8. Modeling using HOMER – Part 2

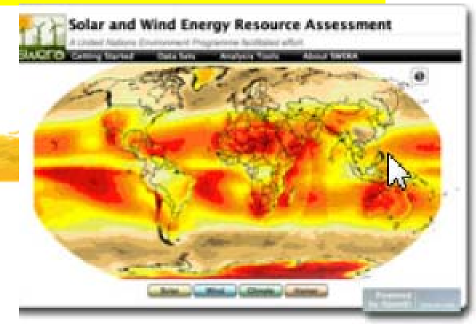
Practice 2 & Grid-Connected Micropower System

Course Contents and Schedule

- Day 4
  - HOMER Simulation 2
    - Grid Data Details
    - Grid-Connected System Design
  - Team Practice
    - **Isolated** or **Grid-Connected** Power System Design
- Day 5
    - Team Presentation
    - Summary and Conclusions

On SWERA

- 2001: The Solar and Wind Energy Resource Assessment (SWERA)
  - began with support from the Global Environment Facility within the **United Nations Environment Program** (UNEP) with contributions by many national agencies.
  - SWERA was initially a country-centric project focused on the production of National Solar and Wind Assessments supporting renewable energy decision makers in 13 countries within a global framework that included several continental datasets.
  - Ethiopia, Kenya, Ghana, Bangladesh, China, Nepal, Sri Lanka, Brazil, Cuba, El Salvador, Guatemala, Hondurans, and Nicaragua

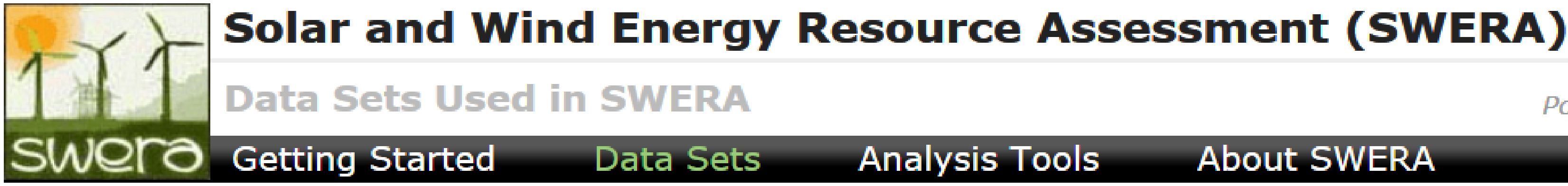


Agency/Company /Organization	United Nations Environment Programme
Partner	National Renewable Energy Laboratory, German Aerospace Center (DLR), Risoe National Laboratory for Sustainable Energy, Brazil's National Institute for Space Research (INPE), State University of New York (SUNY), Technical University of Denmark (DTU), UNEP Global Resource Information Database (UNEP/GRID), NASA, Global Environment Facility (GEF)
Sector	Energy
Focus Area	Solar, Wind
Topics	Resource assessment, Pathways analysis
Resource Type	Software/modeling tools, Maps, Dataset
User Interface	Website
Website	http://openei.org/SWERA

SWERA

- 2005: support from NASA, SWERA began the transition into a global decision support system (DSS) with integrated tools including prototype small hydropower assessments to complement the solar and wind assessments.
  - NASA global renewable energy assessments and climate data were integrated into SWERA to provide global coverage and a more complete portfolio of information needed to assess the global renewable energy potential.
  - United States National Renewable Energy Laboratory (NREL) contributed renewable energy expertise and 27 national data sets.

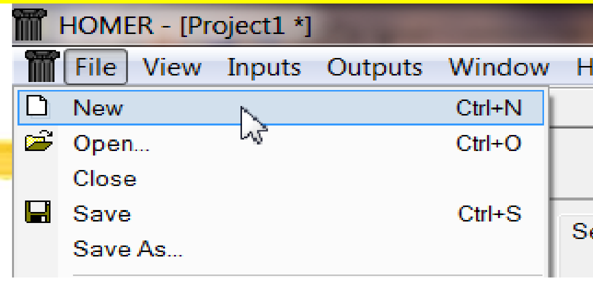
Data Set

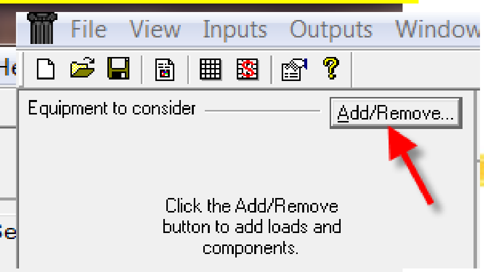


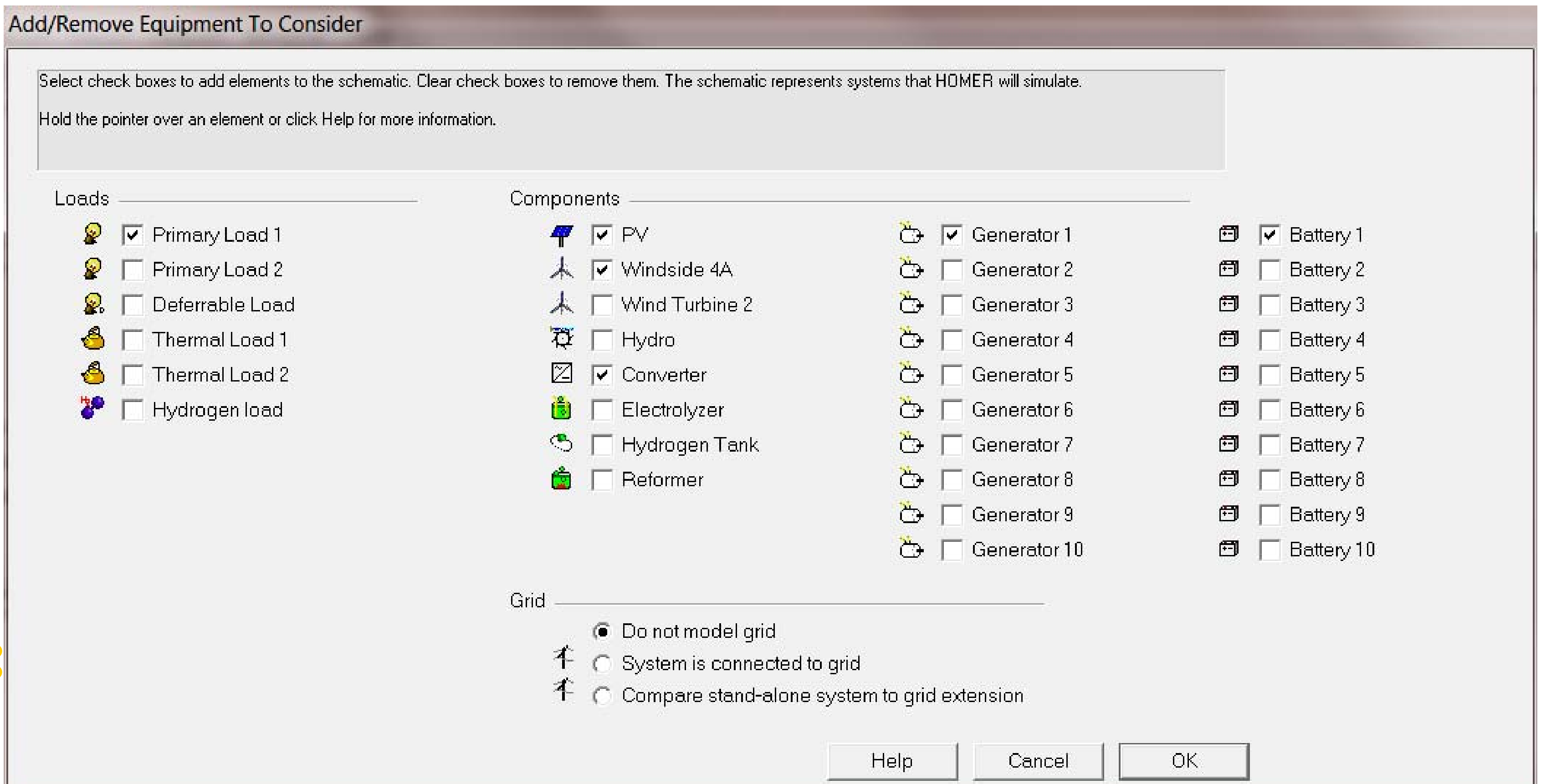
- Data obtained from the NASA Science Mission Directorate's satellite and re-analysis research programs
- Parameters were validated based on recommendations from partners in the energy industry
- Continued to adapt and tailor updated and new data sets from NASA's satellite observation analysis and modeling program.
- The **Clouds and Earth's Radiant Energy System** (CERES) computes the most accurate global surface radiation fluxes using radiance and retrievals to date. These fluxes include the computation of direct and diffuse fluxes.
- Other data: tilt irradiance, direct normal irradiance, global horizontal irradiance, wind, relative humidity, atmospheric pressure, air temperature, etc.
- For Solar, NASA data exist for 22 years globally.
- Other data sets: 40-km data available for much of the world, and 10-km data for countries and regions.

HOMER practice 2: Making a New file from scratch

- HOMER
- File > New
- Click “Add/Remove”
- Select: Primary Load, PV, Wind Turbine 1, Converter, and Generator1

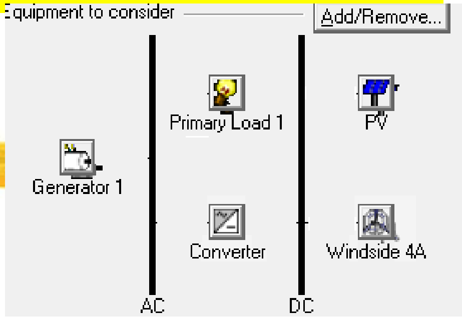


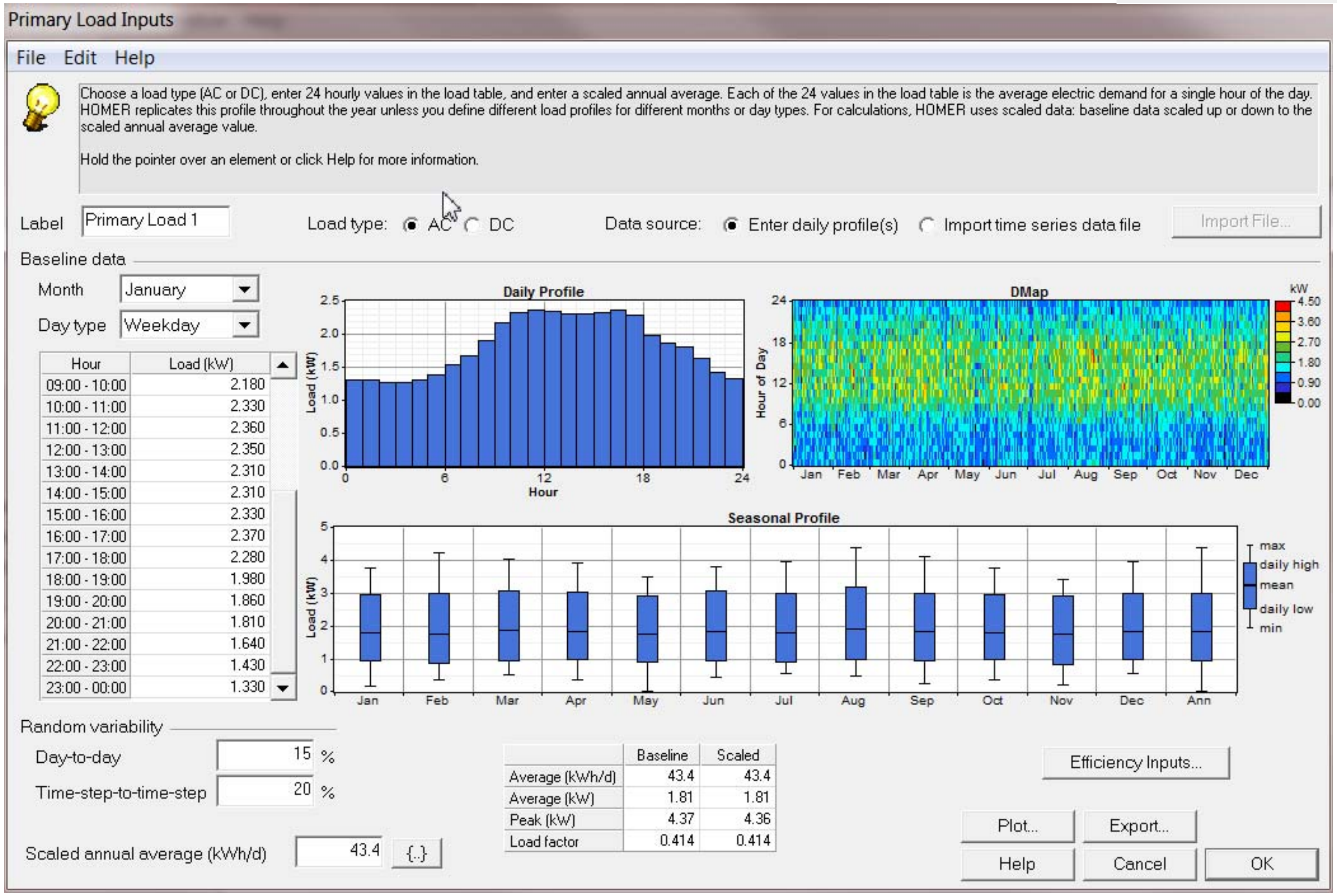




Load Data

- HOMER buttons appear
- NOW click the load button
- Type in the load [kW] every hour period





Load Profile Example

- Load Data Example

Small Commercial Load Profile [kW]

====================================

0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
1.31	1.30	1.27	1.27	1.30	1.39	1.54	1.67	1.90	2.18	2.33	2.36

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
2.35	2.31	2.31	2.33	2.37	2.28	1.98	1.86	1.81	1.64	1.43	1.33

Daily Total [kW]44.60

Stret Light Load Profile [kW]

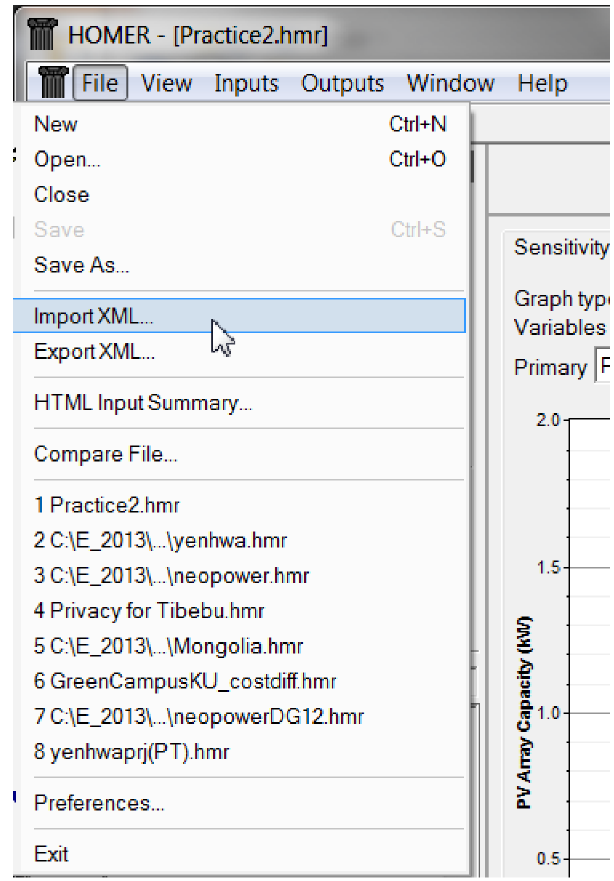
====================================

0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
3.24	3 24	3.24	3.24	3.24	2.62	1.40	0.18	1.90	0.00	0.00	0.00

1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
0.00	0.00	0.00	0.00	0.00	0.42	0.88	1.28	2.47	3.24	3.24	3.24

Alternative way for Solar and Wind Resources --- Import XLM File from SWERA

- 1. Find Lat & Lon of your location
- 2. On SWERA
  - Type in Lat & Long
  - Click "Get Homer"
  - From the XLM data screen
    - CTRL+S (save to an XLM file)
- 3. Now with HOMER
  - File>"Import XLM"
  - Wind Resources are automatically filled
  - Solar Resources are automatically filled
    - Lat N, Long E → marking error
    - But kWh/m2 is kept the same.

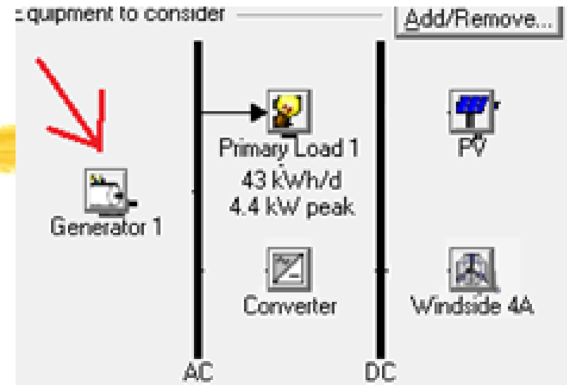


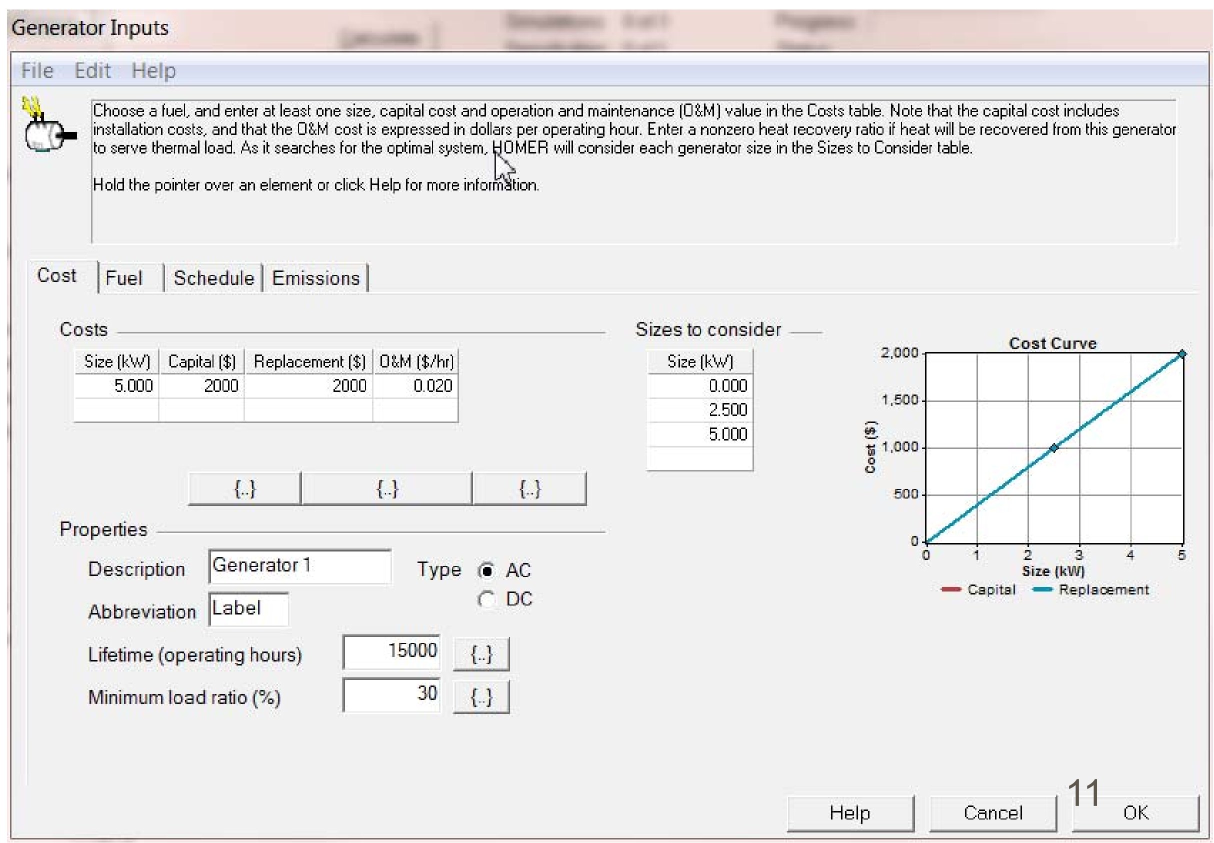
How about Load Profile for this Mobile Security on Demand?

- Mobile security: 2 PV, 4 cameras, Digital recording, battery charger circuits, battery status of charge monitoring and wireless alerting.

Generator Information

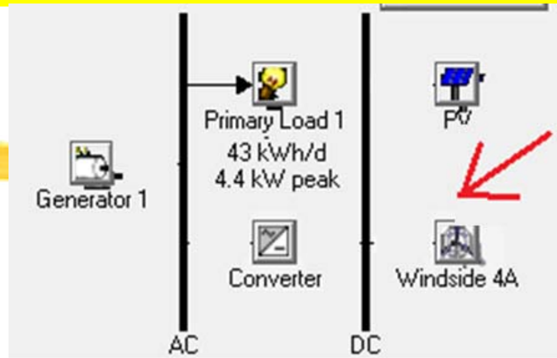
- Now arrow appears from AC bus to load
- Click “Generator”
- Size: 5.0 kW
- Capital: $2000
- Replacement: $2000
- O&M: $0.02/hr
- Sizes to consider: 0, 2.5kW, 5.0kW
- Minimum load capacity: 30%



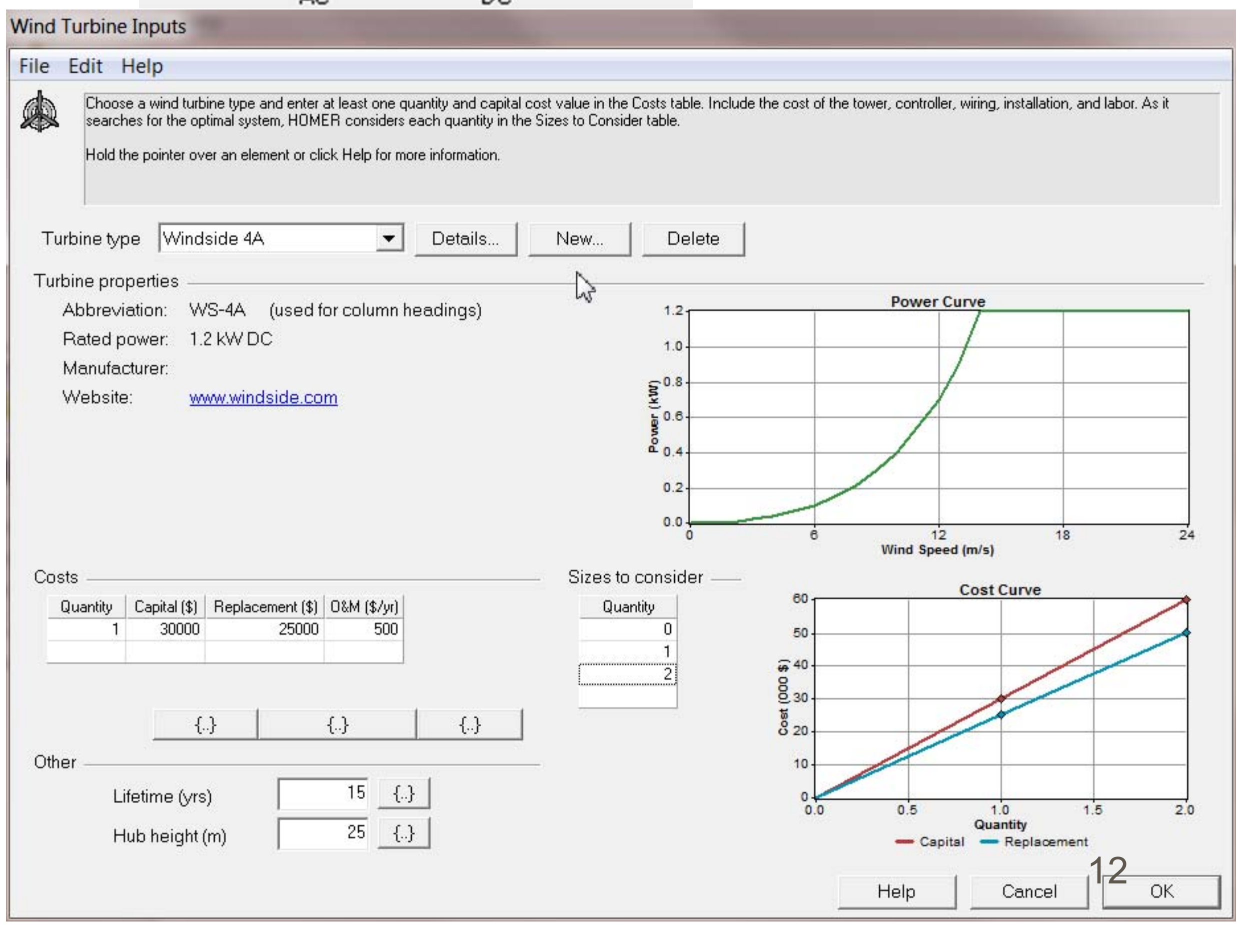


Wind Turbine Information

- Click Wind Turbine 1

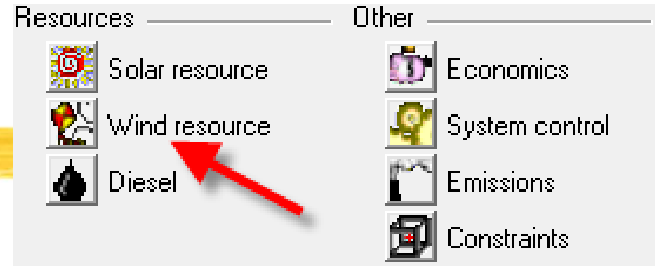


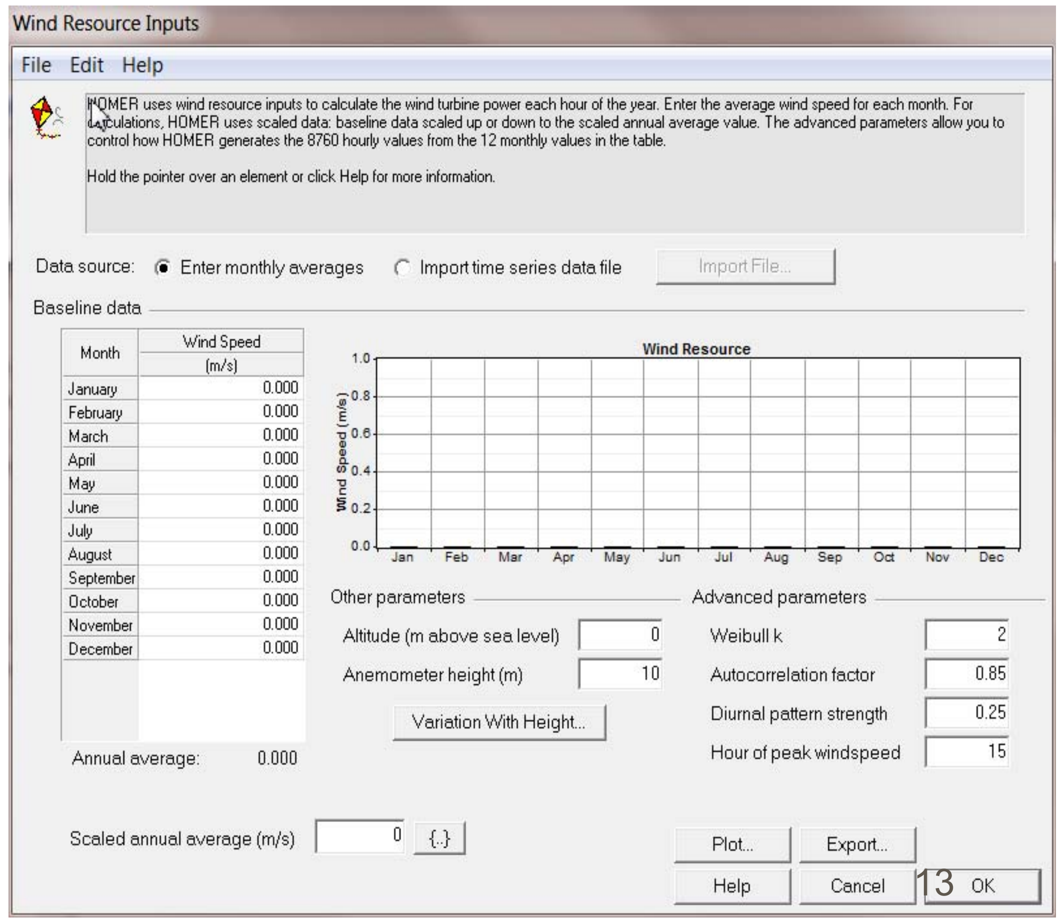
- Quantitty:1
- Capital: $30000
- Replacement: $25000
- O&M: $500/yr
- Sizes to consider (Qty): 0, 1, 2, and 3



Wind Resources

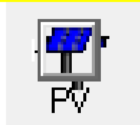
- Click Wind Resources Button
- **Location of your choice**
  - Your small store
  - Your side of street lights
  - Your (future) vacation home
- Find **Latitude and Longitude**
- Find Wind Speed [m/s] using SWERA or WINDFINDER
- Type in the speed

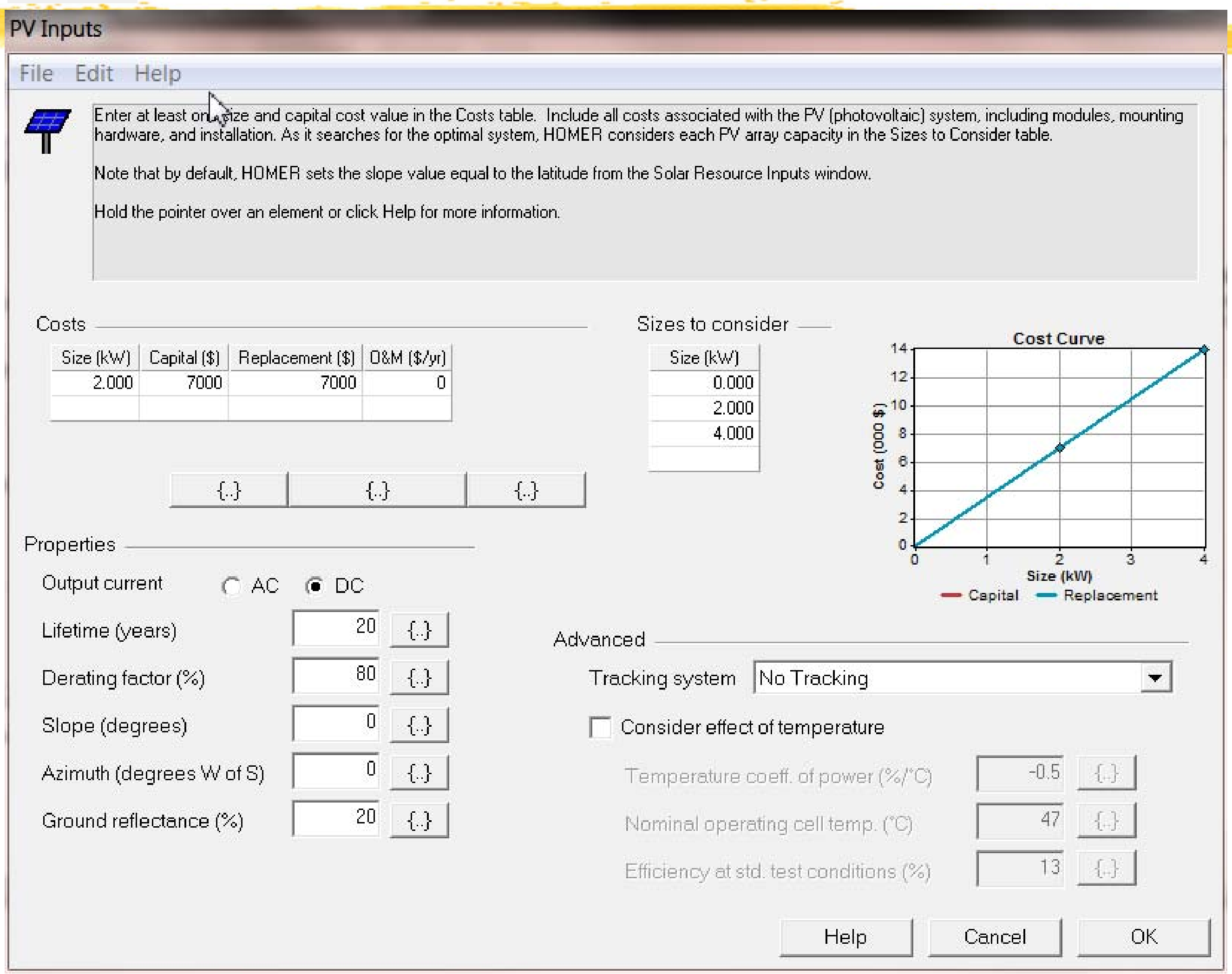




PV Information

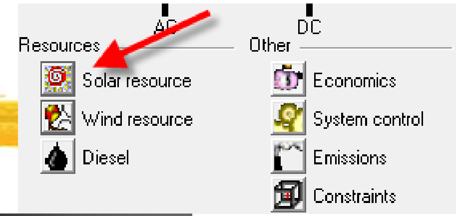
- Click "PV"
- Size: 2kW
- Capital: $7000
- Replacement: $7000
- O&M: $0/yr
- Sizes to consider: 0, 2kW, 4kW
-

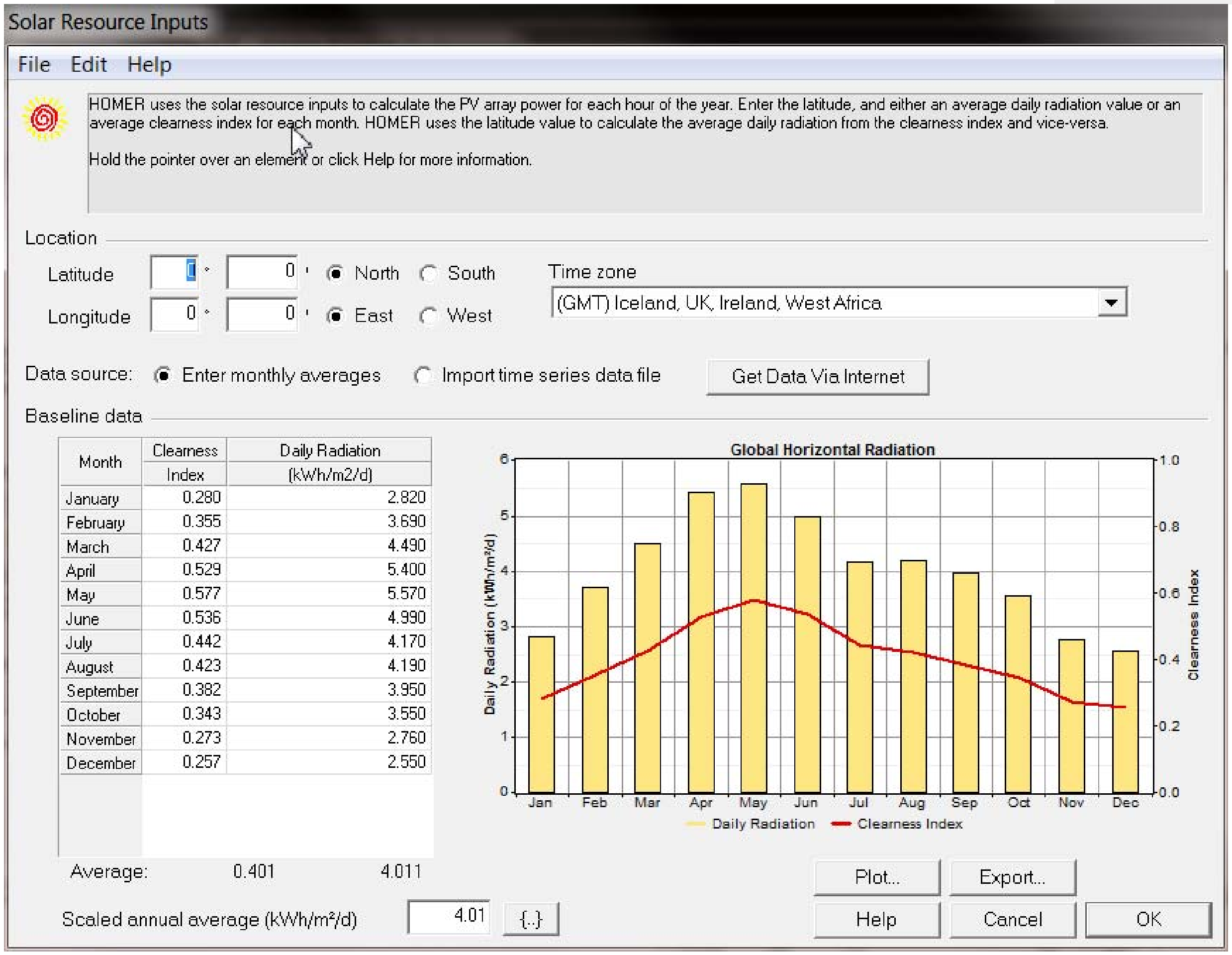




Solar Resources Information

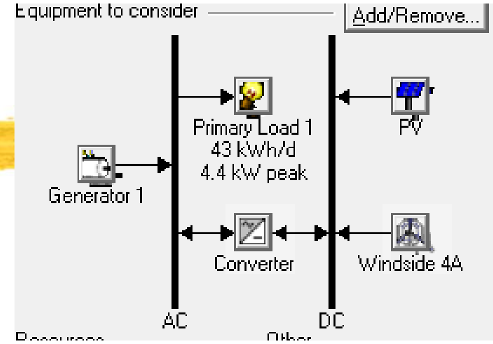
- Type in the solar radiation data obtained from SWERA

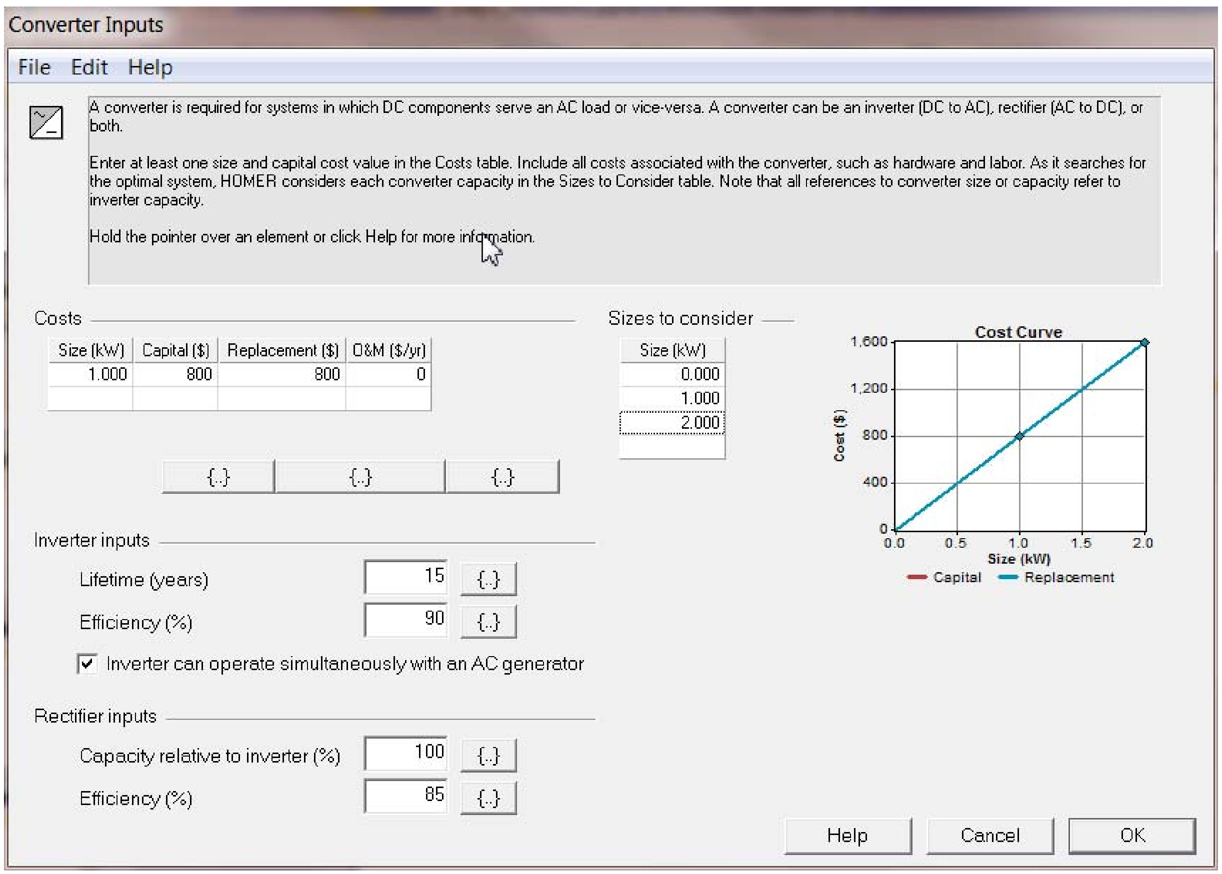




Converter Information

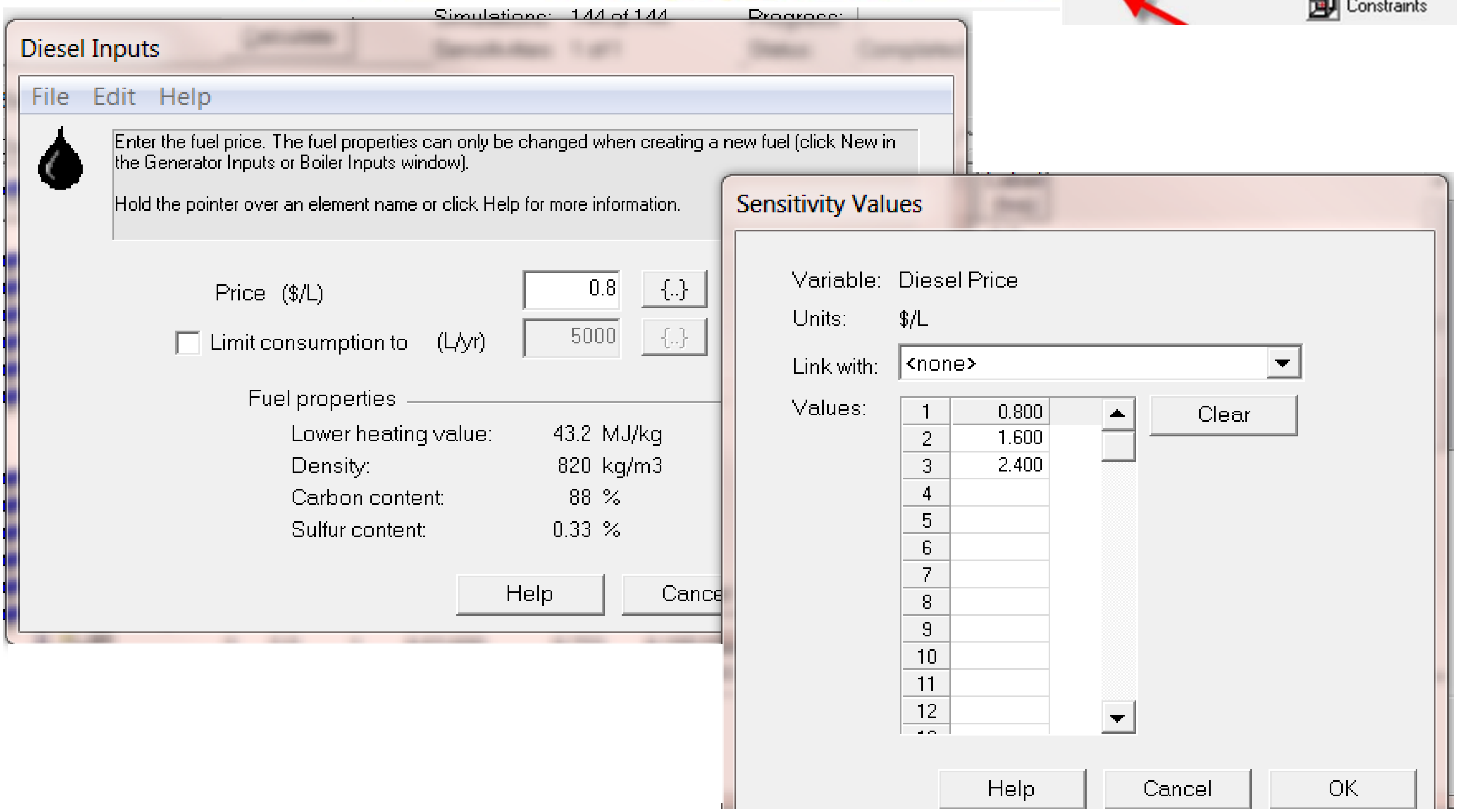
- Converter (DC→ AC)
- Size: 1kW
- Capital: $800
- O&M: $0
- Sizes to consider: 0, 1, 2 kW





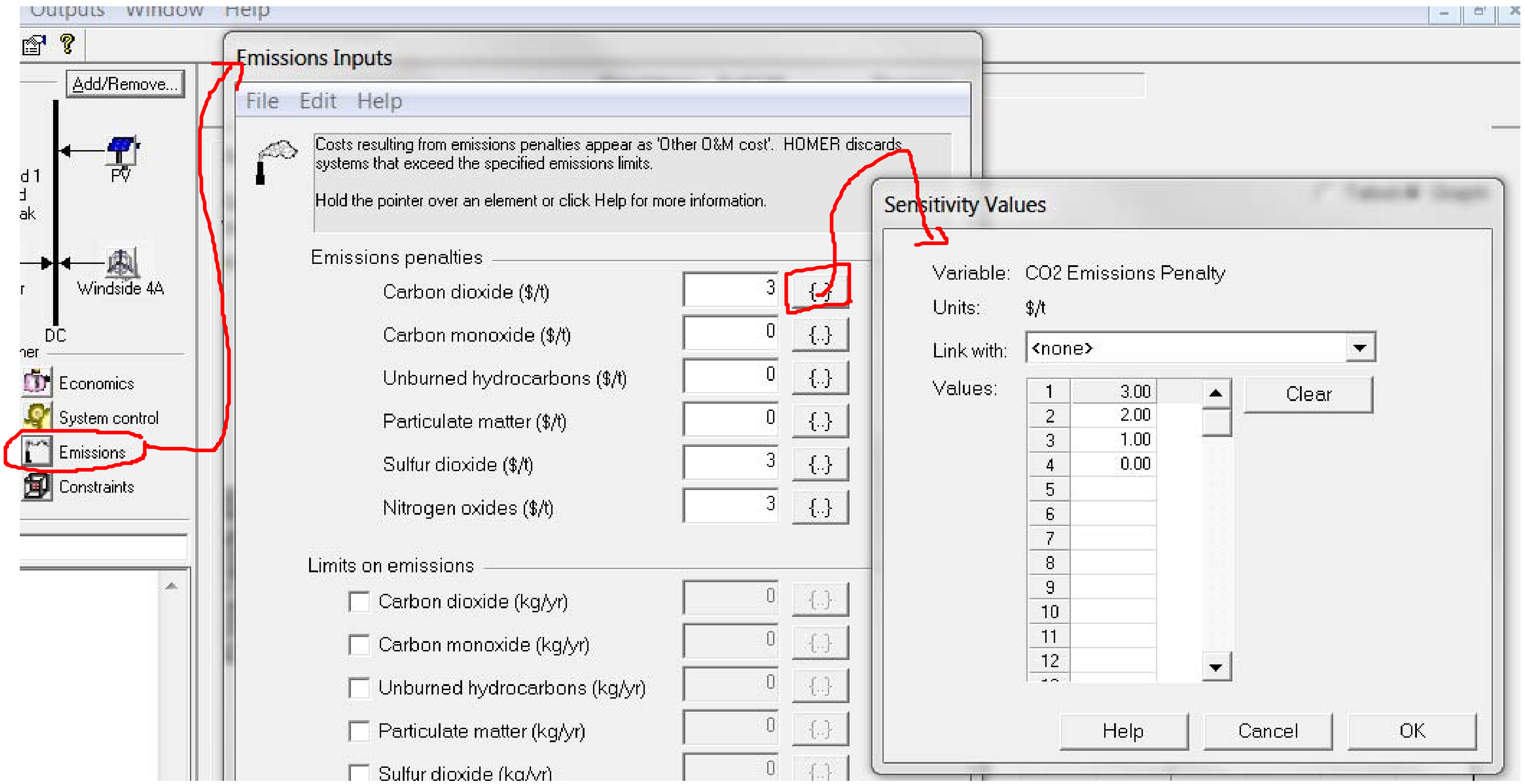
Diesel Resources Information

- Fuel Price: $0.8/L
- Sensitivity Price: $0.8, 1.6, 2.4/L



Emission Information

- CO2: $3/ton
- CO: $0
- C02: Sensitivity Data {0, 1, 2, 3}



Simulation

⌘ Optimization Result

Sensitivity Results | Optimization Results

Sensitivity variables

Diesel Price ($/L) 2.4

Double click on a system below for simulation results.

Categoriz Ov

PV (kW)	WS-...	Label (kW)	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Label (hrs)
2		5.0	1	$ 10,600	19,040	$ 253,996	1.254	0.13	7,350	8,754
		5.0		$ 2,000	19,788	$ 254,962	1.259	0.00	7,711	8,759
2		5.0	2	$ 12,200	19,056	$ 255,798	1.263	0.13	7,339	8,754
4		5.0	2	$ 19,200	18,596	$ 256,925	1.269	0.24	7,123	8,658
4		5.0	1	$ 17,600	18,836	$ 258,390	1.276	0.24	7,235	8,743
6		5.0	2	$ 26,200	18,239	$ 259,355	1.281	0.33	6,952	8,517
6		5.0	1	$ 24,600	18,781	$ 264,687	1.307	0.32	7,181	8,735
2	1	5.0	1	$ 40,600	20,107	$ 297,631	1.470	0.15	7,310	8,753
2	1	5.0	2	$ 42,200	20,116	$ 299,351	1.478	0.15	7,296	8,753
	1	5.0	1	$ 33,600	20,856	$ 300,205	1.482	0.02	7,653	8,759
4	1	5.0	2	$ 49,200	19,673	$ 300,683	1.485	0.26	7,086	8,652
4	1	5.0	1	$ 47,600	19,927	$ 302,339	1.493	0.25	7,204	8,742
	1	5.0	2	$ 35,200	20,898	$ 302,348	1.493	0.02	7,653	8,759
6	1	5.0	2	$ 56,200	19,333	$ 303,343	1.498	0.34	6,923	8,514
6	1	5.0	1	$ 54,600	19,885	$ 308,802	1.525	0.33	7,156	8,735

⌘ Electrical

System Architecture: 2 kW PV, 5 kW Generator 1, 1 kW Inverter, 1 kW Rectifier

Total NPC: $ 253,996
Levelized COE: $ 1.254/kWh
Operating Cost: $ 19,040/yr

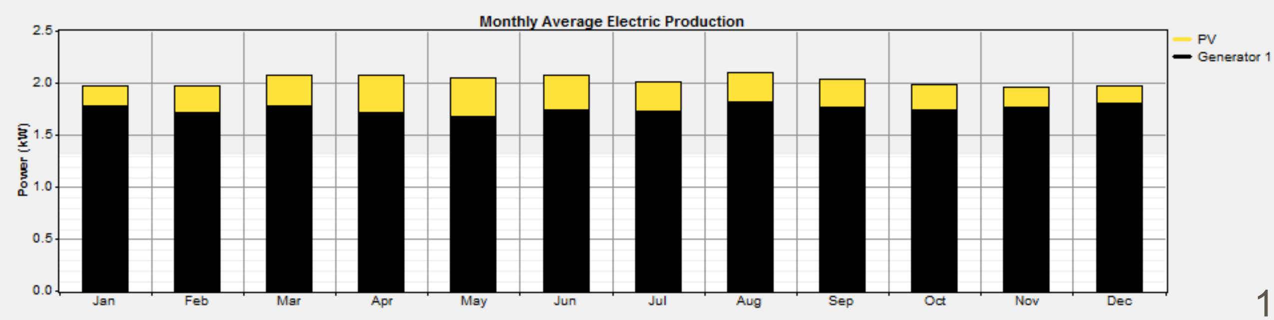
Cost Summary | Cash Flow | Electrical | PV | Label | Converter | Emissions | Hourly Data

Production	kWh/yr	%
PV array	2,341	13
Generator 1	15,396	87
Total	17,737	100

Consumption	kWh/yr	%
AC primary load	15,841	100
Total	15,841	100

Quantity	kWh/yr	%
Excess electricity	1,737	9.79
Unmet electric load	0.0000340	0.00
Capacity shortage	0.00	0.00

Quantity	Value
Renewable fraction	0.132



XML Report | HTML Report | Help | Close

Sensitivity Analysis

◉ Tabula ◯ Graphi

Export... | Details...

Double click on a system below for optimization results

Diesel ($/L)					PV (kW)	WS-...	Label (kW)	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kW...	Ren. Frac.	Diesel (L)	Label (hrs)
0.800							5.0		$ 2,000	7,451	$ 97,252	0.480	0.00	7,711	8,7...
1.600							5.0		$ 2,000	13,620	$ 176,107	0.870	0.00	7,711	8,7...
2.400					2		5.0	1	$ 10,600	19,040	$ 253,996	1.254	0.13	7,350	8,7...

Graph type: Spider graph

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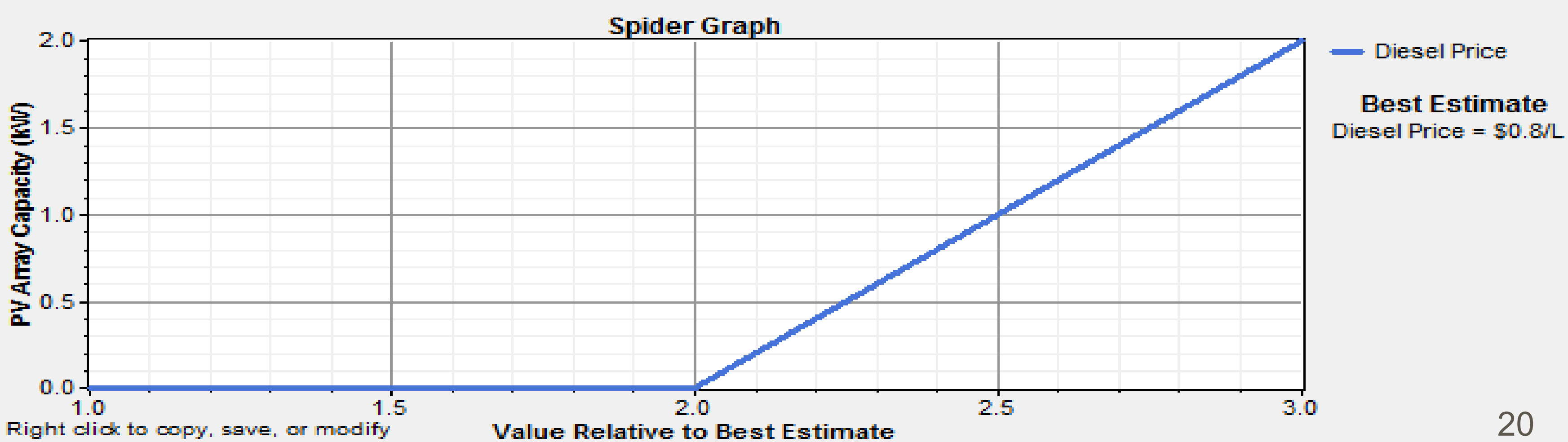
Sensitivity variables

Diesel Price ($/L): 0.8

Variables to plot

Primary: PV Array Capacity

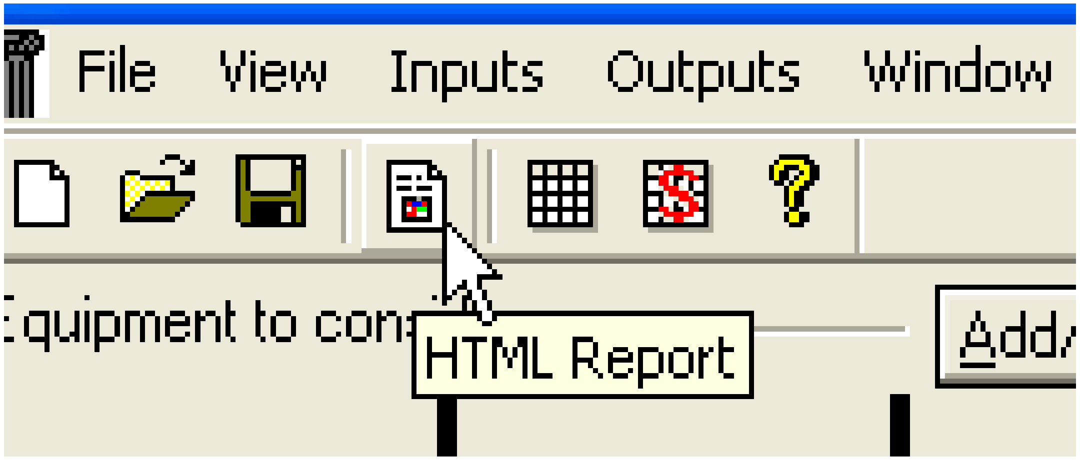
New Window...



Right click to copy, save, or modify

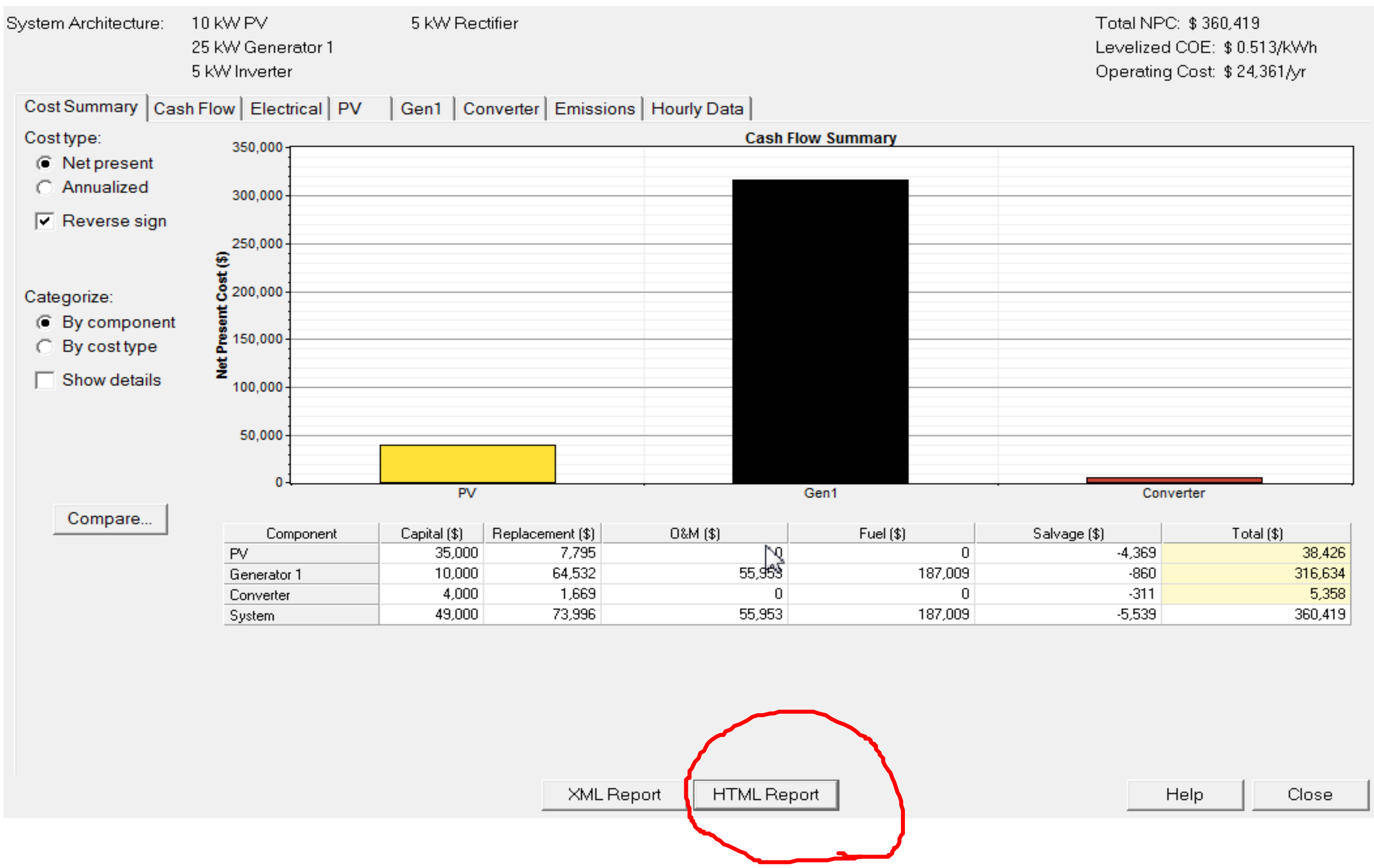
HOMER – Input Summary Report

- HOMER Produces An Input Summary Report:
  - Click HTML Input Summary from the File menu, or click the toolbar button:
  - HOMER will create an HTML-format report summarizing all the relevant inputs, and display it in a browser. From the browser, you can save or print the report, or copy it to the clipboard so that you can paste it into a word processor or spreadsheet program.

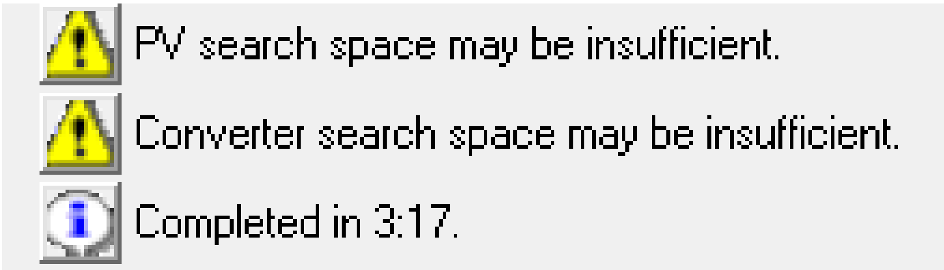


HOMER – Simulation Result Report

- HOMER Produces A Report Summarizing The Simulation Results
  - Just click the HTML Report button in the Simulation Results window:



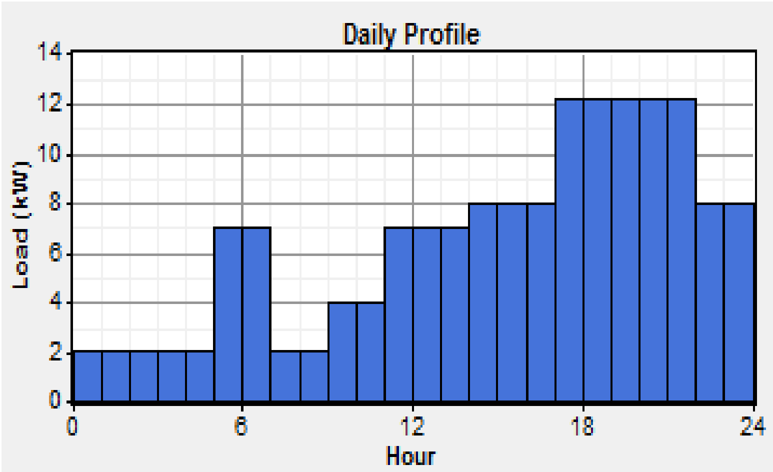
What is this message for?



- Those messages mean that:
  - you need to expand your search space to be sure you have found the cheapest system configuration.
  - If the total net present cost varied with the PV size in this way, and you simulated 10, 20, 30, and 40 kW sizes, HOMER would notice that the optimal number of turbines is 40 kW, but since that was as far as you let it look, it would give you the "search space may be insufficient" warning because 50 kW may be better yet.
  - It doesn't know that until you let it try 50kW and 60kW.
  - If you expanded the search space, HOMER would no longer give you that warning, since the price started to go up so you have probably identified the true least-cost point.

HOMER: Grid-Connected Micro-Power system

- Place: A commercial/retail in Seoul/Cheonan/Byungchon
- This project investigates the options for providing electricity to the commercial/small store using wind, solar, or diesel power.
- It also analyzes the impact of different assumptions about the wind resource, fuel price, and required system reliability.
- Solar Resources: Actual data via Internet
- Wind Resources: Wind speed data
- Load: 35kWh/d and 4.5 kW peak

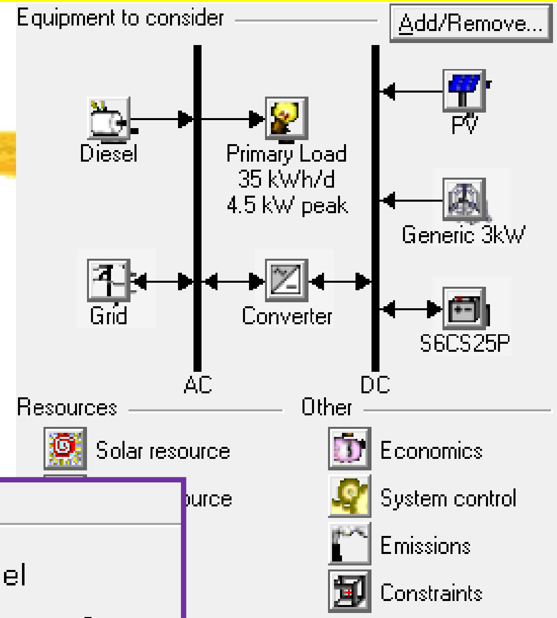


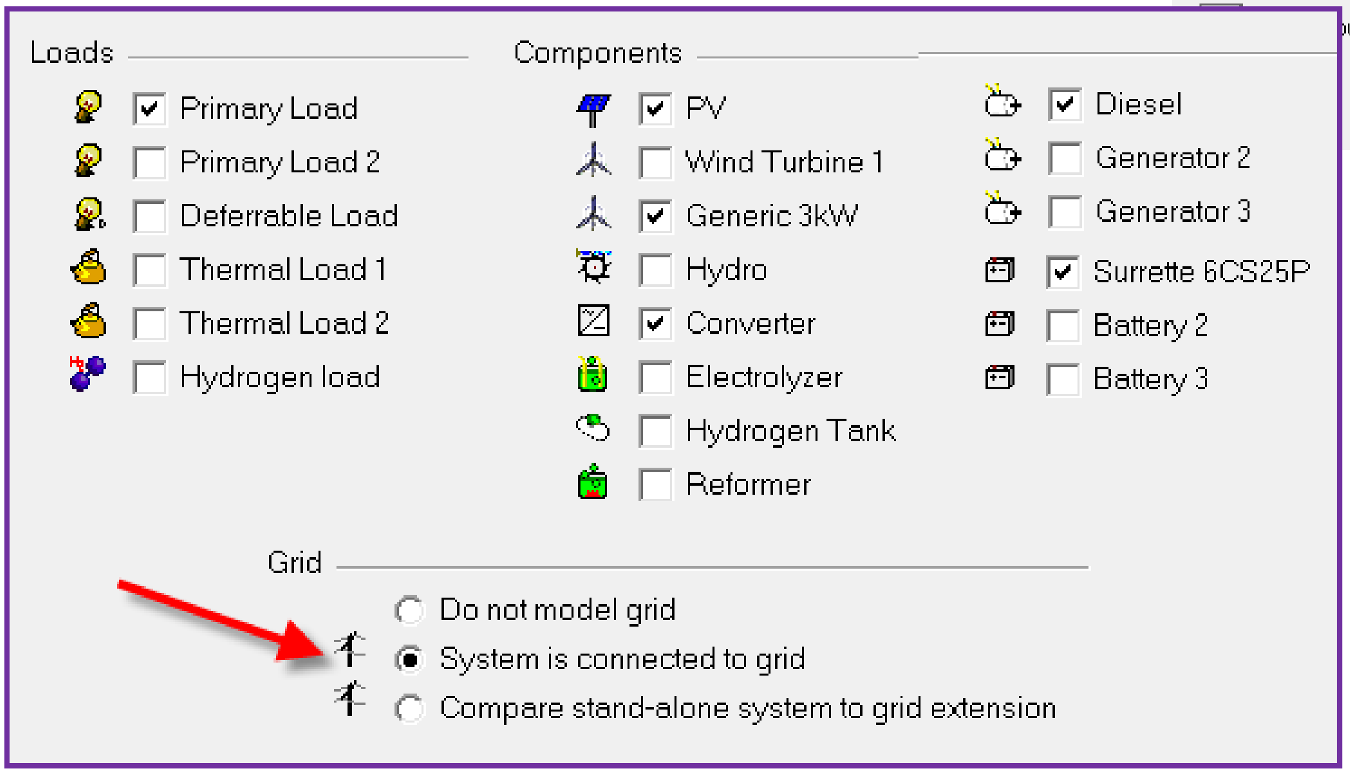
Components and Constraints

- Components:
  - PV: Default performance: 1kW [0, 2, 4 kW]
  - Wind Turbine: 3kW [Qty 0 1 2 3]
  - Diesel Generator: 5 kW is considered (peak load is 4.5 kW)
    - Fuel: $0.3/L [0.3, 0.5, 0.7]
    - Limit Consumption: 5000 L/year
  - Batteries: Marine Battery [6V, 1167 Ah] [0 10 20 30]
  - Inverter: 10kW size. (cost: $1250/kW) [0, 2, 4, 6, 8 kW]
  - Grid: Single rate at $0.15/kWh; Sellback at $0.15/kWh; Demand Charge at $5.0/kW/month
- Economics:
  - Real interest rate: 8%
  - Project lifetime: 25 years
  - System fixed capital cost: $6000
    - It represents balance of system and distribution system costs that cannot be allocated to a specific component.
- Reliability:
  - Maximum Annual Capacity Shortage: 0% [0.0, 0.1]

Start HOMER

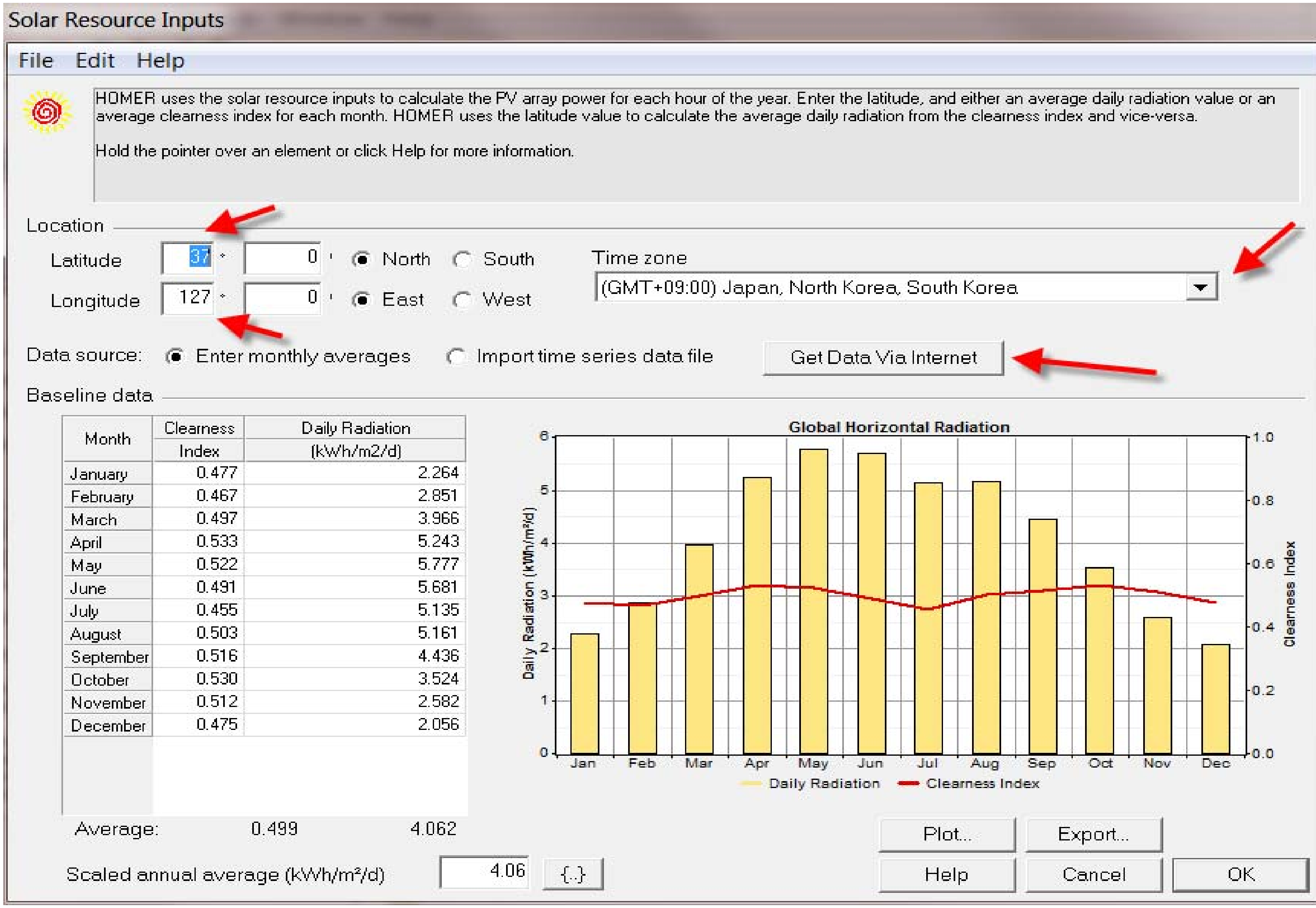
- New File
- Component and Resources
  - Load, Diesel
  - PV, Battery
  - Wind
  - “System is connected to grid”





Solar Resources

- Latitude, Longitude, Time Zone, Get Data of **your location**

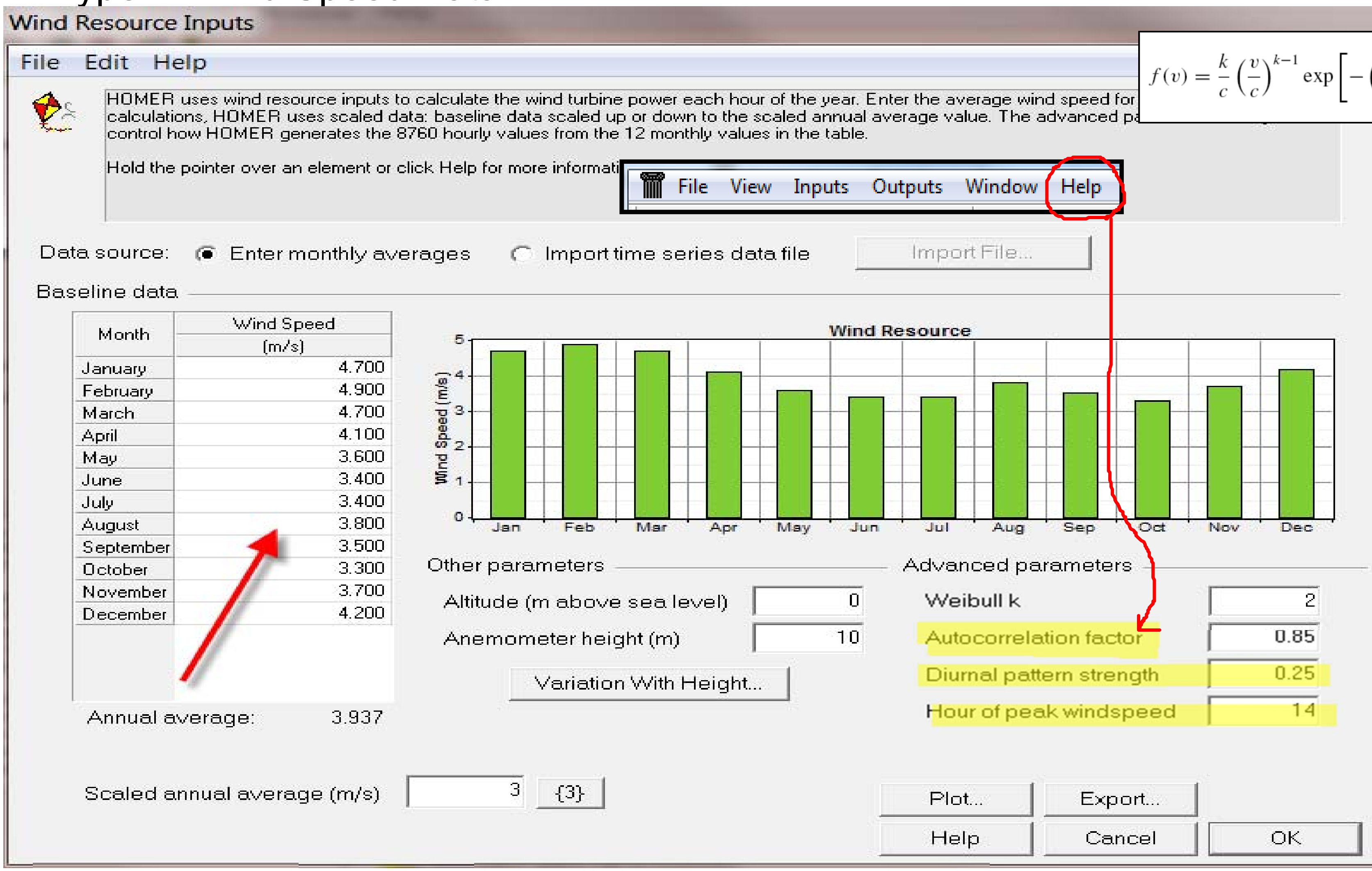


Month	Clearness Index	Daily Radiation (kWh/m2/d)
January	0.477	2.264
February	0.467	2.851
March	0.497	3.966
April	0.533	5.243
May	0.522	5.777
June	0.491	5.681
July	0.455	5.135
August	0.503	5.161
September	0.516	4.436
October	0.530	3.524
November	0.512	2.582
December	0.475	2.056

Wind Resources

- Type in Wind Speed Data

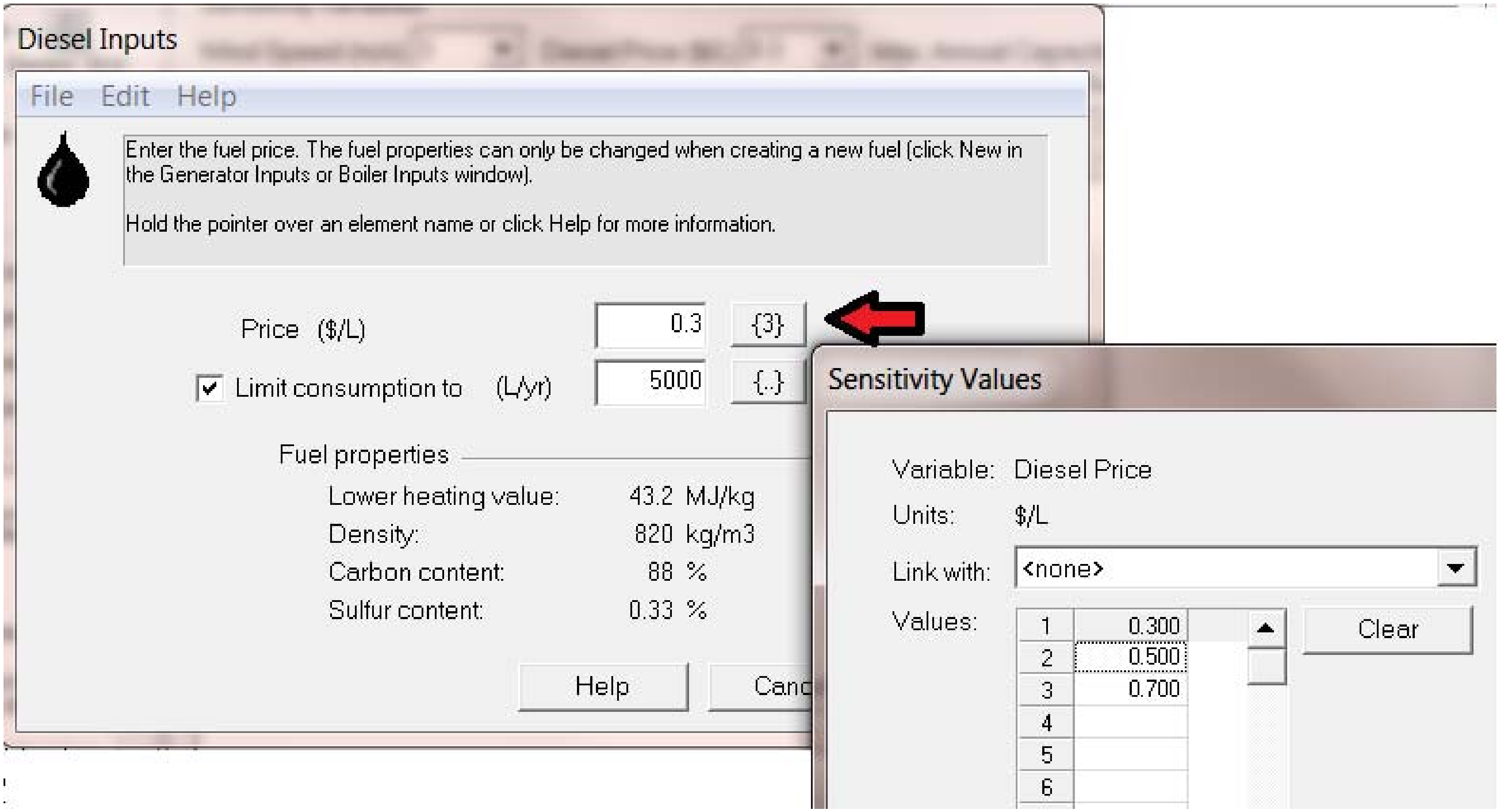
$$f(v) = \frac{k}{c}\left(\frac{v}{c}\right)^{k-1} \exp\left[-\left(\frac{v}{c}\right)^{k}\right]$$



The diurnal pattern strength simply indicates how strongly the wind speed depends on the time of day. If the wind speed tends to peak at the same time as the load, then a strong daily pattern would be a good thing. It would mean the wind blows when you need the power. If the wind speed peak was out of sync with the load peak, then a strong daily pattern would be a negative.

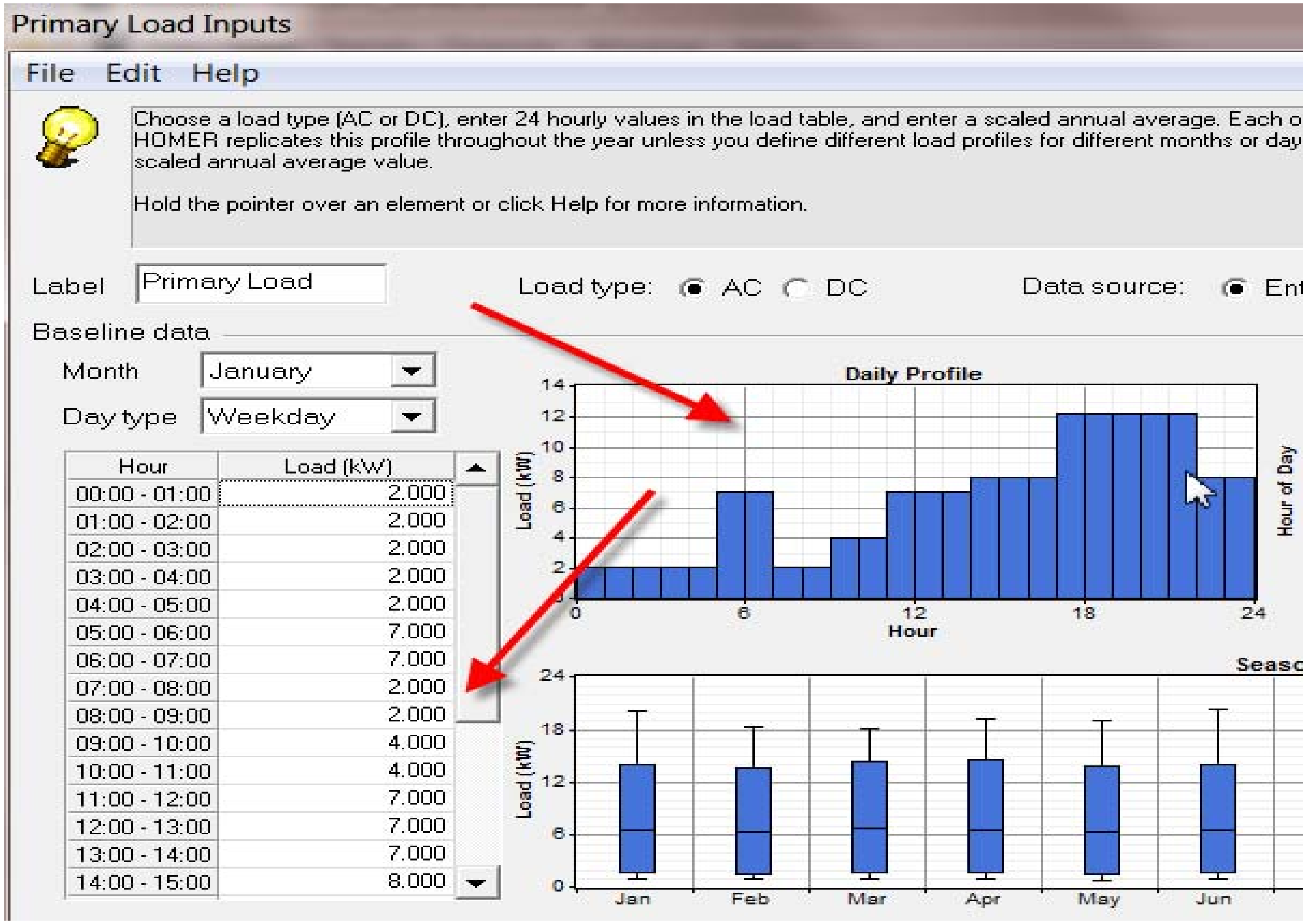
Diesel Resources

- $0.5/L
- Sensitivity: [$0.3, 0.5, 0.7]/L



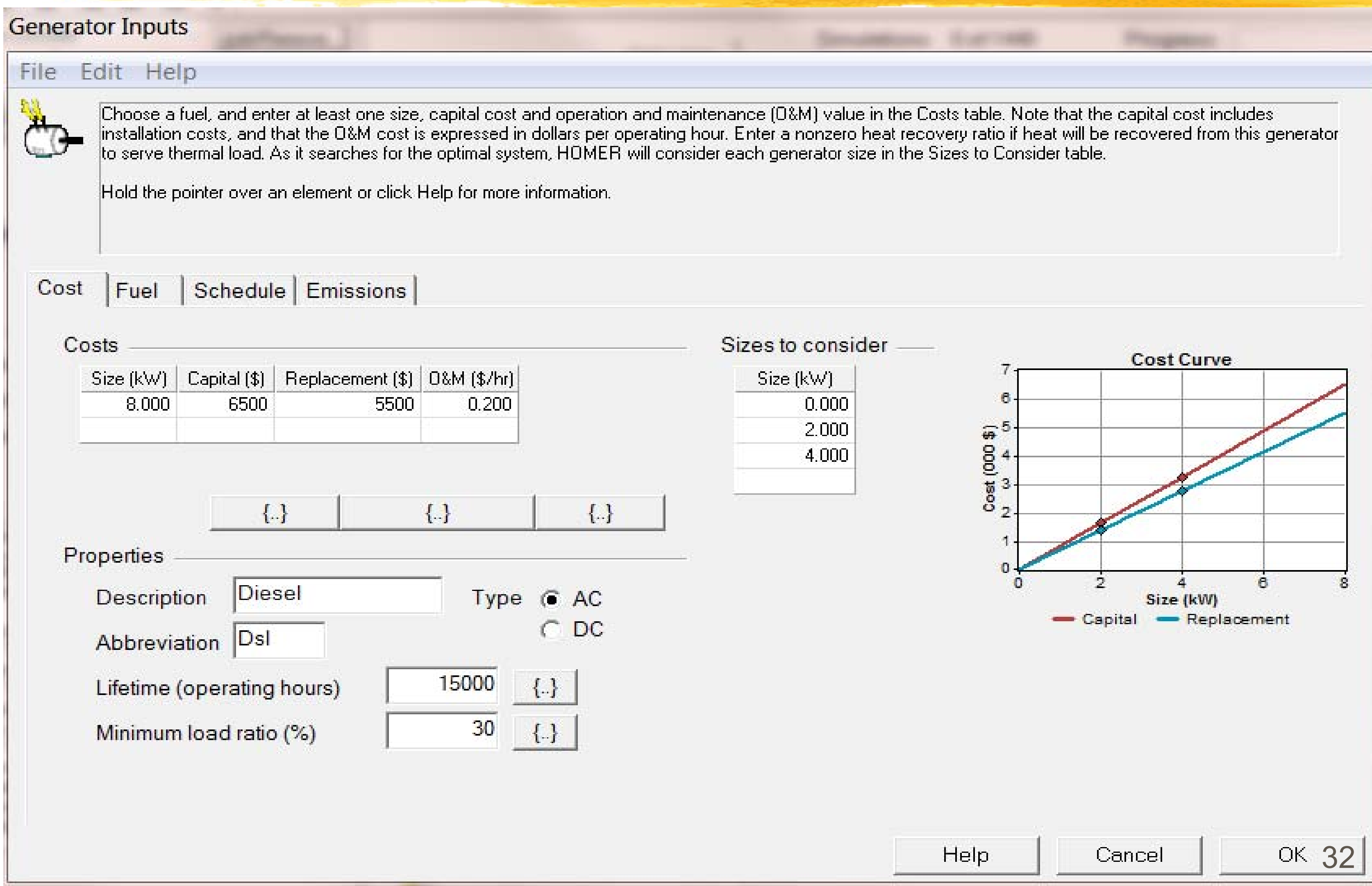
Component: Load Input

- Type in hourly load [kW]
- [0000 – 1200]: 2, 2, 2, 2, 2, 7, 7, 2, 2, 4, 4, 7 kW
- [1300 - 0000]: 7, 7, 8, 8, 8,12, 12, 12, 12, 12, 8, 8 kW

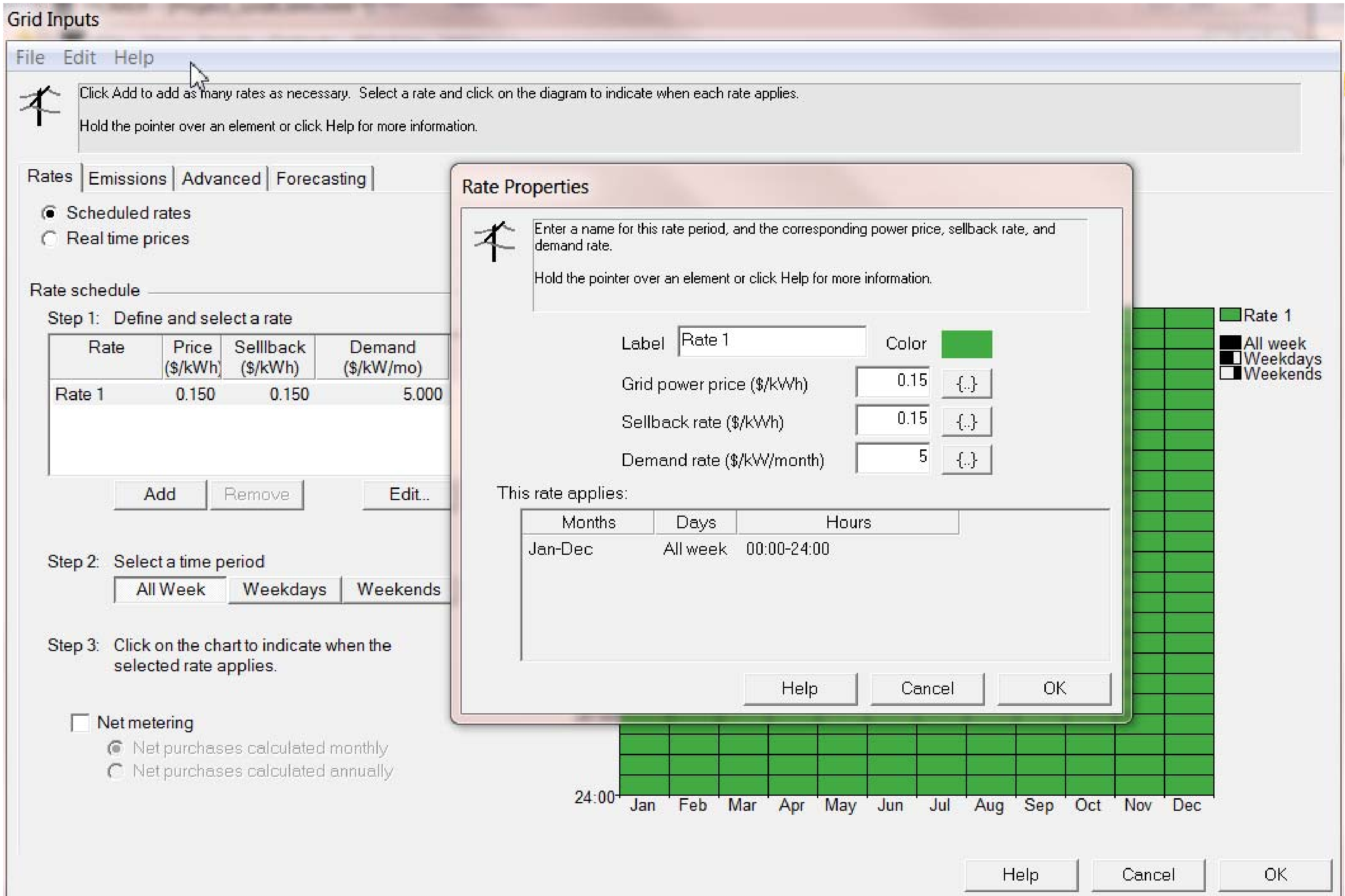


Component: Diesel Input

- 8kW generator
- Sensitivity: [0, 2, 4] kW

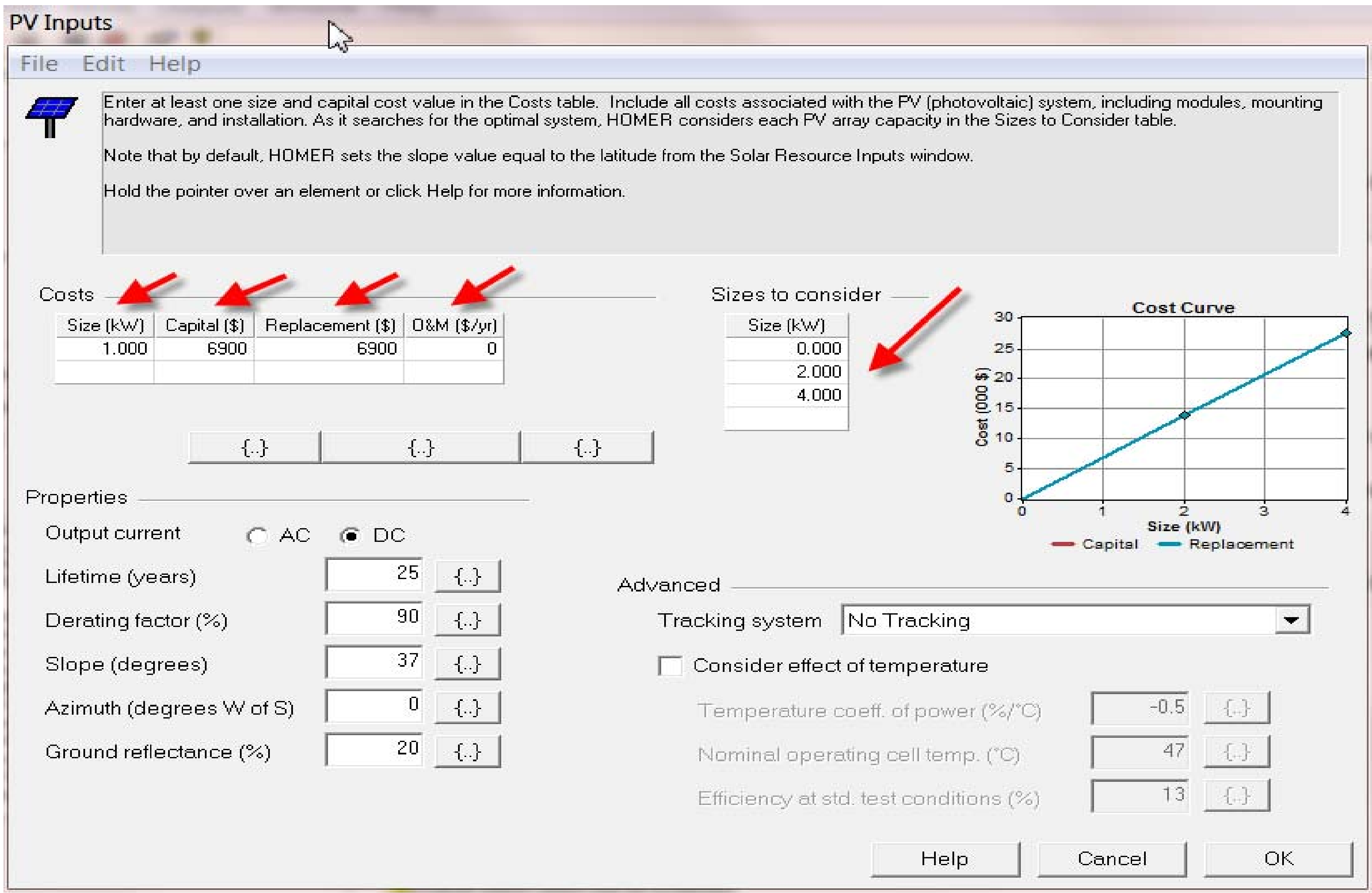


Component: Grid Input



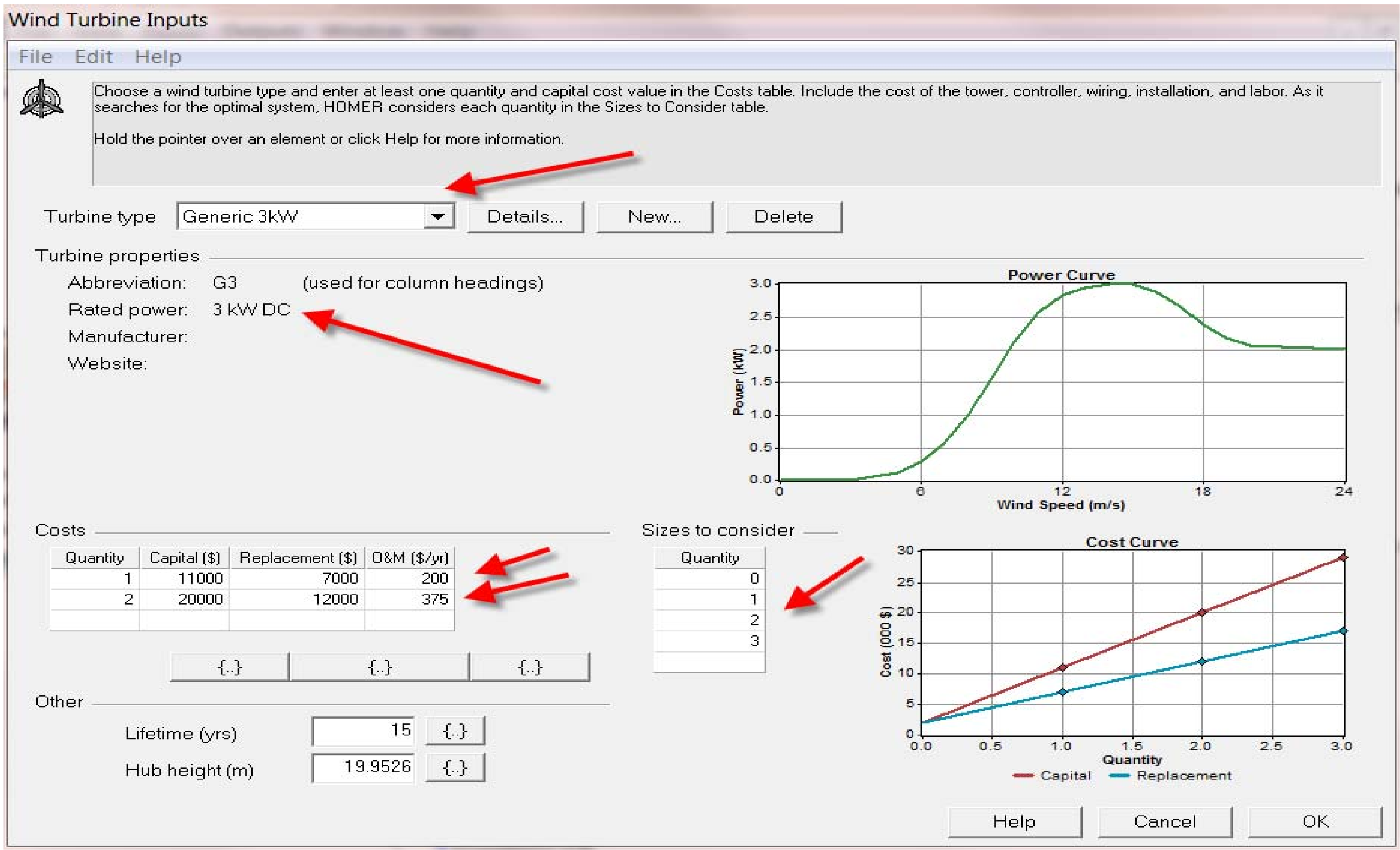
Component: PV Input

- 1kW, $6900, $6900, $0/yr
- [0, 2, 4] kW for sensitivity analysis



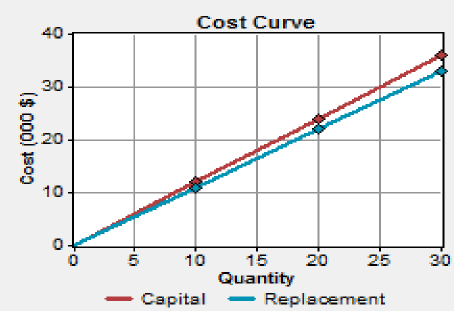
Component: Wind Turbine Input

- Generic 3kW DC
- Quantity [0,1, 2, 3] for sensitivity analysis
- Cost: $11000, $7000, $200/yr



Component: Battery Input

- Rolls/Surrette 1156 Ah 6V
- Cost per unit: $1200, $1100, $50/yr
- Quantity [0, 10, 20, 30] for Sensitivity
- 1 per string



Choose a battery type and enter at least one quantity and capital cost value in the Costs table. Include all costs associated with the battery bank, such as mounting hardware, installation, and labor. As it searches for the optimal system, HOMER considers each quantity in the Sizes to Consider table.

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

Battery type: Surrette 6CS25P | Details... | New... | Delete

Battery properties

Manufacturer: Rolls/Surrette
Website: www.rollsbattery.com
Nominal voltage: 6 V
Nominal capacity: 1,156 Ah (6.94 kWh)
Lifetime throughput: 9,645 kWh

Costs

Quantity	Capital ($)	Replacement ($)	O&M ($/yr)
1	1200	1100	50.00

{..} {..} {..}

Sizes to consider

Batteries
0
10
20
30

Advanced

Batteries per string: 1 (6 V bus)
Minimum battery life (yr): 4 {..}

Help | Cancel | OK

Battery Sizing

10291 - System configuration, battery sizing

Posted by on 22 December 2010 10:28 AM

Is there any particular criteria for sizing of battery storage in HOMER ? How do we size a converter ?

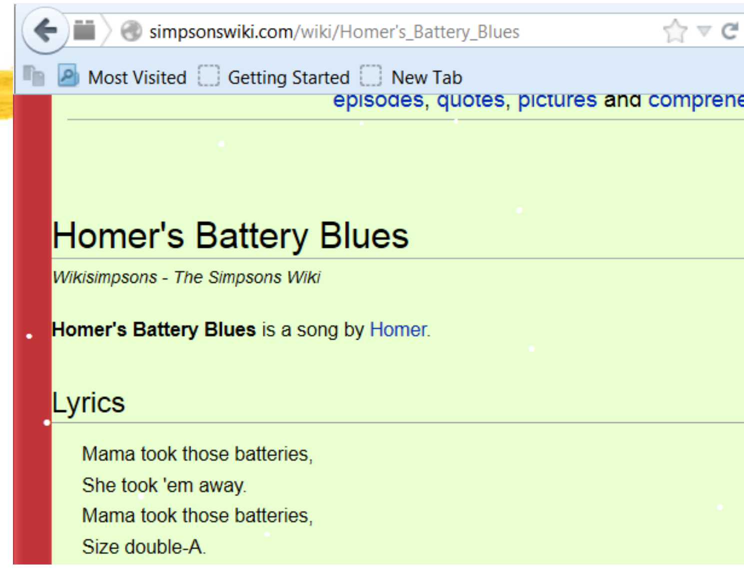
We have found that there is no reliable rule of thumb for determining optimal value of battery autonomy. It depends on many factors, including the daily and seasonal patterns of the load, the daily and seasonal patterns and the intermittency of the relevant renewable resources, the correlation between the load and renewable resources, the fuel price, the size of the backup generator relative to the peak and average load, etc.

So we always rely on HOMER's ability to optimize the size of the battery bank, rather than using some pre-defined size. One possibility is to calculate the number of batteries corresponding to a comfortably long autonomy such as 4 days, and specify a range of possible values from that value down to zero. In truth, I usually rely on trial and error, using HOMER's feedback to revise the battery search space over several runs. This process is much easier in version 2.1 that it was previously because in version 2.1 the information on "winning sizes" appears in the Optimization Inputs window. So you can specify some battery sizes, hit Calculate, then check the bottom half of the Optimization Inputs window to see which battery size was optimal, and use the top half of the window to revise the battery search space if necessary. You can do the same for any other component as well.

Sizing the converter is somewhat easier that the battery bank because there is a clear upper limit to the converter size, namely the peak load. For example, if the load is AC and its peak value is 6 kW, it is very unlikely that the optimal converter size will exceed 6 kW. I might try a size range such as 6, 4, 3, 2, 1,and 0 kW.

Battery Blues ?

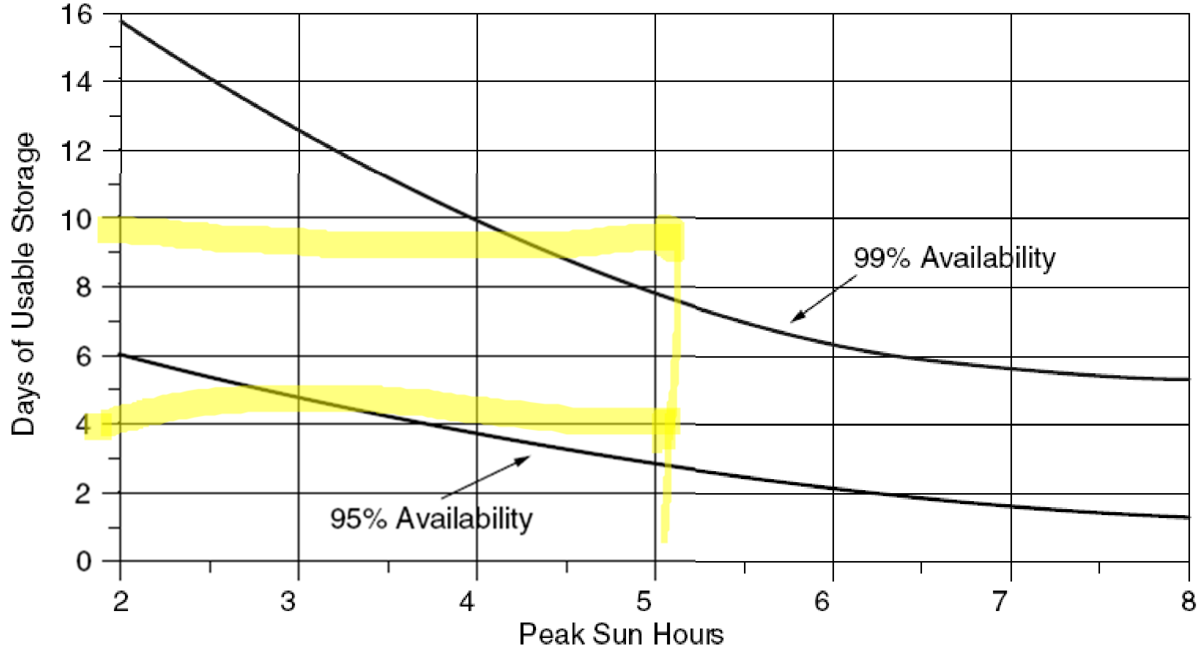
- Batteries from Remote
- Youtube link: http://www.youtube.com/watch?feature=player_detailpage&v=63mn4iDYL_c



- Refer Battery Sizing examples in the lectures on Solar Energy --- “the number of usable days” requirement/suggestion

Review - Battery Sizing

- Statistical nature of weather
- No set rules about how best to size battery storage except the cost trade-off
- Battery system of meeting demand 99% of the time may be 3 times higher in cost than that of meeting 95% of the time.
- The number of days of storage to supply a load in the design month [the month with the worst combination of insolation and load]
- **Days of "usable battery storage"** needed for a stand-alone system
- Nominal Battery Storage -- 3 days

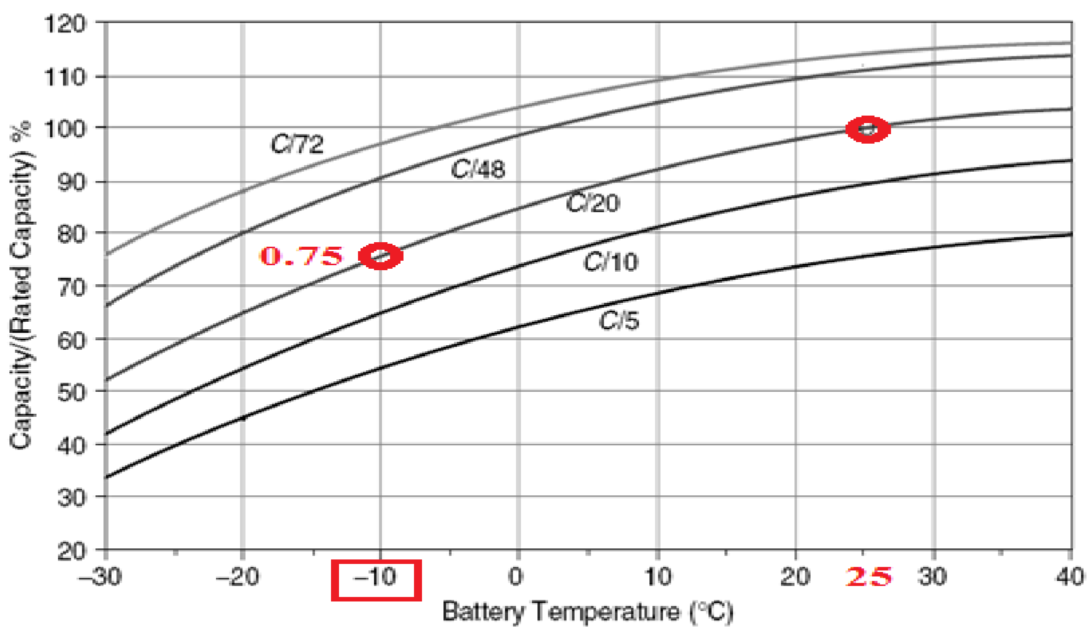


Review - Battery Sizing

- Nominal rated storage vs. usable storage:

$$\text{Nominal } (C/20, 25^\circ\text{C}) \text{ battery capacity} = \frac{\text{Usable battery capacity}}{(\text{MDOD})(\text{T, DR})}$$

- Variables:
  - MDOD (maximum depth of discharge): 0.8 for lead-acid; 0.25 for auto SLI
  - (T,DR): **Discharge Rate Factor** under a given Temperature



Review - Battery Sizing Example

- A cabin near Salt Lake City, Utah, has an ac demand of 3000 Wh/day in the winter months. A decision has been made to size the batteries such that a 95% system availability will be provided, and a back-up generator will be kept in reserve to cover the other 5%. The batteries will be kept in a ventilated shed whose temperature may reach as low as −10◦C. The system voltage is to be 24 V, and an inverter with overall efficiency of 85% will be used.
- SOLUTION APPROACH
  - 1. AC load → DC load demand (with 85% inverted efficiency)
  - 2. Battery Capacity (Ah)
  - 3. Usable storage (Ah) – Use the nominal 3 day storage
  - 4. Nominal capacity (Ah)
    - Assumption: 80% deep discharge ←MDOD
    - Assumption: 97% discharge rate ← (T,DR)
  - 5. Battery Bank Design

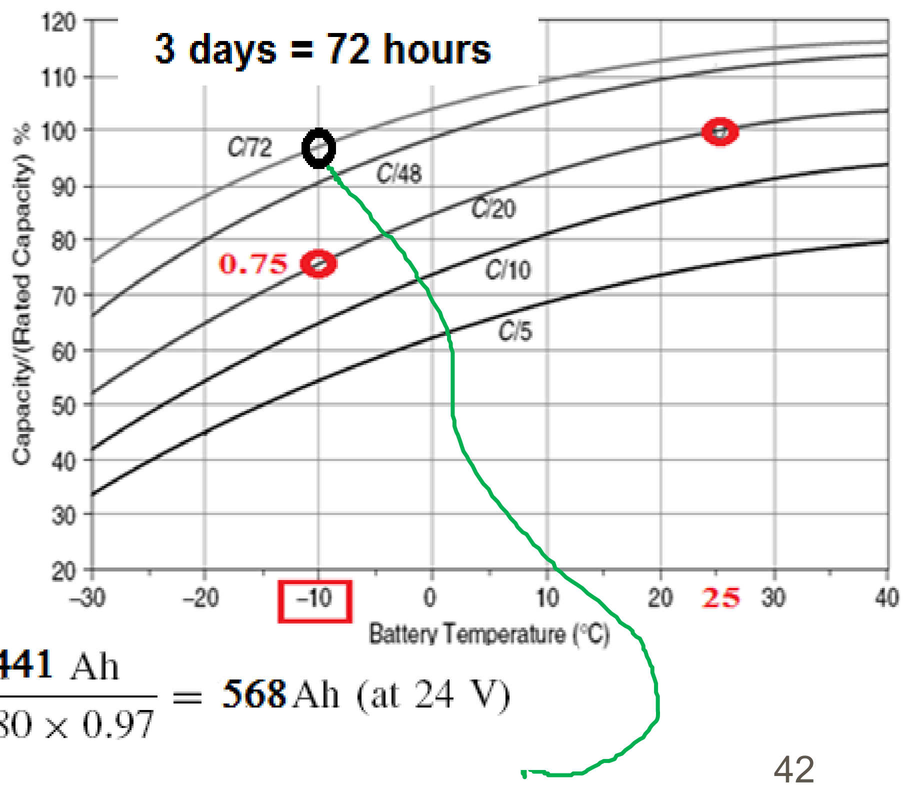
Review - SOLUTION - details

$$\text{DC load} = \frac{\text{AC load}}{\text{Inverter efficiency}} = \frac{3000 \text{ Wh/day}}{0.85} = 3529 \text{ Wh/day}$$

$$\text{Load} = \frac{3529 \text{ Wh/day}}{24\ V} = 147 \text{ Ah/day @ 24 V}$$

Nominal 3-day storage

$$\text{Usable storage} = 147 \text{ Ah/day} \times 3 \text{ day} = \mathbf{441} \text{ Ah}$$



$$\text{Nominal } (C/20, 25^{\circ}\text{C}) \text{ battery capacity} = \frac{\mathbf{441} \text{ Ah}}{0.80 \times 0.97} = \mathbf{568} \text{ Ah (at 24 V)}$$

Review - MathCad Solution

Battery Sizing.xmcd   Charles Kim 2013

A Cabin near Salt Lake City, Utah, has an AC energy demand of 3 kWh per day in the winter months. With a battery system, a 95% availability will be provided, while a back-up generator will be kept to cover the other 5%. The battery system will be kept in a ventilated shed where the temperatue may go as low as - 10 C degrees. The system voltage is 24 V, and an inverter efficiency is 85%. Assume 80% deep discharge (MDOD) and 97 % discharge rate (T,DR)

(Q) Calculate the size of the battery system.

$MDOD := 0.8$

$TDR := 0.97$

$Eac := 3$ kWh / day

$D2A := 0.85$ Inverter Efficiency

$Bvolt := 24$ Battery System Voltage

40.7500° N, 111.8833° W

Salt Lake City, Coordinates

SOLUTION
=========

1. DC energy demand (Edc):

$Edc := \frac{Eac}{D2A} = 3.5294$ kWh /day

2. Expression of the energy demand in terms of Amp-Hour per day. Remember that Energy=Power*Time = V*A*time,
==> A*hour = Wh/V

$AH := \frac{Edc \times 1000}{Bvolt} = 147.0588$ Ah/day

Review- MathCad Solution

3. Find the usable storage Ah at -10 C degree (use the graph)

   a. Peak-Sun-Hour information

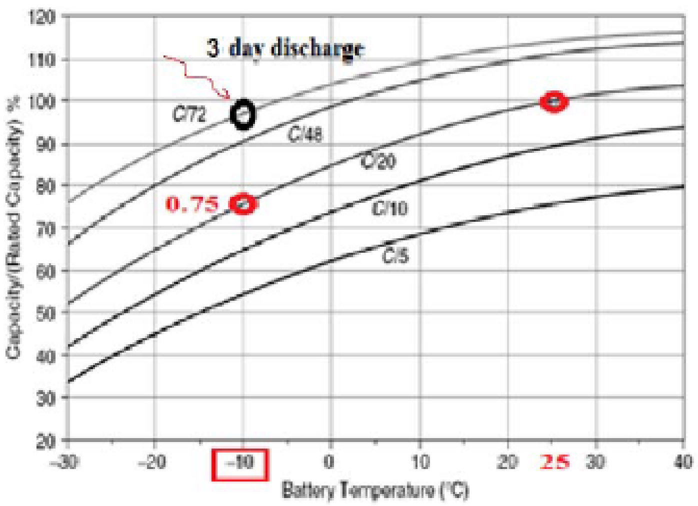
   b. Find the # of days of usuable storage(Dus) --- Use nominal 3-day storage

$$Dus := 3$$ days

   c. Now we calculate the Usuable Storage Amp-Hour (AHus)

$$AHus := AH \times Dus = 441.1765$$ Ah

   d. Finally, the nominal (C/20, 25 C) capacity:



$MDOD = 0.8000$ Nominal 3-day storage

$TDR = 0.9700$

$$MDOD \times TDR = 0.7760$$

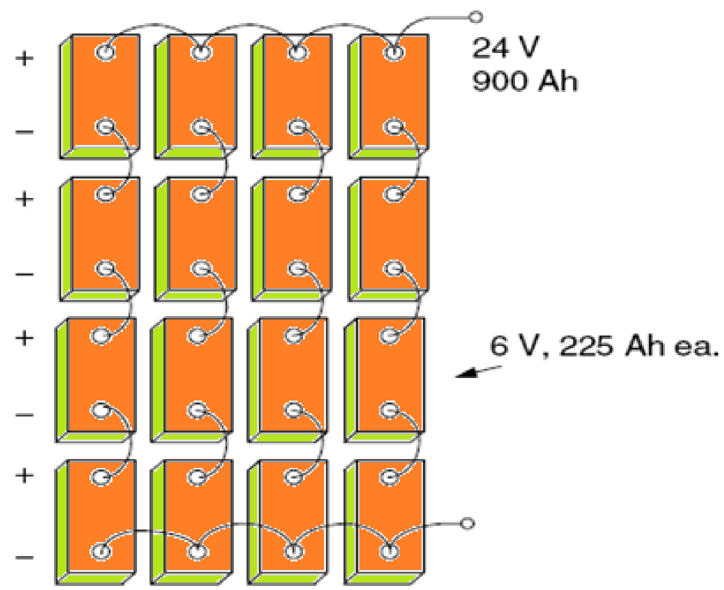
$$AHnorm := \frac{AHus}{MDOD \times TDR}$$ Ah

$$AHnorm = 568.5264$$

Review - Battery Selection - Example

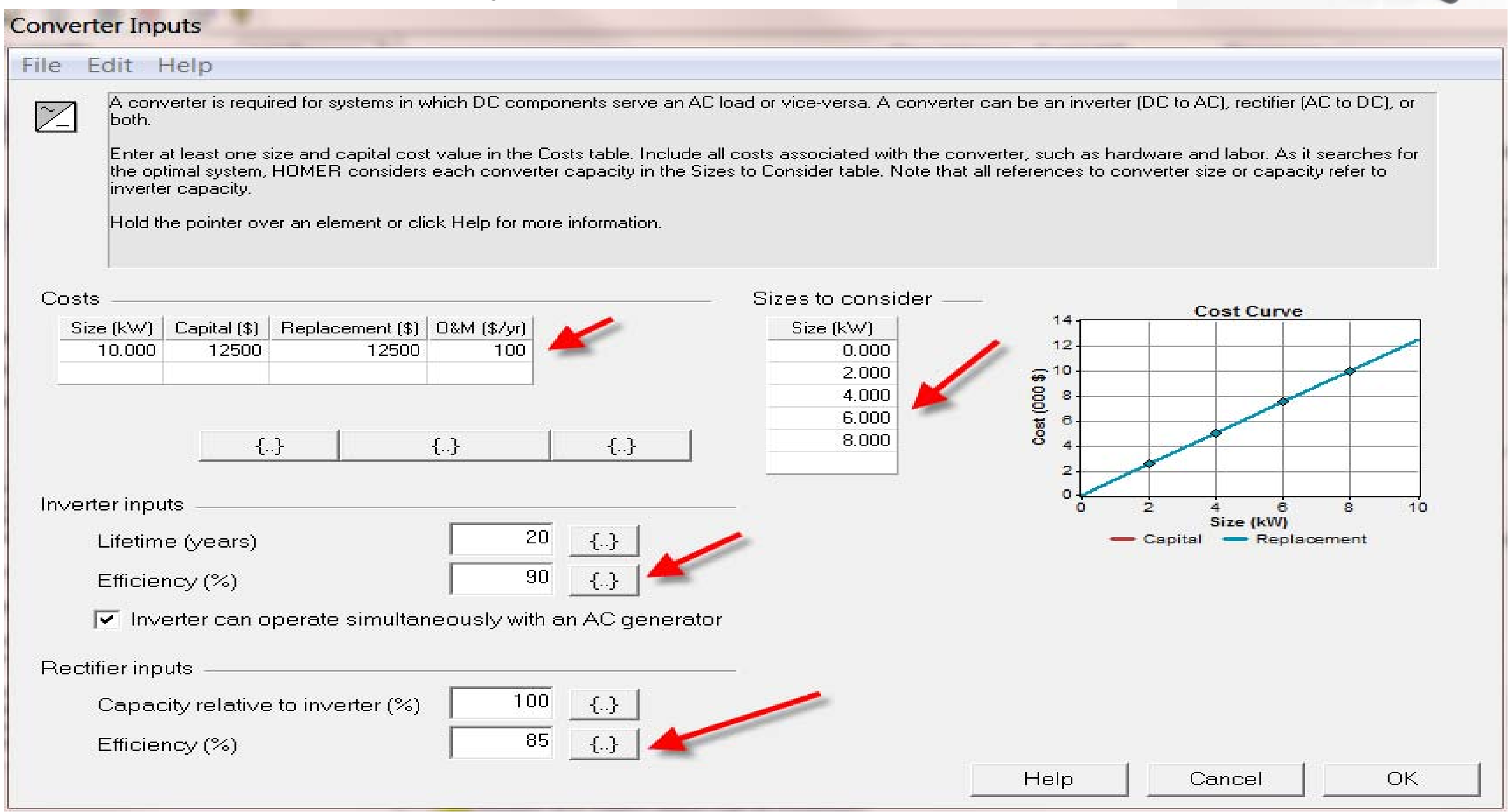
- 871 Ah @ 24V

BATTERY	Voltage	Weight (lbs)	Ah @ *C*/20	Ah @ *C*/100
Concorde PVX 5040T	2	57	495	580
Trojan T-105	6	62	225	250
Trojan L16	6	121	360	400
Concorde PVX 1080	12	70	105	124
Surette 12CS11PS	12	272	357	503



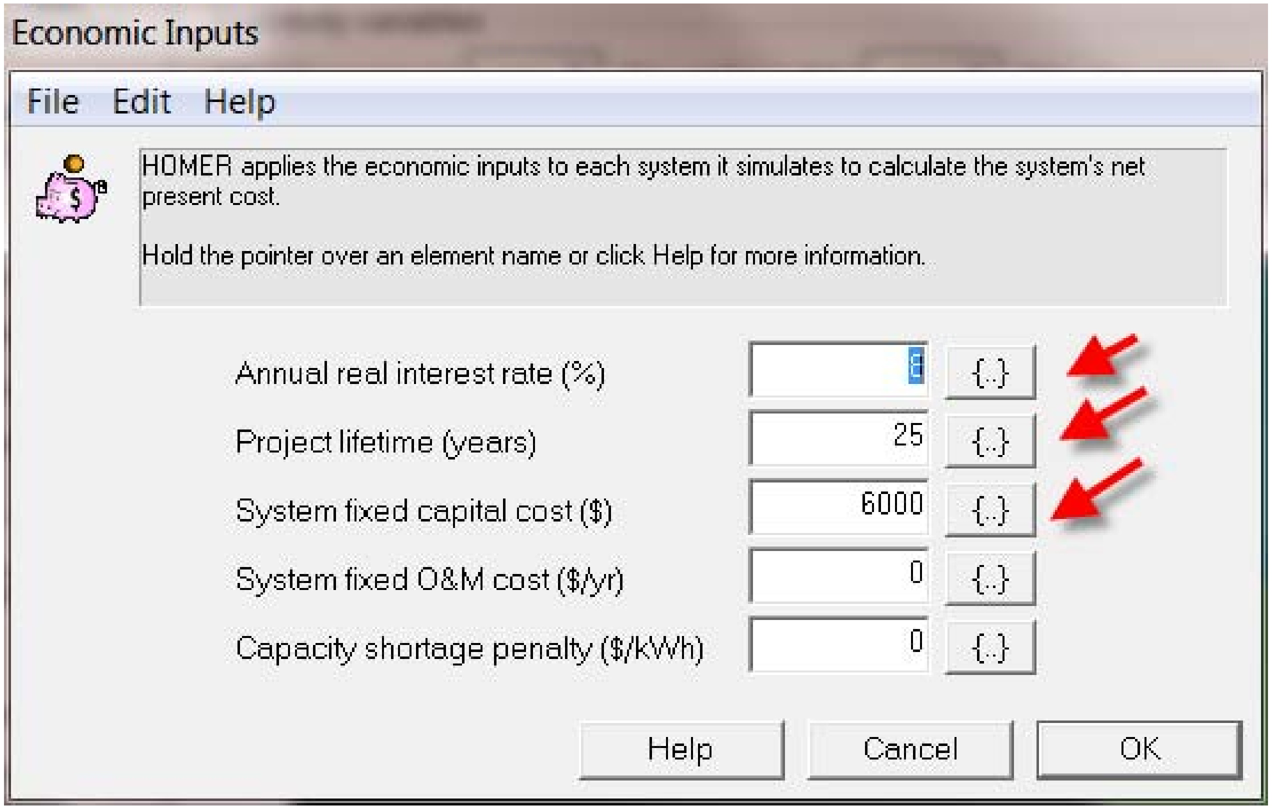
Component: Converter Input

- 10kW
- Cost: $12500, $12500, $100/yr
- [0, 2, 4, 6, 8kW] for sensitivity analysis
- Inversion Efficiency 90%
- Rectification Efficiency 85%



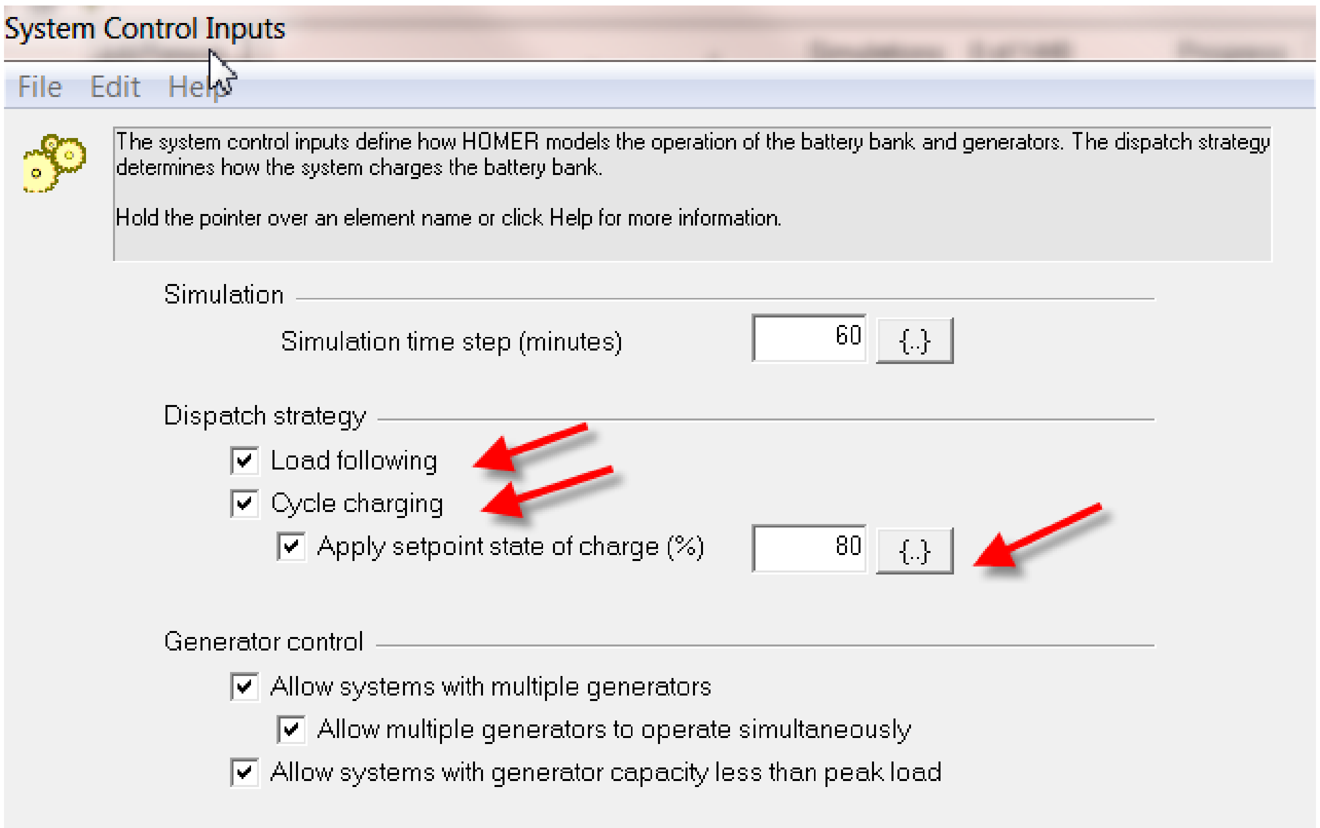
Other: Economics

- Real annual interest: 8%
- Project Lifetime: 25 years
- System fixed cost: $6000
  - It represents balance of system and distribution system costs that cannot be allocated to a specific component.



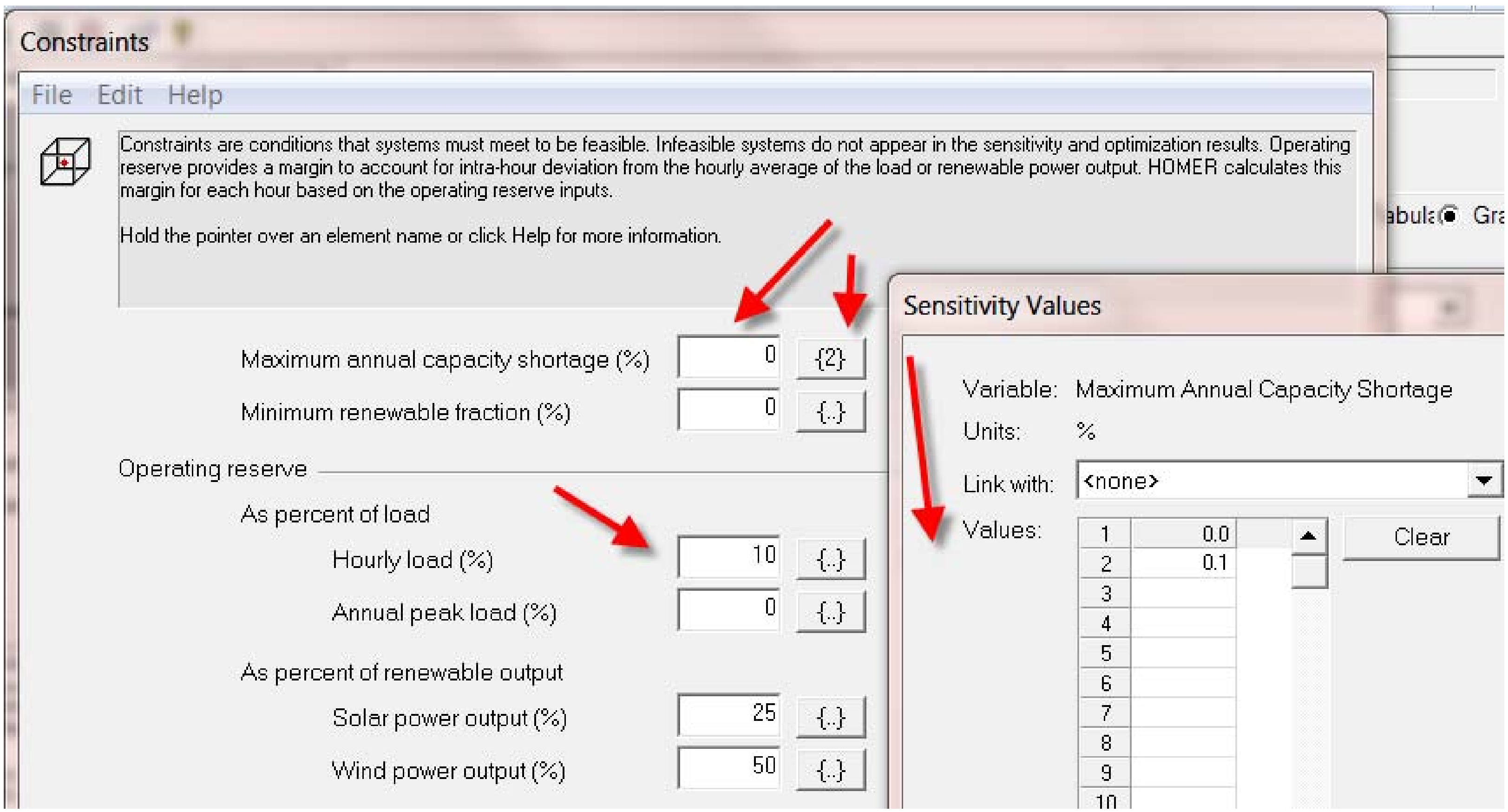
Other: System Control

- Simulation Time Step: 1 hr (60 min)
- Dispatch Strategies:
  - load following
  - cycle charging
    - Charge state set point: 80%



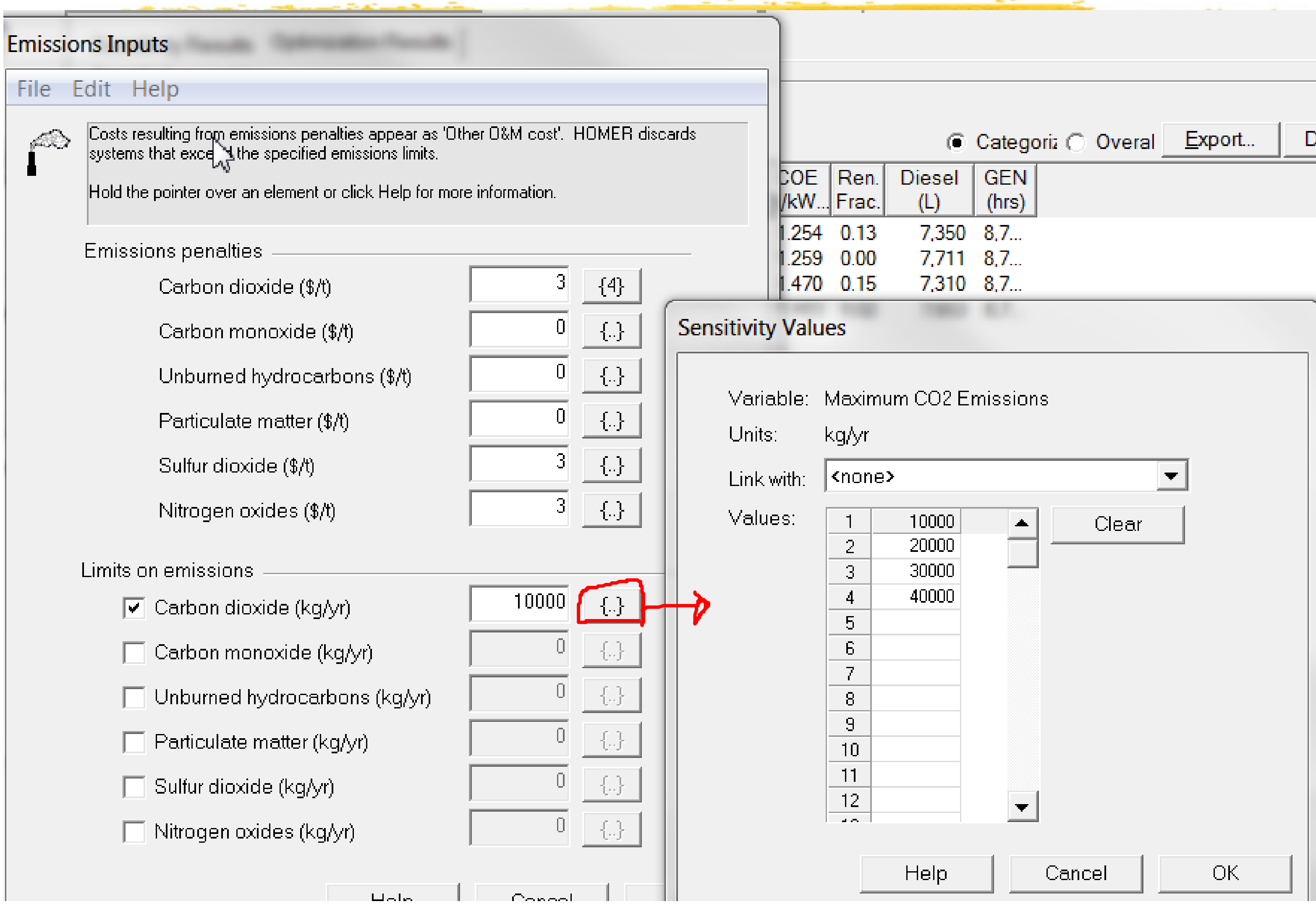
Other: Constraints Input

- Max annual capacity storage: 0% [0.0, 0.1] for sensitivity analysis
- Operating Reserve: 10% of hourly load



Emission Input (Optional)

⌘CO2 Emission Limit



Simulation

- Calculate: Optimization Result
- Categorized

Sensitivity Results | Optimization Results

Sensitivity variables

Wind Speed (m/s) 3 Diesel Price ($/L) 0.3 Max. Annual Capacity Shortage (%) 0

Double click on a system below for simulation results. ◉ Categoriz ○ Overal Export... Details...

	PV (kW)	G3	Dsl (kW)	S6CS2...	Conv. (kW)	Disp. Strgy	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kW...	Ren. Frac.	Capacity Shorta..	Diesel (L)	Dsl (hrs)
			2	10	2	CC	1	$ 22,125	3,152	$ 55,776	0.409	0.00	0.00	2,904	4,400
	2		2	10	2	CC	1	$ 35,925	2,670	$ 64,428	0.472	0.22	0.00	2,031	3,077
		1	2	10	2	CC	1	$ 33,125	3,401	$ 69,434	0.509	0.06	0.00	2,646	4,009
	2	1	2	10	2	CC	1	$ 46,925	2,927	$ 78,175	0.573	0.28	0.00	1,796	2,721

- Overall

Sensitivity Results | Optimization Results

Sensitivity variables

Wind Speed (m/s) 3 Diesel Price ($/L) 0.3 Max. Annual Capacity Shortage (%) 0

Double click on a system below for simulation results. ○ Categoriz ◉ Overal Export... Details

	PV (kW)	G3	Dsl (kW)	S6CS2...	Conv. (kW)	Disp. Strgy	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kW...	Ren. Frac.	Capacity Shortage	Diesel (L)	Dsl (hrs)
			2	10	2	CC	1	$ 22,125	3,152	$ 55,776	0.409	0.00	0.00	2,904	4,400
			2	10	4	CC	1	$ 24,625	3,204	$ 58,824	0.431	0.00	0.00	2,921	4,426
	2		2	10	2	CC	1	$ 35,925	2,670	$ 64,428	0.472	0.22	0.00	2,031	3,077
			2	10	6	CC	1	$ 27,125	3,613	$ 65,693	0.482	0.00	0.00	4,660	7,061
	2		4	10	2	LF	1	$ 37,550	2,917	$ 68,686	0.504	0.16	0.00	4,883	3,699
			2	10	8	CC	1	$ 29,625	3,693	$ 69,048	0.506	0.00	0.00	4,929	7,468
		1	2	10	2	CC	1	$ 33,125	3,401	$ 69,434	0.509	0.06	0.00	2,646	4,009
	2		2	10	4	CC	1	$ 38,425	3,107	$ 71,592	0.525	0.17	0.00	3,708	5,618
	2		4	10	4	LF	1	$ 40,050	3,002	$ 72,101	0.529	0.16	0.00	4,723	3,578
		1	2	10	4	CC	1	$ 35,625	3,450	$ 72,454	0.531	0.06	0.00	2,660	4,031

Result: Electrical & Cash Flow

Simulation Results

System Architecture: 1 kW Grid, 2 kW Diesel, 10 Surrette 6CS25P, 2 kW Inverter, 2 kW Rectifier, Cycle Charging

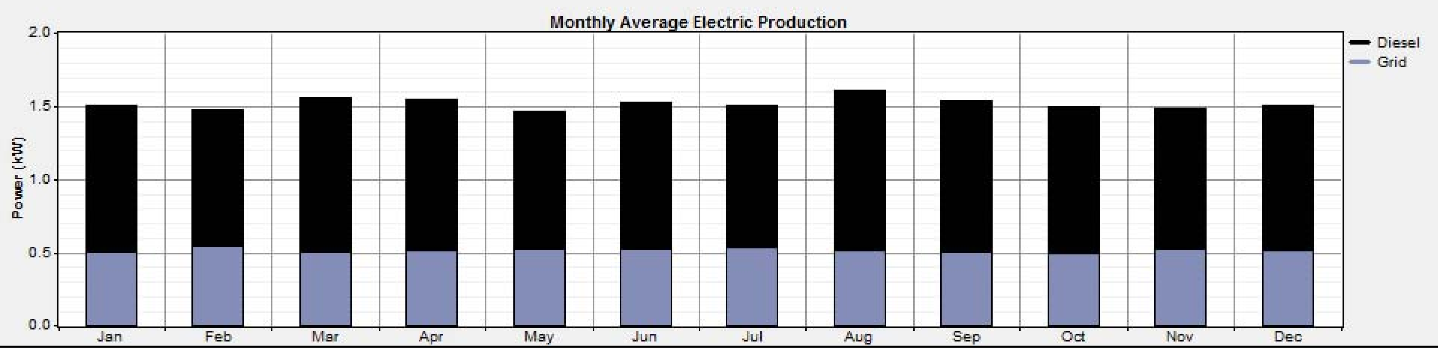
Total NPC: $ 55,776
Levelized COE: $ 0.409/kWh
Operating Cost: $ 3,152/yr

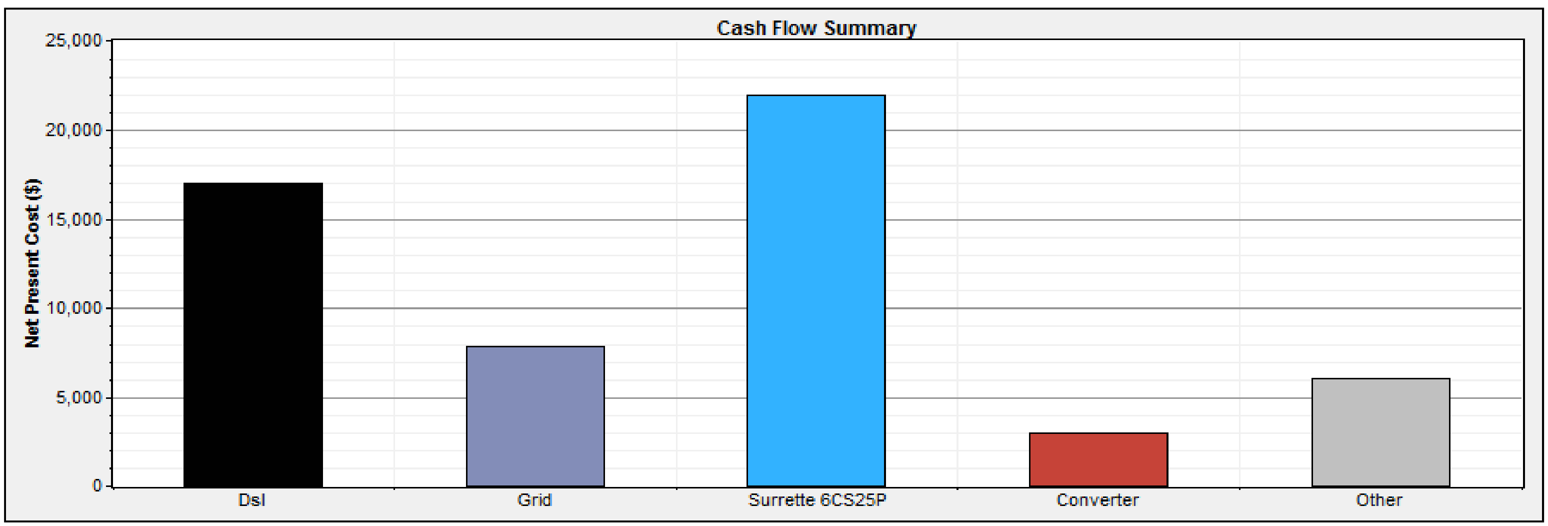
Cost Summary | Cash Flow | Electrical | Dsl | Battery | Converter | Grid | Emissions | Hourly Data

Production	kWh/yr	%
Diesel	8,800	66
Grid purchases	4,510	34
Total	13,310	100

Consumption	kWh/yr	%
AC primary load	12,775	100
Grid sales	14	0
Total	12,789	100

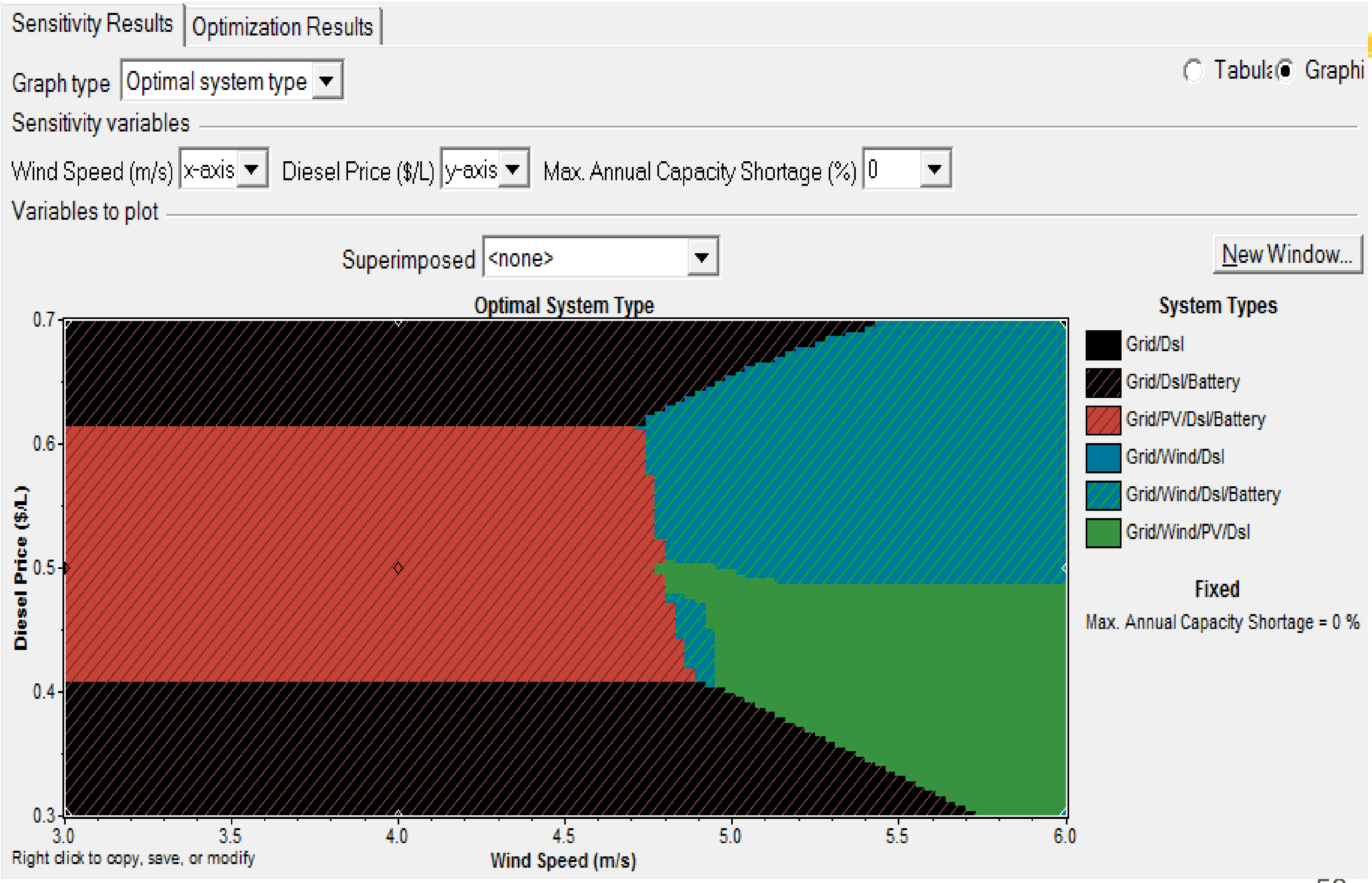
Quantity	kWh/yr	%
Excess electricity	0.0000127	0.00
Unmet electric load	0.00	0.00
Capacity shortage	0.00	0.00





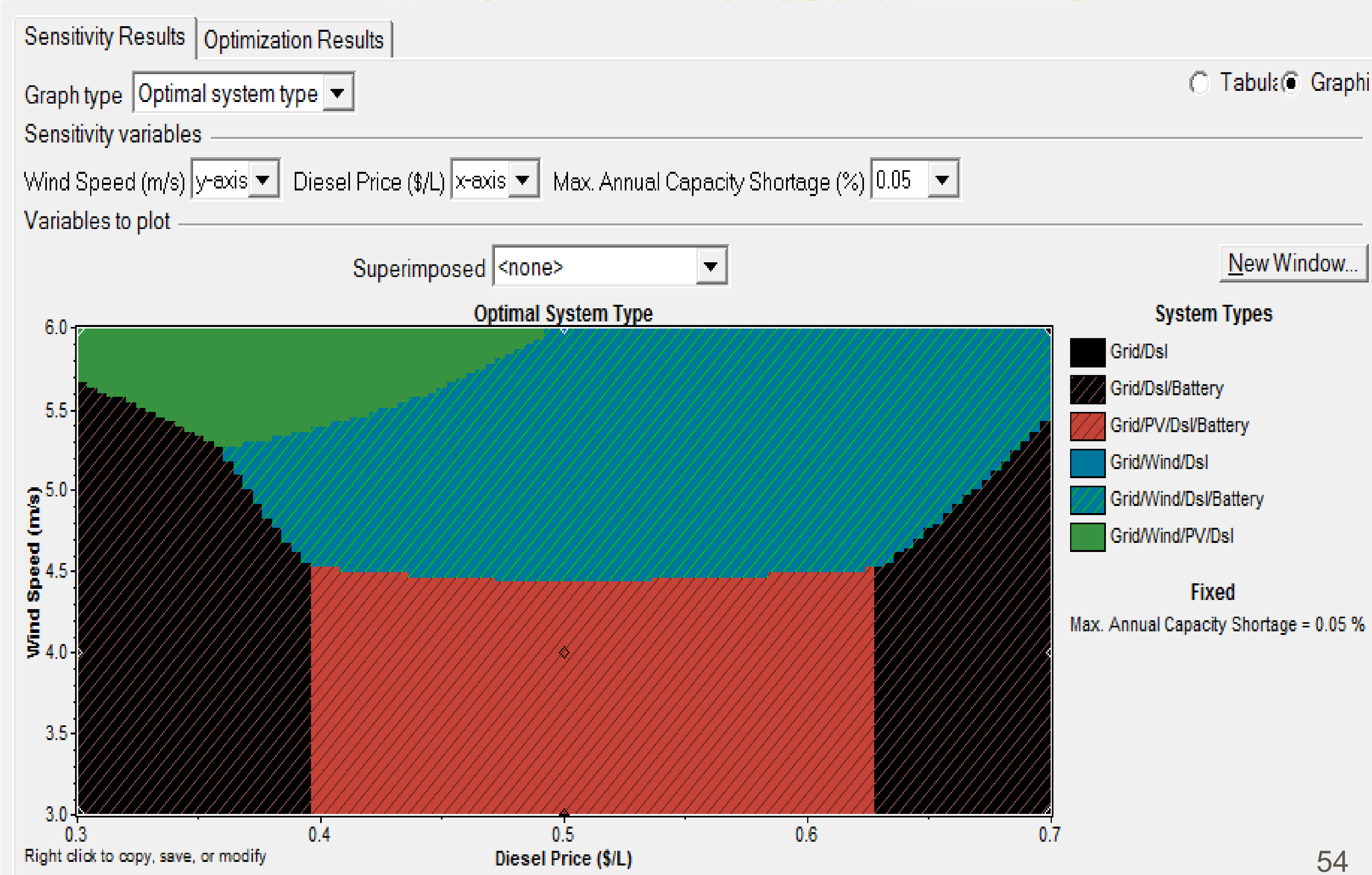
Sensitivity Analysis

⌘ Wind Speed (x) vs. Diesel Price with 0% capacity shortage

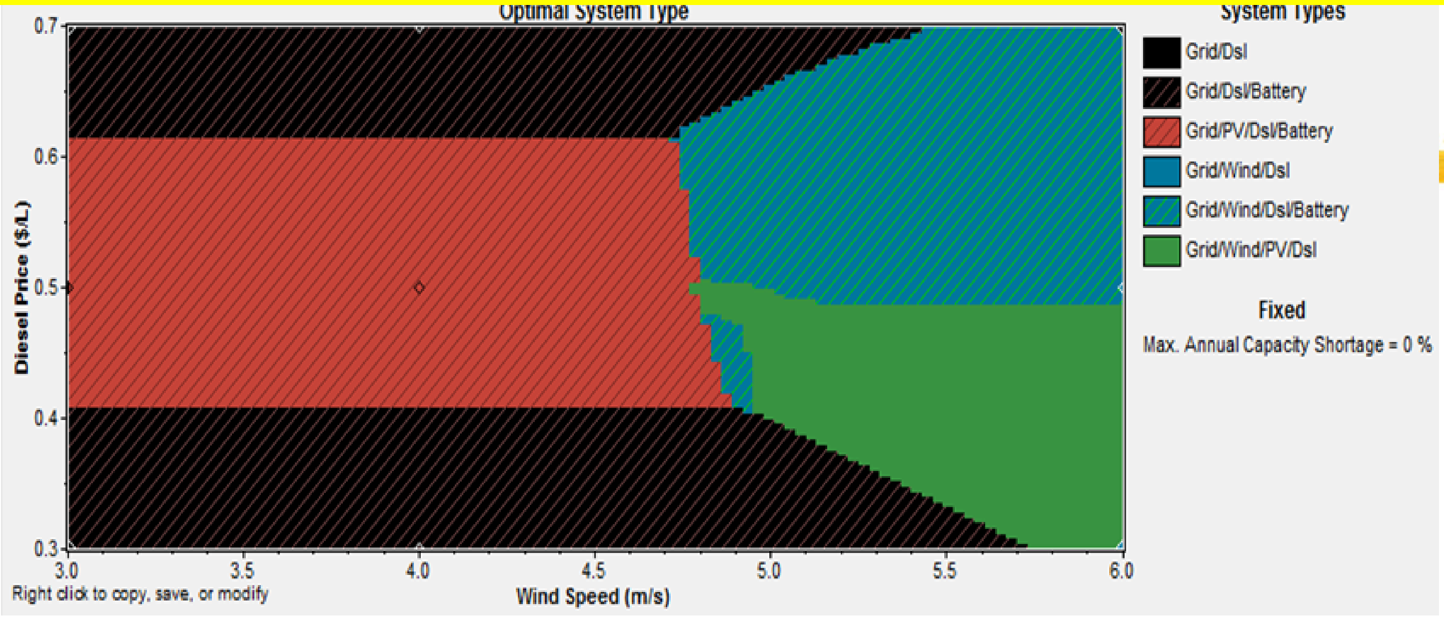


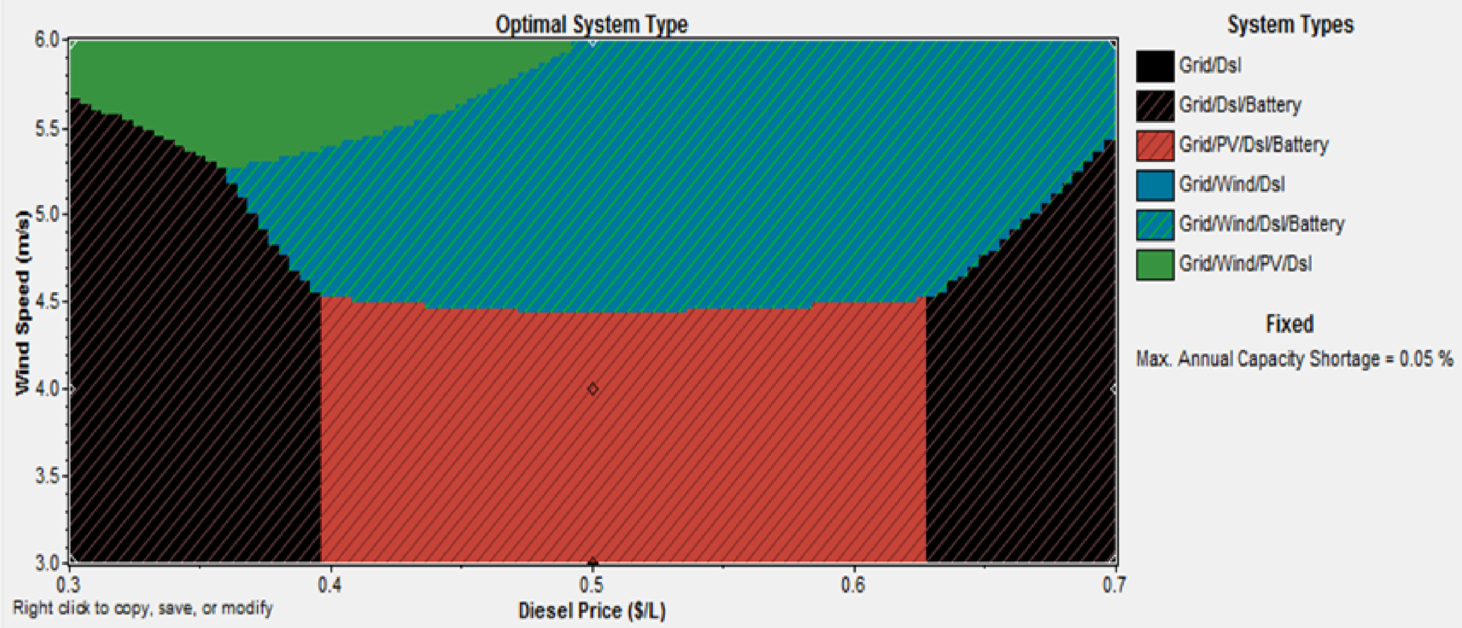
Sensitivity Analysis

- Diesel Price(x) vs. Wind Speed (y) with 0.05% capacity shortage



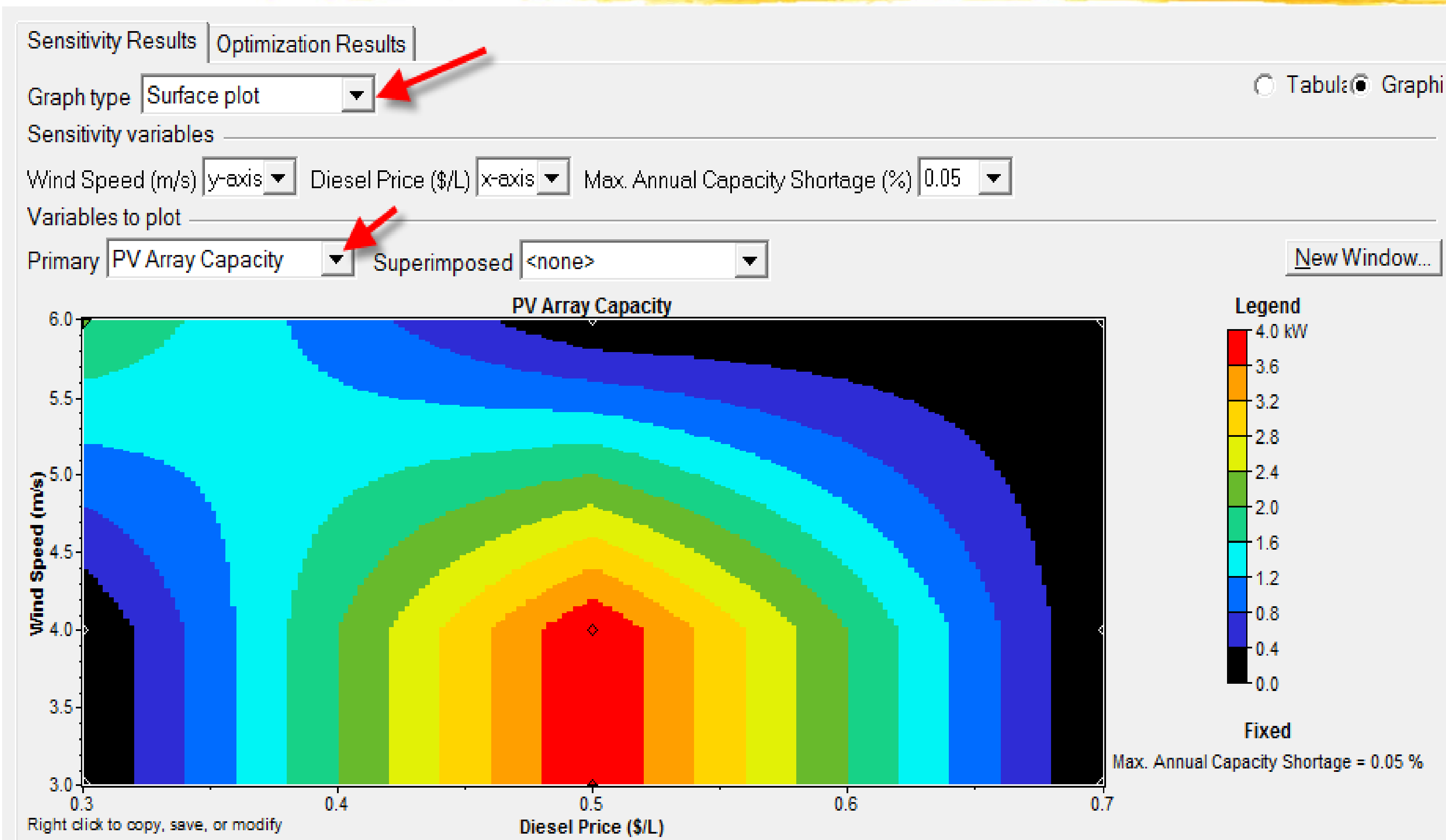
Capacity Shortage Impact





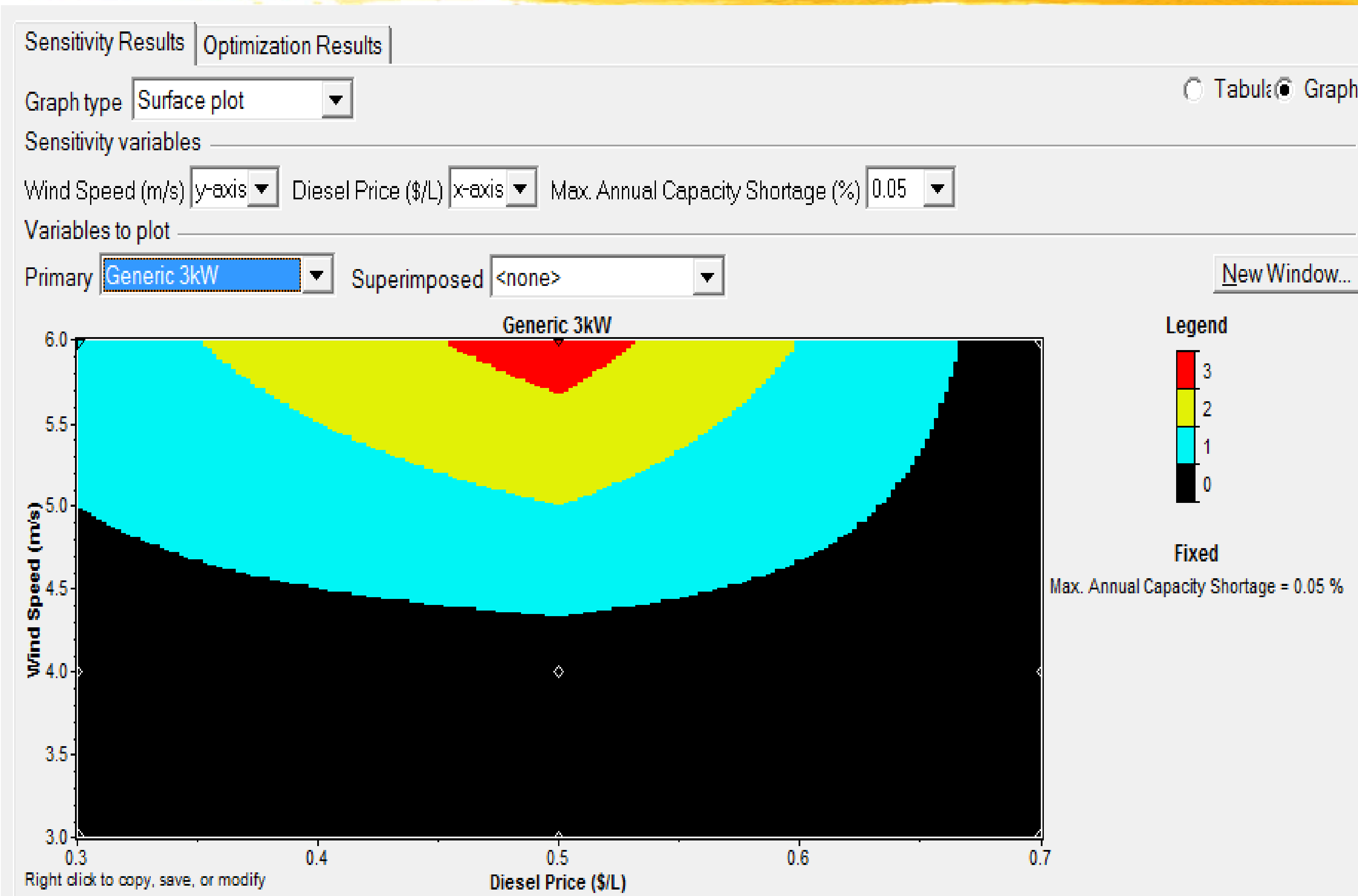
Surface Plot View

⌘ PV Array Capacity



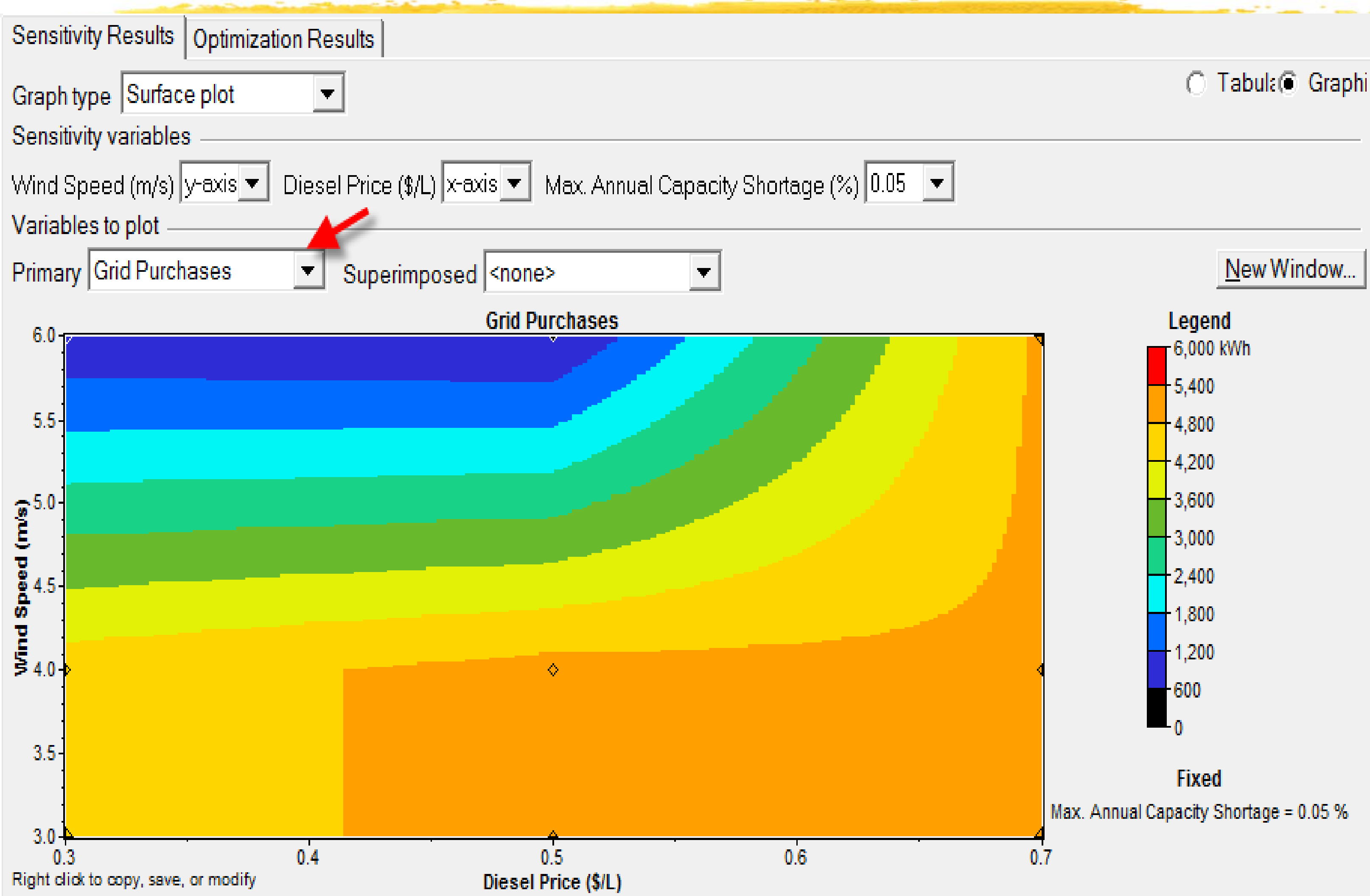
Surface Plot View

⌘ Wind Power



Surface Plot View

⌘ Grid Purchase



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)