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Current Status of Solar Power Generation in Jinju City Close to the South Coast and Jeonju City Close to the West Coast

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Abstract: Recently, renewable energy has been increasing in Korea to reduce greenhouse gas, and solar power generation, which accounts for the largest proportion of renewable energy, is noteworthy. The government policy will further increase solar power generation. In order to implement the policy, it is important to understand the current status of domestic solar power generation facilities. Therefore, the current status of solar power generation facilities in Jinju city close to the south coast and Jeonju city close to the west coast was investigated and compared. By 2020, 618 solar power plants had been installed in Jeonju city and 269 in Jinju city. However, there is not much difference in the amount of solar power generation for business at 9 GWh. The reason is that Jinju city has a lower population density than Jeonju city, so there are enough places to install a large-scale solar power facilities with a large power generation capacity. Monthly solar power generation was the highest in April in both Jeonju city and Jinju city and the lowest in January. In particular, in December, Jinju city showed more solar power generation than Jeonju city because of the large amount of insolation, long sunshine hours, and few clouds.

Keywords: Monthly solar power generation, Jinju city and Jeonju city, Renewable energy, Solar power plants, Climatic element

1. INTRODUNTION

Korea ranks ninth in the world for consumption of primary energy such as coal and oil, which are forms of energy that can be obtained in a natural state, but Korea is an energy poor country with 93.3% dependence on energy imports. Among them, the domestic economy is greatly affected by fluctuations in oil prices due to its high dependence on oil, and many greenhouse gases are emitted. Accordingly, the Korean government is reducing its dependence on oil and replacing it with renewable energy through policy [1-4]. The basic direction of this policy is to reduce greenhouse gas emissions and expand renewable energy. To this end, the Ministry of Trade, Industry and Energy has decided to promote the Renewable Energy 3020 Implementation Plan, which aims to increase the proportion of renewable energy generation to 20% by 2030, and the phase-out of nuclear power plants by reducing the number of nuclear power plants to 14 by 2038, and recently, the Korean version of the Green New Deal policy to establish a foundation for the spread of renewable energy and the 2050 carbon neutral policy, which will reduce net carbon emissions by 2050, are promoting the conversion of the power supply system centered on fossil fuel power generation to renewable energy and green hydrogen [5-8].

Among renewable energy sources, solar power generation is noteworthy. Solar power generation has grown rapidly due

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to the mandatory renewable energy supply system implemented in earnest in 2012 and the price drop of solar modules, and Solar power generation has surpassed wind power generation since 2013 and now accounts for the second largest proportion of renewable energy generation, and according to the government's 5th Basic Renewable Energy Plan, it is expected to account for 39.3% of renewable energy generation by 2034, so the solar power market and related facilities will be expanded. As the proportion of solar power generation increases not only in Korea but also in China, the US and Europe, the growth of the global solar power market is expected to accelerate [9-12].

In order to implement the aforementioned renewable energy expansion policy, it is important to understand the current status of domestic renewable energy. Therefore, among the domestic status of solar power generation, which will take up the largest proportion among renewable energy, Jinju city close to the southern coast and Jeonju city close to the west coast were investigated and compared.

2. CURRENT STATUS OF SOLAR OF SOLAR POWER GENERATION IN KOREA

2.1 Trend of increase in solar power generation in Korea

Solar power generation uses solar modules to generate electricity, and it is divided into solar power generation for business and solar power generation for homes depending on how the generated electricity is used. Solar power generation for homes is mainly grid-connected type, in which electricity generated from solar power generation facilities is used by the owner who installed solar power generation facilities, and the surplus electricity is transmitted back to KEPCO (korea electric power corporation) and large power generation companies for sale. Solar power generation for business is mainly a power generation business that generates profits by selling electricity generated from solar power generation facilities to KEPCO and power generation companies obligated to supply [13].

The amount of solar power generation did not increase significantly until 2007, but as the oil price surged in 2007, research on alternative fuels was actively conducted around the world, and interest in solar power generation business naturally began to grow. And from the second half of 2007, new entry of solar power generation companies started to increase, and the amount of solar power generation increased explosively. After that, as the 500 MW of capacity subject to the government-restricted power generation gap subsidy was exhausted, the construction of new solar power generation facilities decreased sharply from 2010, and the amount of solar power generation did not increase significantly [14,15].

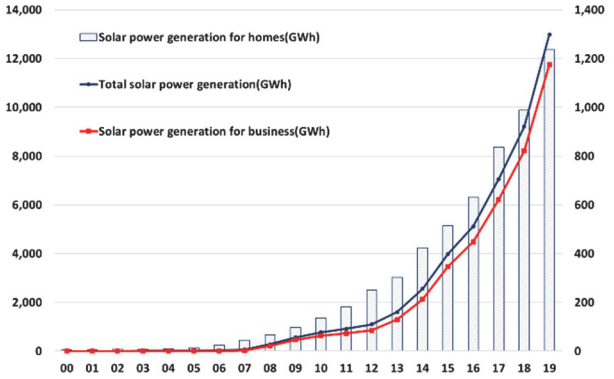

Fig. 1. Solar power generation by year [55].

In the case of solar power generation for business, the FIT, a system that supports the difference between the standard price and the electricity transaction price when the electricity transaction price of electricity supplied by renewable energy generation is lower than the reference price announced by the Minister of Knowledge Economy, ended at the end of 2011. Since 2012, the number of solar power generation facilities for businesses has increased explosively due to a drop in the price of solar modules at the beginning of RPS, which requires power generation businesses with a facility size of 500 MW or more to supply a certain amount of renewable energy [16-24]. Solar power generation for homes has also grown steadily every year, exceeding 1,200 GWh in 2019. However, when comparing the power generation capacity of solar power generation for homes with the power generation capacity of solar power generation for business, it can be seen that most of the total solar power generation is solar power generation for business. In fact, 90.5% of the total solar power generation in 2019 is solar power generation for business and 9.5% is solar power generation for homes.

2.2 Installation status of solar power generation facilities in Korea

In Korea, a total of 25,456 solar power generation facilities for business were installed by 2017, 9,370 were installed in 2018, 18,265 were installed in 2019, and 23,917 were installed, the largest number in 2020. By 2020, a total of 77,008 solar power generation facilities for business are installed. The number of solar power generation facilities for business installed by 2017 is 25,456, which is 33.1% of solar power generation facilities for business installed by 2020. There were 51,552 solar power generation facilities for business installed from 2018 to 2020, accounting for 66.9% of solar power generation facilities for business installed by 2020. Of the solar power generation facilities for business installed by 2020, 12.2% were installed in 2018, 23.7% were installed in 2019, and 31.1% were installed in 2020 when the largest number of solar power generation facilities for business were installed. Therefore, it achieved the biggest growth in 2020 [25].

The number of solar power generation facilities for business installed for three years from 2018 to 2020 accounted for 66.9% of the total solar power generation facilities for business installed by 2020. This seems to be because the policy to expand renewable energy, including solar power generation facilities, was implemented, such as announcing the 3020 implementation plan and establishing the 8th basic electricity supply and demand plan to prepare detailed plans for the expansion of renewable energy [26].

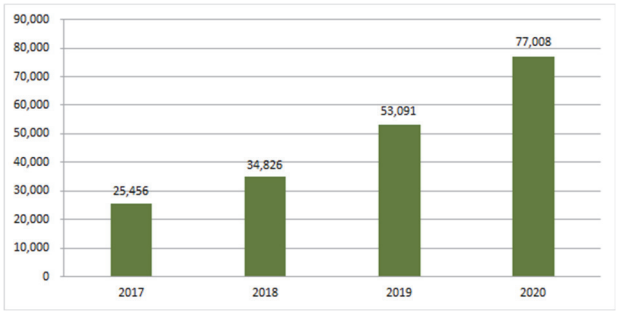

Fig. 2. Cumulative number of solar power generation facilities for business [54].

3. SOLAR POWER GENERATION IN JINJU CITY AND JEONJU CITY

3.1 Current status of solar power generation facilities in Jinju city and Jeonju city

In Jeonju city, 63 solar power generation facilities for business were installed in 2018, and in 2019, 32 increased to 95, and in 2020, 5 decreased to 90. In Jinju city, 26 solar power generation facilities for business were installed in 2018 and 82 in 2019, an increase of 56, and 87 in 2020, an increase of 5.

From 2018 to 2020 in Jinju city, the number of solar power generation facilities for business installed annually increased, but Jeonju city showed a decrease compared to the previous year in 2020. In 2018, the difference in the number of installed solar power facilities for business in the two cities was 37, but the difference was reduced to 13 in 2019 and 3 in 2020.

Fig. 3. The number of installations of solar power generation facilities for business in Jinju city and Jeonju city by year [54].

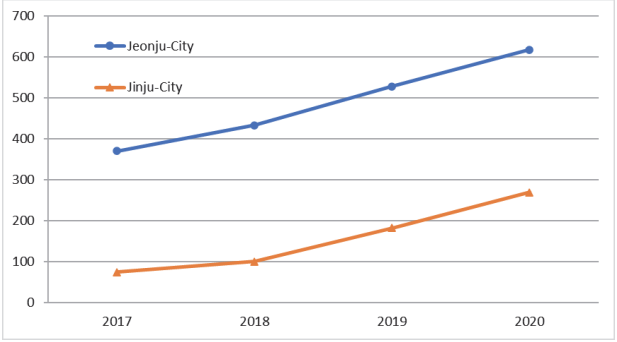

Fig. 4. Accumulated number of solar power generation facilities for business in Jinju city and Jeonju city [54].

As the graph shows the same trend, the number of solar power generation facilities for business in the two cities increased similarly. Looking at the cumulative number, Jeonju city had 370 installed by 2017, 433 by 2018, 528 by 2019, and a total of 618 solar power generation facilities for business by 2020. In Jinju city, 74 were installed by 2017, 100 by 2018, 182 by 2019, and a total of 269 by 2020. Until 2017, the difference between Jeonju city and Jinju city was 296, but in 2020, the difference has grown to 349.

3.2 Current status of solar power generation and power generation capacity in Jinju city and Jeonju city

In 2020, the generation of solar power facilities for business is 54.3 GWh in Jeonju city and 45.4 GWh in Jinju city. By 2020, there are 618 solar power generation facilities for business in Jeonju city, more than twice as many as 269 in Jinju city. However, the difference in power generation is about 9 GWh, and 9 GWh is about 16.6% of Jeonju city's power generation, so the difference is small. In fact, the number of solar power generation facilities for business in Jeonju city ranked 36th out of 161 surveyed areas and Jinju city ranked 109th, which is quite a difference. However, in terms of power generation, Jeonju city ranked 106th out of 161 surveyed areas and Jinju city ranked 116th, showing a small difference.

In terms of solar power generation capacity, the solar power generation capacity of the solar power generation facilities for business installed in Jeonju city by 2020 is 43.2 MW, and the solar power generation capacity of Jinju city is 38.1 MW. The difference in solar power generation capacity of the two

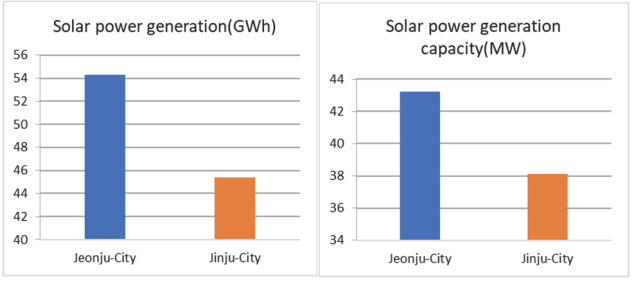

Fig. 5. Solar power generation and solar power generation capacity of solar power generation facilities for business in Jinju city and Jeonju city (2020) [54].

Table 1. The area and population of Jinju city and Jeonju city (2021).

City	Area	Population
Jeonju city	206.2km^2	657,664
Jinju city	712.6km^2	347,314

regions is also small, just like solar power generation. When looking at the solar generation capacity of the 161 regions surveyed, Jeonju city ranked 110th and Jinju city ranked 116th, which is smaller than the solar power generation capacity.

Therefore, it seems that the amount of solar power generation and the solar power generation capacity are closely related. The reason why there is no significant difference in the amount of solar power generation even if the number of solar power generation facilities is large is judged to be because the solar power generation capacity of the installed solar power generation facilities for business is different. Jeonju city has a large number of solar power generation facilities for business, but the solar power generation capacity of the solar power generation facilities is small, so the amount of solar power generation is relatively small. Therefore, it is judged that the difference in solar power generation between Jeonju city and Jinju city is small.

Looking at Table 1, Jeonju city has about twice the population than Jinju city, but the area of Jinju city is about three times that of Jeonju city. Jeonju city has a small area but has a large population, so there are not enough places to install large-scale solar power generation facilities for business with large power generation capacity. Because Jinju city has a large area and small population, there were enough places to install large-scale solar power generation facilities for business with large power generation capacity. Therefore, although the number of solar power generation facilities for business is small, it seems that the amount of solar power generation is large by installing solar power generation facilities for business with large power generation capacity [27].

3.3 Monthly solar power generation in Jinju city and Jeonju city

Looking at the monthly solar power generation of solar power generation facilities for business in Jinju city and Jeonju city, both cities generated a lot in March, April, and May, and the month with the most solar power generation was April and

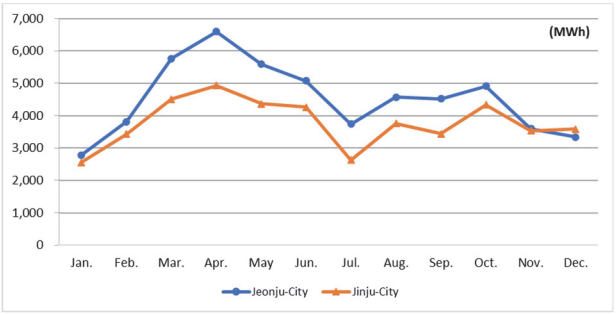

Fig. 6. Monthly solar power generation in Jinju city and Jeonju city (2020) [54].

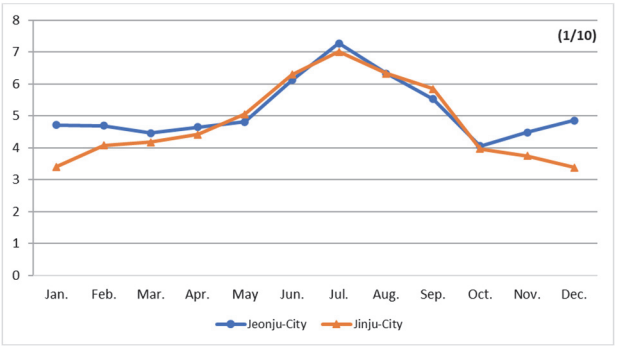

Fig. 7. Average monthly cloudiness for the past 20 years in Jinju city and Jeonju city [60].

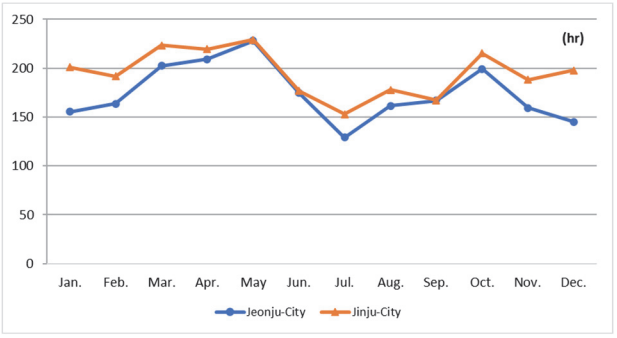

Fig. 8. Average monthly sunlight hours for the past 20 years in Jinju city and Jeonju city [60].

the month with the least solar power generation was January. The difference in solar power generation between April, which has the most solar power generation, and January, the smallest, is 3,806 MWh in Jeonju city and 2,376 MW in Jinju city, so Jinju city has a more uniform annual solar power generation [28]. Although it seems that the solar power generation is highest in the summer, both cities actually generate less power in the summer. The reason is that in summer, the temperature of the solar module rises due to hot weather, and there are many clouds due to the rainy season, so the solar power generation efficiency decreases. In addition, since Jeonju city had a larger solar power generation capacity than Jinju city, Jeonju city generally generated more solar power generation by month. However, the difference in solar power generation was the smallest in November, December, and January, and especially in December, Jinju city generated more solar power generation than Jeonju city [29-34].

The most influential factor in solar power generation is climatic element. Among the climatic element, the amount of cloud cover, insolation, and sunshine time are mainly affecting the amount of solar power generation [35,36]. First, the amount of cloud cover represents the amount of cloud cover over the entire sky, with 0 representing no clouds and 10 representing full clouds. Generally speaking, when the amount of cloudiness is 2 or less, it is said to be sunny, when it is 3-7, it is slightly cloudy, and when it is 8 or more, it is called cloudy [37]. In the monthly average cloudiness graph for the past 20 years in Jinju city and Jeonju city, it can be seen that there is a lot of cloudiness in June, July, and August, which are summer months. The amount of cloud cover between the two cities is not significantly different except in the winter months of November, December, January, and February. In winter, the amount of cloudiness in Jinju city was small, so the difference was large, and the biggest difference was especially in December [38].

Sunshine hours refers to the amount of time that the sun's rays illuminate the earth's surface without being blocked by clouds or fog. In general, as the amount of cloud increases, the number of sunshine hours decreases. In the graph of monthly average sunshine hours for the past 20 years in Jinju city and Jeonju city, it can be seen that both cities had the longest sunshine hours in May and the shortest hours in July. Overall, Jinju city had longer hours of sunshine each month than Jeonju city, and the difference in sunshine hours between the two cities was large from November to February, the winter season, and the largest difference was in December. This is believed to be because there was more cloudiness in Jeonju city in winter [37].

Insolation, a factor that determines the amount of solar power generation, is the amount of solar energy that a unit area

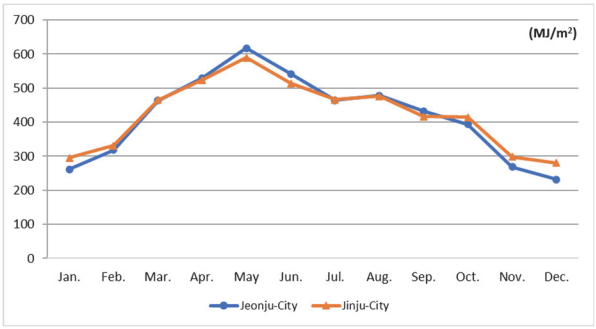

Fig. 9. Average monthly insolation for the past 20 years in Jinju city and Jeonju city [60].

receives per unit time and refers to the amount of solar energy that reaches the earth's surface. In the graph of average monthly insolation for the past 20 years in Jinju city and Jeonju city, both cities show the highest insolation in May and the lowest in December [39-42]. In winter, the amount of insolation near the southern coast is high, so in the winter months of November, December, and January, Jinju city had more insolation than Jeonju city [43-45]. In addition, the annual cumulative insolation in Jinju city is 5,074 MJ/m^2 and Jeonju city is 5,001 MJ/m^2, which is higher in Jinju city [46,47]. A dense industrial complex such as Jeonju city has low air clarity, and the midwest region of Namhae, such as Jinju city, has the best air clarity in the country. Therefore, it is thought that Jinju city receives more insolation [48]. The difference in the amount of solar power generation for business in Jinju city and Jeonju city was small in November, December, and January. The reason seems to be that in the winter months of November, December, and January, the amount of clouds in Jinju city was less than that in Jeonju city, the sunshine hours were longer, and the amount of insolation was higher. And since the difference in cloudiness, sunshine hours, and insolation between the two cities was the largest in December, it is thought that Jinju city had more solar power generation than Jeonju city. In this way, the weather conditions for solar power generation in Jinju city are better than in Jeonju city, and land factors such as land price and forest area ratio that affect the site selection for solar power generation facilities are also favorable to Jinju city, so it is considered a good area to install solar power generation facilities. Therefore, it is expected that the number of solar power generation facilities in Jinju city will increase more than in Jeonju city [49-51].

Jeonju city is a large city in Jeollabuk-do, which has the largest number of solar power facilities for business, and is adjacent to the west coast, and Jinju city is a large city in Gyeongsangnam-do, which has the least solar power facilities for business in the province except Jeju Island, and is close to the south coast. For this reason, Jeonju city and Jinju city were compared and analyzed among domestic cities. From the weather data and solar power generation of this paper, it can be seen that more solar power generation can be obtained by installing more solar power facilities in cities with good weather conditions for solar power generation such as Jinju city. Therefore, through the government's policy, more solar power facilities should be installed in cities such as Jinju city to expand renewable energy.

4. CONCLUSIONS

The Korean government is expanding renewable energy by promoting the Renewable Energy 3020 Implementation Plan, nuclear phase-out, the Korean version of the Green New Deal, and the 2050 carbon-neutral policy. Accordingly, we investigated and analyzed the current status of Jeonju city, which is close to the west coast, and Jinju city, which is close to the south coast, for solar power generation, which accounts for the largest share of domestic renewable energy and the share of power generation is increasing worldwide.

Solar power generation for business has increased rapidly since 2012 due to the government's mandatory renewable energy supply system and a drop in the price of solar modules. Of the solar power generation, 90.5% is solar power generation for business and 9.5% is solar power generation for homes. By 2020, there are 77,008 solar power generation facilities for business, of which 66.9% were installed between 2018 and 2020, which is considered to be due to the recent government policy to expand renewable energy.

Looking at the installation status of Jinju city and Jeonju city, by 2020, 618 were installed in Jeonju city and 269 were installed in Jinju city. The amount of solar power generation in 2020 is 54.3 GWh in Jeonju city and 45.4 GWh in Jinju city, which is small compared to the number of installed solar power generation facilities. This seems to be because Jeonju city has a large population and small area, so many solar power generation facilities with small power generation capacity

were installed, and Jinju city has a small population and a large area, so large-scale solar power generation facilities with large power generation capacity were installed. Looking at the monthly solar power generation graph of Jinju city and Jeonju city, Jeonju city has the most solar power generation, but the difference with Jinju city is the smallest in November, December, and January. In particular, in December, Jinju city's solar power generation was higher than that of Jeonju city. The reason for this is that in the winter months of November, December, and January, the amount of cloudiness in Jinju city was less than that in Jeonju city, the sunshine hours were longer, and the amount of insolation was higher. Also, since the difference in cloudiness, sunshine hours, and insolation between the two cities was the largest in December, it seems that Jinju city's solar power generation was higher than that of Jeonju city.

Although this paper has dealt with the current status of solar power generation for business, I think that the status of solar power generation in Jinju city and Jeonju city can be known in more detail if the current status of solar power generation for homes is also investigated and analyzed. In addition, it is regrettable that we could not investigate and add solar power generation facilities to be installed by Jinju city and Jeonju city in the future.

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