Performance and Economic Analysis of Thin-Film Photovoltaic vs. Concentrated Solar Power

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Photovoltaic Systems

Introduction

The thin film photovoltaic cell (TFPV) also referred to as thin film solar cell(TFSC), is defined as "a cell created by putting down one or more thin layers (thin film) of photovoltaic material on a substrate." (Onoda, Bekki & Mc Cready, 2012).

According to Harris (2008), there are three types of thin-film solar cells depending on the semiconductor used and include: amorphous silicon (a-Si), cadmium telluride (CdTe) and copper indium gallium selenide (CIGS).

Performance

Amorphous silicon is arranged spontaneously and thinly layered. It was the earliest attempt at thin layered photovoltaic cells. Its however not efficient in large scale therefore has been restricted to small scale applications. The cadmium telluride has been determined as the most ecofriendly of solar panels since it requires the least amount of energy to develop. It also has a very thin band gap therefore is an effective semiconductor. However cadmium is a highly toxic material therefore can result in environmental degradation. Onoda, Bekki & Mc Cready (2012) observe that copper indium gallium selenide is the newest technology and has the highest efficiency levels attained by any thin film. However, the mass production of the cells may result in difficulty in production of reliably efficient cells.

Thin film cells were considered as less efficient than their counterparts. In recent times though, a flexible photovoltaic cell that has surpassed the 18.7% efficiency rating attained by earlier flexible photovoltaic cells and equaled that of rigid silicon based solar cells by attaining a 20.4% efficiency, has been developed the Swiss Federal Laboratories for Materials Science and Technology (Empa). The cells are based on copper indium gallium selenide semiconductors which absorb 99% of all the incident light in the first micron of the material. This results in very thin, light weight and low cost solar cells. (Lombardo, 2013)

Economic

The production cost of the photovoltaic systems is low. This is due to reduced land occupied, the system doesn't require conventional building materials They are also extremely low in weight and highly flexible. This reduces the cost of transportation and storage. There is reduction of power loss associated with distribution of power thus increasing overall efficiency. (Davis,2003).

It also reduces the complexity of installation and the number of support machinery required thus significantly reducing the cost and time required for installation. They therefore have the max potential in terms of electricity output among the reusable energy systems. The data related to economic parameters in photovoltaic systems lacks in their economic assessment and are based on their annual life cycle cost methods. The cost of photovoltaic defers for various countries depending on factors such as the availability of materials thus the economic feasibility defers as well. The photovoltaic systems can also result in saving large amounts of fuel used in generation of fuel. This also reduces the use of fuel generators, reduces wear and tear of generators thus minimizing the cost of maintenance. (Jamil, Kirmani, & Rizwan., 2012)

Concentrated solar power

Introduction

Smith, (2012) notes that the concentrated solar power is a system that uses thousands of mirrors to reflect or concentrate sunlight and convert that energy into high temperature heat which in turn is used to generate a electricity.

Performance

Smith (2012) explains that the concentrated solar power system consists of heliostats that reflect sun rays and concentrate them on a large heat exchanger called a receiver. The receiver contains a fluid flowing through the piping forming the external walls. After passing through the receiver, the fluid flows into a storage tank where energy is stored as high temperature until electricity is required. Once electricity is required the heated fluid is pumped into a steam generator and water is also pumped through and is heated into steam which is used to run a turbine as the fluid is pumped back to the receiver to be reheated.

The commercial CSP have estimated capabilities that range between 14-80 MWe, maximum temperatures of about 390•c, an efficiency rate of about 14%-16% with a capacity factor of 25%-30%. These factors however vary with location. Those systems that use molten salt have a higher efficiency of about 40%-70% and a storage capacity of about 6-15 hours. Their lifetime cycle is more than 30 years. The cost of CSP is relatively higher than that of other conventional systems. In CSP, the investment and financing costs account for 84% of the levelised cost of electricity and the rest of it is operational and maintenance cost. (Simboloti, Taylor andTosato, 2013)

Economic

The concentrated solar power (CSP) systems are large systems that require conventional building materials and large tracts of land to be implemented. They are also expensive to install. It also extremely reduced mobility. However, despite its various demerits it has a high economic feasibility. For instance, the concentrated solar power system in California. According to Stoddard, Abiecunas & O'Connell (2006) a CSP with 6 hours of storage can perform peaking for a utility depending on point of interconnection and the load profile of the local electricity provider. They have proven in their study of the system at California that they provide greater profits both financially and also employment, for instance CSP in California provides approximately $1.40 to the Gross state product for every dollar spent while natural gas plants contribute 0.90-1.00. It also provides more permanent jobs in maintenance and operations fields. They also determined that the technological advancements that have been attained so far, the efficiency has been improved thus the cost of power has reduced and made it cheaper. CSP also minimize fluctuating power costs because they are a fixed cost generation systems. They also have minimum emissions thus they have little or no environmental pollution.

Conclusion

Photovoltaic (PV) can be installed almost everywhere concentrated solar power(CSP) can but not vice versa. The production of the photovoltaic is also less demanding than that of CSP in terms of material and plant requirements as well as production cost therefore, more manufacturers are interested in PV than CPS. He also states that the simplicity of the PV enables the production to major only on the reduction of cost per watt, while CSP has multiple challenges such as increasing optical efficiency, transfer fluids, higher efficiency turbines and so on. Although, PV is cheap and very quick to install it has a major downside, which is its dispatch ability. While, CSP plants can store energy for long hours thus the production profile matches the demand profile, PV can't be dispatched as a feasible commercial storage system just yet. (Gasper,2013).

Although the photovoltaic power sources are more advantageous in terms of size, cost of production, weight as well as many other factors in comparison to the concentrated solar power, it has a major demerit on its commercial feasibility, since it can't store energy for long periods of time. Therefore, the PV produce the largest amount electrical energy when the sunlight is maximum and it fluctuates with the amount of sunlight available. Some of the photovoltaic systems use toxic materials such as cadmium. It therefore cannot match the levels of demand therefore the concentrated solar power is the best option as of now. The concentrated solar power has its merits such as it stores energy for extended periods of time. The fluids used in the production of power are also reused unlike conventional gas and coal systems. Its also completely environmental friendly since there are no emissions whatsoever. That said, it requires alot of refining like: Find a method that can reflect more light more efficiently without taking up so much space, reducing the cost of production.

There are also other factors as stated by Gasper (2013), improving the optical efficiency of collectors, more effective and efficient heat transfer fluids and the procurement of higher efficiency turbines.

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