Potential Environmental Impacts of Solar Energy Technologies

M. Srinivasan[1], A.Velu[2], B. Madhubabu[3]

[1, 2, 3]Department of Electrical and Electronics Engineering, Navodaya Institute of Technology, Raichur, Karnataka, India

Abstract: ***Sun is prime supply of all energy within the world and be it the traditional sources of energy. Solar energy systems such as photovoltaic, solar thermal, solar power to provide significant environmental benefits in comparison to the conventional energy sources, thus contributory, to the sustainable development of human activities. Sometimes their wide scale preparation has to face potential negative environmental implications. These potential issues appear to be a powerful barrier for an extra dissemination of those systems in some customers. However, it might be foolishness to completely write away the negative impacts of solar technology, which becomes significant in large scale production scenario. To address with these issues this paper presents an overview of an Environmental Impact Assessment. It analyses the environmental impacts of solar energy technologies.***

Keywords: Environmental impacts, Solar Energy Technologies, Solar thermal systems, Photovoltaic power generation

1. Introduction

In the present era with much more knowledge, people are much concerned about the ill effects of conventional sources of energy and give prime importance to the fast depletion of the conventional resources. Renewable energy as an alternate is on the rise, to reduce dependency on limited reserves of fossil fuels and to mitigate negative impacts on environment. Among various forms of renewable energy the generation of electricity from sunlight over the last decade has been growing exponentially worldwide due to its Ecofriendly image. In most countries, industrial development is contingent on the developer obtaining a Permit from a regulatory authority which involves assessing the impact the development may have on the environment. Preservation of the environment isn't merely a local issue however a global concern. The brief comparison between environmental advantages and prices of the use of different types of RES is presented in the Fig. 1 and Table 1. Carbon dioxide (CO2) is known as a greenhouse gas (GHG)—a gas that absorbs and emits thermal radiation, creating the 'greenhouse effect'. Along with other greenhouse gases, such as nitrous oxide and methane, CO2 is important in sustaining a habitable temperature for the planet: if there were absolutely no GHGs, our planet would simply be too cold. It has been estimated that without these gases, the average surface temperature of the Earth would be about -18 degrees Celsius.

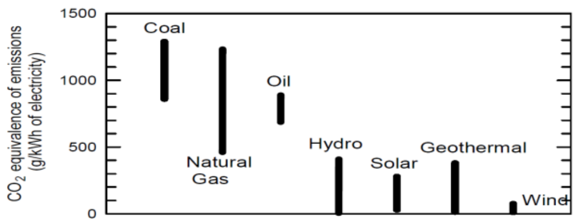

Figure 1: Relative amounts of greenhouse gas emissions from various types of electricity generation methods, data expressed as CO_2 equivalents.

Table 1: Comparison between environmental benefits and costs

Environmental benefits	Environmental Price
1) Energy produced by the renewable energy systems 2) Greenhouse gas savings	1) Production of devices and BOS Greenhouse gas emissions Heavy metals emissions Energy used (Energy pay-back time1) 2) Wastes generated by different RES industry

However, is solar technology completely free from negative environmental impacts? The answer would be no. In general, solar energy technologies fall in to two broad categories:

- Solar thermal systems and
- Photovoltaic power generation.

Each is seen superior in environmental aspect compared to its conventional predecessor. However, they too have some notable ill effects on nature and when it comes to large scale production, it becomes significant.

2. Environmental Impacts of Solar Energy Technologies

Solar Energy Technologies (SETs) on the whole provide significant environmental benefits when compared to the conventional energy sources, contributing to the sustainable development. The use of SETs has positive environmental implications such as:

- Reduction of the CO_2 emissions
- No degradation of quality of water supplies
- Reclamation of degraded land
- Reduction in the number of required power transmission lines.

2.1 Impacts to soil, water and air resources

The construction of solar facilities on large areas of land imposes clearing and grading, resulting in soil compaction, alteration of drain channels and accumulated erosion. Central tower systems would like overwhelming water for cooling, that could be a priority in arid settings, as a rise in water demand may strain available water resources similarly as chemical spills from the facilities which might result in the contamination of groundwater or the ground surface. just like the development of any large-scale industrial facility, the development of solar power plants can create hazards to air quality. Such threats embrace the discharge of soil-carried pathogens and leads to an increase in air material that has the impact of contaminating water reservoirs.

2.2 Land use and ecological impacts

In the point of generating electricity at a utility-scale, solar energy facilities necessitate large areas for collection of energy. Due to this, the facilities may interfere with existing land uses and can impact the use of areas such as wilderness or recreational management areas. As energy systems may impact land through materials exploration, extraction, manufacturing and disposal, energy footprints can become incrementally high. Thus, some of the lands may be utilized for energy in such a way that returning to a pre-disturbed state necessitates significant energy input or time, or both, whereas other uses are so dramatic that incurred changes are irreversible.

3. Solar Thermal (ST) Systems

Solar thermal systems are an ecological way of providing domestic hot water. They are experiencing a rapid growth since the beginning of the last decade. Indeed, it is a robust, efficient and simple technology to implement for individual households. Its capacity in reducing energy load for domestic hot water (DHW) is significant in locations with high irradiation level.

3.1 Environmental impacts

- Reduction in the use of conventional fossil fuels, thereby leading to less CO_2 emission.
- Though the land area required is determined by the topography and intensity of the place usually the area required is comparatively large.
- Chance of accidental water pollution due to leakage in coolants is high.
- Thermal and concentrated systems consume much more water and withdraw similar amounts as a natural gas.

4. Photovoltaic (PV) Power Generation

4.1 Environmental impacts

4.1.1 Air pollution

The emissions associated with transport of the modules are minor in comparison to those associated with manufacture. Transport emissions were still only 1% of manufacturing related emissions

4.1.2 Environmental benefits

Significant emission reductions can be accomplished through PV electricity (PVe) production since PVs do not generate noise or chemical pollutants during their normal operation. Besides, PV cells help the increase of soil humidity and improve flora formation in dry/arid areas.

4.1.3 Waste management

In the case of standalone systems the effects on health of chemical substances included in the batteries should also be studied. Moreover a large amount of energy and raw materials is required for their production. A battery-recycling scheme can assist. As it usually goes for construction activities, there will be little noise during operation of electrical equipment.

4.1.4 Social impacts

Some direct benefits are related to lighting for domestic and community activities and mainly to the opportunity to suburban and borderland's habitants to have access to computers, lighting, radio and phone. Therefore PVe improves the quality of life and reduces migration. Full- and part-time jobs creation during installation and maintenance improves local micro economics and drives to poverty alleviation.

4.1.5 Visual impact

Visual intrusion is highly dependent on the frame design and the surroundings of the PVs. It is obvious that, for a system near an area of natural beauty, the visual impact will be significantly high.

4.1.6 Effect on building

PV is a viable technology in an urban environment, to replace the existing building's cladding materials. Also, PV panels can be directly used into the façade of a building instead of mirrors.

4.1.7 Accidental releases and occupational health

Emissions into soil and groundwater may be caused by inadequate storage of materials. In large-scale plants a release of these hazardous materials is likely to occur as a result of abnormal plant operations, damaged modules or fire and therefore to pose a small risk to public and occupational health . The increased potential danger of electrocution from the direct current produced by systems, needs to be taken into account especially by untrained users.

4.1.8 Land use

The impact of land use on natural ecosystems is depended on specific factors such as the topography, the area and the type of the land covered by the system, the distance from areas of natural beauty or sensitive ecosystems and the biodiversity. The impacts and the modification on the landscape are likely to come up during construction stage, by activities such as earth movements and by transport movements. Also an application of a system in once-cultivable land is possible to reserve soil productive areas. Thus the siting in arid areas is recommended.

4.1.9 Depletion of natural sources and energy consumption

The production of current generation poly- and mono-crystalline modules is rather energy intensive. Other indirect impacts include the requirement of large quantities of bulk materials and small quantities of scarce (In/Te/Ga) and/or toxic (Cd) materials. Options for energy demand reduction must always be considered along with the assessment of PV applications.

4.2. Hazard classification of chemicals typically used in PV module manufacturing

A variety of acids or corrosive liquids are used in fairly large quantities during the manufacturing process. These acids or corrosive liquids include hydrochloric acid, sulfuric acid, nitric acid, and hydrogen fluoride. These chemicals are primarily used for the cleaning of wafers or to remove impurities from raw semiconductor materials. Solvents including 1,1,1-trichloroethane and acetone are also used in large quantities in the various cleaning steps conducted during the production processes. Etching compounds such as sodium hydroxide can also be used in relatively large quantities. The amount of a given chemical used will vary depending upon numerous factors including the type of cell being produced, the amount of material processing required, and the amount of wafer cleaning required. The manufacturing of solar cells involves the use of multiple chemicals classified as hazardous, including highly explosive and toxic gases.

4.3 Technologies/techniques to mitigate the environmental impacts

Almost all the negative environmental impacts can be faced:
PVs can be used in isolated areas, avoiding ecologically sensitive areas or archeological sites. The integration in large commercial buildings (facades, roofs) it is also recommended as well as the use as sound isolation in highways or nearby hospitals, on condition of proper sitting and frequent maintenance. Careful system design and production of cells in variable shapes, which can be easily integrated in buildings as architectural elements and replace mirrors or metallic areas used to decorate modern buildings. Furthermore the PV use as a cladding material for commercial buildings is showing their architectural possibilities. Referring to construction activities, site restoration is needed to alleviate visual impacts. Color can be used to assemble the PV modules in large-scale systems. Occupational accidents can be averted by good working practices and by the use protective sunglasses and clothing during construction, maintenance and decommission stage .Integrated PVe schemes help to regenerate rural areas.

5. Solar Thermal Electricity

5.1 Environmental impacts

- Intermittent
- Low energy density
- Does not produce electricity
- Supplemental energy source or storage required
- for long sunless stretches
- Expensive compared to conventional water heaters
- Construction/installation costs can be high
- Harder to compete against very cheap natural gas
- Some people find them visually unattractive
- Manufacturing process can create pollution
- Installers not available everywhere
- Generally not practical to store or sell excess heat reduce low grade energy (heat vs. electricity)
- Limited scalability
- Dependent on home location and orientation

5.2 Technologies/ techniques to mitigate the environmental impact

- Most potential impacts of STE systems can be avoided or mitigated by:
- Proper siting (away from densely populated areas and not in protected areas or areas of significant natural beauty).
- Proper operational practices (reasonable water use, safety measures, waste disposal practices, use of possible biodegradable chemicals etc.).
- Improvement of technology (e.g., use of air as the heat-transfer medium in central tower systems, 'advanced' noiseless Stirling engines).
- Cultivation of photo-sensitive mosses or bushes in the area where shaded by the reflectors
- Exploitation of warm water in the nearest industry in the production stream Training of workers, familiarization with the system.
- Re-establishment of local flora and fauna, giving the environment enough time to come up again to its previously state.
- Good operating practices and compliance with existing safety regulations.

6. Conclusion

SETs give important socio-economic advantages. On the other hand it should be realized that no man-made project can completely avoid some impact on the atmosphere, neither can SET installations. Potential environmental burdens are related to loss of amenity, depend on the size and nature of the project and are usually site specific. However, adverse effects are usually small and can be reduced by appropriate mitigation measures, technologies or techniques that may involve the utilization of air emission or odor control equipment, design tools for optimal design and siting of the installations, best practice guidelines, improved items of equipment (such as gearless or lubricant-free motors), or, fully innovative design it's up to the involved factors (investors, developers, and allowing authorities) to create the appropriate decisions by taking environmental problems into serious consideration.

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Author Profile

M.Srinivasan received the B.E degree in Electrical and Electronics Engineering at Govt. College of Technology, Coimbatore, TN, India in 1996 and the M.E. degree in Electrical Machines from PSG College of Technology, Coimbatore, TN, India, in 2004. He has completed Ph.D. In Power Systems from Anna University, Tamil Nadu, India in 2014... He has been in the field of technical teaching and research for more than two decades. Currently, His research interests include power electronics circuits, renewable power conversion systems and solid state control of electrical drives. He is a life member of ISTE, AMIE (India) and System Society of India.

Velu A, received the B.E degree in Electrical and Electronics Engineering at Institute of Road and Transport Technology, Erode, Tamilnadu, India in 2010 and the M.Tech. Degree in Power Electronics and Drives from SRM University, Chennai, Tamilnadu, India, in 2013. He is Working as Assistant Professor in the Department of Electrical & Electronics Engineering. He is having six years of teaching experience. His area of interest includes Power Electronics Circuits and its Applications in Renewable Power Conversion Systems and HVDC Power Transmission Systems.

B Madhu Babu, received the B.Tech degree in Electrical and Electronics Engineering at Ellenki college of engineering & Technology, Hyderabad, Telangana, India in 2011 and the M.Tech. degree in Electrical power systems from Samskruti College of Engineering &Technology, Hyderabad, Telangana, India, in 2013.He is Working as assistant professor in the department of Electrical & electronics engineering. He is having six years of teaching experience. His area of interest is power quality improvement‖ in distributed generation.