

Solar Power Potential In Saudi Arabia

F. R. Pazheri^{1, 2}

(¹Saudi Aramco Chair in Electrical Power, Electrical Engineering University, King Saud University Riyadh-11421, Saudi Arabia.

² Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Skudai 81310, Johor, Malaysia.)

ABSTRACT

The expansion of power generation in Saudi Arabia is essential in order to meet the expected growth of its electricity demand. Due to the availability of high solar irradiation, vast rainless area and longtime sun light, Saudi Arabia is one of the most suitable countries to utilize solar energy resources in greater extend. Kingdom has planned to increase the production of solar power in order to meet a considerable share of country's future energy demand. Numerous installation and research works are going on nowadays in the kingdom in order to attain its targets of solar power capacity in the coming years. Hence latest updates of country's solar industry are essential for further research and R&D works in this field. Saudi Arabia's current status and future possibility of solar industry are discussed in this paper.

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

I. INTRODUCTION

The development and utilization of renewable power industry is increasing rapidly throughout the world. In the end of 2012 the global renewable power capacity was exceeded 1500 GW and it is expected that renewable energy can cover almost 13% of global energy demand by the year 2020 [1]. Highest solar potential is available in Middle East countries (MEC) and the yearly solar irradiation of these countries are more than 2100 KWh/m² as shown in Fig. 1 [2]. The average annual rate of solar radiation is between 100-200 W/m² in most of the high potential solar areas, while in the Middle East countries, it reaches to about 250 W/m². Saudi Arabia is one of the most potentially productive region among MEC for harvesting solar power [3].

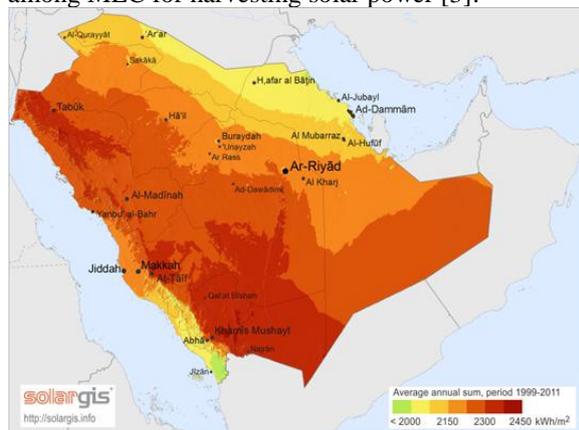


Fig. 1. Map of Global Horizontal Solar Irradiation of Saudi Arabia (kWh/m²/year) [2].

The average bright sunshine available in Saudi Arabia is 8.89 hours and it has vast, rainless region with an average horizontal solar radiation of 5591

Wh/m² [4]. Even though Saudi Arabia is the world's hub of solar potential, it mainly depends on fossil fuel based power plants to meet its energy demand. About 56% of country's oil and 46% of natural gas productions are now used for domestic consumption. However, due to the increase in demand for oil in global market and concern on global warming, Saudi Arabia wishes to use renewable and nuclear resources to produce energy in order to meet a major share of country's power demand which is expected to become nearly triple in next 20 years [5].

Saudi Arabia planned to install about 54 GW of renewable power capacity by 2032 and almost 76% of these capacity would be met by solar power [6]. The world oil price is expected to increase rapidly. Hence the production cost of electricity from conventional plants will also expected to increase accordingly [7]. However, the rapid growth of solar power industry would decrease the cost of solar electricity in future [8]. Moreover, the solar power production is cheaper than conventional power production if the costs paid for the health and environmental damages caused by the pollutants emission from the conventional plants are considered [9]. Hence, the dependence of solar energy would ensure an economic and environmental friendly power generation in the kingdom [10, 11]. It is easy and practicable to install solar power plants locally and near the load center in the Saudi Arabia due to country's availability of vast high potential solar areas. Such installation of solar power plants near the load center would help to reduce considerable amount of transmission losses also [12]. This paper discussed the current solar power potential in Saudi

Arabia. The future projection and scope of solar energy are also reported here.

II. KINGDOM'S SOLAR POWER PROJECTS

In 1960, the applications of solar energy started in Saudi Arabia. The research and development on solar energy technologies was initiated in the kingdom on 1977 by King Abdulaziz City for Science and Technology (KACST). In 1980, Saudi Arabia started "solar village" program to supply energy for three rural villages by using solar power. It was the biggest solar project of its type on that date [13].

In 2010, the first large scale photovoltaic (PV) rooftop solar system in kingdom was commissioned on the roof of the King Abdullah University of Science and Technology (KAUST in Thuwal). The installation capacity of this PV plant is 2 MW with 9,300 panels which occupies almost 11,600 m² of roof space. It can save 1700 tons of carbon emissions and produces about 3,281 MWh of energy per year [14, 15]. A 500 kW solar plant, located on Farasan Island, Southwest Saudi Arabia was inaugurated on 2011. It was the first solar plant in the kingdom which saves the transfer of equivalent of 28,000 barrels of diesel fuel per year for power generation on the island [16, 17]. In 2012, the world largest solar thermal plant was gone into full operation at Princess Noura University for Women (PNUW) near Riyadh. The plant uses 36,160 m² of large flat plate solar collectors and generating 25MW thermal power which provides hot water for almost 40,000 students at PNUW. It saves approximately 52 million liters of conventional fuel and 125 million kg CO₂ emission in the 25 year system-life [18].

Saudi Arabia has built 10 MW photovoltaic carport system at recently built North Park of Saudi Aramco's headquarters in Dhahran. It is the world largest solar car parking lot and covers all of the 4,500 parking spaces. More than 120,000 Copper Indium Selenide photovoltaic modules are used over the parking area in order to serve parking shades as well as to produce clean electricity [19, 20]. Fig. 2 shows the 10 MW photovoltaic carport system in Saudi Arabia. A 200 kW rooftop photovoltaic plant by using over 800 PV modules have been installed at King Abdullah Financial District (KAFFD) in Riyadh. It can produce over 330 MWh of clean energy and will save 180 tons of CO₂ emissions, per year [14].



Fig. 2. The 10 MW Photovoltaic Carport System in Saudi Arabia [20].

Kingdom's solar industry has been developing steadily. A concentrated photovoltaic plant (CPV) at Nofa Equestrian Resort, near Riyadh has been commissioned earlier this year. Countries largest ground mounted PV plant, the Saudi Aramco's KAPSARC II project, will come online with next few months. The project will extend its existing solar plant capacity from 3.5 MW to 5.3 MW [8, 21]. Moreover, three large scale solar projects: (i) 100 MW PV plant, (ii) 100 MW solar powered lightening project and (iii) solar-geothermal hybrid projects, are planned by Makkah municipality [8].

In the end of 2012, Makkah municipality received bids to build 100 MW solar power project. The project costs almost 640 USD and could make Makkah the first city in the kingdom to generate clean energy from renewables. It will be established on an area of about 2 million square meters and will capable to meet the entire energy demand of municipality [22, 23]. Saudi Electricity Company (SEC) has planned to install an integrated concentrated solar power (CSP) and gas-fired Duba 1 independent power project (Duba 1-IPP) with capacity of 550 MW at Duba near Tabuk, Saudi Arabia. SEC called for applications for expression for interest (EOI) in December 2013 to build and commission this project. It will be the country's first commercial CSP plant project. It is designed to integrate a parabolic trough unit of around 20 to 30 MW capacity with natural gas as main fuel and Saudi Arabian Super Light Crude oil (ASL) as back up fuel [24, 25]. The current growth of solar power capacity implies that Saudi Arabia has a bright future for solar power industry.

III. FUTURE SOLAR MARKET IN SAUDI ARABIA

The solar power sector in Saudi Arabia is expected to grow aggressively in the coming years. By 2032, the power demand in Saudi Arabia is expected to exceed 120 GW per year and country planned to supply about half of this demand by renewable and nuclear power. The country's forecasted daily electricity demand pattern is shown in Fig. 3 [5].

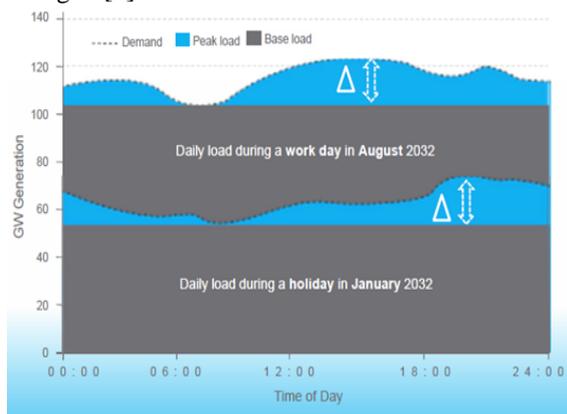


Fig. 3. Saudi Arabia's forecasted daily electricity demand pattern of 2032 [5].

Saudi Arabia targets to produce 17.35 GW solar power by 2022 [6] and within next 20 years, it is planned to produce approximately 30% of its power needs from solar energy source. About 54 GW of renewable power capacity is going to be installed in the country by 2032 and almost 41 GW of this capacity is expected from solar power only. Out of 16.1% to 22.65% of targeted annual share of energy generation from solar plants by 2032, about 11.7% to 17.2% is expected by CSP plants and remaining share may be supplied by PV plants [5, 6]. An agreement has been signed in August, 2014 by Chinese National Nuclear Corporation (CNNC) and King Abdullah City for Atomic and Renewable Energy (K. A. CARE) to collaborate on the development of renewable and nuclear energy in the Kingdom [26]. The target of conventional, renewable and nuclear power capacities by 2032 are given in Table 1.

TABLE 1. Target of Power Capacities by 2032 in Saudi Arabia [5, 6].

Resource		Capacity (GW)
Fossil Fuel		60
Solar	CSP	25
	PV	16
Nuclear		17.6
Wind		9
Waste to Energy		3
Geothermal		1

Earlier this year, Belmont's SunEdison Inc., has signed an agreement with Kingdom to explore the building of one of the world's largest silicon technology based integrated solar panel factory at Wa'ad Al Shammal, an industrial city at North of country. It plans to invest about 6.4 billion USD for the proposed factory which would produce enough PV modules each year to generate 3 GW of power [27, 28].

Saudi Arabia has the capability to generate solar power at a low levelized cost of energy (LCOE) compared to other mature solar markets due the presence of high solar irradiance, vast land availability, low cost finance, etc. Nowadays, it is possible to reach solar LCOE in the range of 70 USD to 90 USD per MWh for plants larger than 10 MW capacity and it is expected to reduce 50 USD to 70 USD per MWh by 2020 [8]. Moreover, a significant amount of pollutants emissions from conventional power plants can be saved by replacing these plants by solar power plants. Hence, a considerable amount of cost paid for health and environmental damages caused by the pollutants emissions from conventional power plants are also saved.

IV. CONCLUSION

The current solar power capacity and the expected growth of solar industry in Saudi Arabia are discussed in this paper. An aggressive growth in solar electricity production is expected in the kingdom. World largest solar thermal plant and solar parking lot are now fully functioned in Saudi Arabia. It is projected that almost 30% of country's future power demand would be met by solar power by 2032. Major steps to attain the target are initiated and lot of research and R&D works are continuing in this field.

REFERENCES

- [1] F. R. Pazheri, M. F. Othman, and N. H. Malik, *A review on global renewable electricity scenario, Renewable and Sustainable Energy Reviews*, 31, 2014, 835-845.
- [2] Solar GIS. *SolarGIS data validation for the Kingdom of Saudi Arabia*, http://geomodelsolar.eu/_docs/various/SolarGIS_validation_SaudiArabia_2013-02.pdf.
- [3] F. R. Pazheri and N. H. Malik, et al., *Use of renewable energy sources in Saudi Arabia through smart grid,* *Journal of Energy and Power Engineering*, 6(7), 2012, 1065-1070.
- [4] M. Mohandes, S. Rehman, and T. O. Halawani, *Estimation of global solar radiation using artificial neural networks,* *Renewable Energy*, 1(4), 1998, 179-184.
- [5] KA-CARE, *Saudi Arabia's renewable energy strategy and solar energy deployment roadmap*, <https://www.irena.org>

- /DocumentDownloads/masdar/Abdulrahman%20A1%20Ghabban%20Presentation.pdf, 2013].
- [6] REN21, *MENA renewables status report*, Renewable Energy Policy Network for the 21st Century, 2013.
- [7] F. R. Pazheri and M. F. Othman, et al., *Optimization of pollution emission in power dispatch including renewable energy and energy storage*, *Research Journal of Applied Sciences, Engineering and Technology*, 4(23), 2012, 5149-5156.
- [8] SASIA, *Now is the time to go solar in Saudi Arabia*, <http://saudi-sia.com/now-is-the-time-to-go-solar-in-saudi-arabia/>, 2014].
- [9] F. R. Pazheri, M. F. Othman, N. H. Malik et al., *Reduction in pollutants emission by increase in renewable penetration: A case study*, *Research Journal of Applied Sciences, Engineering and Technology*, 7(19), 2014, 4137-4142.
- [10] F. R. Pazheri, M. F. Othman, N. H. Malik, et al., *Economic and environmental dispatch at high potential renewable area with renewable storage*, *International Journal of Environmental Science and Development*, 3(2), 2012.
- [11] F. R. Pazheri, M. F. Othman, N. H. Malik, et al., *Optimum power dispatch management in presence of renewable energy and energy storage* (Jahan and M. M. Rashid, eds., Science and Technology Publishing Inc, 2014).
- [12] F. R. Pazheri, M. F. Othman, N. H. Malik, et al., *Pollution emission reduction with minimum transmission loss in power dispatch including renewable energy and energy storage*, *International Review of Electrical Engineering*, 7(5), 2012.
- [13] F. R. Pazheri, N. H. Malik, A. A. Al-Arainy, et al., *Smart Grid can make Saudi Arabia megawatt Exporter*, *IEEE Asia-Pacific Power and Energy Engineering Conference (APPEEC)*, Wuhan, China, 2011, 1-4.
- [14] Arab-News, "Solar energy: Saudi Arabia is shining as key growth market," arab news, 2013.
- [15] SUNPOWER, "King Abdullah University of Science and Technology (KAUST) Builds largest PV installation in Saudi Arabia," <http://global.sunpower.com/success-story/ku-st/>, 2010].
- [16] B. Stuart, "Saudi inaugurates first solar power plant," pv magazine, 2011.
- [17] Arab-News, "First solar power plant opens in Farasan," arab news, 2011.
- [18] MEI, "MEI Solar References September 2013," <http://millenniumenergy.co.uk/sites/default/files/uploads/u27/MEI%20Solar%20References%20September%202013v.pdf>, 2013].
- [19] I. Slim, "Saudi Arabia builds world's largest solar parking lot," <http://despardes.com/tag/photovoltaic-carport-system>, 2013].
- [20] SASIA, "Saudi Aramco solar car park," <http://saudi-sia.com/gallery-name-7/>, 2013].
- [21] Saudi-Gazette, "Saudi Arabia offers one of lowest solar energy costs," <http://www.saudigazette.com.sa/index.cfm?method=home.PrintContent&fa=regcon&action=Print&contentid=20140812214405&simplayout=1>, 2014].
- [22] Arab-News, "Makkah to establish SR 2.4 billion solar energy project," arab news, 2012.
- [23] A. DiPaola, "ACWA Power says it's named best bidder for Mecca solar plant ", <http://www.bloomberg.com/news/2013-01-31/acwa-power-says-it-s-named-best-bidder-for-mecca-solar-plant.html>, 2013].
- [24] R. Gayle, "Saudi Arabia reveals plans for its first power plant using CSP to supply to the grid," <http://social.csptoday.com/markets/saudi-arabia-reveals-plans-its-first-power-plant-using-csp-supply-grid>, 2014].
- [25] SEC, Request for Expressions of Interest for Duba 1 IPP, <http://www.se.com.sa/SEC/English/Menu/Partners/IPP+Program/>, 2013].
- [26] I. Clover, "China, Saudi Arabia to cooperate on renewable energy development," pv magazine, 2014.
- [27] D. R. Baker, "Saudi Arabia plans solar panel factory," <http://www.sfgate.com/business/article/Saudi-Arabia-plans-solar-panel-factory-5205034.php>, 2014].
- [28] S. Journal, "SunEdison explores \$6.4 billion Saudi Arabia plant," http://www.bizjournals.com/stlouis/morning_call/2014/02/sunedison-explores-65-billion-saudi.html, 2014].