U.S. ARMY RDECOM

energy & environmental lab

Presented to:

Energy Forum

HOMER Energy Simulation Demonstration

AMRDEC

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Presented by:

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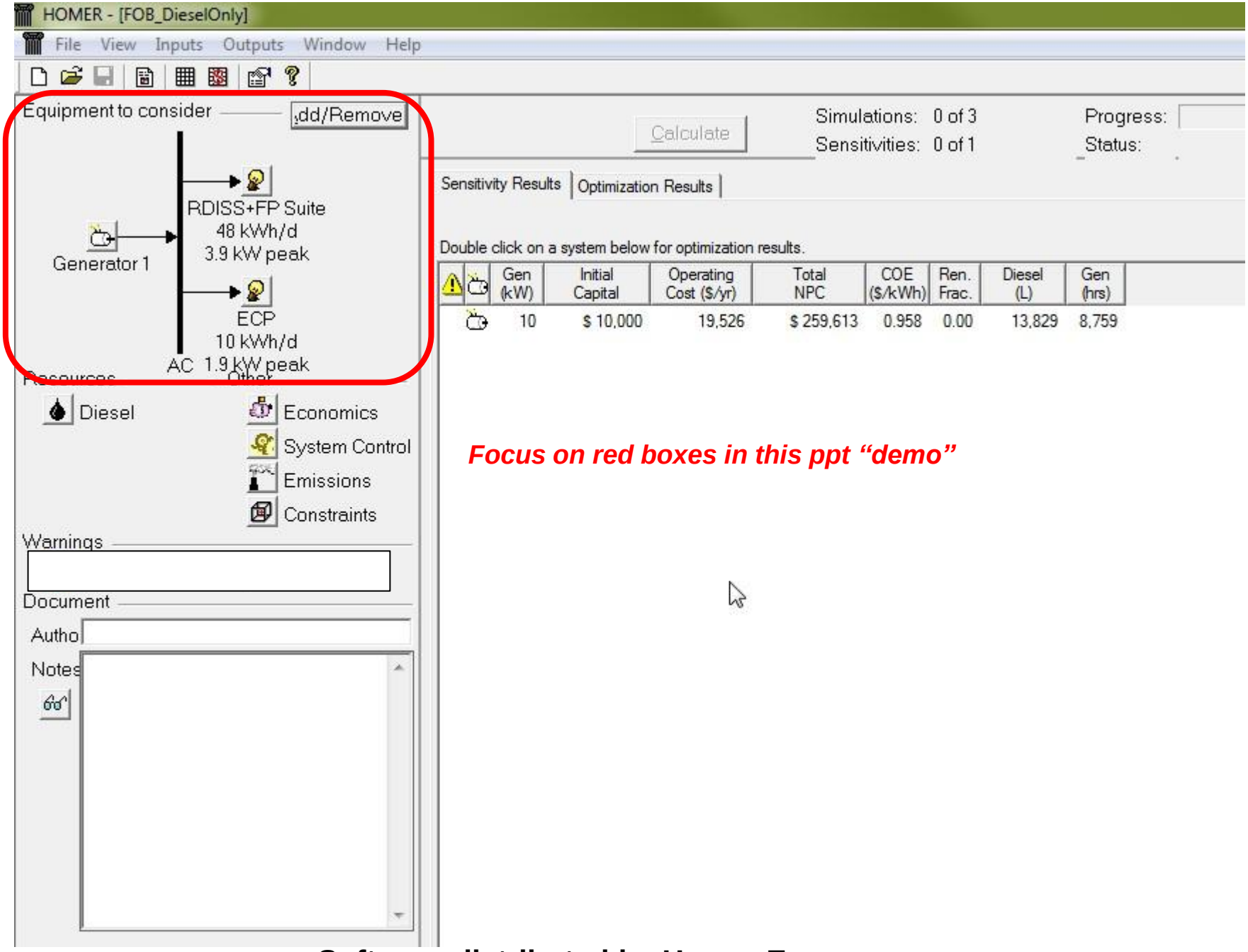
August 2013

HOMER Energy Simulation Tool Demo

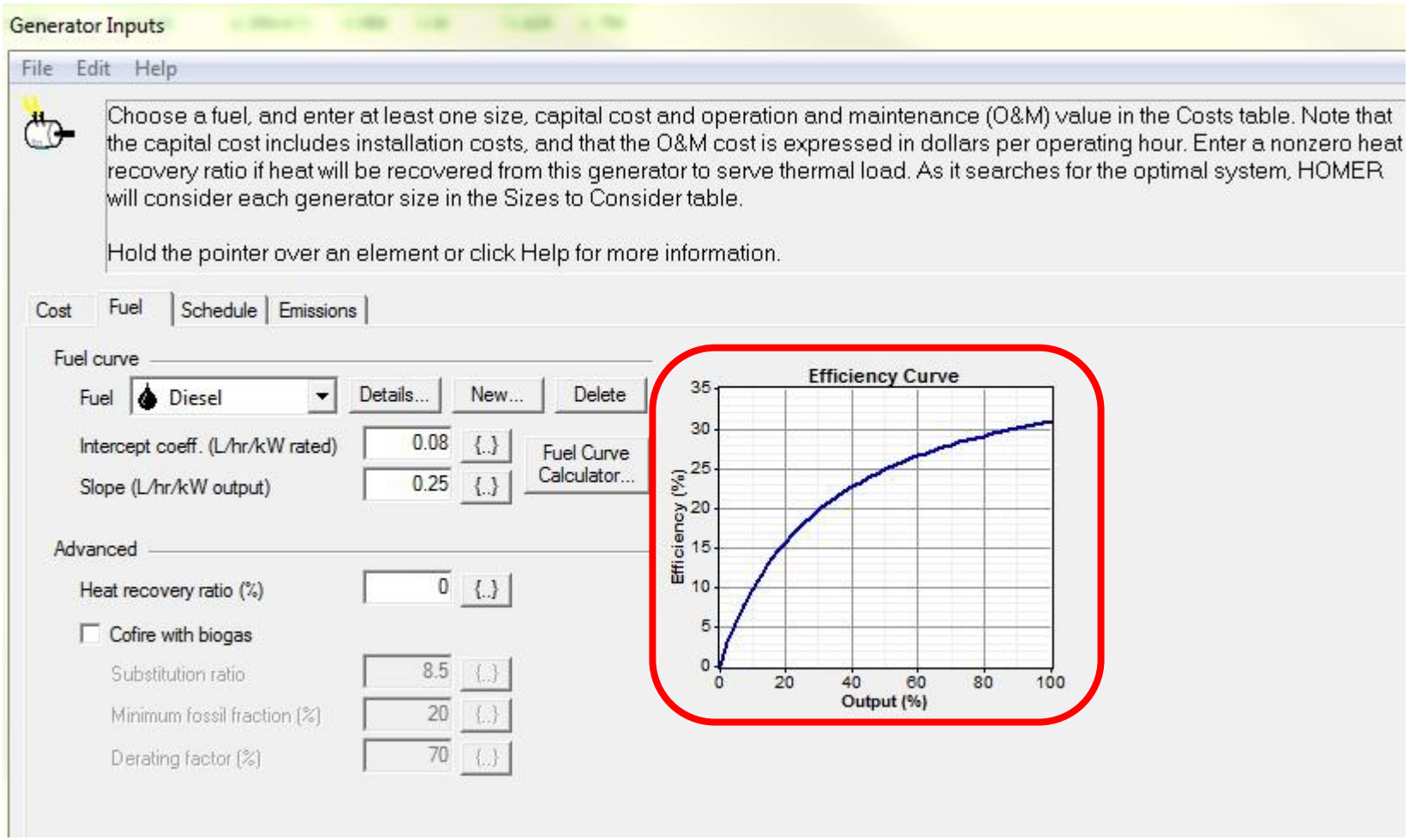
Setting the stage

- **Terminology**
  - **Power Watts, kilowatts (kW)**
  - **Energy kilowatt hours (kW hr), or British Thermal Unit (BTU)**

- **This Example Application of Homer vs Other Uses of HOMER**
  - **Not hooked to power grid, such as military forward operating bases**
  - **Similar to some cabins that are off the grid**
  - **HOMER can work grid tied problems too**



Software distributed by Homer Energy


Generator Inputs
File Edit Help
Choose a fuel, and enter at least one size, capital cost and operation and maintenance (O&M) value in the Costs table. Note that the capital cost includes installation costs, and that the O&M cost is expressed in dollars per operating hour. Enter a nonzero heat recovery ratio if heat will be recovered from this generator to serve thermal load. As it searches for the optimal system, HOMER will consider each generator size in the Sizes to Consider table.
Hold the pointer over an element or click Help for more information.
Cost
Fuel
Schedule
Emissions
Fuel curve
Fuel
Diesel
Details...
New...
Delete
Intercept coeff. (L/hr/kW rated)
0.08
Slope (L/hr/kW output)
0.25
Fuel Curve Calculator...
Advanced
Heat recovery ratio (%)
0
Cofire with biogas
Substitution ratio
8.5
Minimum fossil fraction (%)
20
Derating factor (%)
70
Efficiency Curve
Efficiency (%)
Output (%)
0
5
10
15
20
25
30
35
0
20
40
60
80
100

Generator Inputs

File Edit Help

Choose a fuel, and enter at least one size, capital cost and operation and maintenance (O&M) value in the Costs table. Note that the capital cost includes installation costs, and that the O&M cost is expressed in dollars per operating hour. Enter a nonzero heat recovery ratio if heat will be recovered from this generator to serve thermal load. As it searches for the optimal system, HOMER will consider each generator size in the Sizes to Consider table.

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

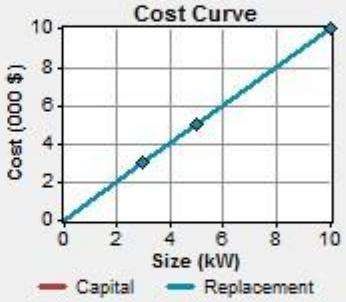
Cost | Fuel | Schedule | Emissions

Costs

Size (kW)	Capital ($)	Replacement ($)	O&M ($/hr
3.000	3000	3000	0.100
5.000	5000	5000	0.167
10.000	10000	10000	0.334
	{..}	{..}	{..}

Sizes to consider

Size (kW)
3.000
5.000
10.000



Properties

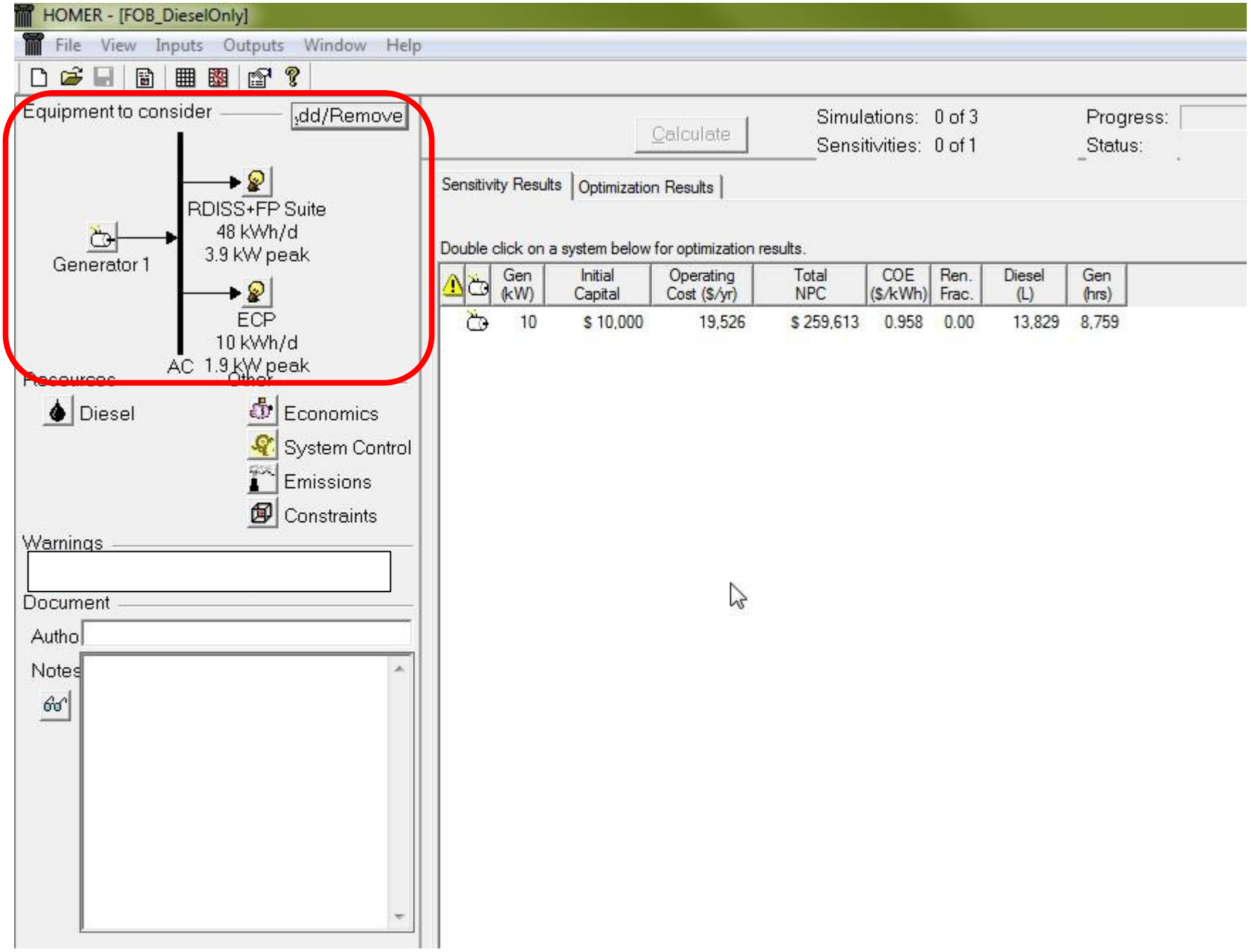
Description: Generator 1 Type: (•) AC ( ) DC

Abbreviation: Gen

Lifetime (operating hours): 15000 {..}

Minimum load ratio (%): 30 {..}

Help Cancel OK


HOMER - [FOB_DieselOnly]
File View Inputs Outputs Window Help
Equipment to consider
dd/Remove
RDISS+FP Suite
48 kWh/d
3.9 kW peak
Generator 1
ECP
10 kWh/d
AC 1.9 kW peak
Diesel
Economics
System Control
Emissions
Constraints
Warnings
Document
Autho
Notes
Calculate
Simulations: 0 of 3
Sensitivities: 0 of 1
Progress:
Status:
Sensitivity Results
Optimization Results
Double click on a system below for optimization results.
Gen (kW) | Initial Capital | Operating Cost ($/yr) | Total NPC | COE ($/kWh) | Ren. Frac. | Diesel (L) | Gen (hrs)
10 | $ 10,000 | 19,526 | $ 259,613 | 0.958 | 0.00 | 13,829 | 8,759

Primary Load Inputs

File Edit Help

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: RDISS+FP Suite

Load type: (•) AC ( ) DC

Data source: (•) Enter daily profile(s) ( ) Import time series data file

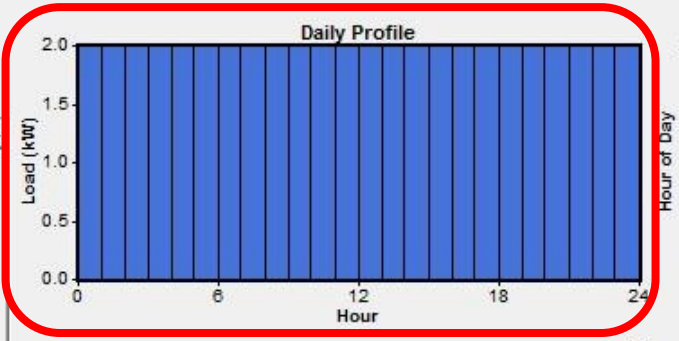
Import File...

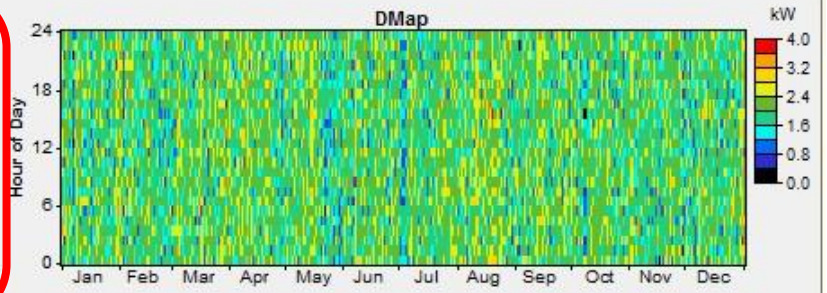
Baseline data

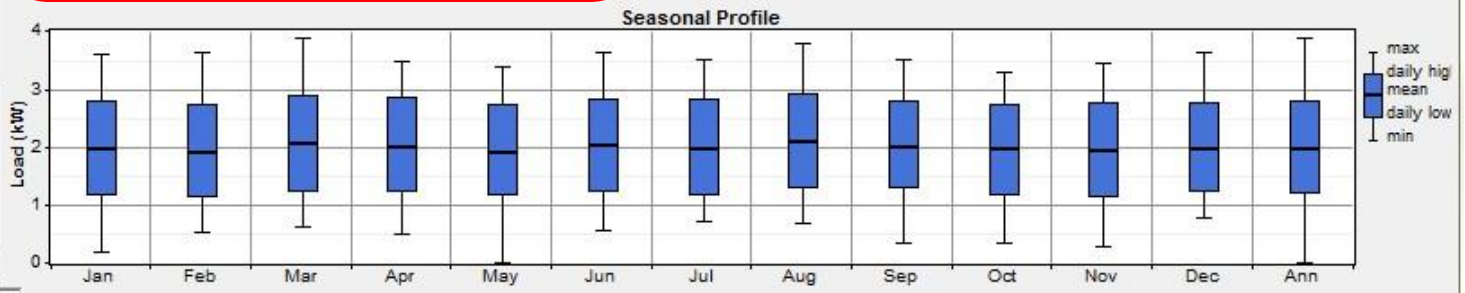
Month: January

Day type: Weekday

Hour	Load (kW)
00:00 - 01:00	2.000
01:00 - 02:00	2.000
02:00 - 03:00	2.000
03:00 - 04:00	2.000
04:00 - 05:00	2.000
05:00 - 06:00	2.000
06:00 - 07:00	2.000
07:00 - 08:00	2.000
08:00 - 09:00	2.000
09:00 - 10:00	2.000
10:00 - 11:00	2.000
11:00 - 12:00	2.000
12:00 - 13:00	2.000
13:00 - 14:00	2.000
14:00 - 15:00	2.000







Time step (minutes): 60

Random variability

Day-to-day: 15 %

Time-step-to-time-step: 20 %

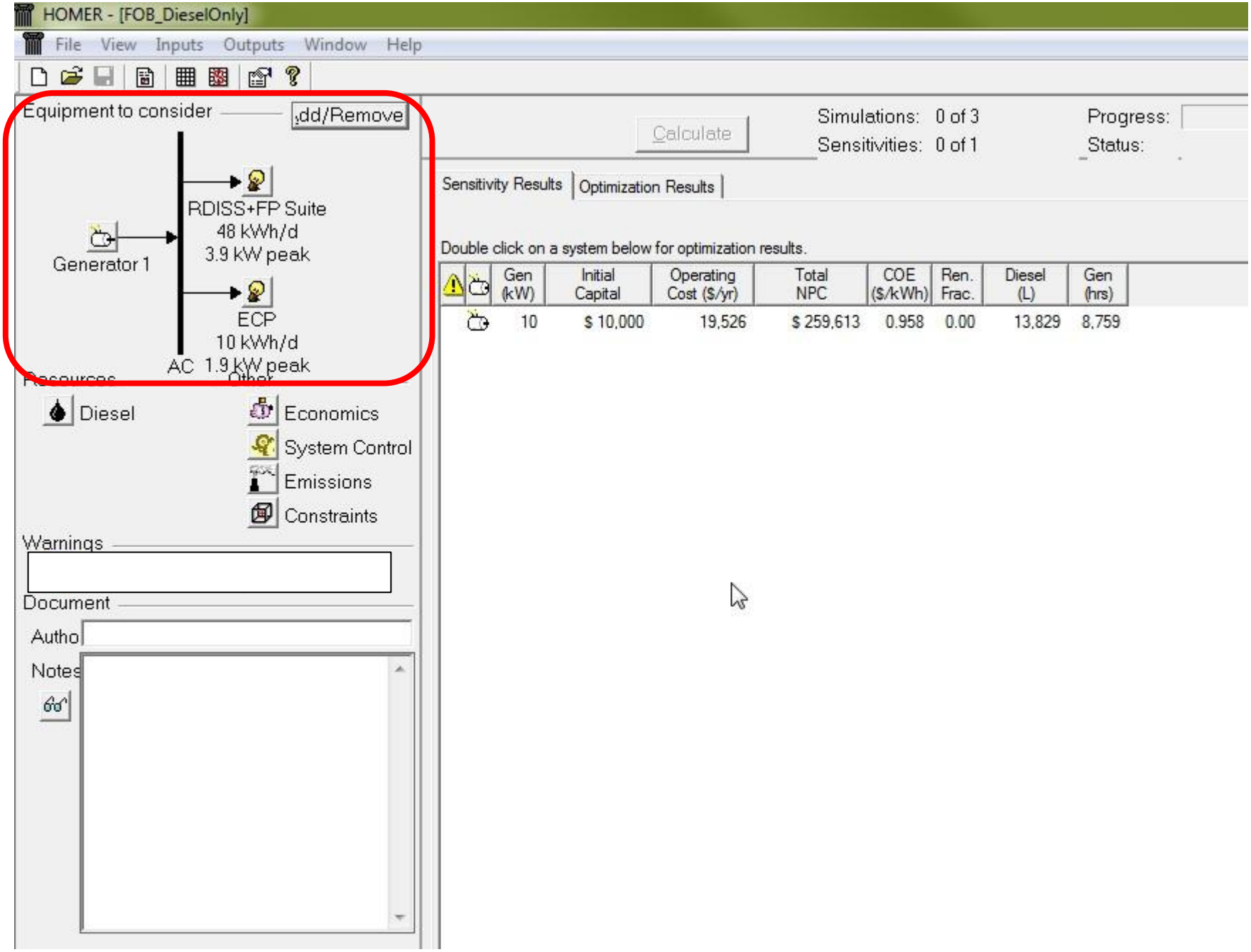
Scaled annual average (kWh/d): 47.6 {..}

	Baseline	Scaled
Average (kWh/	48.0	47.6
Average (kW)	2.00	1.98
Peak (kW)	3.89	3.86
Load factor	0.514	0.514

Efficiency Inputs...

Plot... Export...

Help Cancel OK


HOMER - [FOB_DieselOnly]
File View Inputs Outputs Window Help
Equipment to consider
Add/Remove
RDISS+FP Suite
48 kWh/d
3.9 kW peak
Generator 1
ECP
10 kWh/d
AC 1.9 kW peak
Diesel
Economics
System Control
Emissions
Constraints
Warnings
Document
Autho
Notes
Calculate
Simulations: 0 of 3
Sensitivities: 0 of 1
Progress:
Status:
Sensitivity Results
Optimization Results
Double click on a system below for optimization results.
Gen (kW)
Initial Capital
Operating Cost ($/yr)
Total NPC
COE ($/kWh)
Ren. Frac.
Diesel (L)
Gen (hrs)
10
$ 10,000
19,526
$ 259,613
0.958
0.00
13,829
8,759

Primary Load Inputs

File Edit Help

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: ECP

Load type: (•) AC ( ) DC

Data source: (•) Enter daily profile(s) ( ) Import time series data file

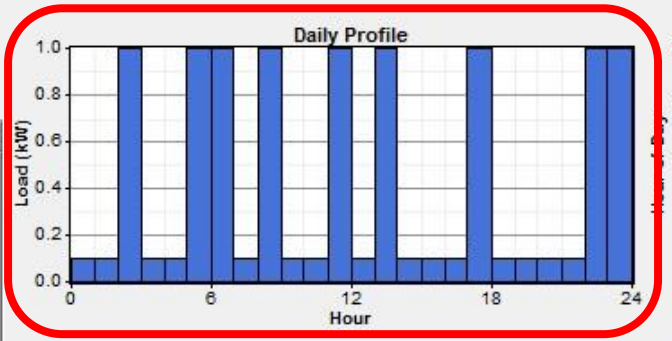
Import File...

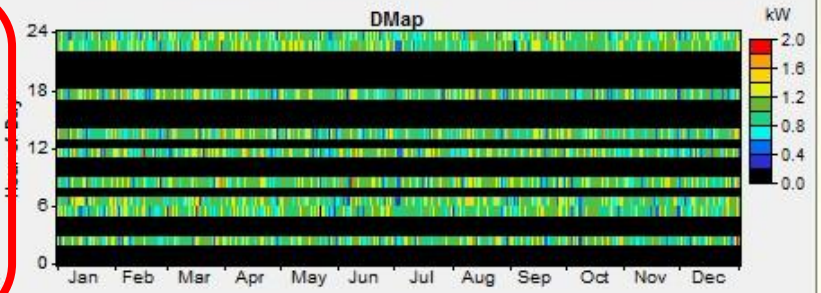
Baseline data

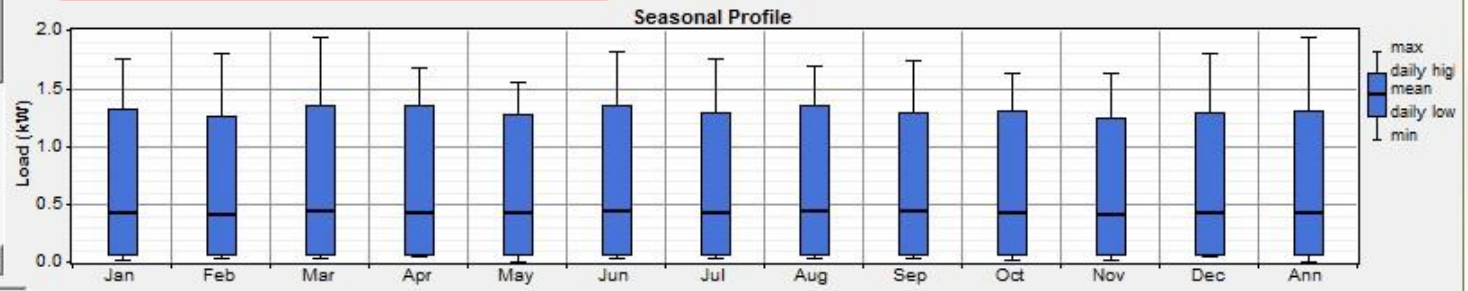
Month: January

Day type: Weekday

Hour	Load (kW)
00:00 - 01:00	0.100
01:00 - 02:00	0.100
02:00 - 03:00	1.000
03:00 - 04:00	0.100
04:00 - 05:00	0.100
05:00 - 06:00	1.000
06:00 - 07:00	1.000
07:00 - 08:00	0.100
08:00 - 09:00	1.000
09:00 - 10:00	0.100
10:00 - 11:00	0.100
11:00 - 12:00	1.000
12:00 - 13:00	0.100
13:00 - 14:00	1.000
14:00 - 15:00	0.100







Time step (minutes): 60

Random variability

Day-to-day: 15 %

Time-step-to-time-step: 20 %

Scaled annual average (kWh/d): 10.5 {..}

	Baseline	Scaled
Average (kWh/	10.5	10.5
Average (kW)	0.438	0.437
Peak (kW)	1.94	1.94
Load factor	0.226	0.226

Efficiency Inputs...

Plot... Export...

Help Cancel OK

Simulation Results

System Architecture: 10 kW Generator 1

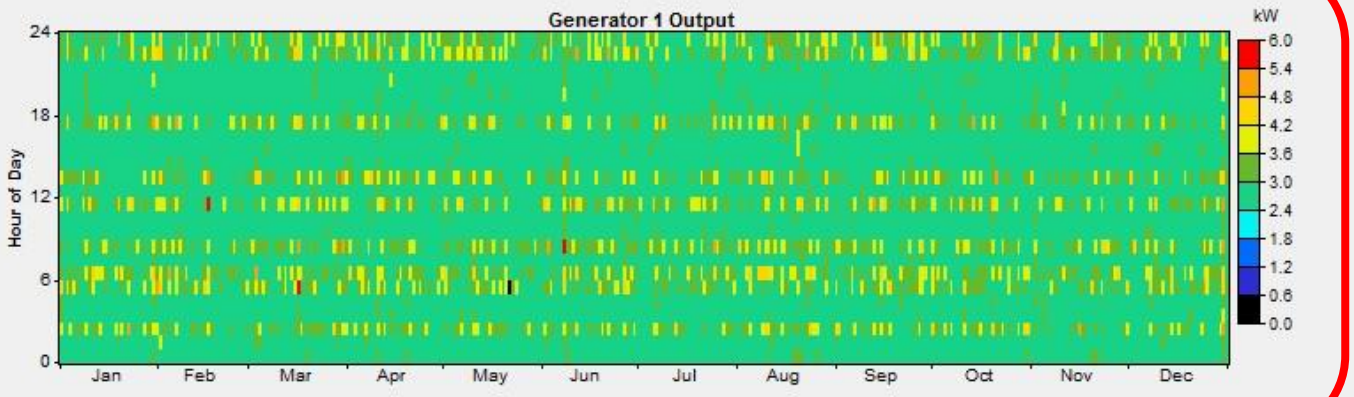
Total NPC: $ 259,613
Levelized COE: $ 0.958/kWh
Operating Cost: $ 19,526/yr

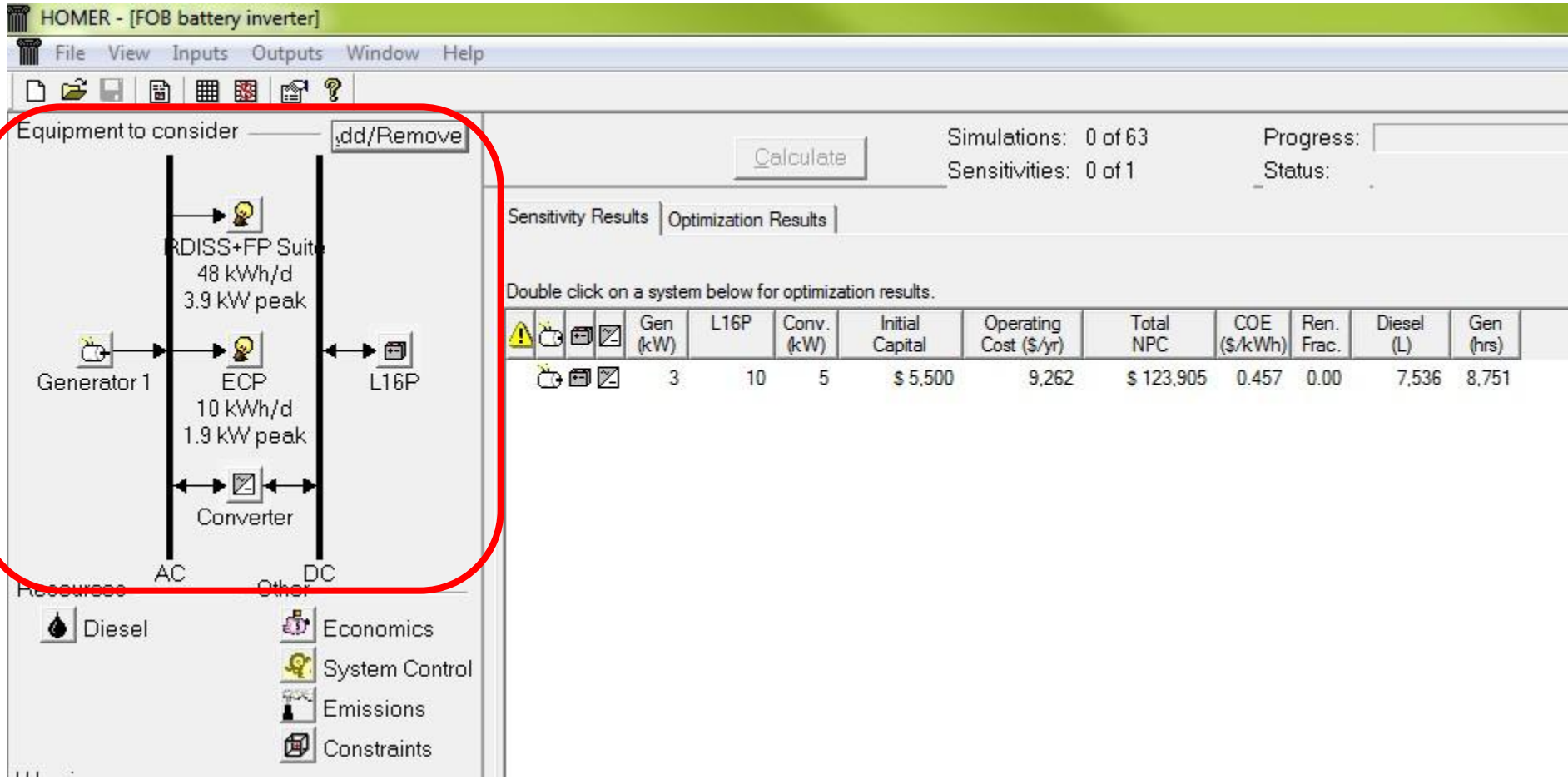
Cost Summary | Cash Flow | Electrical | Gen | Emissions | Time Series

Quantity	Value	Units
Hours of operation	8,759	hr/yr
Number of starts	2	starts/y
Operational life	1.71	yr
Capacity factor	31.2	%
Fixed generation cos	1.64	$/hr
Marginal generation	0.200	$/kWh

Quantity	Value	Units
Electrical productio	27,290	kWh/y
Mean electrical outp	3.12	kW
Min. electrical outpu	3.00	kW
Max. electrical outp	5.79	kW

Quantity	Value	Units
Fuel consumption	13,829	L/yr
[illegible]	[illegible]	[illegible]
Fuel energy input	136,077	kWh/yr
Mean electrical efficie	20.1	%




HOMER - [FOB battery inverter]
File View Inputs Outputs Window Help
Equipment to consider
Add/Remove
RDISS+FP Suite
48 kWh/d
3.9 kW peak
Generator 1
ECP
10 kWh/d
1.9 kW peak
L16P
Converter
AC
DC
Diesel
Economics
System Control
Emissions
Constraints
Calculate
Simulations: 0 of 63
Sensitivities: 0 of 1
Progress:
Status:
Sensitivity Results
Optimization Results
Double click on a system below for optimization results.
Gen (kW) L16P Conv. (kW) Initial Capital Operating Cost ($/yr) Total NPC COE ($/kWh) Ren. Frac. Diesel (L) Gen (hrs)
3 10 5 $ 5,500 9,262 $ 123,905 0.457 0.00 7,536 8,751

Battery Inputs

File Edit Help

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: Trojan L16P | Details... | Copy... | New... | Delete

Battery properties

Manufacturer: Trojan Battery Company
Website: www.trojan-battery.com
Nominal specs: 6 V, 360 Ah, 2.16 kWh
Lifetime throughput: 1,075 kWh

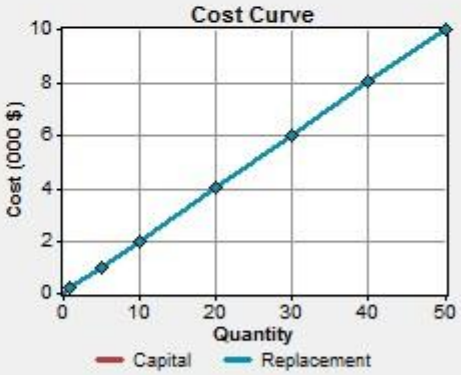
Costs

Quantity	Capital ($)	Replacement ($)	O&M ($/yr
1	200	200	10.00

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

Sizes to consider

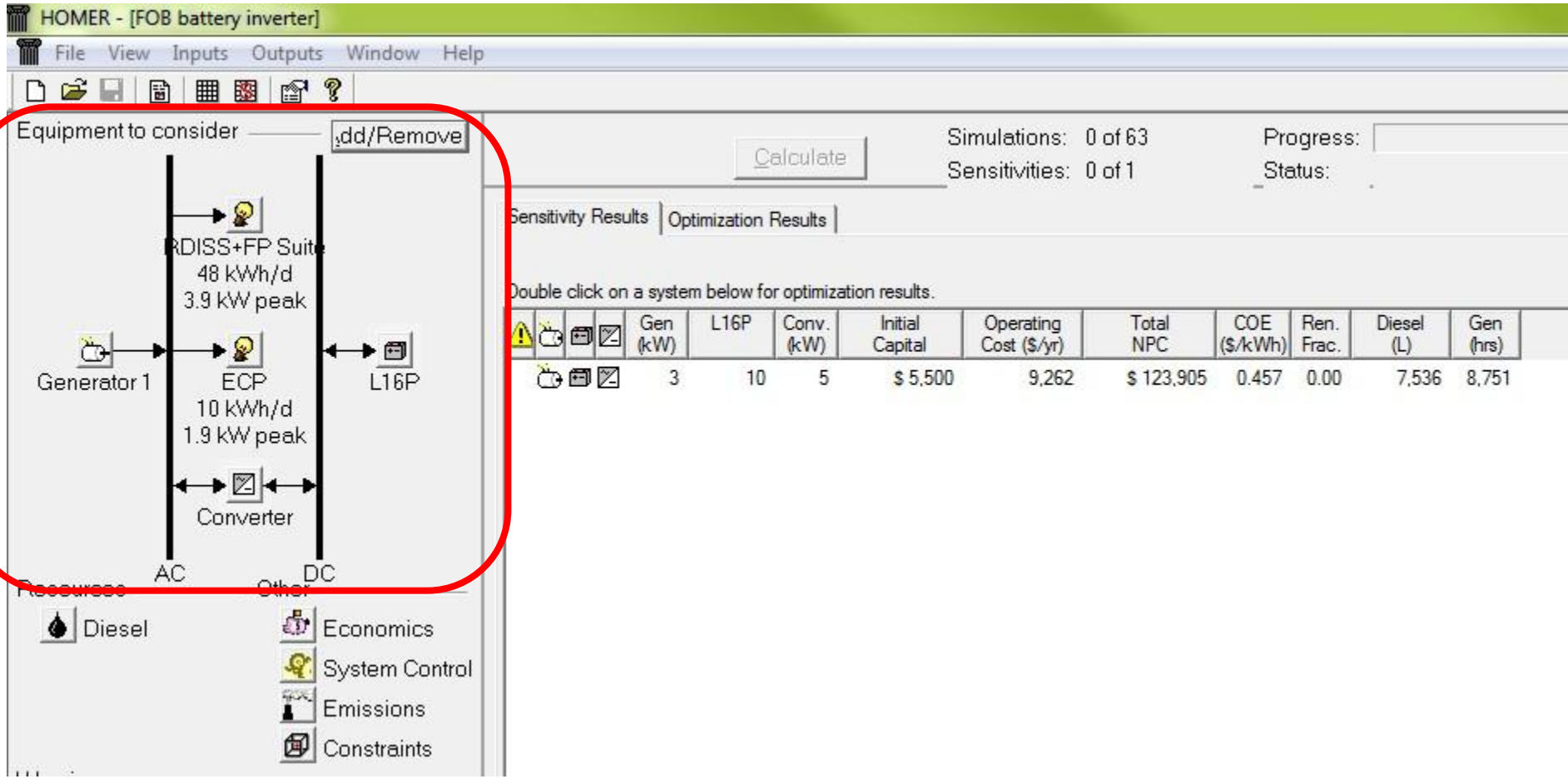
Batteries
1
5
10
20
30
40
50



Advanced

Batteries per string: 1 (6 V bus)
Initial state of charge (%): 100 {..}
Minimum battery life (yr): 4 {..}

Help | Cancel | OK


HOMER - [FOB battery inverter]
File View Inputs Outputs Window Help
Equipment to consider
Add/Remove
RDISS+FP Suite
48 kWh/d
3.9 kW peak
Generator 1
ECP
10 kWh/d
1.9 kW peak
L16P
Converter
AC
DC
Diesel
Economics
System Control
Emissions
Constraints
Calculate
Simulations: 0 of 63
Sensitivities: 0 of 1
Progress:
Status:
Sensitivity Results
Optimization Results
Double click on a system below for optimization results.
Gen (kW) L16P Conv. (kW) Initial Capital Operating Cost ($/yr) Total NPC COE ($/kWh) Ren. Frac. Diesel (L) Gen (hrs)
3 10 5 $ 5,500 9,262 $ 123,905 0.457 0.00 7,536 8,751

Converter Inputs

File Edit Help

A converter is required for systems in which DC components serve an AC load or vice-versa. A converter can be an inverter (DC to AC), rectifier (AC to DC), or both.

Enter at least one size and capital cost value in the Costs table. Include all costs associated with the converter, such as hardware and labor. As it searches for the optimal system, HOMER considers each converter capacity in the Sizes to Consider table. Note that all references to converter size or capacity refer to inverter capacity.

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

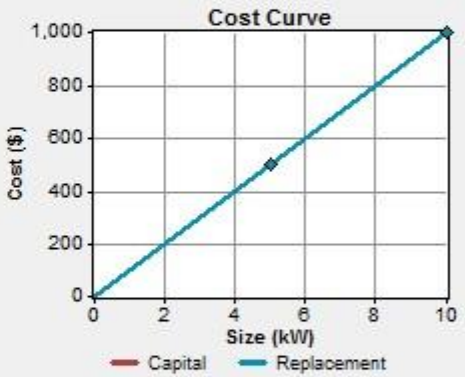
Costs

Size (kW)	Capital ($)	Replacement ($)	O&M ($/yr
5.000	500	500	10

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

Sizes to consider

Size (kW)
0.000
5.000
10.000



Inverter inputs

Lifetime (years) 15 {..}

Efficiency (%) 90 {..}

☑ Inverter can operate simultaneously with an AC generator

Rectifier inputs

Capacity relative to inverter (%) 100 {..}

Efficiency (%) 85 {..}

Help Cancel OK

Simulation Results

System Architecture: 3 kW Generator 1
10 Trojan L16P
5 kW Inverter
5 kW Rectifier
Cycle Charging

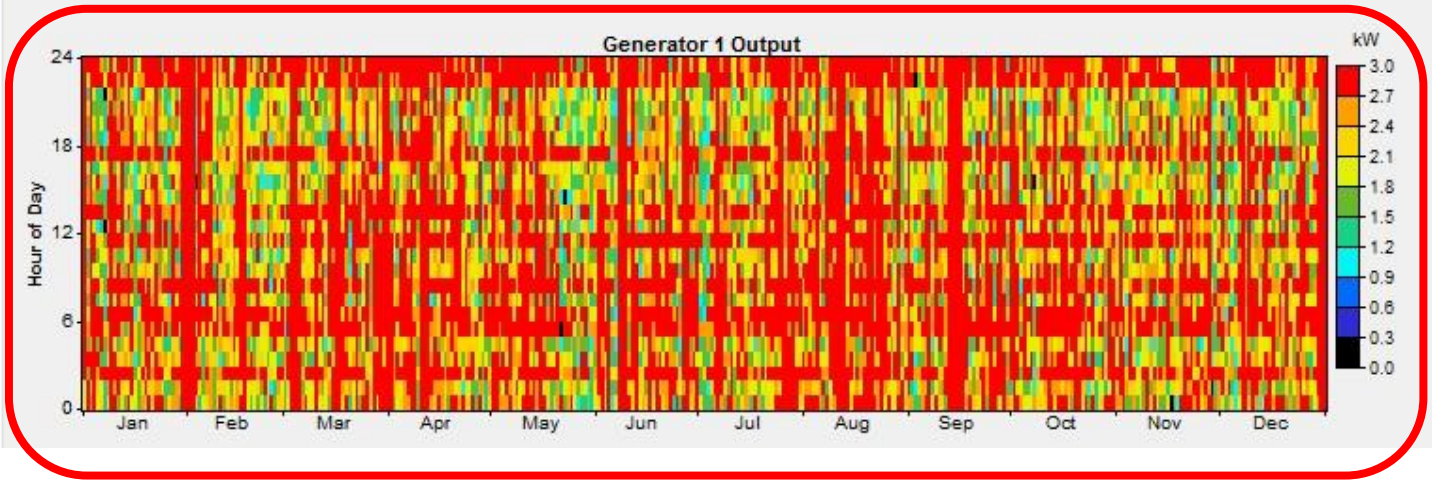
Total NPC: $ 123,905
Levelized COE: $ 0.457/kWh
Operating Cost: $ 9,262/yr

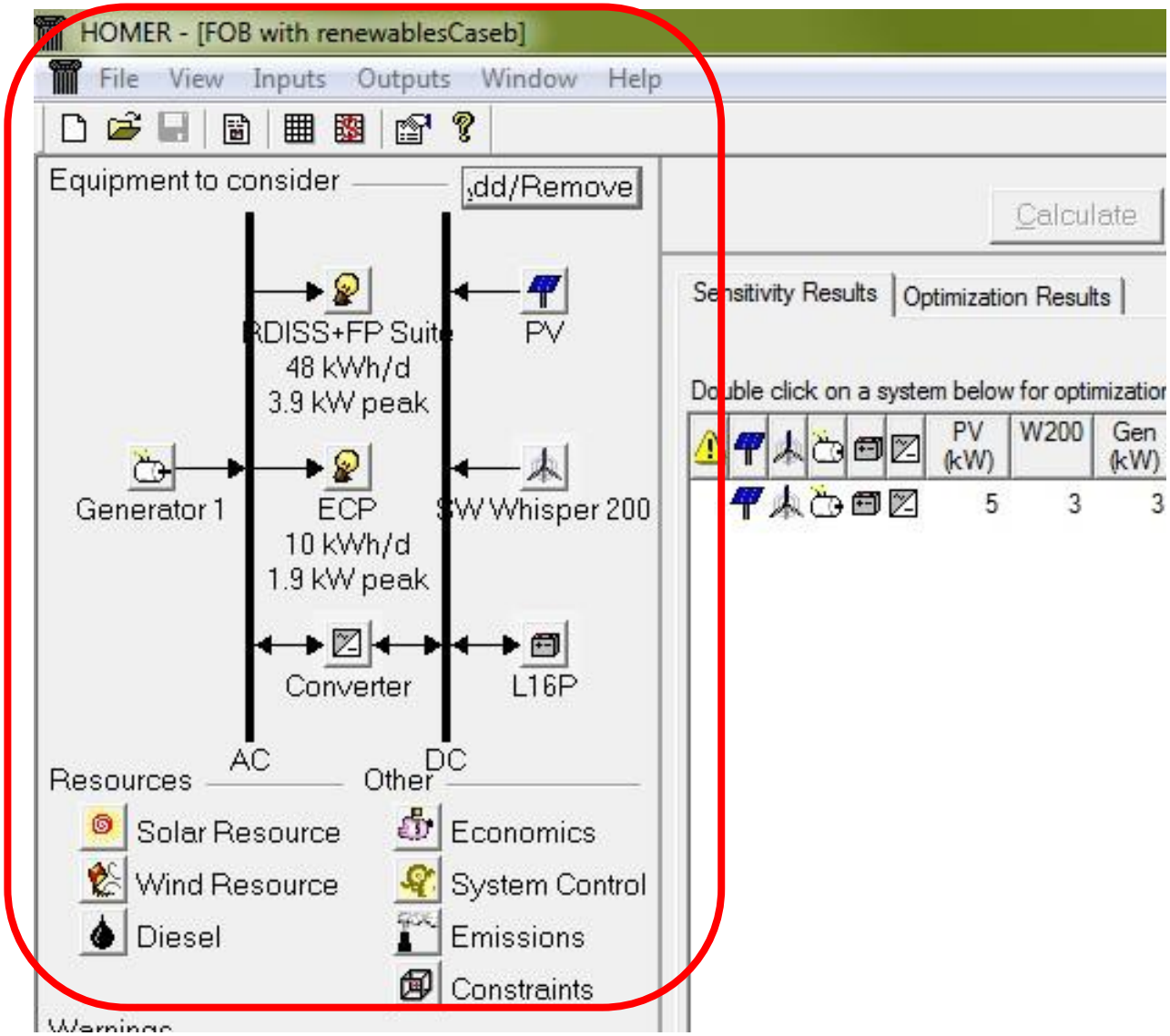
Cost Summary | Cash Flow | Electrical | Gen | Battery | Converter | Emissions | Time Series

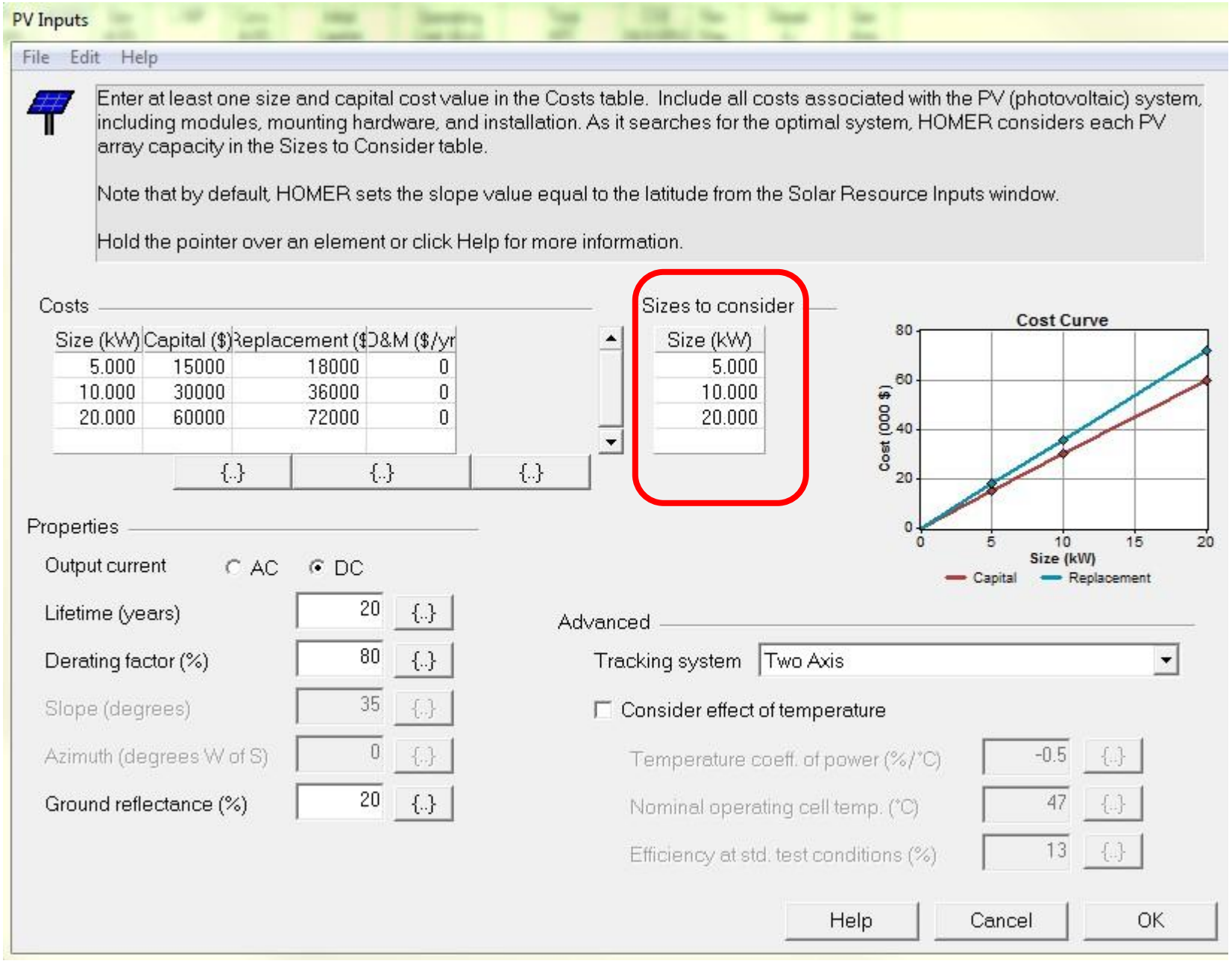
Quantity	Value	Units
Hours of operation	8,751	hr/yr
Number of starts	10	starts/y
Operational life	1.71	yr
Capacity factor	82.7	%
Fixed generation cos	0.492	$/hr
Marginal generation	0.200	$/kWh

Quantity	Value	Units
Electrical productio	21,743	kWh/y
Mean electrical outp	2.48	kW
Min. electrical outpu	0.900	kW
Max. electrical outp	3.00	kW

Quantity	Value	Units
Fuel consumption	7,536	L/yr
Specific fuel consum	0.347	L/kWh
Fuel energy input	74,158	kWh/yr
Mean electrical efficie	29.3	%




HOMER - [FOB with renewablesCaseb]
File View Inputs Outputs Window Help
Equipment to consider
Add/Remove
Calculate
RDISS+FP Suite
48 kWh/d
3.9 kW peak
PV
Generator 1
ECP
10 kWh/d
1.9 kW peak
SW Whisper 200
Converter
L16P
AC
DC
Resources
Other
Solar Resource
Wind Resource
Diesel
Economics
System Control
Emissions
Constraints
Sensitivity Results
Optimization Results
Double click on a system below for optimization
PV (kW)
W200
Gen (kW)
5
3
3


PV Inputs
File Edit Help
Enter at least one size and capital cost value in the Costs table. Include all costs associated with the PV (photovoltaic) system, including modules, mounting hardware, and installation. As it searches for the optimal system, HOMER considers each PV array capacity in the Sizes to Consider table.
Note that by default, HOMER sets the slope value equal to the latitude from the Solar Resource Inputs window.
Hold the pointer over an element or click Help for more information.
Costs
Size (kW) Capital ($) Replacement ($) O&M ($/yr
5.000 15000 18000 0
10.000 30000 36000 0
20.000 60000 72000 0
{..} {..} {..}
Sizes to consider
Size (kW)
5.000
10.000
20.000
Cost Curve
Cost (000 $)
Size (kW)
Capital
Replacement
Properties
Output current AC DC
Lifetime (years) 20
Derating factor (%) 80
Slope (degrees) 35
Azimuth (degrees W of S) 0
Ground reflectance (%) 20
Advanced
Tracking system Two Axis
Consider effect of temperature
Temperature coeff. of power (%/°C) -0.5
Nominal operating cell temp. (°C) 47
Efficiency at std. test conditions (%) 13
Help
Cancel
OK

Solar Resource Inputs

File Edit Help

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 35 ° 0 ' North South

Longitude 69 ° 0 ' East West

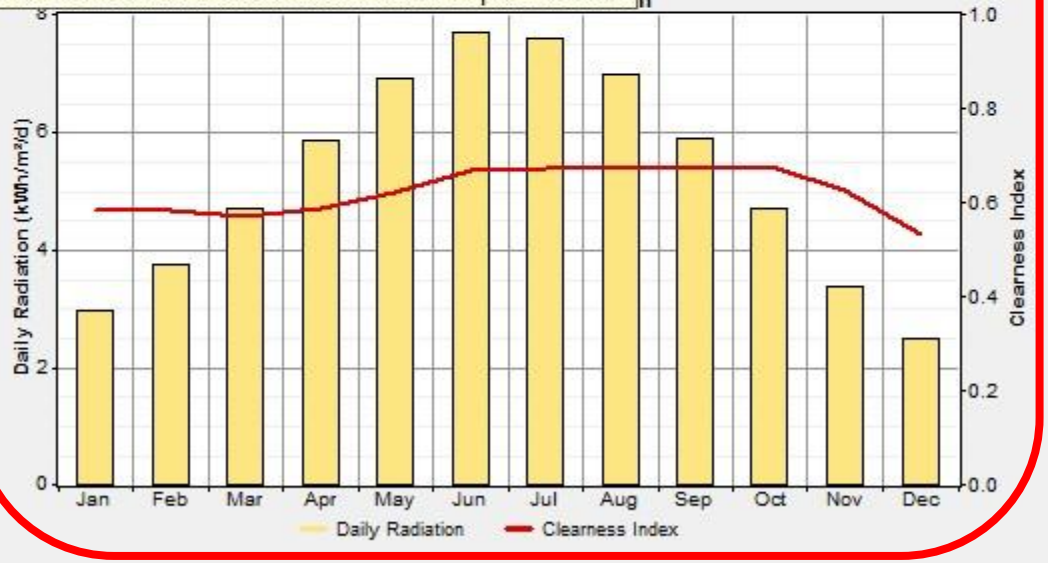
Time zone: (GMT+04:30) Afghanistan

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

Baseline data

Type monthly average radiation or clearness index values into the table or import a data file

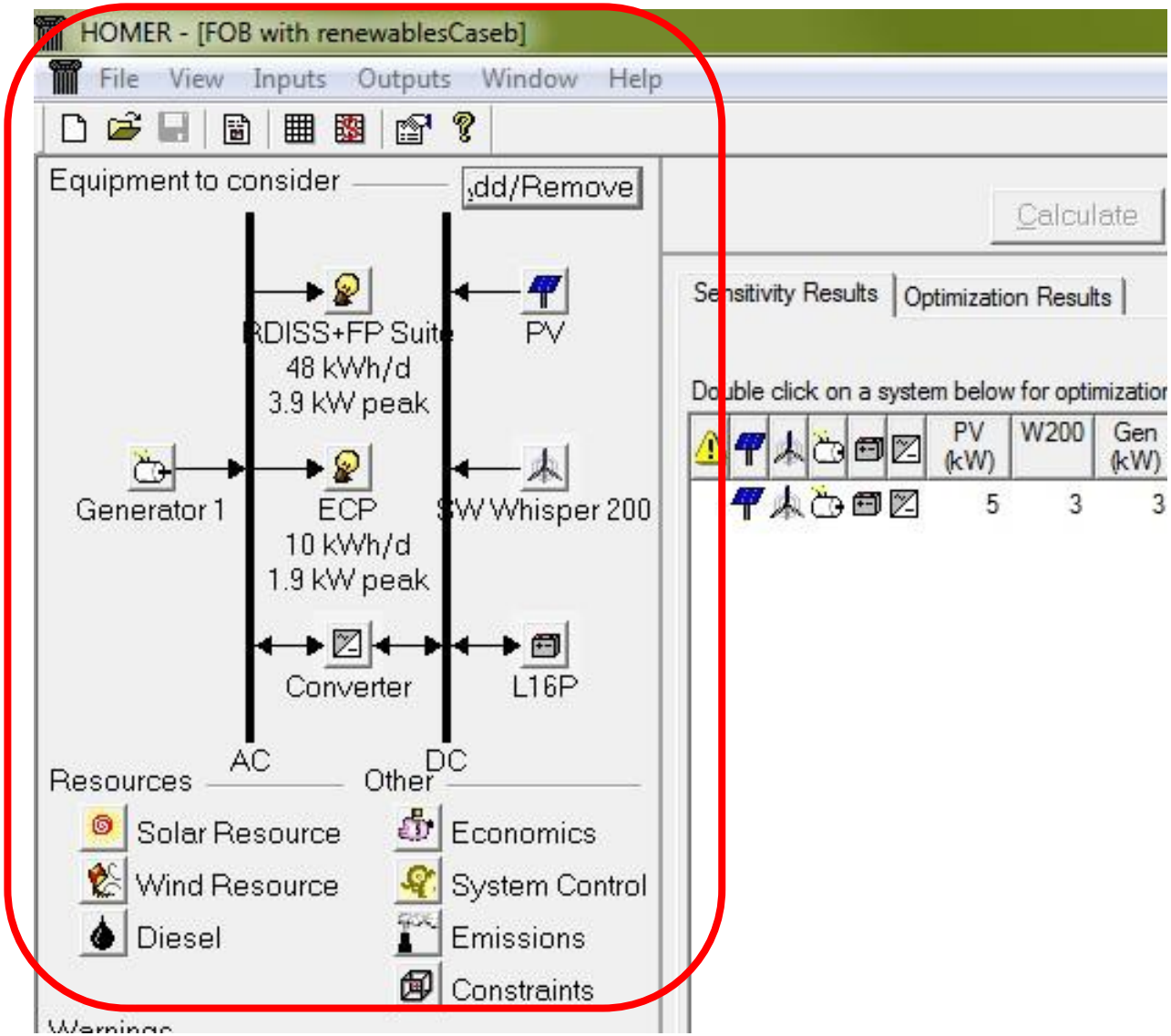
Month	Clearness Index	(kWh/m2/d)
January	0.581	2.955
February	0.582	3.731
March	0.570	4.690
April	0.588	5.856
May	0.622	6.909
June	0.667	7.692
July	0.672	7.587
August	0.673	6.968
September	0.671	5.902
October	0.676	4.688
November	0.625	3.359
December	0.533	2.492
Average:	0.630	5.243



Data Source... Plot... Export...

Scaled annual average (kWh/m²/d) 5.24299 {..}

Help Cancel OK


HOMER - [FOB with renewablesCaseb]
File View Inputs Outputs Window Help
Equipment to consider
Add/Remove
Calculate
Sensitivity Results
Optimization Results
Double click on a system below for optimization
PV (kW)
W200
Gen (kW)
5
3
3
RDISS+FP Suite
48 kWh/d
3.9 kW peak
PV
Generator 1
ECP
10 kWh/d
1.9 kW peak
SW Whisper 200
Converter
L16P
AC
DC
Resources
Other
Solar Resource
Wind Resource
Diesel
Economics
System Control
Emissions
Constraints
Warnings

Wind Turbine Inputs

File Edit Help

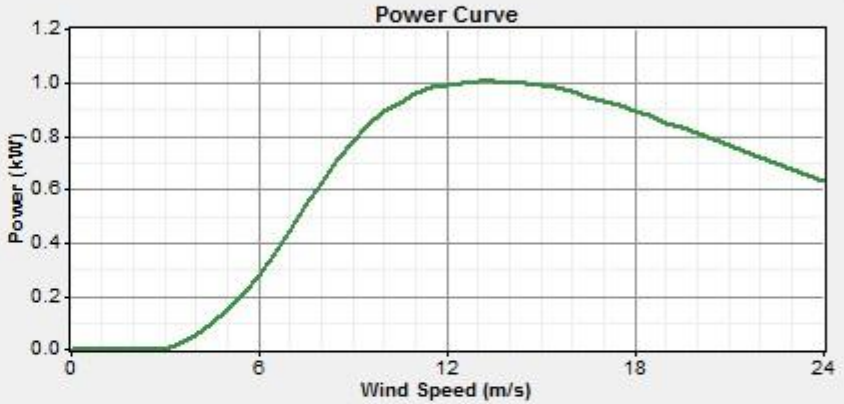
Choose a wind turbine type and enter at least one quantity and capital cost value in the Costs table. Include the cost of the tower, controller, wiring, installation, and labor. As it searches for the optimal system, HOMER considers each quantity in the Sizes to Consider table.

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

Turbine type: SW Whisper 200 | Details... | New... | Delete

Turbine properties

Abbreviation: W200 (used for column headings)
Rated power: 1 kW DC
Manufacturer: Southwest Windpower
Website: www.windenergy.com



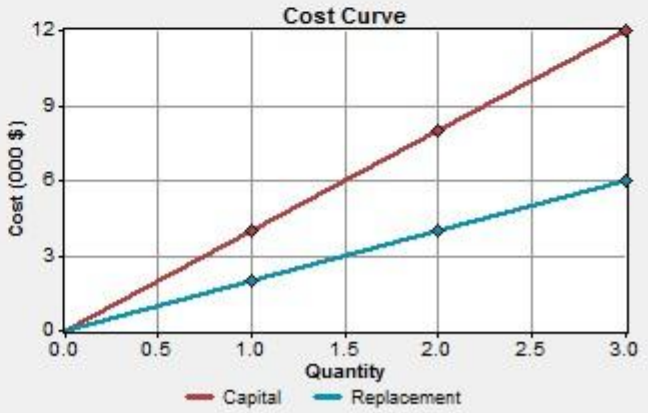
Costs

Quantity	Capital ($)	Replacement ($)	O&M ($/yr
1	4000	2000	50
2	8000	4000	100
3	12000	6000	150

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

Sizes to consider

Quantity
1
2
3



Other

Lifetime (yrs): 15 {..}
Hub height (m): 25 {..}

Help | Cancel | OK

Wind Resource Inputs

File Edit Help

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.

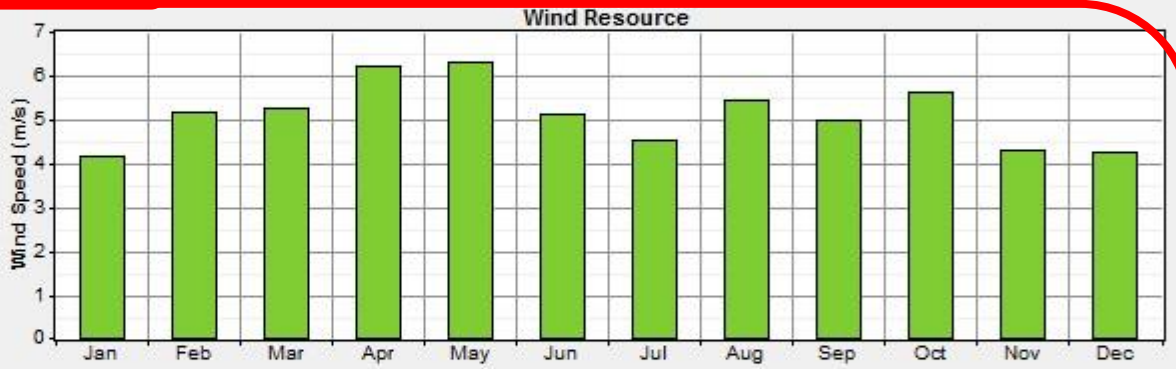
Hold the pointer over an element or click Help for more information.

Data source: Enter monthly averages | Import time series data file — Import File...

Baseline data (from Central Asia Plains.wnd)

Month	Wind Speed (m/s)
January	4.181
February	5.153
March	5.251
April	6.240
May	6.295
June	5.125
July	4.533
August	5.427
September	4.986
October	5.632
November	4.282
December	4.235

Annual average: 5.111



Other parameters

Time step (minutes)	60
Altitude (m above sea level)	0
Anemometer height (m)	10

Variation With Height...

Advanced parameters

Weibull k	1.83
1-hr autocorrelation factor	0.898
Diurnal pattern strength	0.1
Hour of peak windspeed	16

Scaled annual average (m/s) 5.11 {..}

Plot... Export...

Help Cancel OK

Simulation Results

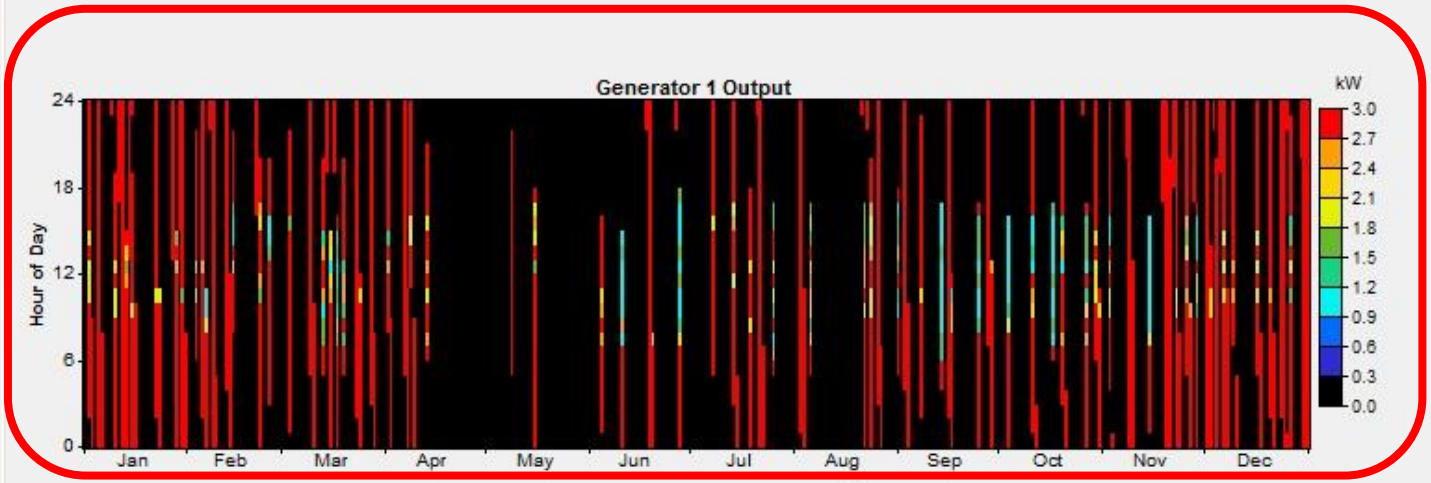
System Architecture:					
	5 kW PV	40 Trojan L16P	Cycle Charging	Total NPC:	$ 89,367
	3 SW Whisper 200	10 kW Inverter		Levelized COE:	$ 0.330/kWh
	3 kW Generator 1	10 kW Rectifier		Operating Cost:	$ 3,940/yr

Cost Summary | Cash Flow | Electrical | PV | W200 | Gen | Battery | Converter | Emissions | Time Series

Quantity	Value	Units
Hours of operation	1,862	hr/yr
Number of starts	73	starts/y
Operational life	8.06	yr
Capacity factor	20.0	%
Fixed generation cos	0.492	$/hr
Marginal generation	0.200	$/kWh

Quantity	Value	Units
Electrical productio	5,262	kWh/y
Mean electrical outp	2.83	kW
Min. electrical outpu	0.900	kW
Max. electrical outp	3.00	kW

Quantity	Value	Units
Fuel consumption	1,762	L/yr
Specific fuel consum	0.335	L/kWh
Fuel energy input	17,343	kWh/yr
Mean electrical efficie	30.3	%



System Architecture:					
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	3 kW Generator 1	10 kW Rectifier		Operating Cost:	$ 3,940/yr

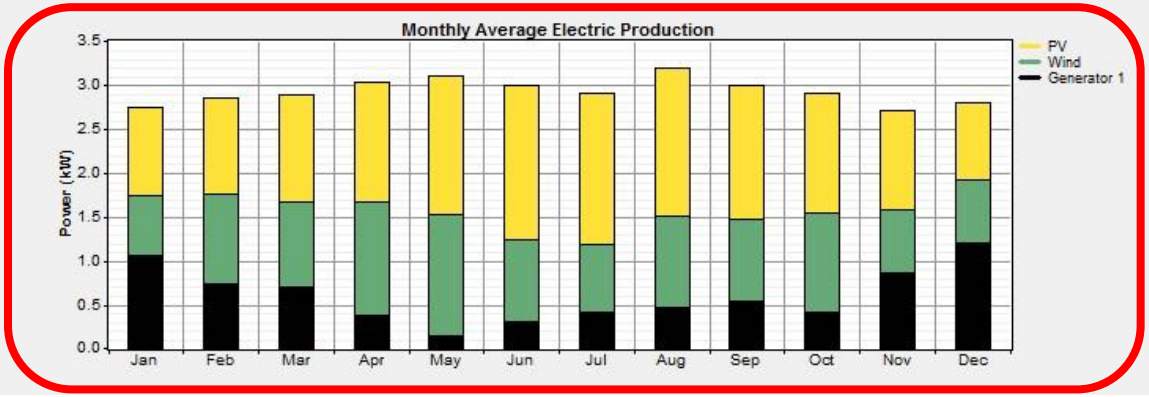
Cost Summary | Cash Flow | Electrical | PV | W200 | Gen | Battery | Converter | Emissions | Time Series

Production	kWh/yr	%
PV array	11,907	46
Wind turbines	8,465	33
Generator 1	5,262	21
Total	25,634	100

Consumption	kWh/yr	%
AC primary load	21,199	100
Total	21,199	100

Quantity	kWh/yr	%
Excess electricit	1,152	4.50
Unmet electric lo	7.05	0.03
Capacity shorta	13.8	0.06

Quantity	Value
Renewable fraction	0.752
Max. renew. penetratic	1,498 %



Simulation Results

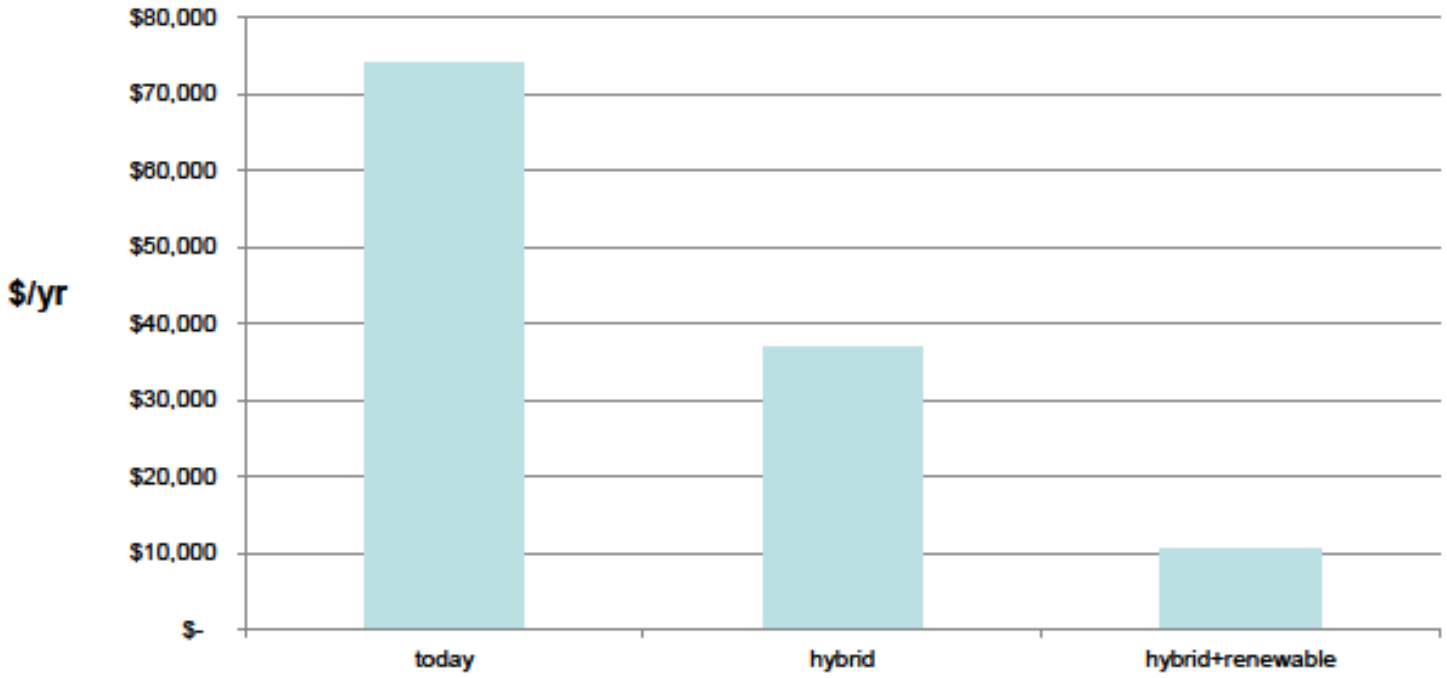
System Architecture:			
	5 kW PV	40 Trojan L16P	Cycle Charging
	3 SW Whisper 200	10 kW Inverter	
	3 kW Generator 1	10 kW Rectifier	

Cost Summary | Cash Flow | Electrical | PV | W200 | Gen | Battery | Converter | Emissions | Time Series

Pollutant	Emissions (kg/yr
Carbon dioxide	4,641
Carbon monoxide	11.5
Unburned hydrocarbo	1.27
Particulate matter	0.864
Sulfur dioxide	9.32
Nitrogen oxides	102

UNCLASSIFIED

Annual Generator Diesel Consumption Reduction



- Based upon an initial Homer assessment for a single Army TQG with associated simplifying assumptions
- Assumes fully burdened cost of diesel fuel of $20/gallon
- Initial investment and ROI needs to be further assessed to determine the practicality of realizing these levels of reduction

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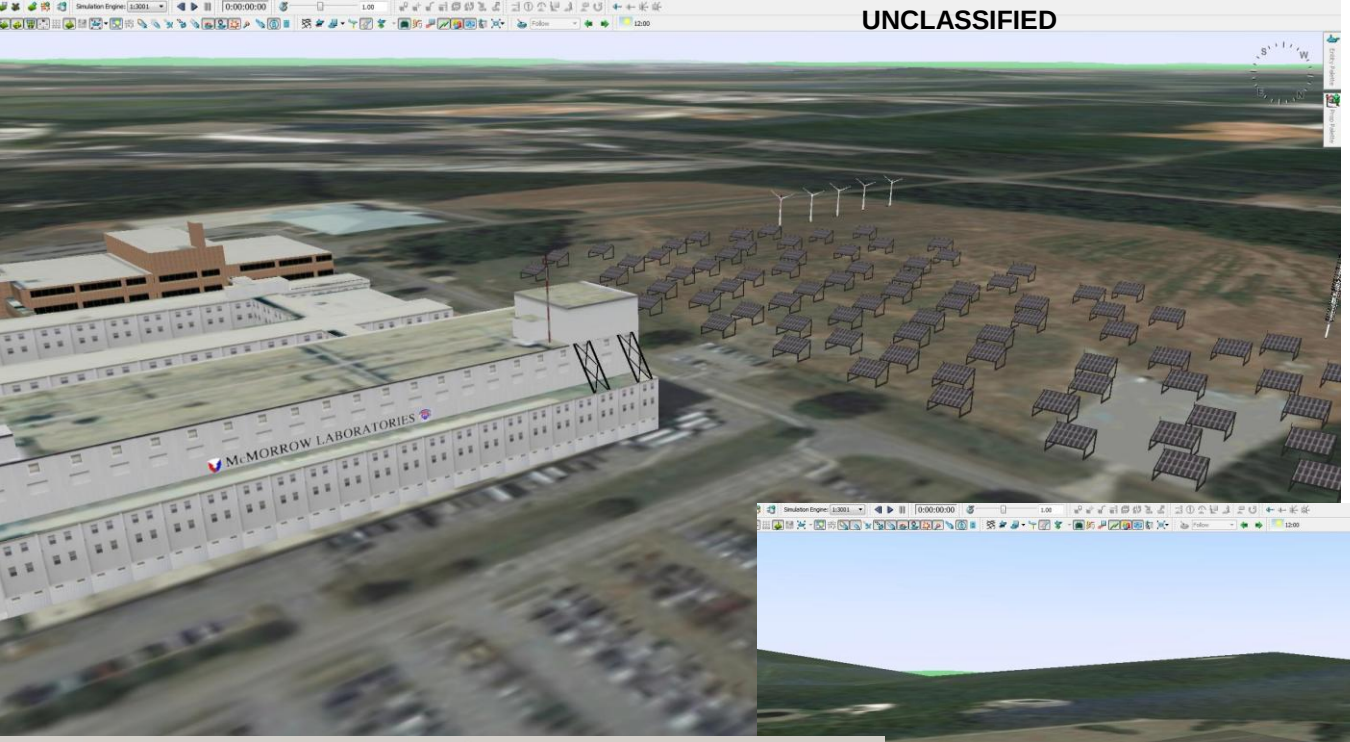
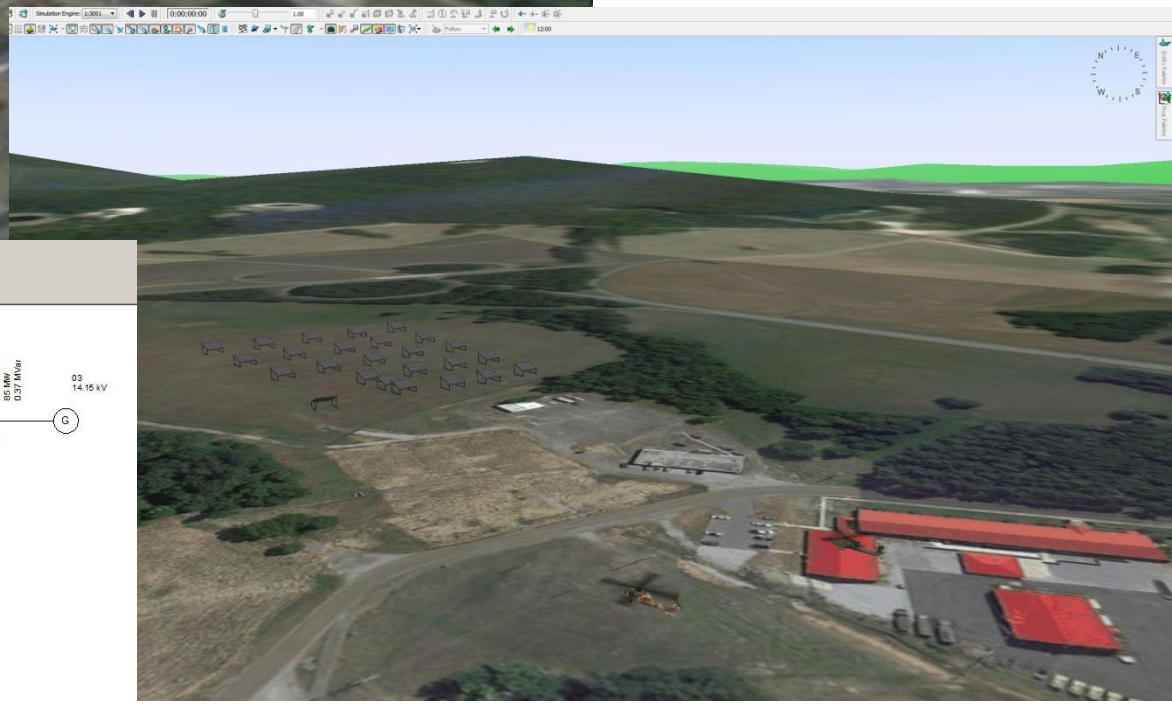
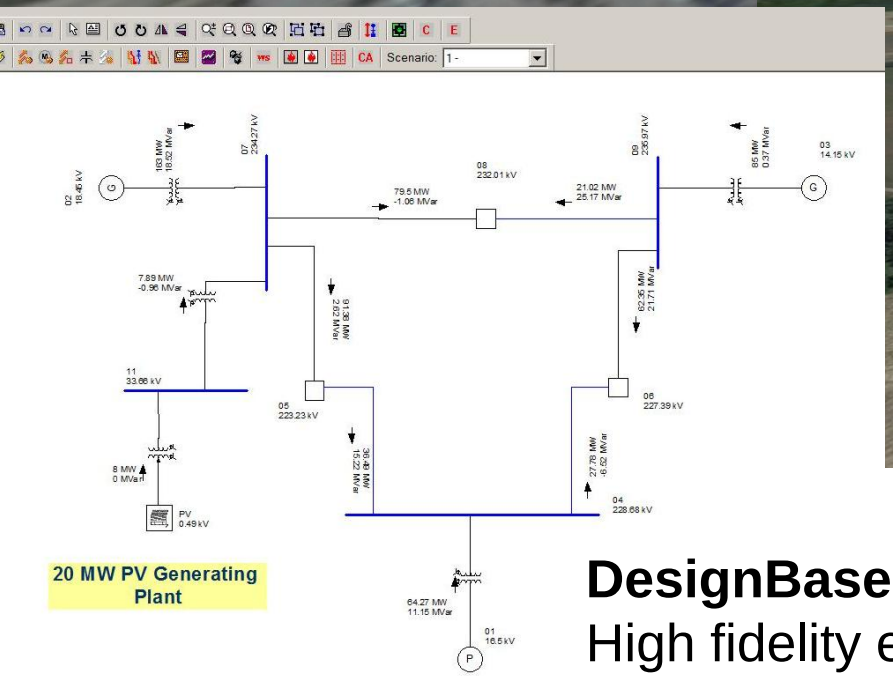


VR Forces
3d simulation toolset





DesignBase
High fidelity energy system/network analysis


iOS

AMRDEC

EEL

Energy & Environment Lab