TOOLS AND SOFTWARE - DISTRICT MODELLING – ENERGYPRO

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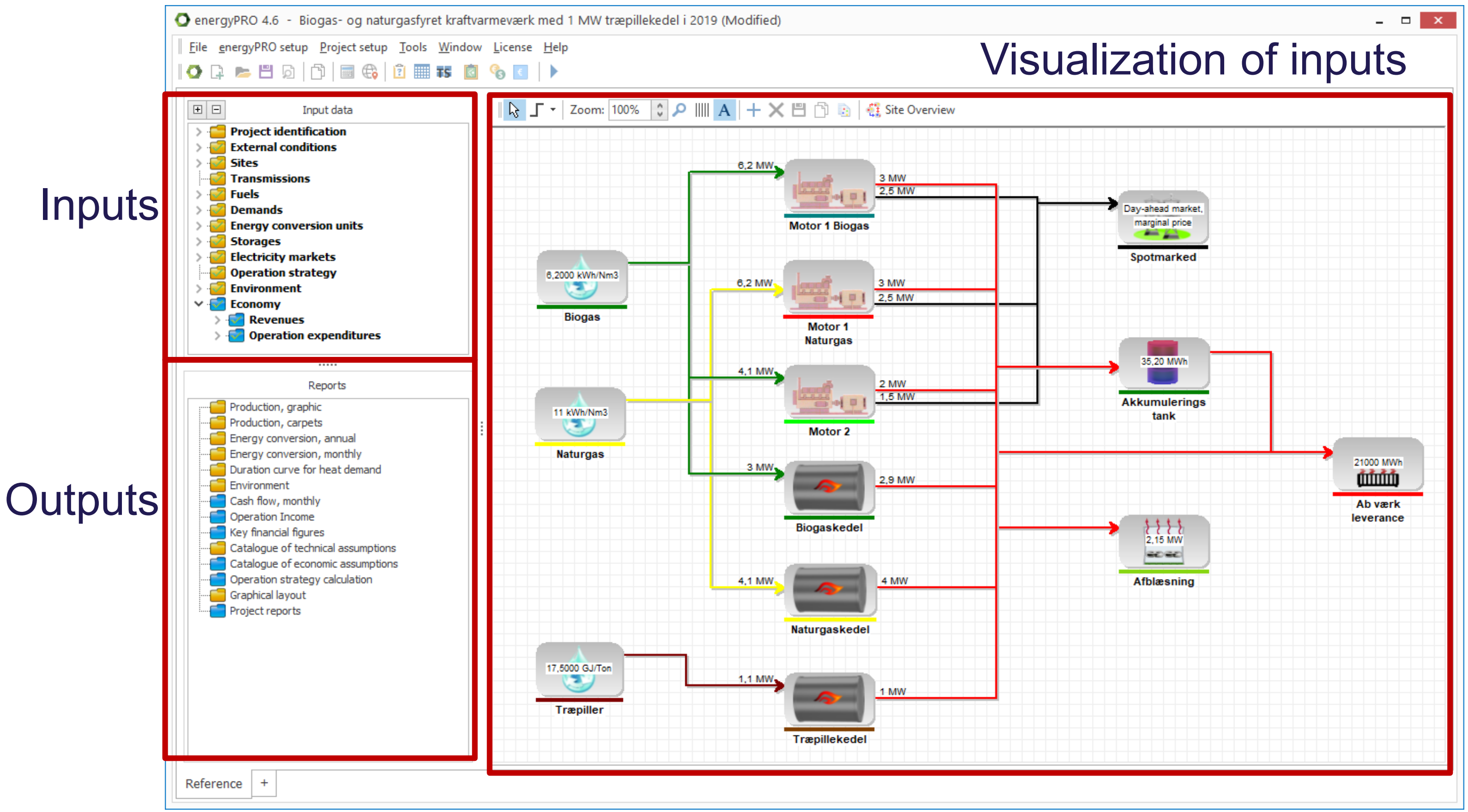
energyPRO

- Commercial tool developed and maintained by EMD International A/S. (www.emd.dk)

- A deterministic energy balancing tool for combined techno-economic simulation and analysis of energy projects.
- Conversion units are operated based on a priority list (least-cost or user-defined).
- Simulations can be done down to 10 minutes steps over any given timespan.

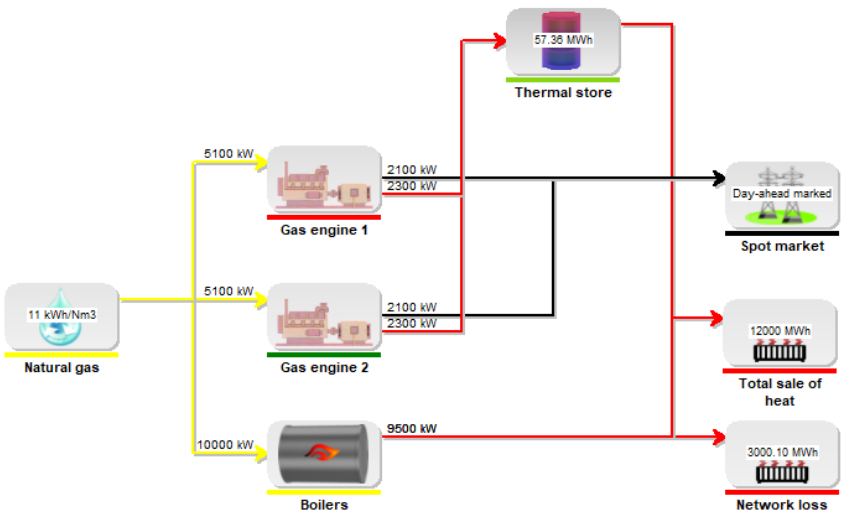
- energyPRO can e.g. be used for:
  - Simulating the operation of an energy plant
  - Making detailed investment analyses
  - Modelling industrial cogeneration and trigeneration
  - Simulating energy plants participating on different electricity markets
  - Analysing the interaction between separate energy plants
- Primarily used for simulation of district heating plants. (not the grids, though)

energyPRO UI

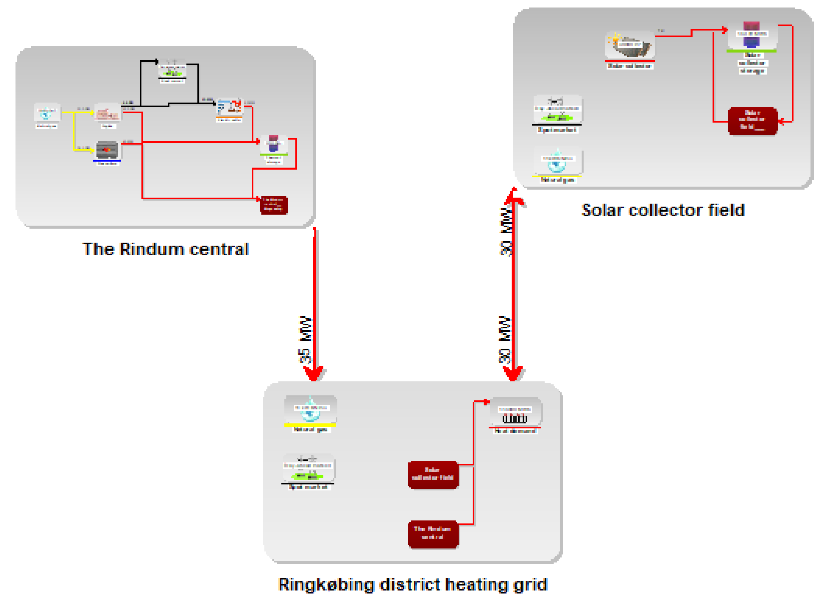


Examples of district heating plant models

Simple one site plant



District heating system with plants in several sites



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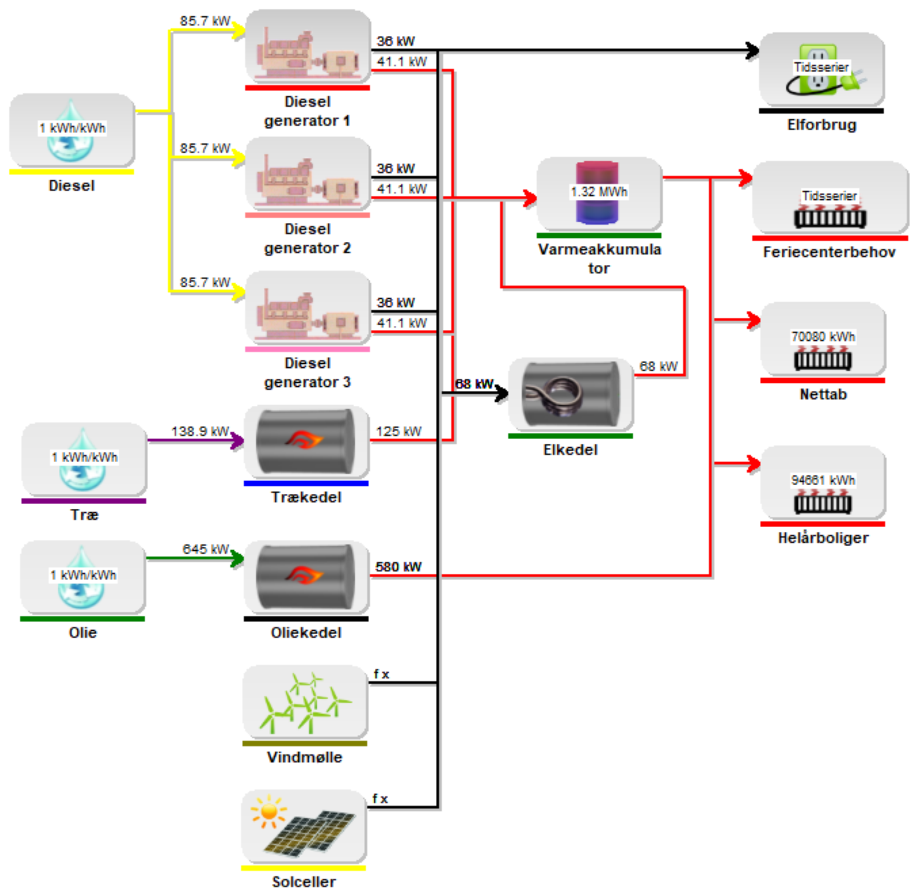
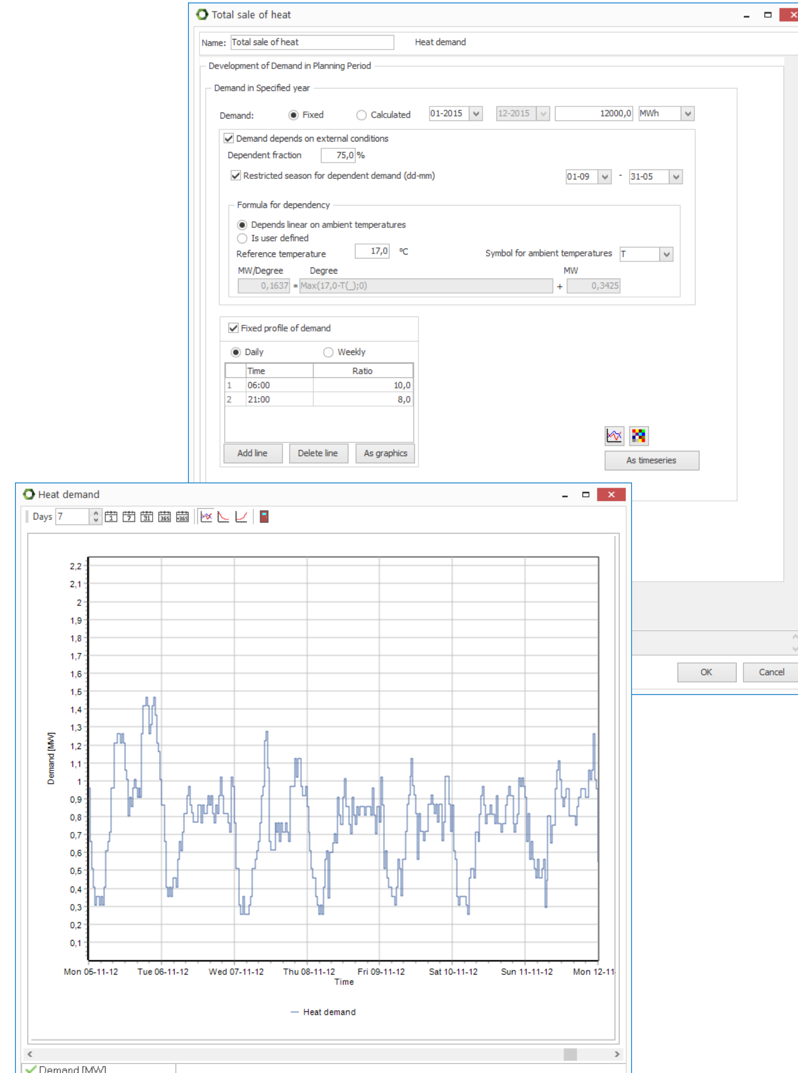
Also possible to simulate island energy systems



Energy demands in energyPRO

- Heat
- Electricity
- Process heat
- Cooling
- (Fuel)

- energyPRO aims to meet all energy demands in a given model by utilizing energy conversion units, storages, and electricity markets.
- Also possible to produce electricity for sale on electricity markets.



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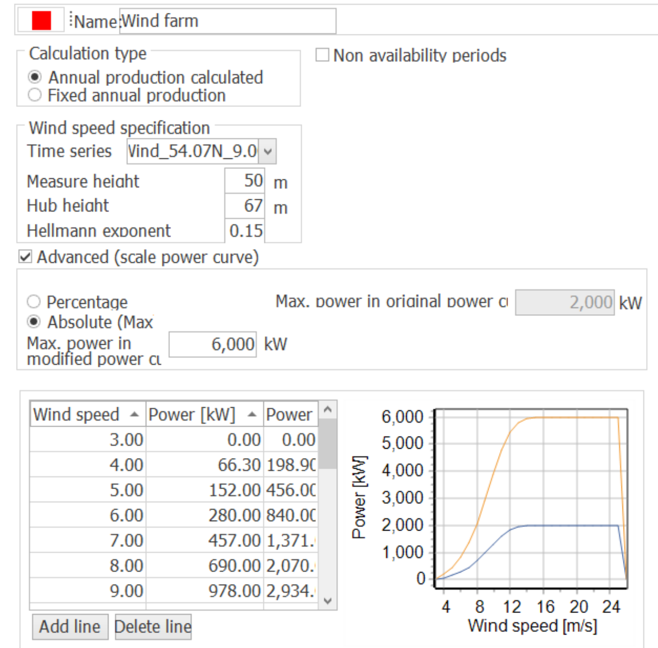
Energy conversion units in energyPRO

- Power plants
- CHP plants
- Fuel boilers
- Electric boilers
- Electric-driven heat pumps and chillers
- Absorption heat pumps and chillers
- Electrolysers and other fuel producing units
- Wind turbines
- PV
- Solar thermal
- Etc.



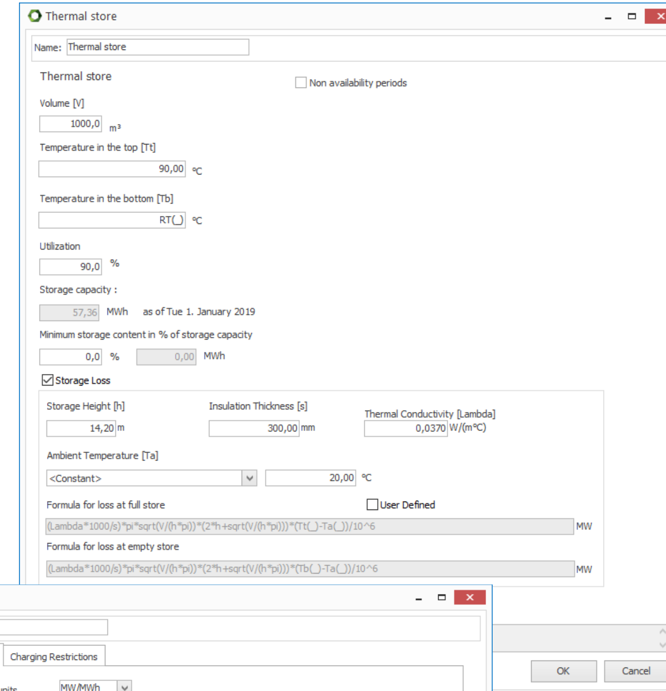
Power curves

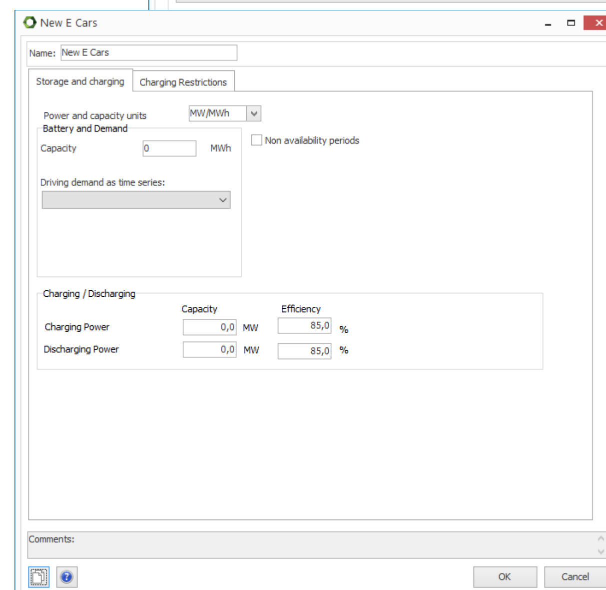
Operation	Fuel input	Elec. consur	Heat Consur	Proc. Heat C	Fuel output	Heat	Process Hea	Elec. power	Cooling
Performance	MW	MW	MW	MW	MW	MW	MW	MW	MW
Max.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Add line | Delete line | ☐ Enable formulas in power curve

Energy storage systems in energyPRO

- Thermal
- Cooling
- Fuel
- Battery
  - Stand-alone
  - Part of electric vehicle
- Pumped hydro station





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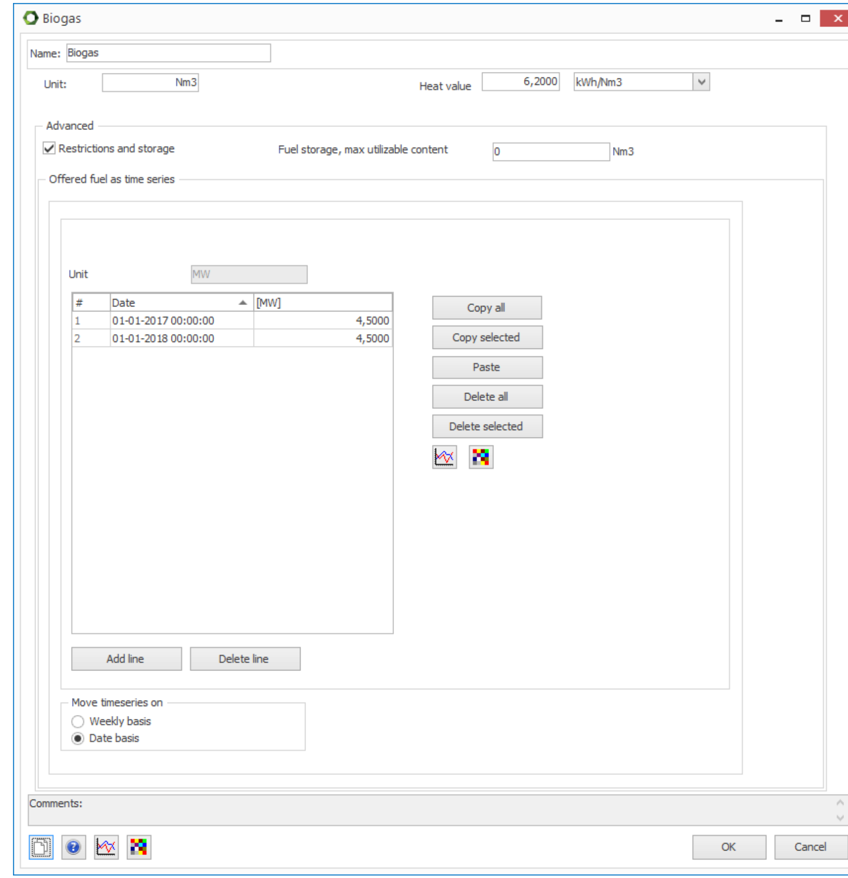
Fuels in energyPRO

- Customizable.
- Possible to add restrictions to available amounts and to add fuel storage.
- Also possible to require the fuel to first be produced by other units in the model.
- Emissions for fuel usage can be added.



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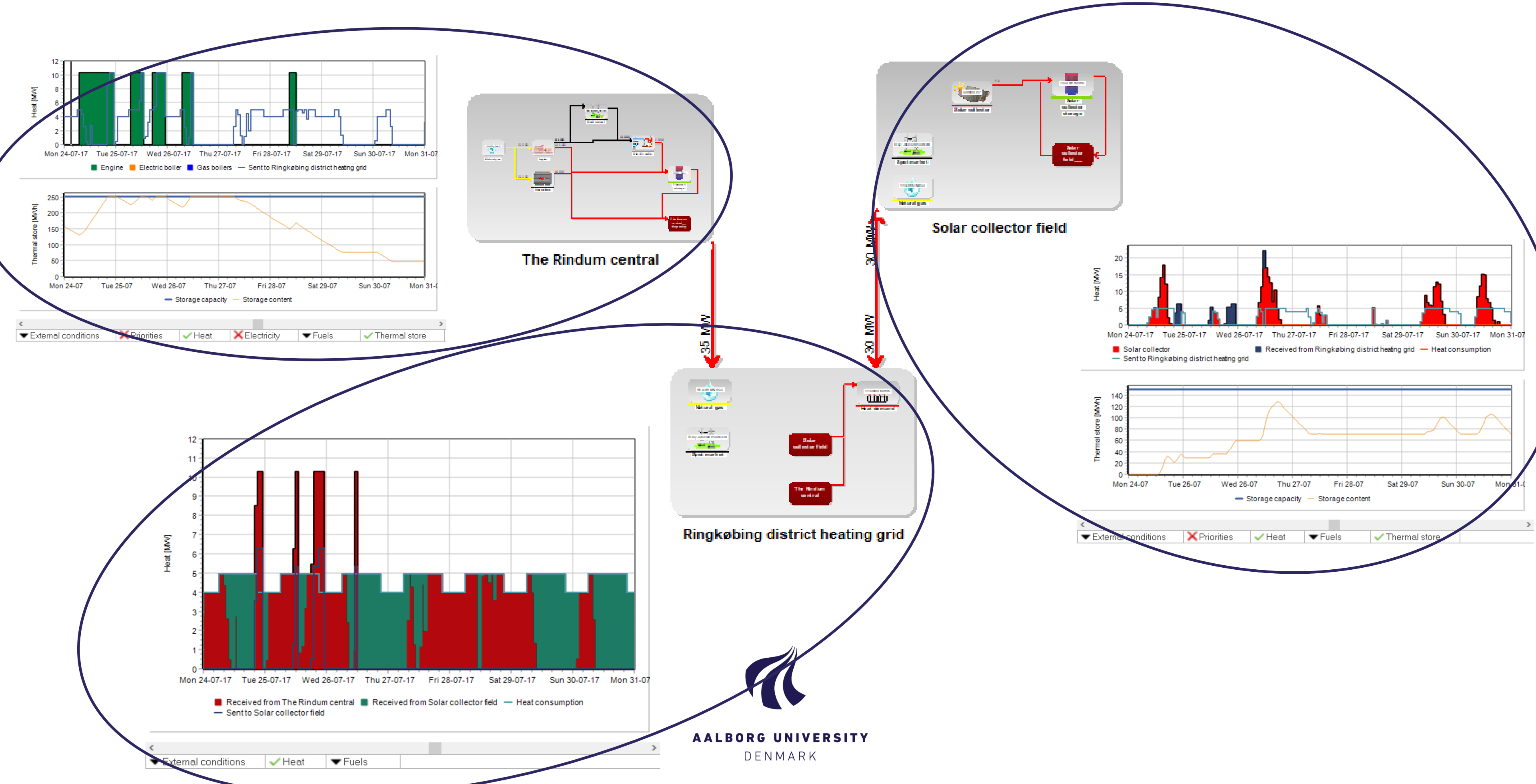
Example of one week of operation – One site district heating plant with CHP units, thermal storage system, and a fuel boiler

Example of one week of operation – District heating system with several sites



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Possible to change input files and run input files in energyPRO with XML files (Requires INTERFACE module)

Command line: …\energyPRO.exe /XMLMod input.xml

Simple example where the XML file is used to get energyPRO to print Operation income of a energyPRO model to a CSV file:

```
  <?xml version="1.0"?>
- <XMLtoEnergyPRO>
  - <Head>
      <energyPRODataFile>c:\Interface\Vestdansk 5MW-kraftvarmeværk på markedsvilkår i 2013.epp</energyPRODataFile>
    </Head>
    <InputDataElements> </InputDataElements>
  - <OutputDataElements>
      <ReportBaseID>10030</ReportBaseID>
      <ReportDelimiter>;</ReportDelimiter>
      <ReportFileName>c:\Interface\Resultat af ordinær drift.csv</ReportFileName>
      <ReportFile>csv</ReportFile>
    </OutputDataElements>
  </XMLtoEnergyPRO>
```

A few examples of published research where energyPRO has been used

- Sorknæs P, Lund H, Andersen AN. Future power market and sustainable energy solutions – The treatment of uncertainties in the daily operation of combined heat and power plants. Appl Energy 2015;144:129–38. doi:10.1016/j.apenergy.2015.02.041.
- Sorknæs P, Lund H, Andersen AN, Ritter P. Small-scale combined heat and power as a balancing reserve for wind – The case of participation in the German secondary control reserve. Int J Sustain Energy Plan Manag 2015;4:31–42. doi:10.5278/ijsepm.2014.4.4.
- Østergaard PA, Andersen AN. Booster heat pumps and central heat pumps in district heating. Appl Energy 2016;184:1374–88. doi:10.1016/J.APENERGY.2016.02.144.
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- Andersen AN, Østergaard PA. A method for assessing support schemes promoting flexibility at district energy plants. Appl Energy 2018. doi:10.1016/j.apenergy.2018.05.053.
- Østergaard PA, Jantzen J, Marczinkowski HM, Kristensen M. Business and socioeconomic assessment of introducing heat pumps with heat storage in small-scale district heating systems. Renew Energy 2019. doi:10.1016/j.renene.2019.02.140.
- Kiss VM. Modelling the energy system of Pécs - The first step towards a sustainable city. Energy 2015. doi:10.1016/j.energy.2014.11.079.
- Ben Amer-Allam S, Münster M, Petrović S. Scenarios for sustainable heat supply and heat savings in municipalities - The case of HelsingØr, Denmark. Energy 2017. doi:10.1016/j.energy.2017.06.091.
- Rämä M, Wahlroos M. Introduction of new decentralised renewable heat supply in an existing district heating system. Energy 2018. doi:10.1016/j.energy.2018.03.105.
- Büchele R, Kranzl L, Hummel M. Integrated strategic heating and cooling planning on regional level for the case of Brasov. Energy 2019. doi:10.1016/j.energy.2019.01.030.
- Kontu K, Rinne S, Junnila S. Introducing modern heat pumps to existing district heating systems – Global lessons from viable decarbonizing of district heating in Finland. Energy 2019. doi:10.1016/j.energy.2018.10.077.
- Wahlroos M, Pärssinen M, Manner J, Syri S. Utilizing data center waste heat in district heating – Impacts on energy efficiency and prospects for low-temperature district heating networks. Energy 2017. doi:10.1016/j.energy.2017.08.078.

QUESTIONS?