A MULTI CRITERIA ANALYSIS TO EVALUATE FUNCTIONING OF PHOTOVOLTAIC POWER PLANTS IN PAKISTAN

ABSTRACT

Since 2005 Pakistan has been entrenched in an energy crisis which has not only crippled the economy but has also resulted in huge problems for the masses. Presently the energy shortfall is at 6000MW with an average load shedding of 6 to 8 hours in urban areas of the country. Apart from that 40% of the rural areas are not connected to the national grid and have no access to electricity. Pakistan being close to the equator receives abundant sunlight and therefore has a huge solar potential. The irradiation in majority of the cities in Pakistan is close to 4.5 kilo watt hour per day which is very high and can be used to produce electricity through solar technologies such photovoltaic or solar thermal. The solar potential in Pakistan is enormous and can play a key role in minimizing the energy shortfall in Pakistan. In this context, promoting the use of photovoltaic technologies could represent an opportunity for the country. Thus, the aim of the present study is to investigate, through an AHP model, effective factors for the correct functioning of the plant to increase its potential.

Keywords: Photovoltaic technologies, solar plant, AHP.

1. Introduction

The government in Pakistan is promoting the use of photovoltaic energy throughout the country by abolishing the 32.5% taxation, which until recently, was imposed on solar systems. The aim of the executive is in fact to reduce the costs for the installation in such a way as to incentivize and encourage citizens and entrepreneurs to adopt this form of renewable energy. A choice aimed at strengthening the national economy and defense capacity, as well as at making itself more independent from oil. A way, therefore, to also reduce pollution and to promote eco-sustainable attitudes among the population. Indeed, renewable energy technologies offer clean sources of energy that have a much lower environmental impact than conventional energy technologies. The first photovoltaic plant, the *Quaid-e-Azam power plant* was inaugurated in 2014. Since then the nation has tried to give a more organic development to the solar component without necessarily aiming at mega installations. This is demonstrated by the Khadim-e-Punjab Ujala program, with which the regional government intends to give new impetus to small-scale photovoltaic technology.

2. Literature Review

Solar photovoltaics generate energy by the employment of solar panels which consist of solar cells that employ direct conversion of incoming photons to electrical energy. The basic principle involves the absorption of photons by the silicon solar cells which causes the generation of an electron hole pair, the electrons are carried into the external circuit which contribute to the electrical energy. The main solar photovoltaic technologies can be divided into three categories polycrystalline, mono crystalline and thin films. The thin films

are then further divided into materials such as Cadmium Telluride, amorphous silicon, CIGS (Copper Indium Gallium Di- selenide) and CIS (Copper Indium Di-selenide). The PV technology employed at Quaid-e- Azam Solar Power consists of polycrystalline solar PV modules. The Polycrystalline technology is the oldest one and therefore is highly mature now (Awan *et al*., 2014). Moreover, the cost for manufacturing the material is less as compared to other technologies. Considering the high temperatures in Bahawalpur the Polycrystalline technology is well suited to bear the high heat and soring temperatures, since the mono crystalline panels are very thin and due to high heat and temperatures they are often damaged, although they offer high efficiency but due to high cost of manufacturing and very thin material which is easily damaged they are not preferable for a location such as Bahawalpur. When considering thin films, the technology is still in research phase and the commercial development is still minimal. Therefore, the best available technology for use in Quaid-e-Azam Solar was Polycrystalline technology.

3. Hypotheses/Objectives

The solar park is a strategic structure and will be used to address the country's energy shortage. In fact, Pakistan's energy demand has grown by about 8% each year, the country with an estimated energy production deficit of 6 GW. It is a fundamental solar farm, which is part of the planning of the "*China-Pakistan Economic Corridor*", a development program for energy and infrastructure projects designed to connect China to southern Pakistan and to develop a new route for trade. Punjab, the province where the project is located, enjoys one of the highest solar radiation rates in the world. It is a 100 MW solar plant that spans 500 acres (200 ha) and houses 392,158 solar modules. The project was carried out at a cost of 131 million dollars. However, Quaid-e-Azam Solar Park was unable to produce affordable energy and expected output, for several reasons. The motivation behind this study is that there has been a lack of extensive research in the field of solar PV power plant installation.

4. Research Design/Methodology

In this study an AHP model was developed. AHP is a helpful method in decision-making processes which is based on mathematics and psychology (Saaty, 1977; De Felice and Petrillo, 2013). The model was developed by an expert team formed by: 1 AHP expert, 2 experienced photovoltaic plant engineers, 1 expert in logistics and 1 expert in feasibility projects. The model is based on information of secondary sources (literature review) and pool of experts. Goal, criteria, alternatives, influences and judgments were obtained following regular meetings of the expert team. Judgments were aggregated through the geometric mean. Inconsistency was checked.

5. Data/Model Analysis

Figure 1 shows the proposed AHP model. The model is formed by 3 criteria: Economic (C1); Technical (C2) and Land (C3). Furthermore, the model is formed by10 sub criteria: Payback Period (SC1.1); Net Present Value (SC1.2); Internal Rate of Return (IRR) (SC1.3); Benefit Costs Ratio (BCR) (SC 1.4); Electricity (SC2.1); Wind (SC2.1); Water (SC 2.3); Reduction in GHG Emissions (SC3.1); Irradiance (SC3.2); Temperature (SC3.3).

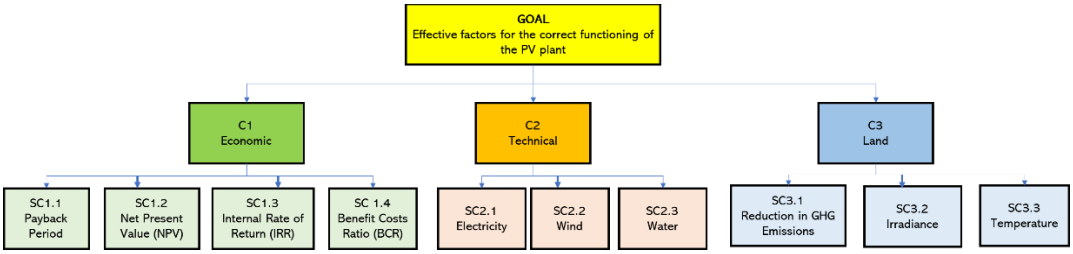

Figure 1: AHP Model

The results indicate that the most significant criteria when evaluating the overall effective factors for the correct functioning of the PV plant are: LAND (45%) which can be explained as Bahawalpur is a desert terrain, with a high number of dust, so the efficiency of the panels has been reduced by 40%. It took 30 people to clean the panels with 15 days to restore the panels to their full capacity, which reduced the output of the installed 100 MW plant to less than 18 MW. The second relevant criteria is ECONOMIC (35%) followed by TECHNICAL (20%). The most important sub-criterion is WATER (18%) which can be explained as each of the 400,000 panels installed required one liter of water to clean. A 15-day cleaning cycle required 124 million liters of water (enough to support 9,000 people) while rain in the Cholistan desert is rare and far between. Providing such a large amount of water in the desert has become a challenging and daunting task for the management team. In addition, manual cleaning methods allowed the dust to settle before it was cleaned up. The second most important sub criterion is TEMPERATURE (15%) which can be explained as Bahawalpur's temperature rises above 45 degrees centigrade, which is much higher than the 25 degrees centigrade required for efficient solar energy production.

6. Limitations

It is important to note that the findings may be related to the characteristics of the analyzed scenario.

7. Conclusions

Based on the study area priorities, a guide map was carried out to assist the decision making process to establish new photovoltaic plants.

8. Key References

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