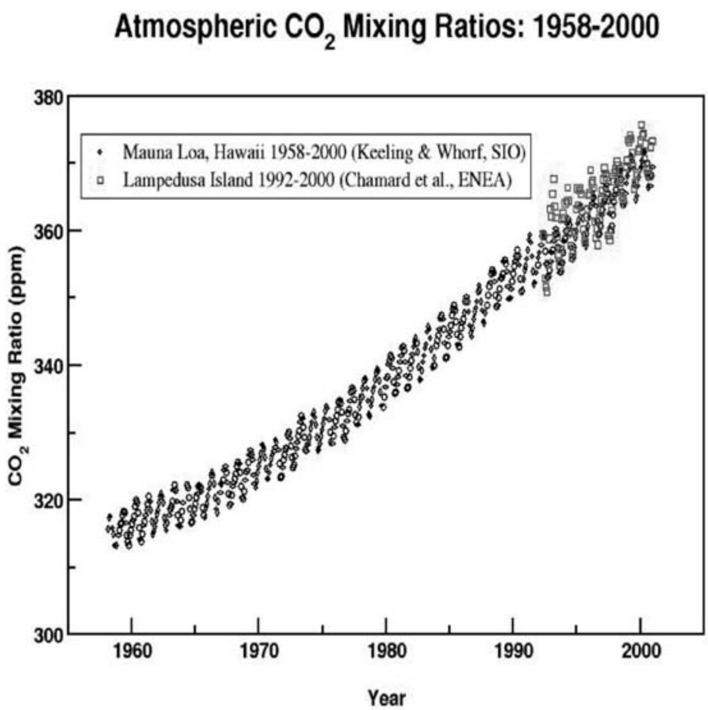

Figure 1. The atmospheric concentration of CO_2 at Mauna Loa Observatory, Hawaii, at Lampedusa Island, Italy. (1958-2000)

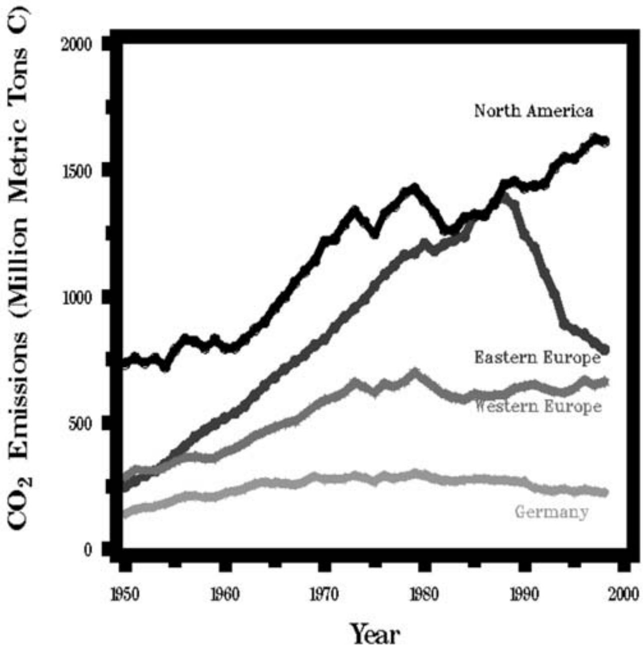

Figure 2. Emissions of CO_2, since 1950, from fossil-fuel combustion and cement manufacture in North America and Europe.

last week of July 2009, the temperature of the U.S. Pacific Northwest reached 92°F (33°C) in the very cool region of Astoria, Oregon, shattering the high temperature mark. At the Seattle-Tacoma International Airport on July 29th, it was 102°F (39°C), breaking the record for the last 118 years. Britain continued to experience its warmest heat wave in the last three years. Likewise, Australia, the USA, (California), Regina, Japan, Europe, South Asia, and Northern Africa also faced such heat waves [9].

These days, different natural calamities such as draughts, floods, and storms are occurring frequently all over the world, due to pollution. Sea level has been rising for the last 11,000 years, but the rate of rise has rapidly increased over the past 200 years as average global temperature has increased. In the 20th century, sea level rose at the rate of about 1.7 mm per year. The decade-long satellite altimetry data set shows that since 1993 the sea level has been rising at a rate of 3 mm per year.

According to the "mid-range scenario's" prediction, sea level will rise further—40 cm by 2080. The U.S. Environmental Protection Agency

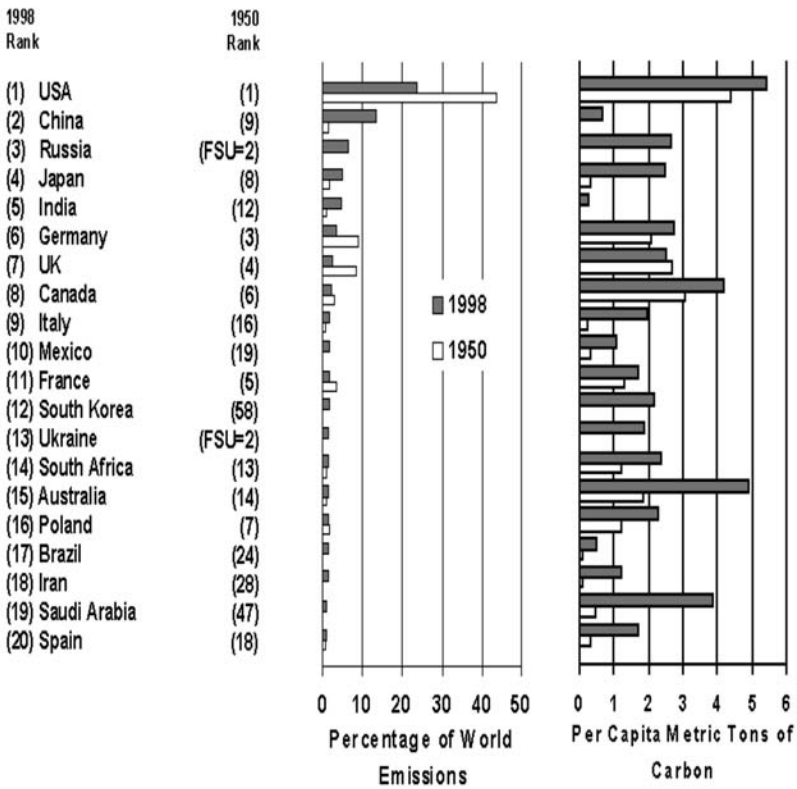

Figure 3. Total and per capita emissions of CO_2, for 1950 and 1998, for the 20 countries that had the largest total emissions in 1998.

predicts a 50 cm (20 inches) rise. Others estimate that it will rise up to 90 cm (3 feet) [12]. Therefore, it is a certainty that if sea level rises so rapidly, small nations like Tuvalu, Majuro in the Marshal Islands will be washed up. The recent prediction is that Carteret Atoll, an Island, will be submerged or lost by 2015.

The next vital point for power generation is fossil fuel, which is now in acute shortage [6]. Only 6.7% oil is used for generating electricity. (See Figure 6.) The rest of the power is generated from coal (39.8%), nuclear (15.7%), gas (19.6%), and other renewable energy resources. The statistics of the world Coal Institute show that fossil fuel, like coal, provides 25% of global primary energy and generates 40% of the world's electricity [11]. Coal is a very malicious power-

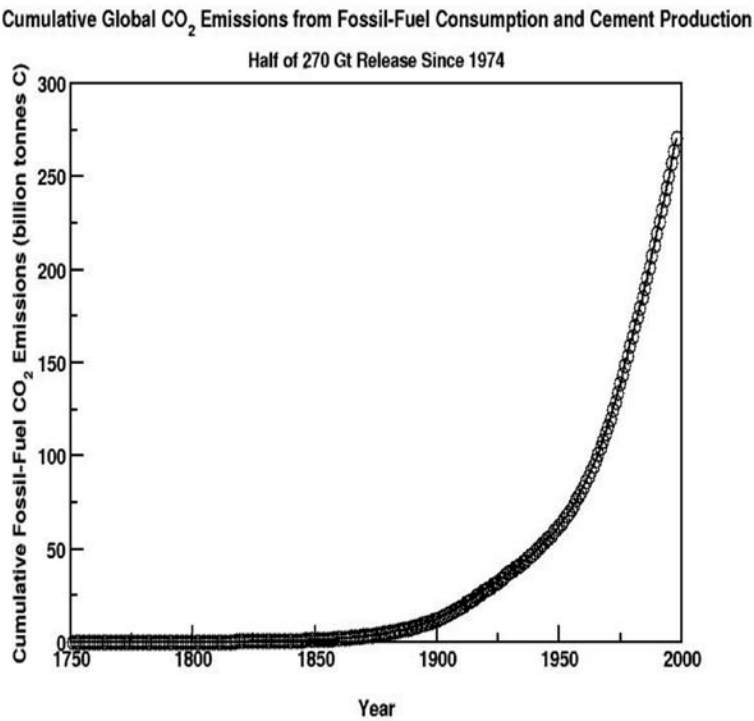

Figure 4. Cumulative emissions of CO_2 from fossil-fuel combustion and cement manufacture since the beginning of the fossil-fuel era.

generating source, as it produces about 70% of the pollution of this power generation. After burning, the dangerous ash is left, affecting soil, air, and water. Using this ash, bricks could be produced, but a lack of awareness means it is not being used for an industrial purpose. An incredible 25 billion tons of CO_2 emissions occur annually from generating power. So, we depend upon fossil fuel for about 66.1% of electricity production. Oil will be sustained for approximately 30 more years [7]. But it is predicted that natural gas and oil will be exhausted by the middle or end of the 21st century and that coal will be sustained for only about another 200 years [8].

Due to sudden draught, it is not reliable to be dependent upon hydro power completely. Generation of power from nuclear resources is a very logical proposition, but it is one for which sufficient infrastructure is needed. Otherwise, genetic deformity in living species can occur

Table 2. Heat Waves of Different Countries [9]

Country	Temperature	Date	Comment
Australia (Adelaide)	45°C	Jan 2009	Hottest day in 70 years.
U.S	32°C	August 2008	Breaking record of 1874 and 1901
California	34.4°C	April 2008	Breaking record of 2000
Regina	28°C	April 2008	Breaking record of 1963
Japan	40.9°C	August 2007	Breaking record of 1933
Europe(Athens)	41°C	July 2007	25 people killed
South Asia	45 to 52°C	Late May 2007	Tremendous heat wave
Northern Africa	Over 40°C	—————	Spread of several fires

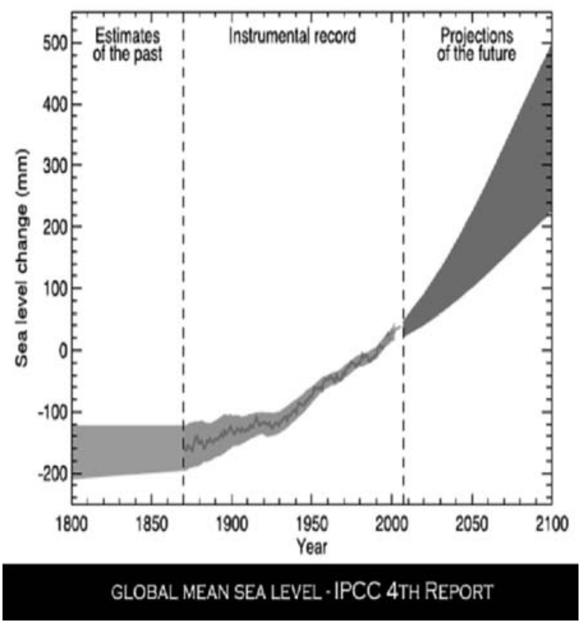

Figure 5. Sea Level Graph [12]

from the nuclear power radiation. The waste of nuclear power cannot be dissolved in water and is of no use.

Harvesting in the world completely depends upon rainwater, and this rain water comes by way of evaporation by sun-light. It is a better

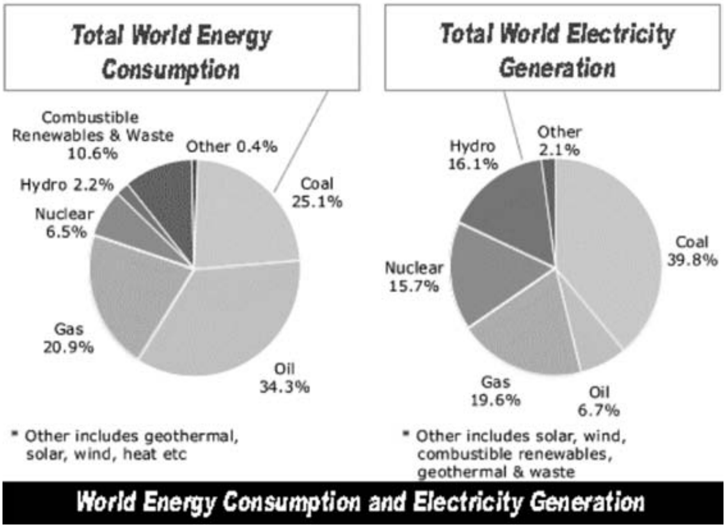

Figure 6. Energy Consumption and Electricity Generation [11]

choice to use solar energy to get electricity, since sunlight is present in adequate proportions for the world. While the sun will stop burning in about 4.5 billion years, for all practical uses or purposes it provides an endless source of energy.

A solar cell electronic device converts sunlight into electricity directly. When sunlight falls on the solar cell, it produces both a current and a voltage to generate electric power. Commonly the material used to absorb the solar energy is a crystalline silicon semiconductor [4]. Two layers of semiconductor material are placed such that they are always in contact with one another. One layer is an "n-type" semiconductor with plenty of electrons, and the other layer is a "p-type" semiconductor with numerous holes. Photons from the sunlight are absorbed in the photo active p-layer [10].

It is very important to tune these layers to absorb as many incoming photons as possible and to also free up as many electrons as possible [5]. Crystalline silicon solar cells are also of different types, such as mono crystalline silicon and poly crystalline silicon. The mono crystalline has the highest efficiency, almost 18% after the fabrication process. Poly crystalline silicon has an efficiency of about 17%. Solar cells that are made of GaAs or related materials (called III-V materials since they are in general made from groups III and V of the periodic table) have a higher efficiency than silicon solar cells; their efficiency is almost 25%. To increase the efficiency of solar cell technology, a multi-junction solar cell called tandem has an efficiency of up to 33%. Thin film solar cells may be made of amorphous silicon, cadmium telluride, copper indium dieseline, or thin layers of silicon, having an efficiency of approximately 6-12%. Theoretically, solar cell operates with higher efficiency under intense sunlight than under all other conditions encountered on earth. Concentrator solar systems avoid this effect by focusing sunlight into a concentrated spot or line. Concentrator systems are applicable to both silicon and III-V solar cells. Silicon concentrator systems have reached efficiencies of 28%, whereas III-V based systems have already reached about 33% [3].

Work is going on to increase the efficiency to between 30% and 60%. A very new technology (nanotechnology) has been adopted to enhance the efficiency of solar cell and make its operational cost cheaper. Nanomaterials show required properties, such as high strength and flexibility, and can also grab more energy than conventional solar cells. Nanotechnology reduces manufacturing costs by using a low temperature process similar to printing instead of the high temperature vacuum decomposition process that is used to produce conventional cells made with crystalline semiconductor material. It reduces installation costs, producing flexible rolls instead of rigid crystalline panels. In nanotechnology, the "quantum dot" method is used. Quantum dot refers to a semiconductor whose pair of conduction band's electron and valance band holes is bounded in all three spatial dimensions. For usual solar cells that have power conversion efficiencies of 15%, the quantum dot efficiencies may reach over 90% for the same operation. A quantum dot is a mega molecule of semiconductor material that converts light of different colors into electricity. Another advanced technology uses four-legged quantum dots (tetrapods), more efficient than quantum dots. The basic problem of tetrapods is that there is no good way to produce tetrapods. Quantum dots are produced by lots of advanced epitaxial techniques, like those for nanocrystals, which are produced by chemical methods or ion implantation, or in nanodevices. Large types of quantumdots that are very closely placed have a higher level of energy that lasts for a long time. This allows for absorbing photons containing less energy, like those closer to the red end of the spectrum. If solar cell is in 10% darkness, it can also generate current, but the amount will be 5 to 10 % less than the total maximum amount [3].

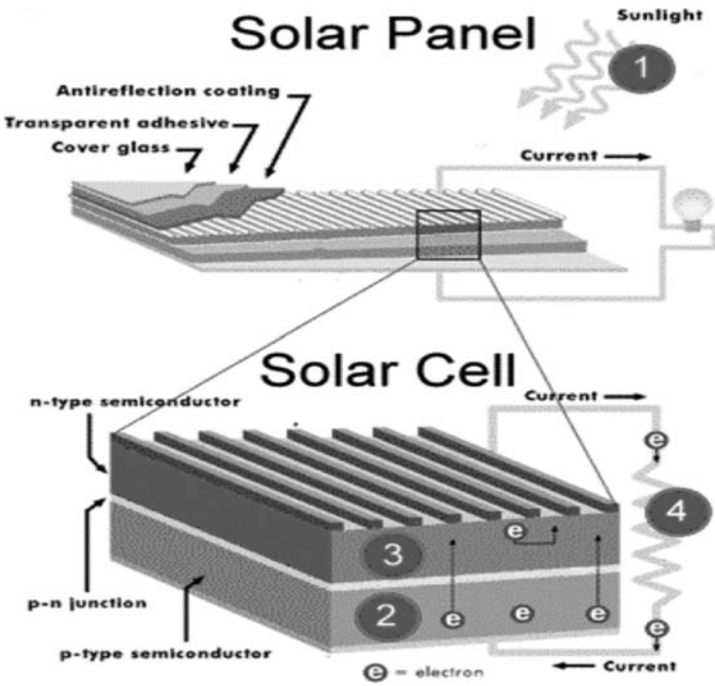

Figure 7. Solar Cell [6]

In Germany, a rooftop technique has achieved a huge success. According to Germany, the country produces solar photo voltaic components across the value chain-silicon production (10000 tons equivalent to 1000 MW), wafer production (around 1300 MW), and solar cell production (1300 to 1400 MW). Currently, 10 grams of polycrystalline silicon can produce 1 WP (watt/peak) of energy. A few year years ago, the amount of polycrystalline silicon needed was 13 grams to produce 1 WP. A plant, generating a minimum of 1 MWP, may be set up as a single unit or through modular units at a single location. The U.S, Europe, and Japan have accepted solar technologies positively. According to IREDA (Indian Renewable Agency Limited) officials, the government of India is interested in investing 12,000-15,000 crore under the 12th five-year plan. Presently, the U.K, Northern Europe, and Canada have an average of 1 hour of peak sunshine per day in winter and 3 hours in summer. On an average British summer day, a 30-watt peak panel can produce 90 watt hours of power. Watt peak is a measurement of how much power the panels can produce under stabilized laboratory conditions. For the Solar Taos, LLC company, a 50-watt module, working at 13 volts, can produce 39 watts of power.

Through the use of rooftop technique solar cell, thermal power plants can be omitted. This might not be able to provide the bulk power source, but for less pollution, it would be acceptable.

CONCLUSION

In thermal power plants, first the thermal power is converted into kinetic steam energy. Next, this steam helps to move the turbine, and the turbine rotates the magnetic field, producing electricity. So, before producing electricity, lots of conversion of energy is required, and each conversion results in some loss of energy. In the case of solar cell, solar energy is directly converted into electricity, with lower efficiency. But when the nanotechnology is applied, the cost of solar cell will be reduced and the efficiency improved. Thus, thermal power plants can be replaced by solar cell technology in the near future, and the pollution will be very low—almost zero. In rural areas where electricity is yet to arrive, people will highly benefit from this solar cell technology. For both rural areas and cities, if rooftop solar cell is used it can generate at least some amount of power that will help to reduce the amount generated from conventional energy sources. As a result, less pollution will occur. World-wide awareness of such possibilities will be required to get rid of the energy/environmental problem.

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