Indian Streams Research Journal

ISSN: 2230-7850 Impact Factor : 4.1625(UIF) Volume - 6 | Issue - 11 | December - 2016

SOLAR ENERGY SYSTEMS – IMPACT ON ENVIRONMENT

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ABSTRACT

Solar energy technologies offer a clean, renewable, and domestic energy source, and are essential components of a sustainable energy future. Solar energy systems (i.e., Photo voltaic Cells, Solar Panels) provide significant environmental benefits in comparison to the conventional energy sources. But it should be known that these systems also have some negative impacts on the environment during their production and operation. The analysis provides the potential burdens to the environment, which include—during the construction, the installation and the demolition phases, as well as especially in the case of the central solar technologies—noise and visual intrusion, greenhouse gas emissions, water and soil pollution, energy consumption, labour accidents, impact on sensitive ecosystems, archaeological sites.

KEYWORDS: *Solar energy systems (Solar Cells), Environmental impact, Renewable Energy.*

INTRODUCTION

Extensive fossil fuel consumption in almost all human activities has led to some undesirablephenomena such as atmospheric and environmental pollutions, which have not been experienced before in known human history. Consequently, global warming, greenhouse affect, climate change, ozone layer depletion, and acid rain terminologies started to appear in the literature frequently. Since 1970, it has been understood scientifically by experiments and researches that these phenomena are closely related to fossil fuel uses because they emit greenhouse gases such as carbon dioxide (CO2) and methane (CH4), which hinder the long-wave terrestrial radiation escape into space, and, consequently, the earth troposphere becomes warmer. In order to avoid further impacts of these phenomena, the two concentrative alternatives are either to improve the fossil fuel quality with reductions in their harmful emissions into the atmosphere or, more significantly, to replace fossil fuel usage as much as possible with environmentally friendly, clean, and renewableenergy sources. Among these sources, solar energy comes at the top of the list due to its abundance and more even distribution in nature than any other renewable energy type, such as wind, geothermal, hydro, wave, and tidal energies (Sen, 2004).

Solar energy technologies are essential components of a sustainable energy future.Energy from fossil fuels may be inexpensive and assurances may have been given of the plentiful supplies of petroleum and other fossil fuels, but these fuels are finite in nature and a major source of greenhouse gas emissions (IEA, 2002).

When energy demands increase, energy production and its negative impacts on theenvironment increase as well. As a result, environmental pollution became a global threat. Therefore, the importance of unpolluted energy sources such as solar energy has increased in recent years. But even

solar energy technologies have introduced some level of environmental effects. In this study, these effects will be discussed and necessary conditions to avoid this environmental effects will be investigated.

2. SOLAR ENERGY

Solar energy has been used since time immemorial to dry agricultural products, to providespace heat in cold seasons, or to create ventilation in homes, applications which are still used in many developing countries. More than 2,000 years ago, Heron of Alexandria constructed a simple water pump driven by solar energy, and in 214 B.C., Archimedes of
Syracuse used concentrating solar mirrors to set fire to Roman ships (Vanderhulst et al.,2006).

The sun showers the earth with a nearly infinite supply of energy. Each day moresolar energy falls to the earth than the total amount of energy the planet's 5.9 billion inhabitants would consume in 27 years. While it is neither possible nor necessary to use but a small portion of this energy, the potential of solar energy was hardly tapped. Only in the last few decades, when growing energy demands, increasing environmental problems, and declining fossil fuel resources made us look to alternative energy options, has the attention been focused on truly exploiting this tremendous resource (NREL, 2002).

The sun is the main energy source of the earth. Almost all of the natural energysources (excluding nuclear and geothermal energy) on the earth are a converted form of solar energy. For example, water cycle, wind cycle, and other energy systems require solar energy as the primary driving source. Due to being a relatively environmentally friendly energy form, solar energy systems have covered a wide range of applications in the recent years. It is also a relatively infinite energy source compared to fossil energyforms (Atagunduz, 1989).

3. SOLAR ENERGY SYSTEMS

Solar Collectors: There are basically three types of collectors: flat-plate, evacuated-tube, and concentrating. Flat-plate collectors are the most commonly used types.

i). Flat-plate collectors: The basic working principle of these collectors is based onthe conversion of the solar energy to the thermal energy. Flat-plate collectors are made of a glass cover as a transparent material, an absorbing plate, and a body. Radiation passed through the glass plate is absorbed by the solar plate. This plate is covered with paints or special surfaces for high absorbing properties. Almost 90% of the solar radiation felt on the surface are absorbed by these plates. The remaining are radiated back as thermal radiation and convective losses.

ii).Concentrating collectors: These collectors are used to obtain higher enthalpywater or other processing fluids. Usually temperatures above 140^{O} C cannot be obtained by flat-plate solar collectors, and concentrating collectors are utilized above 140^{O}C. Concentrating collectors are made of two components, namely, the optical system and the receiver. The function of the optical system is to directand focus the solar rays to the receiver. The function of the receiver is to absorbthe solar rays and convert it to the thermal energy. The receiver is made ofabsorber, protection, and isolation parts. The ratio of open space for solar rays tothe receiver space where the solar rays will be absorbed is called the condensingratio. Concentrating collectors can be classified according to their condensingratios (Atagunduz, 1989):

- flat receiver and flat reflectors
- pipe or spherical-shaped receiver and parabolic reflectors

- pipe or spherical-shaped receiver and flat, moving reflectors in separate rows
- pipe or spherical-shaped receiver and flat, single-moving reflectors.

iii). Evacuated-tube collectors: Evacuated tubes are the absorber of the solar waterheater. They absorb solar energy converting it into heat for use in water heating.Evacuated tubes have already been used for years in Germany, Canada, China,and the UK. There are several types of evacuated tubes in use in the solar industry(Apricus, 2006).

4. SOLAR HEATING

i). Active heating systems: There are examples of solar active heating systems, likeheating the water by solar collectors and the transmission of heated water to theexisting central heating installation, and thus the transportation of heated air forneeded areas.

ii).Passive heating systems: Passive heating systems using solar energy operate asa ray trap. Solar radiation enters a covered volume through glass and similar transparent materials and is absorbed by some absorbing surfaces. The heated surfaces radiate energy by radiation, but these heat rays cannot pass through the glass surface where sun rays can get through. Thus, the heat energy carried by the solar rays is kept inside (Atagunduz, 1989).

5. ELECTRICAL ENERGY CONVERTERS

a) Solar cells: Solar cells are systems that convert solar rays to electrical power. Radiation energy radiated as electromagnetic waves that reach the surfaces of the solar cells cause a photo-electromotive power with the help of the forming of electron/deflection pairs during the P-N transition of the semi-conductive crystals. These pairs get separated in the electrical area during the P-N transition and thus cause a current in the circuit that was connected to the semi-conductive crystal.

b)**Thermal solar power systems**: In these systems, solar radiation is concentrated by some concentrators and boiled to a working fluid that goes to a thermal cycle (Rankine cycle is the most common one, although Kalina and similar multi-liquid working fluid cycles are starting to take a place) and work created through the thermal cycle is converted to electricity by a electrical generator. Another form of thermal solar power system can convert solar energy to a hydrocarbon fuel, and stored hydrocarbon fuel can be reconverted to electrical energy by an internal combustion engine generator set-up.

6. ENVIRONMENTAL IMPACTS FROM THE SOLAR ENERGY SYSTEMS IN THE EXAMPLE OF SOLAR CELLS

Solarenergy systems have many significant advantages, like being cheaper and not producingany pollutants during operation, and being almost an infinite energy source when comparedwith fossil fuels. Nevertheless, solar energy systems have some certain negative impacts on the environment just like any other energy system (Tsoutsos et al., 2005).Some of these impacts will be summarized in this section.

a. Land Use and Thermal Pollution

Solar cells (photovoltaic) have miscellaneous impacts on the natural ecosystem. Theseimpacts are related to some specific factors, like the area and the topography of land thatwould be covered, sensitive ecosystems, and biodiversity. The application of the solarcells in cultivable land can cause possible harm on the land's productive areas(Tsoutsoset al., 2005). Large-scale utilization of the land also effects thermal balance of the areaby absorbing more energy by the earth than otherwise would be reflected by the surfaceback to space. A serious solar power application needs to utilize square kilometres ofEnvironmental Impacts from the Solar Energy Systems 135desert area. Thermal balance of

this land space can certainly be effected by such anapplication. Also, additional heat might destroy a few species living in this kind of harshenvironment. In order to avoid this big land utilization, space solar power stations arealso in consideration, but energy from these systems should be transported to the earth asmicrowave, which could cause radiation pollution and endanger bird life passing throughthe irradiated zone.

b. Discharge of Pollutants

Solar cells do not emit any pollutants during their operations. But solar cell modulescontain some toxic substances, and there is a potential risk of releasing these chemicalsto the environment during a fire. Necessary precautions should be taken for emergencysituations like fire. The possibility of an accidental release of the chemicals of the solarcell modules to soil and groundwater poses a great threat for the environment (Tsoutsoset al., 2005).

c. Visual Impacts

Visual impacts depending on the type of the scheme and the surroundingsof the solar cells. Especially for applications on the buildings, solar cells can be used as a cladding material that could be integrated into the building during the construction phase. Solar cell applications after the construction phase of the buildings might cause negative visual impacts. Solar cell utilization should be planned at the architectural phase and fitted to the building to minimize visual pollution. For the other application areas, proper sitting and design are important factors, especially for large solar cell applications. Another important factor about the control of the visual impacts is the use of colour. Enough care should be taken for the usage of proper colours while assembling the solar cell modules (Tsoutsos et al., 2005).

d. Impacts on Natural Resources

Despite being a benign energy system during operation, solar cells have some negativeimpacts on the environment during their production phase like many other systems. The energy needed for the production of solar energy systems is still produced in conventional methods today. Some toxic chemical substances used during the production phase are produced as a by-product. Especially, the solar cell batteries pose a threat on naturalresources by having a short lifespan and containing heavy metals such as cadmium (Tsoutsos et al., 2005).

e. Air Pollution

Solar cells do not emit any substances to the air during operation. But there could be some emissions during manufacturing and transport. The emissions associated with thetransport of the modules are insignificant when compared with the emissions associatedwith the manufacture. Transport emissions are 0.1–1% of the manufacturing emissions. In the case of poly- and mono-crystalline modules, the estimated emissions are 2.757–3.845 kg CO2/kWp, 5.049–5.524 kg SO2/kWp, and 4.507–5.273 NOx/kWp(kWp: peak kilowatt) (Tsoutsos et al., 2005).

Noise Intrusion

Solar cells do not make a noise during operation. But during the construction phase,there will be a little noise as usual in other construction activities.

Fig.1: An example of solar panlels not causing visual impact

Figure 2. An example of solar collector causing visual burdens.

7. CONCLUSIONS AND RECOMMENDATIONS

Solar energy is increasing in importance as an alternative energy source. It has become indispensable today due to being an environmentally friendly and infinite energy source.But solar energy systems have some impacts on the environment. These potential impactsdepend on the size and nature of the project and are site specific. Most of these burdensare associated with loss of amenity (Tsoutsos et al., 2005).

Negative impacts of the solar energy systems could be minimized with appropriatemeasures. First, site choosing should be done carefully before application. Roofs are thebest areas for little buildings, and solar cell modules are good alternatives for glass coveron the sides of larger buildings, like skyscrapers. In order not to cause visual burdens,solar modules should be used as construction material during the construction phase, andthey should be applied totally integrated with the buildings. An EIA analysis should bedone especially for central solar energy systems.

There are miscellaneous precautions that could be taken to minimize the environmentalimpacts of the solar energy systems. Because of the toxic substances used in thesolar cell modules, it will be wise to increase the module efficiency and lifespan, andresearch the possibilities of recycling.

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