

## 9. Team Project & Summary

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

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### 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)

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## 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

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## 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

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## 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

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## Side Bar- Hydrogen Systems

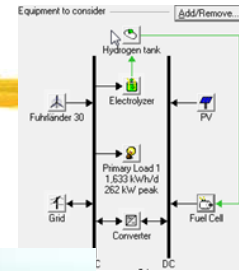
- ⌘ Electrolyzer system converts electricity into hydrogen by electrolyzing water
- ⌘ Hydrogen is stored in steel tanks or geological cavern
- ⌘ Reconverted to Electricity using 2 methods:
  - ☒ **Polymer Electrolyte Membrane (PEM) fuel cell**
  - ☒ Hydrogen Expansion Combustion Turbine

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# Fuel Cell Modeling

## ⌘ Fuel Cell In HOMER modeling:

- ☑ Pick a generator
- ☑ Type: DC
- ☑ Fuel: Stored Hydrogen



The screenshot shows the 'Generator Inputs' dialog box with the 'Fuel' tab selected. The 'Costs' table is as follows:

Size (kW)	Capital (\$)	Replacement (\$)	O&M (\$/hr)
200.000	1000000	0	0.100

The 'Fuel curve' section shows:

- Fuel: Stored hydrogen
- Intercept coeff. (kg/hr/kW rated): 0.08
- Slope (kg/hr/kW output): 0.25
- Heat recovery ratio (%): 0

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# 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

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## 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

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## 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



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## 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

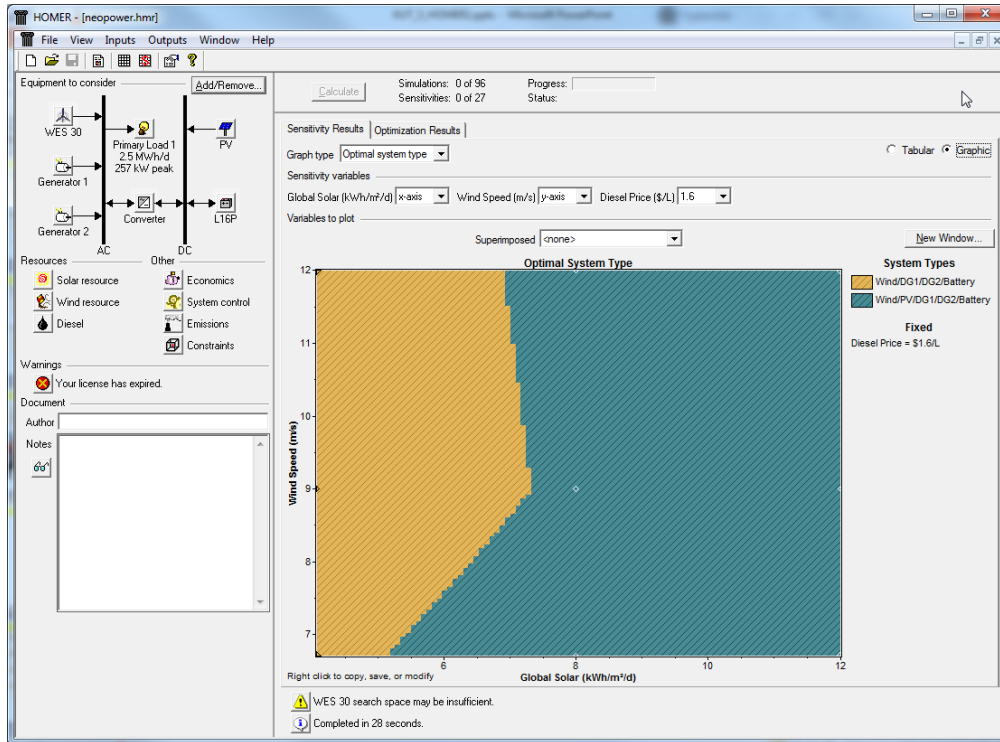
- ⌘ Site: Gapa-do Island
- ⌘ Analysis of Carbon Free Island program for Gapa-do

### 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

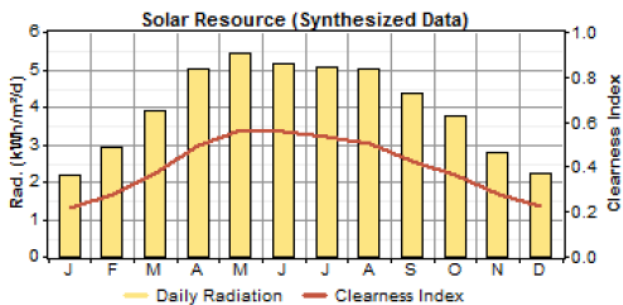
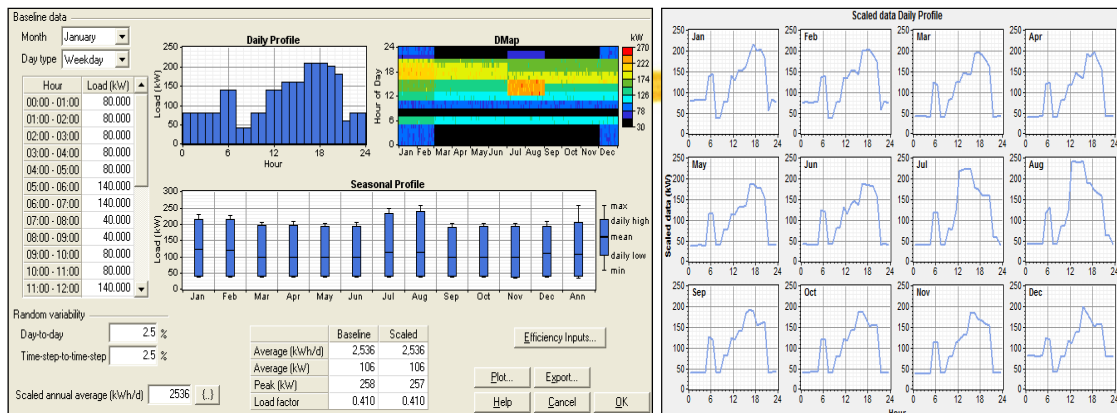


# Case 1 - Homer Simulation



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## Case 1 - Simulation Input data



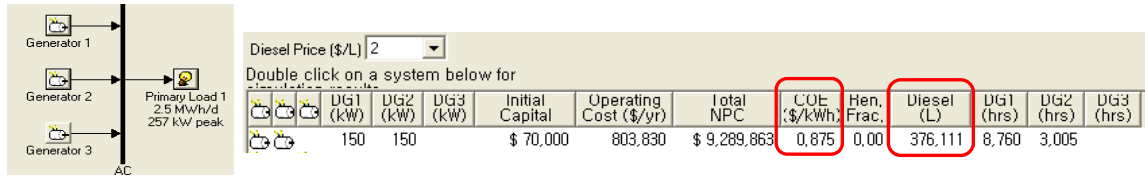
### Emissions

- 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

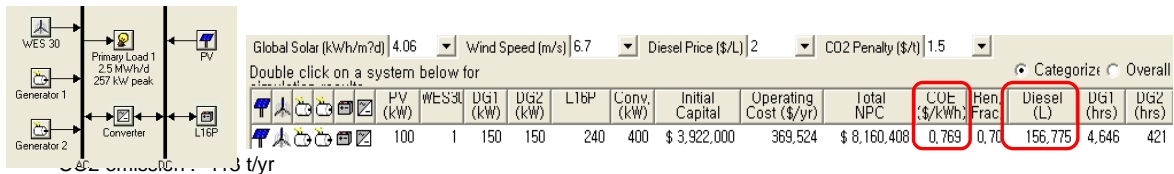
- Diesel Generators Only (existing system)



\* CO2 emission : 1000 t/yr

## Case 2

- Diesel Generator – WT – PV – Battery



\* CO2 emission : 1000 t/yr

# Case 1 – System Output

## System architecture

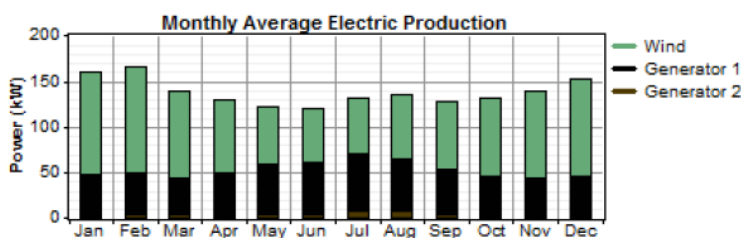
Wind turbine	1 WES 30
Generator 1	150 kW
Generator 2	150 kW
Battery	240 Trojan L16P
Inverter	400 kW
Rectifier	400 kW
Dispatch strategy	Cycle Charging

## 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

## Cost summary

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



## Emissions

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



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

Country	Carbon Tax
Denmark	<ul style="list-style-type: none"> <li>• 1993: 50% Carbon Tax introduction</li> <li>• 1996: Introduction of Carbon Tax on Natural Gas</li> <li>• Carb Tax: \$1 - 6/CO2.ton (2004)</li> </ul>
Germany	<ul style="list-style-type: none"> <li>• 1999: Increased rate on the Special mineral oil tax on gasoline, PLG, and Natural Gas</li> <li>• Carbon Tax : \$ 0.5- 20/CO2.ton (2004)</li> </ul>
United Kingdom	<ul style="list-style-type: none"> <li>• 2001: Taxation on LPG, cola, natural gas, and electricity</li> <li>• Carbon Tax: : \$ 0.3- 2.5/CO2.ton (2004)</li> </ul>
France	<ul style="list-style-type: none"> <li>• Carbon Tax: As of 2004, under review after the verdict of violation of the constitution on General Tax on Pollution Activities (TGAP)</li> </ul>
New Zealand	<ul style="list-style-type: none"> <li>• Carbon Tax: \$ 10.67/CO2.ton (2005) was approved by an act, however, the tax collected is currently being used to lower other taxes.</li> </ul>
USA (Colorado)	<ul style="list-style-type: none"> <li>• First Carbon taxation in the US in April 2007.</li> <li>• Carbon Tax: \$7/CO2.ton, which amount to \$1.33\$/m to each household. Households with renewable installation could get reduction.</li> </ul>
Canada (Quebec)	<ul style="list-style-type: none"> <li>• Carbon Tax: Taxation started in 2007 for petroleum, coal, and natural gas, and the annual amount is expected to reach at \$200M.</li> </ul>
Canada (Vancouver)	<ul style="list-style-type: none"> <li>• Carbon Tax: \$0.025/L on gasoline, diesel, and natural gas from July 2008.</li> </ul>

## 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

Label: Primary Load 1    Load type:  AC  DC    Data source:  Enter daily profile(s)  Import time series data file    Import File...

Baseline data  
 Month: January    Day type: Weekday

Hour	Load [kW]
02:00 - 03:00	500.000
03:00 - 04:00	500.000
04:00 - 05:00	500.000
05:00 - 06:00	1,000.000
06:00 - 07:00	2,000.000
07:00 - 08:00	4,000.000
08:00 - 09:00	6,000.000
09:00 - 10:00	8,000.000
10:00 - 11:00	9,000.000
11:00 - 12:00	10,000.000
12:00 - 13:00	9,800.000
13:00 - 14:00	10,000.000

Random variability  
 Day-to-day: 14 %  
 Time-step-to-time-step: 10 %

Scaled annual average (kWh/d): 143001

	Baseline	Scaled
Average (kWh/d)	143,001	143,001
Average (kW)	5,958	5,958
Peak (kW)	15,445	15,445
Load factor	0.386	0.386

Efficiency Inputs...  
 Plot... Export...  
 Help Cancel OK

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# Case 2 - Inputs

Location  
 Latitude: 37° 59' North    Longitude: 127° 4' East    Time zone: [GMT+09:00] Japan, North Korea, South Korea

Data source:  Enter monthly averages  Import time series data file    Get Data Via Internet

Baseline data

Month	Cleanness Index	Daily Radiation (kWh/m2/d)
January	0.618	2.830
February	0.622	3.700
March	0.565	4.450
April	0.555	5.420
May	0.506	4.970
June	0.429	3.930
July	0.348	3.350
August	0.405	4.140
September	0.475	4.040
October	0.535	3.480
November	0.559	2.730
December	0.608	2.530
Average	0.495	3.984

Scaled annual average (kWh/m2/d): 3.98

Plot... Export...  
 Help Cancel OK

Baseline data

Month	Wind Speed (m/s)
January	4.090
February	4.190
March	4.120
April	4.170
May	3.750
June	3.290
July	3.270
August	3.090
September	3.000
October	3.140
November	3.700
December	3.960
Annual average	3.644

Other parameters: Altitude (m above sea level): 0    Anemometer height (m): 50    Variation With Height...

Advanced parameters: Weibull k: 2    Autocorrelation factor: 0.85    Diurnal pattern strength: 0.25    Hour of peak windspeed: 15

Scaled annual average (m/s): 3.65

Plot... Export...  
 Help Cancel OK

## Grid

Rate	Power Price
	\$/kWh

Rate W\_20.04, 0.50, 1.00, 2.00, 3.00

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

- CO2 emissions factor: 632 g/kWh
- CO emissions factor: 0 g/kWh
- UHC emissions factor: 0 g/kWh
- PM emissions factor: 0 g/kWh
- SO2 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,bsl (kW)	FC (kW)	S4KS25H Conv. (kW)	Elec. (kW)	H2 tank (kg)	Grid (kW)	Initial Capital	Operating Cost (\$/yr)	Total NPC	COE (\$/kWh)	Hen. 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)

Double click on a system below for

	PV (kW)	1,bsl (kW)	FC (kW)	S4KS25H Conv. (kW)	Elec. (kW)	H2 tank (kg)	Grid (kW)	Initial Capital	Operating Cost (\$/yr)	Total NPC	COE (\$/kWh)	Hen. Frac.	Capacity Shorta...	FC (hrs)	
							1000	\$ 1,000	318,930	\$ 3,659,096	0.040	0.00	0.95		
							1000	\$ 577,000	368,255	\$ 4,800,859	0.052	0.00	0.95		
			200	36	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					1000	\$ 60,577,...	3,434,068	\$ 99,965,488	0.767	0.34	0.88		
			200	36	30...	100	1000	\$ 90,001,...	2,800,462	\$ 122,122,...	0.521	0.64	0.71	0	
			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...		30...		1000	\$ 110,001,...	5,846,951	\$ 177,065,...	0.657	0.71	0.64		
			10...		36	30...	1000	\$ 110,577,...	5,896,991	\$ 178,215,...	0.661	0.71	0.64		
			10...	5	200	30...	1000	\$ 150,000,...	5,838,046	\$ 216,962,...	0.805	0.71	0.64	0	
			10...	5	200	36	30...	1000	\$ 150,576,...	5,888,088	\$ 218,112,...	0.809	0.71	0.64	0

# Case 2 – System Output

Annualized Costs

## System architecture

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

## Cost summary

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

Component	Capital (\$/yr)	Replacement (\$/yr)	O&M (\$/yr)	Fuel (\$/yr)	Salvage (\$/yr)	Total (\$/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

## Electrical

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

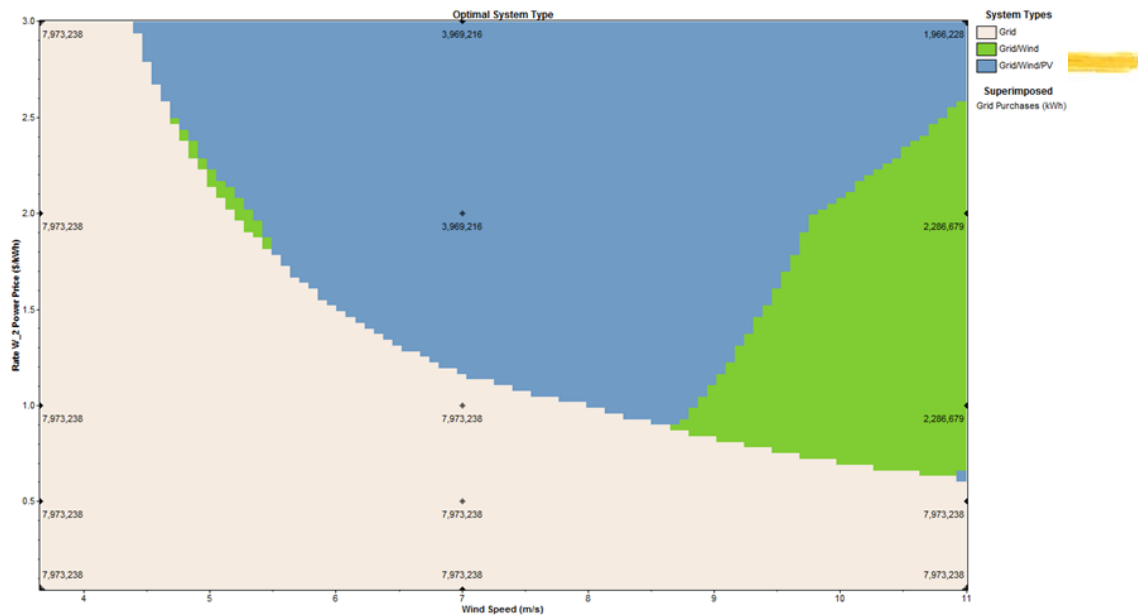
## Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	4,972,574
Carbon monoxide	0
Unburned hydrocarbons	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



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## Case 3 - Solar/Wind Pump

### ⌘ Site Information

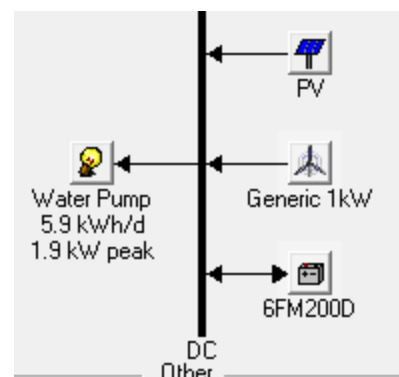
- ☒ Location : Bayannuur, Bulgan, Mongolia (Lat : 47.83. Long : 104.44)
- ☒ Population: 1000
- ☒ Elevation : 850[m]
- ☒ Wind Speed : 10~12[m/s]
- ☒ Temperature : -42~30[°C]

⌘ 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.



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# Case 3 – Water Flow

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

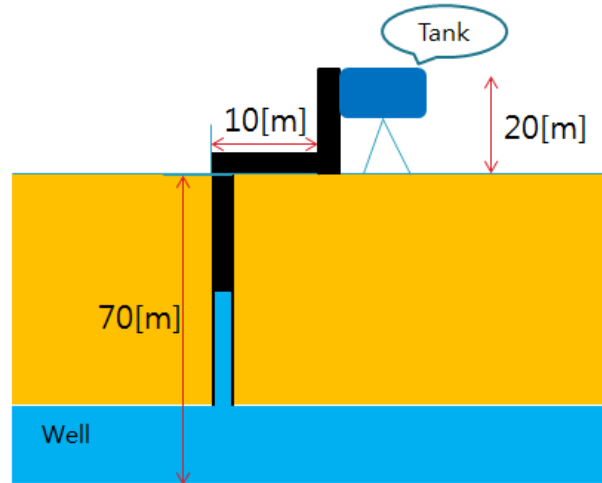
### Static and Dynamic Head:

Elbow = 3[ea] ⇒ 6[ft]

Check Valve ⇒ 5[ft]

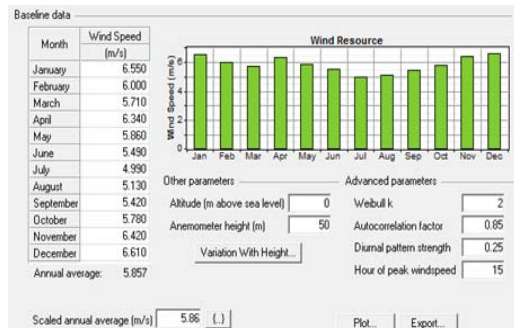
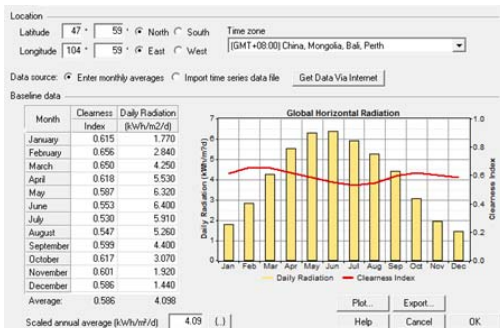
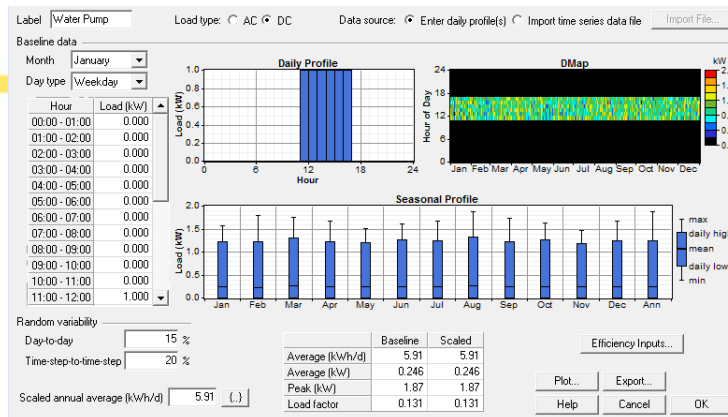
Gat Valve ⇒ 1[ft]

Total Head= 340[ft]



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# Case 2 - Inputs



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## Case 3 -- Optimization

⌘ Best Combination:

⌘ 2.2[kW] PV + 1[kW] Wind Turbine

Sensitivity variables

Global Solar (kWh/m<sup>2</sup>/d) 4.09 Wind Speed (m/s) 5.86

Double click on a system below for

	PV (kW)	G1	bFM2UUD	Initial Capital	Operating Cost (\$/yr)	Total NPC	COE (\$/kWh)	Hen. 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

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## Case 3 - Sensitivity Analysis

Location

Latitude 47° 59' North Longitude 104° 53' East Time zone (GMT+08:00) China, Mongolia, Bali, Perth

Data source:  Enter monthly averages  Import time series data file

Baseline data

Month	Clearness Index	Daily Radiation (kWh/m <sup>2</sup> /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	0.539	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/m<sup>2</sup>/d) 4.09

Global Horizontal Radiation

Daily Radiation (kWh/m<sup>2</sup>/d) vs Clearness Index

Sensitivity variables

Global Solar (kWh/m<sup>2</sup>/d) 5 Wind Speed (m/s) 5.86

Double click on a system below for

	PV (kW)	G1	bFM2UUD	Initial Capital	Operating Cost (\$/yr)	Total NPC	COE (\$/kWh)	Hen. 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

## Cost summary

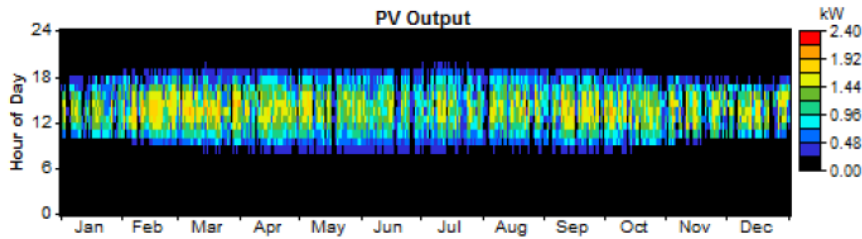
Total net present cost	\$ 6,162
Levelized cost of energy	\$ 0.298/kWh
Operating cost	\$ 20.2/yr

## Emissions

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

## 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



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# Case 4 - Light to Yon Hwa



- ⌘ Electrification of Yon Hwa island
- ⌘ Area : 3.41 km<sup>2</sup>
- ⌘ Number of households : 102
- ⌘ Population : 199
- ⌘ Location : Yeon Hwa Peak (212m) Latitude 34.64 N, Longitude 128.35 E
- ⌘ Costal Perimeter : 12.5km
- ⌘ Tourist Facility : 16 (average 5 rooms) Home stay places
- ⌘ Transportation: 1 hour by ferry from Tong Young

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# Case 4 - Inputs

**Primary Load Inputs**

Choose a load type (AC or DC), enter 24 hourly values in the load table, and enter a scaled annual average. Each of the 24 values in the load table is the average electric demand for a single hour of the day. HOMER replicates this profile throughout the year unless you define different load profiles for different months or day types. For calculations, HOMER uses scaled data; baseline data scaled up or down to the scaled annual average value.

Hold the pointer over an element or click Help for more information.

Label: Primary Load 1 Load type: AC DC Data source: Enter daily profile(s) Import time series data file

Baseline data

Month: January Day type: Week-day

Hour	Load (kW)
02:00-03:00	7.500
03:00-04:00	10.000
04:00-05:00	22.000
05:00-06:00	45.000
06:00-07:00	45.000
07:00-08:00	85.000
08:00-09:00	85.000
09:00-10:00	95.000
10:00-11:00	95.000
11:00-12:00	105.000
12:00-13:00	105.000
13:00-14:00	120.000

Random variability: Day-to-day 15% Time-step-to-time-step 20%

Scaled annual average (kWh/d): 2016 (1)

Baseline: Average (kWh/d) 2,010 Scaled: 2,010 Average (kW) 83.7 Scaled: 83.8 Peak (kW) 268 Scaled: 268 Load factor 0.312 Scaled: 0.312

**LatLong.net** Lat&Long Finder Convert Address to Lat Long

Latitude and Longitude Finder

Search place name or Click on map to get lat long coordinates.

Latitude: 34.642565 Longitude: 128.352799

Map Mouse Over Lat & Long

Lat: 34.634267 Long: 128.374472

Map showing location in South Korea (연희리, 연희도).

**Wind Resource Inputs**

HOMER uses wind resource inputs to calculate the wind turbine power each hour of the year. Enter the average wind speed for each month. For calculations, HOMER uses scaled data; baseline data scaled up or down to the scaled annual average value. The advanced parameters allow you to control how HOMER generates the 8760 hourly values from the 12 monthly values in the table.

Hold the pointer over an element or click Help for more information.

Data source: Enter monthly averages Import time series data file

Baseline data

Month	Wind Speed (m/s)
January	7.350
February	7.450
March	6.590
April	6.100
May	5.420
June	5.170
July	5.220
August	5.430
September	5.620
October	6.070
November	6.510
December	7.110
Annual average	6.175

Other parameters: Altitude (m above sea level) 0 Anemometer height (m) 50 Variation With Height

Advanced parameters: Weibull k 2 Autocorrelation factor 0.85 Diurnal pattern strength 0.25 Hour of peak windspeed 15

Scaled annual average (m/s): 6.16 (2)

**Solar Resource Inputs**

HOMER uses the solar resource inputs to calculate the PV array power for each hour of the year. Enter the latitude, and either an average daily radiation value or an average clearness index for each month. HOMER uses the latitude value to calculate the average daily radiation from the clearness index and vice versa.

Hold the pointer over an element or click Help for more information.

Location: Latitude 50° North South Longitude 128° East West Time zone (GMT+09:00) Japan, North Korea, South Korea

Data source: Enter monthly averages Import time series data file Get Data Via Internet

Baseline data

Month	Clearness Index	Daily Radiation (kWh/m <sup>2</sup> /d)
January	0.603	3.070
February	0.589	3.780
March	0.592	4.540
April	0.592	5.500
May	0.557	5.740
June	0.495	5.990
July	0.440	4.970
August	0.504	5.200
September	0.514	4.520
October	0.593	4.110
November	0.584	3.140
December	0.631	2.960
Average	0.531	4.422

Scaled annual average (kWh/m<sup>2</sup>/d): 3.79 (1)

# Case 4 - Configuration and Optimization

Equipment to consider: Add/Remove... Calculate Simulations: 0 of 576 Progress: Sensitivities: 0 of 8 Status:

Sensitivity Results Optimization Results

Graph type: Optimal system type

Sensitivity variables: Global Solar (kWh/m<sup>2</sup>/d) x-axis Wind Speed (m/s) y-axis Diesel Price (\$/L) 1.7

Variables to plot: Superimposed <none>

**Optimal System Type**

Right click to copy, save, or modify

- ⚠️ PV search space may be insufficient.
- ⚠️ Fuhrlander 100 search space may be insufficient.
- ⚠️ Converter search space may be insufficient.
- ✅ Completed in 28 seconds.

Resources: Solar resource, Wind resource, Diesel, Economics, System control, Emissions, Constraints

Warnings: Your license has expired, Check Generator 1 O&M cost, Check Fuel Cell O&M cost

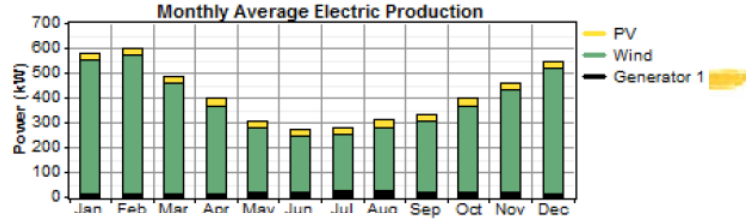
Document: Author hong333



# 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 hydrocarbons	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	Fraction
	(kWh/yr)	
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

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## Course Contents and Schedule

⌘ Day 5: December 27, 2013

☒ Team Project

- Hybrid Renewable System Design

☒ Team Presentation

☒ Summary and Conclusions



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## 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}

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## 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}



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## 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

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## 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

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## 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

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## 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



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## 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 ( )

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## Thank You !

감사합니다 kiitos!  
Danke Ευχαριστίες Dalu Obrigado  
Thank You Köszönöm  
Grazie Спасибо Dank Tack Gracias  
谢谢 Merci Seé ありがとう

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