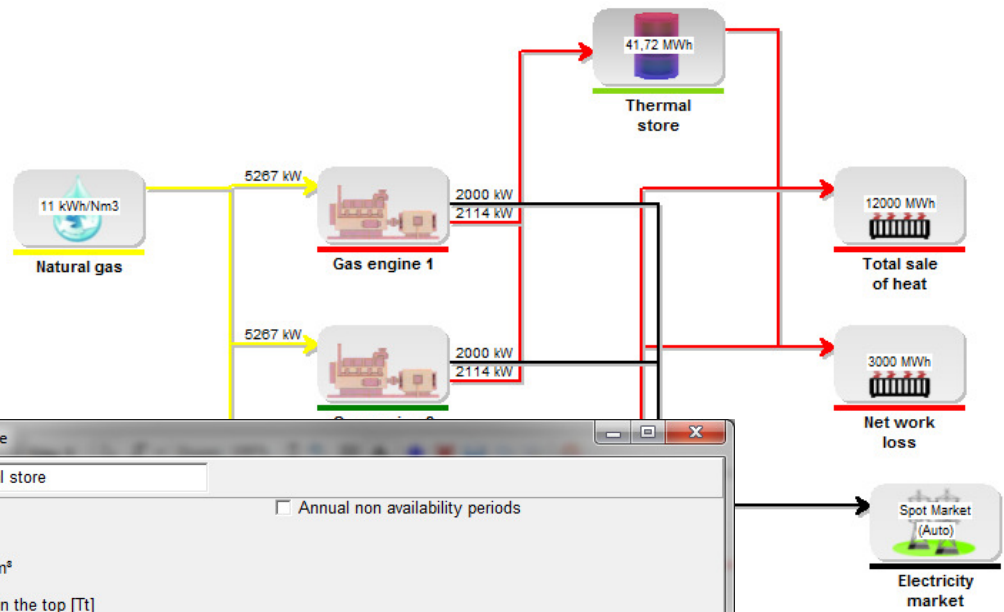




Storage losses

energyPRO 4.0.2



Thermal store

Name: Thermal store

Annual non availability periods

Volume [V]
1000,0 m³

Temperature in the top [Tt]
90,00 °C fx Check

Temperature in the bottom [Tb]
50,00 °C fx Check

Utilization
90,0 %

Thermal storage capacity :
41,7 MWh as of Fri 1. January 2010

Storage Loss

Storage Height [h]	Insulation Thickness [s]	Thermal Conductivity [Lambda]
14,20 m	300,00 mm	0,0370 W/(m°C)

Ambient Temperature [Ta]
Outdoor temperature 20,00 °C

Formula for heat loss at full store User Defined fx Check
$$\frac{(\text{Lambda} \cdot 1000 / \text{s}) \cdot \pi \cdot \sqrt{V / (h \cdot \pi)}}{(2 \cdot h + \sqrt{V / (h \cdot \pi)})} \cdot (Tt(_) - Ta(_)) / 10^6$$
 MW

Formula for heat loss at empty store
$$\frac{(\text{Lambda} \cdot 1000 / \text{s}) \cdot \pi \cdot \sqrt{V / (h \cdot \pi)}}{(2 \cdot h + \sqrt{V / (h \cdot \pi)})} \cdot (Tb(_) - Ta(_)) / 10^6$$
 MW

As Graphics

Comments:

OK Cancel

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1. Introduction

With energyPRO 4.0.2 is introduced a new energy conversion calculation method. For details regarding this please see the relevant document. Among many other things, the new calculation method makes it possible to calculate heat losses from thermal storages. This paper describes how this is implemented in energyPRO 4.0.2.

2. User interface, thermal store

The thermal store window now looks as this:

The screenshot shows the 'Thermal store' dialog box with the following fields and values:

- Name: Thermal store
- Annual non availability periods
- Volume [V]: 1000,0 m³
- Temperature in the top [Tt]: 90,00 °C (fx) [Check]
- Temperature in the bottom [Tb]: 50,00 °C (fx) [Check]
- Utilization: 90,0 %
- Thermal storage capacity: 41,7 MWh as of Fri 1. January 2010
- Storage Loss

Storage Height [h]	Insulation Thickness [s]	Thermal Conductivity [Lambda]
14,20 m	300,00 mm	0,0370 W/(m°C)
- Ambient Temperature [Ta]: Outdoor temperature (dropdown), 20,00 °C
- Formula for heat loss at full store: User Defined (fx) [Check]

$$\frac{(\text{Lambda} \cdot 1000 / \text{s}) \cdot \pi \cdot \sqrt{V / (h \cdot \pi)}}{2 \cdot h + \sqrt{V / (h \cdot \pi)}} \cdot (Tt_ - Ta_) / 10^6$$
 MW
- Formula for heat loss at empty store: User Defined (fx) [Check]

$$\frac{(\text{Lambda} \cdot 1000 / \text{s}) \cdot \pi \cdot \sqrt{V / (h \cdot \pi)}}{2 \cdot h + \sqrt{V / (h \cdot \pi)}} \cdot (Tb_ - Ta_) / 10^6$$
 MW
- As Graphics
- Comments:
- Buttons: OK, Cancel

Figure 1 Thermal store input data window

If you don't want to incorporate storage loss, just unselect the Storage Loss field.

2.1 Temperature setting

In the previous versions of energyPRO the storage capacity has been calculated by setting a temperature difference. This is replaced by setting a temperature at the top of the store and a temperature at the bottom of the store.

The temperatures can be set as fixed numbers, but it is also possible to make a formula expression, where you can include an external time series.

As an example, the return temperature from the district heating network is higher during summer than in the wintertime. The return temperature is typical equal to the temperature in the bottom of the store.

You make a time series as this:

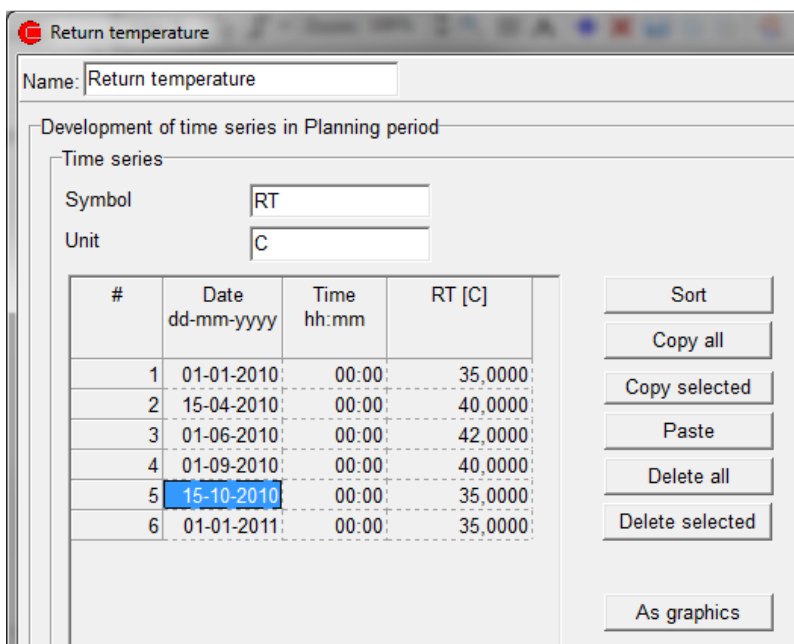


Figure 2 External time series

Next, you make a reference to the time series in field Temperature in the bottom.

Thermal store

Name: Thermal store

Annual non availability periods

Volume [V]
1000,0 m³

Temperature in the top [Tt]
90,00 °C

Temperature in the bottom [Tb]
RT() °C

Utilization
90,0 %

Thermal storage capacity :
57,4 MWh as of Fri 1. January 2010

Storage Loss

Figure 3 Temperature in the bottom as formula

Pressing the As Graphics button you can see how it affects the capacity of the store over the year:

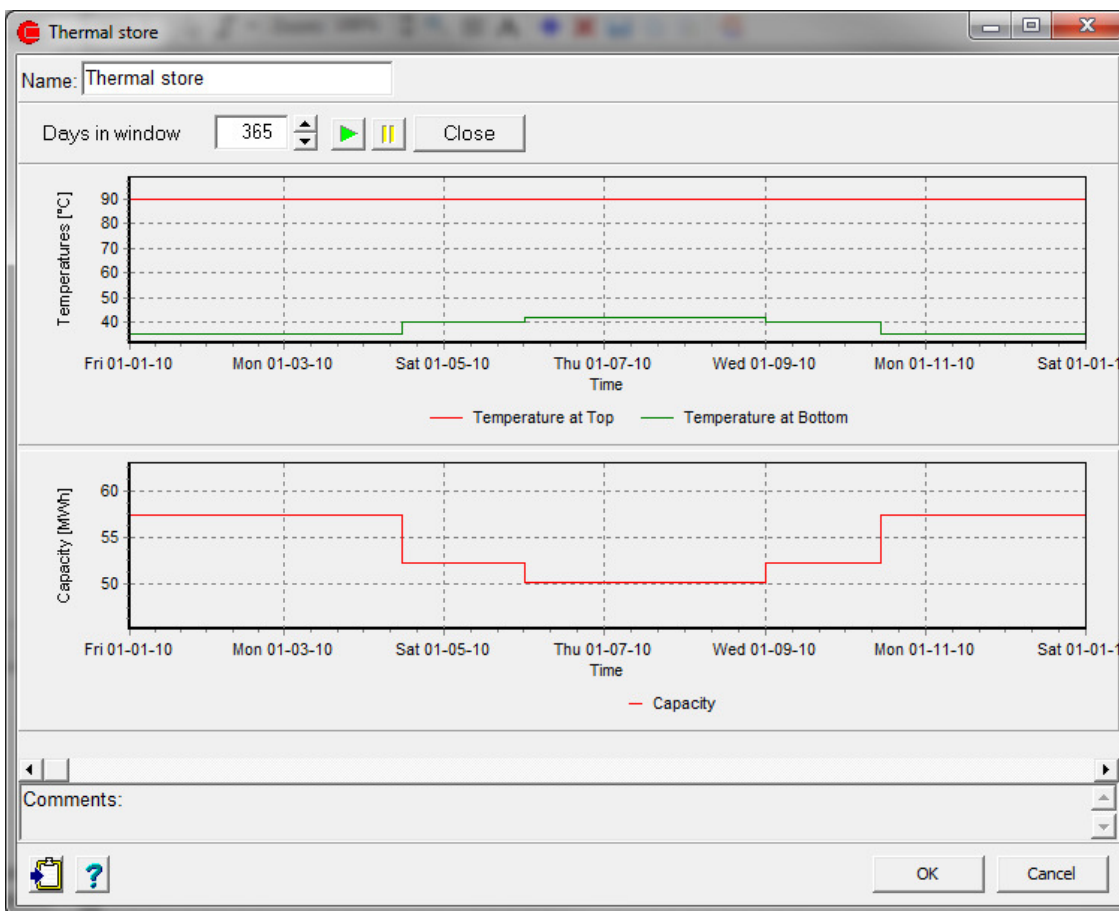


Figure 4 Capacity shown as graphics

2.2 Storage Loss

When marking the field Storage Loss you need to set a little information:

The screenshot shows a software window titled "Thermal store" with the following fields and options:

- Name:** Thermal store
- Annual non availability periods
- Volume [V]:** 1000,0 m³
- Temperature in the top [Tt]:** 90,00 °C (fx) [Check]
- Temperature in the bottom [Tb]:** RT() °C (fx) [Check]
- Utilization:** 90,0 %
- Thermal storage capacity:** 57,4 MWh as of Fri 1. January 2010
- Storage Loss**
 - Storage Height [h]:** 14,20 m
 - Insulation Thickness [s]:** 300,00 mm
 - Thermal Conductivity [Lambda]:** 0,0370 W/(m°C)
 - Ambient Temperature [Ta]:** Outdoor temperature (dropdown), 20,00 °C
 - Formula for heat loss at full store:** $(\text{Lambda} \cdot 1000 / \text{s}) \cdot \pi \cdot \sqrt{V / (h \cdot \pi)} \cdot (2 \cdot h + \sqrt{V / (h \cdot \pi)}) \cdot (Tt() - Ta()) / 10^6$ MW (User Defined) [fx] [Check]
 - Formula for heat loss at empty store:** $(\text{Lambda} \cdot 1000 / \text{s}) \cdot \pi \cdot \sqrt{V / (h \cdot \pi)} \cdot (2 \cdot h + \sqrt{V / (h \cdot \pi)}) \cdot (Tb() - Ta()) / 10^6$ MW
- As Graphics** (button)
- Comments:** (text area)
- Bottom icons: clipboard, help, OK, Cancel

energyPRO gives a suggestion to the storage height based on the volume. Likewise with the Insulation Thickness and the Thermal Conductivity of the insulation. The value of the Thermal conductivity is equal to the value of Rockwools A-batts.

The Ambient Temperature can either be a fixed value, typically if the store is located indoor or refer to an external time series with outdoor temperatures.

The inputs are used for calculating the heat loss at full store and at empty store. In a given hour of the calculation the actual loss is found by interpolating between those two figures depending on the actual level of store content.

The formulas for full and empty store are based on the store's surface area excluding the bottom.

If you want to change the formulas tag the User Defined field. Now you can set the formulas as you like.

3. Reports

The heat storage loss is included in the energy conversion reports:

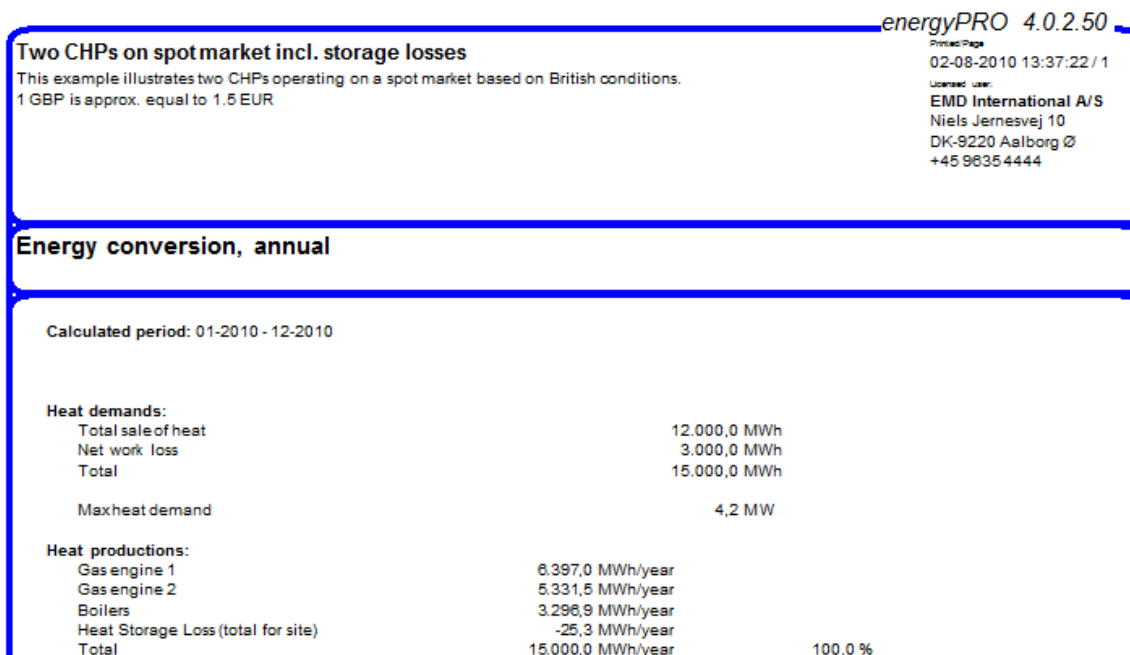


Figure 5 Heat storage loss, Energy conversion, annual

It is also shown in the Production, graphic, place the cursor above the heat graphic and the hint shows the different values at the given time:

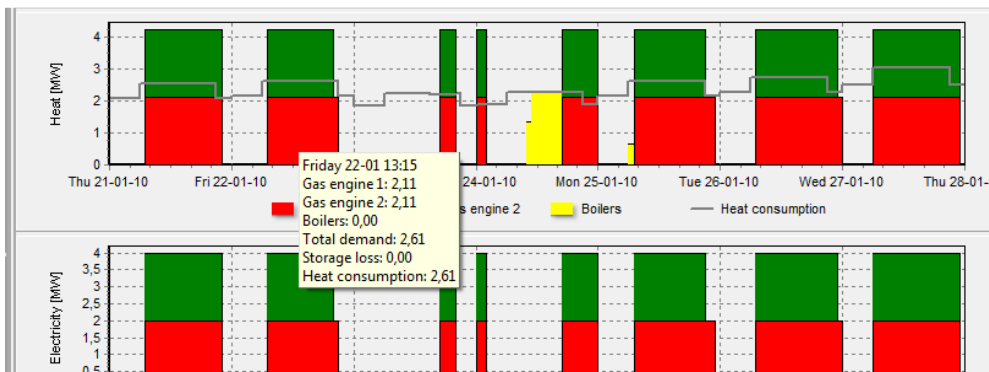


Figure 6 Heat storage loss, Production, graphic.