Foundations of HOMER® Pro Student Training Guide

HOMER Pro, Version 3.14.4

Foundations of HOMER Pro: Student Training Guide

Welcome to Foundations of HOMER Pro. This course is intended to familiarize you with HOMER's user interface and the simulation-optimization-sensitivity analysis paradigm to allow you to begin using HOMER independently for small systems. By the end of the Foundations course, you will have simulated a diesel generator system with and without batteries for an isolated off-grid application, optimized the system design by adding solar panels, explored the sensitivity of the optimal system design to interest rate and diesel fuel cost assumptions, and explored the implications of 100% renewable systems. You will also design distributed solar+storage systems interconnected with a utility grid. You will learn not only how to analyze these systems, but gain tools for communicating their findings with others.

This guide is not intended to be a standalone course guide, but it provides a reference for the samples that we will cover in class, and the topics covered by those samples.

Lesson A1 Objectives: Build a basic model

- Build a basic model with a diesel generator and load
- Select sample load types and profiles in HOMER
- View results
- Determine costs and performance
- See where costs are coming from

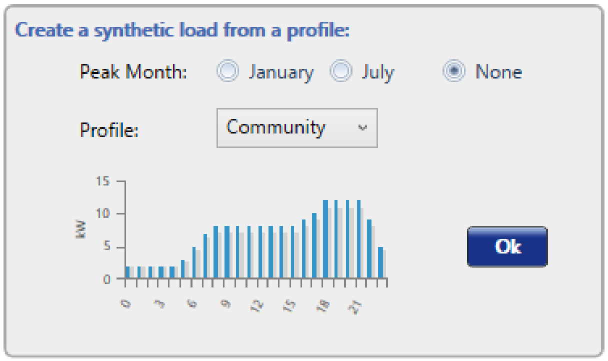
Lesson A1: Trainee model

Using the following input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

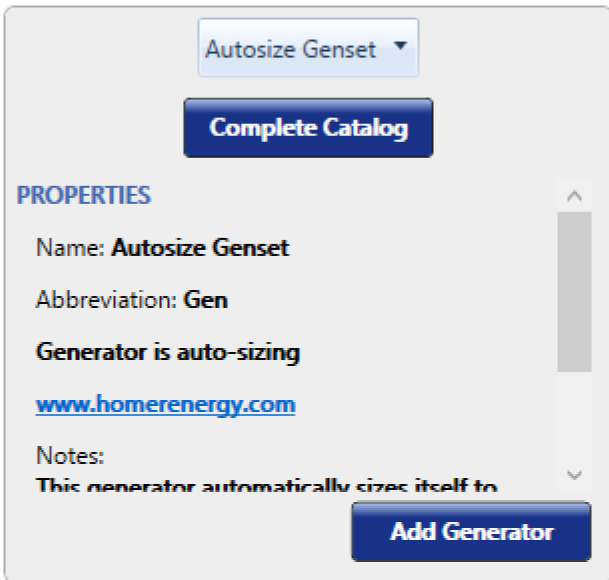
Unless otherwise specified, use the default economic assumptions from the HOMER Pro library.

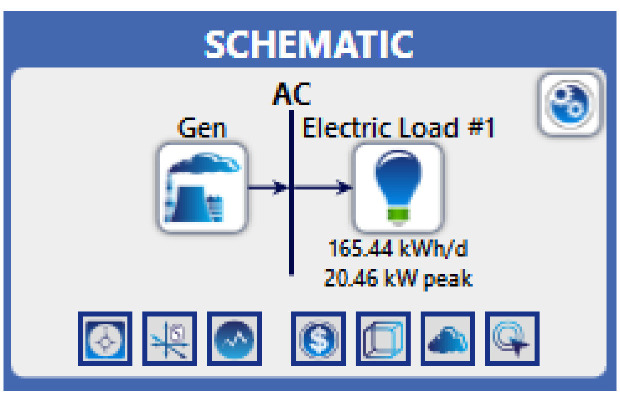
1. **Location**: Nairobi, Kenya

2. **Load**: Select a pre-defined load built into HOMER Pro
   a. **Load type**: Community
   b. **Peak month**: No peak month



3. **Component**: Auto-size Diesel generator.
    a. Use the default cost assumptions from the HOMER Pro library.





SAVE YOUR WORK! File->Save->My Lesson A1

Lesson A2 Objectives: Add storage (batteries) to your model

- Optimize a system design with a storage component
- Use the battery select list

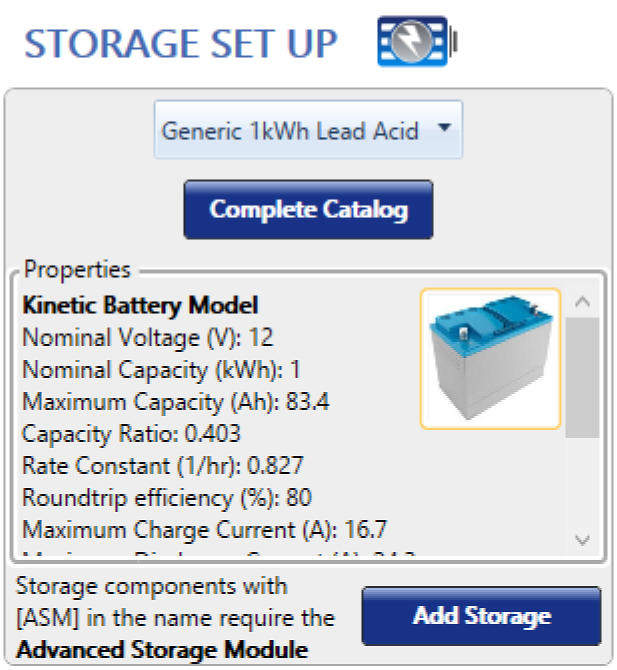
- Describe the 3 levels of error/warning messages
- Add a converter component
- Use the HOMER Optimizer to automatically size storage
- Review viewing optimization and simulation results
- Compare a generator-only and a battery-generator system
- View the key performance metrics of each simulated system
- Double-click to view more detailed simulation results

Lesson A2: Trainee model

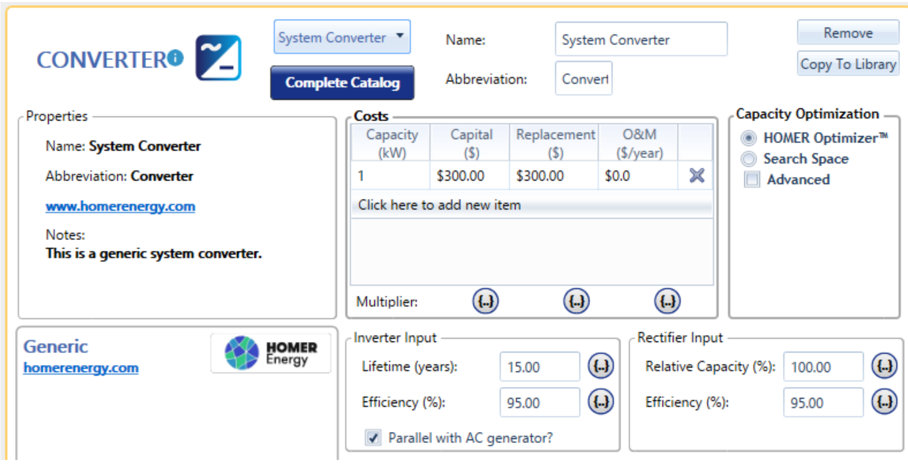
Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

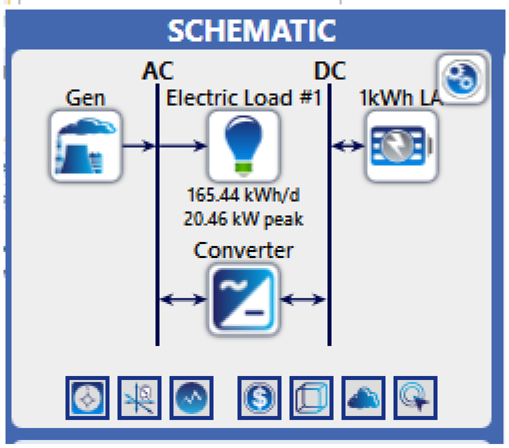
Unique parameters for your model:

1. **Component**: Generic 1 kWh Lead Acid battery
    a. Use the default cost assumptions from the HOMER Pro library.



2. **Component:** Converter
    a. Use the default cost assumptions from the HOMER Pro library.





SAVE YOUR WORK! File->Save->My Lesson A2

Lesson A3: Add PV to your model

- Optimize a design with a PV component
- Select a PV model from a list
- View the PV resource
- View summary of Net Present Cost (NPC) and Cost of Energy
- Compare category winners, look at a 100% renewable system

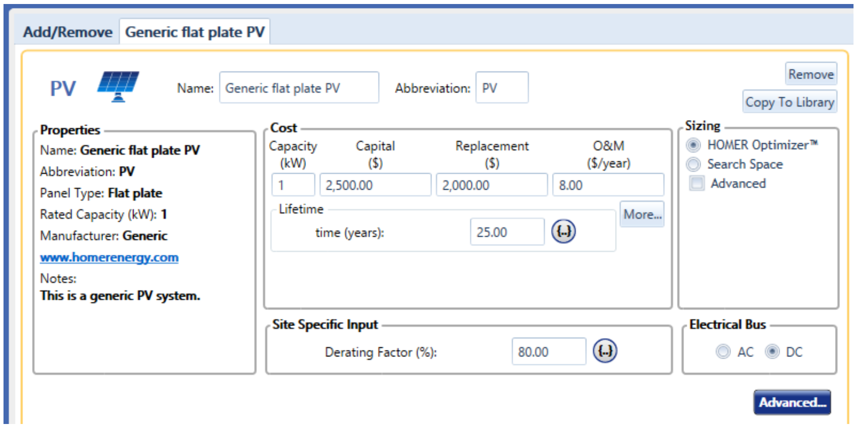
Lesson A3: Trainee model

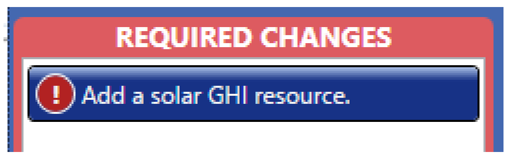
Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Component**: Generic flat plate PV:

Capital cost	*Replacement cost*	*O&M Cost*
2500	2000	8





Add a solar GHI Resource

SAVE YOUR WORK! File->Save->My Lesson A3

Lesson A4: Sensitivity analysis on fuel

- Perform a sensitivity analysis to determine the impact of different fuel prices
- Edit and enter sensitivity variables and values for fuel price
- Review and understand sensitivity results
- See how recommend PV and storage change with fuel price
- View sensitivity graphically

Lesson A4: Trainee model

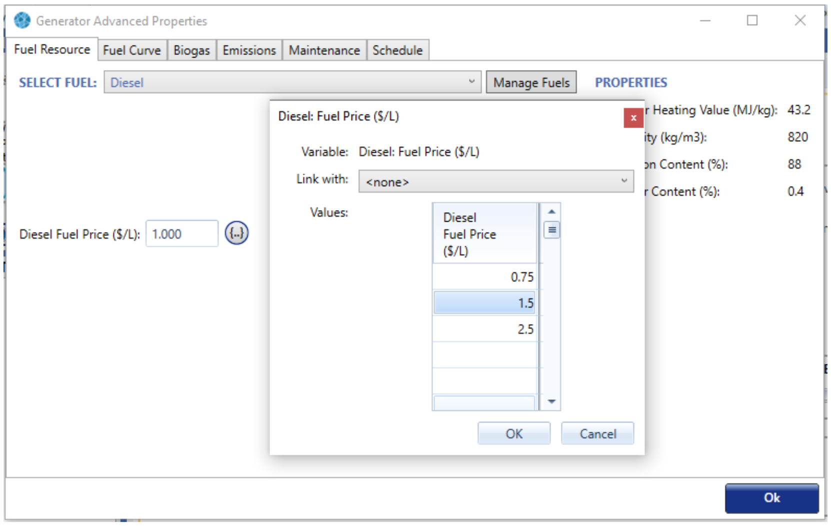
Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Fuel price**:

Fuel price ($/L)		*$/gal equiv*
0.75	-->	2.83875
1.5	-->	5.6775
2.5	-->	9.4625

Select the Autosize Genset, Advanced…, Diesel Fuel Price



SAVE YOUR WORK! File->Save->My Lesson A4

Lesson A5: Sensitivity analysis on reliability

- Perform a sensitivity analysis to determine the impact of allowing lower reliability
- Introduce capacity shortages and reliability to a HOMER model
- See how battery state of charge interacts with different capacity shortage cases
- Compare economics using a base case
- View an Optimal System Type plot
- Export sensitivity cases to a spreadsheet

Lesson A5: Trainee model

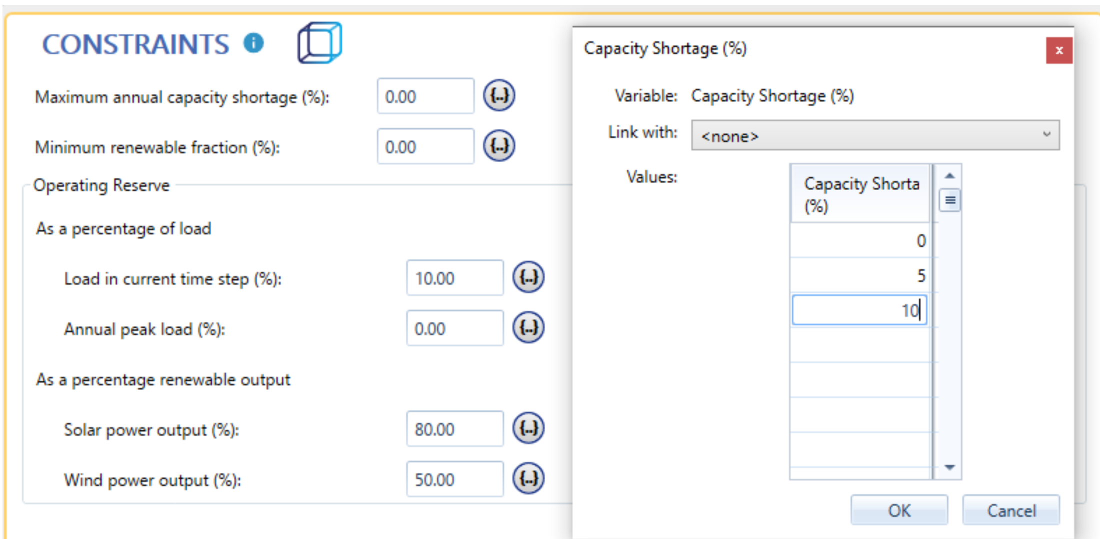
Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Maximum annual capacity shortage:**

Max annual capacity shortage		*Equivalent hours*	*Equivalent days*	*Equivalent weeks*	*Equivalent months*
0	-->	0	0	0	0
5	-->	438.00	18.25	2.61	0.608333333
10	-->	876.00	36.50	5.21	1.216666667

Select the PROJECT tap, Constraints, Maximum annual capacity shortage (%)



SAVE YOUR WORK! File->Save->My Lesson A5

Lesson B1: Refine synthetic load

- Create a load with limited data
- Download location-specific resource data
- Select peak month for a load based on knowledge of location
- Modify basic load parameters including average profile, scaled annual average, and random variability
- Understand relationship between weekday and weekend loads
- Understand how changes in variability affect peak and average loads

Lesson B1: Trainee model

Start a new model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

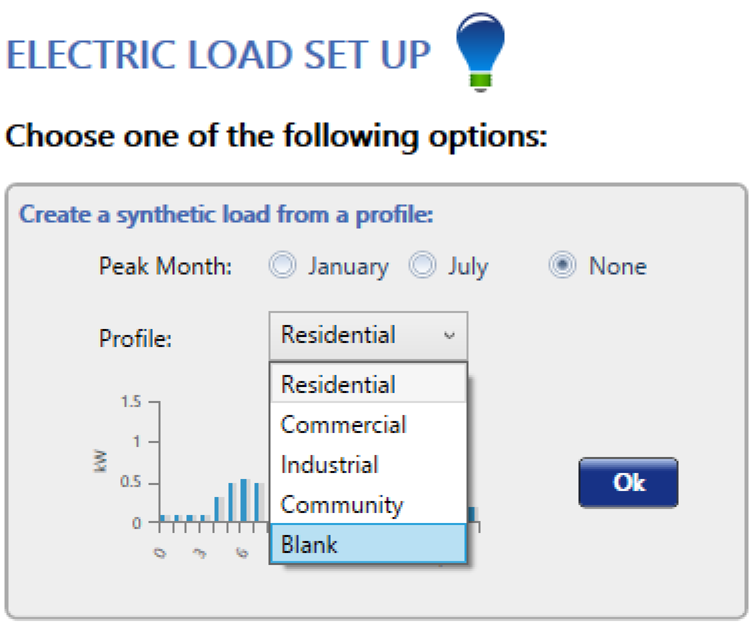
Unless otherwise specified, use the default economic cost assumptions from the HOMER Pro library.

1. **Location**: Nairobi, Kenya

2. **Load**: Add a blank load and input the following load profile

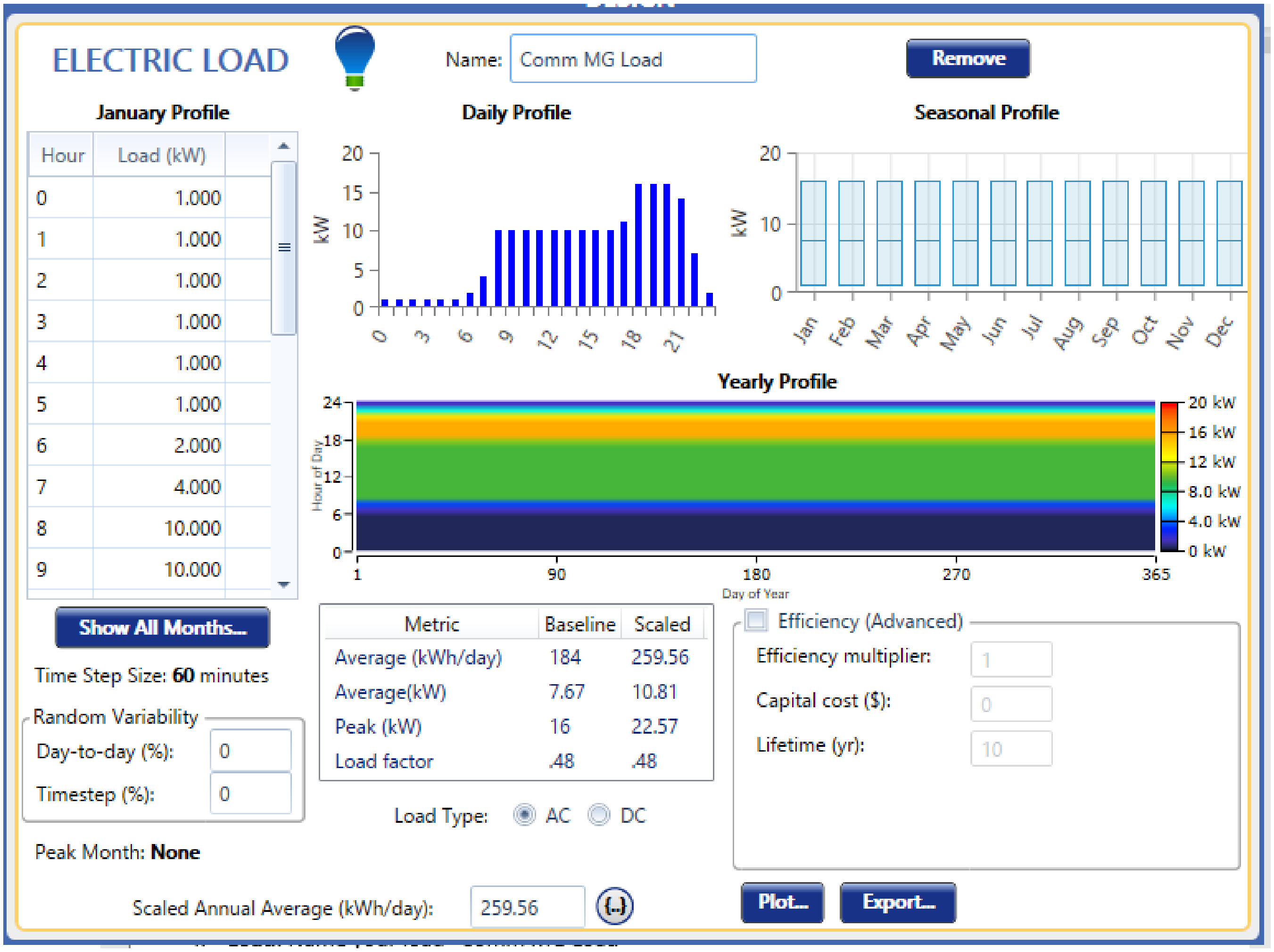
Hour	*Copy/paste*
0	1
1	1
2	1
3	1
4	1
5	1
6	2
7	4
8	10
9	10
10	10
11	10

Hour	Copy/paste
12	10
13	10
14	10
15	10
16	10
17	11
18	16
19	16
20	16
21	14
22	7
23	2



3. **Load**: Adjust the variability to get a 22.57kW peak load. Although it is not always needed, for this lesson make the day-to-day and timestep variability values the same. Baseline peak is 16kW to be scaled to 22.57kW. The Average kWh/day is 184 has to be multiplied with (22.57/16) or 1.410625 to 259.555 for the Peak to reach 22.57kW.

4. **Load**: Name your load “Comm MG Load”



SAVE YOUR WORK! File->Save->My Lesson B1

Lesson B2: Importing load data

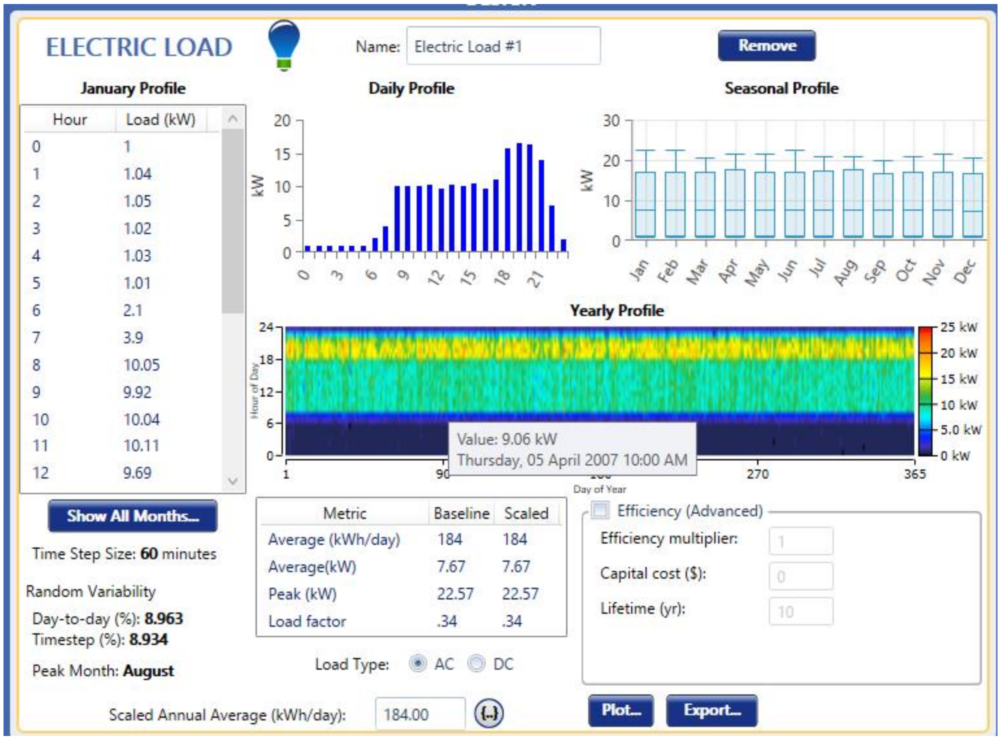
- Import a year of load data
- Understand load importing options
- Replace a synthetic load with an imported load

Lesson B2: Trainee model

Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Load**: Replace the existing load by removing load and import a new load using the “Lesson B2 Importable Load.dmd” provided. Select year 2021 for the imported load.



SAVE YOUR WORK! File->Save->My Lesson B2

Lesson B3: Manually size a generator (first approximation)

- Manually size a generator to serve a load
- Change fuel price
- Carefully examine fuel and O&M costs
- Check for excess electricity
- Generate a plot to understand the effect of an oversized generator

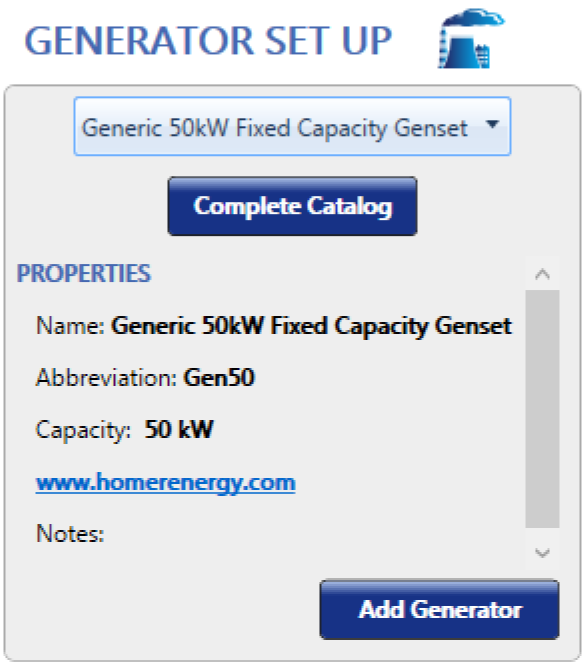
Lesson B3: Trainee model

Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

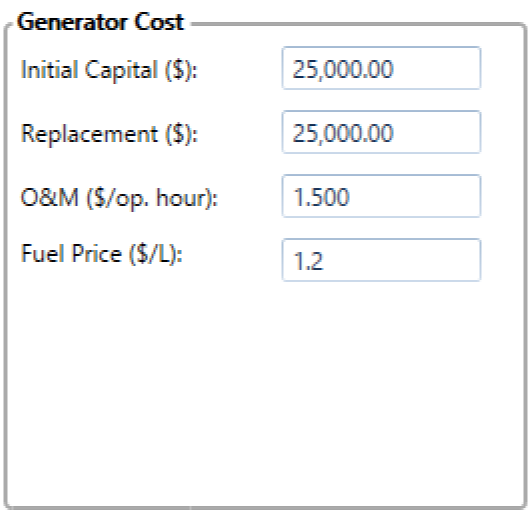
If you'd like to start with a provided model instead of your own, you may use the "My Lesson B2.homer" available in the files for this lesson.

Unique parameters for your model:

1. **Component**: Generic 50 kW Fixed Capacity Genset
    a. Use the default cost assumptions from the HOMER Pro library.



2. **Diesel Price**: 1.2 $/L



SAVE YOUR WORK! File->Save->My Lesson B3

Lesson B4: Manually size a generator (2nd approximation)

- Continue to improve on manually sizing a generator based on information gained in B3
- Set generator cost and performance parameters
- Remove a generator from a system
- Compare system performance with a smaller generator

Lesson B4: Trainee model

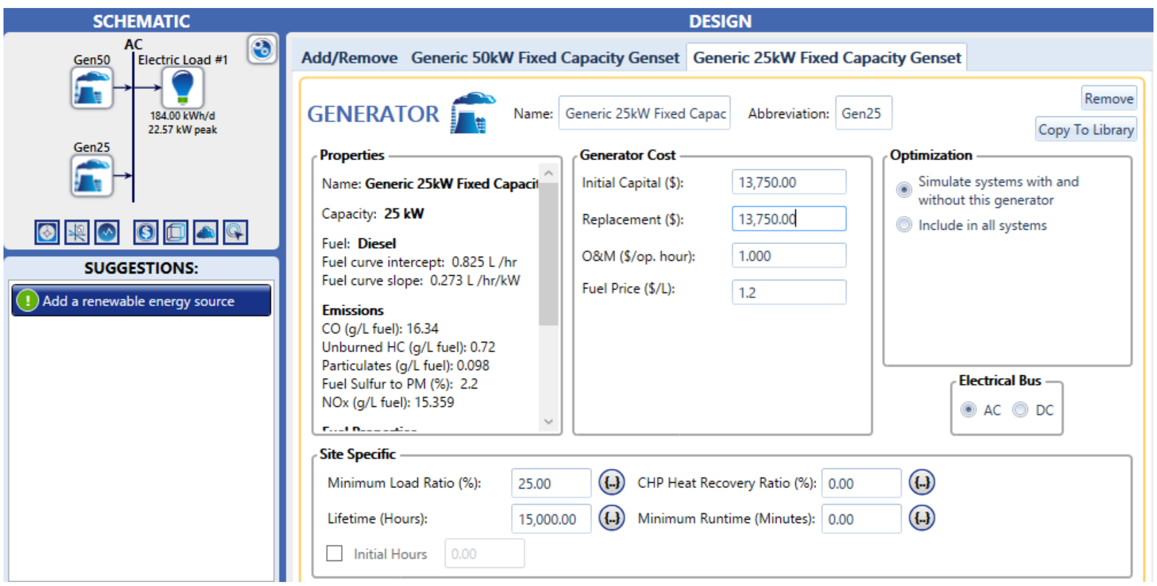
Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Component**: Generic 25 kW Fixed Capacity Genset

	Initial capital ($)	***Replacement ($)***	***O&M (per hour) ($)***
	13750	13750	1.000
Cost per kW:	*550*	*550*	*0.04*

2. **Component**: After reviewing results, remove the more expensive generator



Results

Architecture						
		Gen50 (kW)	Gen25 (kW)	Dispatch	NPC ($)	COE ($)
			25.0	CC	$687,376	$0.792
		50.0	25.0	CC	$706,536	$0.814
		50.0		CC	$1.08M	$1.25

SAVE YOUR WORK! File->Save->My Lesson B4

Lesson B5: Quickly size PV, battery, and converter

- Refine the size of the components in your model
- Understand battery string size in HOMER

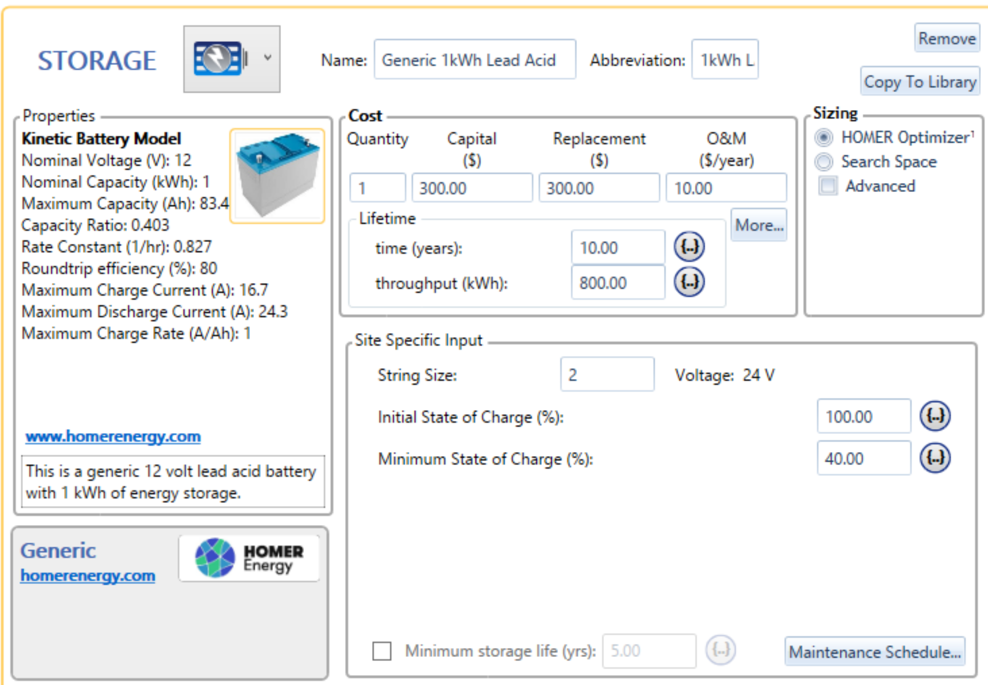
- Compare and understand PV resource types
- Understand how the search space works and impacts your optimization
- Look at how PV components interact with buses
- Understand renewable fraction

Lesson B5: Trainee model

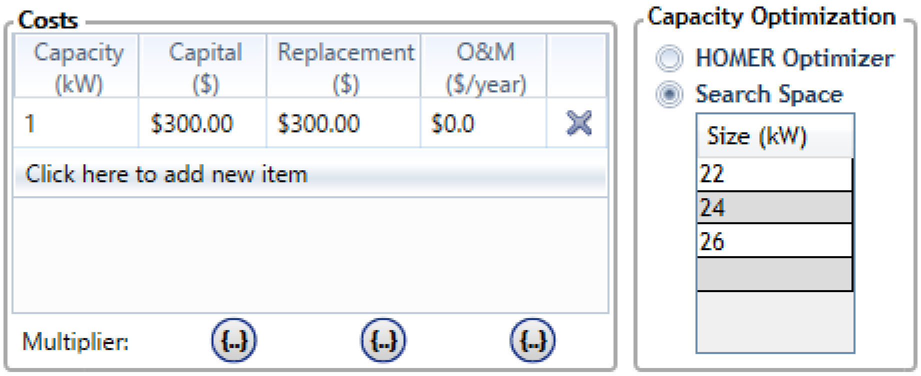
Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Component**: Generic 1 kWh Lead Acid Battery
   a. Use the default cost assumptions from the HOMER Pro library.
   b. Adjust the battery inputs so that you have a 24V battery bus

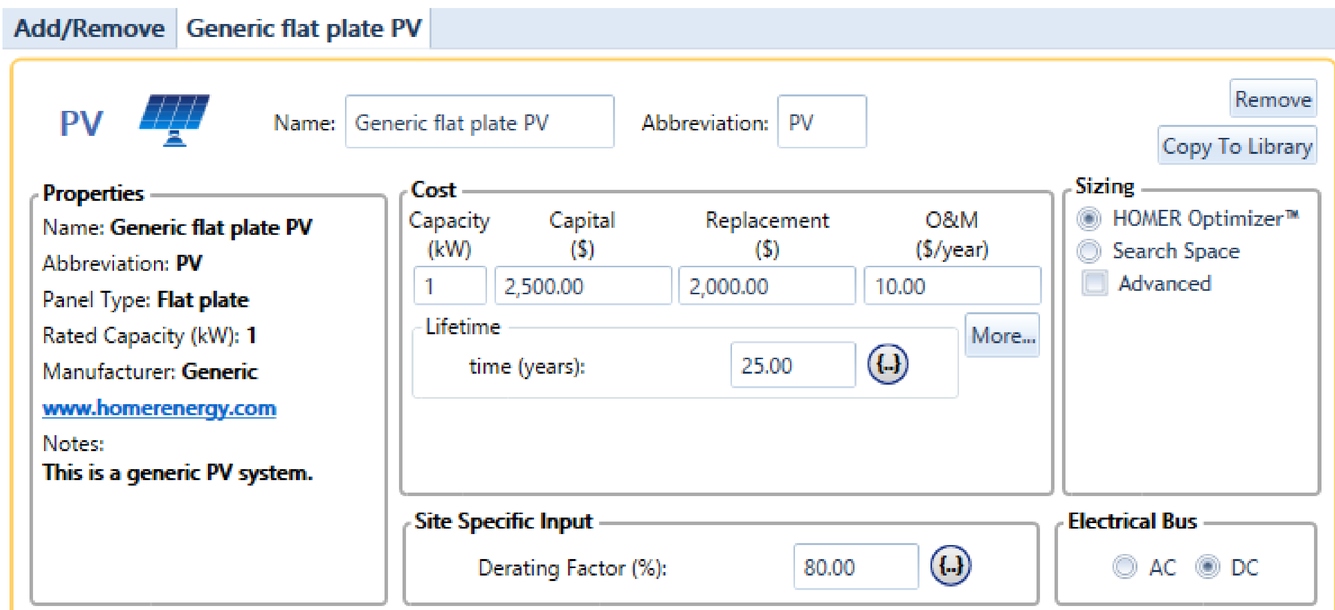


2. **Component**: Converter
   a. Use the default cost assumptions from the HOMER Pro library.
   b. Use the search space and size the converter to meet the peak, as shown in the lesson.



3. **Component**: PV

Capital	***Replacement***	***O&M***
2500	2000	10



Add a solar GHI resource

SAVE YOUR WORK! File->Save->My Lesson B5

Lesson B6: Refine converter size

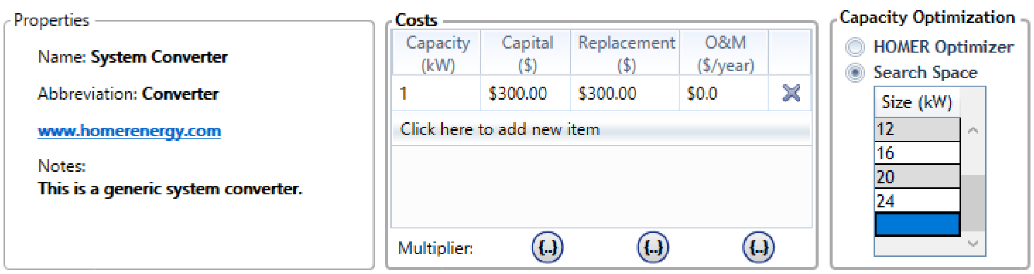
- Refine a converter using the search space
- Learn to move from coarse to granular in sizing
- Check to see if you need to expand the search space
- Determine how converter size impacts costs and performance
- Compare the search space approach to the Optimizer approach
- Examine the impact of changing converter size on battery size

Lesson B6: Trainee model

Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Component:** Converter (existing)
   a. Using the Search Space, adjust the search space based on the ability to purchase a converter in increments of 4kW.



SAVE YOUR WORK! File->Save->My Lesson B6

Lesson B7: Refine design further

- Use the search space to refine the design of components already sized with the Optimizer
- Select a controller and compare controller approaches
- Understand outcomes to properly sized design

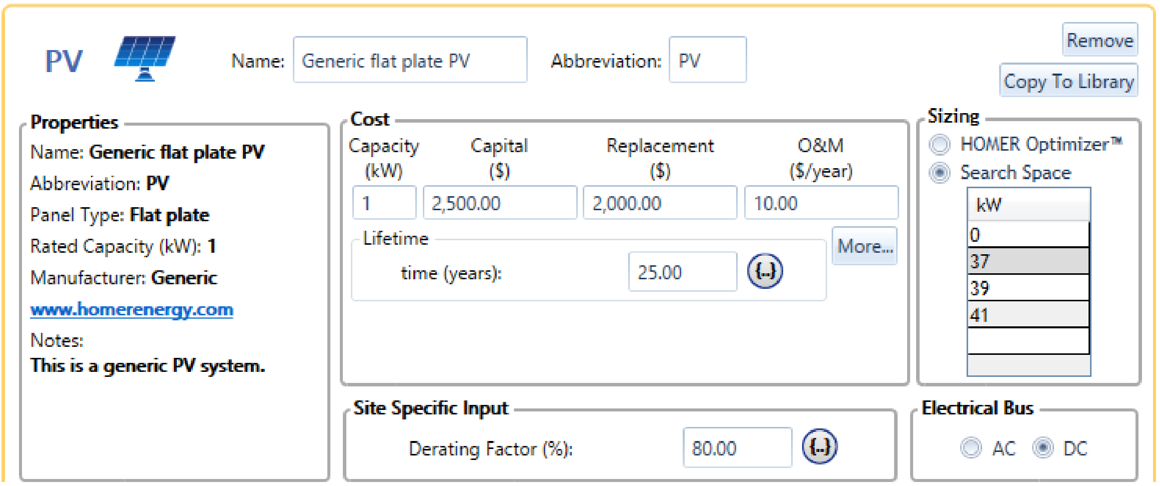
Lesson B7: Trainee model

Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

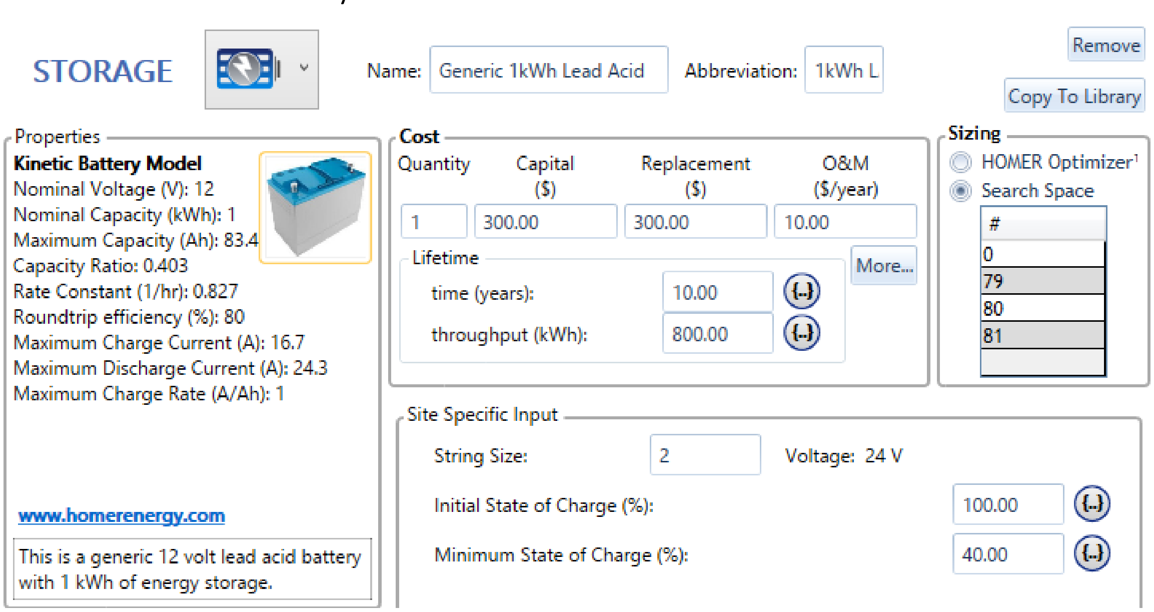
Unique parameters for your model:

Review the results of the existing model

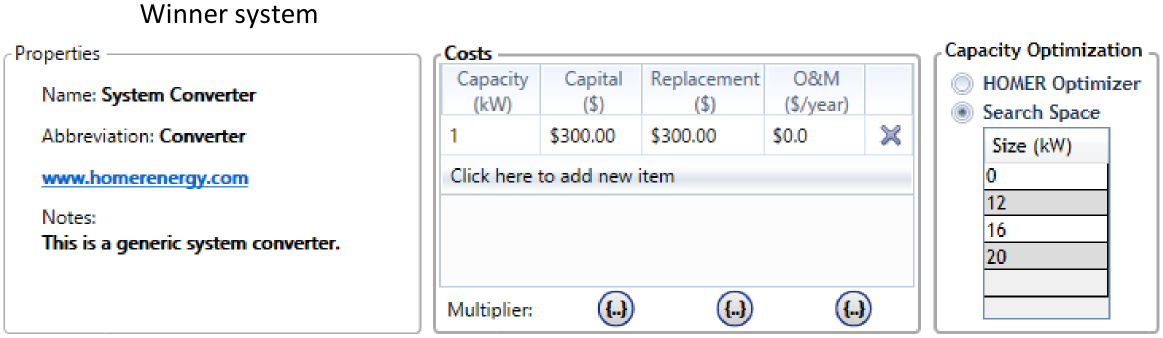
1. **Component:** PV (existing)
   a. Adjust search space based on **2kW larger and smaller** than the PV size in the existing Overall Winner system



2. **Component:** Storage (existing battery)
    a. a. Adjust search space based on **1 string larger and smaller** than the battery size in the existing Overall Winner system

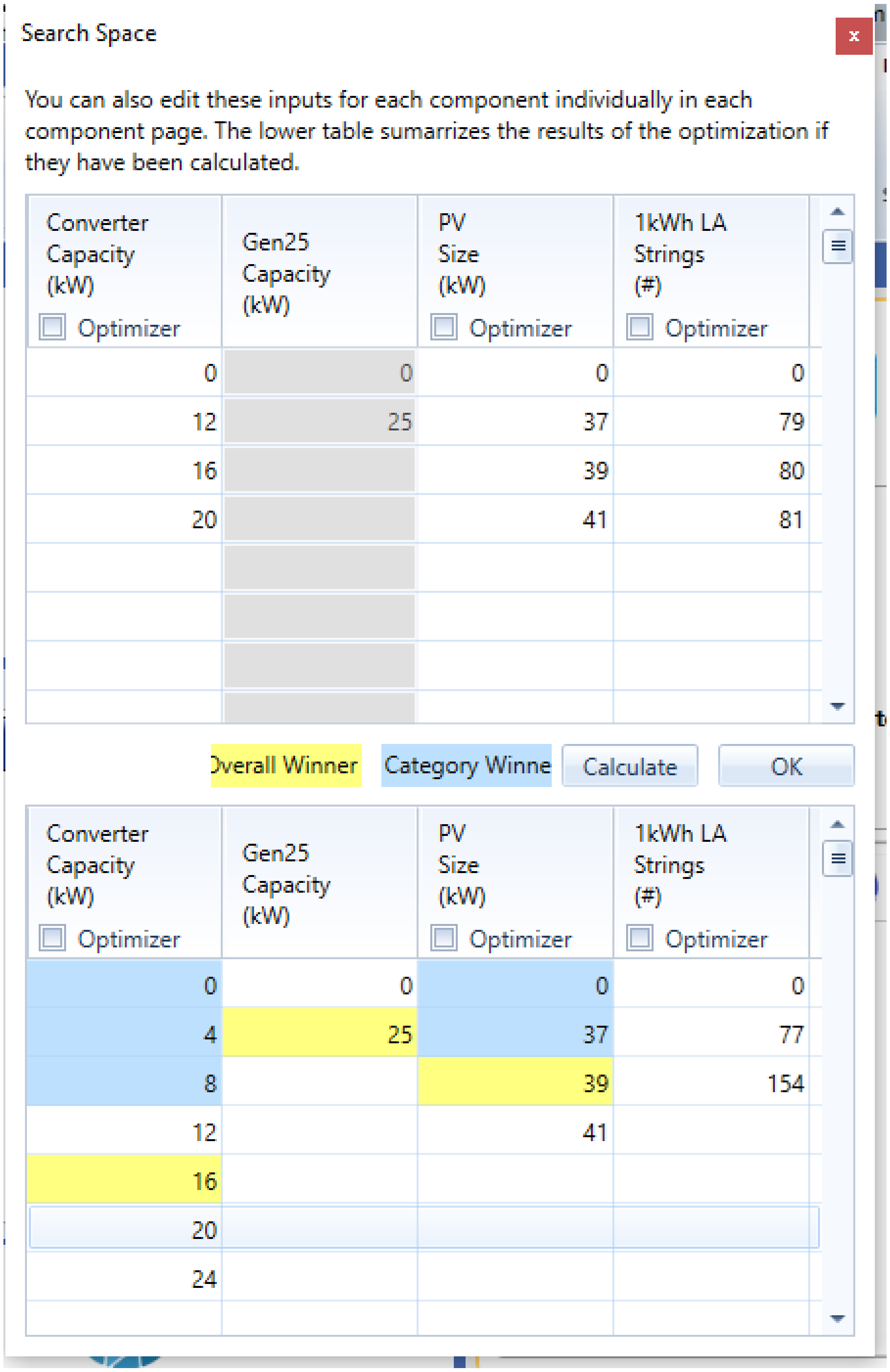


3. **Component:** Converter (existing)
    a. Adjust search space based on **4kW larger and smaller** than the converter size in the existing Overall Winner system



4. **Project Search Space:**

a. Expand the Search Space for all components until you have confirmed that you have found the optimal size. You should still adhere to the accuracy (granularity) listed above for each component.



SAVE YOUR WORK! File->Save->My Lesson B7

Lesson B8: Sensitivity analysis on chosen design

- Use sensitivity analysis to determine how a selected design's economics will change when the discount rate is adjusted
- Generate reports in HOMER
- Export an input report
- Understand nominal discount rate, expected inflation rate, and capacity shortage penalty
- Understand relationship between discount rate and net present cost
- Understand internal rate of return

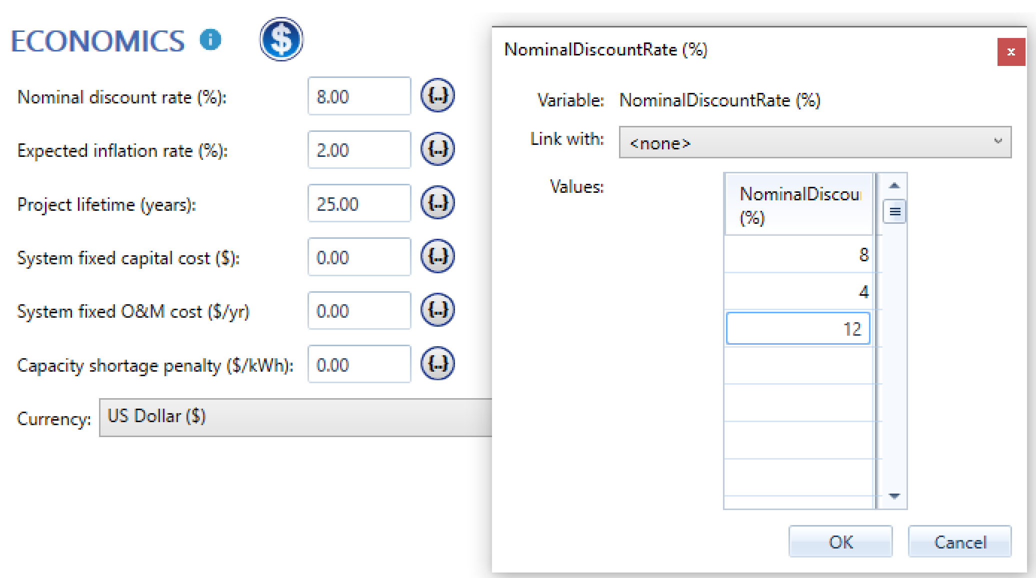
Lesson B8: Trainee model

Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Project search space:**
    a. Delete all component sizes except the component sizes from the Overall Winner of the existing model
2. **Economics: Inflation rate:** 5
3. **Economics: Discount rates:**

Discount rate
8
4
12



SAVE YOUR WORK! File->Save->My Lesson B8

Lesson C1: Create grid-connected net metered PV

- Model net-metered PV
- Understand net metering and options for net purchase calculations in HOMER
- Determine net energy sales to grid
- Understand how PV production meets load versus sales to grid
- Understand grid results in HOMER
- Examine impact of seasonality on grid/PV interactions

Lesson C1: Trainee model

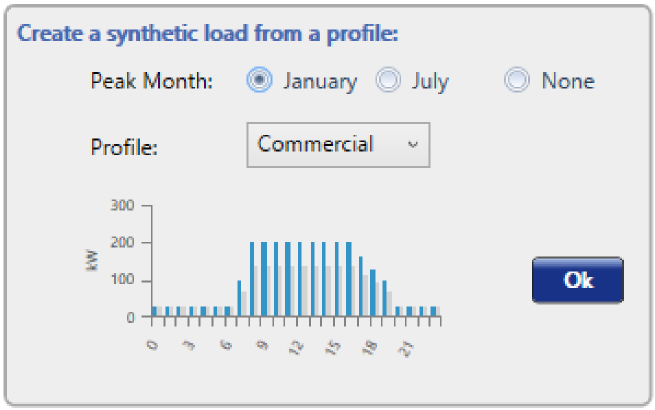
Start a new model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

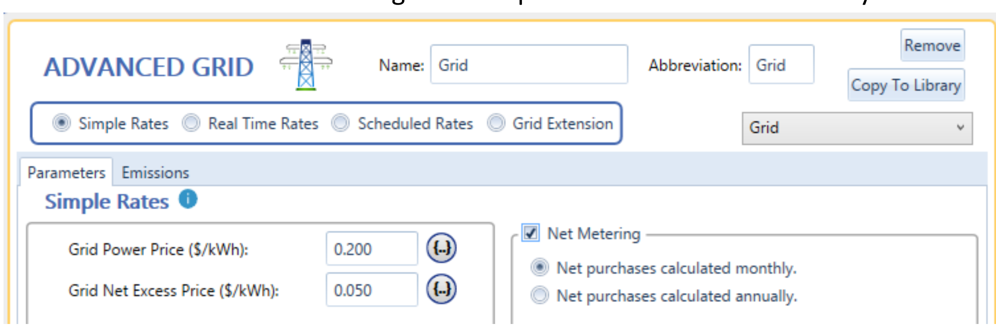
Unless otherwise specified, use the default economic cost assumptions from the HOMER Pro library.

1. **Location**: Sydney NSW, Australia
    a. **Download Solar Resource**

2. **Load**: Select a pre-defined load built into HOMER Pro
    a. **Load type**: Commercial
    b. **Peak month**: January

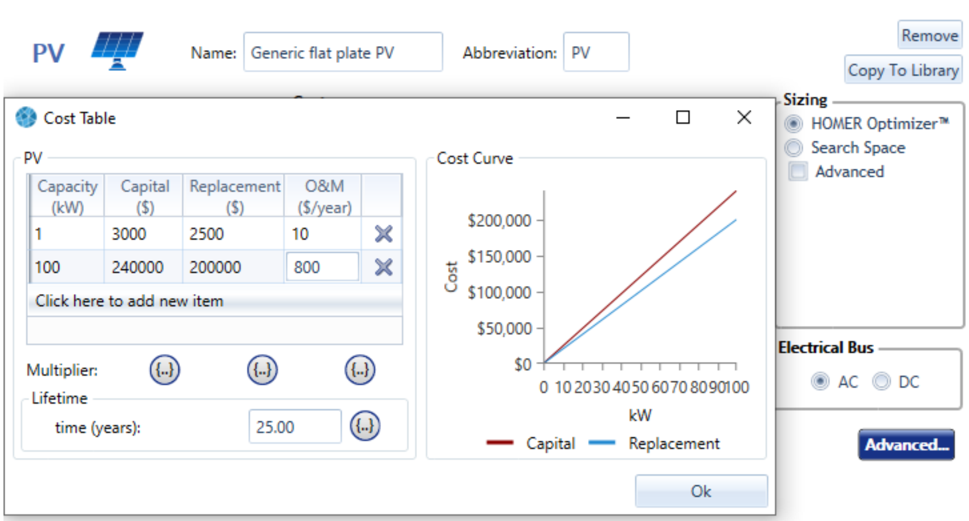


3. **Component**: Grid
    a. Grid price: 0.2
    b. Turn on Net metering with net purchases calculated monthly



4. **Component**: Generic flat plate PV
    a. Put the PV component on to the AC bus

Cost Matrix	***Capital***	***Replace***	***O&M***
1	$3,000	$2,500	$10.00
100	$240,000	$200,000	$800.00



SAVE YOUR WORK! File->Save->My Lesson C1

Lesson C2: Sensitivity on net excess price

- Model PV so that annual PV production that exceeds local annual energy needs is sold at a different price
- Input different grid net excess prices
- Examine impact of grid net express prices on net present cost
- Understand the “maximum net grid purchase” constraint in HOMER

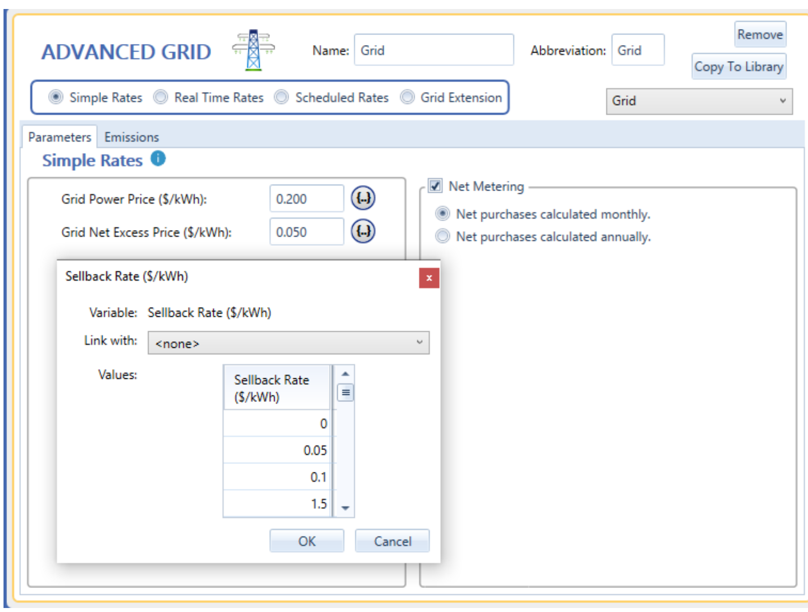
Lesson C2: Trainee model

Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Component:** Grid (existing)
   a. **Grid Net Excess price**:

Grid Net Excess Price
0
0.05
0.1
0.15



SAVE YOUR WORK! File->Save->My Lesson C2

Lesson C3: Create a system with a feed-in-tariff

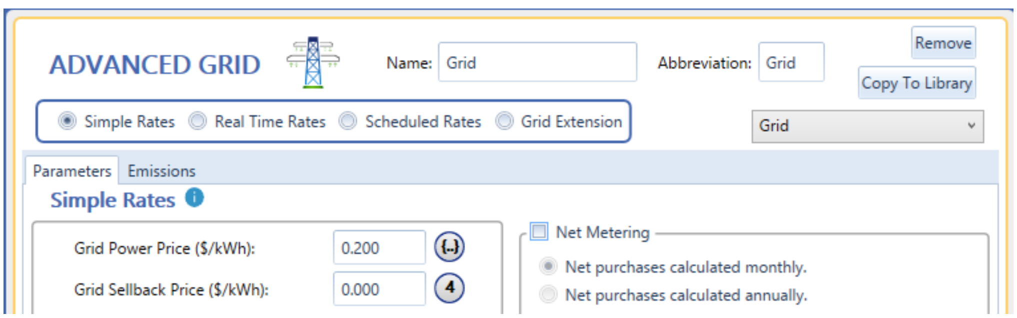
- Model PV such that any production that exceeds the current load demand is sold to the utility at a fixed price
- Define feed-in-tariff, surplus product
- Understand differences between net metering and feed-in-tariffs
- Examine relationship between sellback rate and renewable penetration

Lesson C3: Trainee model

Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Component:** Grid (existing)
    a. **Net Metering**: OFF



SAVE YOUR WORK! File->Save->My Lesson C3

Lesson C4: Design grid-connected solar + storage

- Design a solar PV and battery system to increase local PV energy usage
- Learn how to determine under what conditions a battery is an economical option
- Learn how to turn off grid sales in HOMER
- Examine and compare what impacts the inclusion of storage in a PV system

Lesson C4: Trainee model

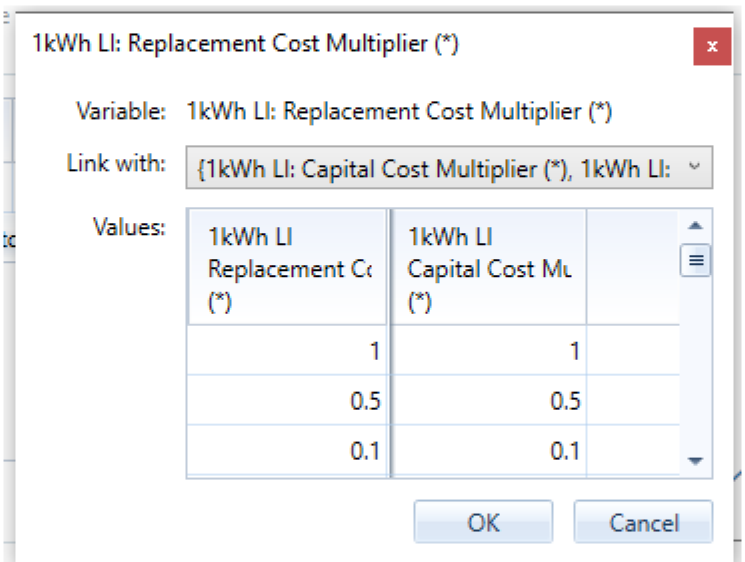
Continuing with your previous model, and using the input parameters here, build a slightly different version of the model you saw built in the lesson presentation.

Unique parameters for your model:

1. **Component:** Grid (existing)
    a. Grid sellback price: o

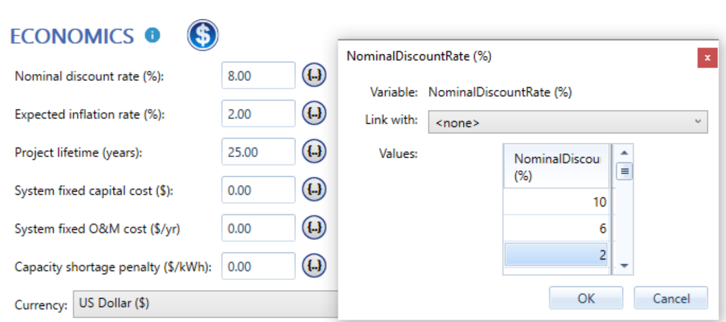
2. **Component**: Generic 1 kWh Lithium Ion battery
    a. Use the default cost assumptions from the HOMER Pro library.
    b. Cost multipliers

Capital	*Replacement*
1	1
0.5	0.5
0.1	0.1



3. **Component:** Converter
    a. Use the default cost assumptions from the HOMER Pro library.
4. **Economics:** Nominal Discount Rate:

Nominal discount rate
10
6
2



5. **SAVE YOUR WORK!** File->Save->My Lesson C4

Definitions

Autosize genset	A generic generator that is set to be 110% of the peak load.
Bus	A part of a power system that carries energy between components or to a load. HOMER has four buses: AC, DC, Thermal, and Hydrogen.
Category (also called system type)	A set of system designs with the same set if component types (e.g. diesel-only, diesel+battery, solar PV fuel saver)
Category winner	The lowest cost of energy system within a particular category.
Component	A piece of equipment that produces and/or manages energy and power in HOMER
Controller	The set of hardware and sometimes software that controls the operation of a power system
Converter	A component that converts power between alternating current (AC) and DC (direct current) parts of a system. This is a simplification that can represent either an inverter (DC to AC), a rectifier (AC to DC), or a bidirectional inverter
Cost matrix	HOMER's input area where you specify the cost for a component's capacities
Dmap	3-D graph showing one year of time series data, with time of day on the vertical axis and day of the year on the horizontal axis. Each time step is represented by a rectangle colored according to its data value. A variant of a heat map.
Hybrid system	A system that uses multiple component types to serve a load
Load	The amount of power required at an end point. HOMER Pro manages 3 types of loads – electric, thermal, and hydrogen. The term "load" used alone in HOMER applies to an electric load, measured in kW per unit of time.
Load type	The type of load being served. HOMER offers four basic load "types" for those who do not have detailed data on how their load is distributed in time: residential, commercial, industrial, and community (residential plus commercial). See also: synthetic load, peak load, peak month
Microgrid or mini-grid	An electric system that can autonomously use components to reliably serve a load. Although the distinction can vary, a microgrid typically includes a grid component, whereas a mini-grid typically does not (i.e. it is remote).
Net present cost	A finance term representing the present value of all the costs of installing and operating that component over the project lifetime, minus the present value of all the revenues that it earns over the project lifetime. HOMER calculates the net present cost of each component of the system, and of the system as a whole.
O&M costs	Operations and maintenance costs. The total cost associated with operating and maintaining a particular component in a power system, usually on an annual basis. For a grid-based system
Optimizer	HOMER's proprietary tool for numerically solving and finding the least-cost system design

OST Plot	Optimal System Type Plot. A HOMER output plot that demonstrates how system categories change over the range of values in a 2-dimensional sensitivity analysis
Overall winner	The lowest cost system of all systems that HOMER considered.
Peak load	The maximum load for all time periods.
Peak month	The month in which load is greatest. This is related to climate, and is used to synthesize a load.
Schematic	Diagram that shows the various components and loads that HOMER will consider in a model, found in the upper-left of HOMER Pro's design view
Search space	The possible sizes/capacities for a component
Sensitivity variable	An input that could be multiple values. In HOMER, these are inputs that the designer cannot control, for example the price of fuel or the interest rate.
Synthetic load	A load that is based on estimated, rather than measured, data. HOMER provides tools to help users specify synthetic data to develop a full year's load. This is in contrast to imported or interval data.