EVS30 Symposium
Stuttgart, Germany, October 9 - 11, 2017

‘Carbon-free Island Jeju by 2030’ Plan and its Progress from the Perspective of EV

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Executive Summary

‘Carbon-free Island Jeju by 2030 (CFI 2030)’ Plan is a regional environment, energy, and transportation plan of Jeju Island, South Korea. For the next twenty years, this plan will make the island rely on renewable energy sources (solar and wind powers). With energy storage and smart grid systems, electricity generated from solar and wind power will be stored and managed. Transportation electrification will replace all internal combustion engine vehicles with electric vehicles (EVs). In the CFI 2030 plan, EVs play an important role not only in transporting people and goods and but also in storing excess electricity and securing electricity supply. Overall, the plan will change the island’s critical systems of energy production and management as well as private and public transportation. This paper introduces the CFI 2030 plan, including backgrounds, policy goals, and annual plans. This paper particularly discusses the progress of the CFI 2030 plan since its announcement in 2012, focusing on EV deployment plan. The number of EVs has largely increased from 190 in December 2010 to 7,205 in June 2017. For the same period, the number of both DC and AC chargers has dramatically increased. Particularly, 417 DC chargers are open to public in June 2017, whereas there were 22 DC chargers in December 2012. This paper discusses policies implemented to deploy more EVs on Jeju Island, including purchase subsidy, free parking fee, and so on. This paper also provides new information: the total amount of electricity that EVs have used monthly, comparing with the total amount of electricity generated from solar and wind powers at the moment. Finally, the possibility of achieving the CFI 2030 plan will be discussed.

1 Introduction

Jeju is the nation’s largest island in South Korea, located 85 kilometers (53 miles) from the Korean peninsula. With a size of 1,849km² (714 square miles), the length of the island is approximately 73 kilometers (45 miles) from east to west, and 41 kilometers (25 miles) from north to south in air distance (see Figure 1 for the map of Jeju Island). As of December 2016, the island has 661,190 residents with 353,304 vehicles.

Jeju Island is a favorite holiday destination for rest and relaxation in the country. While having four seasons, Jeju has mild oceanic climate throughout the entire year. Jeju is a volcanic island, having the nation’s

highest mountain (1,950 meters, equivalently 6,400 ft) located in the center of the island. There are unique hills and forests created by volcanic eruptions spread over the island as well as several beautiful beaches along the shoreline. The total number of annual visitors is 15,852,980 in 2016 while domestic visitors account for about 77% of the annual visitors.

Now, Jeju Island is becoming famous to the world because of its regional environment, energy, and transportation plan, called Carbon-free Island Jeju by 2030 (CFI 2030) [1]. For the next twenty years, this plan will make the island rely on renewable energy sources (solar and wind). With energy storage and smart grid systems, electricity generated from solar and wind powers will be stored and managed. Transportation electrification will replace all internal combustion engine vehicles with electric vehicles (hereafter, an electric vehicle means a battery electric vehicle). The aim of the plan is that the island ultimately produces no greenhouse gas and carbon in the course of generating electricity and transporting people/goods.

This paper introduces the CFI 2030 plan, including backgrounds, policy goals, and annual plans. This paper particularly discusses the progress of the CFI 2030 plan since its announcement in 2012, focusing on EV deployment plan. This paper also provides new information: the total amount of electricity that EVs have spent monthly, comparing with the total amount of electricity generated from solar and wind powers at the moment. Finally, the possibility of achieving the CFI 2030 plan will be discussed.

Figure 1 The map of Jeju island

2 Carbon-free Island Jeju by 2030 Plan

'Carbon-free Island Jeju by 2030' Plan is a long-term regional environment, energy and transportation plan of Jeju Island. In 2012, this plan was suggested as taking into account Jeju's sunny and windy climate as well as a strong desire to be an energy-independent island. Also, climate change was highly considered. In this plan, Jeju will gradually replace all fossil fuels used in the island and reduce greenhouse gas produced in generating electricity and transporting people/goods, becoming carbon-neutral and fully-sustainable through using renewable energy only, 100% electric vehicles, and smart grid technologies by 2030.

The CFI 2030 plan has quantitative goals. First, Jeju will provide 1GW offshore and 300 MW inland wind power generator by 2020, as shown in Table 1. In addition to this, Jeju will provide 30 MW solar power generator over the island. They will make up 3,585GWh/year. By 2030, offshore wind power and solar power generators will rise to 2GW and 100MW, respectively. They can supply 6,561GWh/year, which is

124% of the annual electricity demand, 5,268GWh, projected in 2030. If this plan is successfully implemented, fossil fuels will be perfectly substituted with renewable energy when generating electricity.

Second, Jeju will provide a large amount of electric vehicles as a surface transportation mode. The key concept is that the electric vehicles use renewable energy produced from both wind and solar power as well as function as electric storage facilities. Electricity stored in electric vehicles can be used to power the island when electricity shortage take place. With this plan, 29,000 electric vehicles along with 29,700 chargers will be distributed by 2017, focusing on public fleet and rental cars. This accounts for 10% of the total number of vehicles projected in 2017. The number of electric vehicles distributed will rise to 94,000 by 2020 and 371,000 by 2030, replacing 30% and 100% of the total number of projected vehicles with electric vehicles, respectively. In parallel, the number of chargers that will be available in Jeju is 94,900 by 2020 and 225,000 by 2030.

Table 1: Goals of CFI 2030 (renewable energy)

	Wind power (offshore)	Wind power (inland)	Solar power
2020	1GW	300MW	30MW
2030	2GW	300MW	100MW

Table 2: Goals of CFI 2030 (electric vehicle)

	Electric vehicle	Charger
2017	29,000	29,700
2020	94,000	94,900
2030	371,000	225,000

Third, smart grid that can be defined as an intelligent power transmission and distribution system plays an important role in the CFI 2030 plan. By collecting data on energy usage and demand in real-time, the efficiency of electricity (energy) consumption can be increased and optimized. This also connects electricity generated from renewable energy sources and energy storage system including electric vehicles.

The CFI 2030 plan can make Jeju a model of green growth in the world, responding to the environment issue of global warming. A larger amount of reduction in greenhouse gas is also expected. Overall, 2,234,000 tons from renewable energy, 96,000 tons from smart grids, and 482,000 tons from electric vehicles will be reduced. With this plan, it is also expected to create more than 40,000 jobs in the course of its implementation.

3 Electric Vehicles and Chargers

This paper particularly discusses the progress of the CFI 2030 plan, focusing on EV deployment plan. Since its announcement in 2012, the number of EVs distributed in Jeju has been increased. While EVs were initially distributed through government procurement, in the second half of 2013, a generous amount of financial subsidy for purchase on EVs started to give to the residents. The total amount of the subsidy is 22 million Korean Won (about 20,000 USD), which consists of both national subsidy and regional subsidy.

Until 2015, however, as the total amount of budget was fixed, only limited number of EVs could be purchased through a lottery each year. Also, models for EVs are largely limited. See Table 3 for models of passenger electric vehicles available each year and their features. Although the budget and models for electric vehicles have been restricted, 159 electric vehicles in 2013, 226 in the first half of 2014, 225 in the second half of 2014, and 1,488 in 2015 were purchased by the local residents. As of December 31, 2015, the number of electric vehicles in Jeju is 2,366, accounting for approximately 1% of the total number of registered vehicles in Jeju.

Table 3: Subsidized models of electric passenger vehicles

	Battery type and size	Authorized driving range (under room temperature)	Year to begin on sale
Ray	Lithium-ion 16.4kWh	91km	2013
Spark	Lithium-ion 21.4kWh	135km	2013
SM3 Z.E.	Lithium-ion 26.6kWh	135km	2013
Soul EV	Lithium-ion 27.0kWh	148km	2014
i3	Lithium-ion 21.3kWh	132km	2014
Leaf	Lithium-ion 24.0kWh	132km	2014
Peace	Lithium-ion 17.8kWh	67.5 km	2015
Ionic	Lithium-ion 24.0kWh	191km	2016

Note: Driving range is authorized by the national government of South Korea. The test is done in a very conservative environment; therefore, driving distances tends to be higher for daily use. Peace is an electric truck.

In 2016, a new model of an EV was related to market. Since then, there has been sufficient supply of EVs with subsidy. As shown in Table 4, the cumulative number of EVs in Jeju is 5,613 as of December 31, 2016, accounting for approximately 1.60% of the total number of registered vehicles in Jeju. The cumulative number of EVs rises to 7,205 in June 2017. At the end of 2017, about 10,000 EVs are expected.

There are a couple of reasons for growing number of EVs in Jeju. With the size and the climate of Jeju, an electric vehicle fits the island. The driving distances on full charge of EVs in a market, ranging from about 91 km to 148 km, is sufficient for driving across the island and making return trips. Battery performance is sensitive to temperature. The driving range becomes shorter in winter time. If heating system is on, the driving distance is much shorter than summer time. Typically, the duration of winter is short and extremely cold weather is rare in Jeju; therefore, Jeju has a great condition for its residents to own and use electric vehicles, given the technology of electric vehicle at present.

Other reasons are Jeju's sufficiently charging infrastructure and electric vehicle friendly policies. Over the past years, the number of both DC and AC chargers has dramatically increased. Particularly, 175 DC chargers were open to public as of December 2016, whereas there were 22 DC chargers in December 2012. 417 DC chargers are open to public in June 2017. Also, there are 317 AC chargers open to public (See Table 5). The policies implemented to deploy more EVs in Jeju Island include purchase subsidy (mentioned above), purchase tax exemption , low ownership tax, free parking fee (due to December 2018), and so on.

Table 4: The cumulative number of electric vehicles and all vehicles registered in Jeju [2]

		Num. of EVs	Num. of EVs increased	Num. of all vehicles	Num. of all vehicles increased	Proportion of EV in all vehicles (%)	Proportion of EV in all vehicles increased (%)
2016	Aug	3,297	-	346,802	-	0.95	-
	Sep	3,608	311	347,479	677	1.04	45.94
	Oct	3,888	280	348,181	702	1.12	39.89
	Nov	4,598	710	349,769	1,588	1.31	44.71
	Dec	5,613	1,015	351,506	1,737	1.60	58.43
2017	Jan	6,252	639	353,304	1,798	1.77	35.54
	Feb	6,395	143	354,450	1,146	1.80	12.48
	Mar	6,567	172	355,617	1,167	1.85	14.74
	Apr	6,804	237	358,040	2,423	1.90	9.78
	May	7,040	236	359,651	1,611	1.96	14.65
	Jun	7,205	165	361,516	1,865	1.99	8.85

Table 5: The cumulative number of electric vehicles and all vehicles registered in Jeju [2]

		D C chargers			AC chargers		
		Public	Private	Total	Public	Private	Total
2016	Oct	110	18	128	329	2,926	3,255
	Nov	121	19	140	330	3,168	3,498
	Dec	142	33	175	330	3,502	3,832
2017	Jan	167	45	212	353	3,821	4,174
	Feb	193	60	253	369	4,134	4,503
	Mar	219	62	281	374	4,251	4,625
	Apr	243	84	327	374	4,418	4,792
	May	288	90	378	375	4,589	4,964
	Jun	315	102	417	384	4,784	5,168

4 Electricity: Consumption of Electric Vehicles and Generation of Renewable Energy

This paper also provides new information: the total amount of electricity that EVs use monthly, comparing with the total amount of electricity generated from solar and wind power.

The total amount of electricity used by EVs in Jeju grows as the number of EVs increases linearly. Table 6 shows that there was 3,608 electric vehicles registered in September 2016, which is almost doubled in June 2017. For the same period, the total amount of electricity used by electric vehicles is also doubled from 891,452 kWh to 1,807,417 kWh.

The average amount of electricity used by EVs varies by month, ranging from 204 kWh/veh in December 2016 to 251 kWh/veh June 2017 (see Table 7). The difference over the past months results from seasonal variation in vehicle usage and battery performance. When temperature is low, EVs can drive shorter. Also, composition of vehicle with various uses (electric taxis and rental cars) may affect.

The electricity consumption of EVs compares with the total amount of electricity generated from solar and wind power. The proportion of electricity for EV use is only 1.5% to 5.7% of the total amount of electricity of renewable energy. The total amount of electricity used by electric vehicles is between 848,445 kWh and 1,807,417 while wind and solar power generate from 40,643,906 kWh to 84,169,786 kWh. Interestingly, there are more electricity from wind power in winter time (December to February) while more solar power electricity can be generated in summer time (March to June).

Table 6: Electricity used by EVs in Jeju [2]

		Num. of EVs	Total electricity used by EVs (kWh)	Ave. electricity used by EV (kWh/veh)
2016	Sep	3,608	891,452	247
	Oct	3,888	848,445	218
	Nov	4,598	946,860	206
	Dec	5,613	1,144,879	204
2017	Jan	6,252	1,467,484	235
	Feb	6,395	1,587,106	248
	Mar	6,567	1,485,636	226
	Apr	6,804	1,701,666	250
	May	7,040	1,679,210	239
	Jun	7,205	1,807,417	251

Table 7: The renewable energy generated each month in Jeju [2]

		Total (kWh)	Wind power (kWh)	Solar power (kWh)	Total electricity used by EVs (kWh)	Proportion (%)
2016	Oct	44,576,282	39,185,439	5,390,843	848,445	1.9
	Nov	60,827,252	54,516,237	6,311,015	946,860	1.6
	Dec	75,816,564	69,718,654	6,097,910	1,144,879	1.5
2017	Jan	80,239,962	73,170,286	7,069,676	1,467,484	1.8
	Feb	84,169,786	75,210,636	8,959,150	1,587,106	1.9
	Mar	63,840,478	51,659,019	12,181,459	1,485,636	2.3
	Apr	59,146,542	45,848,214	13,301,328	1,701,666	2.9
	May	40,643,906	25,440,715	15,203,191	1,679,210	4.1
	Jun	31,499,198	19,019,411	12,479,787	1,807,417	5.7

5 Conclusions and Discussions

This paper introduces the CFI 2030 plan, including backgrounds, policy goals, and annual plans, particularly discussing the progress of the CFI 2030 plan with the focus on electric vehicle deployment. This paper shows that the number of electric vehicles and chargers has largely increased, resulting from geographical condition of Jeju Island as well as various policies implemented to deploy more electric vehicles, including purchase subsidy, free parking fee, and so on. This paper also empirically compares the total amount of electricity that electric vehicles have used with the total amount of electricity generated from solar and wind power.

The possibility of achieving the CFI 2030 plan is promising. The fact that sufficient amount of electricity is generated from wind and solar power in Jeju island, which is much more than the needs of EVs use at the moment (31,499,198 kWh vs. 1,807,417 kWh in June 2017). With the amount of electricity generated from the renewable energy in June 2017, approximately 120,000 EVs can run, which is one of third of the total number of EVs projected in 2030. The investment for wind and solar power generation grows; therefore, there should not be a lack of electricity due to the increasing number of EVs in Jeju Island.

The number of electric vehicles rises to 7,205 in June 2017. This can reach about 12,000 at the end of this year. However, this is far behind the goals of 29,000 EVs set in the CFI 2030 plan. There are two reasons. First, over the past years, the national government has restricted the supply of EVs with financial subsidy; therefore, Jeju has not been able to distribute more EVs, despite of its strong desire. Actually, due to the excess demand, lotteries had taken placed from 2013 to 2015. Second, various models of EVs have not been available. This does not satisfy consumers' expectation. The goal would have been achieved without those limitations. If there are enough supply of electric vehicles in terms of quantity and quality, the goal of 94,000 electric vehicles in 2020 can be achieved promisingly.

In the CFI 2030 plan, EVs play an important role not only in transporting people and goods and but also in storing excess electricity and securing electricity supply. In the future, a strong policy that can replace internal combustion engine vehicles with EVs is needed. Otherwise, the number of vehicles in Jeju dramatically increases. Although the total amount of electricity used for EVs in Jeju still small, the time for charging should be strategically managed to avoid the risk of blackout in peak time and season.

References

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