



Prospective Study of Solar Energy as a Sustainable Energy Source of Electrical Power Generation

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Received 12th March 2014 and Revised 3rd October 2014

Abstract: Utilization of solar energy sources in electrical power generation sector is essential on account of its capability to meet the needs of environmental unsustainability, energy depletion and costs increases. Solar energy source utilization is therefore considered a vital element for ensuring reliability and uninterrupted supply of required electrical power output in Pakistan. The fossil fuels in comparison to solar energy are unsustainable sources on account of their finite nature, environmental unsustainability and unstable production costs. In order to establish this proposition it is essential to evaluate these parameters of thermal and solar powered electrical power generation processes in electrical power generation sector. Therefore, research is carried out to analyze the parameters of input energy requirement, production costs and environmental sustainability of both the thermal and solar electrical power generation processes. The result of the research are analysed for determination are promising for better prospects of medium and large scale solar electrical power generation in Pakistan.

Keywords: Sustainable energy, solar electrical power generation, environmental sustainability

1. INTRODUCTION

Fossil fuels are considered potential threat to environmental degradation, ecological imbalance and lack of biological diversity Asif (2009). These fuels are considered main sources of an increase in CO₂ emissions Yuksel (2008). Moreover, its finite nature makes it difficult to continue as reliable energy source. It is anticipated that until 2020 no major increase in primary energy supply sources could be attained under the fossil fuels' system Zerta *et al.*, (2008).

Under the fossil fuels energy scenario, a gap exists between energy demand and supply in developing countries, and has developed multiple challenges to the modern way of living Lloyd and Subbarao (2009). Therefore there is need of exploration of sustainable energy sources, which can meet the challenges of depletion, energy costs, environmental unsustainability and depletion MacKay (2008).

There is likelihood of generation of sustainable electrical power generation processes in solar-rich countries Shah and Edwards (2011). Pakistan is also one of them, and offers considerable opportunities of solar energy utilisation Shah *et al.*, (2013). By doing it would be possible to meet the needs of electrical power in an environmentally sustainable manner. Solar energy is readily available in solar-rich countries and can be used as a source for electrical power generation, water heating, agricultural cultivation and water pumping (Harijan *et al.*, 2007). This source of electrical power generation can be utilized equally by grid connected and off grid systems. According to some estimates 3.525x10⁶ and 455.3 GWh of electricity can be

generated annually in Pakistan from grid connected and off-grid PV systems. Positive impact on socio-economic sectors can also be obtained by the use of feasible energy source Zaigham (2001); Shah and Zhang (2011). It is believed that such development can bring development in electrical power sectors of country.

In order to evaluate existing fossil fuels and renewable solar energy as a sustainable fuel in terms of energy availability, costs optimization and environmental emission reduction, a research over thermal and solar electrical power generation processes is conducted and the results are analysed with the aim to establish that solar energy can be utilized as reliable and sustainable energy source for small, medium and large scale power generation in Pakistan.

The results of the research are promising in terms of decentralized, cost effective and environmental sustainability of solar electrical power generation on small, medium and large scale. However, initial investment for the purchase of solar panels, inverters, charge controllers and batteries would be required for utilization of this source of energy for electrical power generation. The advantages of independent electrical power generation, operational costs optimization and negligible maintenance costs outweigh the disadvantage of capital costs of solar electrical power generation.

2. MATERIAL AND METHOD

Pilot questions and questionnaire survey were used for analysis of fossil fuelled and solar energy based electrical power generation processes. Pilot questions were used to seek the format and pattern of the

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questions used in the main questionnaire. A questionnaire survey was used to extract relevant information on the grey areas of thermal processes and advantages of using alternative energy sources such as solar energy as minput fuel for power generation.

The analysis is carried out on basis of amount of energy consumptions, amount of CO₂ emissions, electrical power generation costs and environmental sustainability. The compiled results of fossil fuelled and solar powered process are analysed comparatively to find out whether solar power generation systems can be used alternatively in an effort to overcome the electrical power supply shortage, increased electrical power generation costs and environmental externality costs. The samples of the survey were taken from thermal electrical power generation and solar electrical power generation units of Pakistan and from the Masdar Institute of Science and Technology, Abu Dhabi, UAE.

The samples were selected keeping in view demographic parameters of the samples such as age and sex of the samples of thermal and solar power generation units,. All the respondents were male and are in the age group of 30-50 years, and are working in middle and senior level positions. Open and closed type questions are used to extract the required information from the professionals and technocrats working in these industries. The questionnaire survey included the variables of input energy consumption in kWh, production costs in US dollars and carbon dioxide emissions releases in kg.

3. RESULTS

The input energy consumption required for generation of one kWh electrical power photovoltaics electrical power generation processes (kWh) is calculated on basis of the data obtained from existing solar power companies working in Pakistan. The data is presented in a graph showing the names of electrical power generation companies horizontally and the input energy consumption (\$) vertically in (Fig.1).

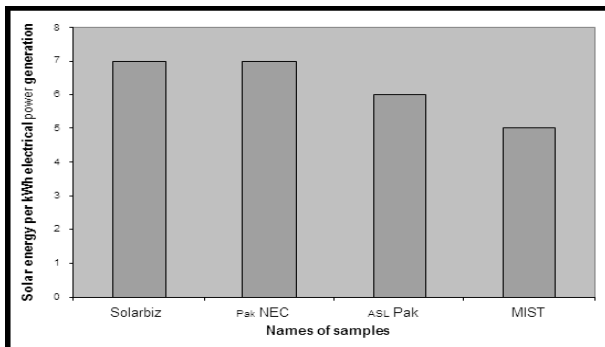


Fig. 1. Estimated input solar energy consumption (kWh) required for one kWh electrical power generation

Various types of emissions are produced by thermal power generation processes such as CO₂, CO, air pollutants like NO_x, SO_x, particulate matter, and smog for generation of each kWh electrical power in fossil fuelled power plants. The data is presented in a graph showing the names of thermal electrical power generation companies horizontally and the estimated amuntps of emissions (kg) vertically in (Fig.2).

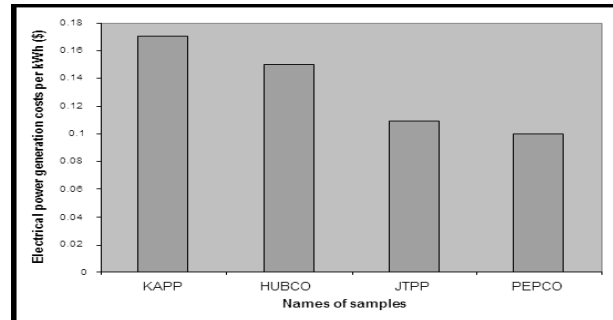


Fig. 2. Estimated amount of emission which are released for one kWh electrical power generation in thermal power process

The electrical power generations costs of solar electrical power and thermal power generation processes are also important parameters that deserve proper attention of the electrical power producers. The data is presented in a graph showing the names of thermal and solar energy based electrical power generation units horizontally and electrical power generation costs (\$) vertically in (Fig.3).

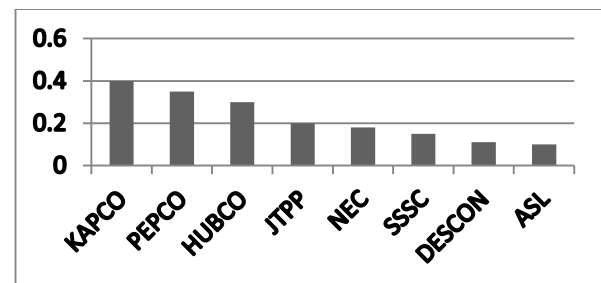


Fig. 3. Estimated thermal and solar electrical power generation costs (\$) for one kWh electrical power.

In (Fig. 3) KAPCO, HUBCO, JTTP and PEPCO are thermal power generation units whereas NEC, ASL SSSC and DESCON are solar energy based electrical power generation units

It is pertinent to mention that environmental sustainability index of thermal and solar electrical power generation processes needs to be considered to analyze the level of environmental neutralization costs of both fossil fuelled and solar energy based power generation units. Therefore environmental sustainability index of both the solar and thermal electrical power generation processes is developed in (Fig. 4).

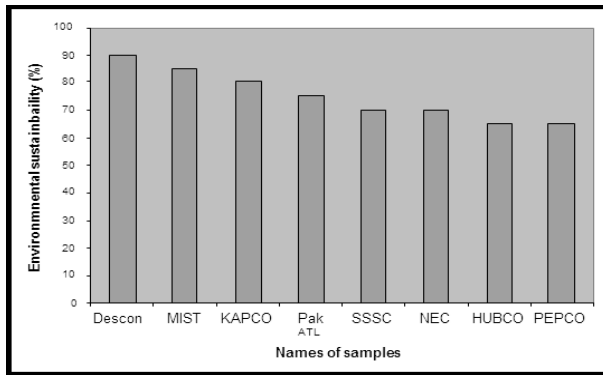


Fig.4. Estimated environmental sustainability for solar energy based electrical power generation process

4. ANALYSIS

The results enumerated above establishes the worth of solar energy as a sustainable energy source for electrical power generation on account of its availability in central, southern, south eastern and south western areas of Pakistan around the year in comparison to purchase of the crude oil i.e. the fuel required for thermal power generation.

Solar energy is a feasible source of electrical power generation on small, medium and large scale on account of its availability in tropical regions and environmental sustainability in comparison to thermal power generation process. Also, downward trends are recorded of solar photovoltaics power generation systems and there is likelihood of a further decrease in the solar power generation costs. Therefore the share of solar electricity generation could be increased substantially in future.

Environmentally, fossil fuelled thermal power plants are considered unsustainable because of the release of considerable volumes of carbon dioxide emissions in comparison to solar electrical power generation plants. Solar electrical power generation process is also free of CO₂, SO_x and NO_x emissions, which cause considerable damage to the user and environment.

5. CONCLUSIONS

The analysis leads to the conclusion that solar electrical power generation process is a reliable and environmentally sustainable source of medium and large scale electrical power generation on account of considerable amounts of solar energy availability, electrical power generation costs optimization and environmental emission reduction potential in Pakistan. In view of these advantages it is considerable potential to increase the scale of the solar electrical power generation to cater to the electrical power needs of domestic, commercial and industrial power consumers.

Therefore, solar power generation processes are considered feasible economically environmentally. The prospects of solar powered power generation are held bright in the short, medium and long term. The research carried out is helpful in reaffirming the hypotheses that solar energy can be considered a sustainable energy source that can be used as a fuel in electrical power generation on large scale to meet the electrical energy needs in all sectors of economy

REFERENCES:

Asif, M. (2009), "Sustainable energy options for Pakistan." *Renewable and Sustainable Energy Reviews* 13, (2009). 204-208

Harijan K., M. A. Uqaili and U. K. Mirza (2015) "Assessment of Solar PV Power Generation Potential in Pakistan" *Journal of Clean Energy Technologies*, Vol. 3, No. 1, 54-56.

Harijan, K., M. A. Uqaili and M. Memon (2007). "Renewable Energy for Managing Energy Crisis in Pakistan." Springer-Verlag Berlin Heidelberg: 7. Kher, S. (2008). 449-455.

Lloyd B. and S. Subbarao (2009), "Development challenges under the Clean Development Mechanism (CDM)- can renewable energy initiatives be put in place before peak oil?" *Energy Policy* 37,237-245.

MacKay, D. J. C (2008), "Sustainable Energy without the hot air." E-Book, UIT Cambridge, England 3, www.withouthotair.com.1-15., dated 15-06-2014.

Shah S A and R. E. Edwards (2011), "Sustainable energy generation processes in the deserts of solar-rich countries," *International Journal of Sustainable Energy*, DOI: 10.1080/14786451. 2011. 622761 vol. 32, 196-203.

Shah S. A and Y. Zhang (2011), "Impact of solar energy utilisation on sustainable development," *Applied Solar Energy*, Vol. 47, 4, 336-341, <http://rd.springer.com/article/10.3103/S0003701X11040128>

Shah S. A, A. F Abbasi, J. Daudpoto (2013) "Energy and emission benefit analysis of solar powered electrical power generation in Pakistan" *Sind University Research Journal* Vol. 46 :1-4.

Yüksel I, (2008), "Global warming and renewable energy sources for sustainable development in Turkey", *Renewable Energy* 33(4): 802-811.

Zerta M, P. R. Schmidta C. Stillera and H. Landinger (2008), "Alternative World Energy Outlook (AWEO) and the role of hydrogen in a changing energy landscape" *International Journal of Hydrogen Energy* 33(2): 5, 321-325.