HOW TO GUIDE

Load changes energyPRO

energyPRO

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, May 23

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1. Introduction

The load change allows you to model ramping times of energy conversion units in energyPRO. This can be done in 4 different ways: by including restriction on load change frequency, including ramping times between load lines, restricting the time between load changes or attaching a payment to load changes a unit undergoes.

This How To Guide contains four main parts:

Section 2.1 – Load change 1: Time restrictions for consecutive unit changes
Section 2.2 – Load change 2: Time restrictions for ramping between load lines
Section 2.3 – Load change 3: Restriction to limit hourly ramping
Section 3 – Load change payments

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2. How to setup the load change restrictions in energyPRO

The energyPRO project case called: "Load change restrictions on a wood chip fired CHP" can be accessed from the English Project examples in the start window of energyPRO, please see Figure 1. The project is used in this guide to illustrate the load change restrictions in energyPRO. Each created alternative is in accordance with the described load changes 1 – 3 plus load change payment.

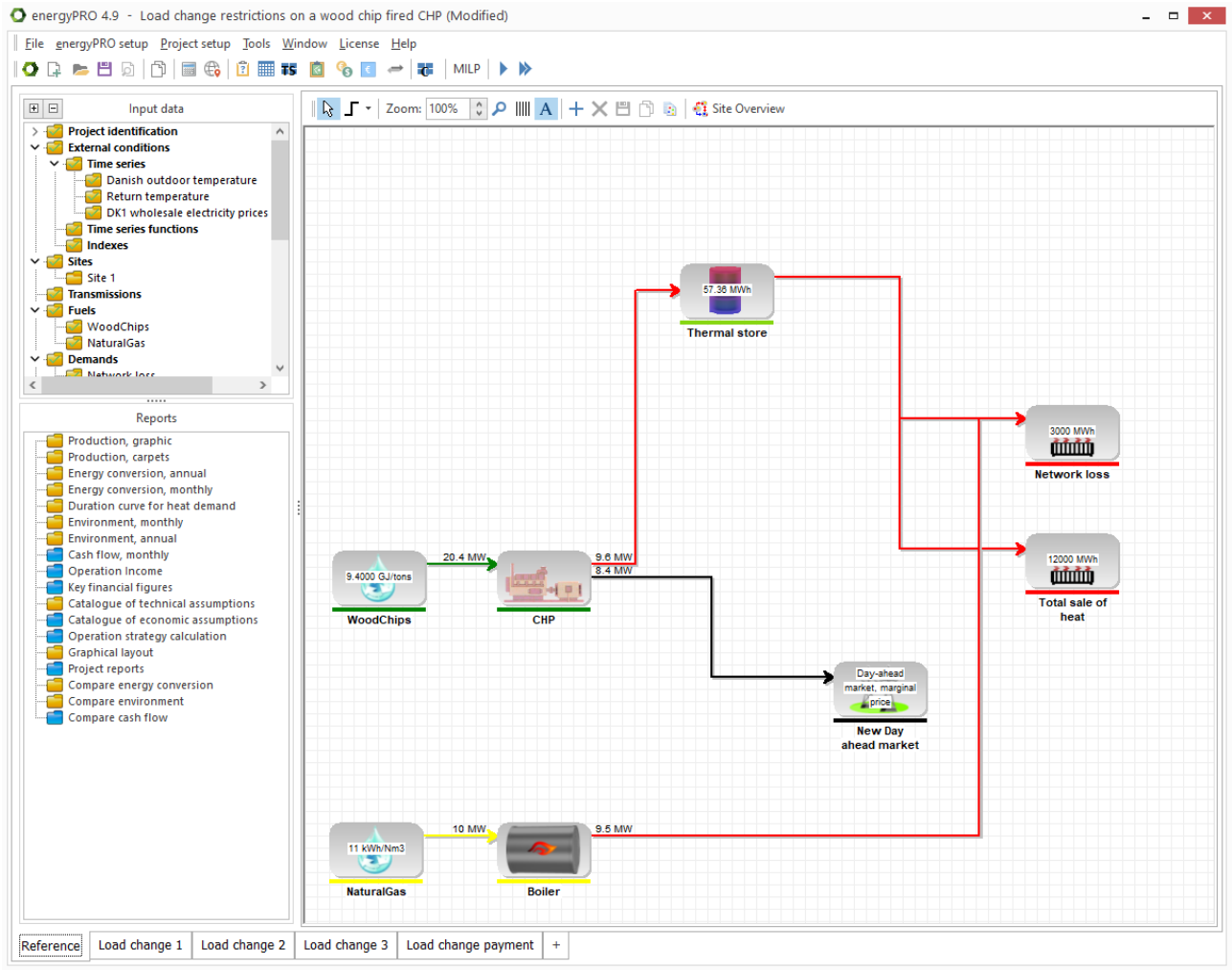

Figure 1. The energyPRO project case, "Load change restrictions on a wood chip fired CHP", used in this HowToGuide, having an alternative for each load change

To include the unit change restrictions in energyPRO, the MILP solver needs to be used as calculation method. To choose the MILP solver, first the project identification needs to be opened as seen in Figure 2.

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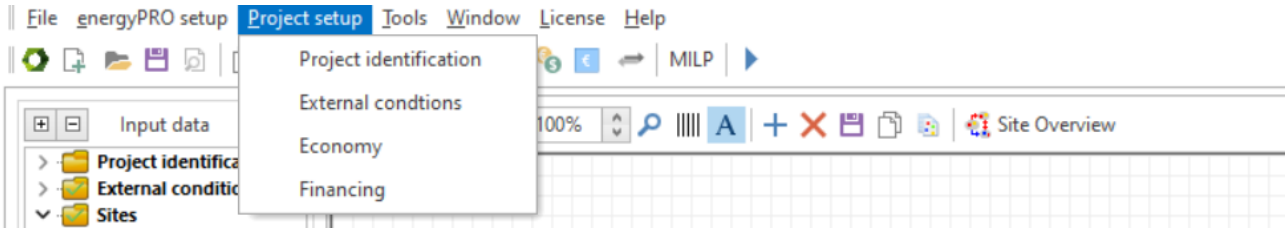

Figure 2. Choosing project identification

In the project identification, the calculation method tab needs to be selected. In the tab the checkbox next to "MILP" is checked as seen in Figure 3.

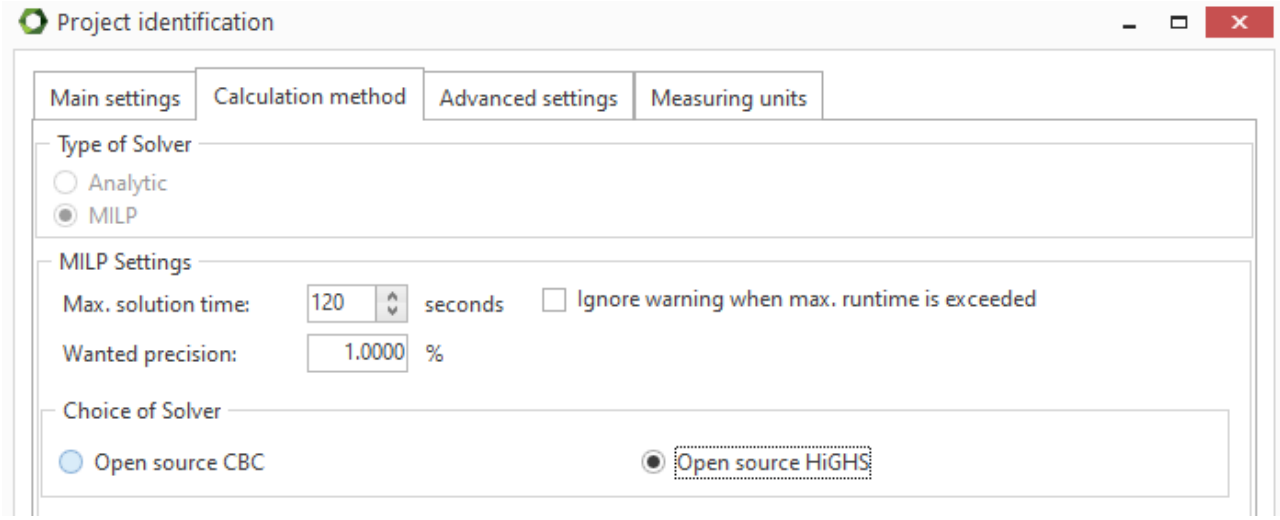

Figure 3. Selecting the MILP-Solver in project identification

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2.1 Load change 1: Time restrictions for consecutive unit changes

A new constraint is introduced to limit how long a unit is not allowed to change its load again after changing its load, specified as a number of timesteps. These timesteps are defined as the calculation step, which can be changed in "project identification", as seen in Figure 4. In the project example it is set to one hour.

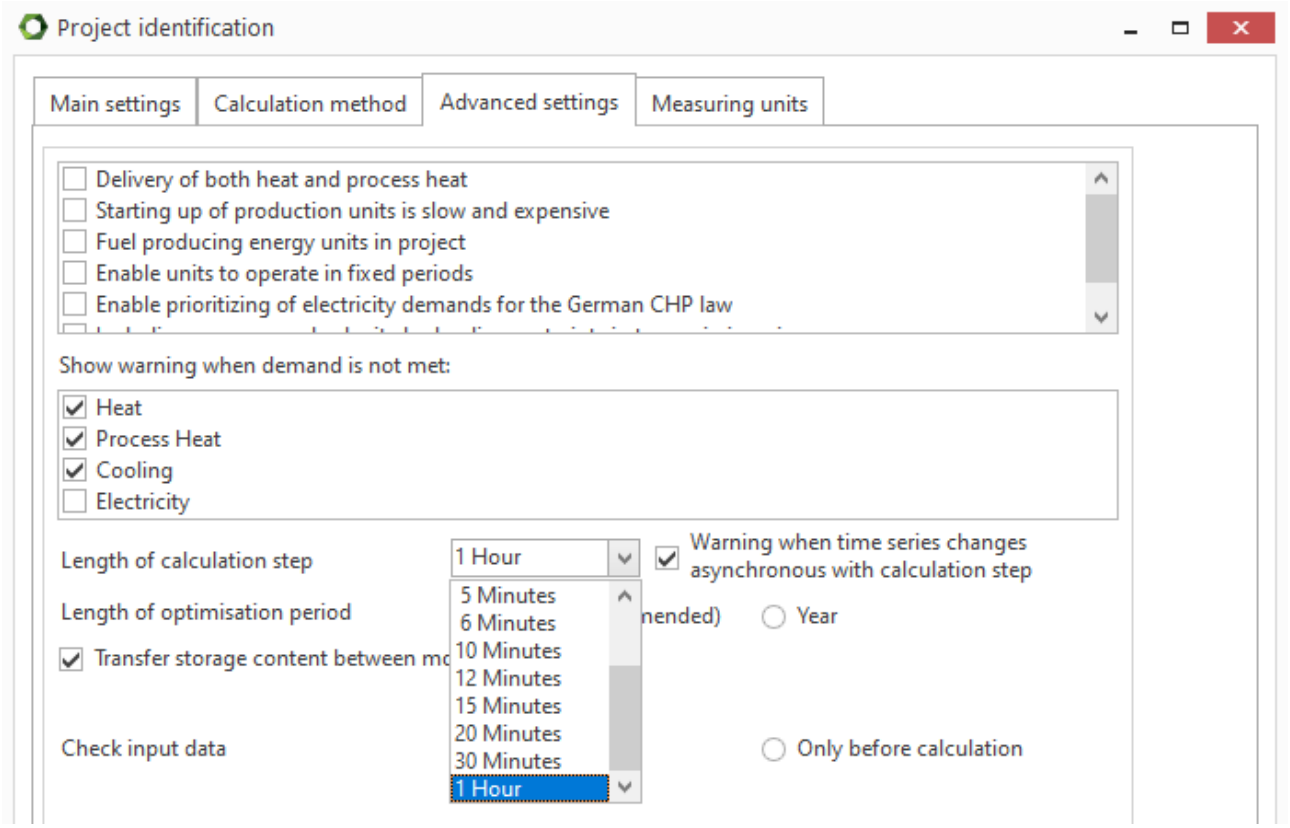

Figure 4. Setting the length of a calculation step in project identification

The unit is not restricted to being at a specific load line – it can still partially load anywhere between minimum and maximum.

To add such a constraint the minimum time between load changes has to be entered into the field next to "Change load no more frequently than" (see Figure 5) as a number of timesteps.

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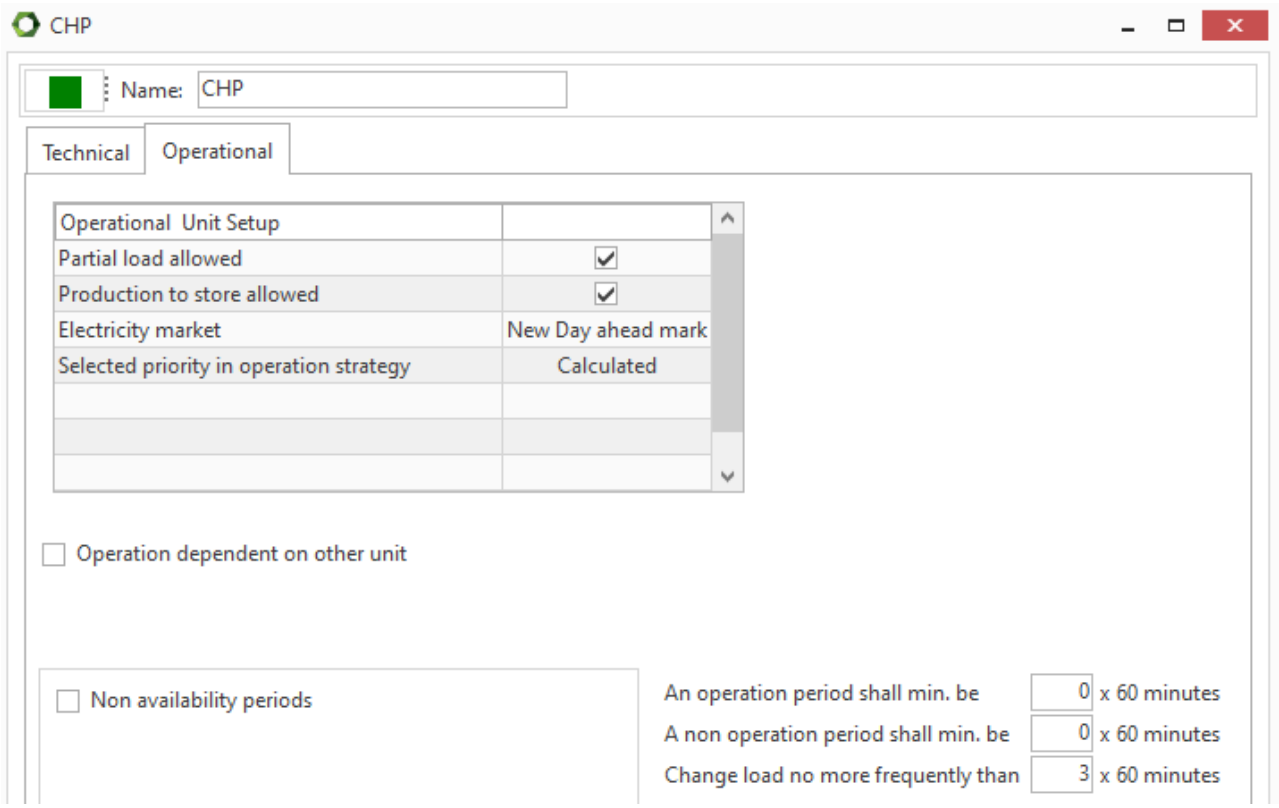

Figure 5. Adding time restriction between load changes

If the unit changed load, exactly the specified number of timesteps must pass before the load can be changed again. A shut down of the unit is also considered as a change in load, and n number of timesteps must pass before the unit can start again.

Be aware that if the Change load setting is higher than an operation or a non-operation period then the load change overrules these settings.

2.2 Unit change 2: Time restrictions for ramping between load lines

A second option to include restrictions on the ramping of units is to include ramping up and ramping down times to each load line added to the unit. These can be defined by what the maximum change in load is in one timestep. Eg. between two timesteps, a CHP cannot increase heat production by more than 1 MW and cannot decrease heat production by more than 2 MW, modelling a ramp up and ramp down respectively. This can be done if the unit is opened per right click and the check box next to "Load change restrictions", as seen in Figure 6. To be able to include such restrictions, at least two load lines need to be inserted. Furthermore, the checkbox next to "Time from one load to the next" needs to be checked.

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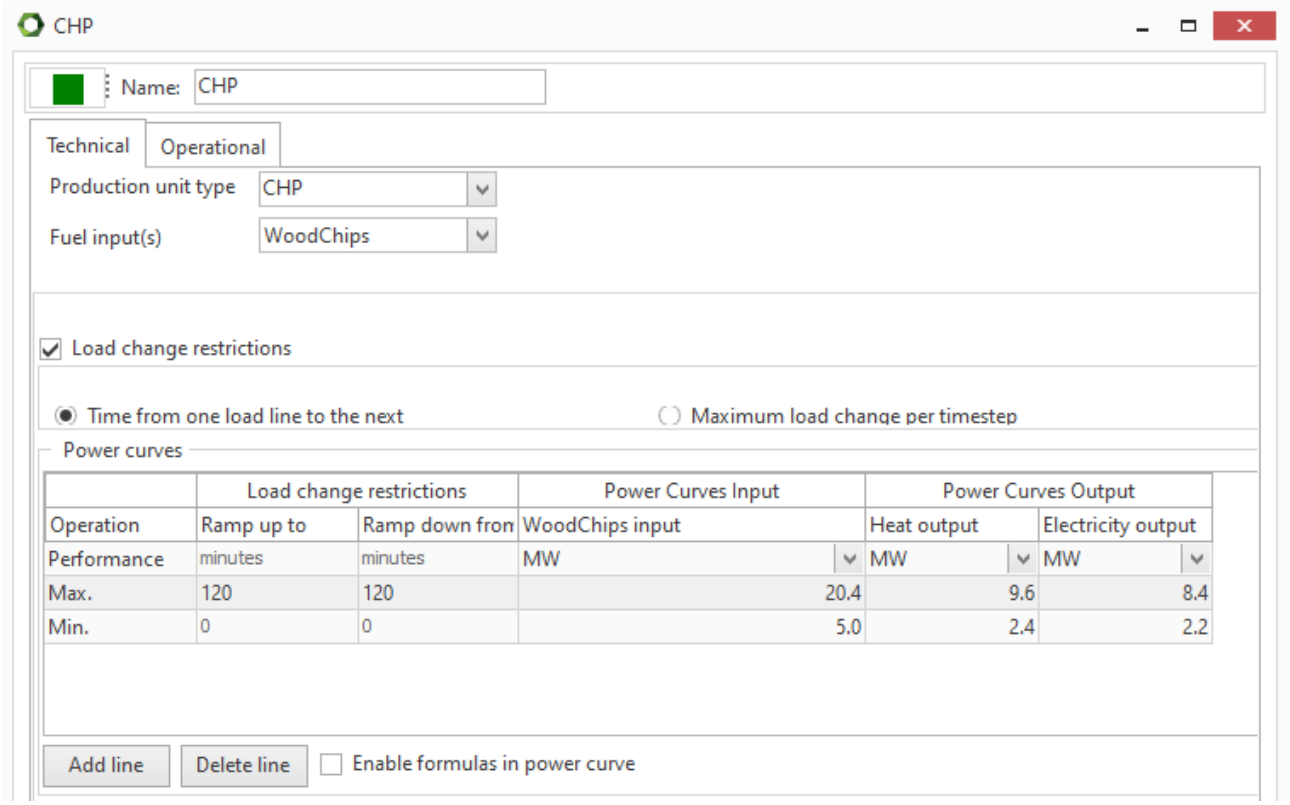

Figure 6. Adding load restrictions to load lines

The ramping times can be included for every load line above the minimum load. The times should be entered in minutes. They specify the time it takes to ramp from up from the load line below ("Ramp up to") and the time it takes to ramp down to the load line below ("Ramp down from").
This can be combined with the feature described in Chapter 2.1 to include a restriction for the amount of unit changes in a time frame.

2.3 Unit change 3: Restriction to limit ramping per timestep

To include a restriction on how much a unit can ramp in a specified time frame (see Figure 4), first the checkbox next to "Load change restrictions" is activated. Then the checkbox next to "Maximum load change per timestep" is selected as seen in Figure 7.

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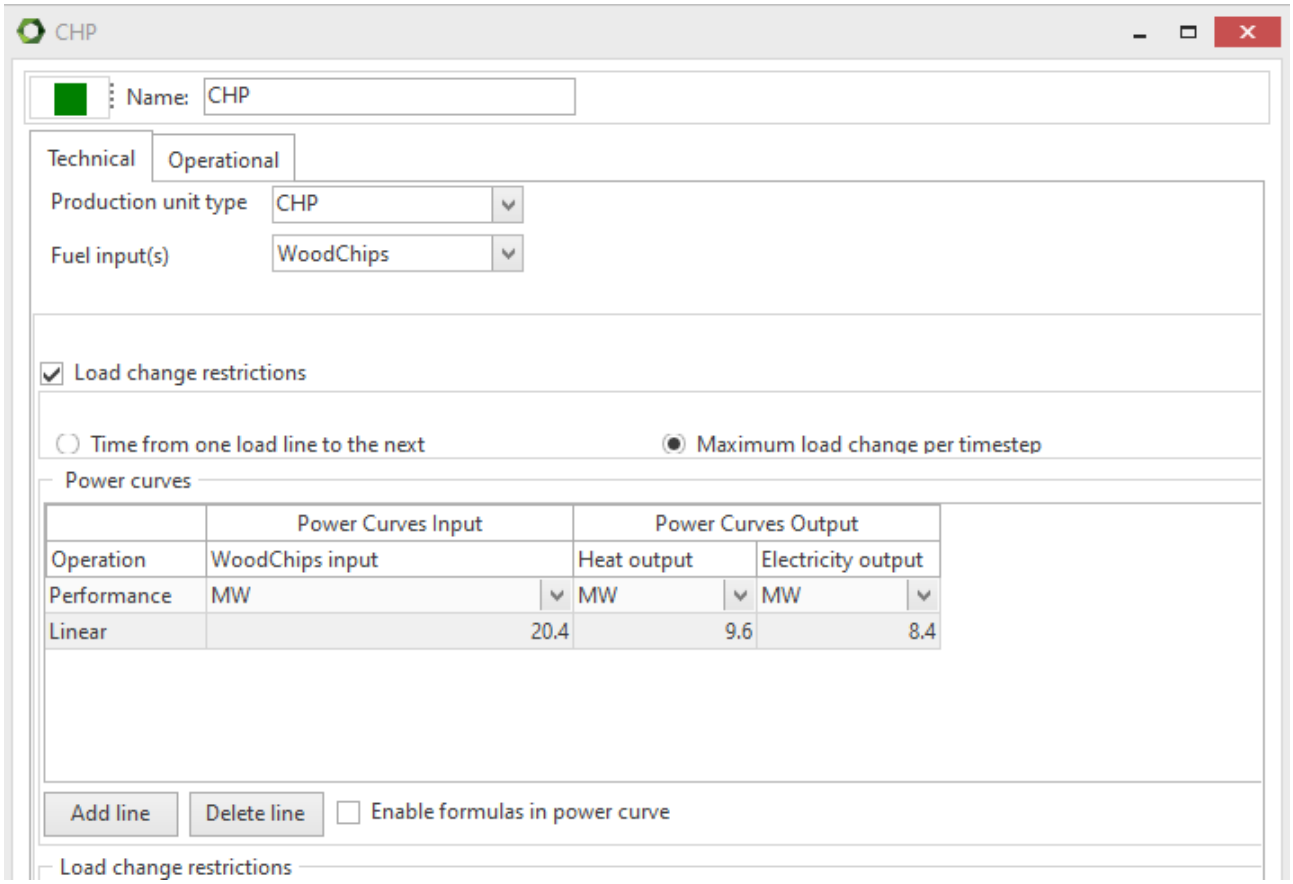

Figure 7. Activating load change restrictions for a maximal load change per hour

A new menu for load change restrictions will appear as seen in Figure 8.

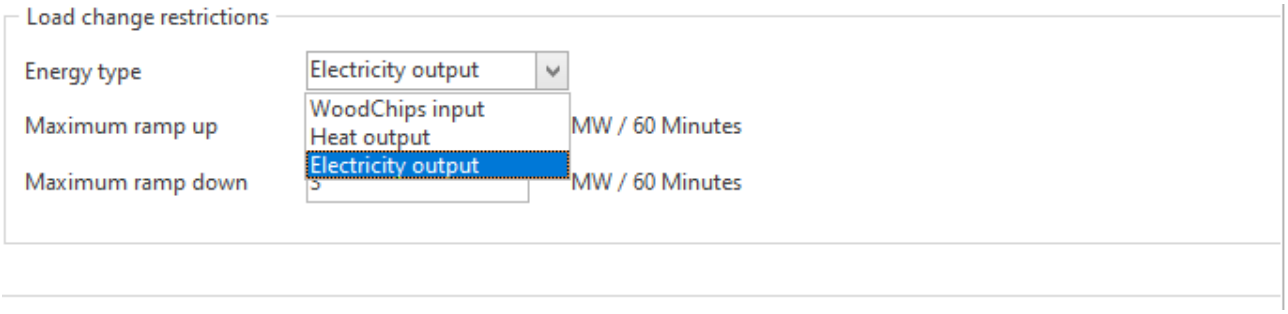

Figure 8. Menu for maximal load change per timestep

Here the energy type that the load restrictions apply to can be selected in a drop-down menu. The dropdown menu will give options for all existing power curves in the unit.

For the selected energy type a maximum ramp as well as a maximum ramp down can be assigned. The maximum ramp up specifies how many MW of the selected energy type can be ramped up in a timestep. The maximum ramp down specifies the amount of MW that the unit can ramp this energy type down in a timestep.

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3. Payment for load changes

Another possibility to restrict the load changes of a unit, is to attach a payment to load changes, meaning that a payment must be performed each time a unit changes its load. To create such a payment, a payment must be added to the project by right clicking operation expenditures and selecting Add Payment. This payment should be opened, as seen in Figure 9

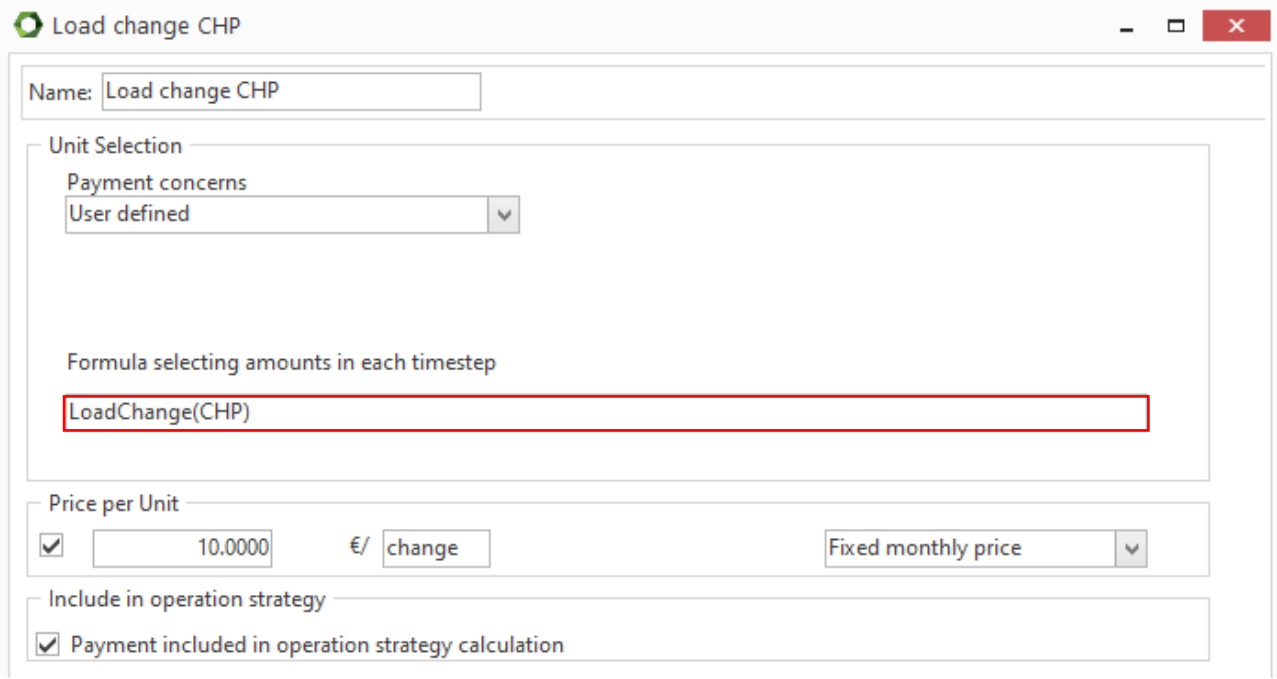

Figure 9. Setting up a payment on load changes

The payment is set up by double-clicking the red marked cell, opening up the menu shown in Figure 10.

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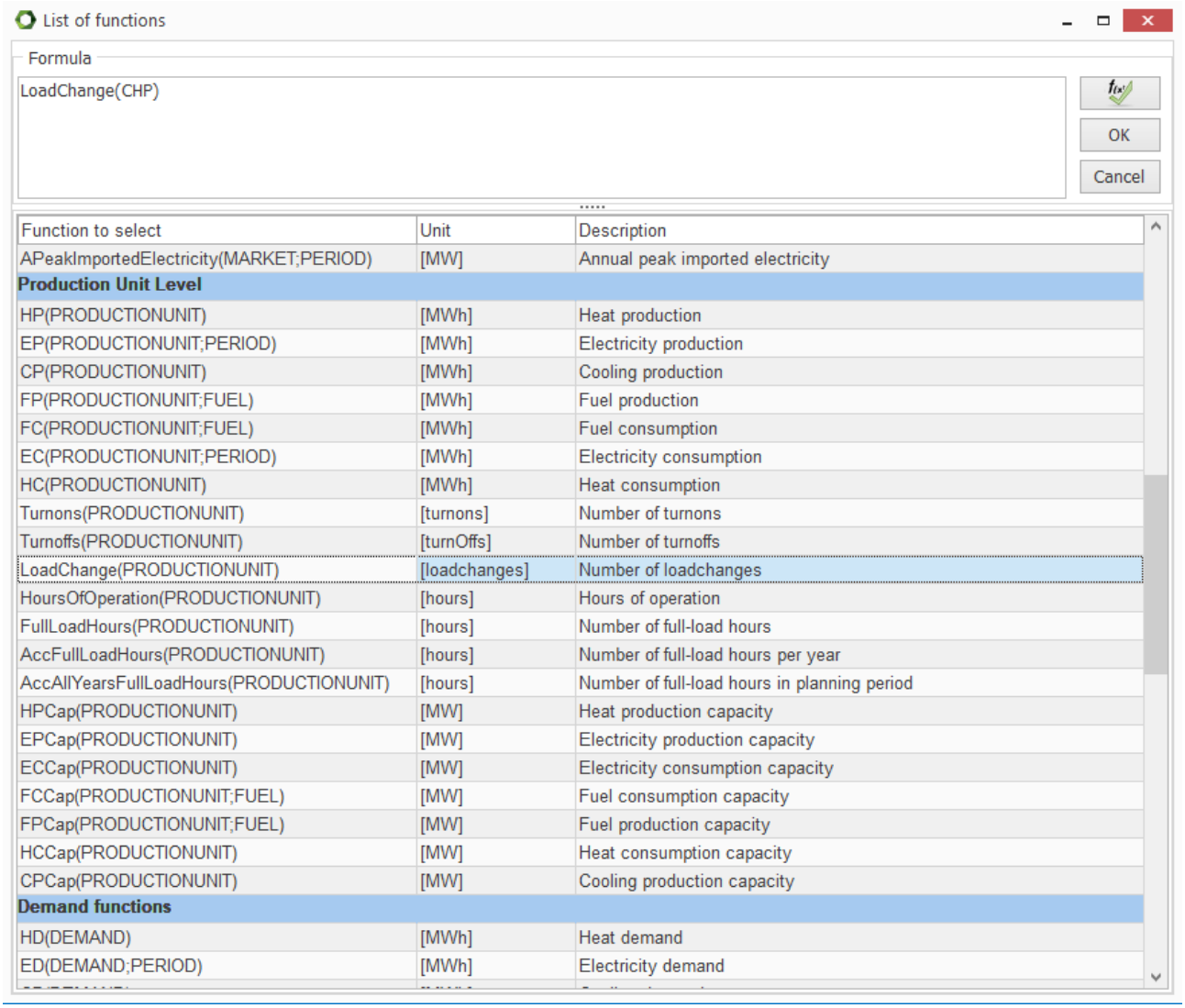

Function to select	Unit	Description
APeakImportedElectricity(MARKET;PERIOD)	[MW]	Annual peak imported electricity
Production Unit Level		
HP(PRODUCTIONUNIT)	[MWh]	Heat production
EP(PRODUCTIONUNIT;PERIOD)	[MWh]	Electricity production
CP(PRODUCTIONUNIT)	[MWh]	Cooling production
FP(PRODUCTIONUNIT;FUEL)	[MWh]	Fuel production
FC(PRODUCTIONUNIT;FUEL)	[MWh]	Fuel consumption
EC(PRODUCTIONUNIT;PERIOD)	[MWh]	Electricity consumption
HC(PRODUCTIONUNIT)	[MWh]	Heat consumption
Turnons(PRODUCTIONUNIT)	[turnons]	Number of turnons
Turnoffs(PRODUCTIONUNIT)	[turnOffs]	Number of turnoffs
LoadChange(PRODUCTIONUNIT)	[loadchanges]	Number of loadchanges
HoursOfOperation(PRODUCTIONUNIT)	[hours]	Hours of operation
FullLoadHours(PRODUCTIONUNIT)	[hours]	Number of full-load hours
AccFullLoadHours(PRODUCTIONUNIT)	[hours]	Number of full-load hours per year
AccAllYearsFullLoadHours(PRODUCTIONUNIT)	[hours]	Number of full-load hours in planning period
HPCap(PRODUCTIONUNIT)	[MW]	Heat production capacity
EPCap(PRODUCTIONUNIT)	[MW]	Electricity production capacity
ECCap(PRODUCTIONUNIT)	[MW]	Electricity consumption capacity
FCCap(PRODUCTIONUNIT;FUEL)	[MW]	Fuel consumption capacity
FPCap(PRODUCTIONUNIT;FUEL)	[MW]	Fuel production capacity
HCCap(PRODUCTIONUNIT)	[MW]	Heat consumption capacity
CPCap(PRODUCTIONUNIT)	[MW]	Cooling production capacity
Demand functions		
HD(DEMAND)	[MWh]	Heat demand
ED(DEMAND;PERIOD)	[MWh]	Electricity demand

Figure 10. Selecting the LoadChange function for payments

In the list shown, the LoadChange function can be selected by double-clicking. The name of the unit that this payment is applied to, needs to be entered into the brackets, to attach the payments to this unit.

4. Production, graphic reports of all load changes

To illustrate the load changes described in sections 2.1 - 2.3 the graphic production reports of the project examples different alternatives are used. Figure 11 shows the production of the project example without any load change restrictions. The figure illustrates the production and consumption of heat and electricity over the duration of a week.

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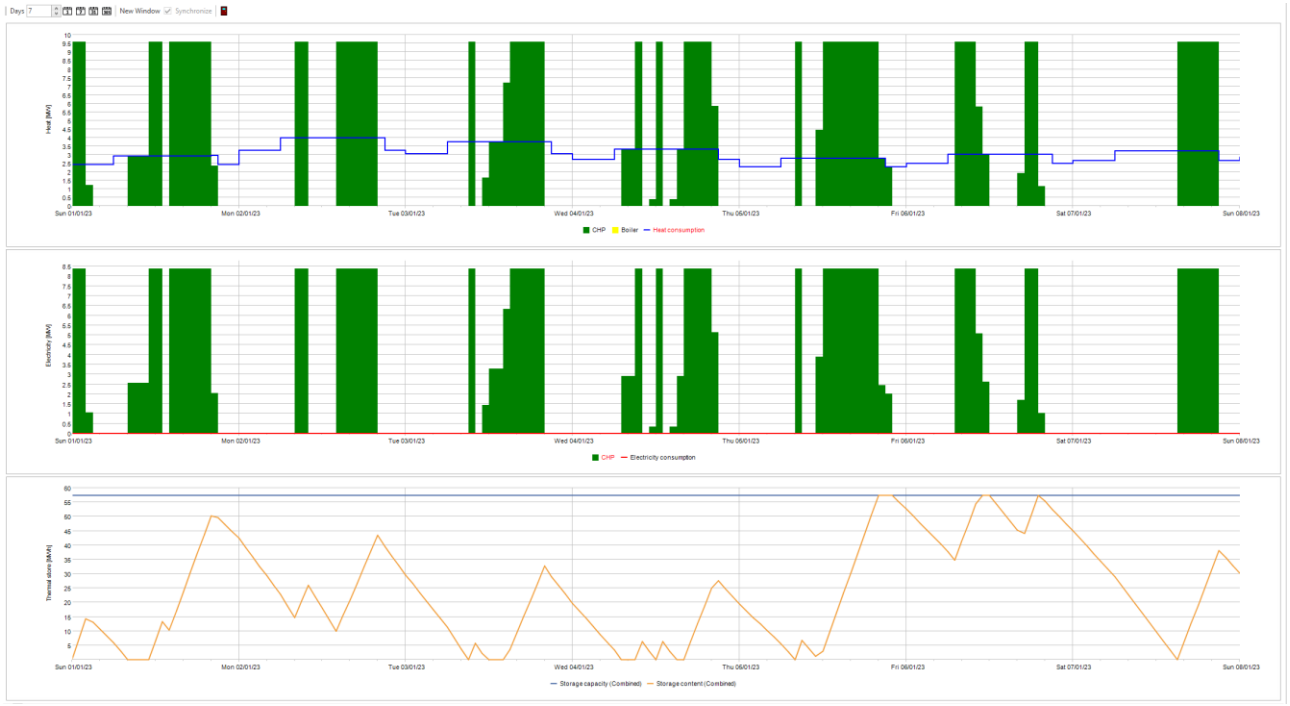

Figure 11. Production, graphic report of a reference model without load change restrictions

Figure 12 shows the production graphic of the load change described in section 2.1 which restricts the time distance between consecutive load changes. This is set to three hours in the example. In comparing the loads in Figure 12 to Figure 11 the load looks more stable and less fluctuating.

Figure 12. Production, graphic report of Load change 1

Figure 13 shows the production graphic of a unit that is restricted in its load changes between two load lines. Therefore, a minimum load is added from which it takes two hours to ramp up to nominal load and

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two hours to ramp down from nominal load to minimum load. The operation of the unit is observed to be less often in nominal load than in Figure 11 . Furthermore, no loads smaller than the minimum load can be observed.

Figure 13. Production, graphic report of Load change 2

Figure 14 shows the production graphic of a unit that is ramp its electricity production not more than 3 MW per hour, using the restriction described in section. It can be observed that the changes in electric and thereby in heat as well do not exceed a certain maximum. No ramps from no load to nominal load in an hour like in Figure 11 are present.

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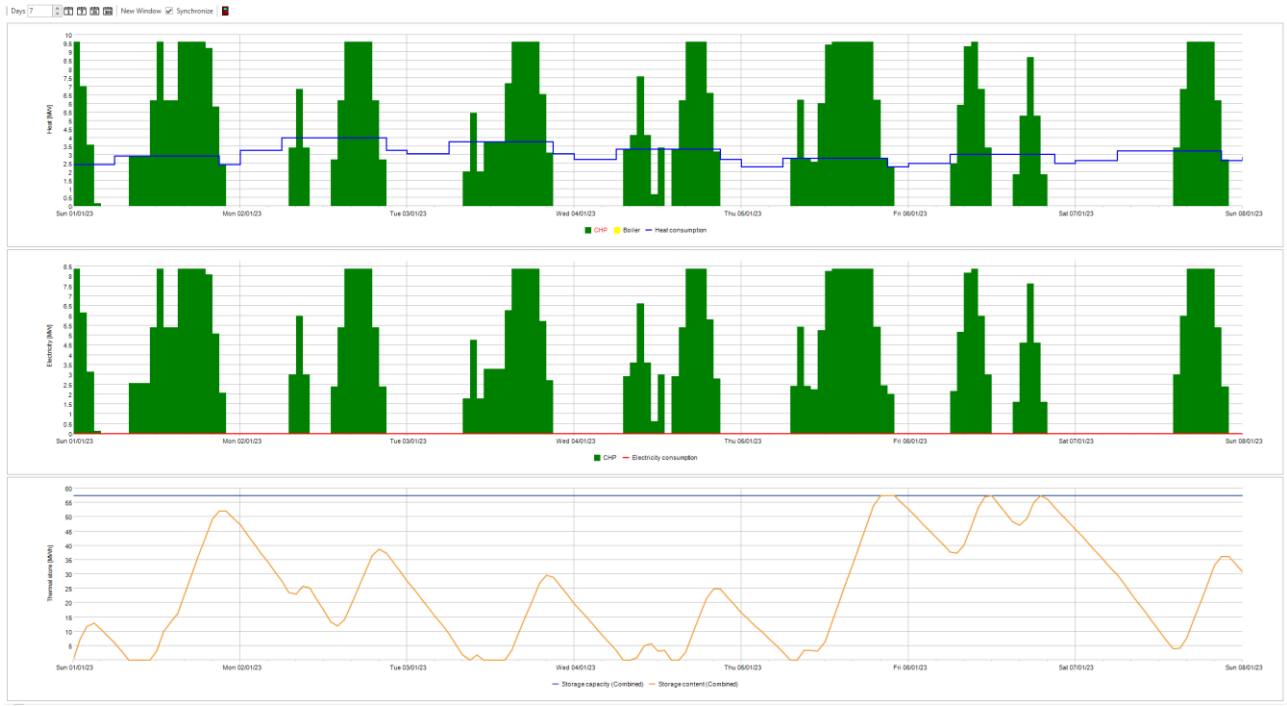

Figure 14. Production, graphic report of Load change 3

Figure 15 shows the production graphic of a CHP unit, with a payment of 10 € attach to load changes. This leads to a comparatively low number of load changes.

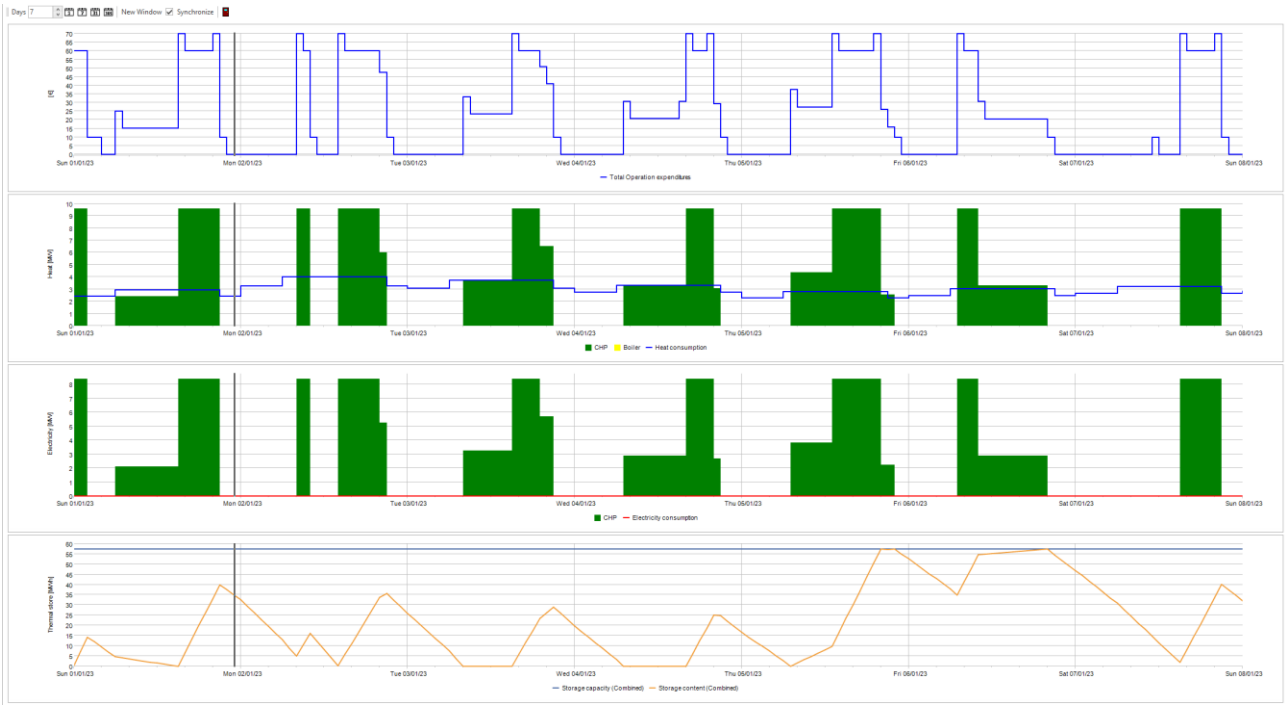

Figure 15. Production, graphic report of a payment of 10 € on each load change, included in operation strategy

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