STUDY OF THE EXISTING SOLAR TECHNOLOGY AND APPLICABILITY OF ALTERNATE THIRD GENERATION PHOTOVOLTAIC TECHNOLOGY IN DUBAI

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Abstract

Third generation photovoltaic technology is an upcoming technology which tries to overcome the Shockley-Queisser limit which states that efficiency of a single band gap solar cell cannot exceed 31-41%. The primary objective of this paper is to access the viability of this technology in high temperature regions especially Dubai which has a high potential for utilizing solar power. The report compares the existing technology of solar cells and their efficiencies. The findings of this report show the efficiency increase that could be obtained by utilizing this technology in Dubai.

Keywords: *Third Generation Solar Cells, Dubai, Energy*

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1. INTRODUCTION

Most of the energy produced today is from non-renewable resources like fossil fuels (coal, petroleum, natural gas). These resources, as the name suggests, are available in limited quantities and are expected to be depleted in the coming years. Another problem with these resources is the environmental pollution caused by their usage. Global warming is occurring at an alarming rate due to this environmental pollution. Although renewable sources may be available and fossil fuels are used at a minimal rate, the demand for electrical power will still be high in the coming years.

The above statistics show the need for upgrading the usage of renewable energy technology for meeting the world's energy demand. Even in the Middle East where oil is available at abundant quantities, renewable sources of energy will help to minimize carbon footprint in the region and dependency on fossil fuels. With the costs of power production from renewable sources decreasing, it is becoming more attractive among power producers.

Solar energy has high potential in Dubai due to its location receiving a high solar insolation on a yearly basis. The UAE was the 6th top carbon dioxide emitter per capita in the world in 2009: 40.31 tonnes per capita [1]. This calls for an urgent need to maximize solar power production. The Dubai Clean Energy Strategy aims to provide 7 per cent of Dubai's energy from clean energy sources by 2020. It will increase this target to 25 per cent by 2030 and 75 per cent by 2050 [2].

Third generation solar cells are upcoming solar cells under research that are capable of overcoming the Shockley-Queisser limit of 31-41% efficiency for single band gap solar cells [3]. In a normal solar cell, the de-excitation of electron from the conduction band to the valence band releases heat thereby increasing the temperature of solar cell and hence lowering the efficiency of the solar cell. A 3rd generation solar cell reduces this de-excitation temperature thereby increasing efficiency. In regions like Middle Est especially Dubai, the potential for solar power is extremely high. However, the temperature in these regions makes it difficult to obtain higher efficiencies. Hence, the 3rd generation solar cells would play a very crucial role in increasing the solar power generated in the region.

The report focusses on the current solar technology in usage in Dubai and impact of 3rd generation technology application.

2. LITERATURE REVIEW

A few reports relating to the solar energy production were found and reviewed. Most of these reports have focussed on existing first and second generation solar technologies and few have indicated the advancements in research in the field of third generation photovoltaics.

Solar power is fast developing and may reduce the cost of turning to alternate resources if implemented early (Chu et al, 2011) and it has the capability of improving the economy of nations. The increasing demand for renewable resources is forcing countries to look at alternatives including solar, wind, geothermal etc. A study by Parida (Parida et al, 2011) highlighted the current developments in solar energy production for meeting the global energy demand and reducing global concern. While meeting the energy demand, solar energy also indirectly contributes to the lowering of

energy expenditure, a reduced CO_2 emission contributing to a safer environment and lesser usage of fossil fuels in Europe (Ortega-Izquierdo et al, 2016).

While the existing first generation and second generation solar technologies are used on a wide scale commercially, with the first generation being more efficient and costlier compared to the second generation, it is the third generation photovoltaics, still under research, which are trying to lower costs while improving the efficiencies further. Multi-junction cells and nanoparticles, both 3rd generation technologies, are being developed to make solar panels more efficient (Lamont, 2013). These nanoparticles are nothing but quantum dot solar cells which once available would replace traditional Si semiconductors. Quantum dots would further increase the efficiency of 3rd generation photovoltaic cells (Berbezier et al, 2013).

With a high exposure to solar radiation, United Arab Emirates has a vast potential for meeting its entire energy demand through solar energy alone. A study by Islam (Islam et al, 2008) showed that Abu Dhabi with its location and amount of sunlight received had a high potential for using solar power. As described before, UAE is one of the largest contributors to CO_2 pollution. This is attributed to its energy consumption through fossil fuels. Kazim (Kazim, 2006) showed the various remedies for the increased energy consumption one of which was usage of renewable resources. The increased fossil fuel consumption means that UAE will not be able to meet natural gas demand by 2042 (Kazim et al, 2001).
A study by Mokri (Mokri et al, 2013) suggested the benefits for the UAE in using solar power. The study argues that availability of fossil fuels is limited and offers a comprehensive plan to equip industrial and residential areas in the UAE with solar panels.

3. ANALYSIS

While the oil resources in the UAE are still abundant, the country has taken several initiatives to increase solar energy dependency. Some of the projects undertaken are-

- Mohammad Bin Rashid Al Maktoum Solar Park of Dubai Electricity and Water Authority [4]
- Abu Dhabi's Shams 1 [5]
- Masdar Project in the city of Masdar near Abu Dhabi [6]

However, the current solar energy production does not meet the demands. Hence, the government will have to step up its effort and adopt measures to increase renewable energy production as seen in the case of Germany which operated only on renewable power during a single day. With the Expo 2020 not very far off, the economy is expected to increase along with the influx of immigrants. Meeting the growing energy demand would hence become a problem if alternate resources are not handled properly.

The current major solar panel manufacturers in Dubai include Microsol, Hollandia Solar, JNC Solar, Bhatia Brothers to name a few [7]. Solar energy conversion efficiency of these solar panels is around 12-16% since these panels utilize the first and second generation technology. The major loses in energy of these panels in the UAE is due to soiling (Dubai being a dusty location hence accumulation of dust in the panel reduces energy production) and temperature (the region has a high average annual temperature) [8]. The various losses are listed in Table-1 below.

Table-1 Loses causing reduction in solar power production in United Arab Emirates

Loss	**Decrease in the output in UAE (%)**
Module Soiling	9
Module Temperature	4.5
Shading	.5
Inverter Loss	4
Mismatch and DC losses	2.5
Approx. Total Loss	25
Power retained	**75**

From Table-1, it is clear that module heating due to temperature represents a significant loss to the solar panel. Fig.1 shows the variation of solar power with temperature. From the figure, it can be seen that solar power increases as temperature of the panel increases and stays at around 700 mW between 30°C and 45°C [9]. The optimum temperature is around 29°C [10]. In places like Dubai, the temperatures go well beyond the 50°C mark with annual average temperature quite high. At the 50°C mark, we can see that the solar power reduces drastically and the efficiency is also lowered for 1st and 2nd generation photovoltaic cells. This is the reason why the implementation of 3rd generation PV cells would be highly beneficial for places like Dubai where the solar panels tend to get heated up rather quickly.

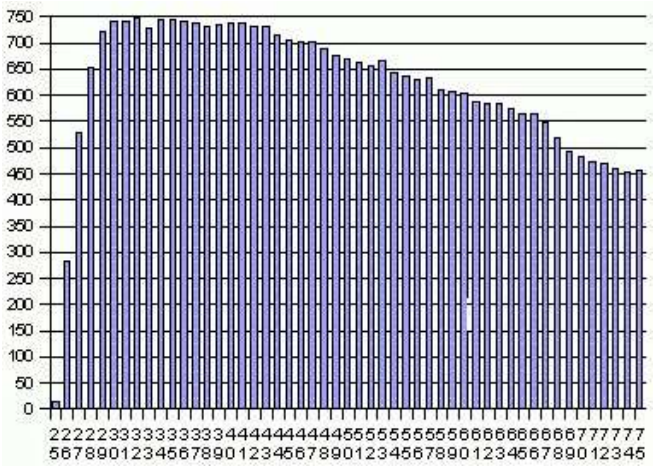

Fig. 1- Variation of solar power (Y-axis) with temperature (X-axis)

4. CONLCUSION

United Arab Emirates has a very high potential for producing solar energy as the country is inherently located in a region receiving high amount of solar radiation. However, due to the abundance of conventional fuels, the cost of such fuels is still low thereby not making renewable

energy as a commercially attractive option. Despite this, the Dubai government has been undertaking several projects to make use of this abundant renewable resource.

The existing solar technologies in Dubai produce an efficiency of less than 16% as compared to the laboratory efficiency of 40%. Such a difference can be overcome through the use of 3rd generation photovoltaics as they reduce de-excitation temperature. Although the cost is yet to be determined, the price is expected to be fairly low.

With the Expo 2020 arriving soon, the government would have to upgrade the energy production in order to meet the growing demand. Soon after the Expo, Dubai is expected to see a commercial and economic boom generating more and more industries which in turn would require more power. Solar energy would be the ideal option.

Not only in the UAE but the world together will have to increase renewable energy dependency with the deterioration of conventional fossil fuels. Added to this is the problem of global warming and environmental pollution. Action towards a greener and sustainable planet is the need of the hour.

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