A Pre-Feasibility Test for Promoting Renewable Hybrid System in Ulleung Island by 2030

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Abstract

'Low Carbon Green Growth Policy and Law' initiated by Korean government represents her objectives to reduce the future dependency on fossil fuel. A couple of projects for the promotion of Zero Carbon Island or Green Island as an off-grid power system are proposed around the world. In Korea, Ulleung local government declared 'Carbon Neutral Plan' and central government planned to promote Ulleung Island as a prototype green island model of zero carbon emission without any fossil fuel use. This paper analyzes the economic feasibility of the promotion of renewable energy hybrid system in Ulleung Island by 2020 compared with the Scenario of maintaining current power generation system.

1. Introduction

Global greenhouse gas(GHG) emissions continue to increase, and in 2010 global energy-related carbon dioxide (CO_2) emissions reached an all-time high of 30.6 gigatonnes (Gt) despite the recent economic crisis. On account of every kind unusual change in climate, United Nation Framework Convention on Climate Change (UNFCCC) has carried forward reducing GHG. GHG mitigation targets for developed countries (Annex1) were adopted in 1997 in Kyoto in Japan. Since over 80 countries ratified a Copenhagen Accord at Conference of the Parties (COP15) in Copenhagen, Korea joined in suggesting Mitigation pledge which were defining that reducing national GHG emissions by 30 percent from the Business As Usual (BAU) emissions by 2020. Mitigation pledge under Copenhagen Accord was unrelated with official procedure of UN. Reducing GHGs emission, especially CO_2, became vital aspect resulted from making an official UN document at Cancun Agreement of COP16. In order to lead this global flows and become green growth fast mover, Korea also declare Low Carbon Green Growth as a National Vision, and is implementing three objectives such as Mitigation of climate change and improvement of energy independence, Creation of new growth engines, and Improvement in the quality of life and enhancement of international standing and ten policy directions precisely.

According to Environmental Outlook Baseline scenario from THE OECD ENVIRONMENTAL OUTLOOK TO 2050 Key Findings on Climate Change[1] (2011), without more ambitious policies than those in force today, GHG emissions will increase by another 50% by 2050. In addition, in order to set clear, credible, more stringent and economy-wide GHG mitigation targets, we should put a price on carbon, reform fossil fuel support policies, foster innovation and support new clean technologies.

There are 299 islands grid connected with mainland, 128 islands generating electric power independently on motherhood standard, and 99islands supplied electricity fully among current 477 inhabited remote islands in

[1] THE OECD ENVIRONMENTAL OUTLOOK TO 2050(2011.11.24) : The official report is planned to publish on The Conference of Environment Ministers of OECD which will be held on 2012.3.29-30. Nevertheless, Climate change chapter was announced early for COP17 had begun from 2011.11.28

Korea. 71.09% of independent electric power plants in Korea are providing electricity through diesel engine generator. Thermal power plant, diesel or fossil fuel are burned as fuel, are causing environmental problem which is emitting carbon dioxide. It also plays part role that combustion of fuel in order to transport diesel to remote island help emit CO_2. Although diesel transmitting cost is included to fuel cost with environmental aspect and increase power cost, Unit kWh charge of electricity is equal regardless of differing between mainland and remote islands due to specific regulation which is supporting for the amount of loss of operating expenses under current detail regulation related to charge of remote island.

Analysis area is Ulleung Island where it not only has the smallest CO_2 emission among Korean local governments but also proclaim carbon neutrality green island.

Of all green- developing model in the global remote area, the Samso Island is the most representative case in terms of lowering dependency on fossil fuel substantially at generation source of electricity by replacing to New·Renewable Energy (NRE). The Samso Island is representative carbon neutrality area, providing 100% electricity by generating abundant wind power. Its grid is connected to Jutland which is mainland of Denmark, so that it is possible to be received electricity in case of emergency. Lolland Island in Denmark converts from excess electricity into hydrogen by using abundant wind resource as well and decreases energy usage dependency, for example, generation and power, on fossil fuel. Ramea Island makes a trial run of wind-hydrogen-diesel generating system with adding new wind power generator to existing power facilities in situation of non grid-connection. It plans to reduce dependency on fossil fuel by the time Newfoundland and Labrador Hydro project will complete by cutting off operating diesel generator.

A program which is called Hybrid Optimization Model for Energy Renewable (HOMER) run to analyze for this paper was made by National Renewable Energy Laboratory (NREL). By using it, this paper analyze a pre-feasibility test for promoting NRE hybrid system to lower CO_2 emission in Ulleung Island which has off-grid system

By using HOMER for the remote island likewise Ulleung Island where grid is not connected, Ahmad et al. (2010) analyze introduction of NRE hybrid system. Lau et al. (2010) analyze NRE hybrid system including Diesel generator and photovoltaic resource by using HOMER. Conti et al. (2010) evaluate independence effect from fossil fuel as saving to chemical energy from excesss electricity of wind generator in Samso Island which is large scale island.

In this paper, we examine current power supply situation and outlook of Ulleung Island and present premise of NRE energy resource in order to analyze it. We analyze supply feasibility of NRE hybrid electricity system in 2020 by using HOMER so as to reduce 30% of GHGs related to BAU by 2020 and achieve 6.08% of NRE penetration rate by 2020 based on the established premise. Power supply and GHG emission are included and change of composition of NRE hybrid system and trend of change about Total Net Present Cost (TNPC) and Levelized Cost of Energy (LCOE). In accordance with increasing of diesel price and CO_2 penalty are also included in this analysis. As a result of this paper not only to meet target emission reduction of CO_2 but also become green fast mover, we assess the meaning of introduction of NRE hybrid system in remote islands.

2. Current Status and forecast of Power demand in Ulleung Island

The hourly maximum electricity load in Ulleung County at year 2010 is 8,393kWh. From the year 2007, the electricity generation had been increased for 6~10% for each year.

A. Power Demand

i. Population and Tourism

For many years, the population growth rate in Ulleung Island had been stabilized to 0.01% per year. By 2030, the population growth rate will gradually be increased until 1.3%. More remarkable thing is that the number of households will be increased caused by nuclear family or one-person household. This demographic trend will cause the increasing demand for one-person electric appliance.

Table 1 Demographic Statistic of Ulleung Island

year	Total population (person)	Household	Population per household (person)	Tourist(person)
2001	9,950	3,773	-	184,239
2002	9,615	3,734	-	173,141
2003	9,245	3,692	-	191,780
2004	9,191	3,755	-	212,489
2005	9,538	4,078	2.3	185,607
2006	10,235	4,508	2.3	202,428
2007	10,160	4,522	2.2	223,208
2008	10,220	4,573	2.2	272,302
2009	10,398	4,848	2.1	252,555

[2]Source: Ulleung County (2009)

Another driving force to lead increase in electricity demand by 2020 is expected to be tourisms. The tourist visiting Ulleung Island has been increased 150% for the last 24 years. It is considerable number in island where total population is 10,398 in 2009 that the daily average entrance number of tourists was 747, indeed, daily maximum number of tourists is 3,347 during peak season. The increasing trend of tourist affects in the daily load profile[3].

ii. New Industrial Electricity Demand

Now, in Ulleung Island, the diesel power plants are under construction for the urgent short-term industrial electricity demand. The main facilities are including 'Deep Ocean Water Exploit, Accommodations, Marine Product Processing Facilities, Monorail for industry and passenger use, and Tourist Facilities'. By 2012, new 6,900kW for industrial demand was created, and Ulleung Local government asked for permission of additional power plant construction. According to Ulleung County Energy Demand Forecast (KIER, 2011), regional GDP of Ulleung County will continually be increased for 3~4% per each year.

Table 2 The short-term large new power demand in Ulleung Island

Year	Use	Requested Capacity(kW)

[2] KIER, Energy supply and demand forecast in Ulleung Island(inside data), 2011

[3] KIER, Energy supply and demand forecast in Ulleung Island(inside data), 2011

2010	Deep Ocean Water Exploit(2 places)	3,000
2010	Accommodations	7000
2010	Marine Product Processing Facilities	1,000
2011	Accommodations	1,000
2011	Monorails	700
2012	Tourist Facilities	500
Total		6,900

Source: MKE (2010)

B. Electricity Generation Facilities

The total capacity of electricity generation facilities in Ulleung Island is 13,318.5kW, the diesel power generation capacity is 12,500kW that is 95% of total power generation facilities. And the capacity of new and renewable power generation facilities is about 800kW. The total capacity of power generation facilities constructing the independent Ulleung Island small grid composed of Ulleung and Namyang Diesel Turbine Power Plants, Choosan 1st and 2nd Small Hydro Power Plants is 13,200kW.

Table 3 Electricity Generation Facilities in Use

Sort		Facility(installed year)	Capacity(kW)	Component	Place
Diesel Power Generation		Ulleung #1, 2(2007)	6,000	3,000kW*2	Judong
		Ulleung #3, 4(1986)	2,000	1,000kW*2	Judong
		Namyang #1, 2(1997)	3,000	1,500kW*2	Namseo
		Namyang #3(2002)	1,500	1,500kW*1	Namseo
Renewable Energy Power Generation	Solar	21 houses	48.5		Ulleung
		1 household	5		Jukdo
		Public	55		Dokdo
	Small Hydro	1st power plant(1966)	600	600kW*1	Bukmyun
		2nd power plant(1978)	100	100kW*1	
	Wind	Wind Turbine	10		
Total			13,318.5		

Source: Ulleung County (2009)

The Fifth Power Supply Master Plan (MKE, 2010) was presented that in order to raise the electrical reserves and equipment reserve at the same time in Ulleung Island, the 6,000kW diesel power generating facilities will be constructed by 2011. By 2014, the 9,000kW will be constructed and 2,000kW will be disposed. The diesel power plant will be composed of 5 diesel turbines of 3000kW, and 2 diesel turbines of 1,000kW. The equipment reserves will be 51.86% in 2014.

Table 4 Capacity and Reserve rate

Year		2010	2011	2012	2013	2014
Sort	Capacity(kW)	13,200	19,200	19,200	19,200	26,200
	Reserves (%)	13.16	37.49	20.23	15.73	51.86

Source: MKE (2010)

From the demand side of electricity, population and tourism trend, new industrial electricity demand are two driving forces of electricity demand. And aging power facilities and equipment reserves ratio enforcement plan from the Fifth Power Supply Master Plan are supporting supply side. And according to the policy will of Ulleung Local government for Green Island, the Electricity Enterprises Act, the Rural Electrification Act, and Act on the Promotion of the Development, Use, and Diffusion of New and Renewable Energy in Korea, the promotion of new and renewable energy power generation equipment can be examined.

3. Premise for Analysis

A. Electrical Load

The actual hourly power generation in year 2010 was imported through the HOMER (Hybrid Optimization Model for Energy Renewable). From the actual hourly power generation data, the peak hourly load is 8.4MW/h, the average load 5.9MW/h and the daily average load are 141.5MWh/day.

From the Ulleung county energy demand prospect(2011), electricity load will be gradually increased. We changed the annual TOE data to the hourly electrical load data. In 2030, the average electric load demand will be expected to 8,609kWh.

Table 5 The hourly average electrical load expectation

	2009	2010	2015	2020	2030
Electricity(kWh)	4,735	4,905	5,766	6,819	8,609

Source: KIER (2010)

B. Renewable Source

i. Wind Power Resource

The Ulleung Island is a bell-shaped volcano which the whole part of island is mountainous terrain. The seasonally formed airflow is certain and enough to wind power generation. From these topographical characteristics, the Ulleung Island is estimated the optimum place for the wind power generation.

The actual hourly wind speed data was measured 10 meter from the earth. The wind speed data were not reflected the height where wind turbine would be installed. And wind speed is non-linearly increased as the height uprising. The logarithmic profile was assumed that the wind speed is proportional to the logarithm of the height above ground. The equation below gives the ratio of the wind speed at hub height to the wind speed at anemometer height:

$$\frac{U_{hub}}{U_{anem}} = \frac{ln\,(z_{hub}/z_0)}{ln\,(z_{anem}/z_0)}$$

U_{hub} = the wind speed at the hub height of the wind turbine [m/s]

U_{anem} = the wind speed at anemometer height [m/s]

z_{hub} = the hub height of wind turbine [m]

z_{anem} = the anemometer height [m]

z_0 = the surface rough length [m]

$ln\,(..)$ = the natural logarithm

As a result of calculation from the equation above, the actual hourly wind speed could be scaled up. According to IPCC (2011), the rating of wind turbine is related to roter diameter and hub height. In case of 3,000kW wind turbine with diameter and hub height are the same as 100 meter from the earth, and the normal terrain description of Ulleung Island (forest and wood land, $z_0 = 0.5$). From the calculation above equation, the actual hourly wind speed has to be multiplied to about 1.769 times.

ii. Solar Resource

Using the latitude and east longitude data of Ulleung Island, HOMER composes the 40km by 40km cell which Ulleung Island is located in the center. The monthly average clearness index and radiation data were synthesized by HOMER because solar resource data of the Ulleung Island has not been measured yet. From the monthly data, HOMER builds a set of 8,760 solar radiation values in a year. HOMER creates the synthesized values using data sequence generating mechanism results in data sequence reflecting variability and autocorrelation. The clearness index is the fraction of solar radiation transmitted at the surface of earth and the surface of atmosphere. Also it’s a measure between 0, 1. It depends extremely on the weather condition.

iii. Small Hydro Resource

Small hydro electrical generation is drastically depends on the weather condition and location. The historical annual average amount of precipitation in Ulleung Island for 30 years is 1383.5mm, the little more than the annual rain fall of Korea. The distribution of rainfall between August and September is about 24% of the year, but annually, it is consistent through the year. The Ulleung Island takes an advantage of small hydro electrical generation because an abundant rainfall is distributed regularly through the year. Another exceptional advantage of Ulleung Island in small hydro power generation is that she a unique place using a gush out water to small hydropower generation in Korea. In other words, the lack of surface water caused by volcanic terrain and the relatively short river cause by the abrupt topography are disadvantages. The Choosan 2nd Small Hydro Power Plant (600kW) uses gush out water ($0.51m^3/s$) from Nari basin and Choosan 1st Small Hydro Power Plant (100kW) generates electricity by effluence from 2nd Hydro Power Plant and branch stream water ($0.133m^3/s$)[4].

4. Hybrid Power Generation System and Model for Analysis

A. System composition and operating

The new and renewable hybrid energy system was built with the existing facilities and feasible new and renewable energy sources. The schematic below is a composition of new and renewable hybrid energy system in each case. In each stand-alone system, wind turbines, hydro turbines and diesel turbines produce AC bus then it directly supplied to the electricity load. To govern the intermittency of wind power energy resource, electrolyzer-hydrogen tank-fuel cell system was designed to store the excess electricity in DC bus also photovoltaic generates DC bus. Whether the system generates enough to electrical load or not, the system operates in other two ways. In case of excess electricity, the excess production of the electricity will be stored in hydrogen tank after forming hydrogen molecules through the electrolysis. If the electricity produced is less than DC bus, the fuel cell and diesel backup system operate to fit the load.

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[4] Ulleung county office, NRE fesibility studying in Ulleung County, 2009

HOMER is a multi-purpose model that assists in the design of micro-grid power systems and facilitates the comparison of power generation compositions across a wide range of applications. HOMER models a power system's chronological behavior and its lifecycle cost, which is the total cost of installing and operating the system over its life span. HOMER can model off-grid and grid connected micropower systems serving electric and thermal loads, and comprising any combination variable energy equipment.

The difference between renewable sources' and conventional non-renewable sources' initial capital and operating cost dynamics is caused by the tendency of operation. In the optimization process HOMER compares wide range economics within various system configurations.

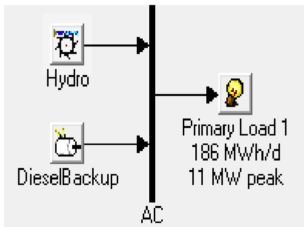

Figure 1. Model of Case1

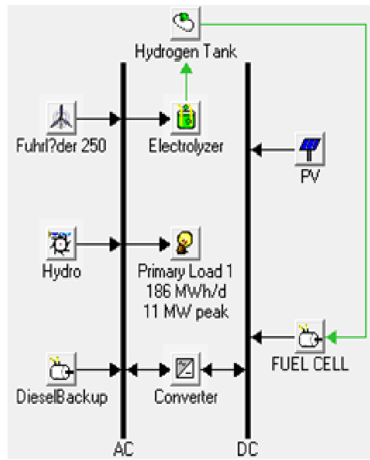

Figure 2. Model of Case2, 3

In this analysis, we compare 3 NRE hybrid system cases that are composed based on disuse and building plan of diesel generator[5] in Ulleung Island from The 5th electricity plan for supply and demand. Case1 is comprised of 700kW small hydro, currently existing NRE in the Island, and diesel generator whose lower bound capacity is 18,500kW which is a standardized in 2011. Case2 also has diesel generator whose setting is equal to Case1 and we additionally put NRE facilities. For example, PV, small hydro, wind turbines, fuel cell-Hydrogen Tank-Electrolyzer. Case3 has no restriction on the lowest capacity of diesel backup and set to be able to choose among large range of diesel capacities from 0Kw, 12500kW, 18500Kw, 25500Kw and higher one. The NRE facility of Case3 is same setting with Case2. Consequentially, those options affect Case3 to get the most optimized results.

We also simulate sensitivity analysis in case of rising diesel price and carbon dioxide penalty. The range of diesel price starts from 0.8$/L, 1$/L, 1.5$/L, 2$/L, 2.5$/L, till 3$/L. In the meantime, the price of CO_2 Penalty begins at $0 and ends at $259. There are CO_2 Penalty table that we collected from literature search.

Table 6 Carbon Price Forecast by Models

Model	Sort	2020	2030	2050	2100
IGSM*	min***	18	26	58	415

[5] Beginning from 6,000Kw diesel generator building in 2011, 9,000Kw in 2014, in the meantime, abolition of 2,000Kw diesel generator. Power generating facility in 2010 : 12,500Kw, in 2011 : 18,500Kw, and in 2014 : 25,500kW

	max****	259	384	842	6,053
MERGE*	min***	1	2	6	67
	max****	110	191	574	609
MiniCAM*	min***	1	2	5	54
	max****	93	170	466	635
EIA-Core Scenario**		29	59	-	
CATF**		22	48	-	
ACCF/NAM-Low Cost**		52	216	-	
ACCF/NAM-High Cost**		61	257	-	
MIT-Offsets+CCS**		58	86	189	
EPA (ADAGE)-Scenario 2**		37	61	159	
EPA (ADAGE)-Scenario 10**		28	46	121	
CRA-Scenario with Banking**		58	84	185	

*Source : U.S. Climate Change Science Program Synthesis and Assessment Product 2.1a, Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations(2007)
** Source : Innovative policy solutions To Global Climate Change in Brief, Insights from Modeling Analysis of the Lieberman-Warner Climate Security Act (S. 2191)(2008)
***min: stabilization level 4, CO_2 intensity in atmosphere 750ppmv
****max: stabilization level 1, CO_2 intensity in atmosphere 450ppmv

B. Economic model

The comparison results depend directly on both capital and operating costs. Considering the life span of project and equipment including all cost and capital, HOMER presents the total net present cost (NPC) to represent the lifecycle cost of a system;

$$C_{NPC} = \frac{C_{A,T}}{CRF(r,N)} = C_{A,T}\frac{(1+r)^N - 1}{r(1+r)^N}$$

$C_{A,T}$ = annual payment
$CRF(*)$ = Return on Capital

HOMER ranks the system configurations according to ascending NPC in its optimization process. The objective function is:

$$Min(NPC_t) = Min\sum_{i=1}^{n}\frac{K_{t+i} + RP_{t+i} + OM_{t+i}}{(1+r)^i}$$

r = interest rate

K_{t+i} = initial capital cost of year $t+i$

RP_{t+i} = replacement cost of year $t+i$

OM_{t+i} = operation and management cost of year $t+i$

The levelized cost of energy is another measure of economics of new and renewable energy hybrid system.

$$LCOE = \frac{C_{A,T}}{E_s} = \frac{C_{NPC} * CRF(r,N)}{E_S}$$

$C_{A,T}$ = total annualized cost of the system [$/yr]

E_s = total electrical load served [kWh/yr]

5. Analyzed results

In this analysis, we composed 3 cases beforehand and compare each cases whose standard of power supply is based on abolition and building additional diesel power generator plan[6] from The 5th electricity plan for supply and demand in Ulleung Island. From the literature review about carbon tax, we make a comparison between maximum, minimum, average, and no existing of carbon emission penalty in 2020 from each envision scenario[7].Furthermore, in case of increasing diesel price in 2020 owing to rising gasoline price and so on, we compare from $0.8 unit liter price to $1, $1.5, $2, $2.5, $3. Optimized power facility composition in Ulleung Island is appeared below resulted from optimizing 3 cases including NRE resources such as wind, PV, small hydro, hydrogen powered fuel cell which are applicable one in the island.

Table 7 The Optimized Result of Case 3

<table>
<tr><td colspan="5">Case3</td></tr>
<tr><td>Production facilities</td><td>Capacity (kW)</td><td>Percent (%)</td><td>TNPC</td><td>$ 264,804,368</td></tr>
<tr><td>PV Array</td><td>0</td><td>0</td><td>LCOE</td><td>$0.306/kWh</td></tr>
<tr><td>Wind turbines</td><td>18,750</td><td>46</td><td>Diesel Price</td><td>0.8($/L)</td></tr>
<tr><td>Hydro turbine</td><td>1,400</td><td>11</td><td>CO_2 Penalty</td><td>0($/t)</td></tr>
<tr><td rowspan="2">DieselBackup</td><td rowspan="2">9,500</td><td rowspan="2">42</td><td>CO_2 Emission</td><td>19,797,442(kg/yr)</td></tr>
<tr><td colspan="2">Power generation</td></tr>
<tr><td>FUEL CELL</td><td>1,000</td><td>1</td><td colspan="2" rowspan="4">We convert pattern of electricity power supply from 2010 to 2020 under assumption of power supply in 2010 will be maintained.</td></tr>
<tr><td>Converter</td><td>1,000</td><td></td></tr>
<tr><td>Electrolyzer</td><td>1,000</td><td></td></tr>
<tr><td>H_2 Tank(kg)</td><td>1,000</td><td></td></tr>
</table>

Source: results from HOMER

When CO_2 Penalty is $0 and diesel price is as same as one in 2010, Summation of NRE facilities occupy 58% of all. Nevertheless, levelized cost of energy is $0.306, which means cost difference is quite slight compared with 304won in present LCOE of Ulleung Island.

If we put together TNPC, LCOE of simulation resulted from case1, 2 in terms of $0.8 diesel price and no CO_2 penalty and optimized case3 values which we already stated above, it is shown below

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[6] Beginning from 6,000Kw diesel generator building in 2011, 9,000Kw in 2014, in the meantime, abolition of 2,000Kw diesel generator. Power generating facility in 2010 : 12,500Kw, in 2011 : 18,500Kw, and in 2014 : 25,500kW

[7] Maximum Carbon Penalty price is $259/ton of IGSM Model, Minimum is $1/ton of MERGE AND MINICAM Model, and Average is $59/ton

Table 8 The comparison of TNPC, LCOE, Diesel Capacity and CO_2 emission by Case

Case	TNPC($)	LCOE($/kWh)	Diesel Backup(kW)	CO_2 emission (kg/yr)
Case1	482,877,248	0.557	18,500	41,081,748
Case2	414,792,320	0.479	18,500	28,760,796
Case3	264,804,368	0.306	9,500	19,797,442

Source: results from HOMER

42% of electricity is provided through diesel power system at optimized Case3 scenario. Fuel cost affects total operating cost, and it continues to rising effect of marginal cost what if we impose a penalty about GHG emission.

In regards of Carbon dioxide price, we examine sensitive analysis according to 1) No penalty on Carbon dioxide, 2) $1/ton suggested carbon price in 2020 from MERGE, MiniCam model, 3) $59/ton, average price in 2020 of all price outlook model searched. 4) $259/ton, the maximum price from IGSM model of all price forecast model.
we also estimate sensitivity analysis from 1) $0.8/L which is present diesel price to 2)$1/L, 3)$1.5/L, 4)$2/L, 5)$2.5/L, 6)$3/L to prepare the time when diesel price goes up. The table below is filled up with facility capacity of PV, wind, diesel backup and TNPC, LCOE, CO_2 emission

Table 9 The Comparison of Sensitivity Result of Each Case

Case	**CO_2 Penalty ($/t)** / **Diesel($/L)**	**0**	**1**	**59**	**259**
Case 1	0.8	0.557	0.559	0.593	0.715
	1	0.604	0.604	0.639	0.761
	1.5	0.719	0.719	0.754	0.876
	2	0.834	0.835	0.904	1.067
	2.5	0.949	0.950	0.985	1.106
	3	1.064	1.065	1.100	1.221
Case 2	0.8	0.479	0.479	0.504	0.586
	1	0.511	0.511	0.535	0.617
	1.5	0.589	0.589	0.613	0.698
	2	0.669	0.669	0.694	0.779
	2.5	0.749	0.750	0.775	0.859
	3	0.829	0.830	0.854	0.938
Case 3	**0.8**	**0.363**	**0.363**	**0.382**	**0.454**
	1	0.388	0.388	0.407	0.484
	1.5	0.456	0.457	0.481	0.552
	2	0.527	0.527	0.548	0.614
	2.5	0.592	0.592	0.611	0.675
	3	0.653	0.653	0.672	0.736

Source: results from HOMER

6. Conclusion

In this study, Ulleung Island is as remote off-grid power generating island. When diesel power plant is expected to be expanded or replaced, economic feasibility test for promotion of new and renewable energy power generation facilities is available.

In this analysis, we used HOMER showing optimized scenarios in ascending order of Total Net Present Cost (TNPC) as we consider the alternation of CO_2 Penalty and Diesel price and NRE hybrid generating facilities.

To sum up the analyzed result, while the fuel cost and CO_2 penalty goes up, HOMER select more NRE facilities such as wind turbines, PV, and then diesel generator pick the minimum capacity as low as possible except 0Kw because of intermittence of NRE. Looking into Levelized Cost of Energy (LCOE) of each cases[8], 1) minimum value: 0.557$/L, maximum value: 1.221$/L at Case1, 2) minimum value: 0.479$/L, maximum value: 0.938$/L at Case2, 3) minimum value: 0.363$/L, maximum value: 0.736$/L at Case3. This simulation results demonstrate Case3, which is not restricted by capacity of diesel generator on account of preliminary building plan in 2011 of the 5th electricity plan for supply and demand, so that it could choose smaller capacity of generator as same built capacity as 2010 in real and include NRE hybrid system, is the most economic case. In addition, a gap between 21,204,950kg/yr - CO_2 emission from Case3 – and 41,081,748kg/yr – CO_2 emission from Case1 will contribute to achieve the targeted mitigation obligation of Korea for UNFCCC by 2020. Furthermore, $0.363 which is LCOE of Case3 in 2020 is quite similar with the 304won which is current LCOE in Ulleung Island.

Acknowledgement

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