9. Team Project & Summary

Charles Kim, "Lecture Note on Analysis and Practice for Renewable Energy Micro Grid Configuration," 2013. www.mwftr.com

What we have learned so far

- HOMER
  - Editing an example code
    - Resources and components
    - Simulation ("calculate") and Optimization
    - Result interpretation
  - Creating a design of code
    - For your system
    - Resources and components
    - Simulation and optimization
- We are ready to do something more our own !!
  - Team Project (Now)
  - Team Project Demonstration/Presentation (Tomorrow)

Team Design Project

- Design a Hybrid Energy System (Grid may be connected)
- Site: **Work (School or Company or store) – team's consensus**
- **Mission/Goal:** Energy reduction, peak shaving, or zero-energy system
- Objective: **Find the optimum system** with sensitivity analysis
- Components: Grid (optional), Converter, Wind Turbine, PV panel, Fuel Cells, Electrolyzer, and Hydrogen Tank
- Project Lifetime: 20 years
- Fixed Cost: $10,000
- Load Study – as realistic and true as possible
- Load Profile →
  - You may have to use your **own load profile** obtained from your work
- You need to provide resource data on your work location
  - Solar Radiation {provide also sensitivity}
  - Wind Speed {sensitivity}

HOUR	[kW]
0000-0100	10
0100-0200	10
0200-0300	10
0300-0400	10
0400-0500	10
0500-0600	20
0600-0700	20
0700-0800	150
0800-0900	140
0900-1000	140
1000-1100	140
1100-1200	140
1200-1300	100
1300-1400	140
1400-1500	140
1500-1600	140
1600-1700	100
1700-1800	100
1800-1900	30
1900-2000	30
2000-2100	30
2100-2200	20
2200-2300	10
2300-2400	10

Suggested Component Data – Wind and PV

Wind Turbine

- Furhlander 30
  - Size: 30 kW
  - Lifetime: 20 years
  - Quantity: 10: [0, 5, 10]
  - Capital Cost: $7,800 [for 1 unit]
  - Replacement Cost: 10% of the Capital Cost
  - O&M Cost/Year: 5% of the Capital cost

PV Module

- Size: 200kW: [0,100,200,300] kW
- Derating Factor: 90%
- Lifetime: 20 years
- Capital Cost: $5000/kW
- Replacement Cost: 10% of Capital Cost
- O&M: 1% of Capital Cost

Suggested Component Data – Hydrogen

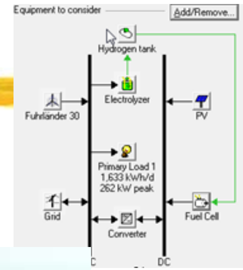
- Electrolyzer
  - Size: 100kW: [0, 50, 100] kW
  - Lifetime: 20 years
  - Capital Cost: $3000/kW
  - Replacement cost: 50% of Capital Cost
  - O&M Cost/Year: 5% of Capital cost
- Fuel Cell
  - Size: 200kW: [0, 100, 200, 300] kW
  - Lifetime: 30000 operating hours
  - Capital Cost: $5000/kW (or $500/kW)
  - Replacement Cost: $0
  - O&M cost: $0.1/hour
- Hydrogen Tank
  - Size: 2000 kg: [0, 1000, 2000, 3000]kg
  - Lifetime: 25 years
  - Capital Cost: $500/kg
  - Replacement Cost: 10% of Capital Cost
  - O&M Cost/year: 0.5% of the Capital Cost

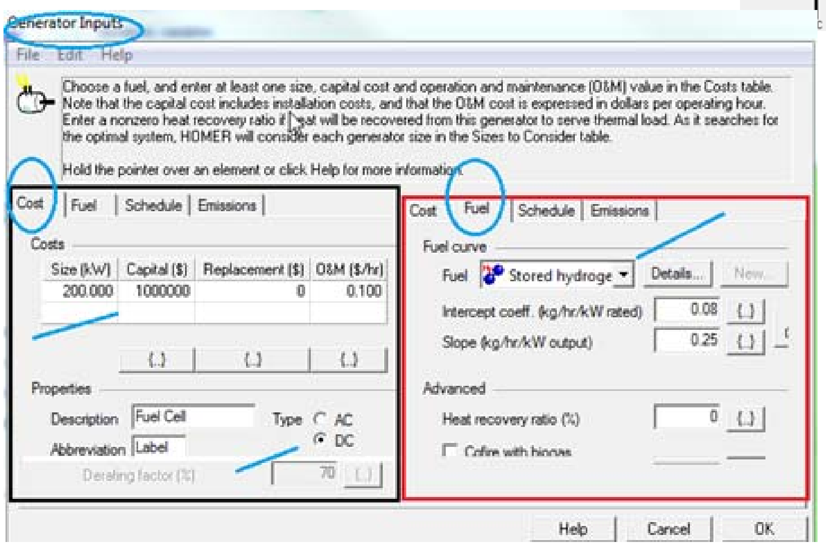
Side Bar- Hydrogen Systems

- Electrolyzer system converts electricity into hydrogen by electrolyzing water
- Hydrogen is stored in steel tanks or geological cavern
- Reconverted to Electricity using 2 methods:
  - **Polymer Electrolyte Membrane (PEM) fuel cell**
  - Hydrogen Expansion Combustion Turbine

Fuel Cell Modeling

- Fuel Cell In HOMER modeling:
  - Pick a generator
  - Type: DC
  - Fuel: Stored Hydrogen





Suggested Component Data – Converter

- Converter
  - Size: 200kW: [0, 100, 200, 300]kW
  - Lifetime: 20 years
  - Efficiency: 90%
  - Capital Cost: $1000/kW
  - Replacement Cost: 30% of Capital Cost
  - O&M Cost/Year: 10% of Capital Cost
- Grid (Optional)
  - Single rate
  - Price ($/kWh): $0.15 :
    Sellback ($/kWh): $0.15
  - Demand: $0
  - **Purchase Capacity: 300kW**
  - Sellback Capacity: 200kW

Analysis Points and Team Presentation

- Analysis Points:
  - Site Identification → Mission or Goal
  - Load study → Should match with the site and the goal
  - Find the Solar Radiation, and give Sensitivity values
  - Find the Wind Speed, and give sensitivity values
  - Calculate and Check the Optimization results
  - Check the Sensitivity Results
  - Find the optimum results
  - Find the components/devices locally available (Important)
  - Prepare Slides for team presentation (Tomorrow morning)
    - System Site, Location, etc (+ Real components and vendor info)
  - Also run the HOMER in the presentation

Example 4 Cases

- Case 1: Neo-Power (2)
  - Kwang Hyun Ahn
  - Hyun Jun Lee
  - Island
  - Zero-Energy

- Case 2: Green Campus (2)
  - Hyun Wook Kim
  - Yong Taek Oh
  - Energy cost impact to the renewable source penetration to university campuses
  - Cost of Energy

4 Cases - Continued

- Case 3: Renewable sourced pump system (2)
  - Jae Bum Park
  - Jung Woon Ahn
  - Supply drinking water to a Mong village

- Case 4: Yonhwa Island (3)
  - Su Hyun Lee
  - Suk Muk Hong
  - Il Dong Kim
  - Zero-energy energy self-sustainability (Energy Independence)

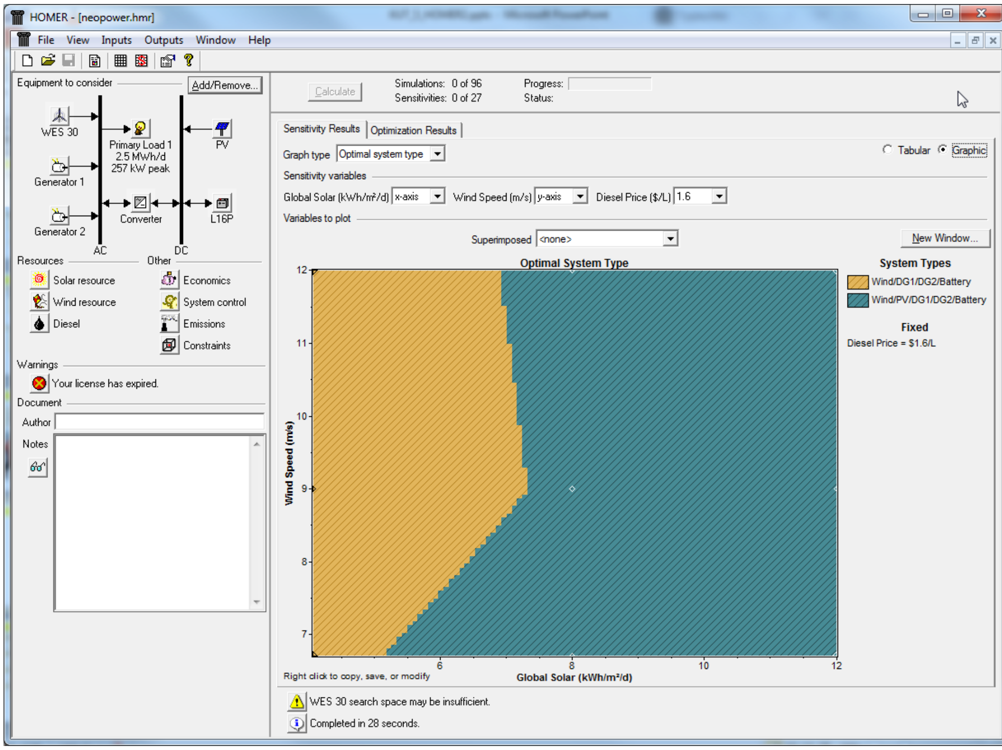
Case 1: Zero-Power

- **Site: Gapa-do Island**
- **Analysis of Carbon Free Island program for Gapa-do**

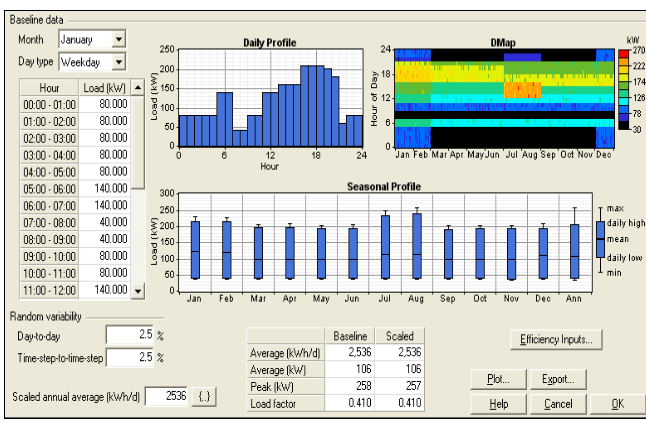
GAPA-DO ISLAND

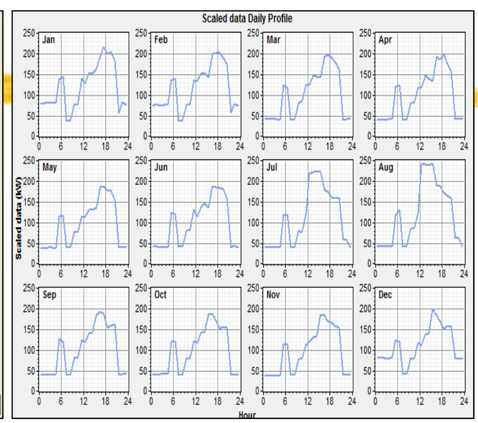
- An island between the main Cheju Island and Mara-do
- 130 households with population at 312
- Peak load: 244kW
- Existing Generation:
  - 150kW Diesel Generator (x 3)
  - Annual energy: 1090MWh/yr

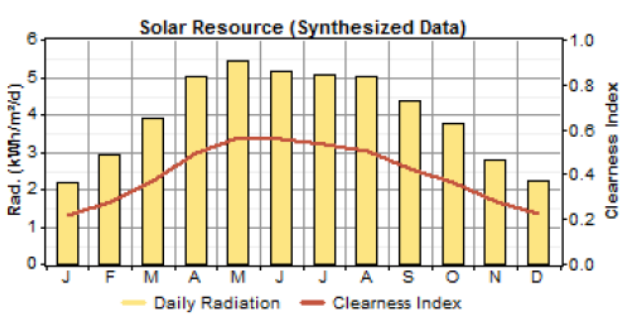
Case 1 - Homer Simulation



Case 1 - Simulation Input data







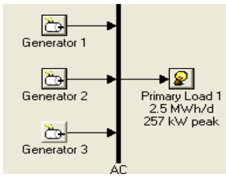
Emissions

Carbon dioxide penalty:	$ 1.5/t
Carbon monoxide penalty:	$ 0/t
Unburned hydrocarbons penalty:	$ 0/t
Particulate matter penalty:	$ 0/t
Sulfur dioxide penalty:	$ 0/t
Nitrogen oxides penalty:	$ 0/t

Case 1 - Simulation Result

⌘ Case 1

- Diesel Generators Only (existing system)



Diesel Price ($/L) 2

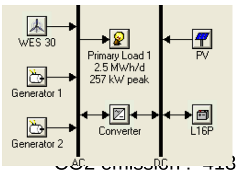
Double click on a system below for simulation results.

	DG1 (kW)	DG2 (kW)	DG3 (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	DG1 (hrs)	DG2 (hrs)	DG3 (hrs)
	150	150		$ 70,000	803,830	$ 9,289,863	0.875	0.00	376,111	8,760	3,005	

* CO_2 emission : 1000 t/yr

⌘ Case 2

- Diesel Generator – WT – PV – Battery



Global Solar (kWh/m?d) 4.06 | Wind Speed (m/s) 6.7 | Diesel Price ($/L) 2 | CO2 Penalty ($/t) 1.5

Double click on a system below for simulation results. ⦿ Categorize ○ Overall

	PV (kW)	WES30	DG1 (kW)	DG2 (kW)	L16P	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	DG1 (hrs)	DG2 (hrs)
	100	1	150	150	240	400	$ 3,922,000	369,524	$ 8,160,408	0.769	0.70	156,775	4,646	421

CO_2 emission : 413 t/yr

Case 1 – System Output

System architecture

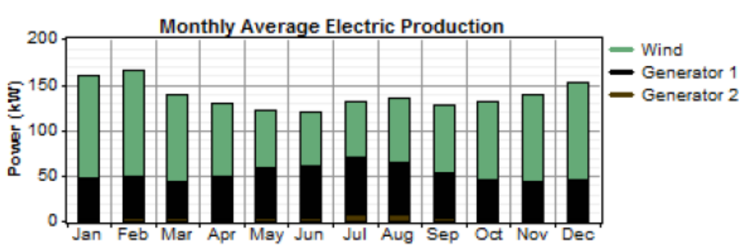
Wind turbine	1 WES 30
Generator 1	150 kW
Generator 2	150 kW
Battery	240 Trojan L16P
Inverter	400 kW
Rectifier	400 kW
Dispatch strategy	Cycle Charging

Cost summary

Total net present cost	$ 7,375,346
Levelized cost of energy	$ 0.695/kWh
Operating cost	$ 344,671/yr

Net Present Costs

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
WES 30	3,200,000	133,525	367,038	0	-66,518	3,634,045
Generator 1	30,000	10,270	0	3,094,466	-233	3,134,502
Generator 2	30,000	0	0	270,646	-251	300,395
Trojan L16P	72,000	40,796	0	0	-1,483	111,313
Converter	80,000	10,014	91,759	0	-4,989	176,785
Other	10,000	0	8,308	0	0	18,308
System	3,422,000	194,606	467,105	3,365,111	-73,475	7,375,348



Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	482,863
Carbon monoxide	1,192
Unburned hydocarbons	132
Particulate matter	89.8
Sulfur dioxide	970
Nitrogen oxides	10,635

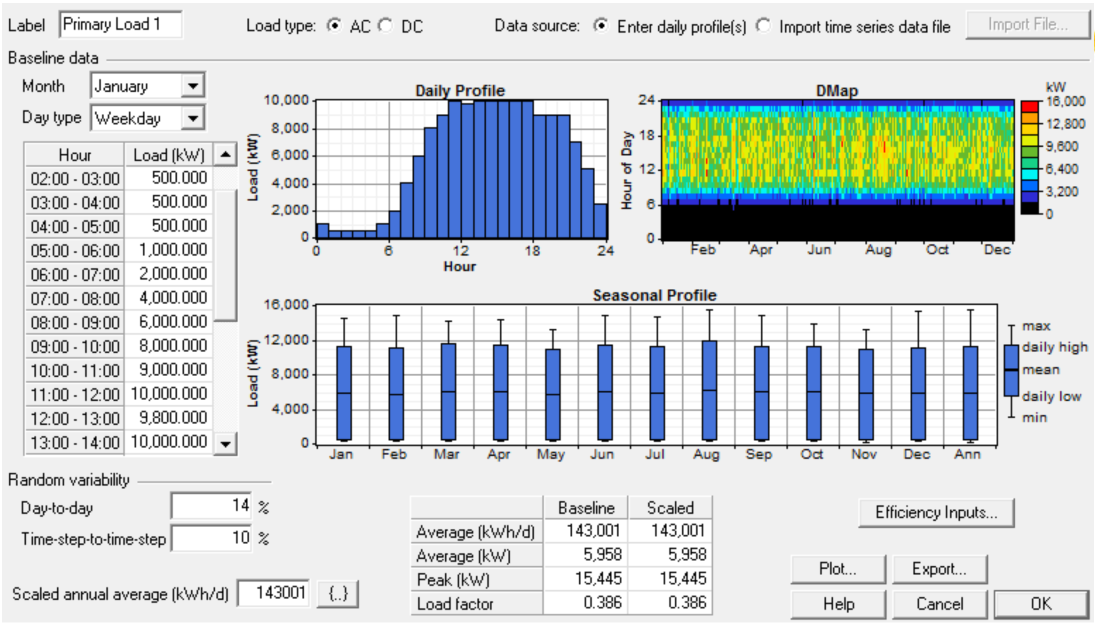
Case 1- Carbon tax: status [in US$]

Country	Carbon Tax
Denmark	・1993: 50% Carbon Tax introduction • 1996: Introduction of Carbon Tax on Natural Gas ・ Carb Tax: $1 - 6/CO2.ton (2004)
Germany	・1999: Increased rate on the Special mineral oil tax on gasoline, PLG, and Natural Gas ・Carbon Tax : $ 0.5- 20/CO2.ton (2004)
United Kingdom	・2001: Taxation on LPG, cola, natural gas, and electricity ・Carbon Tax: : $ 0.3- 2.5/CO2.ton (2004)
France	・Carbon Tax: As of 2004, under review after the verdict of violation of the constitution on General Tax on Pollution Activities (TGAP)
New Zealand	・Carbon Tax: $ 10.67/CO2.ton (2005) was approved by an act, however, the tax collected is currently being used to lower other taxes.
USA (Colorado)	・First Carbon taxation in the US in April 2007. ・Carbon Tax: $7/CO2.ton, which amount to 1.33/m to each household. Households with renewable installation could get reduction.
Canada (Quebec)	・Carbon Tax: Taxation started in 2007 for petroleum, coal, and natural gas, and the annual amount is expected to reach at $200M.
Canada (Vancouver)	・Carbon Tax: $0.025/L on gasoline, diesel, and natural gas from July 2008.

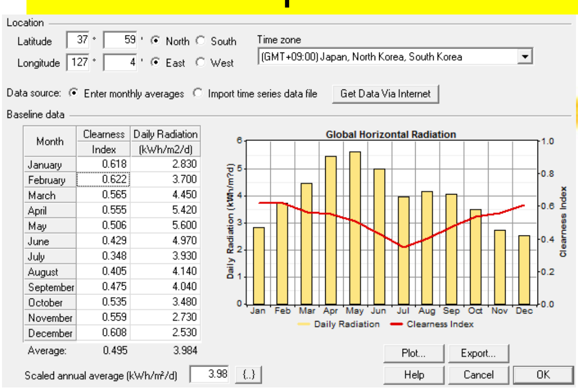
Case 2 – Green Campus

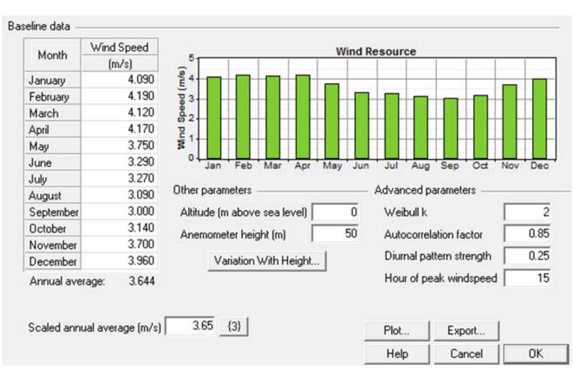
- Green Campus Feasibility Study for Korea University
- Estimation of the grid electricity cost for renewable energy penetration to college campuses
- Available data: Real time measurement and display of the Campus
  - Average Power Demand = 10,435 kW
  - Peak Power Demand = 15,637 kW

Case 2 – Load Profile



Case 2 - Inputs





Grid

Rate	Power Price
	$/kWh
Rate W_2	0.04, 0.50, 1.00, 2.00, 3.00

Sellback Rate	Demand Rate
$/kWh	$/kW/mo.

CO_2 emissions factor: 632 g/kWh
CO emissions factor: 0 g/kWh
UHC emissions factor: 0 g/kWh
PM emissions factor: 0 g/kWh
SO_2 emissions factor: 2.74 g/kWh
NOx emissions factor: 1.34 g/kWh
Interconnection cost: $ 0
Standby charge: $ 0/yr
Purchase capacity: 1,000 kW
Sale capacity: 1,000 kW

Case 2 – Optimal Configuration

Sensitivity Results | Optimization Results |

Double click on a system below for optimization results.

Rate W_2 Price ($/kWh)		PV (kW)	1.5sl	FC (kW)	S4KS25P	Conv. (kW)	Elec. (kW)	H2 Tank (kg)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shorta...
0,040									1000	$ 1,000	318,930	$ 3,659,096	0,040	0,00	0,95
0,500									1000	$ 1,000	3,986,619	$ 45,727,204	0,500	0,00	0,95
1,000									1000	$ 1,000	7,973,238	$ 91,453,408	1,000	0,00	0,95
2,000									1000	$ 1,000	15,946,475	$ 182,905,...	2,000	0,00	0,95
3,000									1000	$ 1,000	23,919,712	$ 274,358,...	3,000	0,00	0,95
4,000									1000	$ 1,000	31,892,950	$ 365,810,...	4,000	0,00	0,95
5,000									1000	$ 1,000	39,866,184	$ 457,263,...	5,000	0,00	0,95

Sensitivity Results | Optimization Results |

Sensitivity variables

Rate W_2 Power Price ($/kWh) 0.04

Double click on a system below for simulation results.

	PV (kW)	1.5sl	FC (kW)	S4KS25P	Conv. (kW)	Elec. (kW)	H2 Tank (kg)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shorta...	FC (hrs)
								1000	$ 1,000	318,930	$ 3,659,096	0,040	0,00	0,95	
				36	30...			1000	$ 577,000	368,255	$ 4,800,859	0,052	0,00	0,95	
			200		30...	100		1000	$ 40,001,...	310,027	$ 43,556,988	0,476	0,00	0,95	0
			200	36	30...	100		1000	$ 40,577,...	359,353	$ 44,698,752	0,488	0,00	0,95	0
	10...				30...			1000	$ 50,001,...	2,809,364	$ 82,224,184	0,351	0,64	0,71	
	10...			36	30...			1000	$ 50,577,...	2,858,782	$ 83,367,000	0,355	0,64	0,71	
		5						1000	$ 60,001,...	3,384,223	$ 98,817,768	0,759	0,34	0,88	
		5		36	30...			1000	$ 60,577,...	3,434,068	$ 99,965,488	0,767	0,34	0,88	
	10...		200		30...	100		1000	$ 90,001,...	2,800,462	$ 122,122,...	0,521	0,64	0,71	0
	10...		200	36	30...	100		1000	$ 90,577,...	2,849,880	$ 123,264,...	0,525	0,64	0,71	0
		5	200		30...	100		1000	$ 100,001,...	3,375,320	$ 138,715,...	1,065	0,34	0,88	0
		5	200	36	30...	100		1000	$ 100,577,...	3,425,165	$ 139,863,...	1,073	0,34	0,88	0
	10...	5			30...			1000	$ 110,001,...	5,846,951	$ 177,065,...	0,657	0,71	0,64	
	10...	5		36	30...			1000	$ 110,577,...	5,896,991	$ 178,215,...	0,661	0,71	0,64	
	10...	5	200		30...	100		1000	$ 150,000,...	5,838,046	$ 216,962,...	0,805	0,71	0,64	0
	10...	5	200	36	30...	100		1000	$ 150,576,...	5,888,088	$ 218,112,...	0,809	0,71	0,64	0

Case 2 – System Output

System architecture

PV Array	10,000 kW
Grid	1,000 kW
Inverter	20,000 kW
Rectifier	20,000 kW

Annualized Costs

Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)
PV	2,179,614	0	25,000	0	0	2,204,614
Grid	0	0	309,364	0	0	309,364
Converter	0	0	0	0	0	0
Other	87	0	0	0	0	87
System	2,179,701	0	334,364	0	0	2,514,065

Cost summary

Total net present cost	$ 28,836,126
Levelized cost of energy	$ 0.123/kWh
Operating cost	$ 334,364/yr

Electrical

Component	Production	Fraction
	(kWh/yr)	
PV array	13,973,497	64%
Grid purchases	7,893,502	36%
Total	21,867,000	100%

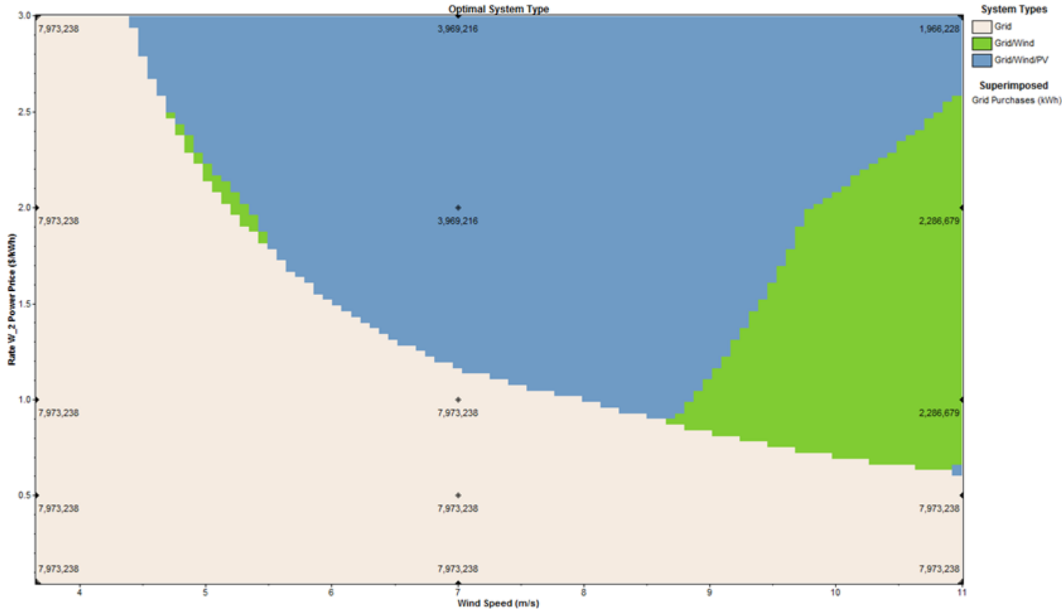
Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	4,972,574
Carbon monoxide	0
Unburned hydocarbons	0
Particulate matter	0
Sulfur dioxide	21,558
Nitrogen oxides	10,543

Net Present Costs

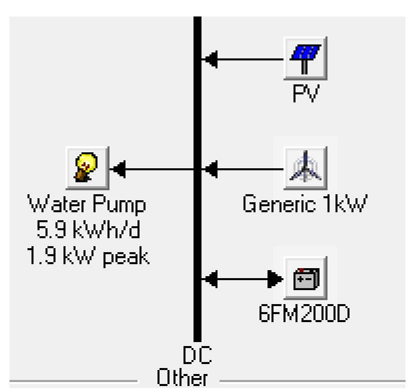
Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($)	($)	($)	($)	($)	($)
PV	25,000,000	0	286,748	0	0	25,286,748
Grid	0	0	3,548,379	0	0	3,548,379
Converter	0	0	0	0	0	0
Other	1,000	0	0	0	0	1,000
System	25,001,000	0	3,835,127	0	0	28,836,128

Case 2 – Sensitivity Analysis



Case 3 - Solar/Wind Pump

- Site Information
  - Location : Bayannuur, Bulgan, Mongolia (Lat : 47.83. Long : 104.44)
  - Population: 1000
  - Elevation : 850[m]
  - Wind Speed : 10~12[m/s]
  - Temperature : -42~30[℃]
- Post-analysis of the solar pump installed in 2010
- Bringing up improvement and simulation of the new design
- Approach
  - Supplying power to a submerged pump from Solar and Wind energy sources and providing drinking water to the village folks.

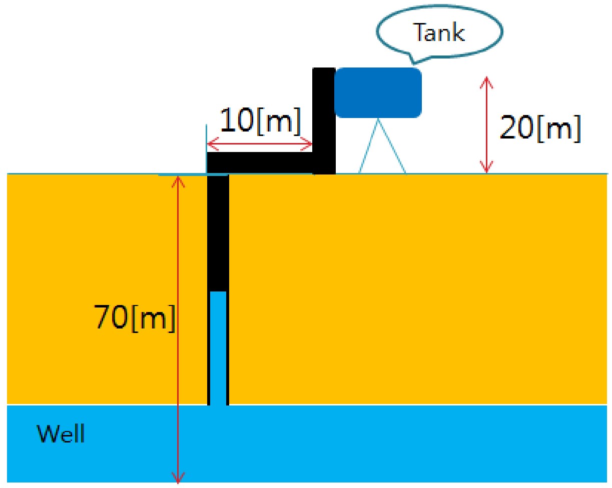


Case 3 – Water Flow

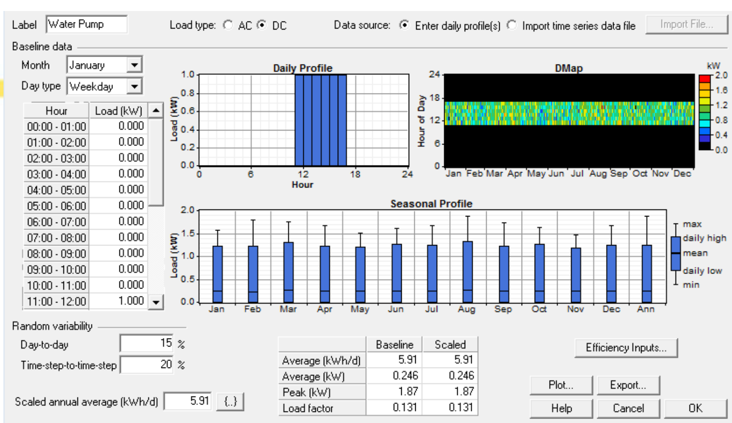
- Water Need per day: 1000 Gal
- Insolation: Full Sun Hour = 4.04
- Q(GPM)=4.2

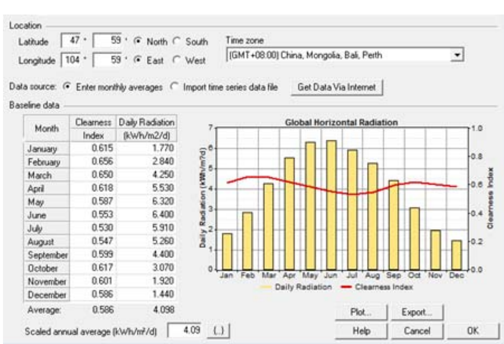
Static and Dynamic Head:
Elbow = 3[ea] ⇒ 6[ft]
Check Valve ⇒ 5[ft]
Gat Valve ⇒ 1[ft]

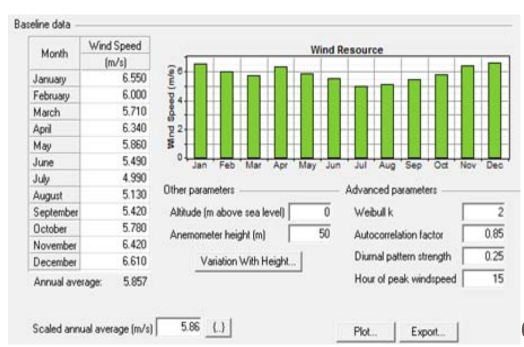
Total Head= 340[ft]



Case 2 - Inputs







Case 3 -- Optimization

- Best Combination:
- 2.2[kW] PV + 1[kW] Wind Turbine

Sensitivity variables

Global Solar (kWh/m?d) 4.09 Wind Speed (m/s) 5.86

Double click on a system below for simulation results

			PV (kW)	G1	6FM200D	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
			2,2	1	5	$ 15,220	43	$ 15,769	0,572	1,00
			2,4	1	5	$ 15,520	43	$ 16,073	0,583	1,00
			2,8	1	4	$ 15,636	41	$ 16,161	0,586	1,00

Case 3 - Sensitivity Analysis

Location

Latitude 47 ° 59 ' (•) North ( ) South

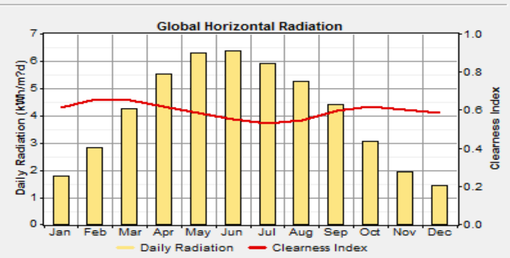
Longitude 104 ° 59 ' (•) East ( ) West

Time zone (GMT+08:00) China, Mongolia, Bali, Perth

Data source: (•) Enter monthly averages ( ) Import time series data file [Get Data Via Internet]

Baseline data

Month	Clearness Index	Daily Radiation (kWh/m2/d)
January	0.615	1.770
February	0.656	2.840
March	0.650	4.250
April	0.618	5.530
May	0.587	6.320
June	0.553	6.400
July	0.530	5.910
August	0.547	5.260
September	0.599	4.400
October	0.617	3.070
November	0.601	1.920
December	0.586	1.440
Average:	0.586	4.098



Scaled annual average (kWh/m²/d) 4.09 {..}

Plot... Export... Help Cancel OK

Sensitivity variables

Global Solar (kWh/m?d) 5 Wind Speed (m/s) 5.86

Double click on a system below for simulation results

			PV (kW)	G1	6FM200D	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
			3,0		5	$ 6,920	19	$ 7,163	0,260	1,00
			1,6	1	5	$ 14,320	42	$ 14,856	0,539	1,00
			1,8	1	5	$ 14,620	42	$ 15,161	0,550	1,00

In consideration of the months

Between April and September,

⇒ 3[kW] PV is most economical

Case 3 - System Report

System architecture

PV Array	2 kW
Battery	6 Vision 6FM200D

Emissions

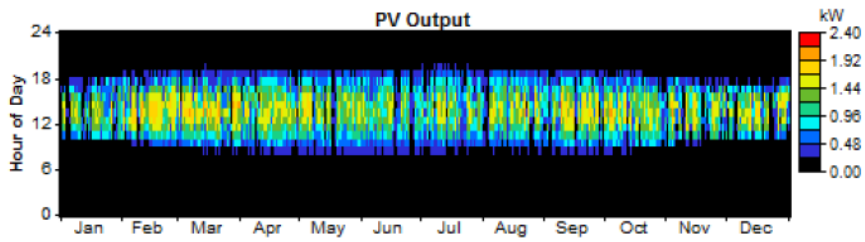
Pollutant	Emissions (kg/yr)
Carbon dioxide	0
Carbon monoxide	0
Unburned hydocarbons	0
Particulate matter	0
Sulfur dioxide	0
Nitrogen oxides	0

Cost summary

Total net present cost	$ 6,162
Levelized cost of energy	$ 0.298/kWh
Operating cost	$ 20.2/yr

Net Present Costs

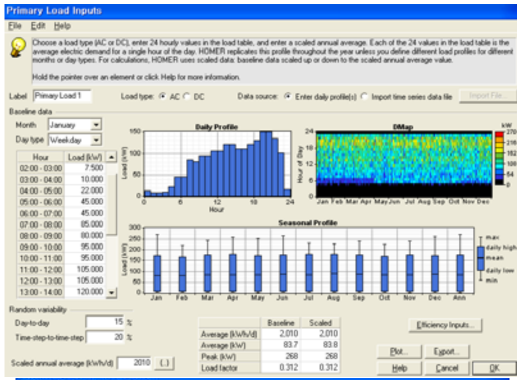
Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($)	($)	($)	($)	($)	($)
PV	3,000	94	0	0	-52	3,041
Vision 6FM200D	2,904	251	0	0	-34	3,121
System	5,904	344	0	0	-86	6,162

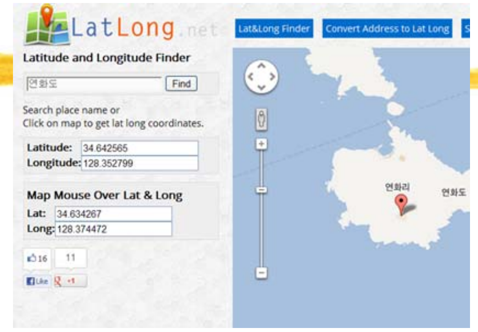


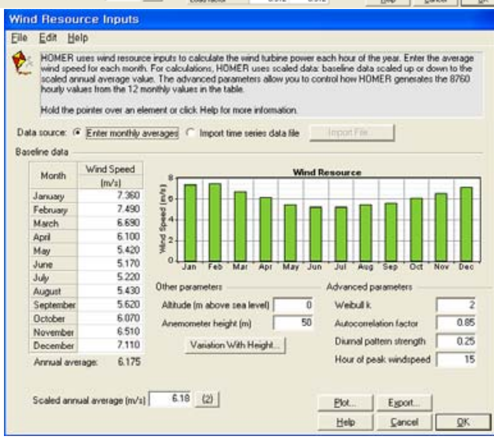
Case 4 - Light to Yon Hwa

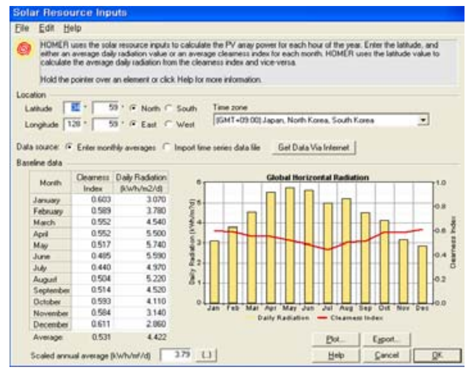
- Electrification of Yon Hwa island
- Area : 3.41㎢
- Number of households : 102
- Population : 199
- Location : Yeon Hwa Peak (212m) Latitude 34.64 N, Longitude 128.35 E
- Costal Perimeter : 12.5㎞
- Tourist Facility : 16 (average 5 rooms) Home stay places
- Transportation: 1 hour by ferry from Tong Young

Case 4 - Inputs

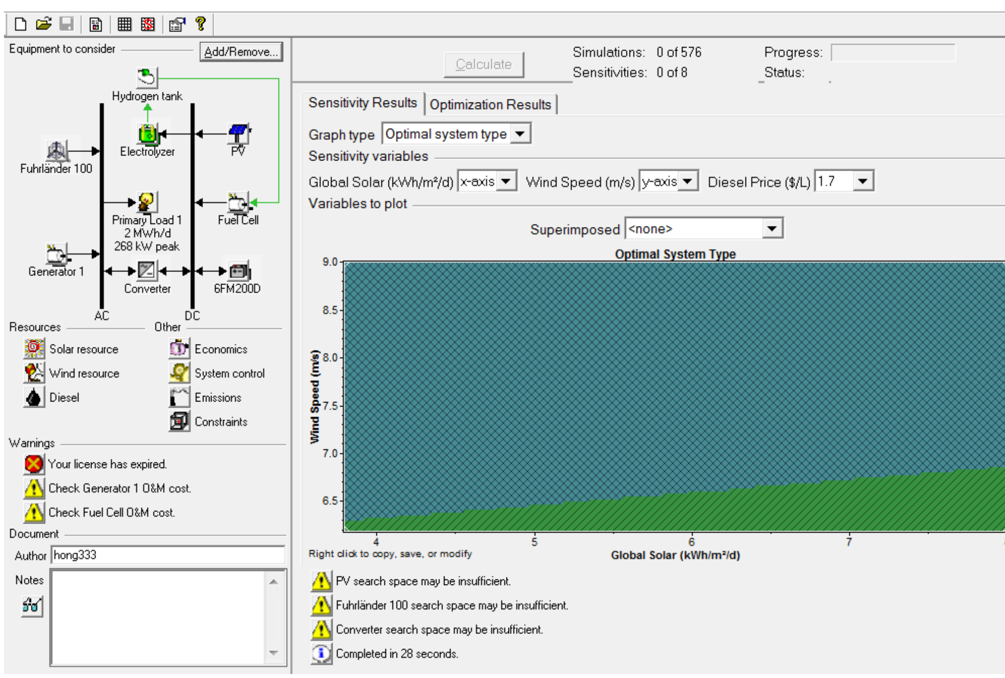








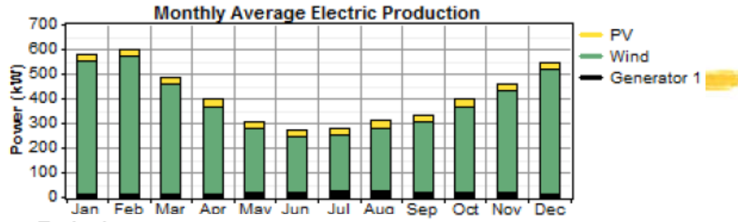
Case 4 – Configuration and Optimization



Case 4 – System Output

System architecture

PV Array	200 kW
Wind turbine	15 Fuhrländer 100
Generator 1	150 kW
Battery	100 Vision 6FM200D
Inverter	100 kW
Rectifier	100 kW
Hydrogen Tank	2,000 kg
Dispatch strategy	Cycle Charging



Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	395,568
Carbon monoxide	976
Unburned hydocarbons	108
Particulate matter	73.6
Sulfur dioxide	794
Nitrogen oxides	8,713

Cost summary

Total net present cost	$ 10,843,879
Levelized cost of energy	$ 1.156/kWh
Operating cost	$ 538,167/yr

Net Present Costs

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
PV	80,000	6,236	127,834	0	-3,495	210,575
Fuhrländer 100	225,000	3,755	57,525	0	-699	285,582
Generator 1	20,000	2,515	2,371,314	3,264,452	-423	5,657,858
Vision 6FM200D	3,636,300	1,006,874	89,484	0	-47,773	4,684,884
Converter	2,000	83	1,278	0	-16	3,346
Hydrogen Tank	1,000	0	639	0	0	1,639
System	3,964,300	1,019,463	2,648,074	3,264,452	-52,406	10,843,882

Electrical

Component	Production (kWh/yr)	Fraction
PV array	248,699	7%
Wind turbines	3,221,259	89%
Generator 1	155,664	4%
Total	3,625,622	100%

Team Project

⌘We can do better this time

Analysis and Practice for Renewable Micro Grid Configuration

- Summary

Course Contents and Schedule

- Day 5:December 27, 2013
  - Team Project
    - Hybrid Renewable System Design
  - Team Presentation
  - Summary and Conclusions

Team Design Project

- Design a Hybrid Energy System (Grid may be connected)
- Site: **Work (School or Company or store) – team's consensus**
- **Mission/Goal:** Energy reduction, peak shaving, or zero-energy system
- Objective: **Find the optimum system** with sensitivity analysis
- Components: Grid (optional), Converter, Wind Turbine, PV panel, Fuel Cells, Electrolyzer, and Hydrogen Tank
- Project Lifetime: 20 years
- Fixed Cost: $10,000
- Load Study – as realistic and true as possible
- Load Profile →
  - You may have to use your **own load profile** obtained from your work
- You need to provide resource data on your work location
  - Solar Radiation {provide also sensitivity}
  - Wind Speed {sensitivity}

Team Project - Brief

- Analysis of a Hybrid Energy System (Grid may be connected)
- Site: **Your (School or Company or resort or …)**
- Objective: Find the optimum system with sensitivity analysis
- Components Considered: Grid, Converter, Wind Turbine, PV panel, Fuel Cells, Electrolyzer, and Hydrogen Tank
- Project Lifetime: 20 years
- Fixed Cost: $10,000
- Load Profile
- Resource data on your work location
  - Solar Radiation {provide also sensitivity}
  - Wind Speed {sensitivity}

Suggested Component Data – Wind and PV

- Wind Turbine
  - Size: 30 kW
  - Quantity: 10: [0, 5, 10]
- PV Module
  - Size: 200kW: [0,100,200,300] kW
  - Derating Factor: 90%
- Electrolyzer
  - Size: 100kW: [0, 50, 100] kW
  - Lifetime: 20 years
- Fuel Cell
  - Size: 200kW: [0, 100, 200, 300] kW
- Hydrogen Tank
  - Size: 2000 kg: [0, 1000, 2000, 3000]kg
- Converter
  - Size: 200kW: [0, 100, 200, 300]kW
- Grid (Optional)
  - Single rate
  - Price ($/kWh): $0.15 :
  - Sellback ($/kWh): $0.15
  - Demand: $0
  - **Purchase Capacity: 300kW**
  - Sellback Capacity: 200kW

Analysis Points and Team Presentation

- Analysis Points:
  - Site Identification → Mission or Goal
  - Load study → Should match with the site and the goal
  - Find the Solar Radiation, and give Sensitivity values
  - Find the Wind Speed, and give sensitivity values
  - Calculate and Check the Optimization results
  - Check the Sensitivity Results
  - Find the optimum results
  - Find the components/devices locally available (Important)
  - Prepare Slides for team presentation
  - Also run the HOMER in the presentation

Summary

- Energy Sources
- Smart Grid and Micro Grid
- Renewable Sources and Characteristics
- Wind Energy Details
  - Wind Speed
  - Wind Turbine
- Solar Energy Details
  - Insolation
  - Power Conversion
- Resource Data: SWERA
- HOMER
- Stand-Alone Renewable System
- Grid-Connect Renewable System

Summary

- Simulation Software – HOMER (Hybrid Optimization Model for Electric Renewables)
- HOMER components
- HOMER optimization by NPC
- Input Requirements
- Optimization Results
- Sensitivity Analysis
- Example Cases: Stand-Alone and Grid-Connected
- Team Project

HOMER
The Micropower Optimization Model

Survey

- 1. My understanding in Micro Grid is:
  - Very satisfactory ( ); Satisfactory ( ); neutral ( ); unsatisfactory ( ); very unsatisfactory ( )
- 2. My learning gain in renewable energy sources and their characteristics is:
  - Very satisfactory ( ); Satisfactory ( ); neutral ( ); unsatisfactory ( ); very unsatisfactory ( )
- 3. My learning gain in micropower system design is:
  - Very satisfactory ( ); Satisfactory ( ); neutral ( ); unsatisfactory ( ); very unsatisfactory ( )
- 4. My learning gain in HOMER simulation is:
  - Very satisfactory ( ); Satisfactory ( ); neutral ( ); unsatisfactory ( ); very unsatisfactory ( )
- 5. After the course, my skill in designing a renewable energy system is:
  - Much improved ( ); Improved ( ); I am not sure ( ); Very little improved ( ); Not improved at all ( )

Thank You !

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