SOLAR ENERGY AND ITS FUTURE IN SAUDI ARABIA

[1]AAMIR JAMAL, [2]KAVITA S. JERATH

[1]Department of Electronics and Communication Engineering [2]Deaprtment of General Science
Email: [1]amazingaamir@gmail.com, [2]kavita@dubai.bits-pilani.ac.in

Abstract-Besides being one of the leaders in oil production, Saudi Arabia is blessed with renewable energy sources like solar energy due to its location in the so called sun-belt. Average solar irradiation in the country exceeds 1.800 kWh/m^2 up to 2.200 in some locations. In order to meet the country's increasing energy demand a significant number of installations and research activity is going on. In order to provide assistance in future R&D work, it is necessary to know about the latest work done in this area. This paper discusses about the present and the future scope of development of solar energy in Saudi Arabia which could make the country as a potential solar leader. The paper focusses on solar energy projects from 2010 onwards.

Keywords-Renewable energy, solar power, photovoltaic, CSP, solar carport

I. INTRODUCTION

As the non-renewable resources are depleting, the world is moving towards the use of renewable energy. By 2020, it is expected that renewable energy would cover almost 13% of the world's energy needs **1)** [1]. As Saudi Arabia is situated on the eastern edge of **2)** the so called Sun Belt, the country has a huge potential to tap solar energy, which is clean, renewable and available for free. About 2200 kWh/m^2 of solar radiation falls on the Arabian Peninsula on an average. Bright sunshine for 8.89 hours on an average is available and the average horizontal solar radiation is 5591 Wh/m^2. These figures clearly indicate that solar radiation is uniquely available in all areas of Saudi Arabia at high intensity throughout the year. This can also be conformed from figure 1.

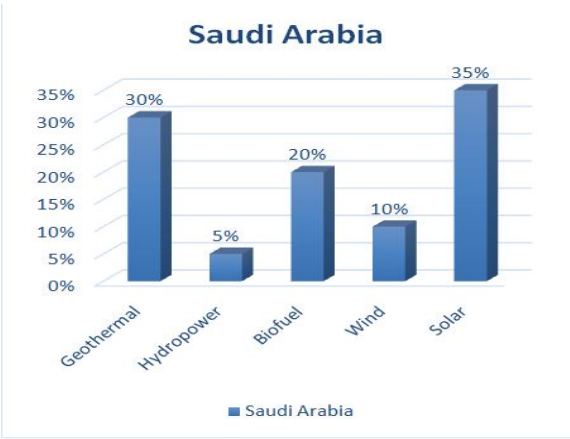

Figure 1: Availability of renewable energy in Saudi Arabia

Saudi's are now realizing this God gifted wealth and are increasingly investing on solar energy to meet its energy demands. The country has planned 41 GW installed solar capacity by 2032 of which 16 GW should be PV [2].

As the country is increasing its dependence on solar energy, this would result in an economic and environmental friendly power generation. The aim of this paper is to discuss the current solar projects in Saudi Arabia (from 2010 onwards) and also predict the future of solar energy in the country.

II. RECENT WORKS ON SOLAR ENERGY IN SAUDI ARABIA

KAUST Solar Park:

KAUST solar park is located on the rooftop of King Abdullah University Of Science and Technology (KAUST) located in Thuwal, Saudi Arabia.

Figure 2: KAUST Solar Park

This project was completed in April 2010 and it is a government funded project with Saudi Aramco being the owner of this project. Coenergy and National Solar Systems were given the contract for this project. A 2 MW photovoltaic (PV) system has been installed on the rooftop of north and south laboratory buildings. It consists of 9,300 Sun Power 215 W solar panels which cover an area of 11,600 m^2. Sun power high efficiency solar modules were chosen as an ideal solution as they made best use of the space and gave high energy output per square meter. The actual output is approximately 5 % higher than the planned output with an annual energy production of about 3,281 MWh which is used to meet the energy requirements of the campus. 4,134 m^2 solar thermal array provides hot water to all the campus buildings while 16,567 m^2 solar photovoltaic arrays generate and distribute power to the buildings in the campus on demand. Arrays can also be incorporated in the future in order to meet increased energy demands.

Two solar towers were also built in the campus in order to create a pressure difference with the help of sun and prevailing winds. The outer part of these towers consists of two glass curtain wall skins. In order to allow maximum solar energy, the outer skin is made transparent while the inner skin is made up of highly absorbent tinted glass that brings together the solar energy to maximize the hot air within the tower. As this hot air rises and escapes from the top of the tower, it is replaced by cooler air from the courtyard. This helps the people inside the campus feel comfortable in exterior courtyard for more than 75 % of the year.

The benefits of this project includes reduction of 1,700 tons of carbon emission annually and equals carbon offsets for 7.3 million miles of air travel. This project also supported the university's aim to become a leader in renewable energy and raise awareness among the people about the benefits of alternative energy. As a result of this, the university has been awarded with the prestigious LEED (Leadership in Energy and Environmental Design) platinum certification from US Green Building Council [3].

3) Solar Water Heater:

Figure 3: Solar panels at Princess Noura University

Located in Princess NouraBintAbdulrahman University for women in Riyadh, this project was commissioned in April 2012. The university is the owner of this project and the contact was given to Millennium Energy Industries. Energy produced from GREENone TEC large sized collectors is utilized in producing hot water and supporting the heating system on the 8 square km campus.

This flagship project was a part of university's $11 billion project with 40,000 engineers, workers and technicians involved in construction. It has an installed capacity of 25 MW (17 MW in winter) there by meeting the hot water needs of all the 40,000 students in the campus.

The solar water heater consists of a collector surface area of 36,305m^2. This size easily makes this as the biggest solar plant in the world. The solar panels are mounted on the roof of the university building. GK 3000 series collectors are used which are 5m^2 in length and 10m^2 in breadth. These collectors are used for high capacity solar thermal systems of more than 60m^2 and are suited to adapt to the climatic condition of the Arabian Desert. Each of these solar collectors are made up of special glass and have an improved mounting system to compensate for the bad weather conditions. It has an absorption capacity of 95% and weigh 170 kg. Up to 52 million liters of fuel and 125 million kg CO_2 emission will be saved by this project in 25 year system life. [4, 5].The university has been awarded with the prestigious LEED (Leadership in Energy and Environmental Design) platinum certification from US Green Building Council.

NPOC and can also supply excess electricity to the grid [6, 7].

4) Al Khafji Solar Powered Desalination Plant:

Figure 4: Proposed Solar Water Desalination Plant in Khafji

This plant will be built in Al Khafji city and would become the world's first large scale solar powered desalination plant. In January 2015, an agreement was made between Advanced Water Technology (AWT) and Abengo to build this solar powered desalination plant. The expected cost is $ 130 million with early 2017 being the expected date of completion. With new solar saline water osmosis desalination method using ultra filtration for pretreatment process it is expected to provide 60,000m^3 of desalinated water each day to the city. This plant will be built over a 250m x 700m land with solar array panels installed on a 90h area approximately 1 km away from the plant.

An ultra-high concentrator photovoltaic (PV) plant will supply power needed by the desalination plant. KACST will design polycrystalline PV solar cells to be fitted in the solar power plant which will have an installed capacity of 15 MW. This plant would be connected to desalination plant as well as the national grid. A tracking technology would also be fitted in the solar plant in order to increase the solar power [8].

5) Makkah Solar Energy Project:

A solar power plant is currently under construction in the city of Makkah which is expected to come into operation in 2018. This project is estimated to cost $640 million and have a capacity of around 100 MW.

An area of 2 million square meters has been allocated for this project. By generating 385 GWh every year it is estimated that Makkah could save $587 million on its annual electricity bill once this plant comes into operation. Rolls Royce and general electric are the contractors of this project. Around 20 international consortiums comprising of around 100 companies will help in completing this project [9].

Apart from this $ 794.6 million bid was received for building solar powered lightening system in the city. This bid came from Rolls Royce and general electric. First phase of this project will be a pilot scheme, which will cover three of the nine parts of Crown Prince Plan 9, in an area of 4.3 square km. if this scheme is successful then this project will be implemented in the city [10].

6) Green Duba Project:

A 600 MW integrated solar combined cycle power plant will be built in Duba and is expected to be completed by 2018. A gas turbine will be used by this plant to produce energy along with an integrated concentrated solar power (CSP) parabolic trough to produce 50 MW. Around 600,000 houses can be powered by this plant in a year.550 MW will be generated from combined cycle plant and the remaining 50 MW of energy will be generated from CSP installation. This project will be the first integration of CSP in a combined cycle in Saudi Arabia [11].

7) Waad Al Shamal ISCC-CSP

In January 2015, Saudi Electricity Company asked companies to bid on the construction of 550 MW integrated Solar Combined Cycle (ISSC) plant. This plant would integrate 50 MW CSP. Bidders for EPC of ISCC System included included companies like Alfana, Al-Toukhi, Gama Enerji, and Abener while those showing interest in constructing solar field were Novatec, Flagsol, TSK, Abengo and Elecnor, Solar Euromed [12]. This will be a government funded project and not much information has been released on this till now.

The pie charts below show an analysis of the projects discussed above in terms of their installed capacity.

III. FUTURE OF SOLAR MARKET IN SAUDI ARABIA

The Kingdom of Saudi Arabia is experiencing rapid growth in population as well as development in industrial and economic sectors. The country requires increase in power generation due to increasing energy demand which is expected to be 120 GW by 2032 [13]. The Saudi's target renewable energy capacity to reach more than 54 GW by 2032 out of which 41 GW would come from solar power which can be easily seen from figure 1.

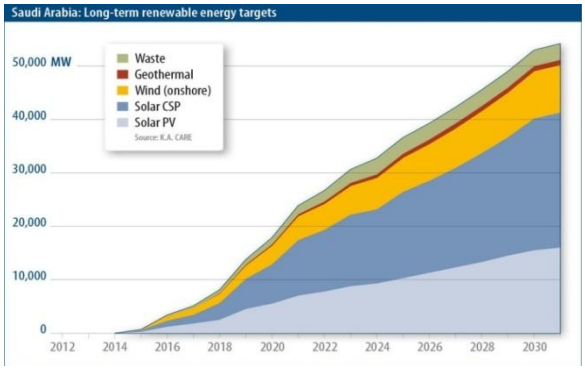

Figure 5: Saudi Arabia's long term renewable energy targets [14]

It is expected that more than $108.9 billion will be invested to achieve the target of 41 GW of solar power by 2032. Out of this 41 GW, 16 GW would be PV of which 6 GW is expected to be installed before 2020 [2]. Research in the area of solar energy in Saudi Arabia is increasing rapidly which can be easily seen from various agreements signed between the authorities to study and install solar plants throughout the country

CONCLUSION

Current solar energy capacity and the forecasted growth of solar industry has been discussed in this paper. Saudi Arabia has the capacity to produce solar power at low rates compared to other establish solar markets due to high solar irradiance, vast land and low cost finance. The country is already moving towards the target of achieving 41 GW of energy from solar power by 2032. The country has made a major stride as mentioned.

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