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Market Status Analysis For Optimization of Solar Power Plant: A Review

Dr Ashwini Mathur

G-3,G-BLOCK,MAKADWALI ROAD, NEAR FIRST STEP SCHOOL,VAISHALI NAGAR, AJMER (RAJASTHAN)-305001

ABSTRACT

Solar energy has experienced phenomenal growth in recent years due to both Technological improvements resulting in cost reductions and government policies supportive of renewable energy development and utilization. This study analyzes the technical, economic and policy aspects of solar energy development and deployment. While the cost of solar energy has declined rapidly in the recent past, it still remains much higher than the cost of conventional energy technologies. Like other renewable energy technologies, solar energy benefits from fiscal and regulatory incentives and mandates, including tax credits and exemptions , feed-in-tariff, preferential interest rates ,renewable portfolio standards and voluntary green power programs in many countries. Despite huge technical potential, development and large scale, market- driven deployment of solar energy technologies world- wide still has to overcome a number of technical and financial barriers .Unless these barriers are overcome, maintaining and increasing electricity supplies from solar energy will require continuation of potentially costly policy supports.

INTRODUCTION

Solar energy has experienced an impressive technological shift. While early solar technologies consisted of small scale photovoltaic (PV) cells, recent technologies are represented by solar concentrated power (CSP) and also by large scale PV systems that feed into electricity grids. Potential expansions of carbon credit markets also would provide additional incentives to solar energy deployment; however, the scale of incentives provided by the existing carbon market instruments, such as the Clean Development Mechanism of the Kyoto Protocol, is limited .The costs of solar energy technologies have dropped substantially over the last thirty years. For example, the cost of high power band solar modules has decreased from about $27,000 /KW in 1982 to about $4,000/KW in 2006; the installed cost of a PV system declined from $ 16,000/KW in 1992 to around $ 6,000/KW in 2008(IEA-PVPS, 2007; Solarbuzz, 2006, Lazard 2009).The rapid expansion of the solar energy market can be attributed to a number of supportive policy instruments, the increased volatility of fossil gas (GHG) emissions.

Theoretically, solar energy has resource potential that far exceeds the entire global energy demand (Kurokawa et al. 2007; EPIA, 2007).Despite this technical potential and the recent growth of the market, the contribution of solar energy to the global energy supply mix is still negligible (IEA, 2009).This study attempts to address why the role of solar energy in meeting the global energy supply mix continues to be so a small.

CURRENT STATUS OF SOLAR ENERGY TECHNOLOGIES AND MARKETS

Technologies and Resources

Solar energy refers to sources of energy that can be directly attributed to the light of the sun or the heat that sunlight generates (Bradford, 2006).Solar energy technologies can be classified along the following *continuum*: 1) passive and active; 2) thermal and photovoltaic; and 3) concentrating and non-concentrating. Passive solar energy technology merely collects the energy without converting the heat or light into other forms. It includes, for example maximizing the use of day light or heat through building design.

In contrast, active solar energy technology refers to the harnessing of solar energy to store it or convert it for other applications and can be broadly classified into two groups: (i) 4 photovoltaic (PV) and (ii) solar thermal. The PV technology converts radiant energy contained in light quanta into electrical energy when light falls upon a semiconductor material, causing electron excitation and strongly enhancing conductivity (Sorensen, 2000). Two types of PV technology are currently available in the market: (a) crystalline silicon-based PV cells and (b) thin film technologies made out of a range of different semiconductor materials, including amorphous silicon, cadmium-telluride and copper indium gallium diselenide1.Solar thermal technology uses solar heat, which can be used directly for either thermal or heating application or electricity generation. Accordingly, it can be divided into two categories: (i) solar thermal non-electric and (ii) solar thermal electric. The former includes applications as agricultural drying, solar water heaters, solar air heaters, solar cooling systems and solar cookers2 (e.g. Weiss et at., 2007); the latter refers to use of solar heat to produce steam for electricity generation, also known as concentrated solar power (CSP).Four types of CSP technologies are currently available in the market: Parabolic Trough, Fresnel Mirror, Power Tower and Solar Dish Collector (Muller-Steinhagen and Trieb, 2004; Taggart 2008 a and b; Wolff et al., 2008).

CURRENT MARKET STATUS

The installation of solar energy technologies has grown exponentially at the global level over the last decade. For example, as illustrated in Figure 2(a), global installed capacity PV (both grid and off-grid) increased from 1.4 GW in 2000 to approximately 40 GW in 2010 with an average annual growth rate of around 49%(REN21, 2011).Similarly, the installed capacity of CSP more than doubled over the last decade to reach 1,095MW by the end of 2010.Non-electric solar thermal technology increased almost 5 times from $40GW^{th}$ in 2000 to 185 GW^{th} in 2010 (see Figure 3).The impetus behind the recent growth of solar technologies is attributed to sustained policy support in countries such as Germany, Italy, United States, Japan and China.

THE ECONOMICS OF SOLAR ENERGY

There is a wide variety of solar energy technologies and they compete in different energy markets, notably centralized power supply, grid-connected distributed power generation and off-grid or stand-alone applications. For instance, large-scale PV and CSP technologies compete with technologies seeking to serve the centralized grid. On the other hand, small-scale solar energy systems, which are part of distributed energy resource (DER)7 systems, compete with a number of other technologies (e.g., diesel generation sets, off-grid wind power etc.). The traditional approach for comparing the cost of generating electricity from different technologies relies on the "levelized cost "method 8 .The levelized cost (LCOE) of a power plant is calculated as follows:

LCOE-OC/CFX8760 x CRF+OMC+FC

Where OC is the overnight construction cost (or investment without accounting for interest payments during construction); OMC is the series of annualized operation and maintenance (O&M) costs; FC is the series of annualized fuel costs; CRF is the capital recovery factor; CF is the capacity factor; r is the discount rate and T is the economic life of the plant.

ESTIMATED FUTURE GROWTH OF SOLAR ENERGY AND BARRIERS TO REALIZING GROWTH

Advocates of solar energy claim that it will play a crucial role in meeting future energy demand through clean energy resources. Existing projections of long -term growth (e.g., until 2050) of solar energy vary widely based on a large number of assumptions. For example,Arvizu et al.(2011) argue that expansion of solar energy depends on global climate change mitigation scenarios. In the baseline scenario (i.e.,in the absence of climate change mitigation policies), the deployment of solar energy in 2050 would vary from 1 to 12 EJ/yr. In the most ambitious scenario for climate change mitigation, where CO_2 concentrations remain below 440 ppm by 2100, the contribution of solar energy to primary energy supply could reach 39 EJ/yr by 2050.

EPIA/Greenpeace (2011) produces the most ambitious projections of future PV installation. The study argues that if existing market supports are continued and additional market support mechanisms are provided, a dramatic growth of solar PV would be possible, which will lead to worldwide PV installed capacity rising from around 40 GW in 2010 to 1,845 GW by 2030. The capacity would reach over 1000 GW in 2030 even with a lower level of political commitment.

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