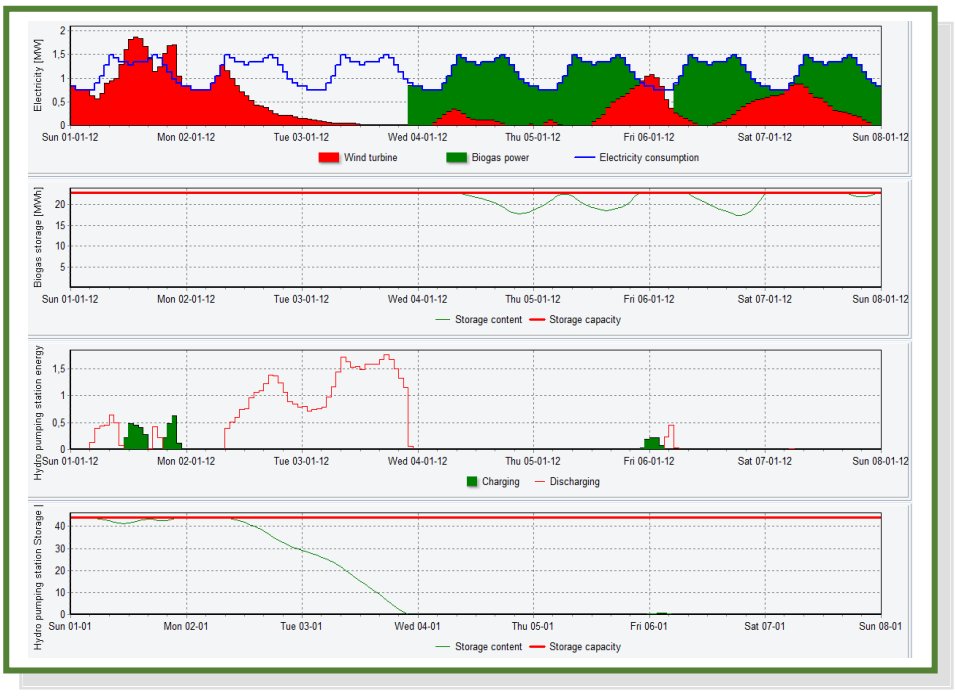
HOW TO GUIDE

Island operation with electricity and fuel storage



Software for techno-economic analyses of energy projects

EMD
www.emd.dk

Preface

energyPRO is a Windows-based modeling software package for combined techno-economic analysis and optimisation of complex energy projects with a combined supply of electricity and thermal energy from multiple different energy producing units.

The unique programming in energyPRO optimises the operations of the plant including energy storage (heat, fuel, cold and electrical storages) against technical and financial parameters to provide a detailed specification for the provision of the defined energy demands, including heating, cooling and electricity use.
energyPRO also provides the user with a detailed financial plan in a standard format accepted by international banks and funding institutions. The software enables the user to calculate and produce a report for the emissions by the proposed project.
energyPRO is very user-friendly and is the most advanced and flexible software package for making a combined technical and economic analysis of multi-dimensional energy projects.
For further information concerning the applications of energyPRO please visit www.emd.dk.

Terms of application

EMD International A/S, November 2013

Content

1. Introduction

This 'How to Guide' details how to use energyPRO for modelling an island operation with both an electricity storage and a fuel storage. The descriptions in this guide have been made using the DESIGN module. The guide is addressed to users who already have a basic understanding of energyPRO.

Through this guide you will learn:

- How to set an energyPRO project to island operation (Chapter "2. Setting energyPRO to island operation")
- How to set up an electrical storage and a fuel storage (Chapters "3. Setting up an electrical storage" and "4. Setting up a fuel storage")
- How to make an operation strategy for technical island optimisation (no costs or revenues) (Chapter "5. Operation strategy for technical island operation")

These elements will be shown by building upon the energyPRO project example "2 MW wind turbine.epp" placed in the folder: energyPRO data\English\Project examples[1].

If you are in need of more detailed information regarding the elements described in this guide, please refer to the energyPRO manual found here: www.emd.dk/energyPRO/Downloads/

2. Setting energyPRO to island operation

Before starting with the guide be sure to have the energyPRO project example "2 MW wind turbine.epp" open. By default it is placed in the folder C:\energyPRO data\English\Project examples.

"2 MW wind turbine.epp" consists of a 2 MW wind turbine, an electricity market and an electricity demand on 10.000 MWh/year as shown on Figure 1.

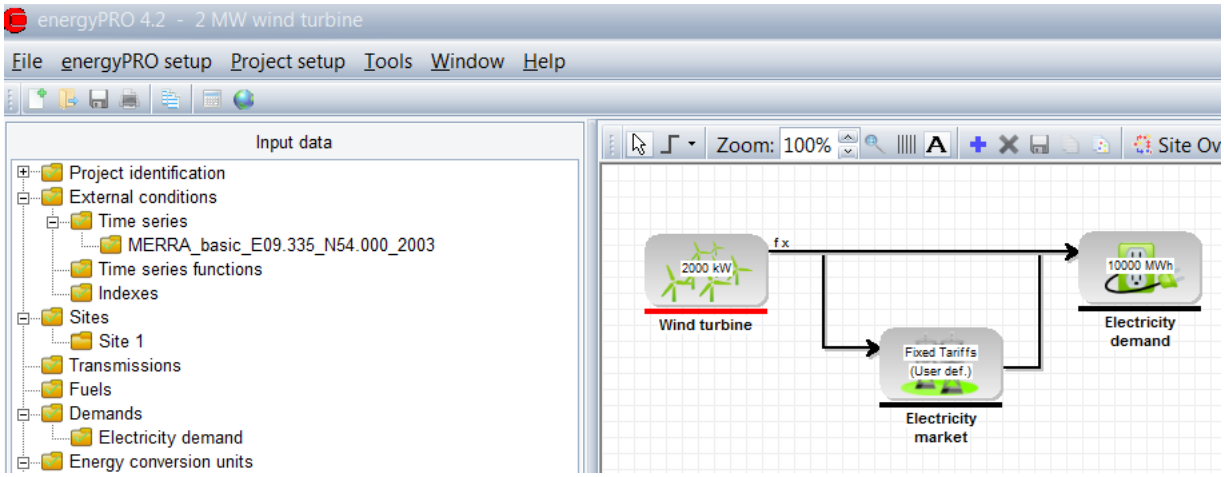


Figure 1. Components existing in energyPRO in relation to this guide

The electricity market will not be used in this guide, and can be deleted by right-clicking the logo and press Delete.

[1] By default the folder's location are C:\energyPRO data\English\Project examples

As the project is not initially in island operation the first step is to change the project to island operation. In order to do this, simply open the "Operation strategy" as shown below on Figure 2.

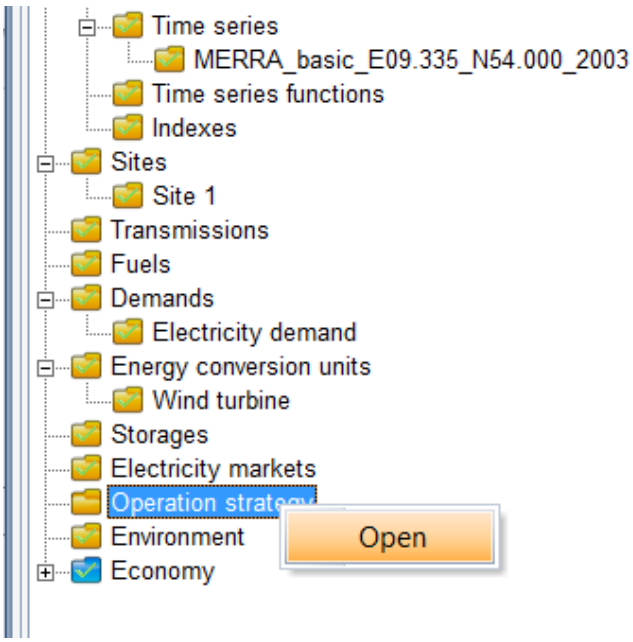


Figure 2. Change of operation strategy

In the upper right corner of the "Operation strategy"-window you will find an option called "Island operation" as seen on Figure 3. Mark this option and press OK to initiate the change.

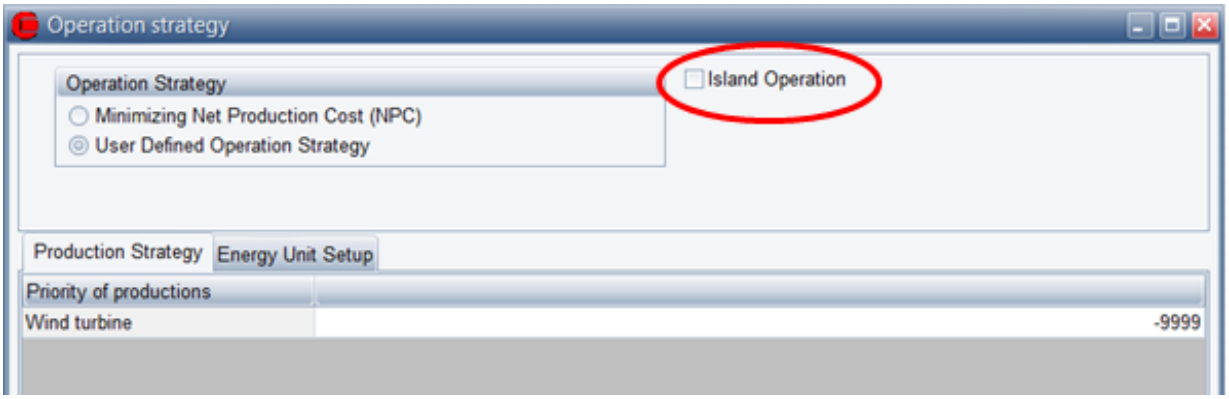


Figure 3. Apply island operation

Note: The "Island operation" option is only visible if an electricity demand is present in the energyPRO project.

When the "Island operation" is marked, the following two options for island operation appear.

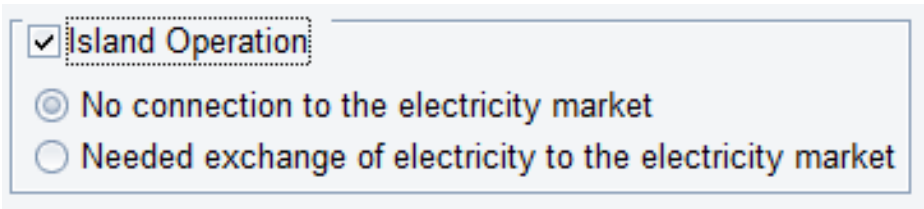


Figure 4. Options for island operation

The option “No connection to the electricity market” is used for modelling island operation without the possibility of importing or exporting electricity from the island. The option “Needed exchange of electricity to the electricity market” makes it possible to both import and export electricity. In this guide the first option will be used, as this is useful for a pure technical island optimisation (no costs or revenues).

3. Setting up an electrical storage

After setting the project to island operation it is relevant to add an electrical storage, to store the production of the wind turbine in hours where the production exceeds the demand. To add an electricity storage right-click “Storages” and choose “Add electrical storage”. This will show the possible electricity storages in energyPRO. Choose “Add hydro pumping station” as shown on Figure 5.

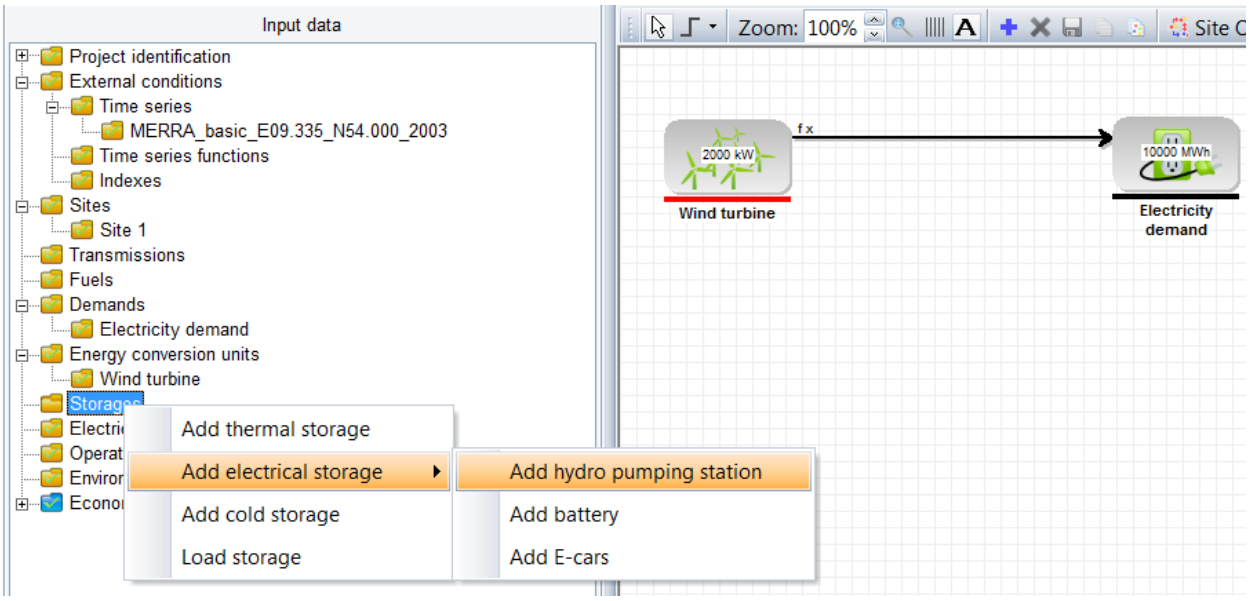


Figure 5. Adding an electrical storage

This will add a hydro pumping station to the project.

If in the “Graphical User Mode” you will notice that graphically the storage has been placed in the top left corner. To rearrange the icons either move the icons around by clicking and dragging them with the mouse, or simply click the “Auto Arrange All Items” button, as seen on Figure 6.[2]

[2] If the hydro pumping station is added by right-clicking in the graphical user interface, then the hydro pumping station will be placed at that position, and not in the top left corner.

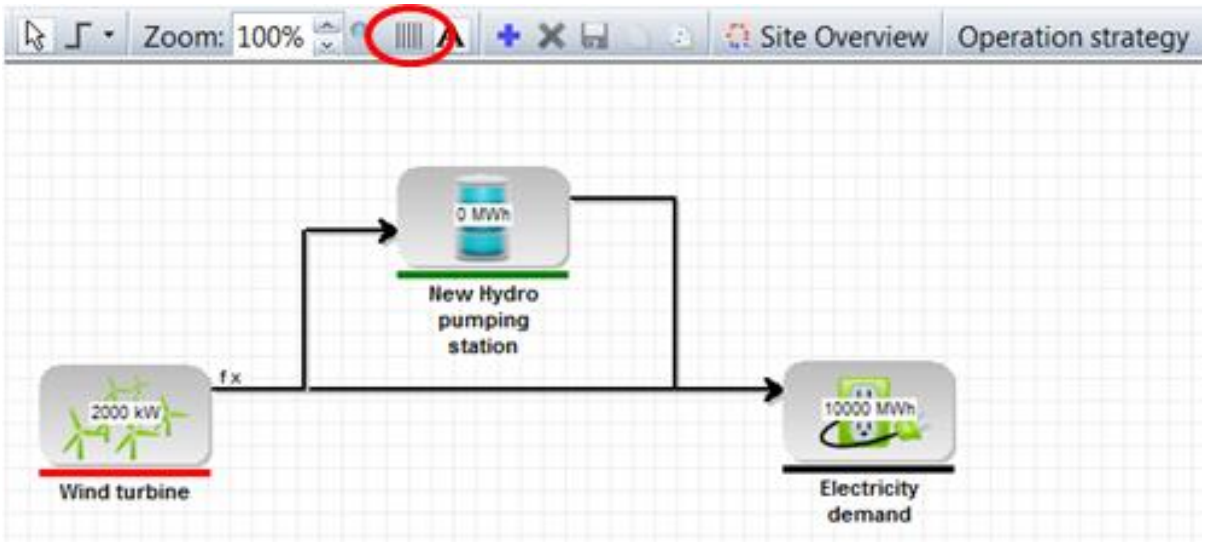


Figure 6. Auto-arrange of the items

By default the hydro pumping station has a capacity of 0 MWh. To change this simply open the hydro pumping station, and type in the relevant values in the interface of the hydro pumping station as shown on Figure 7.

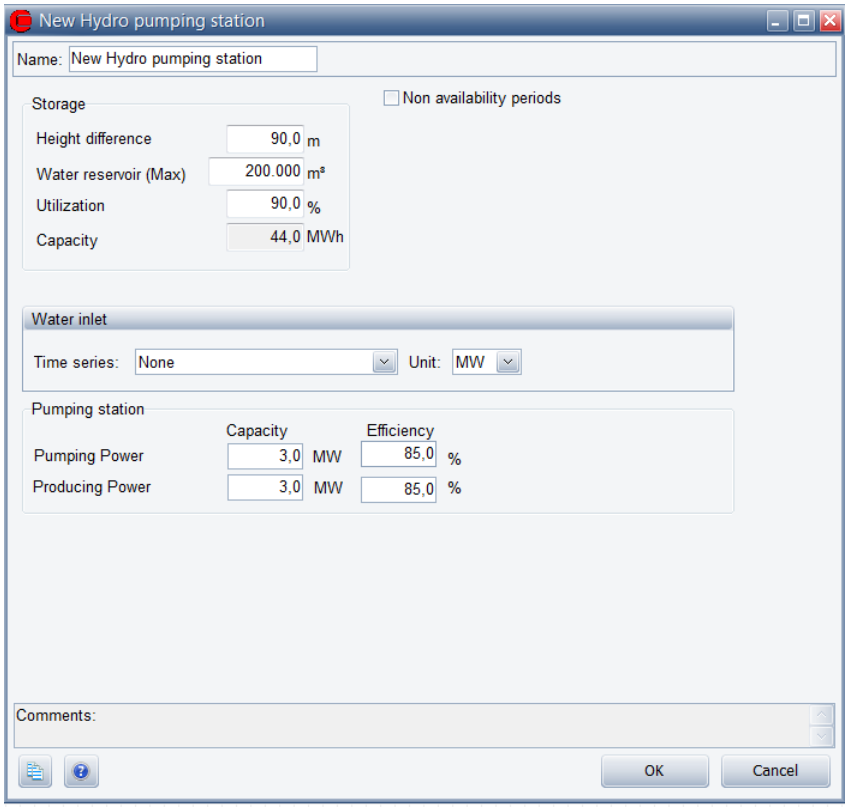


Figure 7. Interface for a hydro pumping station

Looking at the setup of the hydro pumping station there are two overall parts. These are the storage capacity and the pumping/producing capacity. The storage capacity is defined by the height difference between the two reservoirs, the volume of the upper water reservoir and a utilization percentage. The pumping capacity defines at what rate the storage can be filled up, and the producing capacity defines at what rate it can be discharged. In this guide the hydro pumping station is modelled using the values as shown above.

The electricity storage will now store electricity from the wind turbine when the production exceeds the demand. However, if running the calculation, e.g. by clicking the report “Production, graphic” or “Energy conversion, annual”, it is clear that the current wind production is not sufficient to meet the electricity demand.

4. Setting up a fuel storage

As the wind turbine is not sufficient to meet the electricity demand it is relevant to add an electricity producing unit to cover the rest of the electricity demand. This unit will be an engine using biogas that can be stored in a fuel storage if needed. Therefore add a fuel to the energyPRO project. This is done as shown on Figure 8.

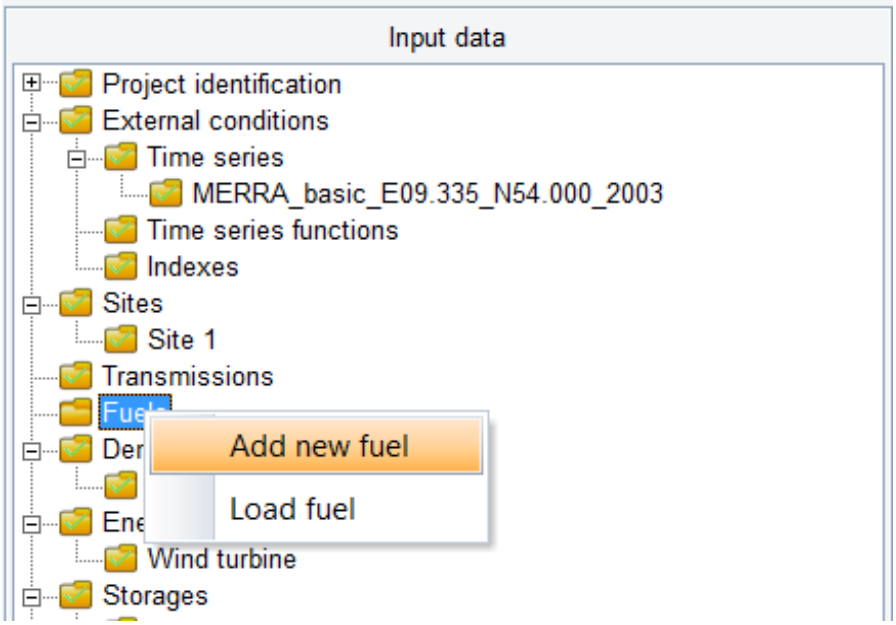


Figure 8. Adding a fuel

Name the fuel Biogas and open it. To add a fuel storage simply mark the option “Restrictions and storage” which will give you the option of setting up a fuel storage, as seen on Figure 9 below.

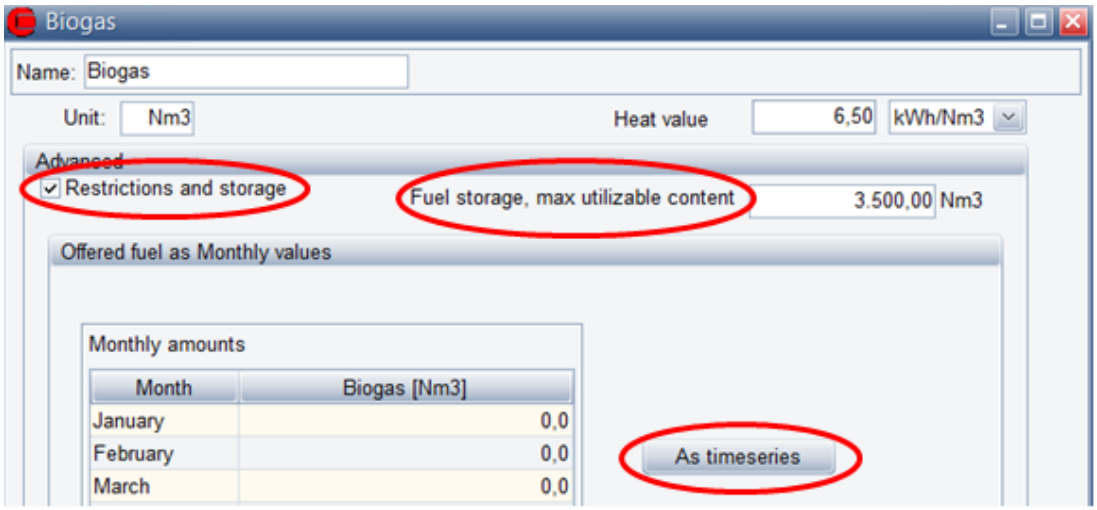


Figure 9. Setting up a fuel storage

Type in the shown values for “Unit”, “Heat value” and “Fuel storage, max utilizable content”.

In this example it is assumed that the biogas is limited to the island, so it is important to set up the amount of biogas produced. This can be done by using monthly amounts or by using a time series. In this guide it will be done by using a time series. Therefore click “As timeseries” as shown above. The window should now look similar to that shown on Figure 10.

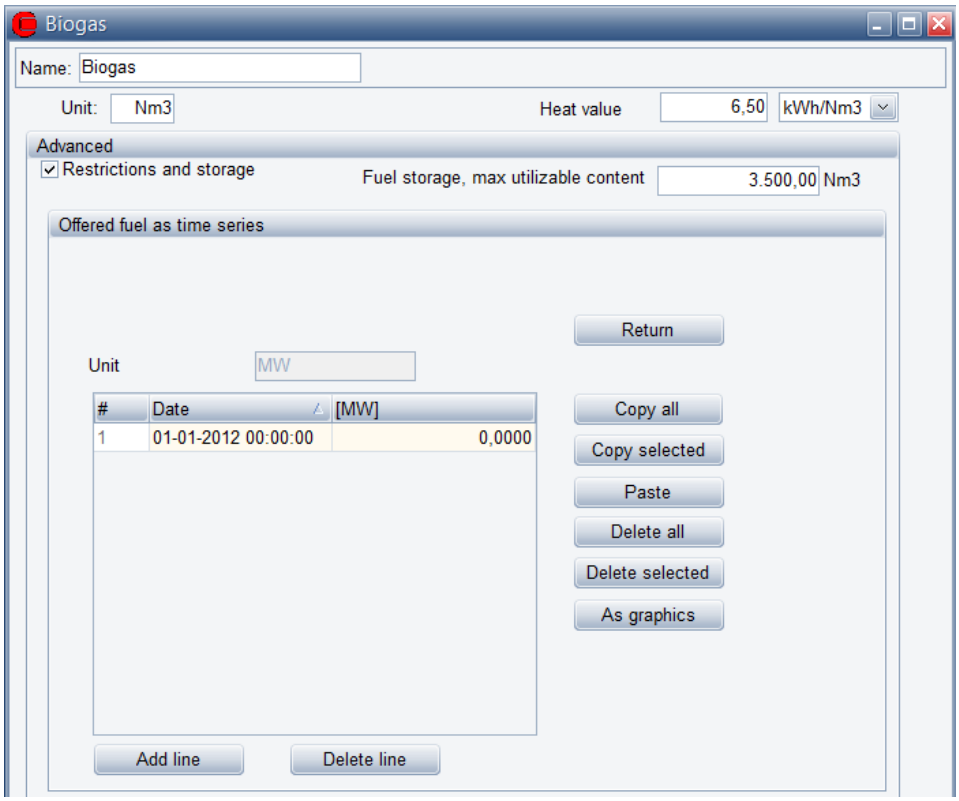


Figure 10. Conversion to time series

Using time series the amount of available fuel can be detailed down to minutes, though the available biogas in this guide will simply be 2.1 MW throughout the year. To model this simply type in 2.1 for the first instance of the modelled period. energyPRO will in a time series continue with a value until a new value is met, and as no new value is met after 2.1 MW, 2.1 MW will be used through the entire period. Then press “Ok”.

To add the biogas engine, right-click “Energy conversion units” and choose “CHP” as shown on Figure 11.

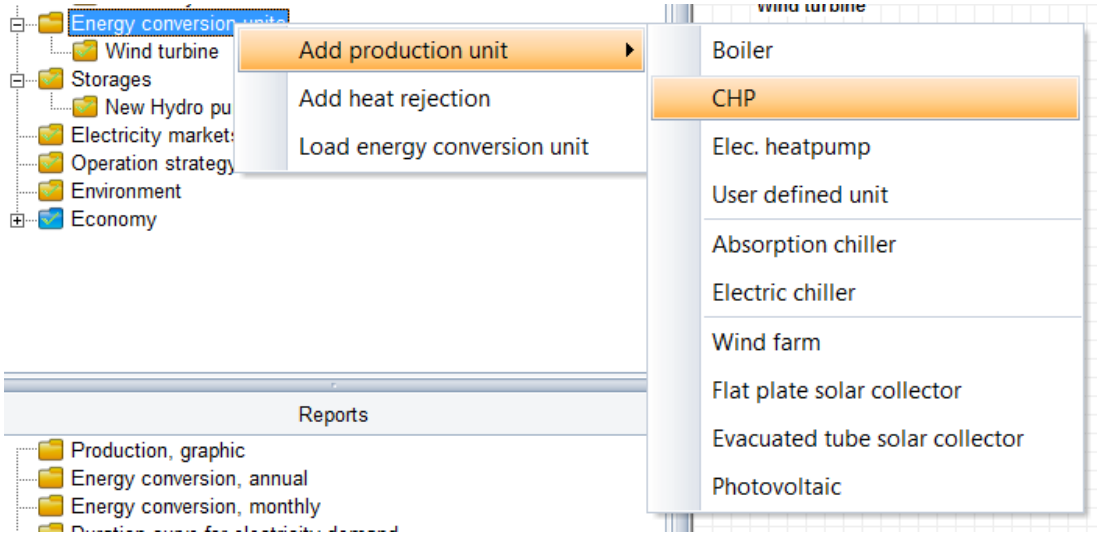


Figure 11. Adding a biogas engine

This added CHP is not an actual CHP, as there is no heat demand in the model. However by leaving the heating capacity at zero and only model capacities for fuel consumption and electricity production, the unit will act as a biogas power plant. To set up the new unit do as shown below.

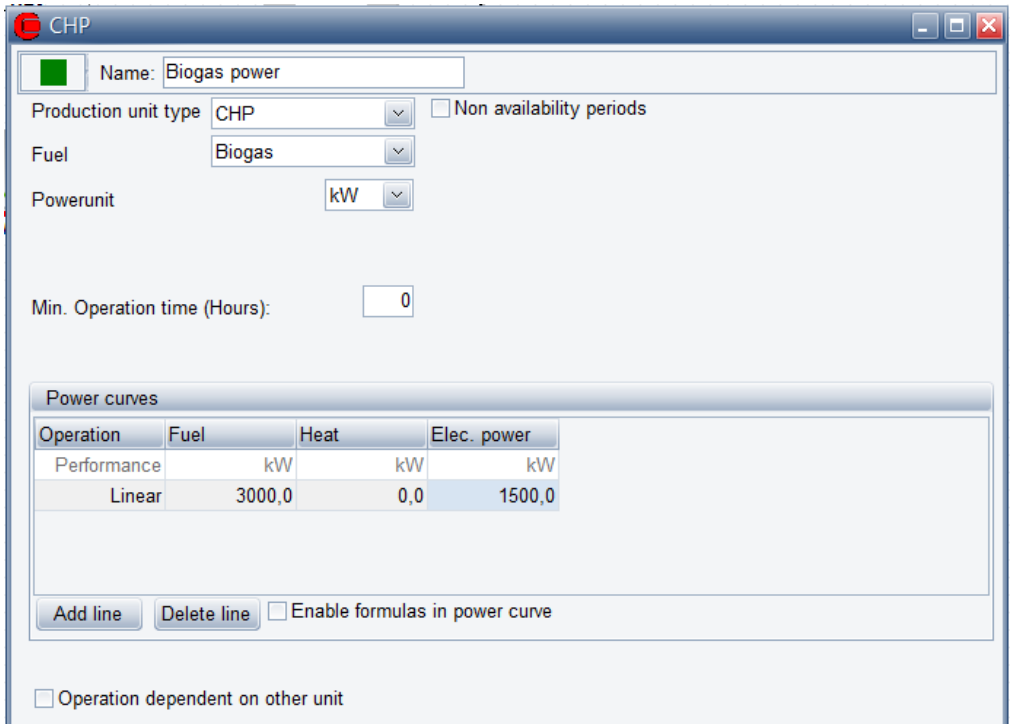


Figure 12. Setting up the biogas power unit

Now the model includes all the needed units for meeting the electricity demand. The next step is to set up the operation strategy for these units.

5. Operation strategy for technical island operation

In this energyPRO project the hydro pumping station is only to be used by the wind turbine, and the biogas power plant will be used for covering the electricity consumption when the wind power production is not sufficient. In order to restrict Biogas power from producing to the hydro pumping station open the “Opera-

tion strategy" so a similar picture as the one on Figure 13. This is done by either clicking on the "Operation Strategy"-folder or by clicking on "Operation Strategy" in the editing window.

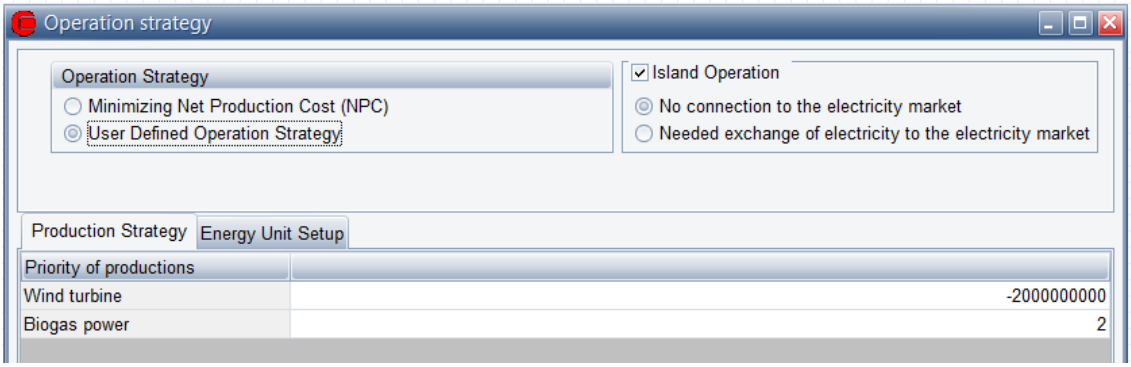


Figure 13. Restrictions on production units

In order to prohibit Biogas power from producing to the electricity storage, it's "Priority of productions"-number has to be above 1, as all units with a priority number of 1 or less are able to produce to electricity storages. In this guide Biogas power will be given the "Priority of productions"-number of 2.

By default units are not allowed to run on partial load, however in this example the unit Biogas power should be allowed to run partial load in order to make up for the wind turbine's fluctuating production. It is also relevant to allow the wind turbine to run at partial load as the wind turbines production cannot be exported if the production exceeds demand and the hydro storage is full. To change this simply click the tab "Energy Unit Setup" and mark the boxes "Partial load allowed", as seen on Figure 14.

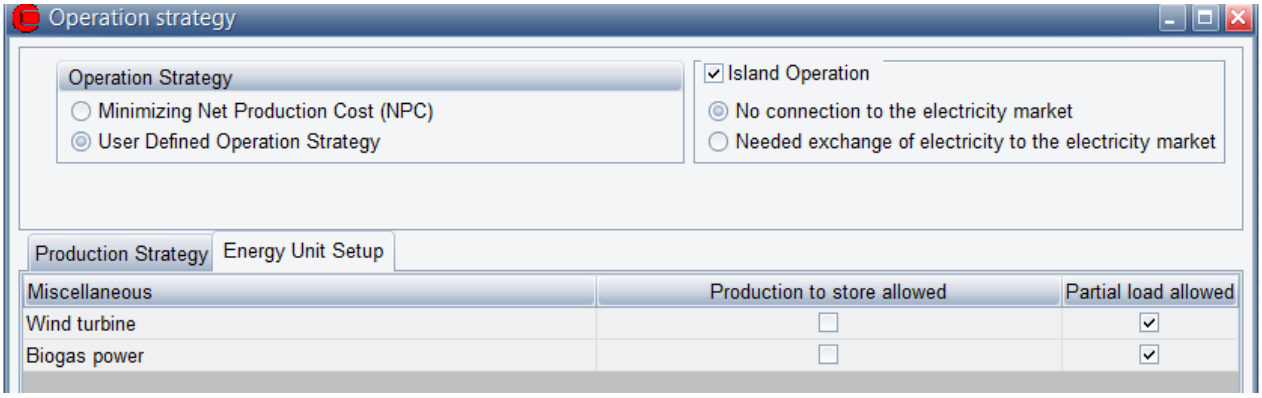


Figure 14. Setting up units to run on partial load

Now close the "Operation strategy" window by pressing "OK".

It is now possible to run the energyPRO calculation and see the results. However, it is recommended to change the optimisation from a default monthly optimisation to a yearly optimization. The reason for this is that the flexibility of the storages is limited to the period of optimisation as energyPRO will make sure that the fuel storage and electricity storage are filled at the end of each optimisation period. As the storages will be used differently through the year in this optimisation, it is relevant to change the optimisation period from monthly to yearly.

The optimisation period-setting is found in "Project identification". Open it as shown on Figure 15.

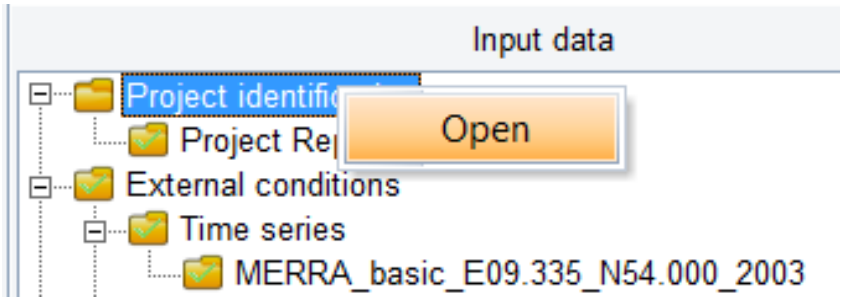


Figure 15. First step in changing the optimisation period

In the opened window mark the option “Advanced” which gives access to new options in the “Project identification” window shown on Figure 16.

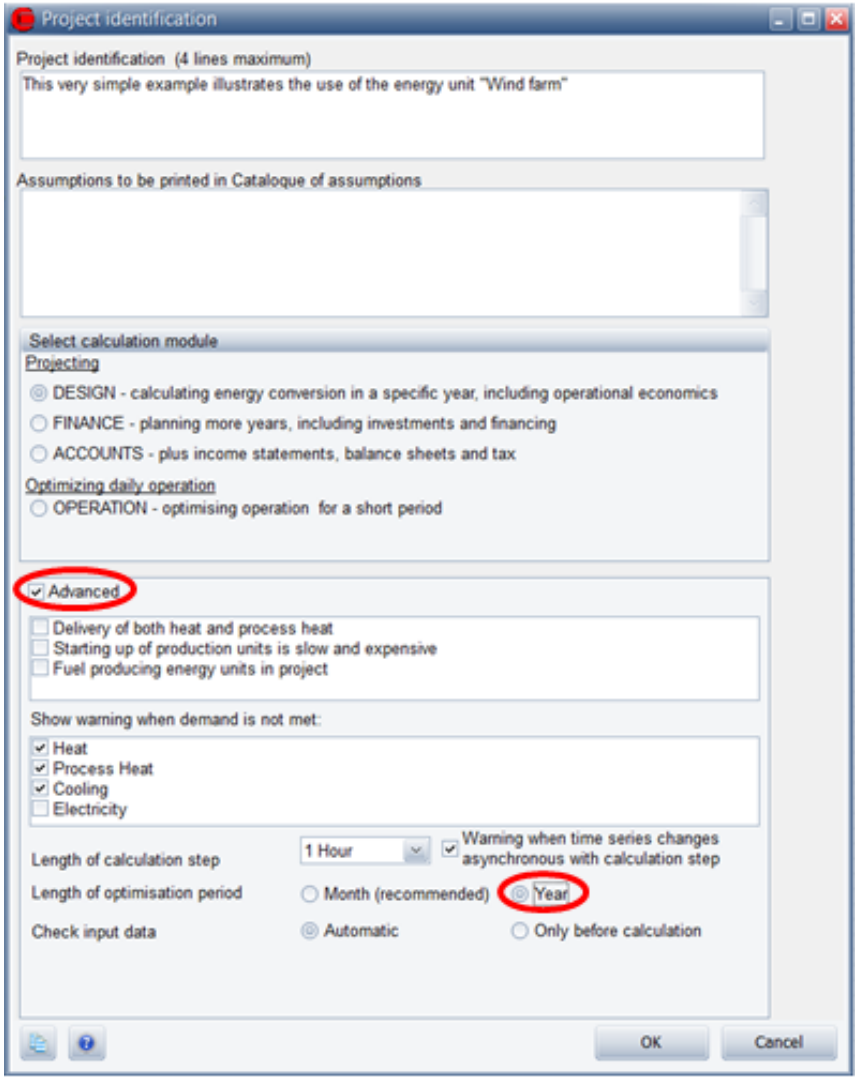


Figure 16. Options in the project identification interface

In the bottom of the window it is possible to select the “Length of optimisation period”. Mark “Year” and press “OK”. The energyPRO project will now be optimised for a full year period.

Note: When using yearly optimisation the calculation time is normally longer than with a monthly optimisation. Yearly optimisation is not recommended for economical optimisations.

To examine how energyPRO utilises the two storages through the modelling period, simply click the report “Production, graphic” as shown below on Figure 17.

Figure 17. “Production, graphic”-report

As shown in the figure above first the wind turbine and hydro storage will be used to meet the electricity demand, and then the biogas power will be used for when the wind turbine and hydro storage are not sufficient.

It is also possible to get the numbers for the entire modelled year. This is done by choosing the report “Energy conversion, annual”, which provides an overview as that shown below.

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2 MW wind turbine
This very simple example illustrates the use of the energy unit "Wind farm"

Energy conversion, annual

Calculated period: 01-2012 - 12-2012

Electricity demands (not including electricity consumed by energy units):

Electricity demand	10.000,1 MWh
Max electricity demand	1,5 MW

Electricity produced by energy units:

	All periods [MWh/year]	Of annual production
Wind turbine	5.141,1	50,3%
Biogas power	5.079,3	49,7%
Total	10.220,5	100,0%
Of annual production	100,0%	

Peak electric production:

Wind turbine	2.000,0 kW-elec.
Biogas power	1.493,1 kW-elec.

Electricity exchange:

Electric storage:

New Hydro pumping station

Charging	794,2 MWh-elec.
Discharging	-573,8 MWh-elec.
Change in storage content	0,0 MWh (As potential elec. output)
Losses	-205,2 MWh-elec.

Hours of operation:

	Total [h/Year]	Of annual hours
Wind turbine	7.914,0	90,1%
Biogas power	5.979,0	68,1%
Out of total in period	8.784,0	

Turnons:

Wind turbine	131
Biogas power	93

Fuels:

By fuel

	Fuel consumption	Fuel production	Offered fuel	Fuel not used
Biogas	1.562.873,8 Nm3	0,00 Nm3	2.837.907,63 Nm3	1.275.033,87 Nm3

By energy unit

Wind turbine	0,0 MWh	=0,0	—
Biogas power	10.158,7 MWh	=1.562.873,8 Nm3	
Total	10.158,7 MWh		

Figure 18. "Energy conversion, annual"-report