International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-3S, February 2019

Recent Status on Power Plants and Power Consumption of Renewable Energy Sources in Jeju Island

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Abstract: ***In 2012, the government of Jeju Special Self-Governing Province (Jeju) in South Korea had a plan to make the carbon-free Island Jeju by 2030. The target of this project was supplied by 100% renewable energy coming from wind turbines generation, solar photovoltaic systems and replaced 100% internal combustion engine vehicles by electric vehicles (EVs). In this study, we provide information on the energy status of Jeju island in the process of implementing the project, such as energy consumption, PV power plant and wind power plant. In addition, the development trends of superconducting wind turbine generators which have the advantages of reducing volume, weight, and losses compared to conversional wind turbines are also introduce in this study.***

Keywords - Renewable energy, electric vehicle, PV, wind power, superconducting technology.

I. INTRODUCTION

Nowadays, we are facing the problems of air pollution and global warming which cause by emissions of carbon dioxide into the earth's atmosphere through burning fossil fuels to meet the increasing energy demand in the country. Fortunately, renewable energy can play a vital role in meeting the targets for sustainable development, minimizing environmental impacts and ensuring national energy security. Therefore, the South Korean government has been actively participating in developing and deploying renewable energy sources. Accordingly, Jeju Island has become one of the promising places for renewable energy development due to favorable wind speed and solar radiation. Jeju self-governing province set the target 100% renewable energy through the project "carbon-free Island Jeju by 2030". The plan of this project will replace the current fossil fuels fired through using offshore and onshore wind turbine, solar panels and electrical storage facilities. Moreover, electric cars will use to replace the internal combustion engines vehicles. This study investigate the recent status of renewable energy on the wind power, solar power and EVs consumption in Jeju Island as well as the implementation policies on "carbon-free Jeju Island by 2030" project. Besides, the superconducting technology application in wind turbine generator which has the significant advantages of high efficiency and power density over conventional technology is also introducing in this study.

II. POLICY ON CARBON FREE ISLAND JEJU BY 2030

In order to achieve target to become neutral carbon by 2030. Beside the technical solutions, the local community acceptance and participation are importance issue that Jeju Self-Governing Province need to be research on the development and growth of wind power project. The policies on carbon free Island Jeju by 2030 are as below:

1. The level of local community acceptance is significant importance. It can be enhanced through understanding community needs and ensuring economic benefits for them.
2. Increasing their positive awareness about wind energy and energy saving by rising local buy-in as well as local community ownership.
3. Evaluating the rights and needs of residents in every region in order to determine and offer the reasonable compensation, operating and management system for that community.
4. Jeju Energy Corporation should provide the local residents not only the easy understand information, supporting service on the wind farm but also assistance for the star-up capital, management and operations.
5. Jeju Special Self-Governing Province should regularly organize seminars for communication among developers, local authorities and the local community to get the cooperation and understand each other.

Manuscript published on 28 February 2019.

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6. Making a plan for the local resident participate at the early stages of cooperative business to maximize profit for both developer and local community.

III. RECENT STATUS ON RENEWABLE ENERGY IN JEJU ISLAND

1. Wind Energy

Wind energy is one of the most fascinating renewable energy sources in the world. Many countries considered wind power generation as the core for the sustainable development and energy security. Jeju Island, which has the excellent wind resources among the promising sites for wind power generation in South Korea. In 2012, Jeju had been constructed 11 wind farm with 62 turbines which had 107 MW production capacities. In september 2016, there was 112 wind turbine installed on Jeju island with the total production capacity around 242 MW.

In 2017, Doosan Heavy Industries & Construction had been installed 30MW wind farm which is comprised of 10 turbines. The total cost for this project is around $148.2 million. According to the roadmap announced by the government, the 700 MW offshore wind farm district will be installed through the second step of the first phase that can replace 50% conversional energy in 2020. At the final phase, 2,35 GW of wind farm will be constructed with 450 MW onshore wind farm and 1,900 MW offshore wind farm that can substituted 100% of existing fossil fuels with renewable energy in 2030. The total budget of the "free carbon Jeju Island by 2030" project is estimated to be USD 5.4 billion.

2. Solar Energy

The total installed capacity of solar power plants of Jeju Island was 72.7 MW in 2015 which is small compared to South Korea capacity of 1011 MW. The installed PV plants in Jeju Island was classified into 4 regions (Eastern, Western, Southern, and Northern) with difference utilization rate which are depend on the number of sunshine hours and average temperature. Fig. 2 shows the comparison of utilization rate of PV plants in the 4 areas in 2016. The highest utilization rates of 4 regions was around 25% in May, followed by 23% in August. The lowest utilization rate was in January.

In order to get the target "free carbon Jeju Island by 2030", the Jeju government officials were being supported in installing solar energy. A total of 500 million won was supported to approximately 250 households for installation of solar energy equipment up to 3 kW. The total numbers of 250 participating households can reduce carbon emissions by 355.5 tons. Additionally, the government have a plan to guarantee income for the farmers to start new solar power plants for 20 years. Many Jeju Island farmers were changing from agricultural operations to solar power installation. There are 164 farmer submitted applications for the new solar farms with 1.2 million square meters in 2016 that expected the output power reaching 80.7 MW. With the financial support of the government, the solar power plants of Jeju Island has continuously invested in development technology and encouraged new farmers running a solar power plant that would be increased solar power generation. The Jeju government make a plan to convert the 5.1 million square meters of citrus farm to solar farm to generate the output power approximately 340 MW by 2030.

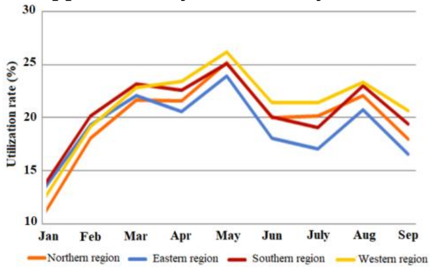

Fig. 1: Comparison the utilization rates of PV plants among 4 regions in 2016.
Source: Sae-wong Kang, *et al.*, "Regional generation characteristics of MW photovoltaic power plants in Jeju Island," 5th International Conference on Renewable Energy, March, 2018.

3. Electric Vehicle

Along with the use of renewable energy, the spread of Electric vehicles (EVs) is one of the key factor of the plan "free carbon Island Jeju by 2030". In order to meet that goal, the government has been providing a subsidy for EVs buyers. A subsidy of 19,000 million won was offered for buyers on Jeju. Besides, the government also guarantee that the infrastructure required is easy to access. There are three kinds of chargers that was constructed all over the island as shown in Table I. The home charger with output power 3 kW and charging voltage AC 220V accounted for more than 90% of the total EVs chargers. The standard charger which has output power 7.7 kW and charging voltage AC 220 V constituted around 8%, while the quick charger with output power 50 kW and charging voltage DC 500 V was responsible for just 2% of the total. Moreover, the province made a roadmap to substitute the internal combustion engines by EVs and install new charging infrastructure every years as shown in Table II.

In order to bring Jeju closer to the future with neutral carbon emission, the International Electric Vehicle Expo (IEVE) was held in Jeju every years. At the event, the international EVs manufacturers and related companies have been showing their development in EVs technology, including battery cell and charging station makers. The IEVE is also a chance to the participants reaffirm the goal "free carbon Island Jeju by 2030" and obtain the new information as well as trend developments related to EV all around the world.

Table I. Specifications of EV Chargers & Results

Items	Unit	Values		
Types	-	Home	Standard	Quick
Power level	kW	≤ 3	≤ 7.7	50
Charging voltage	V	AC 220	AC 220	DC 500
Location	-	Home garage	Public parking lot	Public parking lot

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Source: Hyeon-seong Yoon, et al., "Study on EV charging infrastructure in Jeju Island," 5th International Conference on Renewable Energy, March, 2018.

Table II. Roadmap of developing EV and Charger

Year	2016	2017	2020	2030
EV	9,300	29,300	134,900	377,000
Charger	8,198	21,380	73,150	138,000

Source: Deahwan Kim, "Carbon-free Island Jeju by 2030," The 4th International Electric Vehicle Expo, March, 2017.

4. Development Trends of Superconducting Wind Turbine Generators

Nowadays, wind turbines with high power rate capacity, reliability, and low cost has been required to meet the rapid development of wind energy. Moreover, offshore wind farm is more attractive than onshore due to high wind speed and low interference. Therefore, the new generators will available in large power capacity and in direct-drive generator. Direct-drive turbines has the improvement in the overall efficiency and reliability by removing the gearbox. However, the permanent magnet direct-drive generator of 10 MW or beyond which has the large size and heavy weight will always accompanies with high cost of the installation, operation, and maintenance. Superconducting direct-drive generator which is demonstrated in Fig. 4 is considered as the technical solution for this problem. The characteristics of superconducting wind turbine generator are high power generation efficiency, small volume and light-weight compared to conversional generator. Fig. 5 shows the comparison among the conversional and HTS generator

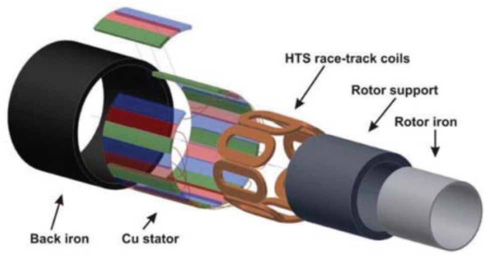

Fig. 2. Components of superconducting generators
Source: A. B. Abrahamsen, *et al.*, "Large superconducting wind turbine generators," SciVerse ScienceDirect, January, 2012.

The price of superconducting wire is the key factor for widely use of superconducting wind turbine generator. It is clear that superconducting generator cannot commercially available in the wind market without low cost of HTS material. The manufacturers are trying to decrease the cost of HTS material below $5/kAm in 2020 to enhance the competitiveness in the wind energy market. Fig. 6 shows the price and production capacity of YBCO, BSCCO, and MgB_2 from 2015 to 2030 which is commonly use in superconducting generator. Nowadays, there are many projects using superconducting wind turbine generator for offshore wind farm all around the world due to the advantages of superconducting generator in term of high efficiency, small size, light-weight, and low cost compared to conversional generator such as SeaTitan 10 MW wind turbine which is design by American energy technologies company, Areva 8 MW wind turbine which is launched in 2013, Vestas V164-8 MW,…etc.

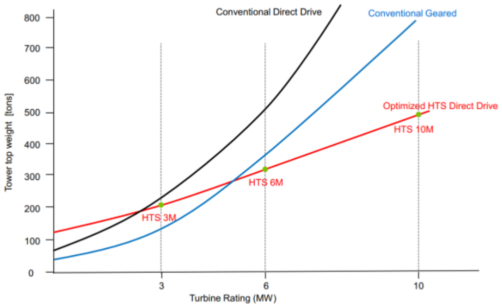

Fig. 3. Comparison among HTS and conversional generators
Source: American superconductor, "10 MW class HTS wind turbine," June, 2010.

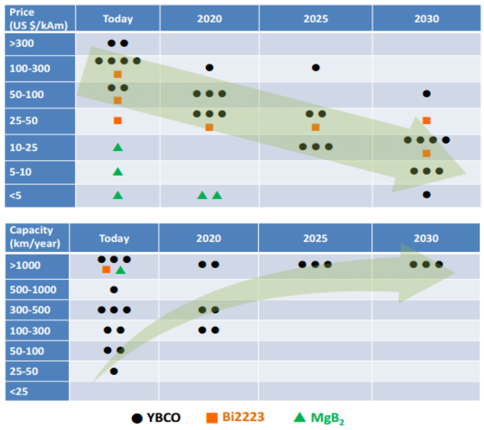

Fig. 4. The price and production capacity of YBCO, BSCCO, and MgB_2 from 2015 to 2030.
Source: B. G. Marchionini, *et al.*, "High temperature superconductivity: A roadmap electric power sector applications, 2015-2030," ASC 2016.

IV. CONCLUSION

In order to get the goal "free carbon Island Jeju by 2030", the Jeju government has implemented plans and policies to replace fossil fuels by renewable energy. For renewable power plant, the government has supported the subsidy for installing solar power and made a plan for the local resident participating at the early stages of business development. Besides, the power consumption such as EVs have also received much subsidies from the Jeju government to substitute 100% internal combustion engines by 2030. Moreover, the developing of superconducting wind turbine generator which has become popular in South Korea in recent year can support to get the target 2.35 GW wind energy by 2030 with low cost compared to conversional generator.

V. ACKNOWLEDGMENTS

This work was supported in part by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP), Republic of Korea, and by Korea Electric Power Corporation. (Nos. 2016R1A2B4007324 and R18XA03)

REFERENCES

1. D. J. Kojetin, *et al.*,"A comparison of perception towards wind power among local and foreign residents of Jeju Island, South Korea," The Korean Journal of Local Government Studies, vol. 18, no. 2, Summer, 2014.
2. E. Park, *et al.*, "Economic Feasibility of Renewable Electricity Generation Systems for Local Government Office: Evaluation of the Jeju Special Self-Governing Province in South Korea," Sustainability, vol. 9, no. 1, January. 2017.
3. http://www.iclei.org/details/article/jeju-island-carbon-free-by-2030.html
4. http://www.jejuweekly.com/news/articleView.html?idxno=2679
5. http://www.go100re.net/properties/jeju-province-korea/
6. http://www.koreatimes.co.kr/www/news/culture/2016/02/320_192345.html
7. Jeju Energy Corporation, "The strategy for constructing carbon free Island Jeju," Jeju Forum 2014 for Peace & Prosperity.
8. S. O. Chang, *et al.*, "Social process for wind farm construction in Jeju Island: A case of PIMFY-ism," World Environment and Island Studies, August. 2013.
9. Deahwan Kim, "Carbon-free Island Jeju by 2030," The 4th International Electric Vehicle Expo, March, 2017.
10. S. W. Kang, *et al.*, "Regional generation characteristics of MW photovoltaic power plants in Jeju Island," 5th International Conference on Renewable Energy, March, 2018.
11. K. W. Kim, *et al.*, "National survey report of PV power applications in Korea 2015," IEA International Energy Agency.
12. http://www.jejuweekly.com/news/articleView.html?idxno=4032.
13. http://koreabizwire.com/jeju-transitions-from-citrus-farms-to-solar-power/61431
14. H. S. Yoon, *et al.*, "Study on EV charging infrastructure in Jeju Island," 5th International Conference on Renewable Energy, March, 2018.
15. A. B. Abrahamsen, *et al.*, "Large superconducting wind turbine generators," SciVerse ScienceDirect, January, 2012.
16. American superconductor, "10 MW class HTS wind turbine," June, 2010.
17. B. G. Marchionini, et al., "High temperature superconductivity: A roadmap electric power sector applications, 2015-2030," ASC 2016.

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