energyPRO/EXCEL tool - guide

September 03 2025

TITLE OF THE DELIVERABLE	
Deliverable number	D1.1
Responsible partner	WIP Renewable Energies
Due date of deliverable	31.05.2025
Actual submission date	
Version/document history	2.0
Authors	Niels Beck-Larsen/Planenergi
Reviewers	Consortium
Work package number and title	4 WP4 Tool box,

DISSEMINATION LEVEL (please select one)		
SEN	Sensitive, limited under the conditions of the Grant Agreement	☒
PU	Public, fully open	☐

PROJECT'S INFORMATION	
Grant Agreement No.	101119914
Project Full Title	Supporting a fast implementation of low-grade renewable energy and waste heat for district heating and cooling
Project Acronym	Support DHC
Start Date	01 October 2023
Duration	36 months
Project Coordinator	WIP Renewable Energies
Project Website	www.supportdhc.eu

DISCLAIMER

Co-funded by the European Union

Table of Contents

1 Guide ePRO/EXCEL tool: SupportDHC standard model

1.1 energyPRO

energyPRO is a complete modelling software package for combined techno-economic analysis and optimisation of both cogeneration and trigeneration projects as well as other types of complex energy projects including PtX with a combined supply of electricity and thermal energy (steam, hot water or cooling) from multiple different energy producing units.

energyPRO is typically used for techno-economic analysis of energy projects such as district heating cogeneration plants with gas engines combined with boilers and thermal storage, industrial cogeneration plants supplying both electricity, steam and hot water to a site, cogeneration plants with absorption chilling (trigeneration), biogas fuelled CHP plants with a biogas store, biomass cogeneration plants. Other types of projects, e.g. geothermal, solar collectors, photovoltaic or wind farms can also be analysed and detailed within the software. energyPRO can also be used for analysing hydro pumping stations, compressed air energy storage and other electricity storage projects.

energyPRO allows the hourly optimization of the operation to be made against fixed tariffs for electricity or against spot market prices. The optimization is taking into account the limited sizes of thermal and fuel stores.

energyPRO provides the user with a detailed financial plan in a standard format accepted by international banks and funding institutions. This includes presentation of the operating results for the project, monthly cash flows, income statements (P&L), balance sheets and key investment figures such as NPV, IRR and payback time. The software enables the user to calculate and produce a report for the environment/emissions (CO2, NOX, SO2, etc.) by the proposed project.

Figure 1 – ePRO[1] standard report

[1] ePRO = energyPRO

1.2 ePRO/EXCEL tool: Support DHCePRO.xlsx

The SupportDHC standard energyPRO model (subsequently referred to as the ePRO model) can be used to calculate the energy and economic basis for economic feasibility of establishing new district heating production units. Technical data, emission factors and price projections can be adjusted, making it easy to use in different countries.

The model includes all relevant factors to compare and propose heat planning scenarios, and can be used in cooperation between DHC professionals and local planners. Among others, the model performs a cost-benefit analysis considering district heating company calculating the economics of the project following Danish standards for tax, fuel prices, electricity cost.

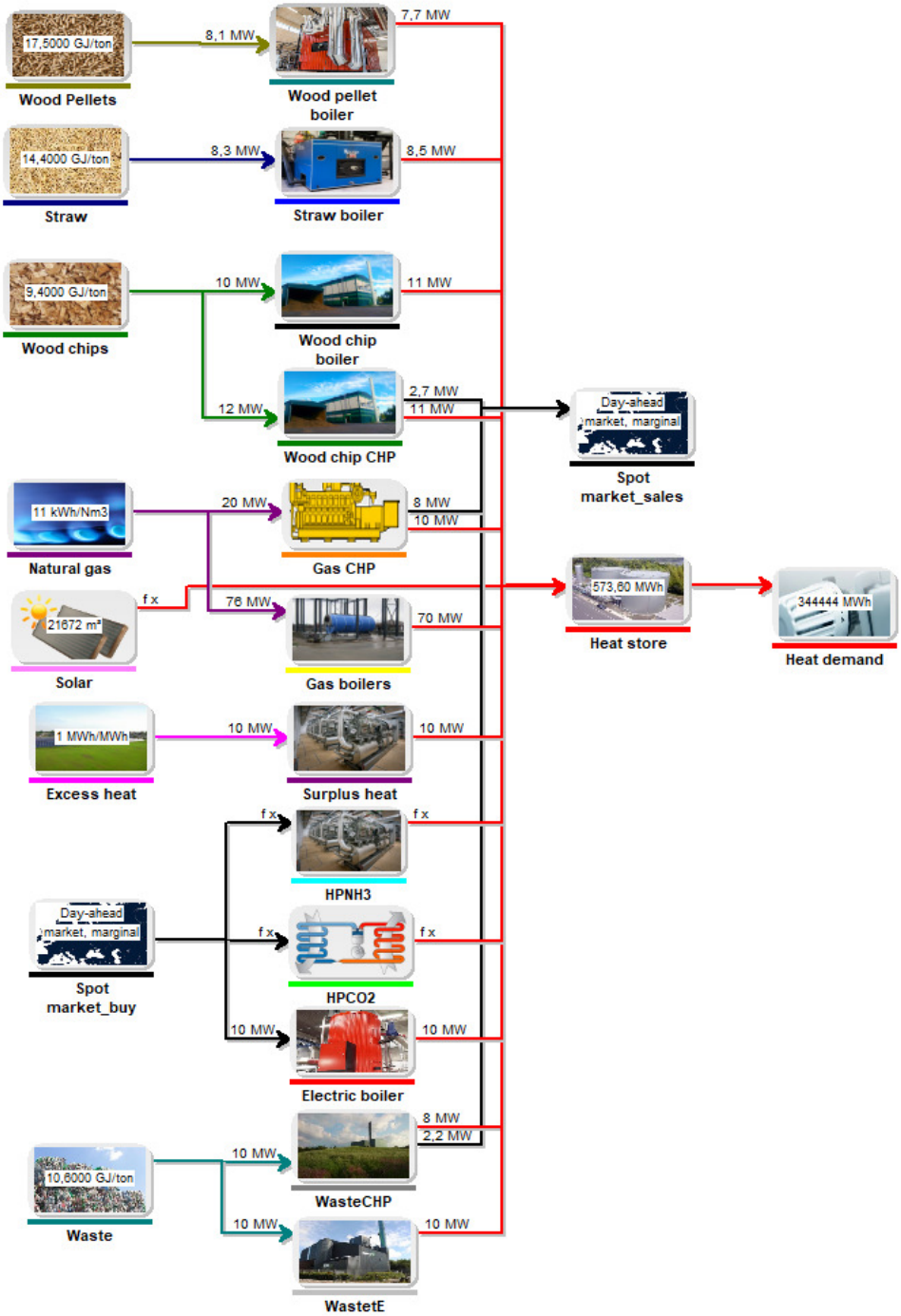


Figure 2 – ePRO standard model – HPNH3 ~ 11 MW and HPCO2 ~ 11 MW - SupportDHCePRO.epp.

The model is developed by Planenergi for SupportDHC and is freely available to everyone interested. The model is recommended to be used for both screening projects and detailed feasibility studies. The standard model includes the following active plants/units:

- Wood chip boiler
- Wood chip CHP
- Wood pellet boiler
- Straw boiler
- Gas CHP
- Gas boilers
- Waste CHP
- Waste boiler
- Electric boiler
- HPCO2
- HPNH3
- Solar
- Surplus heat

The standard model have all plants/units active resulting in the following duration curve:

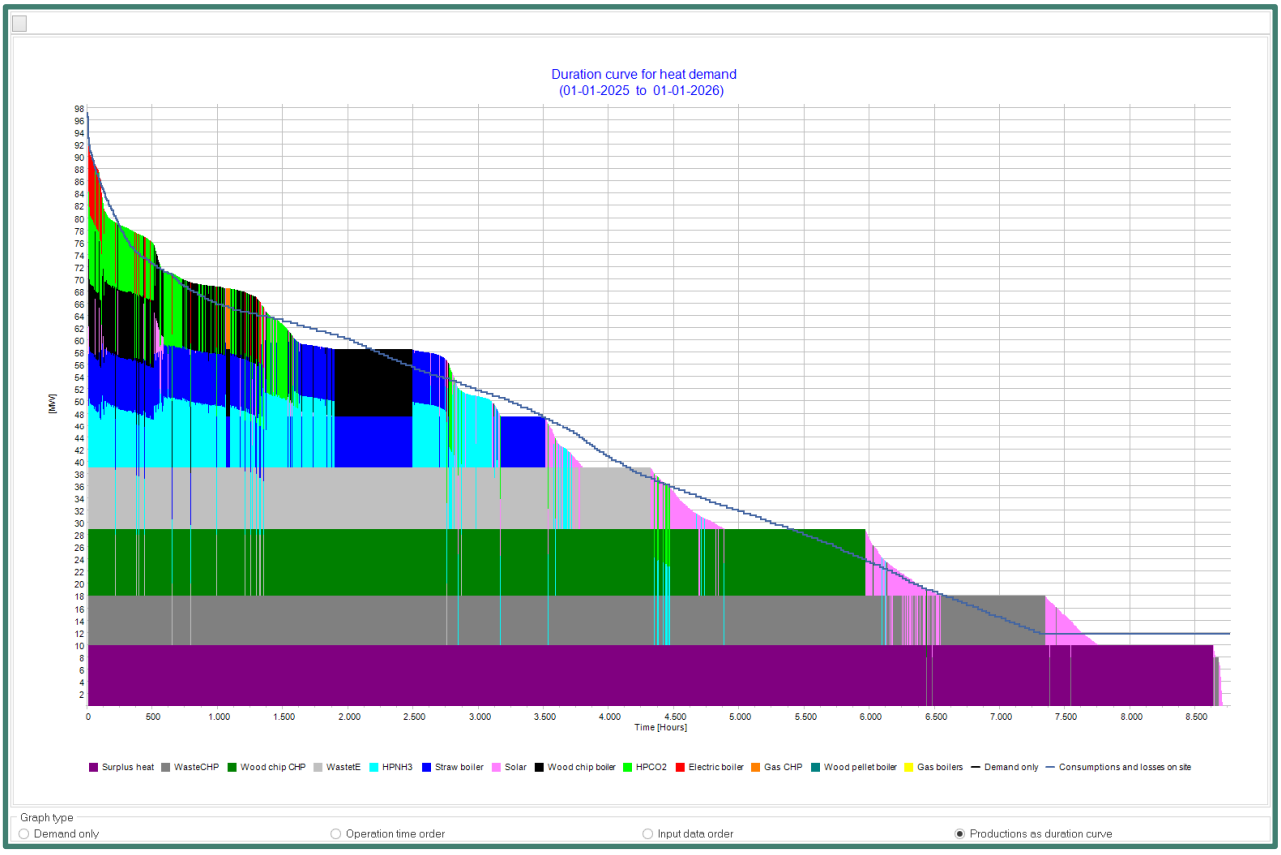


Figure 3 – Duration curve ePRO standard model.

Based on the following Net Heat production costs (ePRO output).

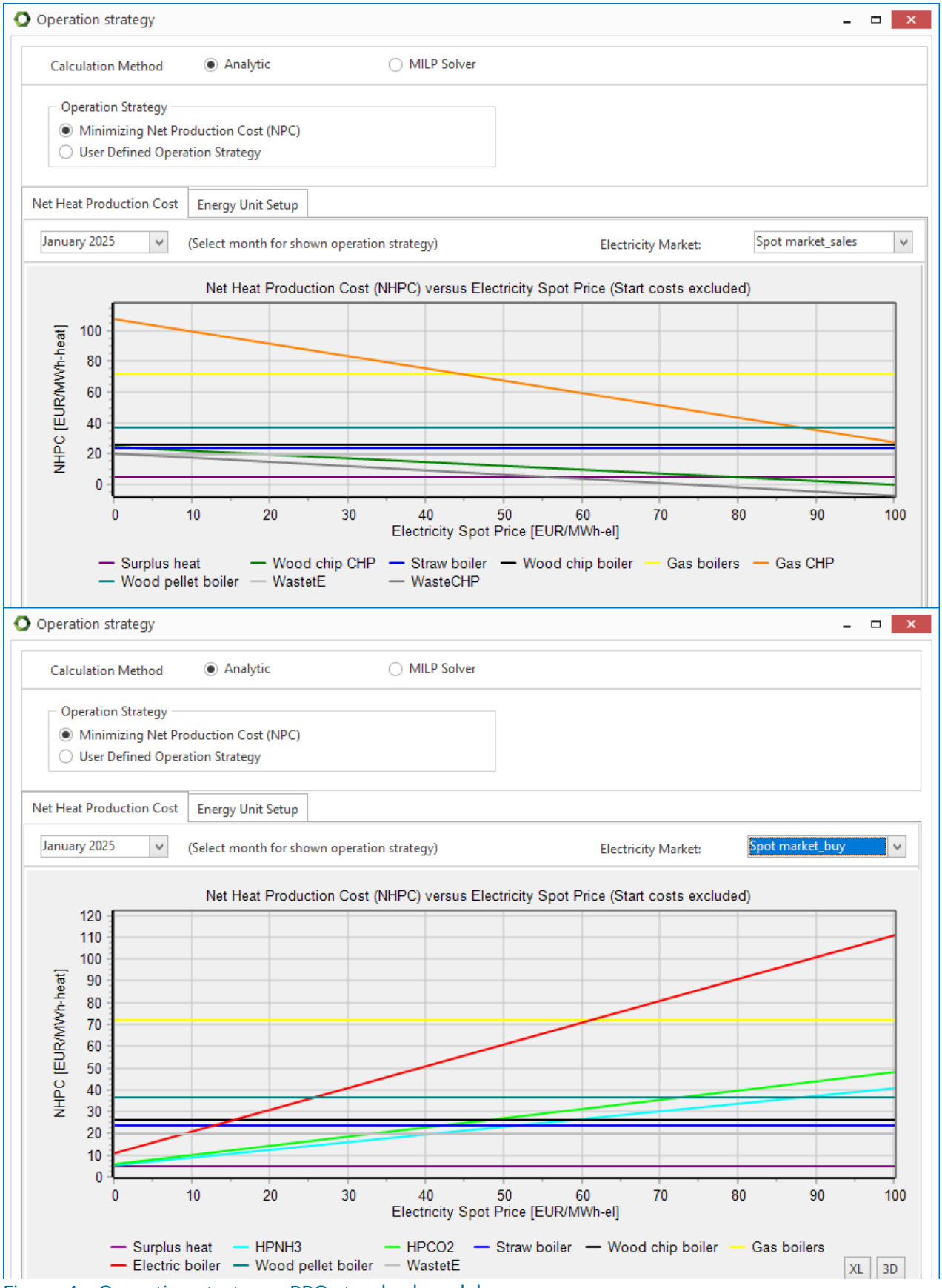


Figure 4 – Operation strategy ePRO standard model.

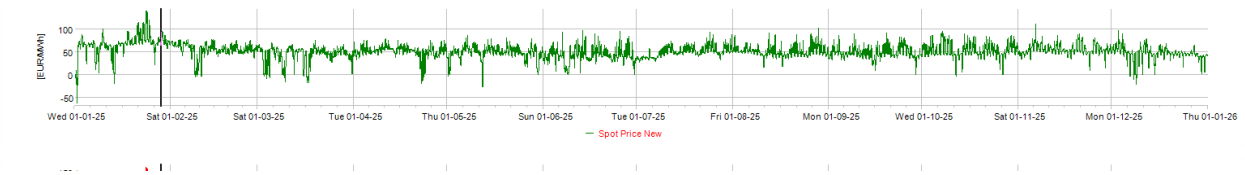


Figure 5 – Electricity spot prices.

The model should be tailormade to local conditions by having "Non availability periods" set for the entire year on plants excluded in the scenarios.

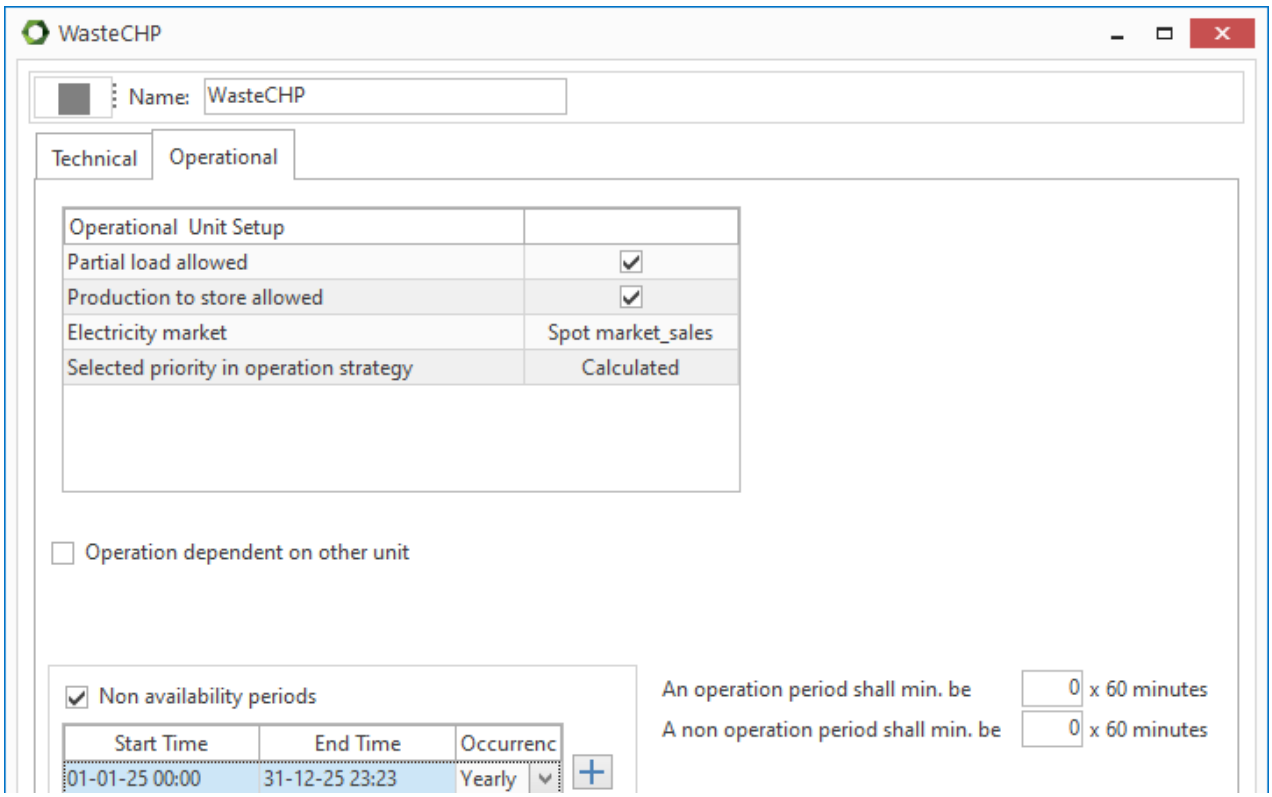


Figure 6 – Definition of "Non availability periods" => unit excluded in the scenarios.

SupportDHCePRO									
energyPRO 4.9.428									
23-01-2025 15:12									
Catalogue of economic assumptions									
Currency: EUR									
3.2 Operating Expenditures									7,45
Fuel cost			Low Heat value		EUR/GJ	EUR/MWh	DKK/GJ	DKK/MWh	DKK/Ton/m3
Wood chips	65	EUR/ton	9,4	GJ/ton	6,91	24,9	51,5	185,5	484
Wood pellets	157,4	EUR/ton	17,5	GJ/ton	8,99	32,4	67,0	241,2	1173
Straw	85,3	EUR/ton	14,4	GJ/ton	5,92	21,3	44,1	158,9	635
Natural gas	0,27	EUR/Nm3	11	kWh/Nm3	6,82	24,5	50,8	182,9	2,01
Waste	-53,6	EUR/ton	10,6	GJ/ton	-5,06	-18,2	-37,7	-135,6	-399
Electricity_El	Elspot_func(_)	EUR/MWh				51,0			

Figure 7 – Fuel costs – ePRO standard model report imported in EXCEL: Support DHCePRO.xlsx

The model include a cost-benefit analysis for a Danish district heating company and therefore calculate the economics of the project following Danish standards for tax, fuel prices, electricity cost.

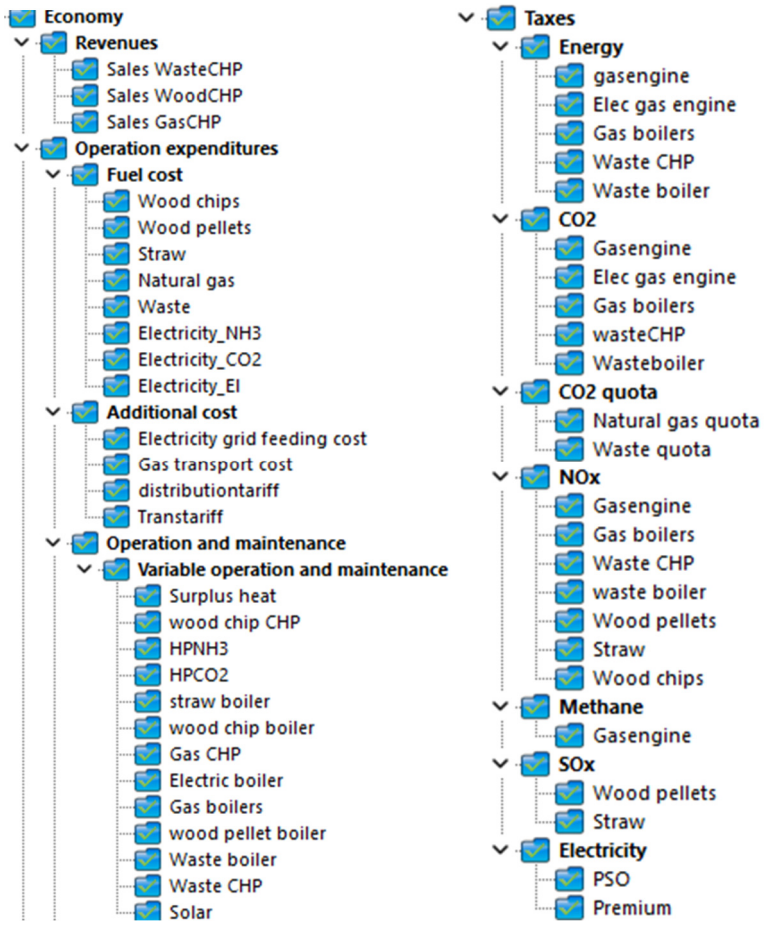
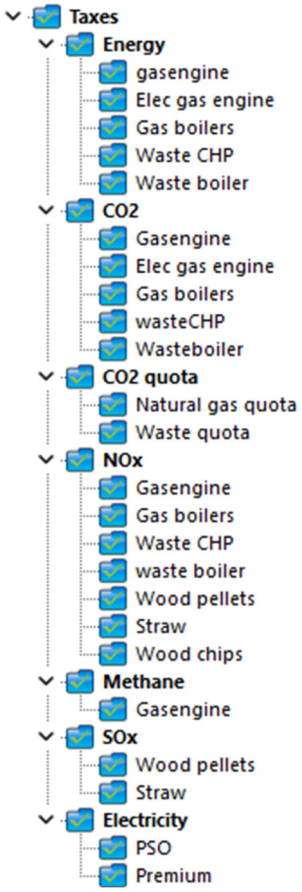


Figure 8 – Cost elements in model.

Operation and maintenance		
Variable operation and maintenance		
Surplus heat	5,00	EUR/MWh
wood chip CHP	1,45	EUR/MWh
HPNH3	1,80	EUR/MWh
HPCO2	1,80	EUR/MWh
straw boiler	2,32	EUR/MWh
wood chip boiler	3,14	EUR/MWh
Gas CHP	5,74	EUR/MWh
Electric boiler	0,96	EUR/MWh
Gas boilers	1,17	EUR/MWh
wood pellet boiler	2,11	EUR/MWh
Waste boiler	8,28	EUR/MWh
Waste CHP	6,25	EUR/MWh
Solar	0,22	EUR/MWh

Figure 9 – O&M variable cost elements. Source: DEA Tech catalogue and “Surplus heat cost”



Taxes			
Energy			
gasengine	0,3	EUR/Nm3	FC(Gas CHP;Natural gas) / HeatValue(Natural gas)
Repayment Gasengi	-0,3	EUR/Nm3	EP(Gas CHP;All Periods) / 0,67 / 0,011
Gas boilers	0,3	EUR/Nm3	FC(Gas boilers;Natural gas) / HeatValue(Natural gas)
Waste CHP	67,2	EUR/ton	FC(WasteCHP;Waste) / HeatValue(Waste)
Waste boiler	67,2	EUR/ton	FC(WastetE;Waste) / HeatValue(Waste)
CO2			
Gasengine	0,05	EUR/Nm3	FC(Gas CHP;Natural gas) / HeatValue(Natural gas)
Repayment Gasmot	-0,05	EUR/Nm3	EP(Gas CHP;All Periods) / 0,67 / 0,011
Gas boilers	0,05	EUR/Nm3	FC(Gas boilers;Natural gas) / HeatValue(Natural gas)
wasteCHP	5,94	EUR/ton	FC(WasteCHP;Waste) / HeatValue(Waste)
Wasteboiler	5,94	EUR/ton	FC(WastetE;Waste) / HeatValue(Waste)
CO2 quota			
Natural gas quota	29,62	EUR/ton CO2	ImportedFuel(Natural gas) * 3,6 * 57,1 / 1000
Waste quota	29,62	EUR/ton CO2	ImportedFuel(Waste) * 3,6 * 42,5 / 1000
NOx			
Gasengine	0,004	EUR/Nm3	FC(Gas CHP;Natural gas) / HeatValue(Natural gas)
Gas boilers	0,001	EUR/Nm3	FC(Gas boilers;Natural gas) / HeatValue(Natural gas)
Waste CHP	0,48	EUR/ton	FC(WasteCHP;Waste) / HeatValue(Waste)
waste boiler	0,48	EUR/ton	FC(WastetE;Waste) / HeatValue(Waste)
Wood pellets	0,94	EUR/ton	ImportedFuel(Wood Pellets) / HeatValue(Wood Pellets)
Straw	0,91	EUR/ton	ImportedFuel(Straw) / HeatValue(Straw)
Wood chips	0,63	EUR/ton	ImportedFuel(Wood chips) / HeatValue(Wood chips)
Methane			
Gasengine	0,044	EUR/Nm3	FC(Gas CHP;Natural gas) / HeatValue(Natural gas)
SOx			
Wood pellets	1,29	EUR/ton	ImportedFuel(Wood Pellets) / HeatValue(Wood Pellets)
Straw	1,29	EUR/ton	ImportedFuel(Straw) / HeatValue(Straw)
Electricity			
PSO	0	EUR/MWh	ImportedElectricity(Spot market_buy;All Periods)
Premium	-20	EUR/MWh	EP(Wood chip CHP;All Periods)

Figure 10 – Cost elements in ePRO model.

Taxes							
Energy							
gasengine	114545,5	Nm3	at	0,3	=	34364	
Elec gas engine	68385,3	Nm3	at	-0,3	=	-20516	
Gas boilers	0	Nm3	at	0	=	0	
Waste CHP	29096,9	ton	at	67,2	=	1955314	
Waste boiler	16999,3	ton	at	67,2	=	1142356	
Energy Total							3111517
CO2							
Gasengine	114545,5	Nm3	at	0,05	=	5727	
Elec gas engine	68385,3	Nm3	at	-0,05	=	-3419	
Gas boilers	0	Nm3	at	0	=	0	
wasteCHP	29096,9	ton	at	5,94	=	172836	
Wasteboiler	16999,3	ton	at	5,94	=	100976	
CO2 Total							276120
CO2 quota							
Natural gas quota	259	ton CO2	at	29,62	=	7672	
Waste quota	20766,4	ton CO2	at	29,62	=	615100	
CO2 quota Total							622772
NOx							
Gasengine	114545,5	Nm3	at	0,004	=	458	
Gas boilers	0	Nm3	at	0	=	0	
Waste CHP	29096,9	ton	at	0,48	=	13967	
waste boiler	16999,3	ton	at	0,48	=	8160	
Wood pellets	221,9	ton	at	0,94	=	209	
Straw	7050,2	ton	at	0,91	=	6416	
Wood chips	36253,7	ton	at	0,63	=	22840	
NOx Total							52048
Methane							
Gasengine	114545,5	Nm3	at	0,044	=	5040	
Methane Total							5040
SOx							
Wood pellets	221,9	ton	at	1,29	=	286	
Straw	7050,2	ton	at	1,29	=	9095	
SOx Total							9381
Electricity							
PSO	30069,5	MWh	at	0	=	0	
Premium	17823,1	MWh	at	-20	=	-356462	

Taxes			
Energy			
gasengine	0,3	EUR/Nm3	FC(Gas CHP;Natural gas) / HeatValue(Natural gas)
Repayment Gasengi	-0,3	EUR/Nm3	EP(Gas CHP;All Periods) / 0,67 / 0,011
Gas boilers	0,3	EUR/Nm3	FC(Gas boilers;Natural gas) / HeatValue(Natural gas)
Waste CHP	67,2	EUR/ton	FC(WasteCHP;Waste) / HeatValue(Waste)
Waste boiler	67,2	EUR/ton	FC(WastetE;Waste) / HeatValue(Waste)
CO2			
Gasengine	0,05	EUR/Nm3	FC(Gas CHP;Natural gas) / HeatValue(Natural gas)
Repayment Gasmot	-0,05	EUR/Nm3	EP(Gas CHP;All Periods) / 0,67 / 0,011
Gas boilers	0,05	EUR/Nm3	FC(Gas boilers;Natural gas) / HeatValue(Natural gas)
wasteCHP	5,94	EUR/ton	FC(WasteCHP;Waste) / HeatValue(Waste)
Wasteboiler	5,94	EUR/ton	FC(WastetE;Waste) / HeatValue(Waste)
CO2 quota			
Natural gas quota	29,62	EUR/ton CO2	ImportedFuel(Natural gas) * 3,6 * 57,1 / 1000
Waste quota	29,62	EUR/ton CO2	ImportedFuel(Waste) * 3,6 * 42,5 / 1000
NOx			
Gasengine	0,004	EUR/Nm3	FC(Gas CHP;Natural gas) / HeatValue(Natural gas)
Gas boilers	0,001	EUR/Nm3	FC(Gas boilers;Natural gas) / HeatValue(Natural gas)
Waste CHP	0,48	EUR/ton	FC(WasteCHP;Waste) / HeatValue(Waste)
waste boiler	0,48	EUR/ton	FC(WastetE;Waste) / HeatValue(Waste)
Wood pellets	0,94	EUR/ton	ImportedFuel(Wood Pellets) / HeatValue(Wood Pellets)
Straw	0,91	EUR/ton	ImportedFuel(Straw) / HeatValue(Straw)
Wood chips	0,63	EUR/ton	ImportedFuel(Wood chips) / HeatValue(Wood chips)
Methane			
Gasengine	0,044	EUR/Nm3	FC(Gas CHP;Natural gas) / HeatValue(Natural gas)
SOx			
Wood pellets	1,29	EUR/ton	ImportedFuel(Wood Pellets) / HeatValue(Wood Pellets)
Straw	1,29	EUR/ton	ImportedFuel(Straw) / HeatValue(Straw)
Electricity			
PSO	0	EUR/MWh	ImportedElectricity(Spot market_buy;All Periods)
Premium	-20	EUR/MWh	EP(Wood chip CHP;All Periods)

Figure 11 – Cash flow annual and cost elements in model.

The Energy-economic results of ePRO model are summarised in the EXCEL sheet: SupportDHCePRO.xlsx, where ePRO standard reports (Cash flow, Energy conversion, Tech.

and economic assumptions, Environment) are integrated through the light green areas. The variable costs included in the energyPRO model are summarised to unit based cost tables, and combined with investment cost and O&M cost based on the DEA, Technology Catalogue[2].

On the sheet "Cash" the economic results are linked to the standard ePRO reports, where all units have their cost divided in the following elements: O&M, Fuel, Tax, Nox++, Elec. Sale, Cap. Cost, Total cost. Fixed O&M cost and capital cost are based on DEA, Tech Catalogue. Tech. cat. sheets for the included unit technologies are included.

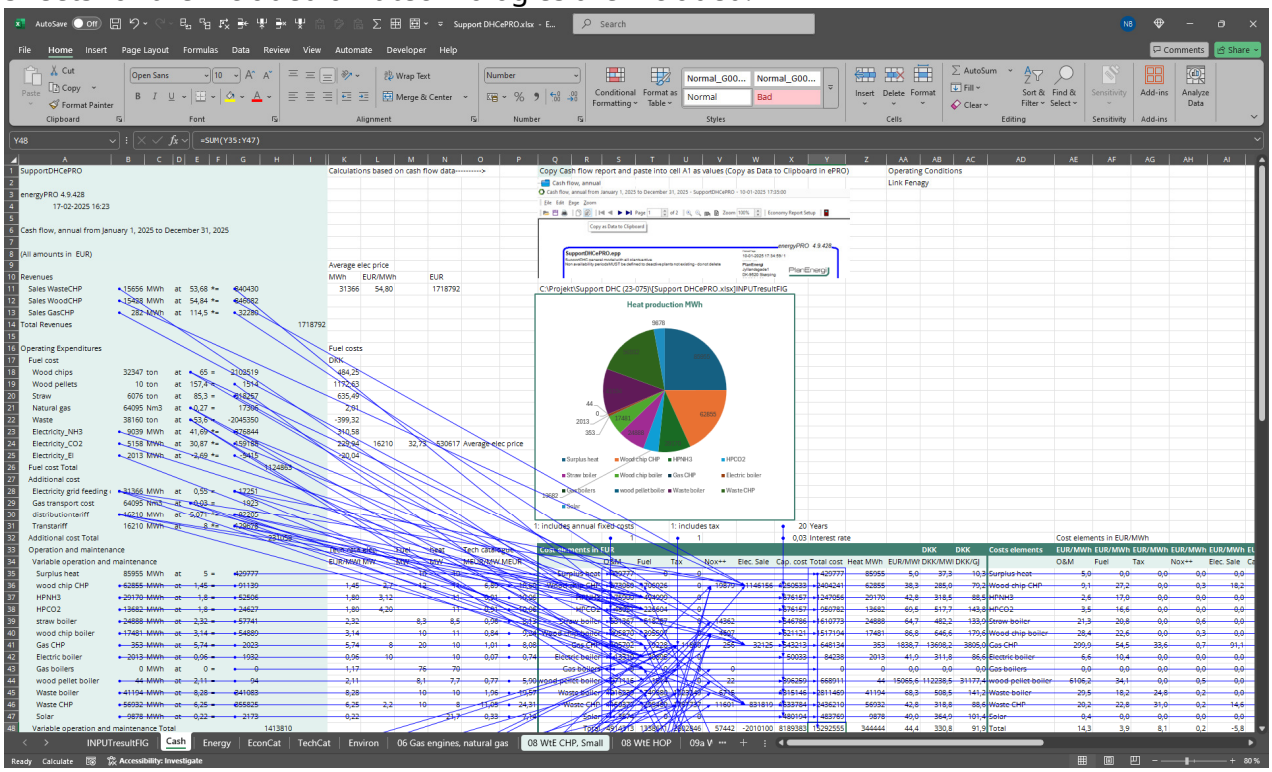


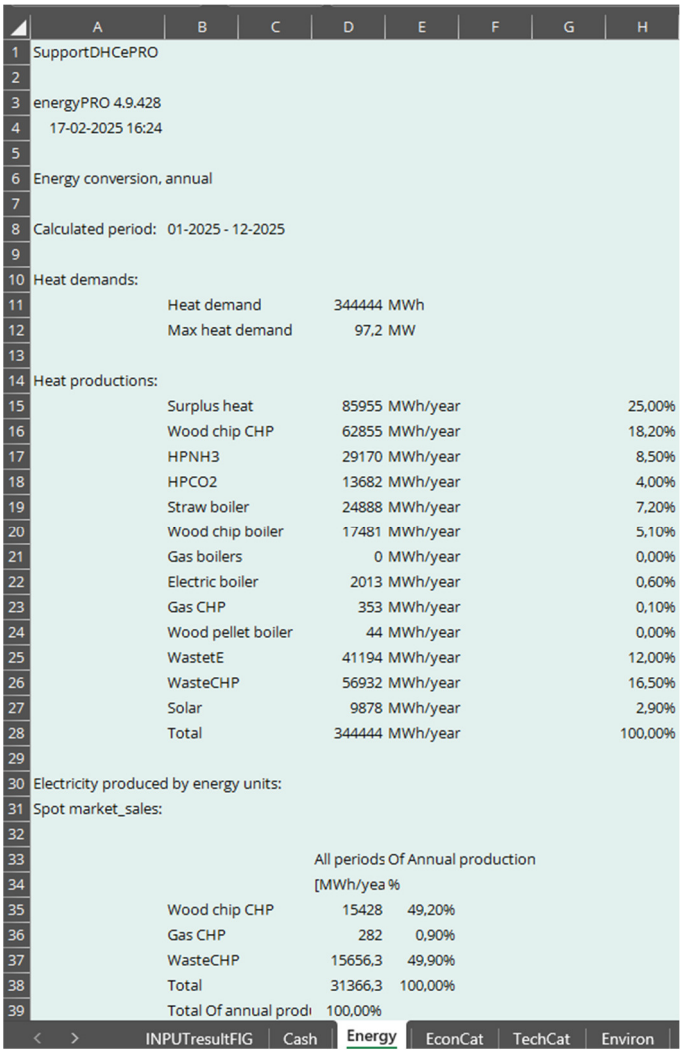
Figure 12 – EXCEL sheet (Support DHCePRO.xlsx) with variable cost elements per plant/unit in model based on standard report: "cash flow annual" – fixed O&M and capital cost based on DEA tech. cat.

Cost elements in EUR									DKK	DKK
	O&M	Fuel	Tax	Nox++	Elec. Sale	Cap. cost	Total cost	Heat MWh	EUR/MWh	DKK/MWh	DKK/GJ
Surplus heat	429777	0	0				429777	85955	5,0	37,3	10,3
Wood chip CHP	573060	1706926	0	19879	-1146156	1250533	2404241	62855	38,3	285,0	79,2
HPNH3	75900	494999	0			676157	1247056	29170	42,8	318,5	88,5
HPCO2	48021	226604	0			676157	950782	13682	69,5	517,7	143,8
Straw boiler	531367	518257	0	14362		546786	1610773	24888	64,7	482,2	133,9
Wood chip boiler	495870	395597	0	4607		621121	1517194	17481	86,8	646,6	179,6
Gas CHP	105702	19228	11860	256	-32125	543213	648134	353	1838,7	13698,2	3805,0
Electric boiler	13310	20895	0			50033	84238	2013	41,9	311,8	86,6
Gas boilers	0	0	0	0			0	0	0,0	0,0	0,0
wood pellet boiler	271116	1514	0	22		396259	668911	44	15065,6	112238,5	31177,4
Waste boiler	1216239	-749880	1023249	6715		1315146	2811469	41194	68,3	508,5	141,2
Waste CHP	1150377	-1295469	1767737	11601	-831819	1633784	2436210	56932	42,8	318,8	88,6
Solar	3574	0	0			480194	483769	9878	49,0	364,9	101,4
Total	4914313	1338671	2802846	57442	-2010100	8189383	15292555	344444	44,4	330,8	91,9

C:\Projekt\Support DHC (23-075)\[Support DHCePRO.xlsx]INPUTresultFIG

Figure 13 – Cost elements pr. plant/unit in model based on cash flow annual – and capital costs.

[2] The Danish Energy Agency (DEA) has produced Technology Catalogues since 1980s to support informed policy-making and long-term energy planning, promoting a least-cost- approach within the green transition. These catalogues provide consistent, reliable data and projections on energy technologies for economic and socio-economic analyses.



	A	B	C	D	E	F	G	H
1	SupportDHCePRO							
2								
3	energyPRO 4.9.428							
4	17-02-2025 16:24							
5								
6	Energy conversion, annual							
7								
8	Calculated period:	01-2025 - 12-2025						
9								
10	Heat demands:							
11		Heat demand	344444	MWh				
12		Max heat demand	97,2	MW				
13								
14	Heat productions:							
15		Surplus heat	85955	MWh/year				25,00%
16		Wood chip CHP	62855	MWh/year				18,20%
17		HPNH3	29170	MWh/year				8,50%
18		HPCO2	13682	MWh/year				4,00%
19		Straw boiler	24888	MWh/year				7,20%
20		Wood chip boiler	17481	MWh/year				5,10%
21		Gas boilers	0	MWh/year				0,00%
22		Electric boiler	2013	MWh/year				0,60%
23		Gas CHP	353	MWh/year				0,10%
24		Wood pellet boiler	44	MWh/year				0,00%
25		WastetE	41194	MWh/year				12,00%
26		WasteCHP	56932	MWh/year				16,50%
27		Solar	9878	MWh/year				2,90%
28		Total	344444	MWh/year				100,00%
29								
30	Electricity produced by energy units:							
31	Spot market_sales:							
32								
33				All periods Of Annual production				
34				[MWh/yea	%			
35		Wood chip CHP	15428	49,20%				
36		Gas CHP	282	0,90%				
37		WasteCHP	15656,3	49,90%				
38		Total	31366,3	100,00%				
39		Total Of annual prodı	100,00%					

INPUTresultFIG | Cash | Energy | EconCat | TechCat | Environ

Figure 14 – Energy conversion, annual – standard ePRO report.

Costs elements	EUR/MWh	EUR/MWh	EUR/MWh	EUR/MWh	EUR/MWh	EUR/MWh	EUR/MWh
	O&M	Fuel	Tax	Nox++	Elec. Sale	Cap. cost	Total cost
Surplus heat	5,0	0,0	0,0	0,0	0,0	0,0	5,0
Wood chip CHP	9,1	27,2	0,0	0,3	-18,2	19,9	38,3
HPNH3	2,6	17,0	0,0	0,0	0,0	23,2	42,8
HPCO2	3,5	16,6	0,0	0,0	0,0	49,4	69,5
Straw boiler	21,3	20,8	0,0	0,6	0,0	22,0	64,7
Wood chip boiler	28,4	22,6	0,0	0,3	0,0	35,5	86,8
Gas CHP	299,9	54,5	33,6	0,7	-91,1	1541,0	1838,7
Electric boiler	6,6	10,4	0,0	0,0	0,0	24,9	41,9
Gas boilers	0,0	0,0	0,0	0,0	0,0	0,0	0,0
wood pellet boiler	6106,2	34,1	0,0	0,5	0,0	8924,8	15065,6
Waste boiler	29,5	-18,2	24,8	0,2	0,0	31,9	68,3
Waste CHP	20,2	-22,8	31,0	0,2	-14,6	28,7	42,8
Solar	0,4	0,0	0,0	0,0	0,0	48,6	49,0
Total	14,3	3,9	8,1	0,2	-5,8	23,8	44,4

Figure 15 – Cost elements pr. Plant/unit in model based on cash flow annual. NB. Premium tariff for wood chip CHP included in electricity sale (Elec. Sale).

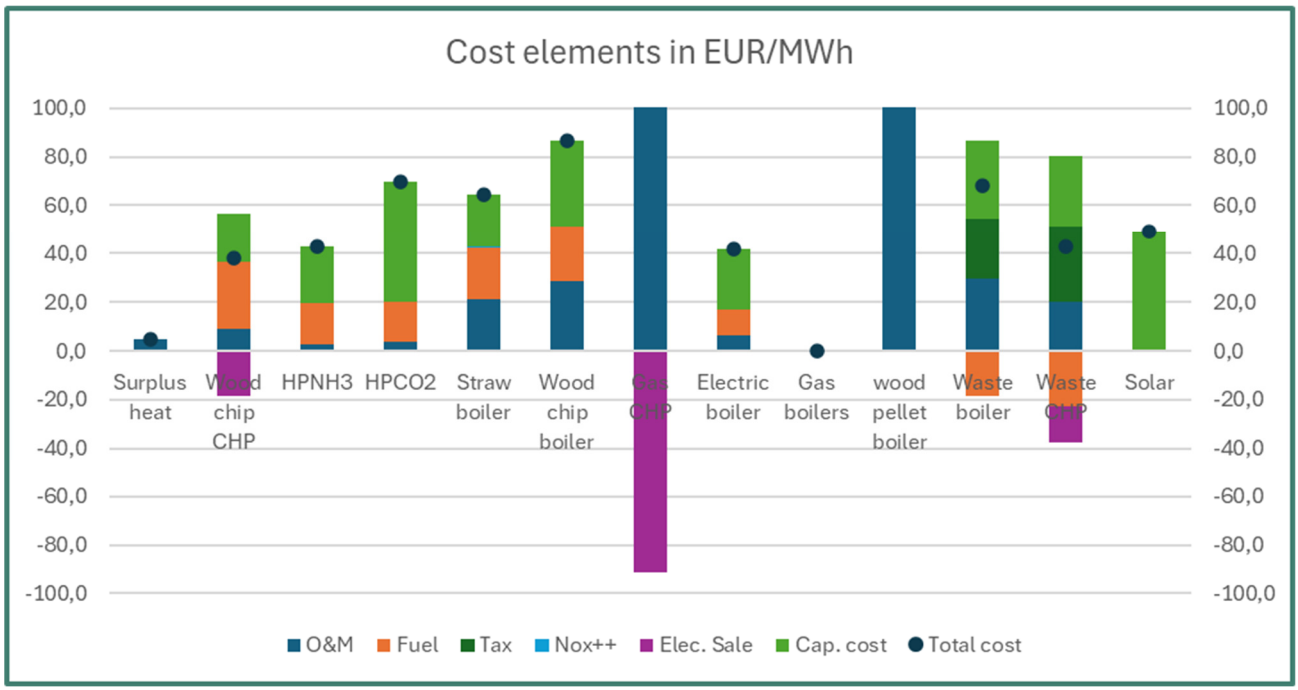


Figure 16 – Cost elements pr. Plant/unit in model based on cash flow annual.

The average production cost are shown on the sheet "INPUTresultFIG", where the cost for each plant/unit's (y-axis) combined with share of annual heat production (x-axis) gives a graphical understanding of all units influence on the average cost.

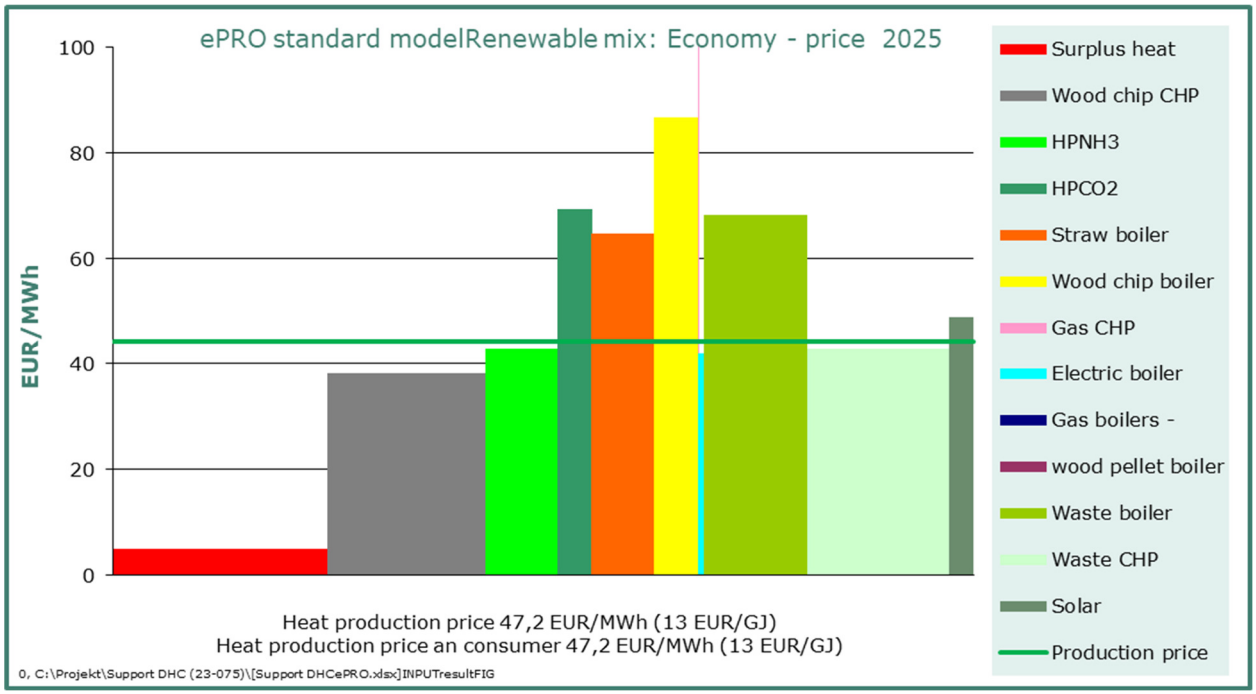


Figure 17 – Average heat production cost and specific cost pr. Plant/unit.

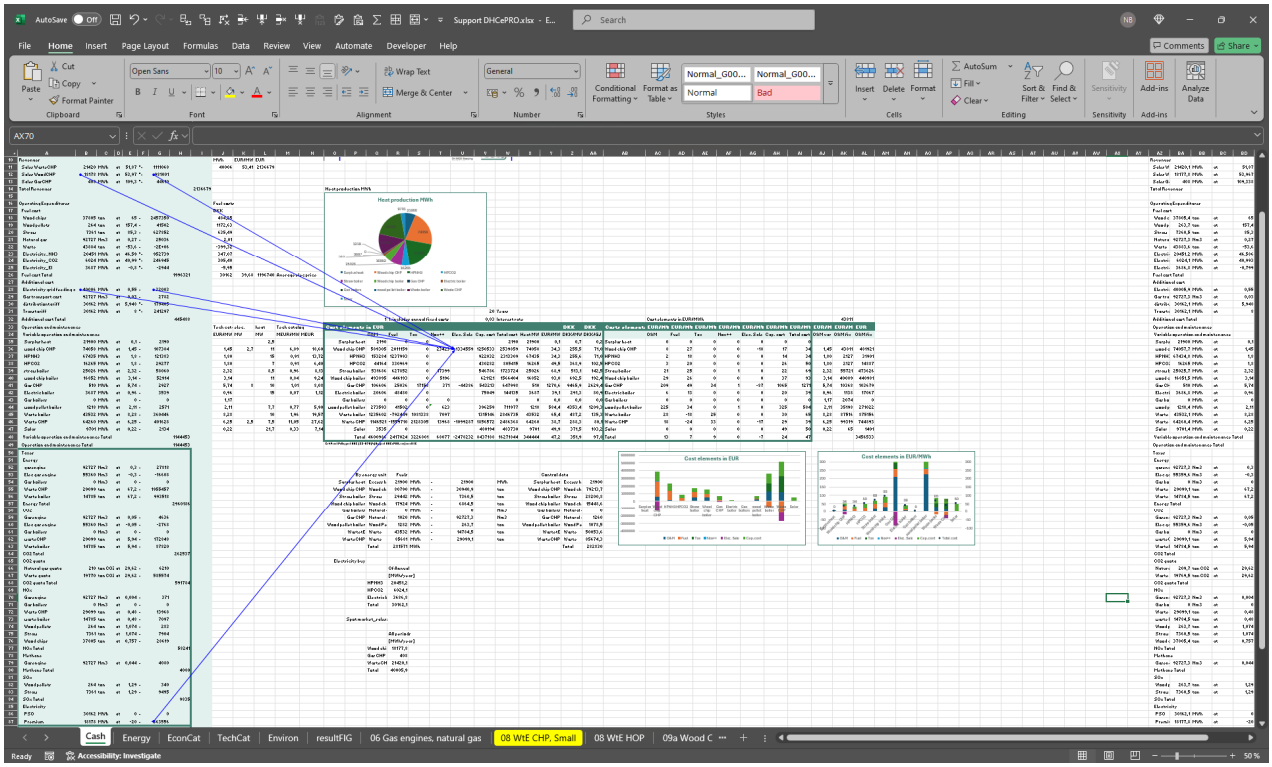


Figure 18 – Cash flow report – NB. Premium tariff for wood chip CHP included in electricity sale

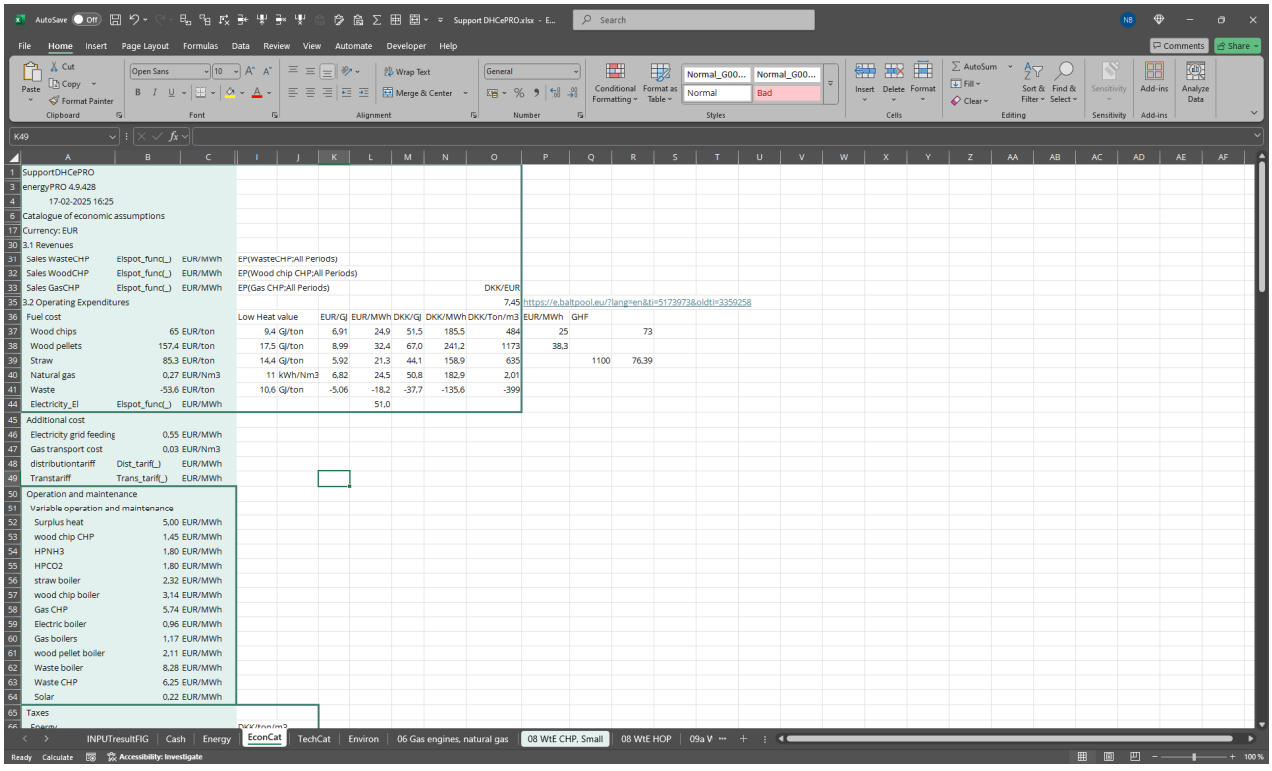


Figure 19 – Catalogue of economic assumptions

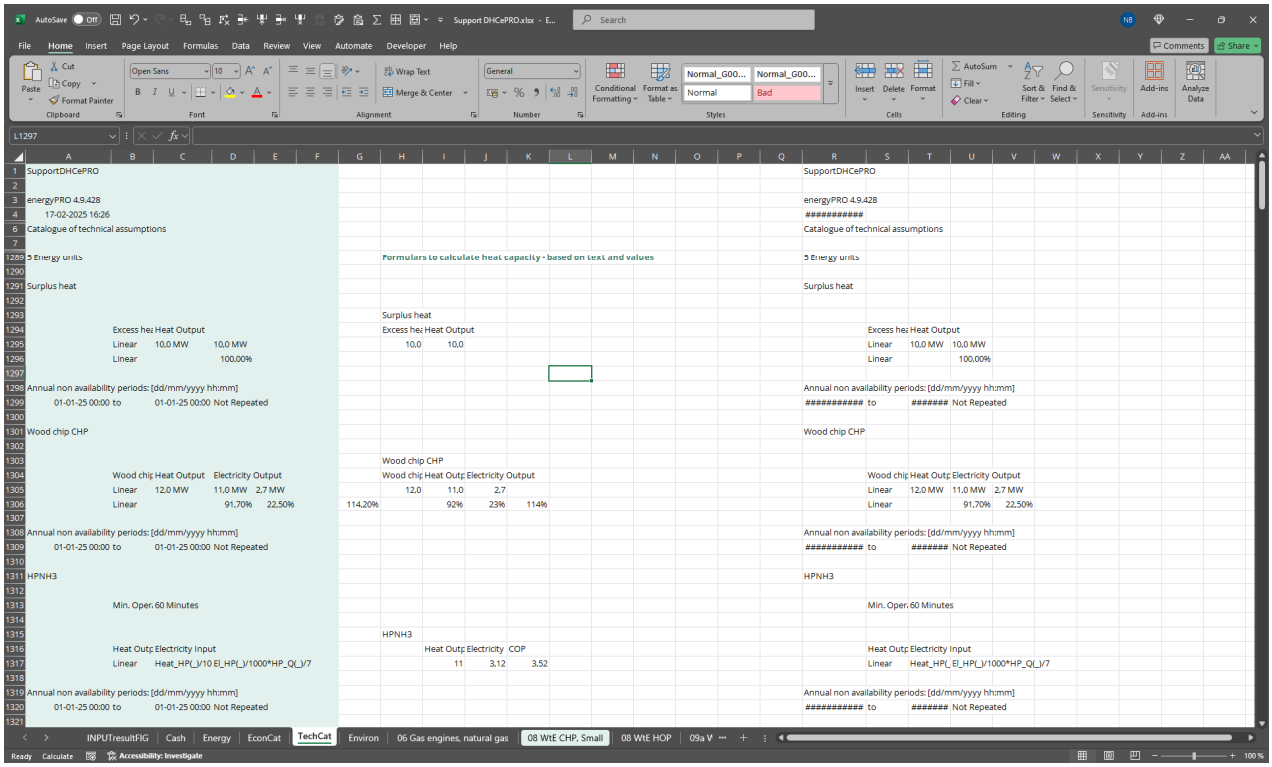


Figure 20 – Catalogue of technical assumptions

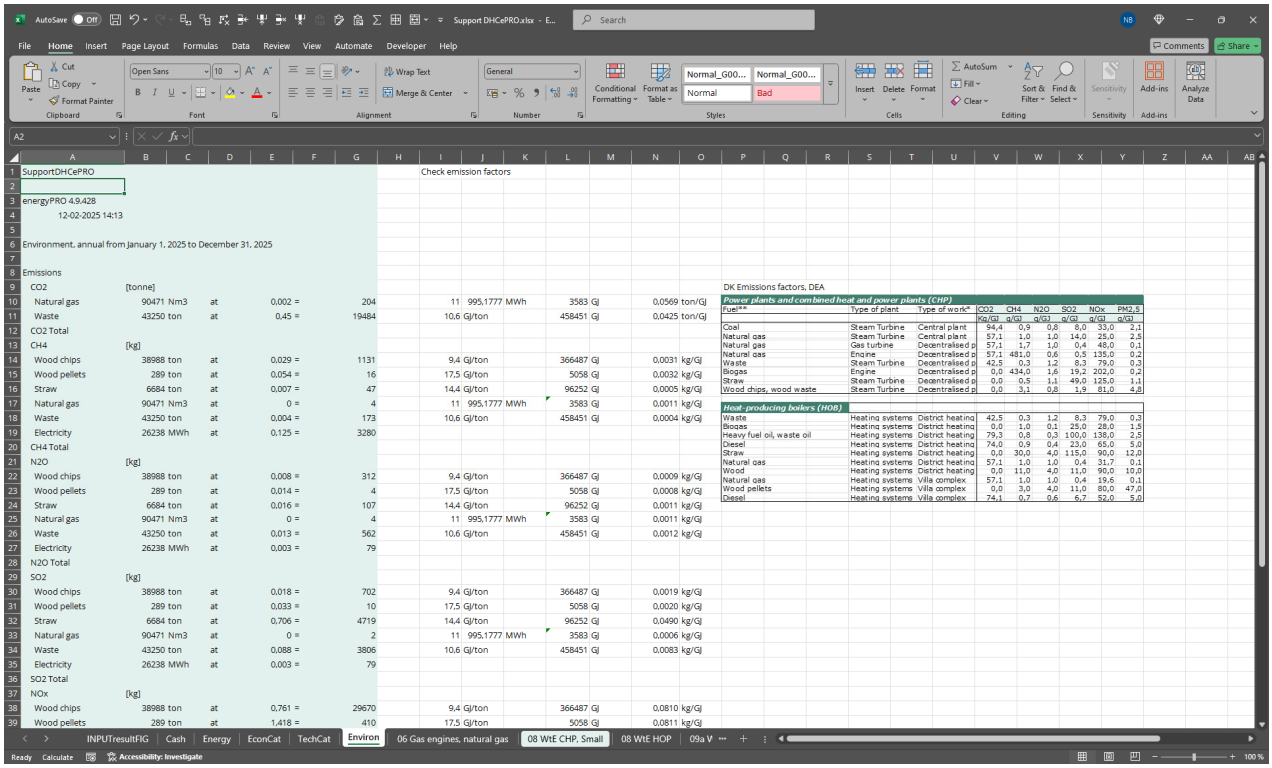


Figure 21 – Environment, annual report – emission factors compared to DEA standard values

	elec.	Fuel	heat	Tech catalogue MEUR/MW	
Units	MW	MW	MW		MEUR
Surplus heat		10,0	10,0	0,0	0,0
Wood chip CHP	2,7	12,0	11,0	6,9	18,6
HPNH3	3,1		11,0	0,9	10,1
HPCO2	4,2		11,0	0,9	10,1
Straw boiler		8,3	8,5	1,0	8,1
Wood chip boiler		10,0	11,0	0,8	9,2
Gas CHP	8,0	20,0	10,0	1,0	8,1
Electric boiler	10,0		10,0	0,1	0,7
Gas boilers		76,0	70,0	0,0	0,0
wood pellet boiler		8,1	7,7	0,8	5,9
Waste boiler		10,0	10,0	2,0	19,6
Waste CHP	2,2	10,0	8,0	11,0	24,3
Solar		0,0	21,7	0,3	7,1
Total		164,4	199,9		

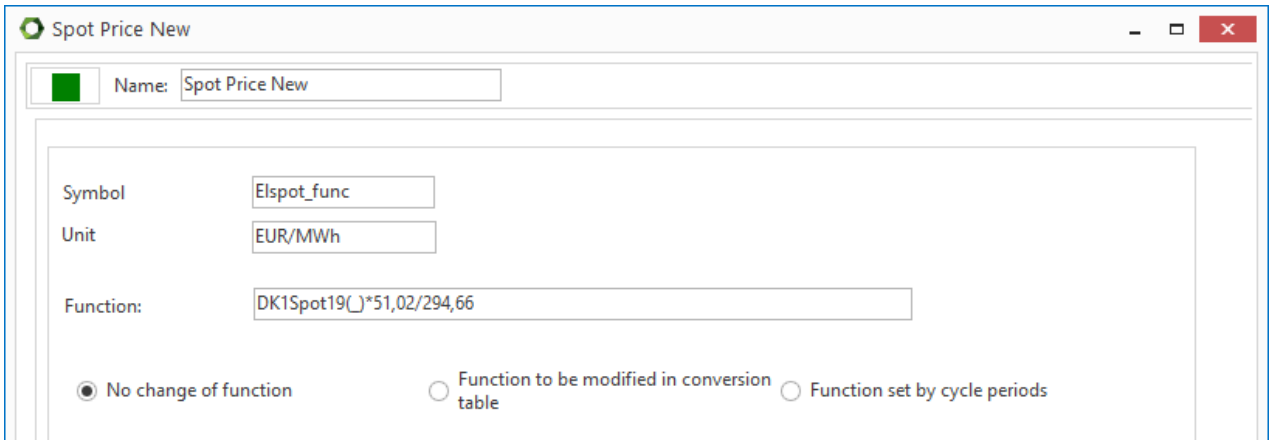
Figure 22 – Unit capacities and investment costs

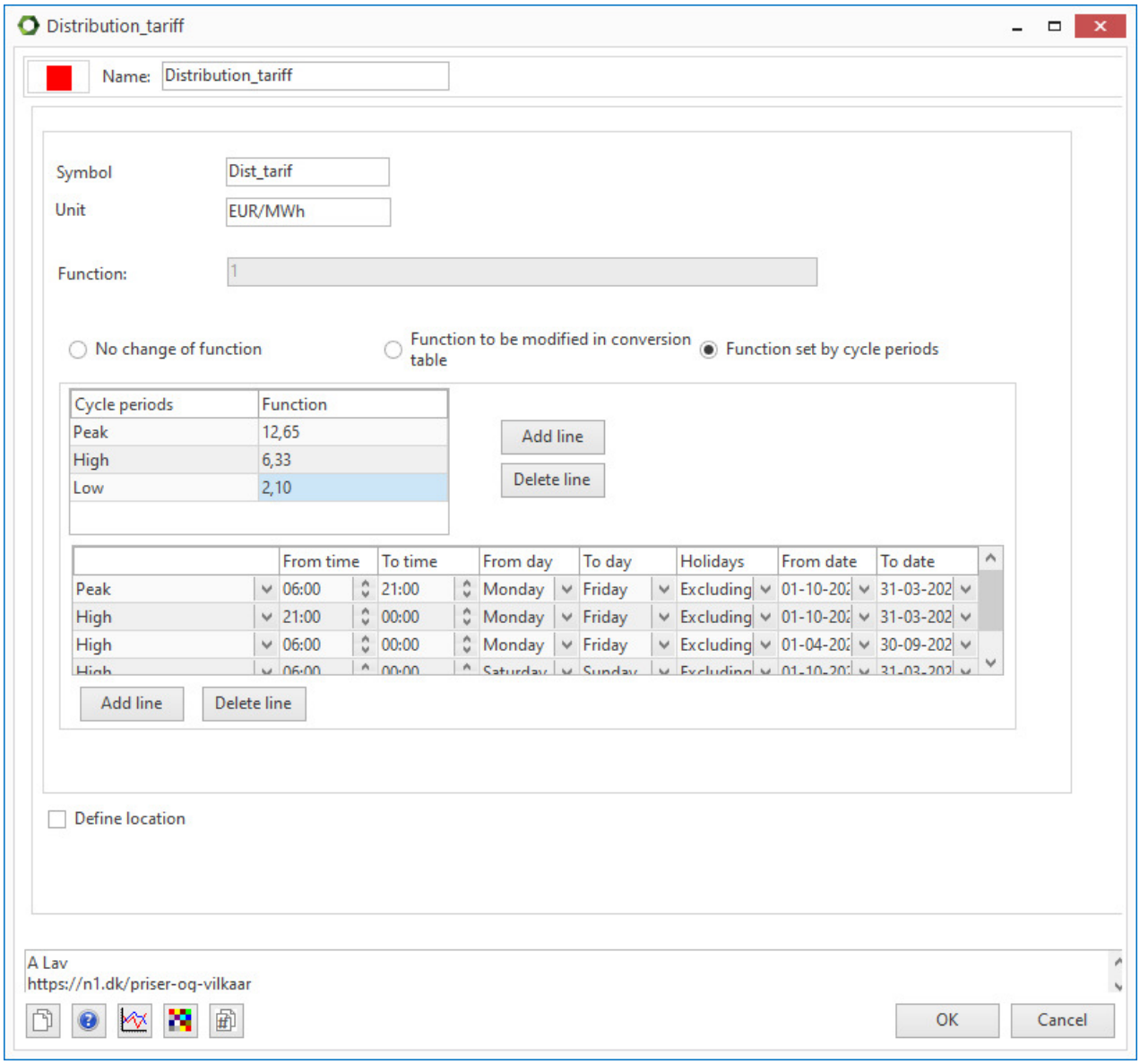
2 Tailormade SupportDHCePRO model to local conditions

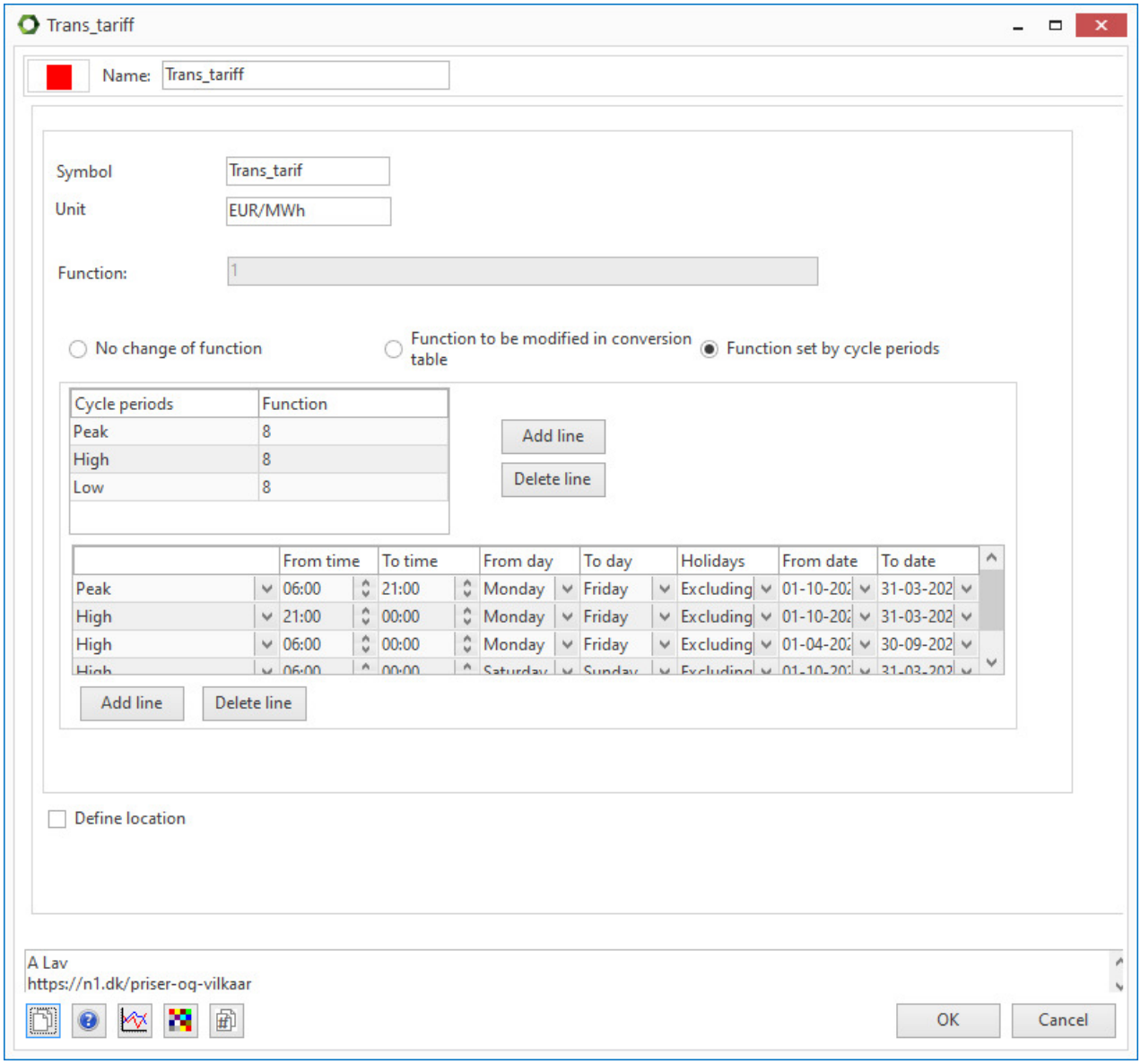
- Adjust energy prices to country and location
- Integrate local weather conditions
- Define “Non availability periods” on plants excluded in the scenarios – do not delete any plants
- Resize the active plants and heat demand according to the local conditions

2.1 Electricity price

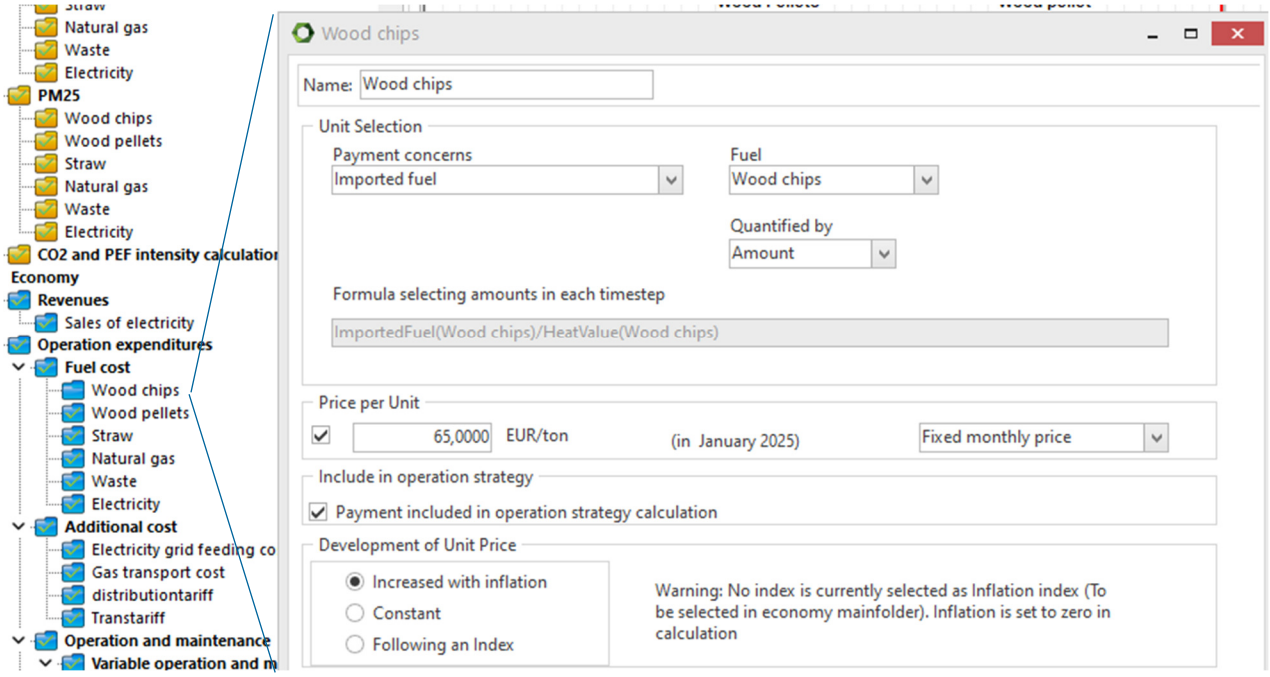
Average DK1Spot 2019 = 294,66 DKK/MWh = 39,55 EUR/MWh, 51,02 EUR/MWh => approx. 1,29 * 2019





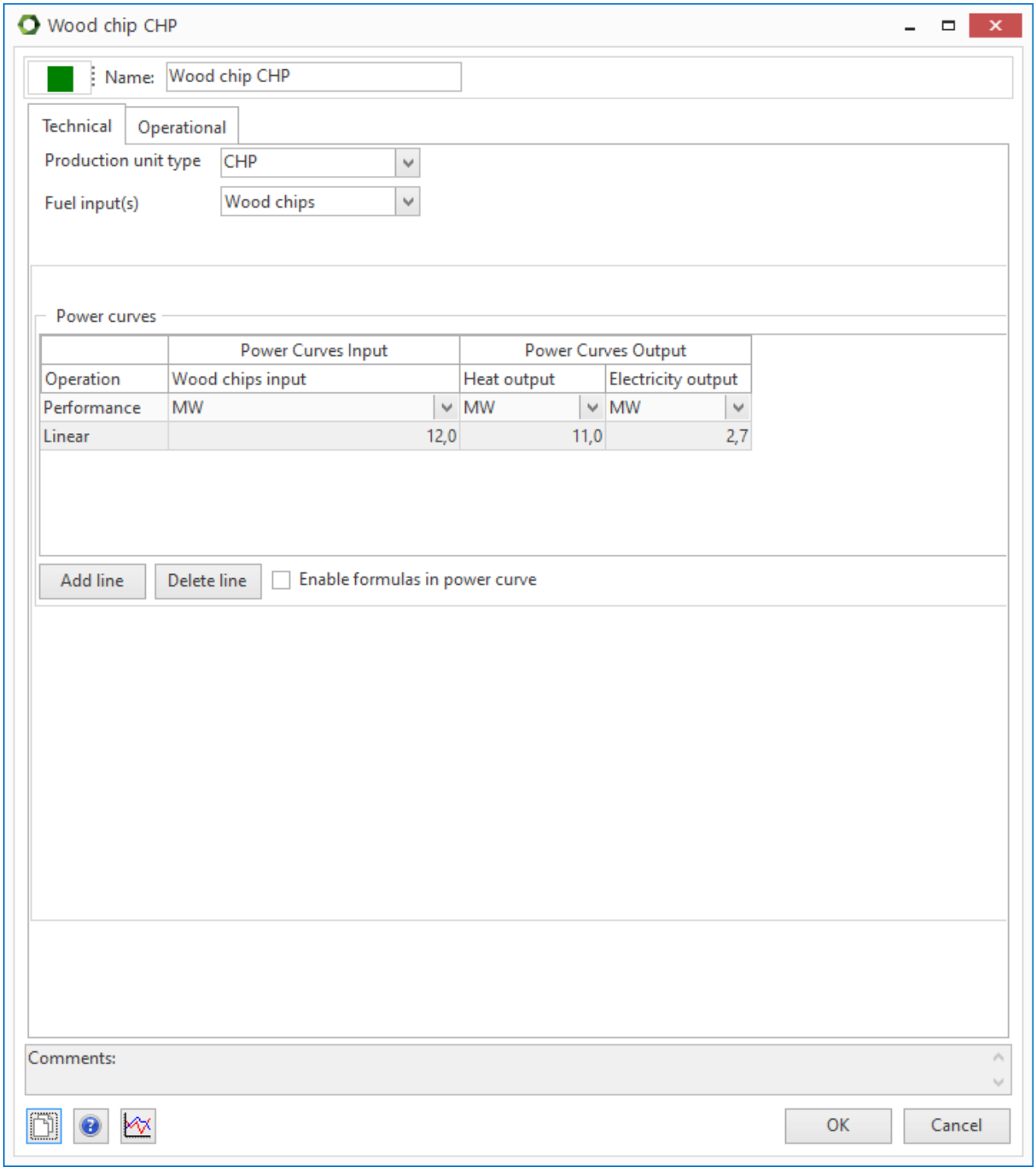

Trans_tariff
Name: Trans_tariff
Symbol
Trans_tarif
Unit
EUR/MWh
Function:
1
No change of function
Function to be modified in conversion table
Function set by cycle periods
Cycle periods
Function
Peak
8
High
8
Low
8
Add line
Delete line
From time
To time
From day
To day
Holidays
From date
To date
Peak
06:00
21:00
Monday
Friday
Excluding
01-10-202
31-03-202
High
21:00
00:00
Monday
Friday
Excluding
01-10-202
31-03-202
High
06:00
00:00
Monday
Friday
Excluding
01-04-202
30-09-202
Add line
Delete line
Define location
A Lav
https://n1.dk/priser-og-vilkaar
OK
Cancel

2.2 Fuel prices

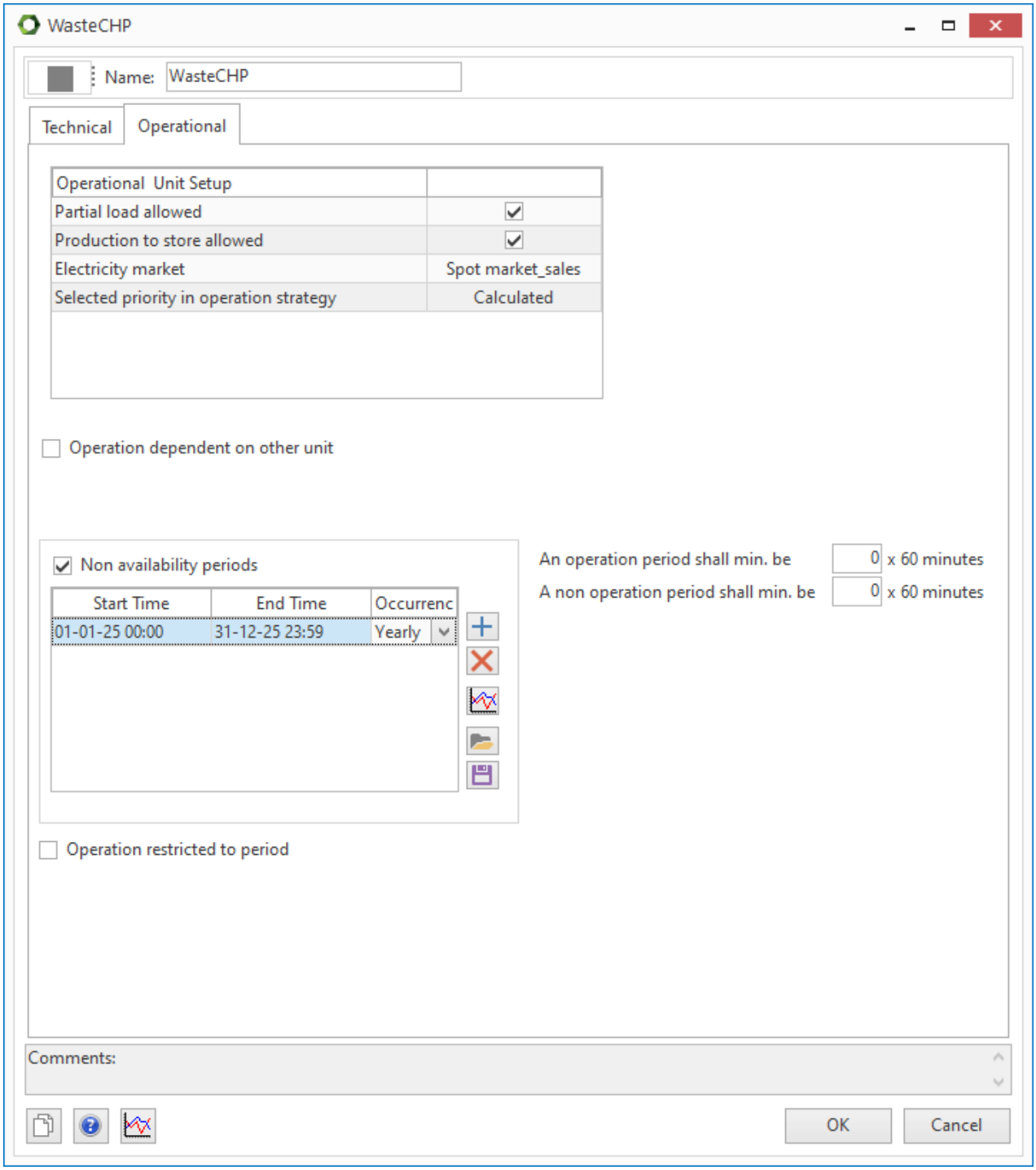


SupportDHCePRO										
energyPRO 4.9.428										
23-01-2025 15:12										
Catalogue of economic assumptions										
Currency: EUR										
3.1 Revenues										
Sales WasteCHP	Elspot_func(_)	EUR/MWh	EP(WasteCHP;All Periods)							
Sales WoodCHP	Elspot_func(_)	EUR/MWh	EP(Wood chip CHP;All Periods)							
Sales GasCHP	Elspot_func(_)	EUR/MWh	EP(Gas CHP;All Periods)							DKK/EUR
3.2 Operating Expenditures										7,45
Fuel cost			Low Heat value		EUR/GJ	EUR/MWh	DKK/GJ	DKK/MWh	DKK/Ton/m3	
Wood chips		65 EUR/ton	9,4	GJ/ton	6,91	24,9	51,5	185,5	484	
Wood pellets		157,4 EUR/ton	17,5	GJ/ton	8,99	32,4	67,0	241,2	1173	
Straw		85,3 EUR/ton	14,4	GJ/ton	5,92	21,3	44,1	158,9	635	
Natural gas		0,27 EUR/Nm3	11	kWh/Nm3	6,82	24,5	50,8	182,9	2,01	
Waste		-53,6 EUR/ton	10,6	GJ/ton	-5,06	-18,2	-37,7	-135,6	-399	
Electricity_El	Elspot_func(_)	EUR/MWh				51,0				

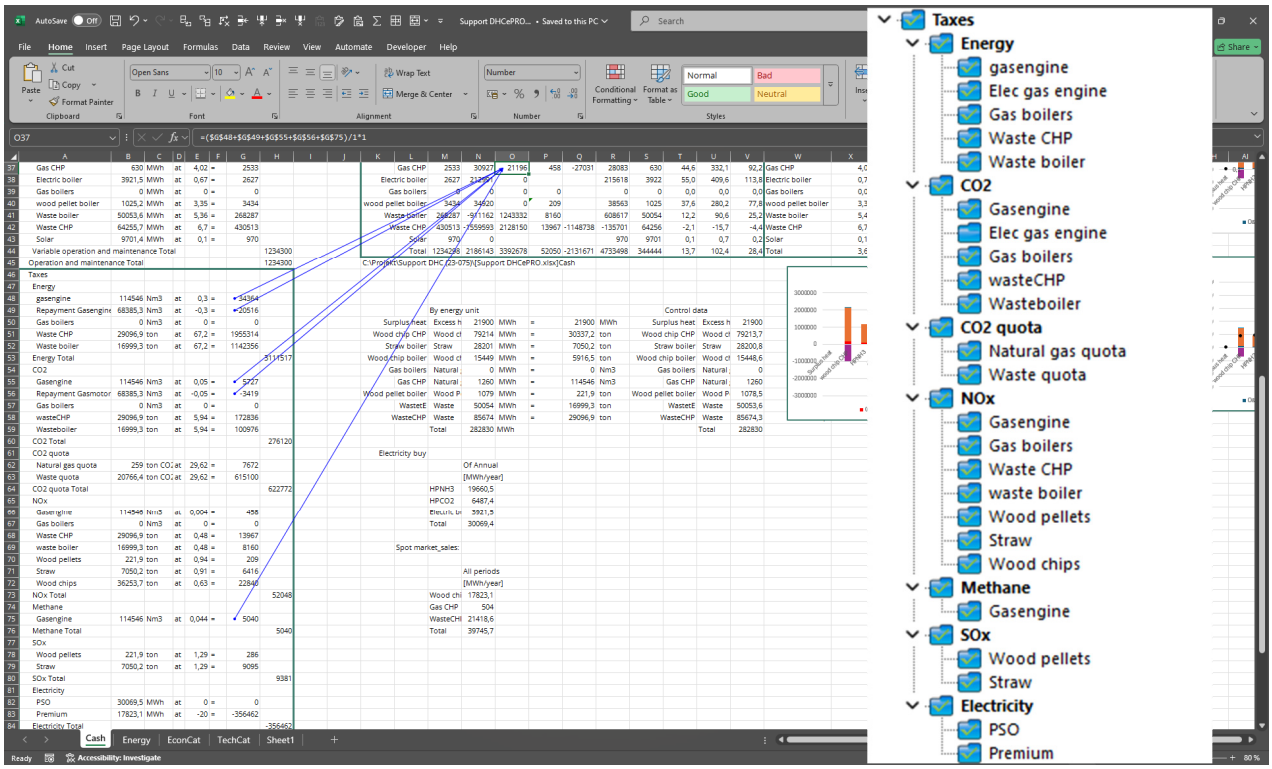
2.3 Unit size


Wood chip CHP
Name: Wood chip CHP
Technical
Operational
Production unit type CHP
Fuel input(s) Wood chips
Power curves
Power Curves Input
Power Curves Output
Operation
Wood chips input
Heat output
Electricity output
Performance
MW
MW
MW
Linear
12,0
11,0
2,7
Add line
Delete line
Enable formulas in power curve
Comments:
OK
Cancel

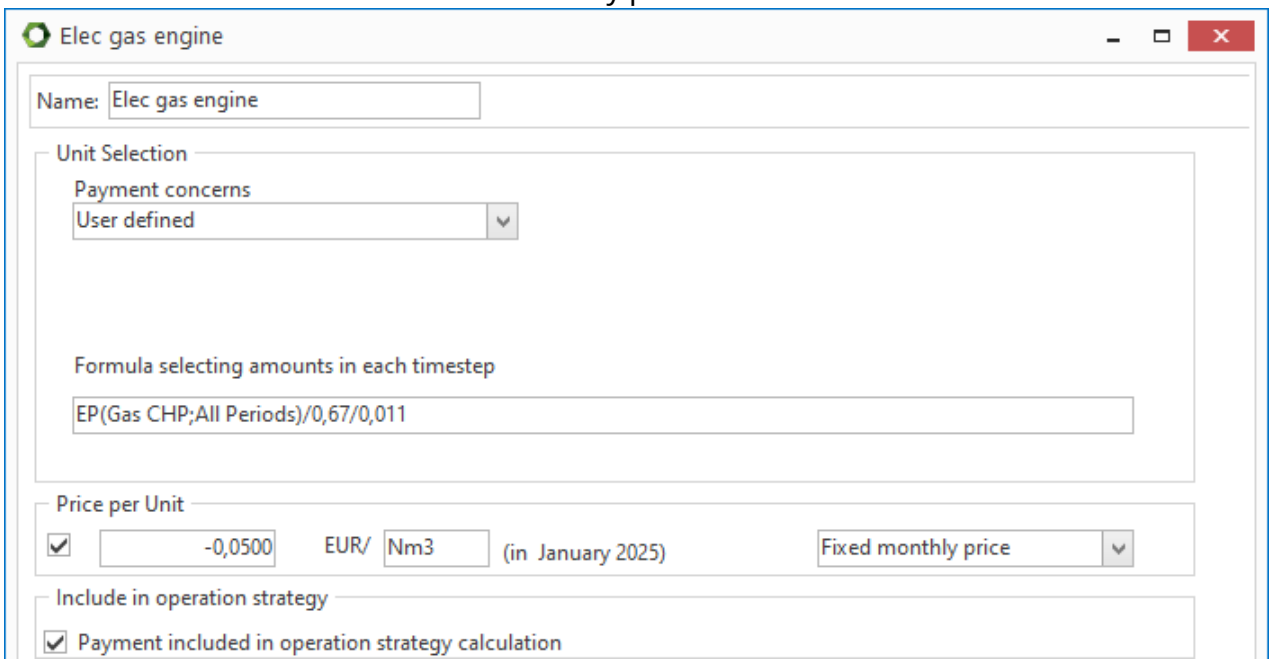
2.4 Unit outage



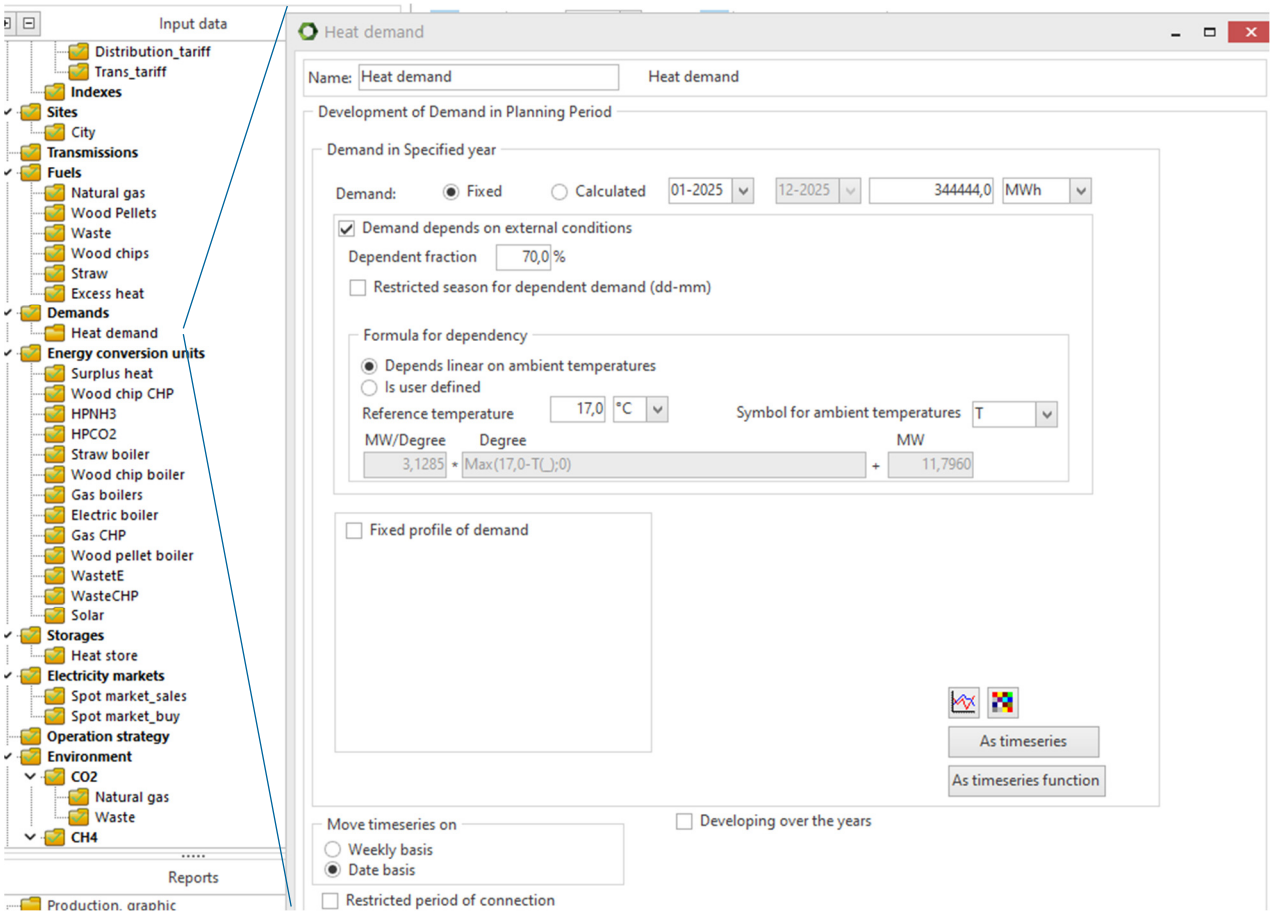
2.5 Tax



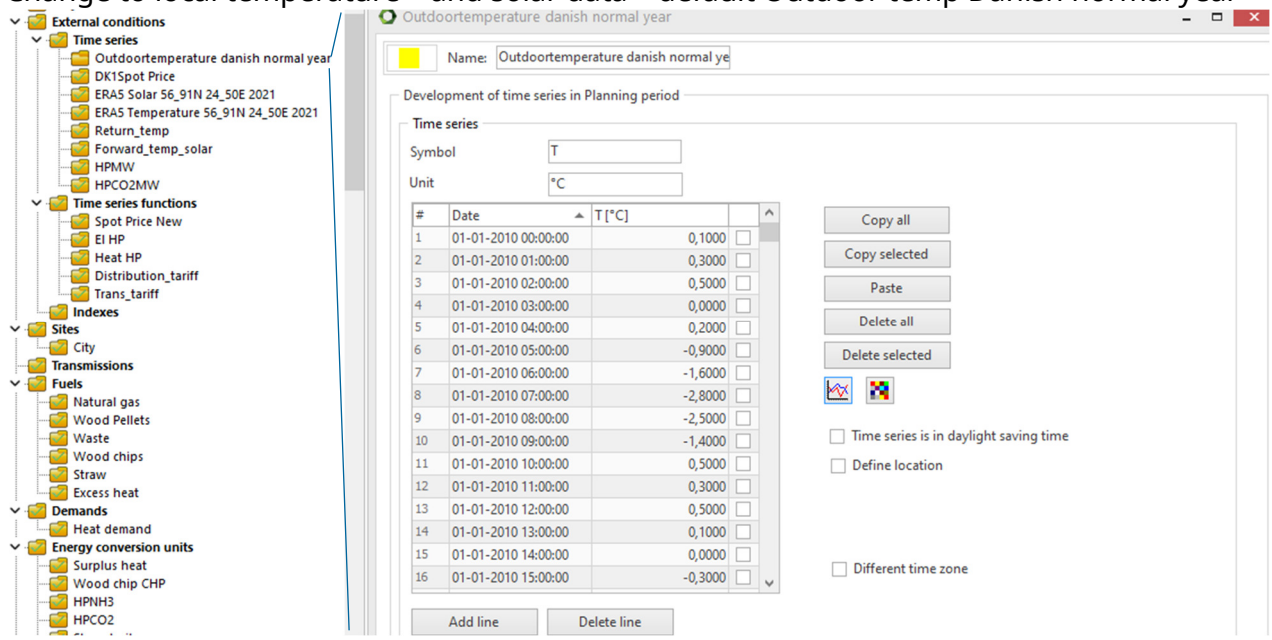
No “heat” tax on the fuel share for electricity production

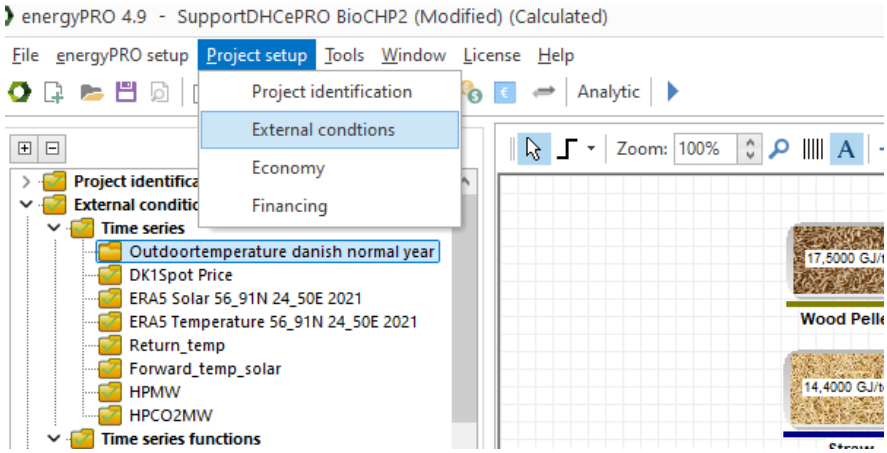


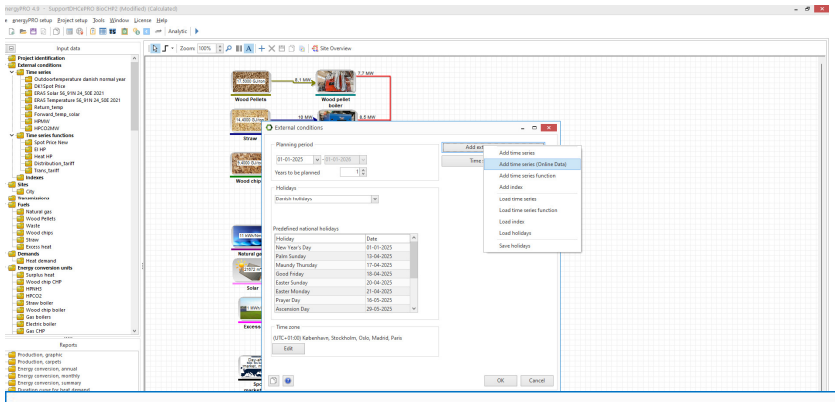
2.6 Heat Demand

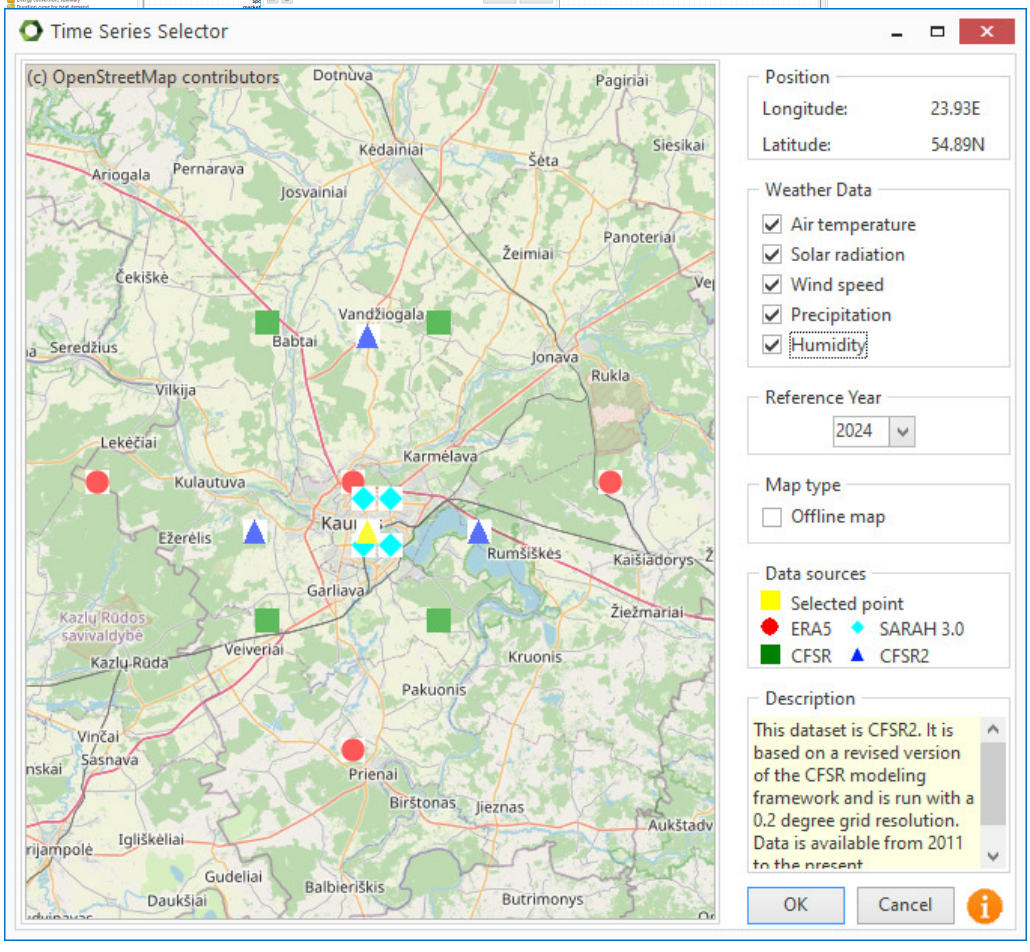


Change to local temperature – and solar data – default Outdoor temp Danish normal year

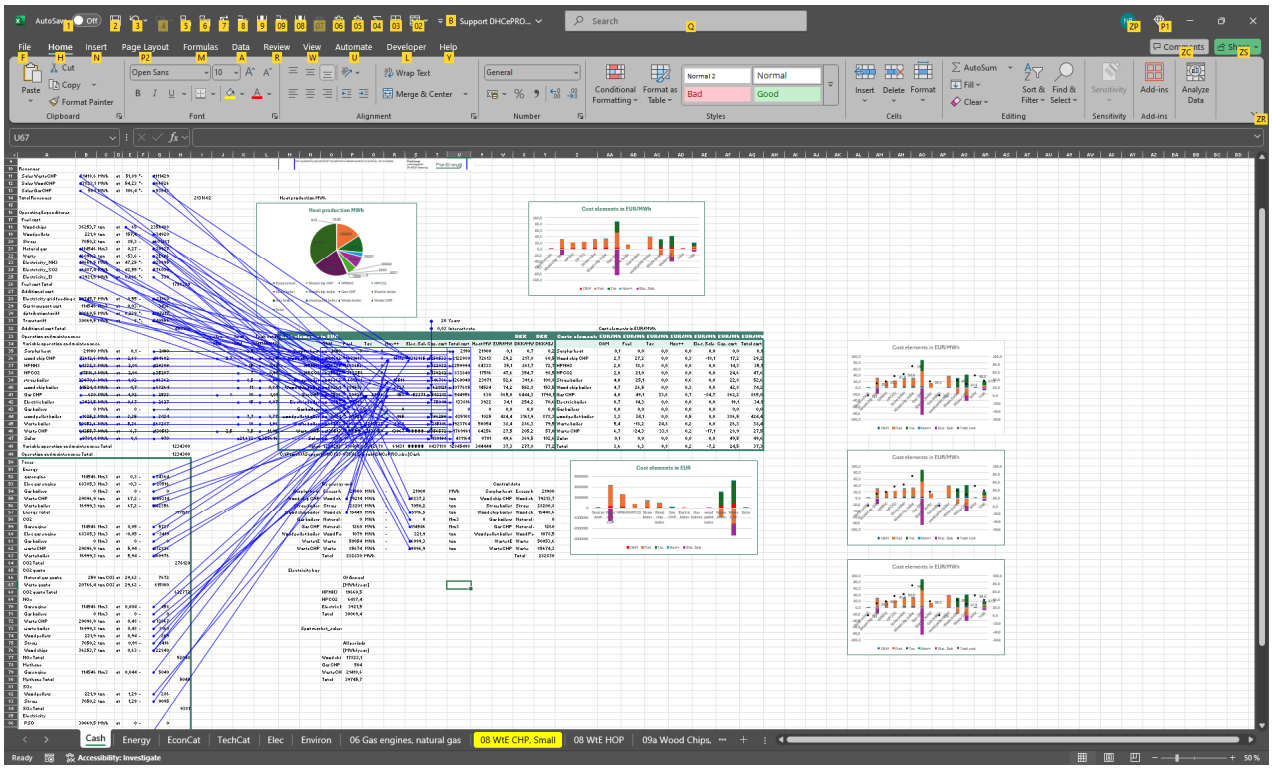



energyPRO 4.9 - SupportDHCePRO BioCHP2 (Modified) (Calculated)
File energyPRO setup Project setup Tools Window License Help
Project identification
External condtions
Economy
Financing
Analytic
Zoom: 100%
Project identifica
External conditio
Time series
Outdoortemperature danish normal year
DK1Spot Price
ERA5 Solar 56_91N 24_50E 2021
ERA5 Temperature 56_91N 24_50E 2021
Return_temp
Forward_temp_solar
HPMW
HPCO2MW
Time series functions
17,5000 GJ/
Wood Pelle
14,4000 GJ/



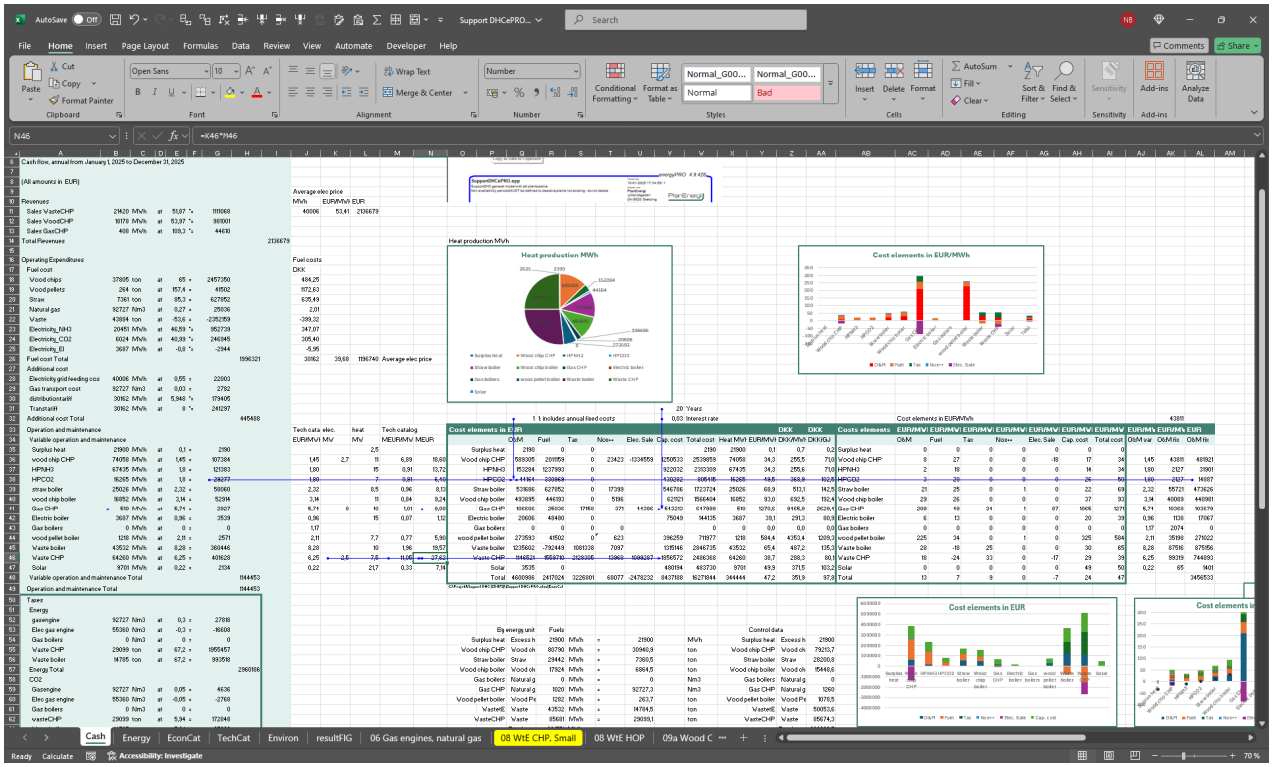

Time Series Selector
(c) OpenStreetMap contributors
Dotnuva
Pagiriai
Kedainiai
Siesikai
Seta
Ariogala
Pernarava
Josvainiai
Panoteriai
Zeimiai
Cekiske
Vandziogala
Babtai
Seredzius
Jonava
Rukla
Vilkija
Lekeciai
Karmelava
Kulautuva
Kaunas
Ezerelis
Rumsiskes
Kaisiadorys
Garliava
Zziezmariai
Kazlu Rudos savivaldybe
Veiveriai
Kazlu Ruda
Kruonis
Pakuonis
Vincai
Sasnava
Prienai
Birstonas
Jieznas
Aukstadv
Igliskeliai
Gudeliai
Balbieriskis
Daukšiai
Butrimonys
Position
Longitude: 23.93E
Latitude: 54.89N
Weather Data
Air temperature
Solar radiation
Wind speed
Precipitation
Humidity
Reference Year
2024
Map type
Offline map
Data sources
Selected point
ERA5
SARAH 3.0
CFSR
CFSR2
Description
This dataset is CFSR2. It is based on a revised version of the CFSR modeling framework and is run with a 0.2 degree grid resolution. Data is available from 2011 to the present
OK
Cancel

2.7 Cost elements



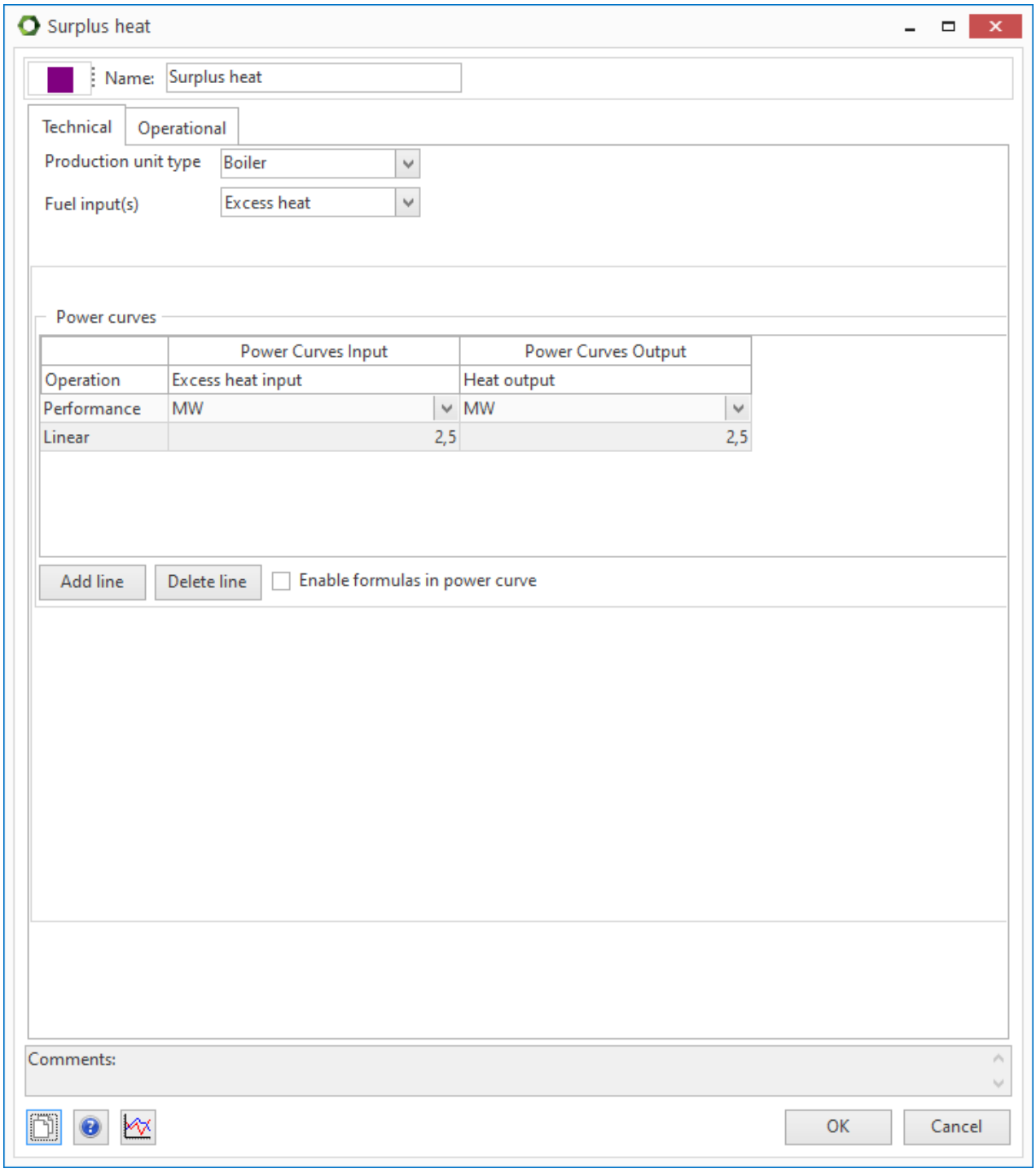
												20	Years	
						1	1: includes annual fixed costs					0,03	Interest rate	
Tech catal	elec.	heat	Tech catalog		Cost elements in EUR									
EUR/MWh	MW	MW	MEUR/MW	MEUR		O&M	Fuel	Tax	Nox++	Elec. Sale	Cap. cost	Total cost	Heat MWh	
		2,5			Surplus heat	2190	0	0				2190	21900	
1,45	2,7	11	6,89	18,60	Wood chip CHP	589305	2011159	0	23423	-1334559	1250533	2539859	74058	
1,80		15	0,91	13,72	HPNH3	153284	1237993	0			922032	2313309	67435	
1,80		7	0,91	6,40	HPCO2	44164	330969	0			430282	805415	16265	
2,32		8,5	0,96	8,13	Straw boiler	531686	627852	0	17399		546786	1723724	25026	
3,14		11	0,84	9,24	Wood chip boiler	493895	446193	0	5196		621121	1566404	16852	
5,74	8	10	1,01	8,08	Gas CHP	106606	25036	17158	371	-44386	543213	647998	510	
0,96		15	0,07	1,12	Electric boiler	20606	48480	0			75049	144135	3687	
1,17					Gas boilers	0	0	0	0			0	0	
2,11		7,7	0,77	5,90	wood pellet boiler	273593	41502	0	623		396259	711977	1218	
8,28		10	1,96	19,57	Waste boiler	1235602	-792449	1081338	7097		1315146	2846735	43532	
6,25	2,5	7,5	11,05	27,62	Waste CHP	1146521	-1559710	2128305	13968	-1099287	1856572	2486368	64260	
0,22		21,7	0,33	7,14	Solar	3535	0				480194	483730	9701	
					Total	4600986	2417024	3226801	68077	-2478232	8437188	16271844	344444	
					C:\Projekt\Support DHC (23-075)\[Support DHCePRO.xlsx]EconCat									

The variable costs included in the energyPRO model are summarised to plant based cost tables, and combined with investment cost and O&M cost based on the DEA, Technology Catalogue.

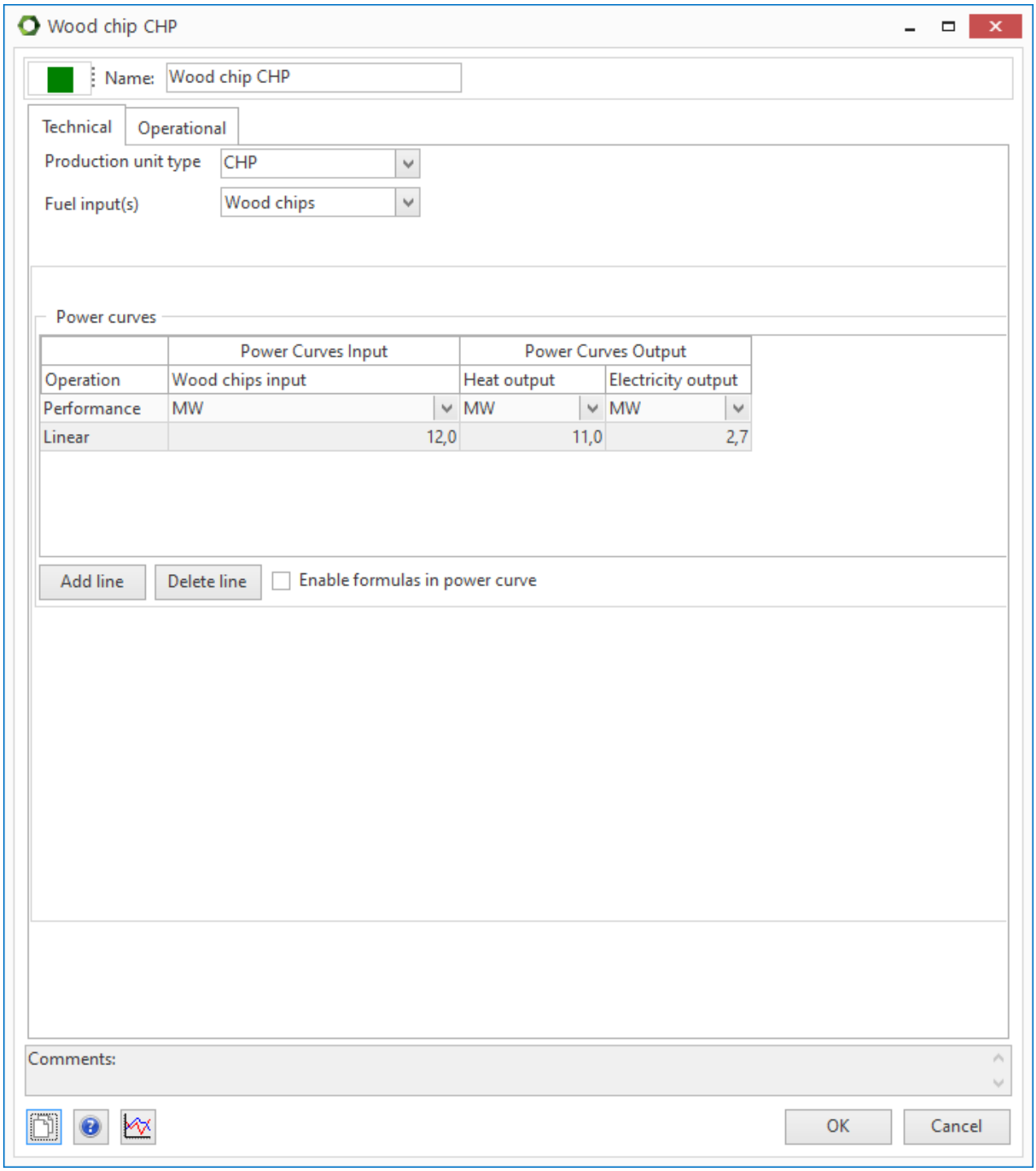


2.8 Plants/units

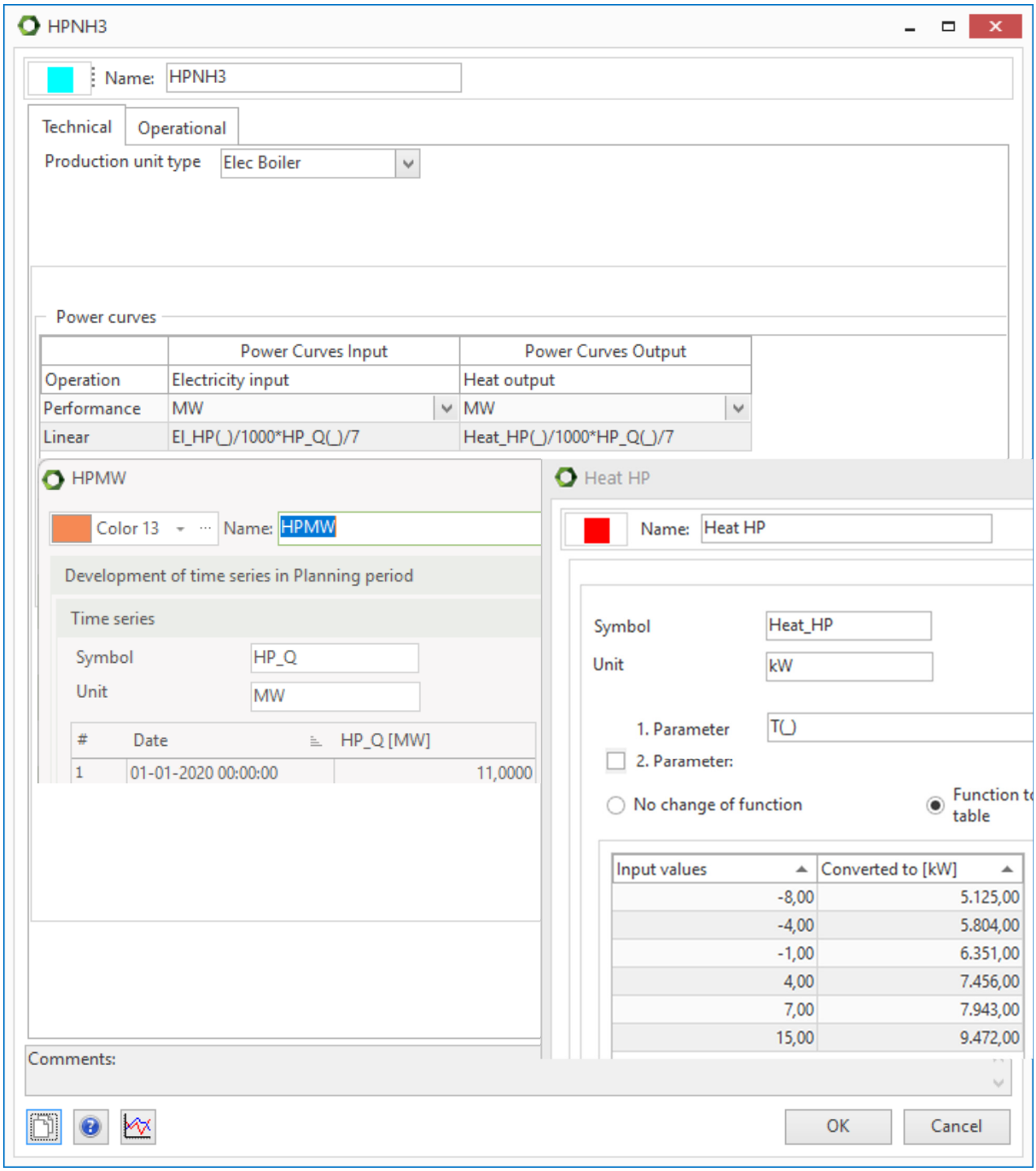
2.8.1 Surplus heat



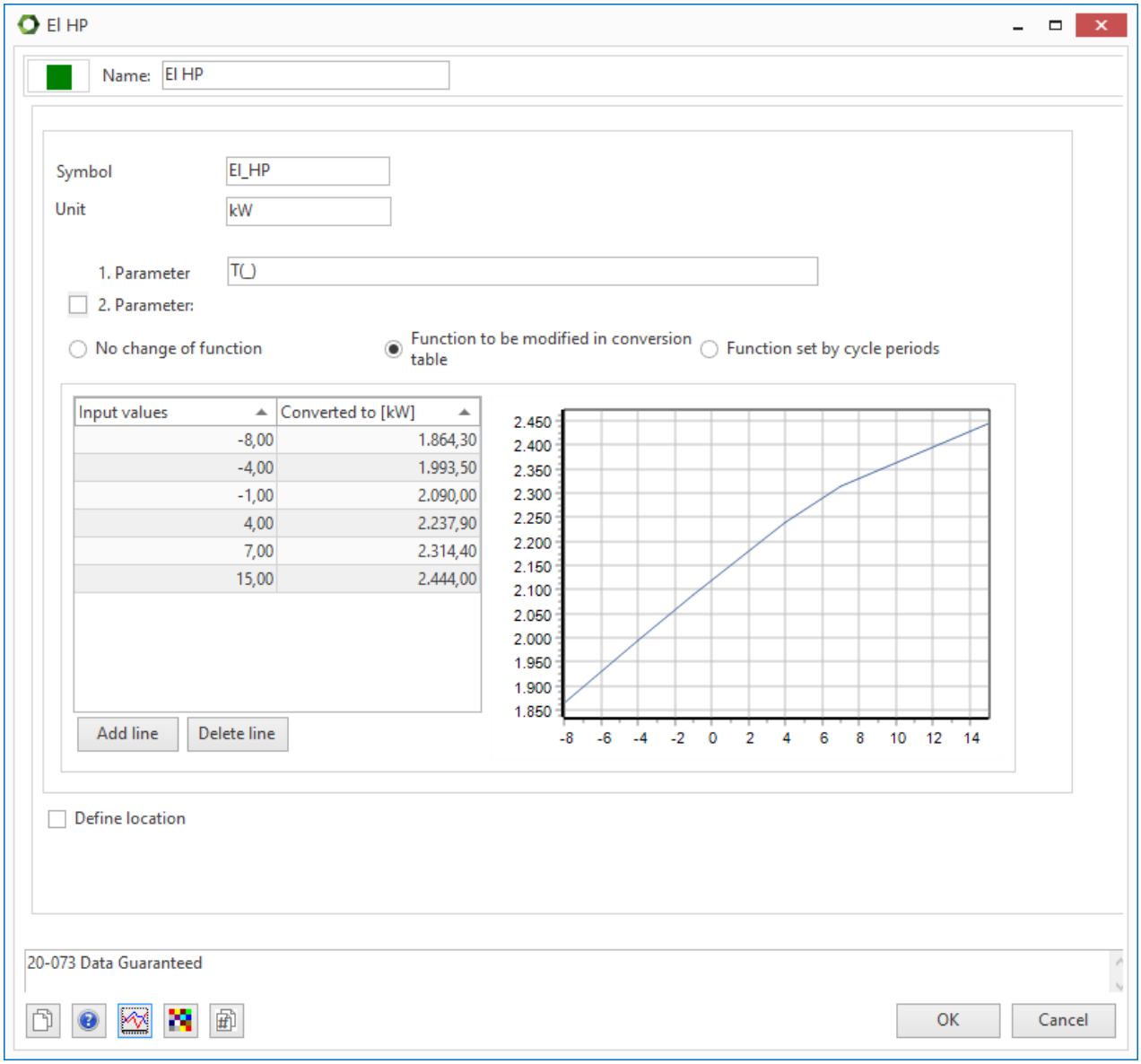
2.8.2 Wood chip CHP



2.8.3 HPNH3

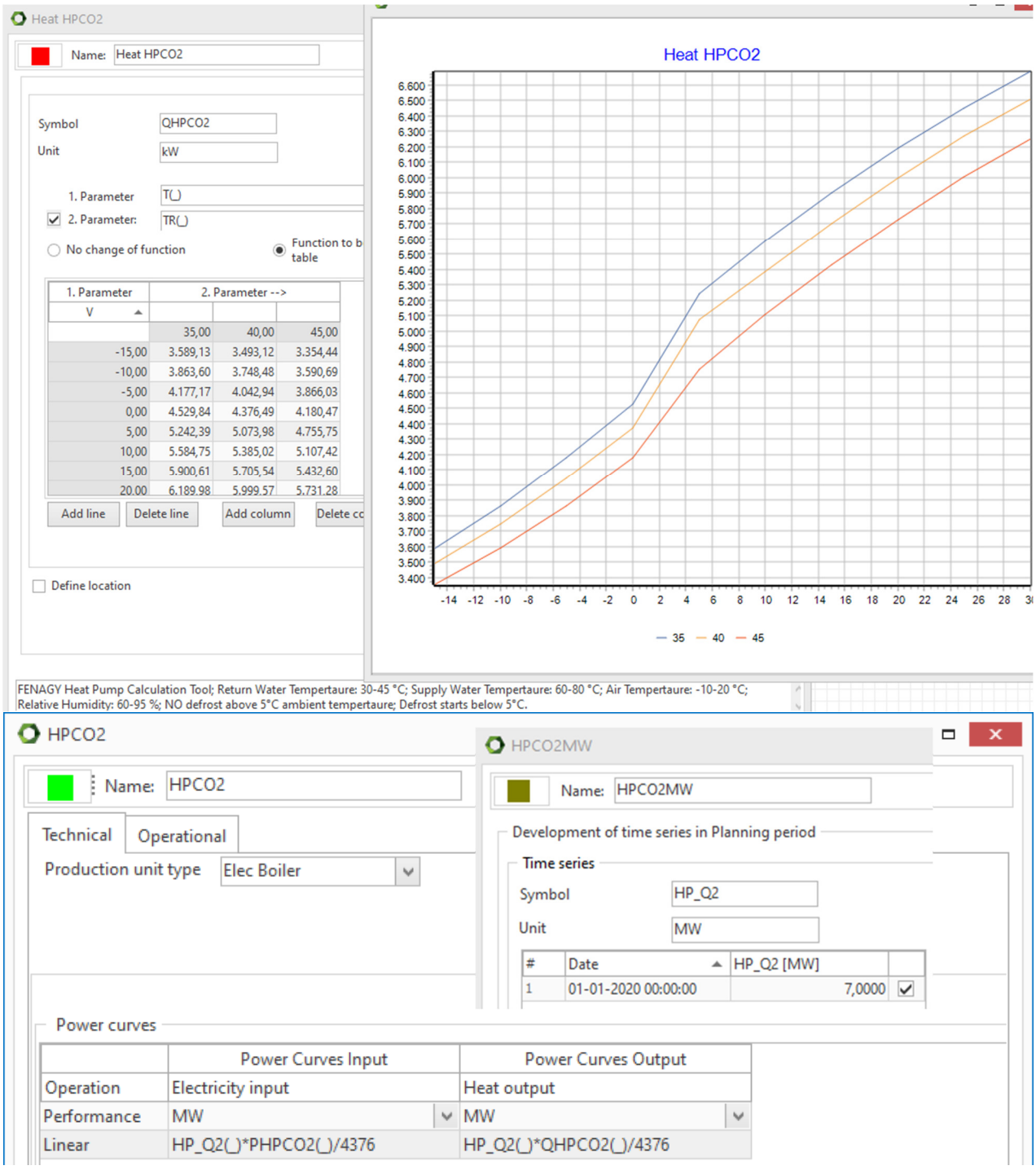


Based on guaranteed data for a 7 MW heat pump, therefore the special electricity and heat production calculations. Scaled with HP_Q to approx. 11 MW.

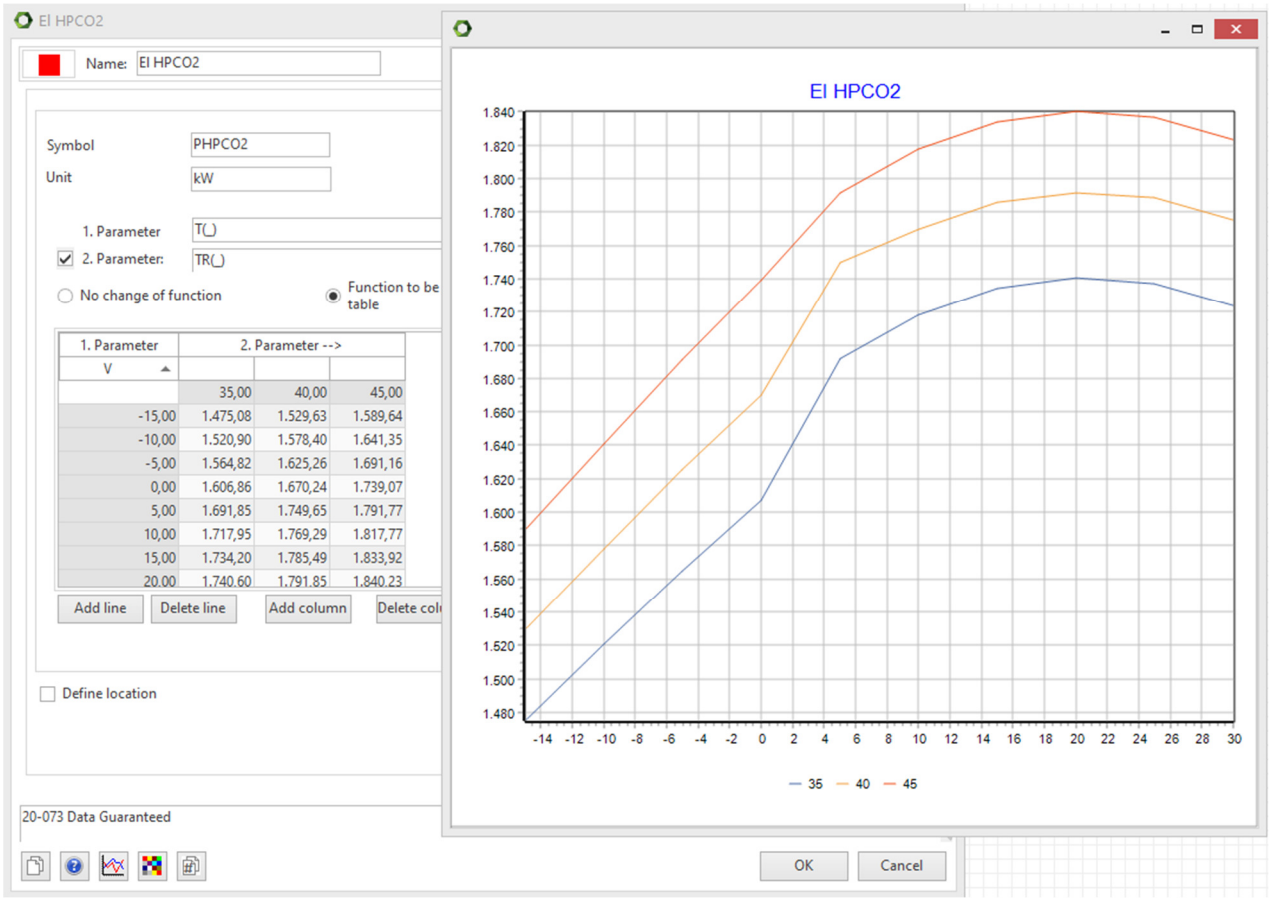


HPNH3	COP
-8	2,75
-4	2,91
-1	3,04
4	3,33
7	3,43
15	3,88

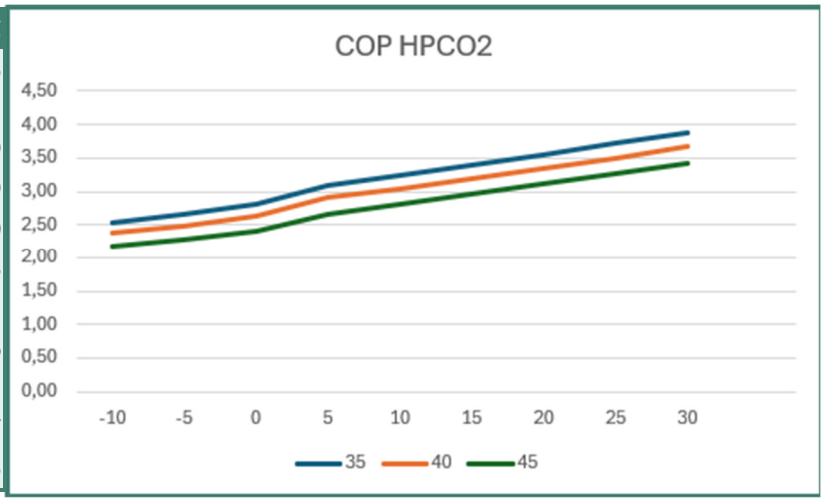
2.8.4 HPCO2



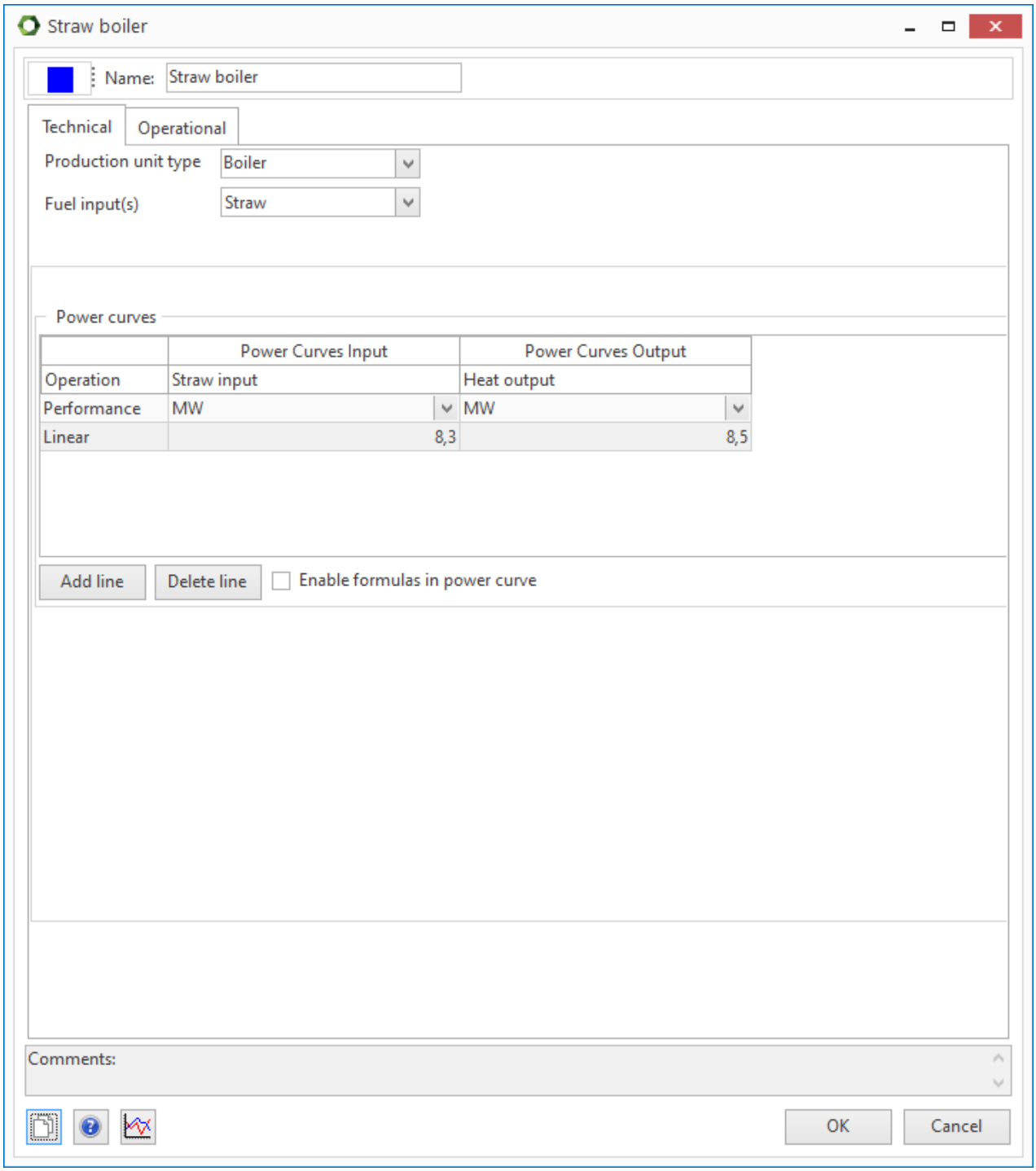
FENAGY Heat Pump Calculation Tool; Return Water Temperature: 30-45 °C; Supply Water Temperature: 60-80 °C; Air temperature: -10-20 °C; Relative Humidity: 60-95 %; NO defrost above 5°C ambient temperature; Defrost starts below 5°C.
Scaled with HP_Q2 to approx. 7 MW.



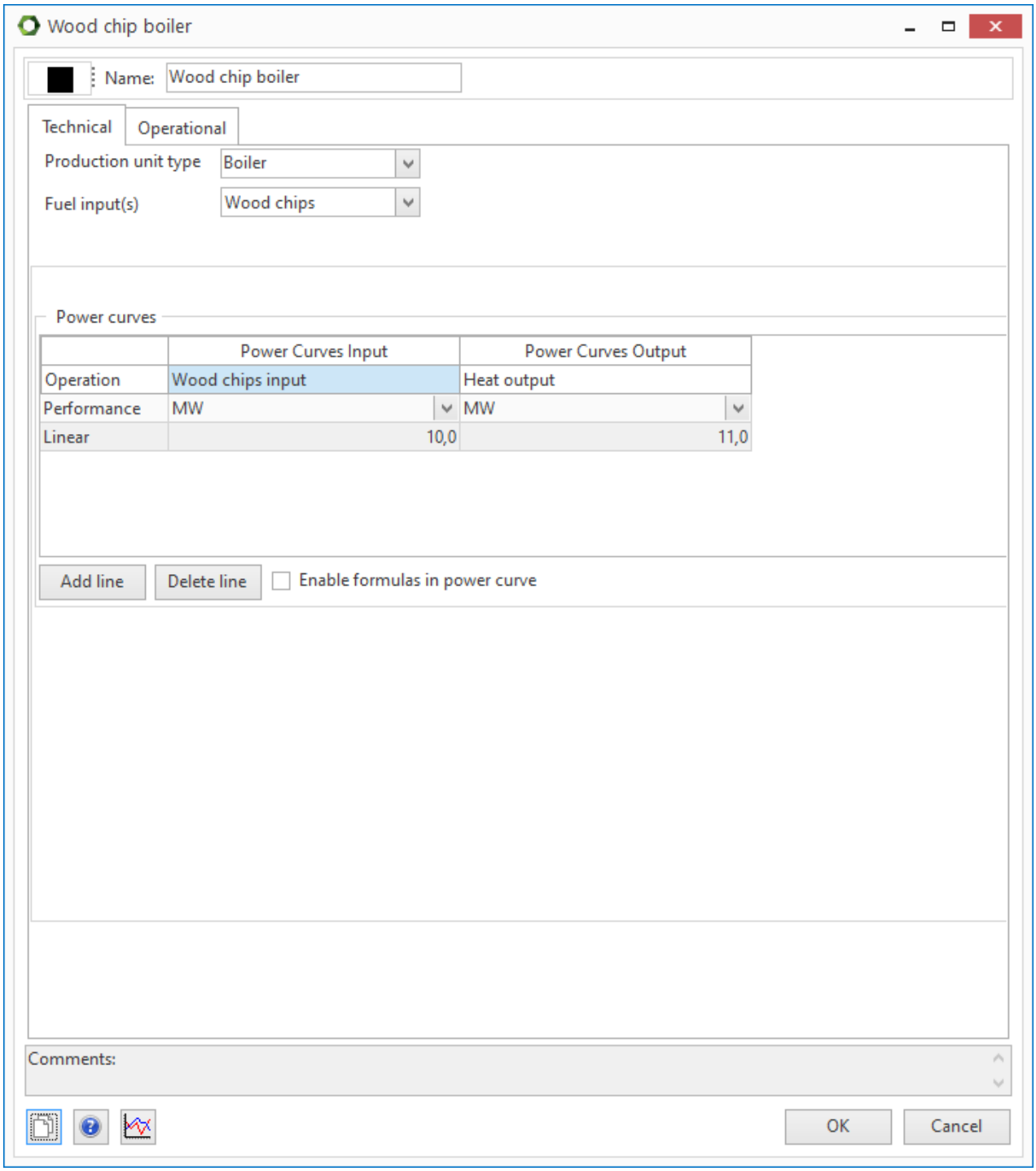
COP	Heat HPCO2		°C
T(_)/TR(_)	35	40	45
-15	2,43	2,28	2,11
-10	2,54	2,37	2,19
-5	2,67	2,49	2,29
0	2,82	2,62	2,40
5	3,10	2,90	2,65
10	3,25	3,04	2,81
15	3,40	3,20	2,96
20	3,56	3,35	3,11
25	3,71	3,50	3,27
30	3,88	3,67	3,43



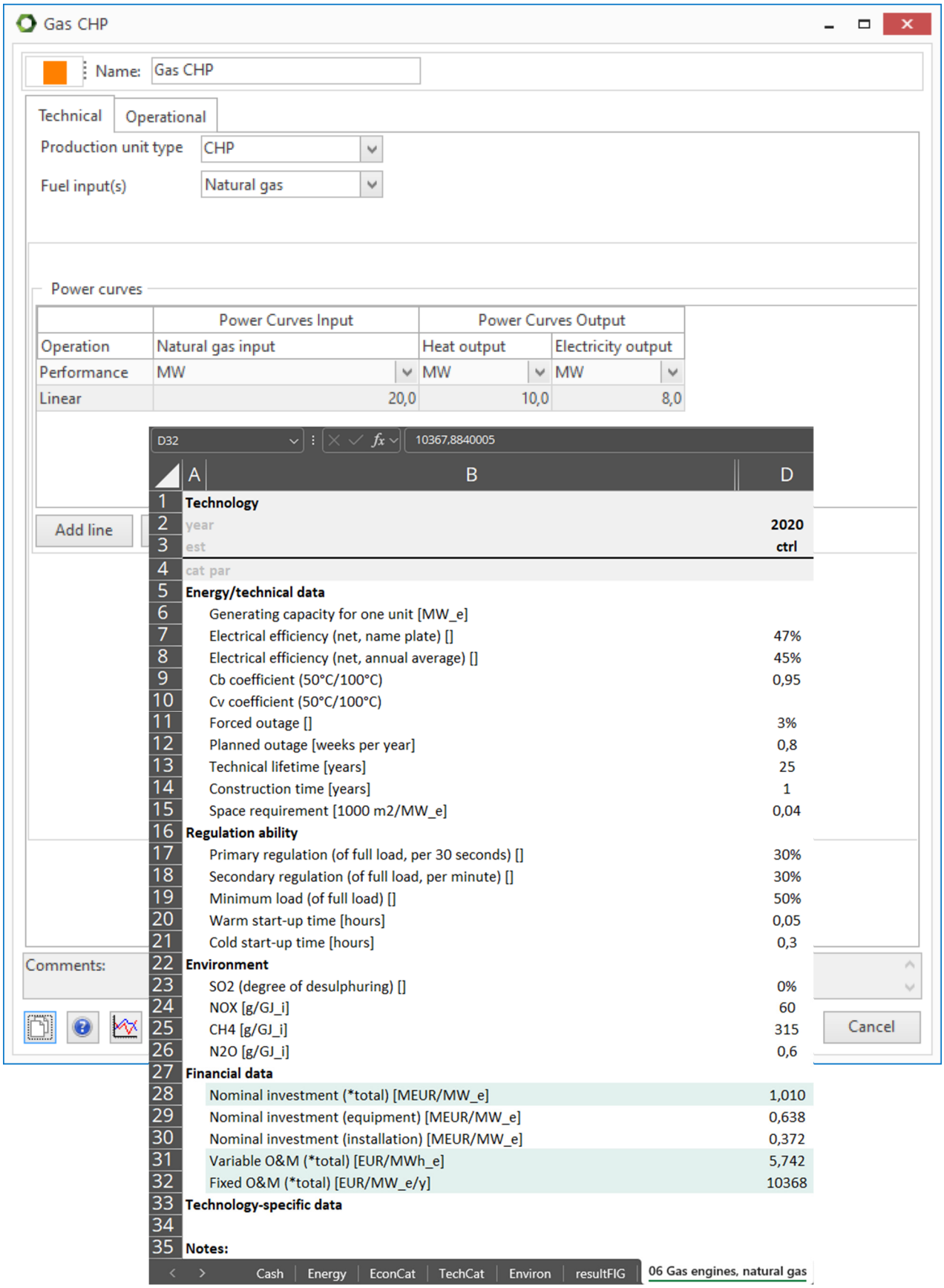
2.8.5 Straw boiler



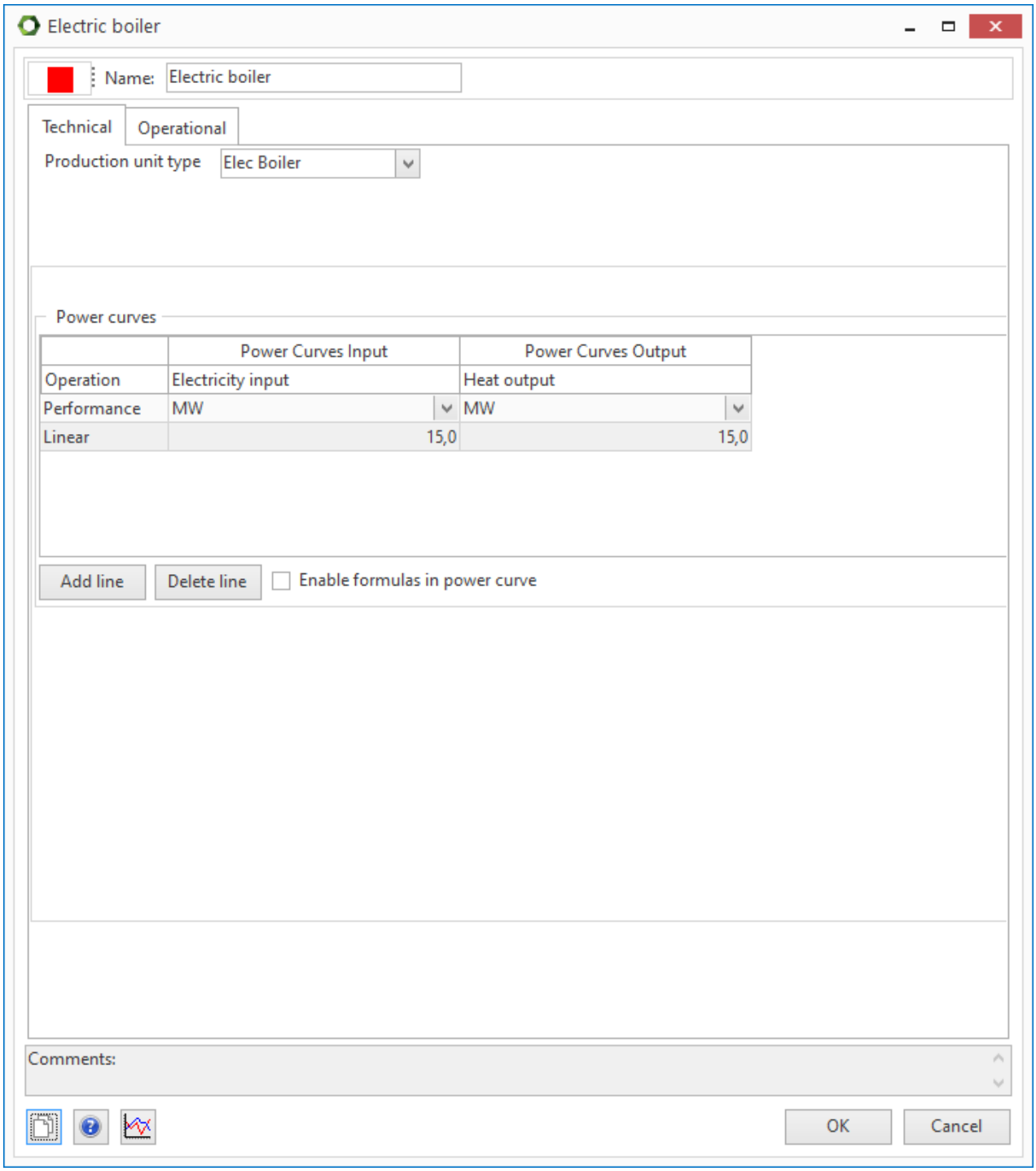
2.8.6 Wood chip boiler



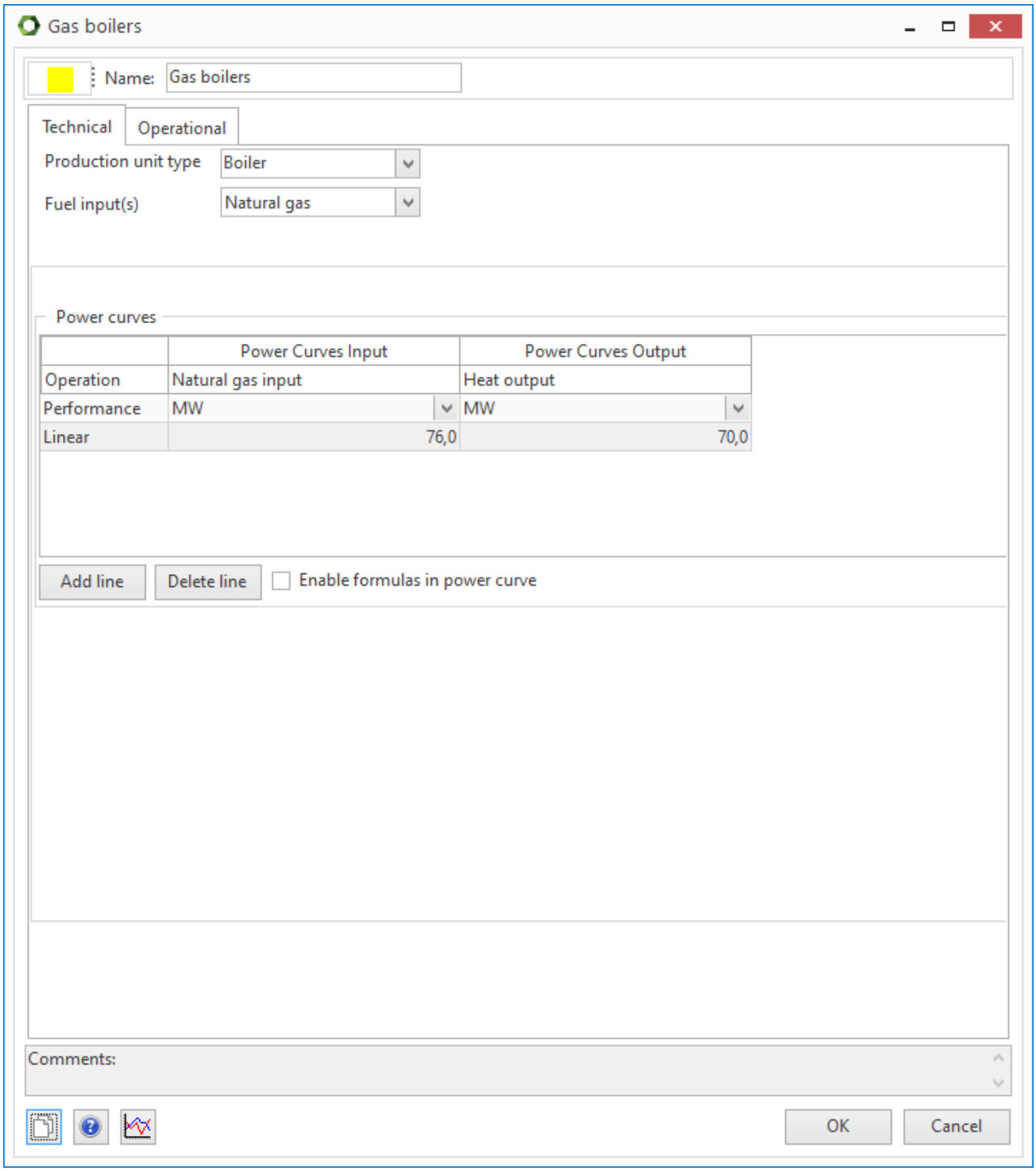
2.8.7 Gas CHP


Gas CHP
Name: Gas CHP
Technical
Operational
Production unit type
CHP
Fuel input(s)
Natural gas
Power curves
Power Curves Input
Power Curves Output
Operation
Natural gas input
Heat output
Electricity output
Performance
MW
MW
MW
Linear
20,0
10,0
8,0
Add line
Comments:
Cancel
D32
10367,8840005
A
B
D
1 Technology
2 year 2020
3 est ctrl
4 cat par
5 Energy/technical data
6 Generating capacity for one unit [MW_e]
7 Electrical efficiency (net, name plate) [] 47%
8 Electrical efficiency (net, annual average) [] 45%
9 Cb coefficient (50°C/100°C) 0,95
10 Cv coefficient (50°C/100°C)
11 Forced outage [] 3%
12 Planned outage [weeks per year] 0,8
13 Technical lifetime [years] 25
14 Construction time [years] 1
15 Space requirement [1000 m2/MW_e] 0,04
16 Regulation ability
17 Primary regulation (of full load, per 30 seconds) [] 30%
18 Secondary regulation (of full load, per minute) [] 30%
19 Minimum load (of full load) [] 50%
20 Warm start-up time [hours] 0,05
21 Cold start-up time [hours] 0,3
22 Environment
23 SO2 (degree of desulphuring) [] 0%
24 NOX [g/GJ_i] 60
25 CH4 [g/GJ_i] 315
26 N2O [g/GJ_i] 0,6
27 Financial data
28 Nominal investment (*total) [MEUR/MW_e] 1,010
29 Nominal investment (equipment) [MEUR/MW_e] 0,638
30 Nominal investment (installation) [MEUR/MW_e] 0,372
31 Variable O&M (*total) [EUR/MWh_e] 5,742
32 Fixed O&M (*total) [EUR/MW_e/y] 10368
33 Technology-specific data
34
35 Notes:
Cash
Energy
EconCat
TechCat
Environ
resultFIG
06 Gas engines, natural gas

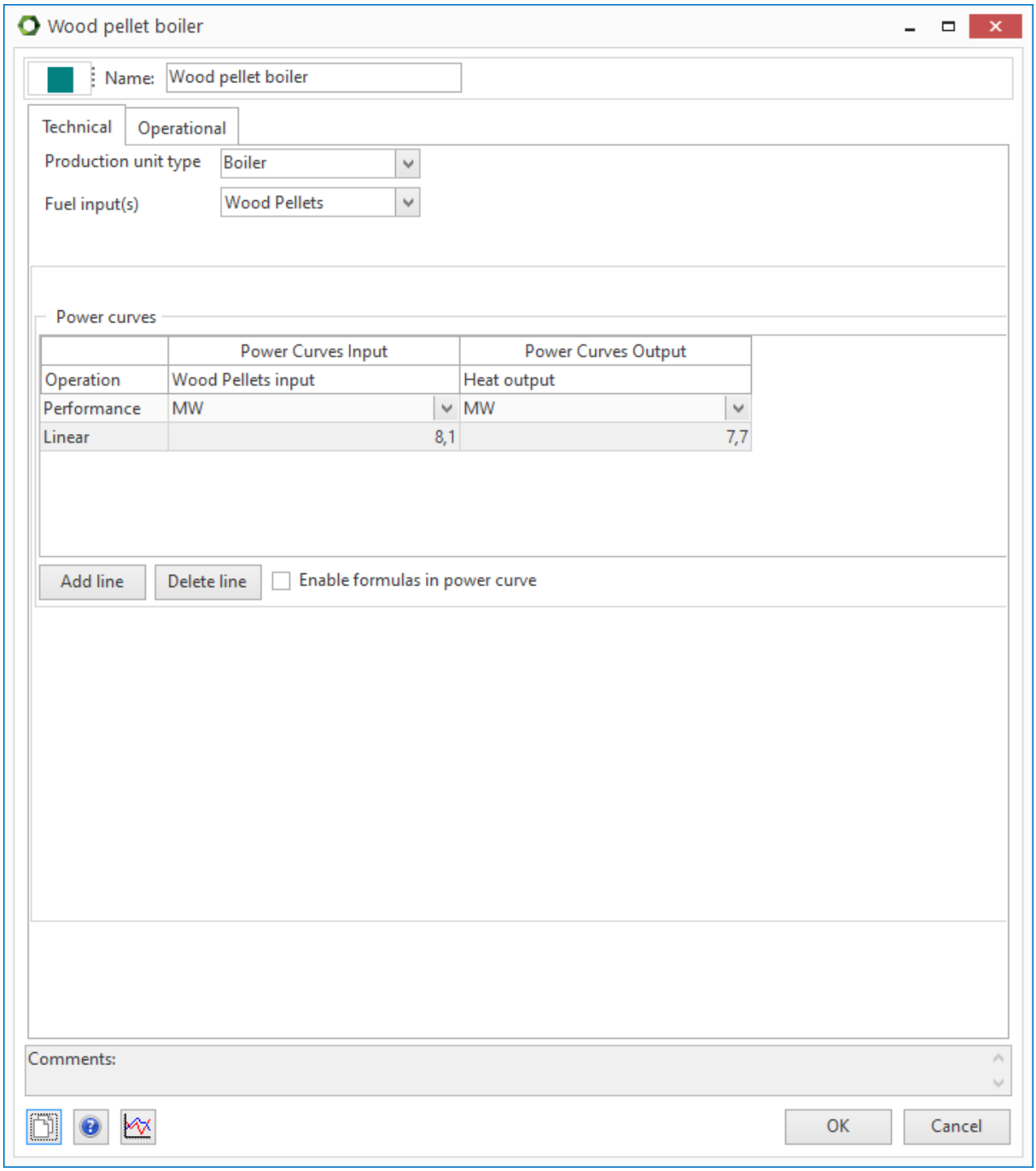
2.8.8 Electric boiler



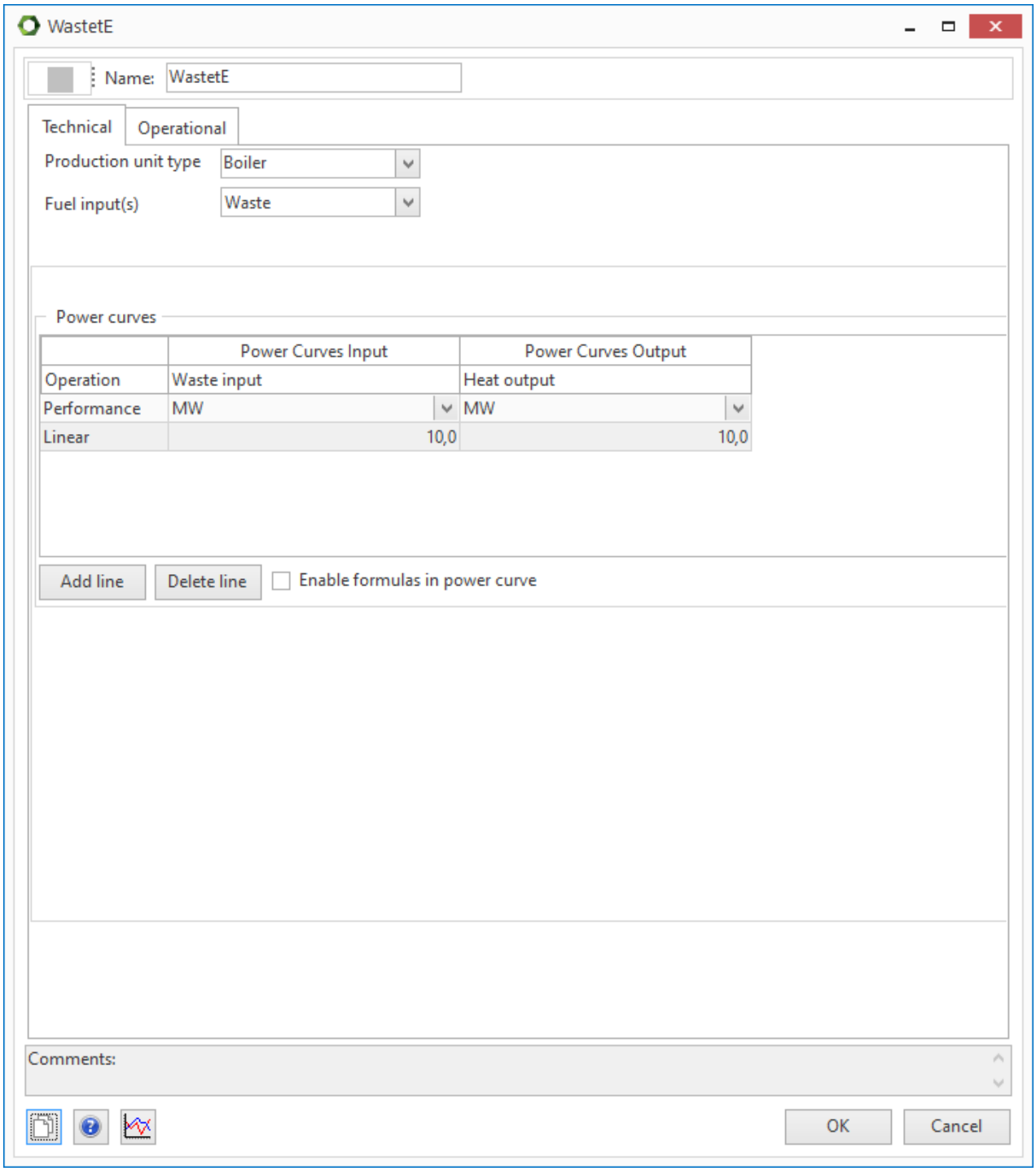
2.8.9 Gas boilers



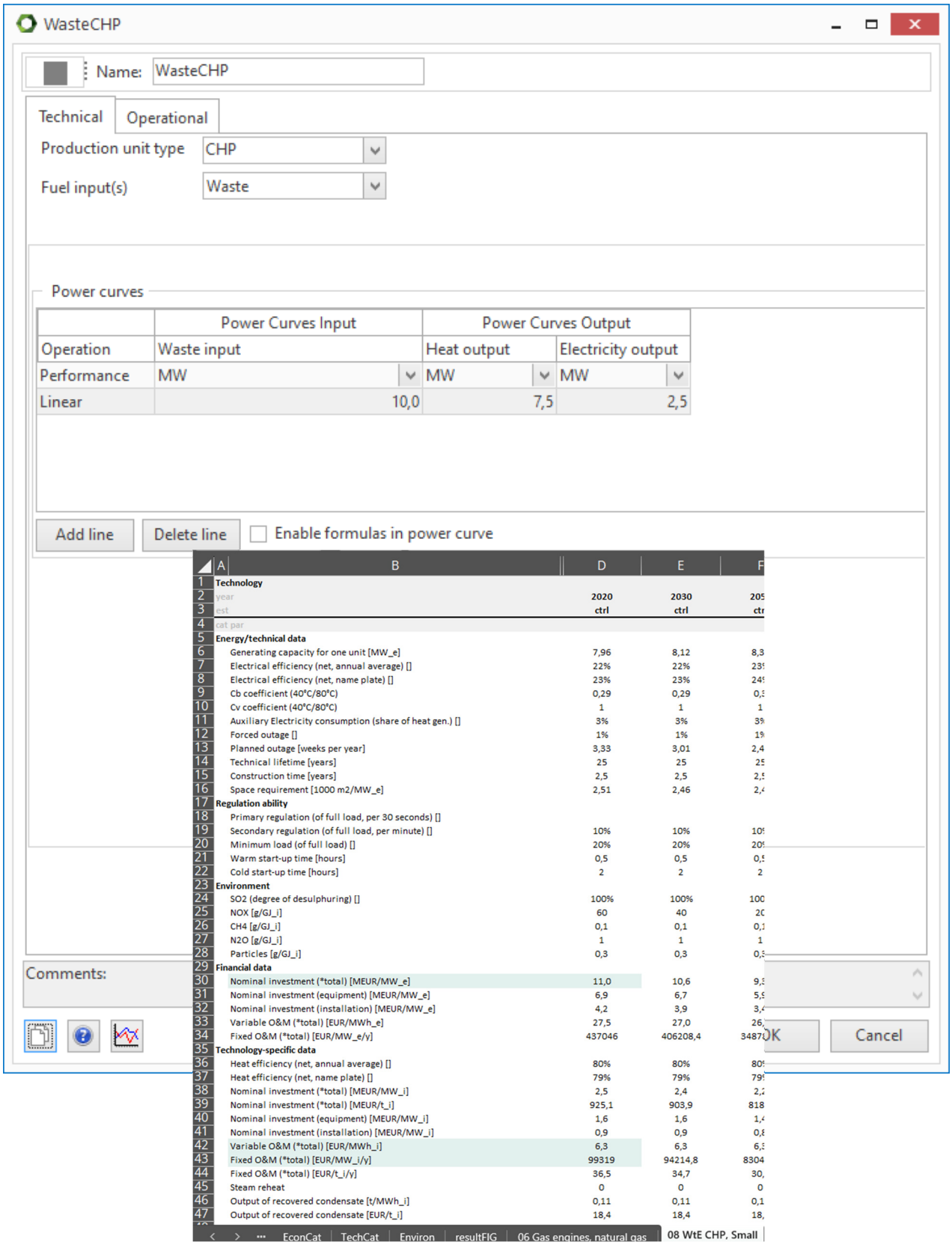
2.8.10 Wood pellet boiler



2.8.11Waste boiler



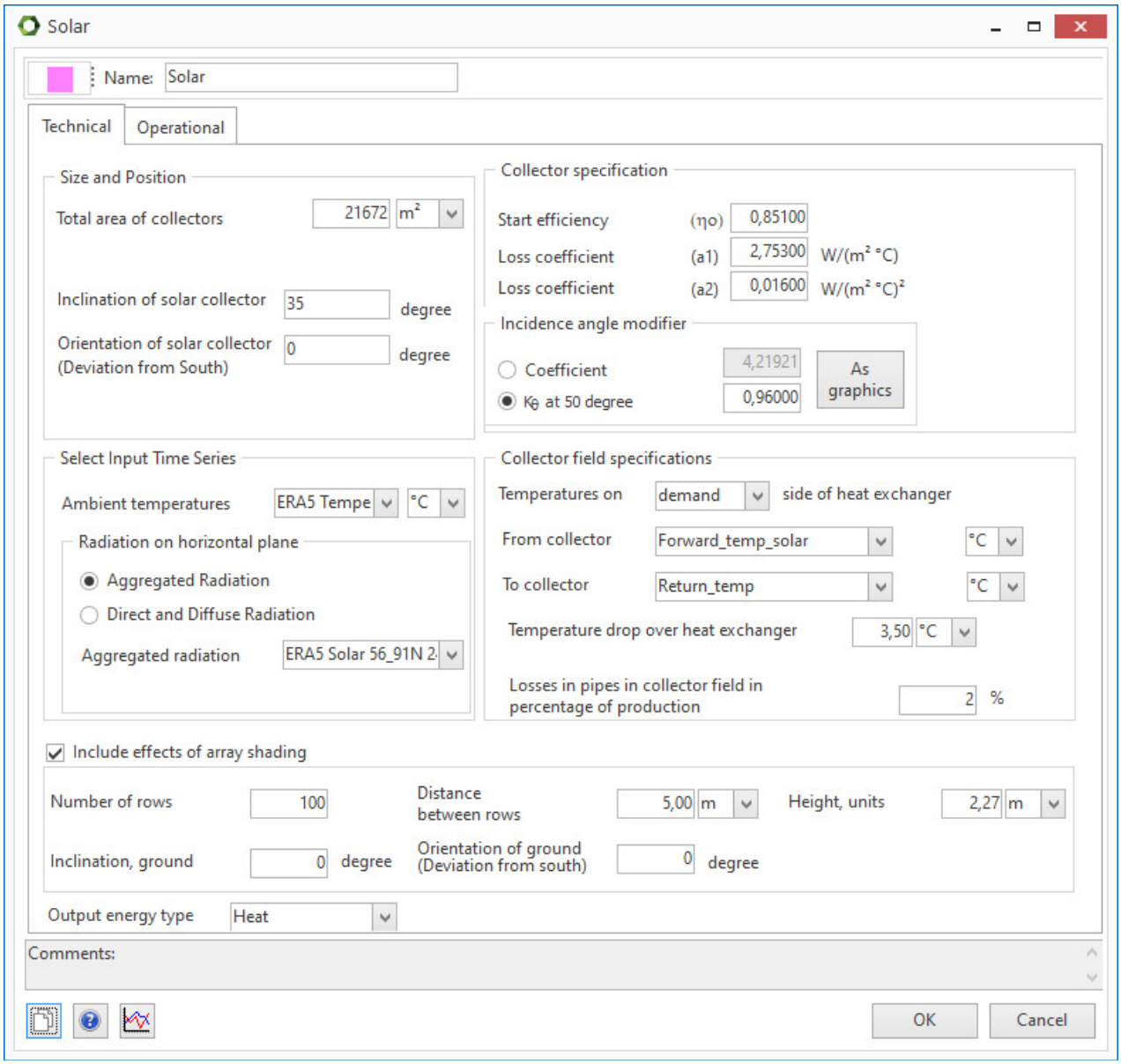
2.8.12Waste CHP



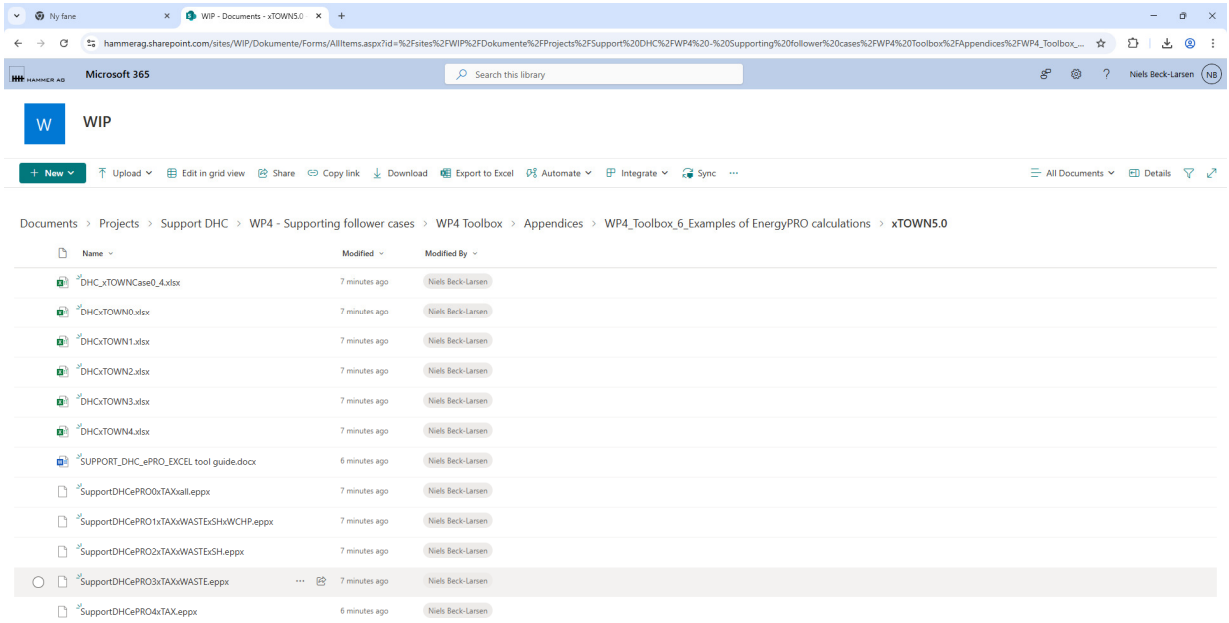
	A	B	D	E	F
1		**Technology**			
2		year	**2020**	**2030**	**205**
3		est	**ctrl**	**ctrl**	**ctr**
4		cat par			
5		**Energy/technical data**			
6		Generating capacity for one unit [MW_e]	7,96	8,12	8,3
7		Electrical efficiency (net, annual average) []	22%	22%	23
8		Electrical efficiency (net, name plate) []	23%	23%	24
9		Cb coefficient (40°C/80°C)	0,29	0,29	0,3
10		Cv coefficient (40°C/80°C)	1	1	1
11		Auxiliary Electricity consumption (share of heat gen.) []	3%	3%	3%
12		Forced outage []	1%	1%	1%
13		Planned outage [weeks per year]	3,33	3,01	2,4
14		Technical lifetime [years]	25	25	25
15		Construction time [years]	2,5	2,5	2,5
16		Space requirement [1000 m2/MW_e]	2,51	2,46	2,4
17		**Regulation ability**			
18		Primary regulation (of full load, per 30 seconds) []			
19		Secondary regulation (of full load, per minute) []	10%	10%	10
20		Minimum load (of full load) []	20%	20%	20
21		Warm start-up time [hours]	0,5	0,5	0,5
22		Cold start-up time [hours]	2	2	2
23		**Environment**			
24		SO2 (degree of desulphuring) []	100%	100%	100
25		NOX [g/GJ_i]	60	40	20
26		CH4 [g/GJ_i]	0,1	0,1	0,1
27		N2O [g/GJ_i]	1	1	1
28		Particles [g/GJ_i]	0,3	0,3	0,3
29		**Financial data**			
30		Nominal investment (*total) [MEUR/MW_e]	11,0	10,6	9,3
31		Nominal investment (equipment) [MEUR/MW_e]	6,9	6,7	5,9
32		Nominal investment (installation) [MEUR/MW_e]	4,2	3,9	3,4
33		Variable O&M (*total) [EUR/MWh_e]	27,5	27,0	26,
34		Fixed O&M (*total) [EUR/MW_e/y]	437046	406208,4	3487
35		**Technology-specific data**			
36		Heat efficiency (net, annual average) []	80%	80%	80
37		Heat efficiency (net, name plate) []	79%	79%	79
38		Nominal investment (*total) [MEUR/MW_i]	2,5	2,4	2,2
39		Nominal investment (*total) [MEUR/t_i]	925,1	903,9	818
40		Nominal investment (equipment) [MEUR/MW_i]	1,6	1,6	1,4
41		Nominal investment (installation) [MEUR/MW_i]	0,9	0,9	0,8
42		Variable O&M (*total) [EUR/MWh_i]	6,3	6,3	6,3
43		Fixed O&M (*total) [EUR/MW_i/y]	99319	94214,8	8304
44		Fixed O&M (*total) [EUR/t_i/y]	36,5	34,7	30,
45		Steam reheat	0	0	0
46		Output of recovered condensate [t/MWh_i]	0,11	0,11	0,1
47		Output of recovered condensate [EUR/t_i]	18,4	18,4	18,

EconCat | TechCat | Environ | resultFIG | 06 Gas engines, natural gas | 08 WtE CHP, Small

2.8.13 Solar


Solar
Name: Solar
Technical
Operational
Size and Position
Total area of collectors
21672
m²
Inclination of solar collector
35
degree
Orientation of solar collector (Deviation from South)
0
degree
Collector specification
Start efficiency (ηo) 0,85100
Loss coefficient (a1) 2,75300 W/(m² °C)
Loss coefficient (a2) 0,01600 W/(m² °C)²
Incidence angle modifier
Coefficient 4,21921
Kθ at 50 degree 0,96000
As graphics
Select Input Time Series
Ambient temperatures
ERA5 Tempe
°C
Radiation on horizontal plane
Aggregated Radiation
Direct and Diffuse Radiation
Aggregated radiation
ERA5 Solar 56_91N 2
Collector field specifications
Temperatures on
demand
side of heat exchanger
From collector
Forward_temp_solar
°C
To collector
Return_temp
°C
Temperature drop over heat exchanger
3,50
°C
Losses in pipes in collector field in percentage of production
2
%
Include effects of array shading
Number of rows
100
Distance between rows
5,00
m
Height, units
2,27
m
Inclination, ground
0
degree
Orientation of ground (Deviation from south)
0
degree
Output energy type
Heat
Comments:
OK
Cancel

3 xTOWN0-4 scenario energyPRO 5.0



This Support DHC energyPRO EXCEL calculation tool offers the feasibility economics calculation of low-grade renewable energy in existing district heating networks, where heat pumps are needed to utilise low temperature sources in DH systems. The energyPRO EXCEL calculation tool purpose is to evaluate the cost-effectiveness/feasibility of the heat pump compared to other decarbonizing technologies and how the technologies meet the threshold of criteria for "efficient district heating and cooling" under the revised Energy Efficiency Directive (EED).

This Support DHC energyPRO EXCEL toolbox consist of 4 energyPRO models combined with and 4 Excel sheets (DHCxTOWN1.xlsx - DHCxTOWN4.xlsx) with preconditions and energyPRO integration of **energyPRO standard reports: Cash flow, annual; Energy conversion, annual; Catalogue of economic assumptions; Catalogue of technical assumptions; Environment annual.** This enable the users to calculate total and specific cost of the involved technologies (in MEUR and EUR/MWh), CO_2e equivalent emissions and how the mix of technologies meet the threshold of criteria for "efficient district heating and cooling" under the revised Energy Efficiency Directive (EED).

The Support DHC energyPRO EXCEL toolbox includes the following heat producing units mainly used for decarbonising EU: Surplus heat, Wood chip CHP, HPNH3, HPCO2, Straw boiler, Wood chip boiler, Gas CHP, Electric boiler, Gas boilers, wood pellet boiler, Waste boiler, Waste CHP, Solar.

DHC_xTOWNCase0_4.xlsx	Overview EXCEL with Basic data, IRR etc.

Scenarios defined:

DHCxTOWN1.xlsx	Scenario1 – Sce2 excl. wood chip CHP – HPNH3 base load
DHCxTOWN2.xlsx	Scenario2 – Sce3 excl. SH (surplus heat)
DHCxTOWN3.xlsx	Scenario3 – Sce4 excl. waste
DHCxTOWN4.xlsx	Scenario4 – all plants active
DHCxTOWN0.xlsx	Scenario0 reference

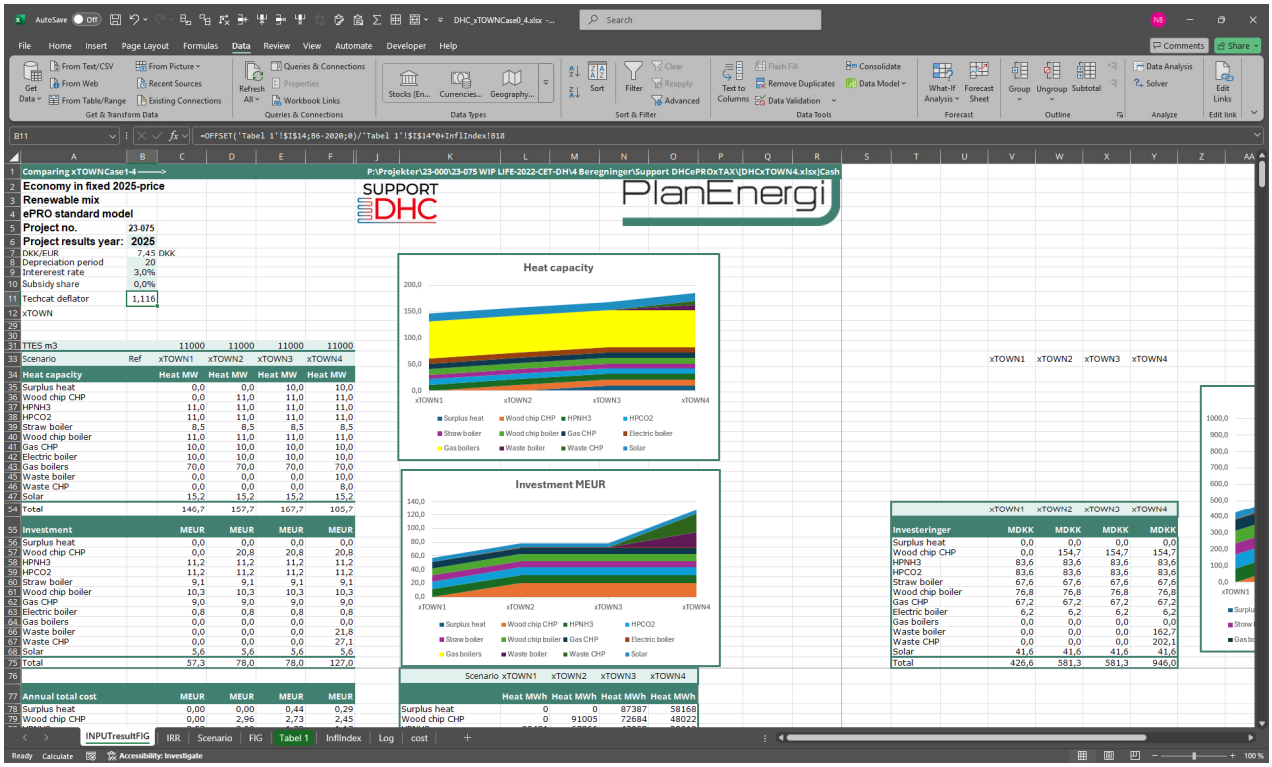


Figure 23 – Overview EXCEL with Basic data, IRR etc.: DHC_xTOWNCase0_4.xlsx

Scenario	xTOWN1	xTOWN2	xTOWN3	xTOWN4	xTOWN0
Production	**Heat MWh**	**Heat MWh**	**Heat MWh**	**Heat MWh**	**Heat MWh**
Surplus heat	0	0	87387	58168	0
Wood chip CHP	0	91005	72684	48022	0
HPNH3	90481	67366	47953	20819	0
HPCO2	52731	38427	24581	9398	0
Straw boiler	45775	37030	31733	24193	0
Wood chip boiler	44276	36710	32408	9064	0
Gas CHP	37066	32447	26760	17273	0
Electric boiler	2860	2680	2291	1850	0
Gas boilers	61375	28900	8768	20	344444
Waste boiler	0	0	0	75690	0
Waste CHP	0	0	0	70067	0
Solar	9881	9881	9881	9881	0
Total	344444	344444	344444	344444	344444

	xTOWN1	xTOWN2	xTOWN3	xTOWN4
HPNH3	26,3%	19,6%	13,9%	6,0%

Figure 24 – Heat production per units/plants – scenario 1-4, 0 (ref.)

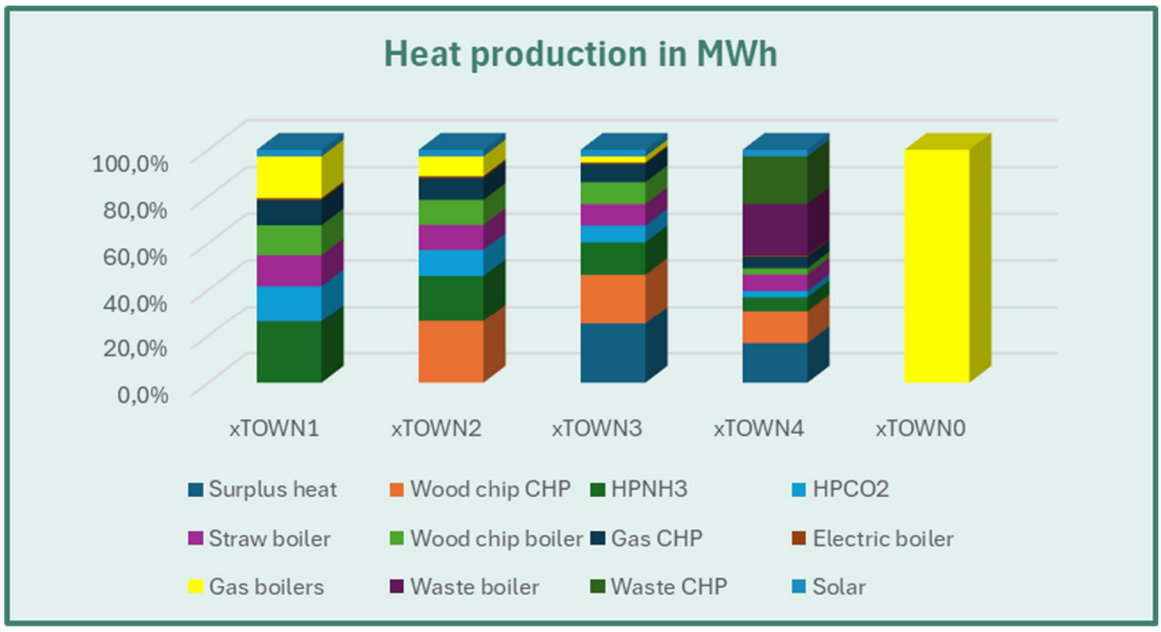


Figure 25 – Heat production per units/plants

Cost elements in EUR	DHCePRO4xTAX									DKK
	O&M	Fuel	Tax	NOx++	Elec. Sale	Cap. cost	Total cost	Heat MWh	EUR/MWh	DKK/GJ
Surplus heat	290840	0	0				290840	58168	5,0	10,3
Wood chip CHP	607388	1304115	0	15188	-876673	1395420	2445437	48022	50,9	105,4
HPNH3	63578	349747	0			754497	1167822	20819	56,1	116,1
HPCO2	43021	148533	0			754497	946050	9398	100,7	208,3
Straw boiler	584629	503782	0	13961		610137	1712509	24193	70,8	146,5
Wood chip boiler	520535	205127	0	2389		693084	1421135	9064	156,8	324,5
Gas CHP	214840	942186	0	12562	-932485	606149	843253	17273	48,8	101,0
Electric boiler	14472	16169	0			55830	86471	1850	46,7	96,7
Gas boilers	23	582	0	2			607	20	30,8	63,8
Wood pellet boiler	0	0	0	0		0	0	0	0,0	0,0
Waste boiler	1603267	-1377847	0	12339		1467520	1705278	75690	22,5	46,6
Waste CHP	1324526	-1594348	0	14278	-972637	1823074	594893	70067	8,5	17,6
Solar	3269	0	0			375081	378349	9881	38,3	79,2
Total	5270387	498046	0	70719	-2781795	8535288	11592644	344444	33,7	69,6

Figure 26 – Heat production cost – divided per plants in O&M, Fuel, Tax, NOx++, Elec. Sale Cap. cost

Heat production cost calculation based on energyPRO standard report export to EXCEL:

- Cash flow, annual;
- Energy conversion, annual;
- Catalogue of economic assumptions;
- Catalogue of technical assumptions;
- Environment annual.

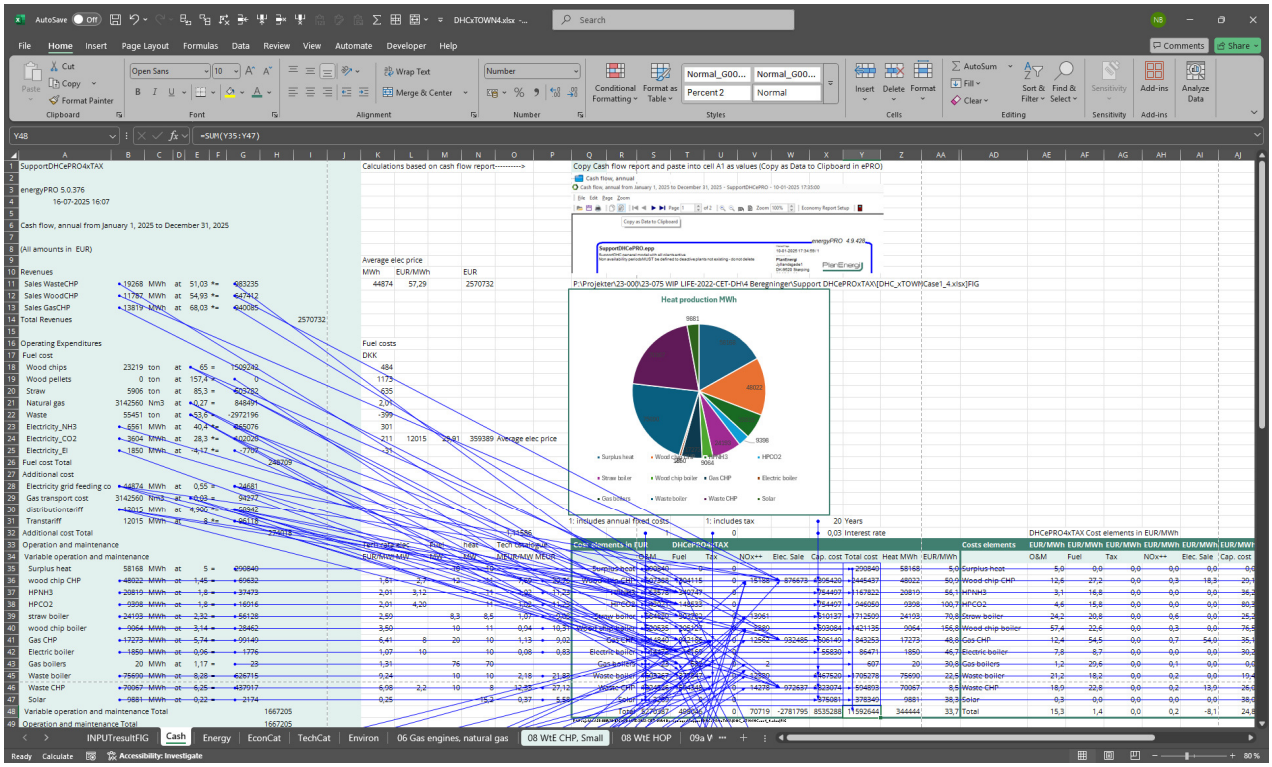


Figure 27 – Heat production cost – xTOWN4

Cost elements in EUR	DHCePRO4xTAX									Costs elements	EUR/MWh	EUR/MWh	EUR/MWh	EUR/MWh	EUR/MWh	EUR/MWh	EUR/MWh
	O&M	Fuel	Tax	NOx++	Elec. Sale	Cap. cost	Total cost	Heat MWh	EUR/MWh		O&M	Fuel	Tax	NOx++	Elec. Sale	Cap. cost	Total cost
Surplus heat	290840	0	0				290840	58168	5,0	Surplus heat	5,0	0,0	0,0	0,0	0,0	0,0	5,0
Wood chip CHP	607388	1304115	0	15188	-876673	1395420	2445437	48022	50,9	Wood chip CHP	12,6	27,2	0,0	0,3	-18,3	29,1	50,9
HPNH3	63578	349747	0			754497	1167822	20819	56,1	HPNH3	3,1	16,8	0,0	0,0	0,0	36,2	56,1
HPCO2	43021	148533	0			754497	946050	9398	100,7	HPCO2	4,6	15,8	0,0	0,0	0,0	80,3	100,7
Straw boiler	584629	503782	0	13961		610137	1712509	24193	70,8	Straw boiler	24,2	20,8	0,0	0,6	0,0	25,2	70,8
Wood chip boiler	520535	205127	0	2389		693084	1421135	9064	156,8	Wood chip boiler	57,4	22,6	0,0	0,3	0,0	76,5	156,8
Gas CHP	214840	942186	0	12562	-932485	606149	843253	17273	48,8	Gas CHP	12,4	54,5	0,0	0,7	-54,0	35,1	48,8
Electric boiler	14472	16169	0			55830	86471	1850	46,7	Electric boiler	7,8	8,7	0,0	0,0	0,0	30,2	46,7
Gas boilers	23	582	0	2			607	20	30,8	Gas boilers	1,2	29,6	0,0	0,1	0,0	0,0	30,8
Waste boiler	1603267	-1377847	0	12339		1467520	1705278	75690	22,5	Waste boiler	21,2	-18,2	0,0	0,2	0,0	19,4	22,5
Waste CHP	1324526	-1594348	0	14278	-972637	1823074	594893	70067	8,5	Waste CHP	18,9	-22,8	0,0	0,2	-13,9	26,0	8,5
Solar	3269	0	0			375081	378349	9881	38,3	Solar	0,3	0,0	0,0	0,0	0,0	38,0	38,3
Total	5270387	498046	0	70719	-2781795	8535288	11592644	344444	33,7	Total	15,3	1,4	0,0	0,2	-8,1	24,8	33,7

P:\Projekten\23-000\23-075 WIP LIFE-2022-CET-DH4 Beregninger\Support DHCePROxTAX\[DHC_xTOWNCase1_4.xlsx]FIG

Figure 28 – Heat production cost – xTOWN4 - in EUR and EUR/MWh

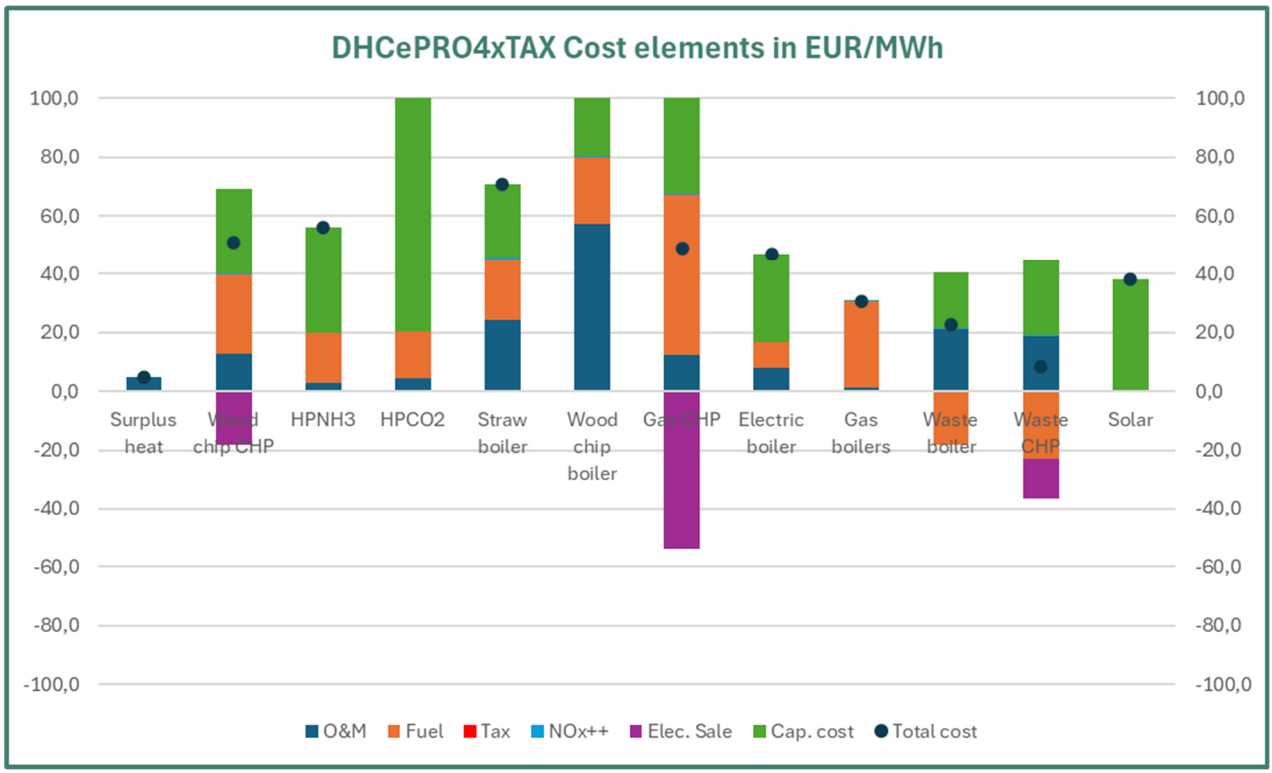


Figure 29 – Heat production cost – xTOWN4 - in EUR/MWh

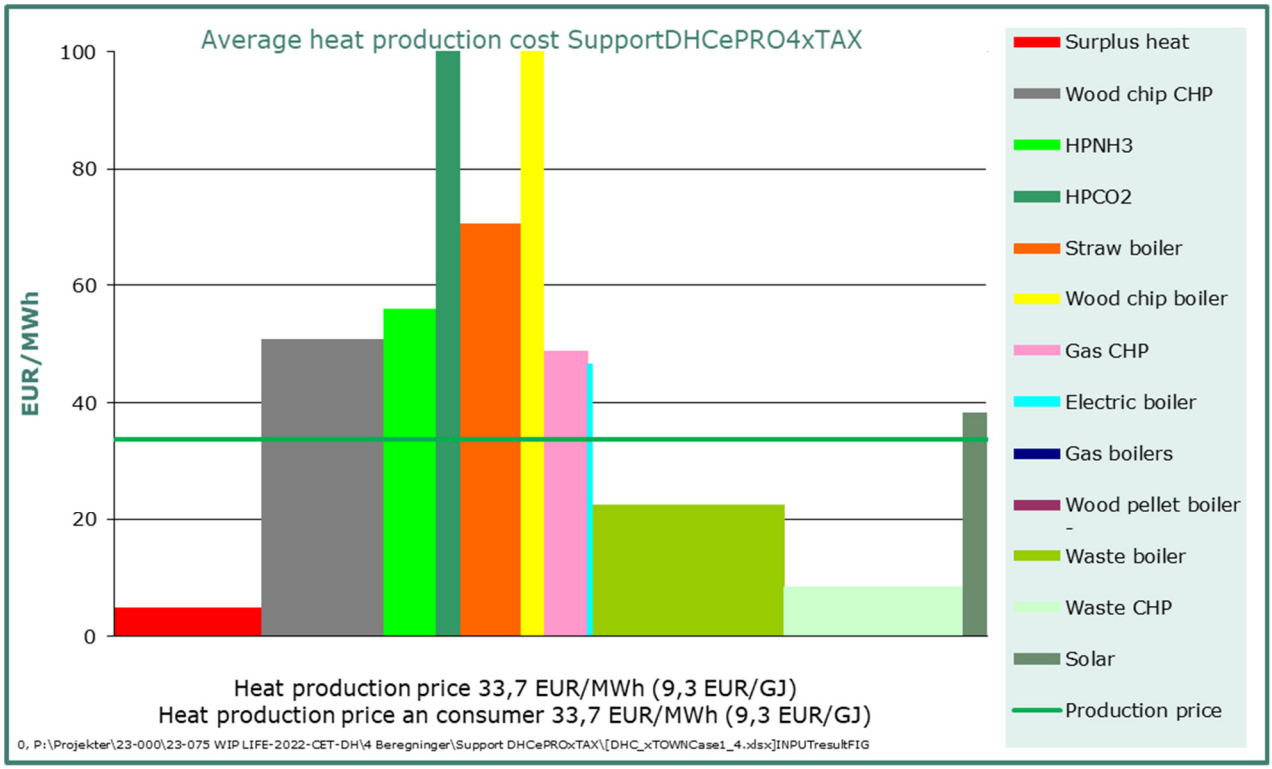


Figure 30 – Heat production cost – xTOWN4 - in EUR/MWh

Emissions fuels	SupportDHCePRO4xTAX		CO2 ton	CH4 kg	N2O kg	SO2 kg	NOx kg	PM25 kg
Wood chips	23219	ton		673	186	418	17670	1045
Wood pellet	0	ton		0	0	0	0	0
Straw	5906	ton		41	94	4170	10631	94
Natural gas	3142560	Nm3	7102	126	126	63	6851	0
Waste	55451	ton	24981	222	721	4880	46413	166
Electricity	12015	MWh		1502	36	36	1250	1334
Total			32083	2564	1163	9567	82815	2639

CO_2 equivalent	CO_2e							
			1	0,025	0,298			
CO_2e	ton	32494	32083	64	347			
Heat delivered	MWh	344444	344444					
EDHC	kg/MWh	94,3	93,1					
		From 1 January 2035 until 31 December 2044						
	kg/GJ	26,20	25,87					

- **EDHC systems definition towards sector decabonisation in 2050– alternative approach**

Applicable GHG emission's thresholds for efficient district heating and cooling

Period	Threshold for 'efficient district heating and cooling system'
Until 31 December 2025	200 grams/kWh
From 1 January 2026 until 31 December 2034	150 grams/kWh
From 1 January 2035 until 31 December 2044	100 grams/kWh
From 1 January 2045 until 31 December 2049	50 grams/kWh
From 1 January 2050	0 grams/kWh

Figure 31 – Calculation emissions – and efficient DHC factor – xTOWN4

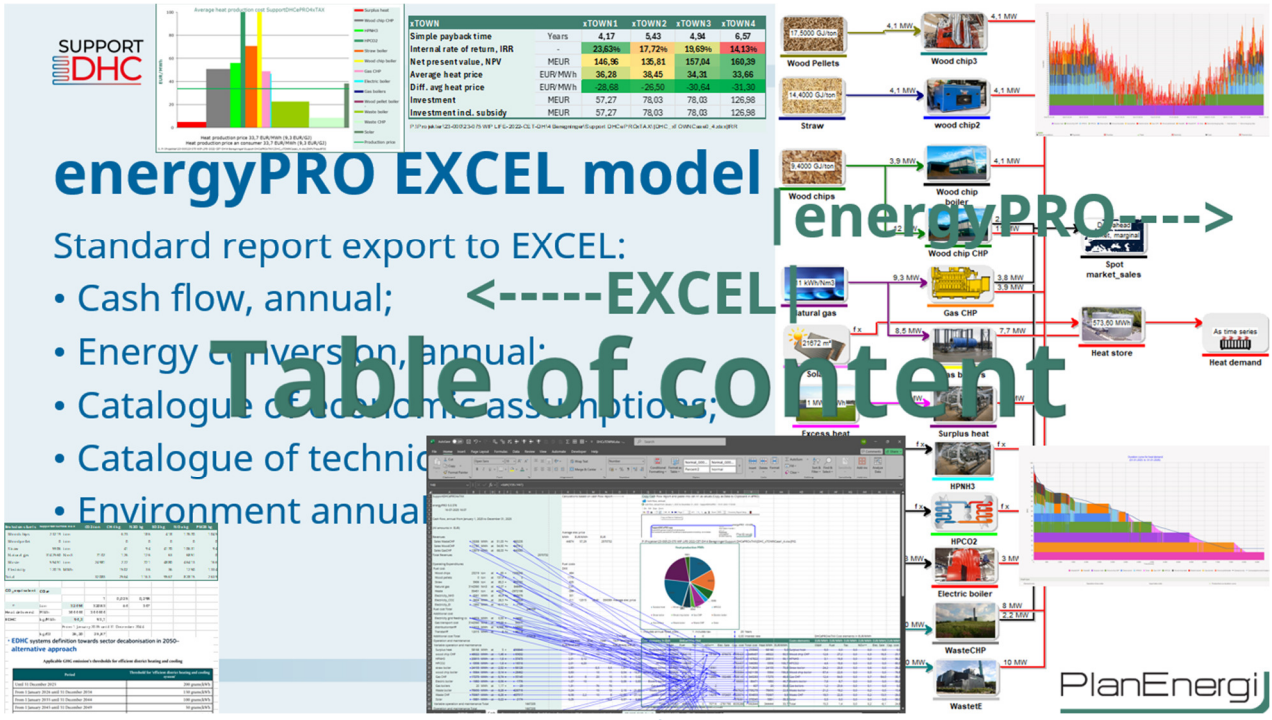


Figure 32 – Heat production cost – xTOWN4 - in EUR/MWh

4 Annex A: Support DHC ePRO 4.9 EXCEL Toolkit address