Solar Aided Green Power Generation and Eco-strategic Challenges

Prabha Malviya

Electrical & Electronics Department
pra_malvika@yahoo.co.in
Oriental University
Indore

Abstract — **Now a days, most power is, and will continue to be, generated by consumption of fossil fuels (mainly coal and gas) which has serious negative impacts on our environment. As a clean, free, and non-depleting source, solar energy is getting more and more attention. However, owing to its relatively low intensity, the application of solar energy for power generation purpose is costly, and the efficiencies of the solar thermal power systems having been developed in which solar energy is used as the main heat source are not satisfactory. In addition, solar energy utilization is subject to the change of seasons and weather.[1] All of these impede the solar energy's application. How to use solar energy to generate power steadily and efficiently is a problem that needs to be addressed. In this chapter a new idea, i.e. Solar aided power generation (SAPG) is proposed. The new solar aided concept for the conventional coal fired power stations, i.e. Integrating solar (thermal) energy into conventional power station cycles has the potential to make the conventional coal fired power station be able to generate green electricity.[2]**

Keyword: **Solar energy, Solar aided power generation, Green house gas emission**

I.INTRODUCTION

Since the industry revolution, humans' economic, Activities are consuming fossil fuel more and more. It causes the consistency of greenhouse elements rapidly going up, such as CO2. This situation not only makes the phenomenon of global temperature raising, sea level getting higher and global climates becoming worse, but also carries increasing and apparent negative impact to water resources, agricultural goods, natural ecosystem and human's health. Many types of renewable energies are being studied hard for application research over the years. Around so many types of renewable energies, hydro power wind power, solar energy, geothermal power, biomass power.

The basis of solar aided power generation (SAPG) technology/concept is to use solar thermal energy to replace the bled-off steam in regenerative Rankine power cycle. In contrast to other solar boosting or combined power systems, solar energy generated heat (or steam), in SAPG, does not enter the turbine directly to do work. Instead, the thermal energy from the sun is used in place of steam normally extracted from turbine stages for feed water pre-heating in regenerative Rankine cycles. The otherwise extracted steam is therefore available to generate additional power in the turbine. Therefore the SAPG is capable of assisting fossil -fuelled power stations to increase generating capacity (up to 20% theoretically if all feed heaters are replaced by solar energy) during periods of peak demand with the same consumption of fuel, or to provide the same generating capacity with reduced green house gas emissions

II. SOLAR RADIATION: GEOPHYSICAL CONSIDERATIONS AND ENERGY POTENTIAL

Located nearly 150 million km from Earth, the Sun is a huge nuclear power plant—the oldest in the history of mankind—and has a capacity of 25 million kW/h per gram of hydrogen, its main component. The nuclear fusion of one kg of hydrogen releases an energy value of 8.3 million tons oil equivalent (Lhomme, 2004). Since the sun accounts for some two billion tons of material, over 90% being hydrogen of which it uses 600 million tons per second, the energy produced is unimaginable. In fact, it produces 4 x 1017 GW, or the equivalent of 400 million billion nuclear power plants! The Earth receives only a tiny fraction of this energy (Centre National de Recherche Scientifique, n.d.; Lhomme, 2004). The major characteristics of sun energy, despite a certain ubiquity, are a large regional disparity and more or less marked by seasonal imbalance. For instance, the average energy received by Europe is 1,200 kWh/m2/y vs. 1,800 to 2,300 kWh/ m2/y in the Middle East (EPIA/Greenpeace, 2011).Latitude; exposure and altitude are parameters that influence the overall daily and seasonal radiation.

III. TECHNOLOGICAL ASPECTS FROM SOLAR ENERGY TO PHOTOVOLTAIC ELECTRICITY

The PV effect consists in the direct conversion of solar energy into electricity. Three interdependent and successive physical phenomena are involved: a) the optical absorption of light rays, b) the transfer of the energy from the photons to the electrons in the form of potential energy; c) the collection of the electrons excited in this manner so that they recover their initial energy. The ideal converter is still the semi-conductor, since both the conductivity and the collection method are both sufficient and efficient. However, there are Two major obstacles with respect to PV conversion. The first one is related to the photons and electrons. In fact, not all the photons are absorbed and not all of the excited electrons are collected. This impacts the energy performance of a semi-conductor, one of the key parameters for the PV industry. In practical terms, the performance of a solar cell is the maximum power produced, expressed in Watts-peak (Wp) and the higher the Wp is, the better the performance of the cell is (Goetzberger & Hoffman, 2005 ; Labouret & Villoz, 2009). The other major obstacle is the price of the solar module. Development of the technologies and the PV materials is continuing while the two goals are to increase energy performance and reduce the cost of the WP beneath the symbolic threshold of $1 US/Wp (Krauter, 2006; Xakalashe & Tangstad, 2011).

IV. SOLAR AIDED POWER GENERATION

The basis of solar aided power generation (SAPG) technology/concept is to use solar thermal energy to replace the bled-off steam in regenerative Rankine power cycle. In contrast to other solar boosting or combined power systems, solar energy generated heat (or steam), in SAPG, does not enter the turbine directly to do work. Instead, the thermal energy from the sun is used in place of steam normally extracted from turbine stages for feed water pre-heating in regenerative Rankine cycles. The otherwise extracted steam is therefore Available to generate additional power in the turbine. Therefore the SAPG is capable of assisting fossil - fuelled power stations to increase generating capacity (up to 20% theoretically if all feed heaters are replaced by solar energy) during periods of peak demand with the same consumption of fuel, or to provide the same generating capacity with reduced green house gas emission

The SAPG technology is thought to be the most efficient, economic and low risk solar (thermal) technology to generate power as it possesses the following advantages:

(I) The SAPG technology has higher thermodynamic 1st law and 2nd law i.e., energy efficiencies over the normal coal fired power station and solar alone power station. Preliminary theoretical studies are presented in the following sections.

(II) Utilizing the existing infrastructure (and existing grid) of conventional power stations,

While providing a higher solar to electricity conversion than stand alone solar power stations. Therefore a relatively low implementation cost, and high social, environmental and economic benefits become a reality.

(III) The SAPG can be applied to not only new built power station but also to modify the existing power station with less or no risk to the operation of the existing power stations.

(IV) The thermal storage system that at present is still technically immature is not necessary. The SAPG system is not expected to operate clock-round and simplicity is another beauty of the SAPG. The pattern of electricity demand shows that nowadays air conditioning demand has a great impact on the electricity load. Afternoon replaces the evening to be the peak loading period in summer. This means that the extra work generated by this SAPG concept is just at the right time. Namely, the solar contribution and power demand are peak at the same time i.e. during summer day time.

(V) The SAPG is flexible in its implement. Depending on the capital a power station has, SAPG can be applied to the power station in stages.

(VI) The SAPG actively involves the existing/traditional power industry into the renewable technology and assist it to generate “green” electricity. It is the authors’ belief that without the engagement of existing power industry, any renewable energy (power generating) targets/goals set by governments are difficult or very costly to fulfill.

(VII) Low temperature range solar collectors eg. Vacuum tubes and flat plate collectors can be used in the SAPG. It is a great new market for the solar (collectors) i

V. LIFE CYCLE OF PHOTOVOLTAIC SYSTEMS AND ECOLOGICAL FOOTPRINT:

As a result of the accelerated growth of the PV industry, a rigorous assessment of the environmental impacts of the systems has become necessary, conducted through a life cycle assessment (LCA) integrating all of the manufacturing, operating, collection and waste recycles. The LCA is an orderly process that analyzes the input/output impact of the PV industry from the “cradle to grave”, with the inputs referring to the materials and energy consumed and the outputs illustrated by greenhouse gas (GHG) type emissions and solid and liquid waste.

In addition to the energy considerations previously illustrated by the calculation of the EPBT and the ERF, the parameter most frequently estimated for the LCA assessment is the ecological footprint describing and quantifying the entire greenhouse gases (GHG) released during the lifespan of the PV system and expressed in carbon dioxide equivalents per kWh. The environmental gain expected by the reduction of GHG related to the operation of PV electricity has also to be taking into account. These two assessments are always determined in comparison with the emissions attributed to fossil energies

VI. HEALTH AND ENVIORNMENTAL EFFECTS OF POWER GENERATION.

Traditionally occupational health risks have been measured in terms of immediate accident, especially fatality rates. However, today and particularly in relation to nuclear power, there is an increased emphasis on less obvious or delayed effects of exposure to cancer-inducing substances and radiation.

Many occupational accident statistics have been generated over the last 50 years of civil nuclear power in North America and Europe. These can be compared with those from coal-fired and other electricity generation. All show that nuclear is distinctly the safer means of electric power generation in this respect. A major reason for coal showing up unfavorably is the huge amount of it which must be mined and transported to supply even a single large power station. Mining and multiple handling of so much material of any kind involves hazards, and these are reflected in the statistics.

Currently solar photovoltaic power is used primarily in Germany and Spain where the governments offer financial incentives. In the U.S., Washington State also provides financial incentives. Photovoltaic power is also more common, as one might expect, in areas where sunlight is abundant.

It works by converting the sun's radiation into direct current (DC) power by use of photovoltaic cells. This power can then be converted into the Solar photovoltaic power offers a viable alternative to fossils fuels for its cleanliness and supply, although at a high production cost. Future technology improvements are expected to bring this cost down to a more competitive range. Its negative impact on the environment lies in the creation of the solar cells which are made primarily of silica (from sand) and the extraction of silicon from silica may require the use of fossil fuels, although newer manufacturing processes have eliminated CO_2 production. Solar power carries an upfront cost to the environment via production, but offers clean energy throughout the lifespan of the solar cell.

Large scale electricity generation using photovoltaic power requires a large amount of land, due to the low power density of photovoltaic power. Land use can be reduced by installing on buildings and other built up areas, though this reduces efficiency. The overall production of electricity, all energy sources combined, generates an average of 600 g CO2-eq/kWh, although this varies between countries

TABLE 1
SHOWS GHG EMISSION (G C02-EQ/KWH) RESULTING FROM DIFFERENT ENERGY SYSTEM.

S.N.	Energy System	Average emission
1.	PV system	15-187
2.	Coal	800-1280
3.	Oil	519-1200
4.	Natural gas	360-991

TABLE 2
SHOWS AVG. SOX AND NOX ATMOSPHERE EMISSION ASSOCIATED WITH ENERGY SYSTEM

S.N.	Energy system	Sox (g/Kwh)	Nox (g/Kwh)
1	Photo voltaic	.05 to .36	.025 to .34
2	Coal	5.2 to 12	1.3 to 4.5
3	Heavy fuel	1.1 to 8	.5 to 1.5
4	Diesel generator	.2 to 1.3	.3 to 12

.

V. CONCLUSIONS

Despite the fact that photovoltaic conversion is still under developed, it is certainly a technology that will progress in a sustained manner since the prospects of this technology are favorable and appealing. Generating few or no greenhouse gases during the operating stage, producing no sound pollution, able to be integrated both aesthetically and functionally into the urban landscape, it should generate more interest and surpass, in an intelligent manner, the technical and technological limitations. The SAPG has special meanings for solar energy. For in summer weather, both the solar radiation and the electrical load demand peak, and it is easy to make heat carrier in different temperatures with different type of collectors. So the increased solar radiation can supply the increased energy to meet the increased power demand. In addition, the solar aided system can also eliminate the variability in power output even without thermal storage system. The concept of the solar aided power system is really a superior energy system and is a new approach for solar energy power generation

REFERENCES

[1] Eastop & McConkey, Applied Thermodynamics for Engineering Technologists, Longman Scientific & Technical, 5th Edition, 1993.

[2] Yongping Yang, Qin Yan, Rongrong Zhai and Eric Hu, An efficient way to use mediumor- low temperature solar heat for power generation--integration into conventional power plant, Applied Thermal Engineering 31 (2011), pp. 157-162.

[3] Eric Hu, Graham J. Nathan, David Battye,Guillaume Perignon, and Akira Nishimura, An efficient way to generate power from low to medium temperature solar and geothermal resources, Chemeca 2010, 27-29 Sept. 2010, Adelaide, Australia. Paper #138, ISBN: 978-085-825-9713.

[4] Eric Hu, YP Yang, A Nishimura and F Yilmaz, “ Solar Aided Power Generation” Applied Energy, 87 (2010) pp2881-2885.

[5] Y.You and Eric Hu: Thermodynamic advantage of using solar energy in the conventional power station, Applied Thermal Engineering, Vol. 19, No. 11, 1999.

[6] H. Zhai et al, Energy and exergy analyses on a novel hybrid solar heating, cooling and power generation system for remote areas, Applied Energy, Volume 86, Issue 9, 2009, Pages 1395-1404.

[7] Q.Yan, YP Yang; A. Nishimura, A. Kouzani; Eric Hu, "Multi-point and Multi-level solar integration into conventional power plant" Energy and Fuels , 2010, 24(7), 3733- 3738.

[8] A.Valero, F.Lerch, L.Serra, J.Royo, Structureal theory and thermodynamic diagnosis, Energy Conversion and Management vol.43 (2002), p1519–1535

[9] JY Qin, Eric Hu and Gus Nathan, "A modified thermodynamic model to estimate the performance of geothermal aided power generation plant", The 2011 International Conference on Energy, Environment and Sustainable Development (EESD 2011), 21-23 Oct. 2011, Shanghai, China.

[10] Aladjidi, G. & Rolland, B. (2010). Photovoltaique : Idées Reçues et Enjeux Industriels, In *Mines Revues des Ingénieurs, Dossier les Énergies Renouvelables*, No. 446, pp. 29-31 (May-June 2010), 02.03.2011, Available from http://www.mines energie.org/Dossiers/ENR2010_16.pdf

[11] Antony, F. ; Durschner, C. & Remmers, K.-H. (2010). *Le Photovoltaique pour Tous, Conception et Réalisation d'Installations* (2ème Édition), Édition Observ'ER, ISBN-13 : 978-2-
913620-48-3, Paris, France

[12]ATSDR (2003). Toxicological Profile for Selenium, In *Agency for Toxic Substances and Disease Registry*, Toxic Substances Portal, 12.07.2011, Available from http://www.atsdr.cdc.gov/ toxprofiles/tp.asp?id=153&tid=28

[13] ATSDR (2004). Toxicological Profile for Polybrominated Biphenyls and Polybrominated Diphenyls Ethers, In *Agency for Toxic Substances and Disease Registry*, Toxic Substances Portal, 13.07.2011, Available from
http://www.atsdr.cdc.gov/toxprofiles/tp68-c8.pdf