

Performance evaluation of municipal heating plants with biomass fired ORC cogeneration units

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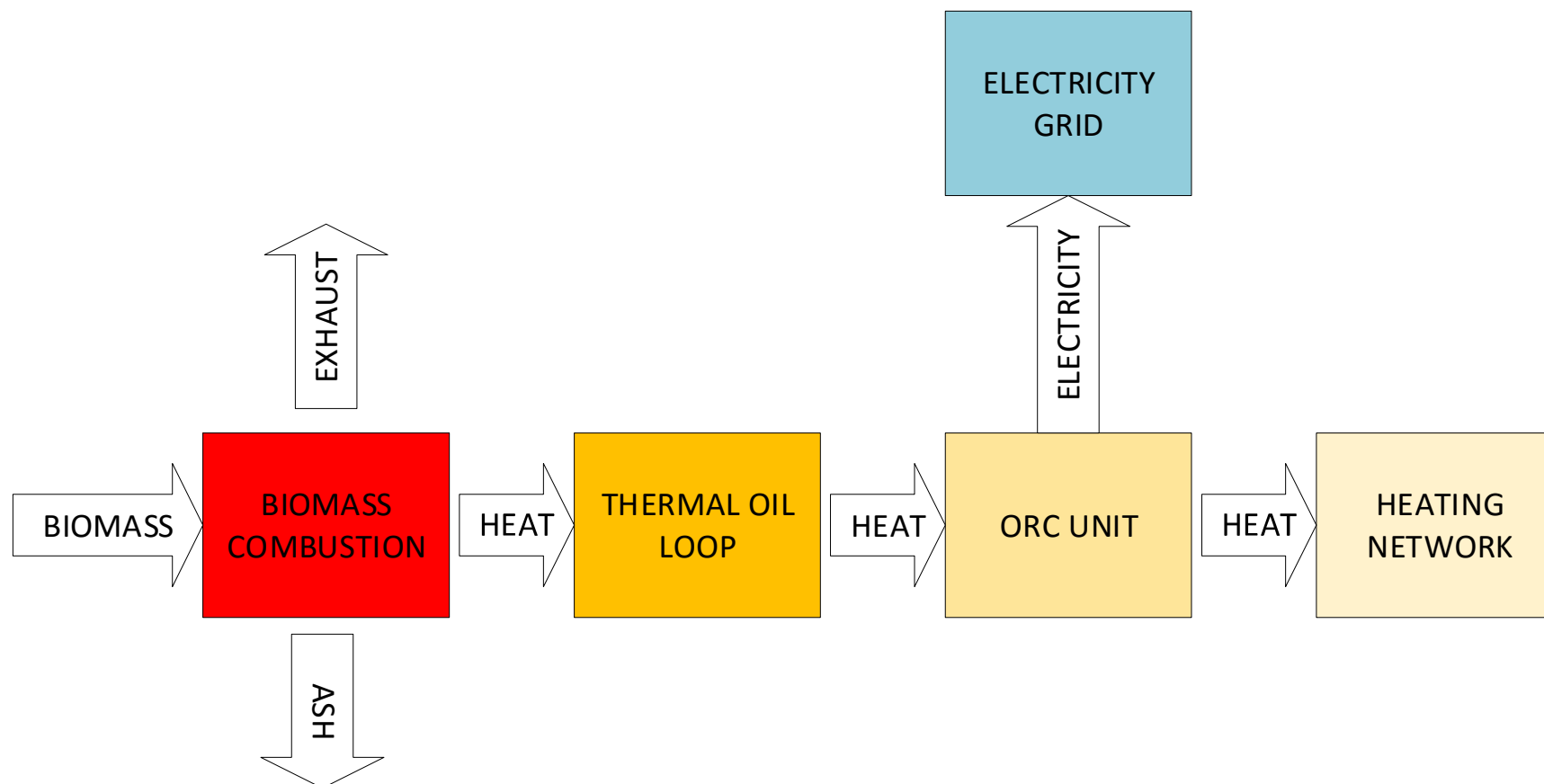
Silesian University of Technology

Gliwice, Poland

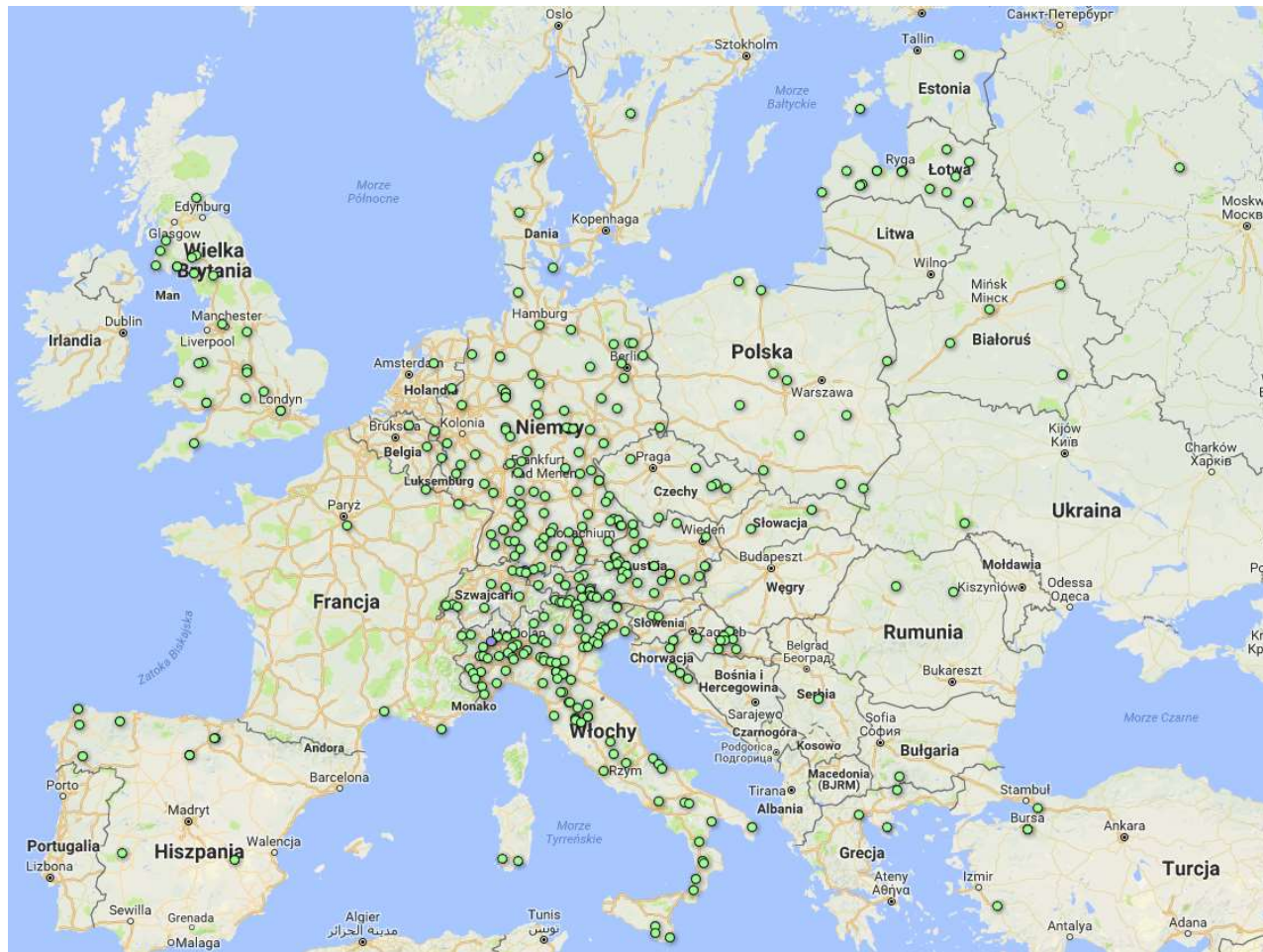
Agenda - Key points

- Introduction
- Problems
- Performance study
- Possible improvements
- Conclusions

Process principles



Organic Rankine Cycle has become popular technology for utilisation of locally available biomass resources



Status of biomass fired cogeneration in Poland:

- Several conventional steam plants ($P > 2 \text{ MWel}$)
- Several gasification + ICE plants (R&D)
- 11 ORC plants ($0.2 \text{ MWel} < P < 1.5 \text{ MWel}$)
- ORC plants of single manufacturer (Turboden + VAS; Turboden + Politechnik)



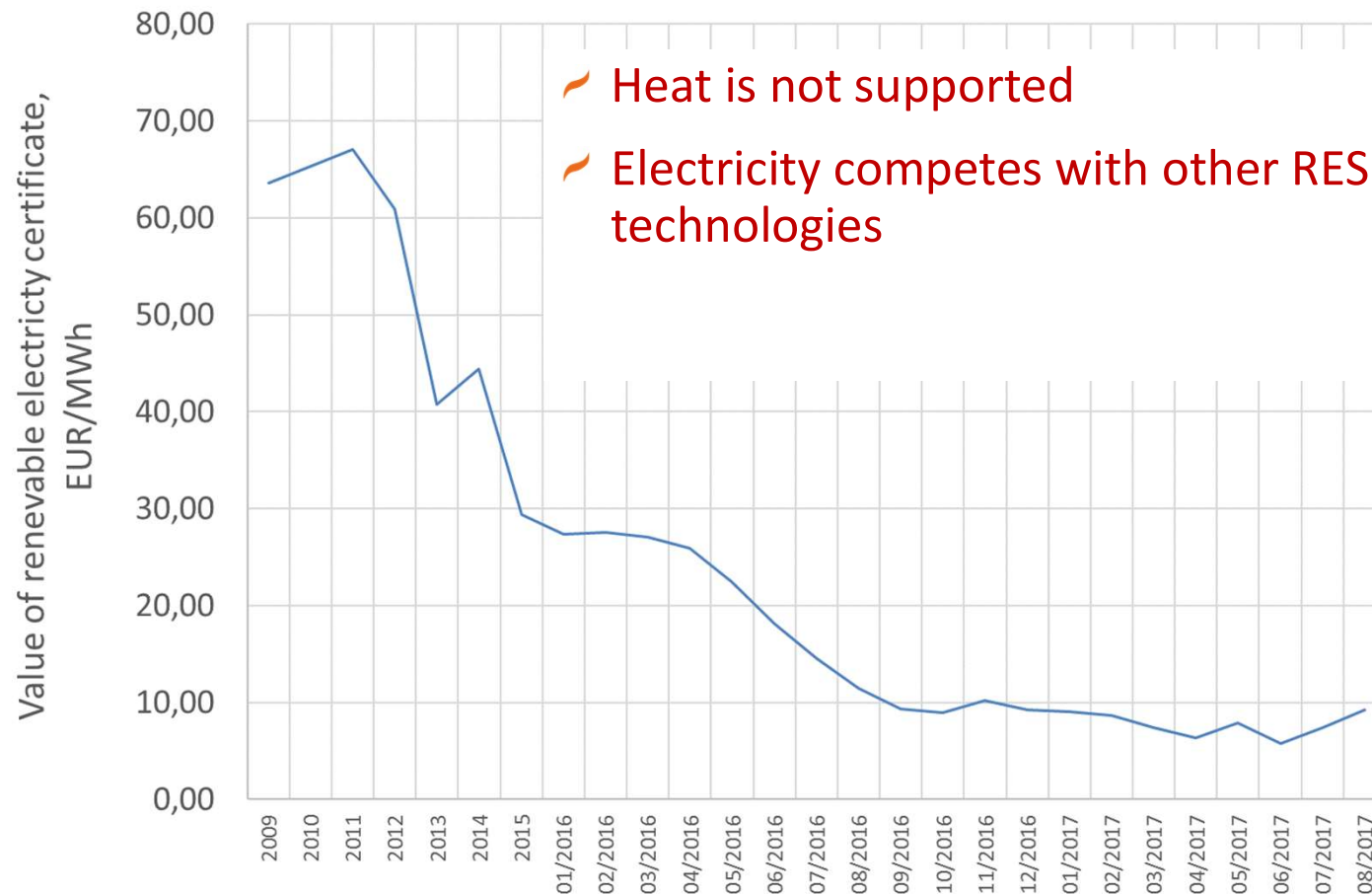
Technology advantages:

- Availability of small-scale units (200 kW – 3000 MW)
- Wide operating window (10% - 100% electric load)
- Flat part load characteristics
- Simple modular systems, simple automatic operation

Technology disadvantages:

- High investment costs
- Low power generation efficiency
- Expensive working fluid
- Low economic performance – subsidies are required

Support mechanism for electricity from RES in Poland is based on tradeable certificates of origin:

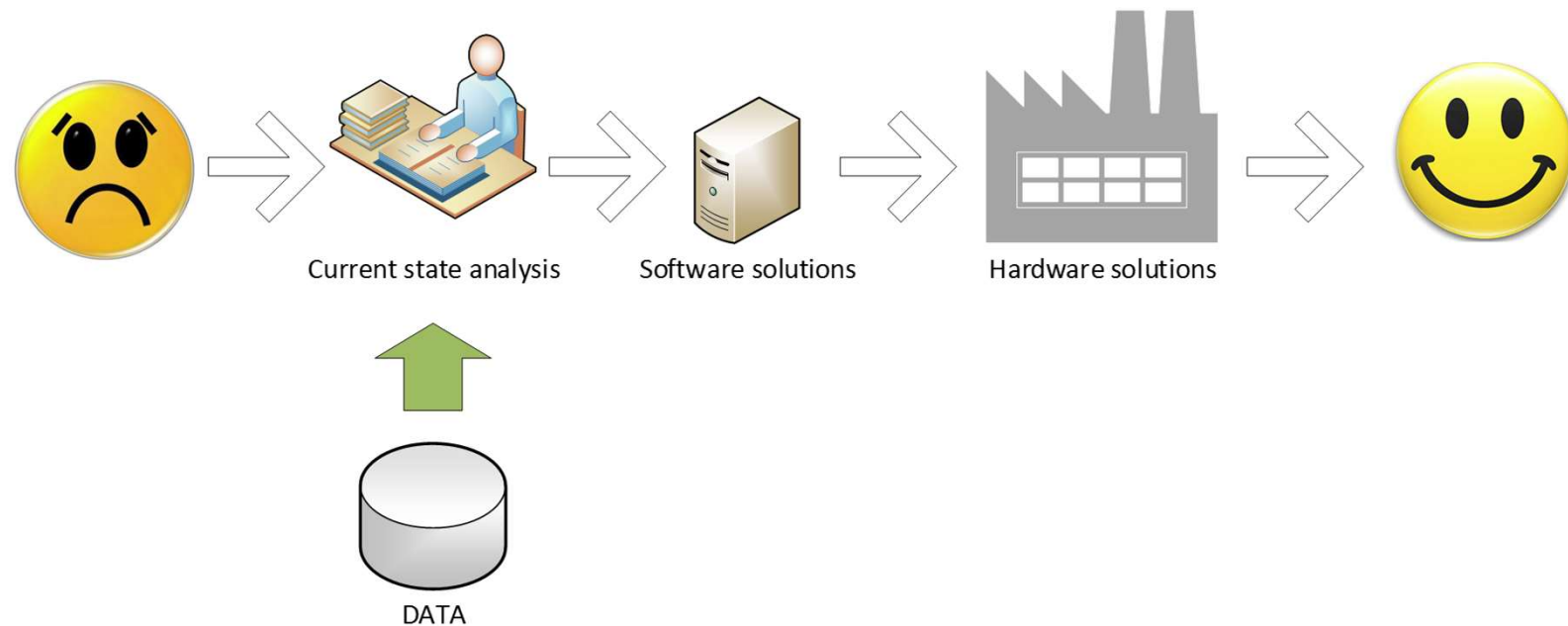


Problem

Is there any chance for improvement ?



How to find solution ?



Project: System integration of biomass fired cogeneration plants





Holzheizkraftwerk Scharnhäuser Park (DE)
ORC + Gas boilers



MPGK Krosno Ltd – Municipal Holding (PL)
ORC + Coal boilers

➤ Biomass fuel – as received

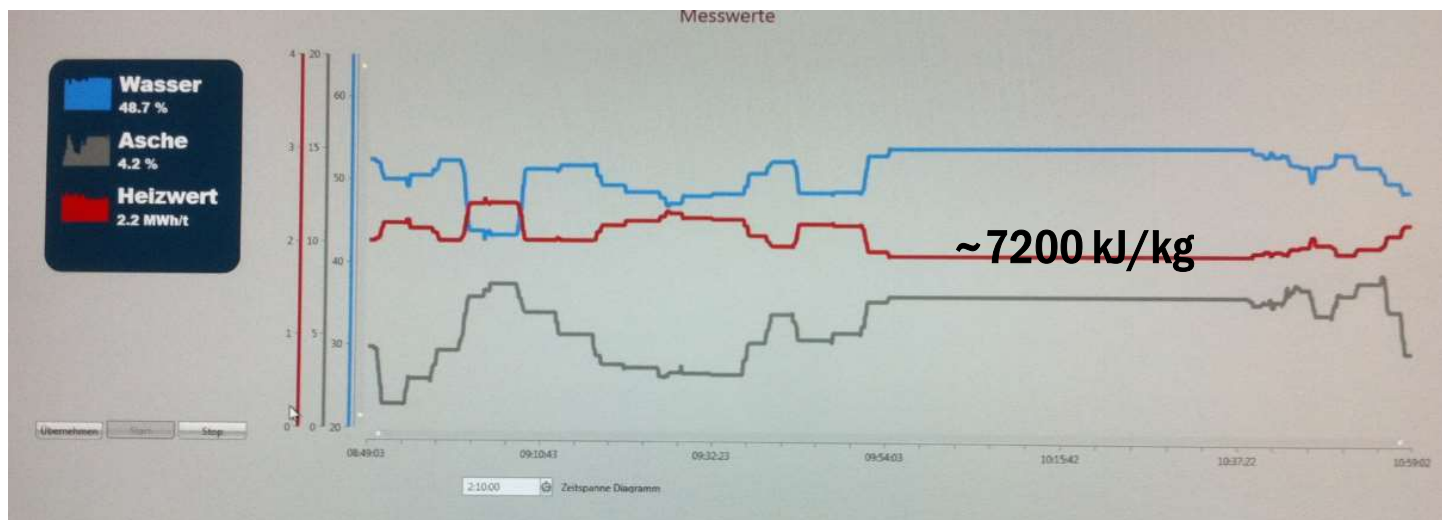


(DE)
Low quality biomass

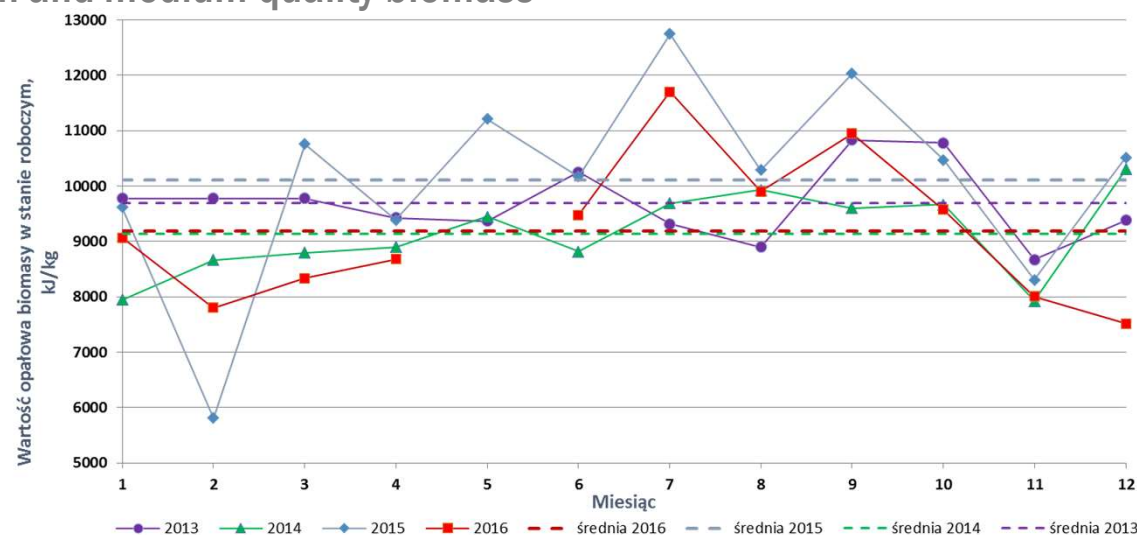


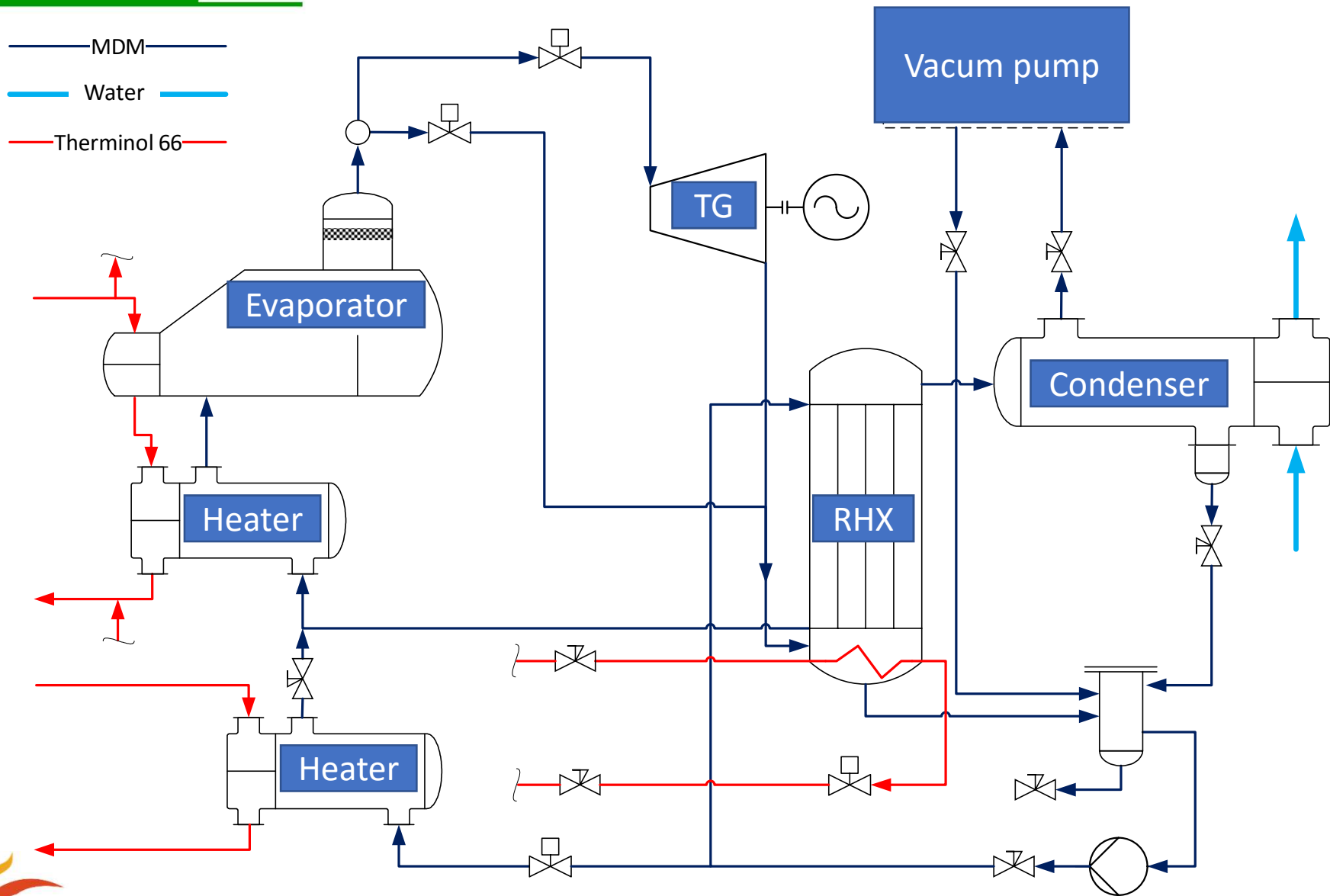
(PL)
High and medium quality biomass

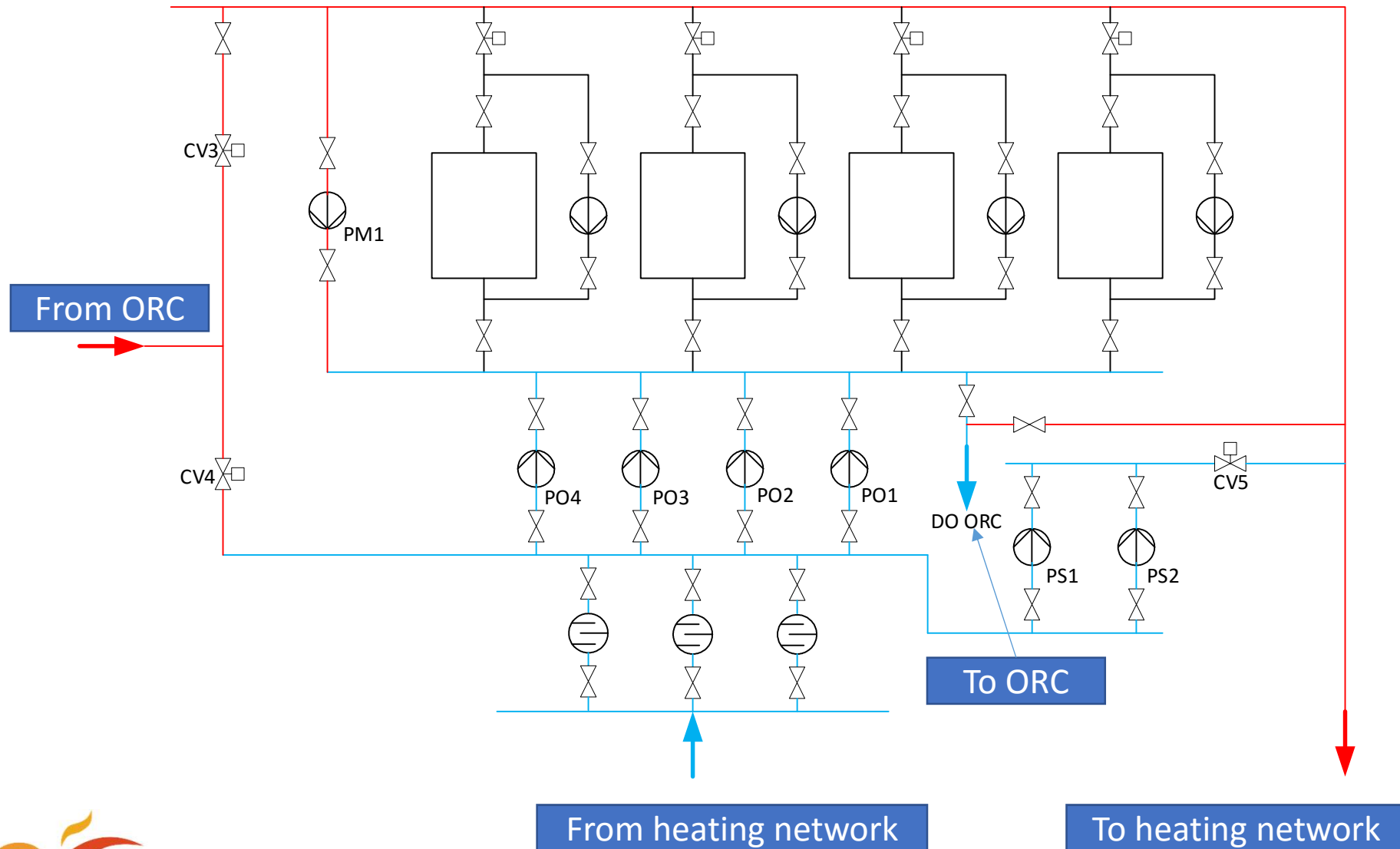
(DE) Low quality biomass

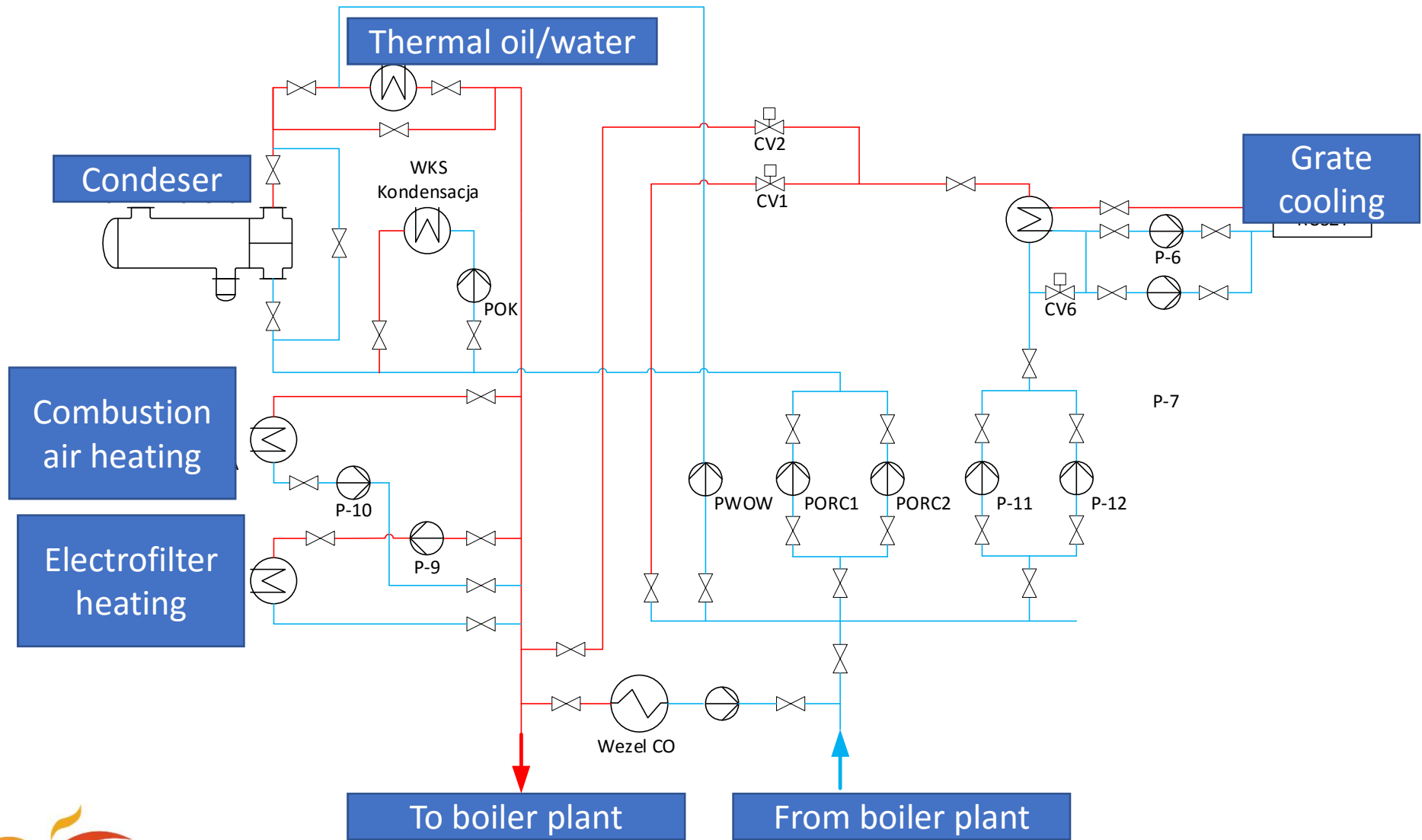


(PL) High and medium quality biomass







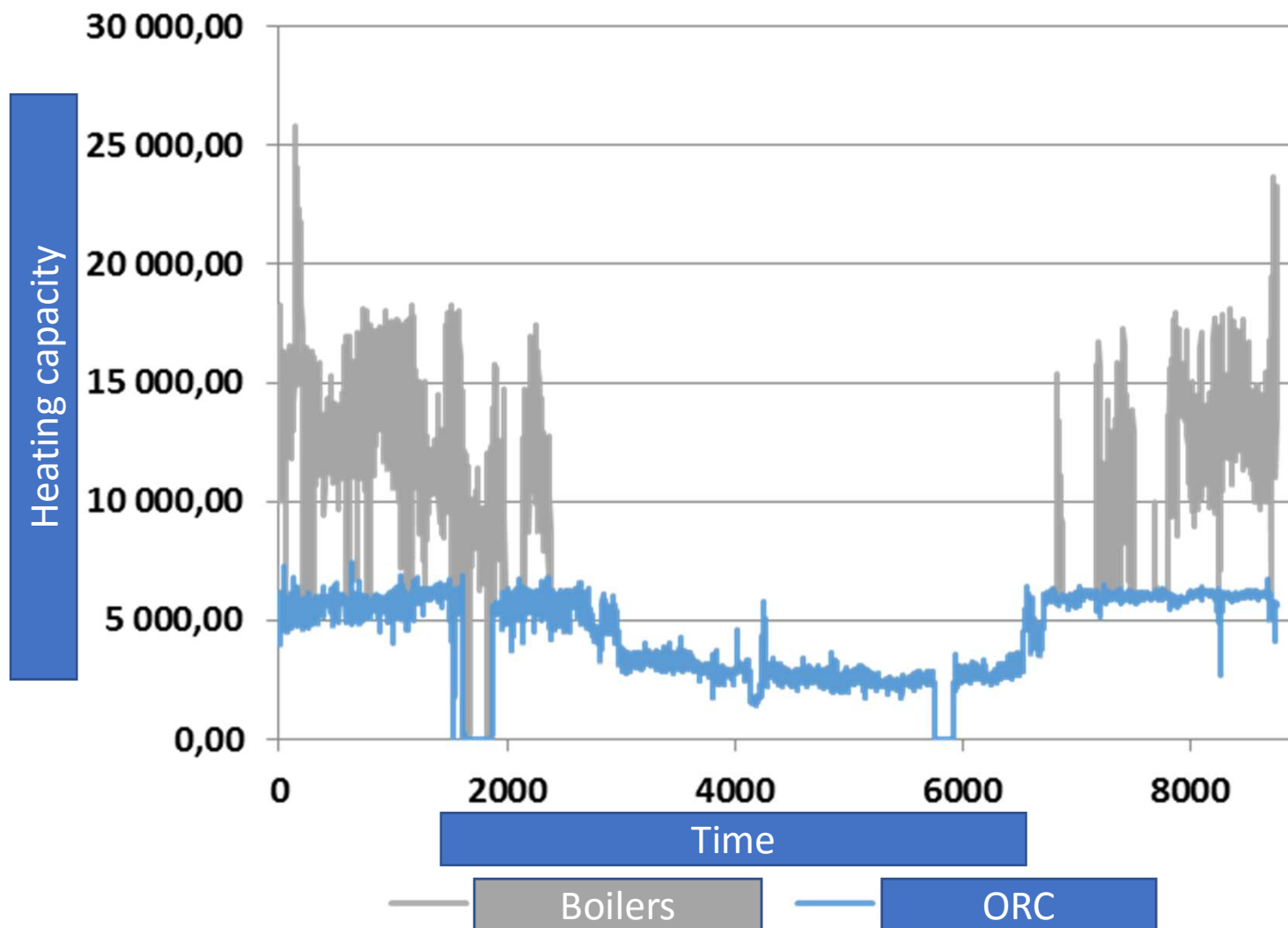


ORC model: **T14-CHP SPLIT**

Manufacturer: **TURBODEN S.r.l. (Italy)**

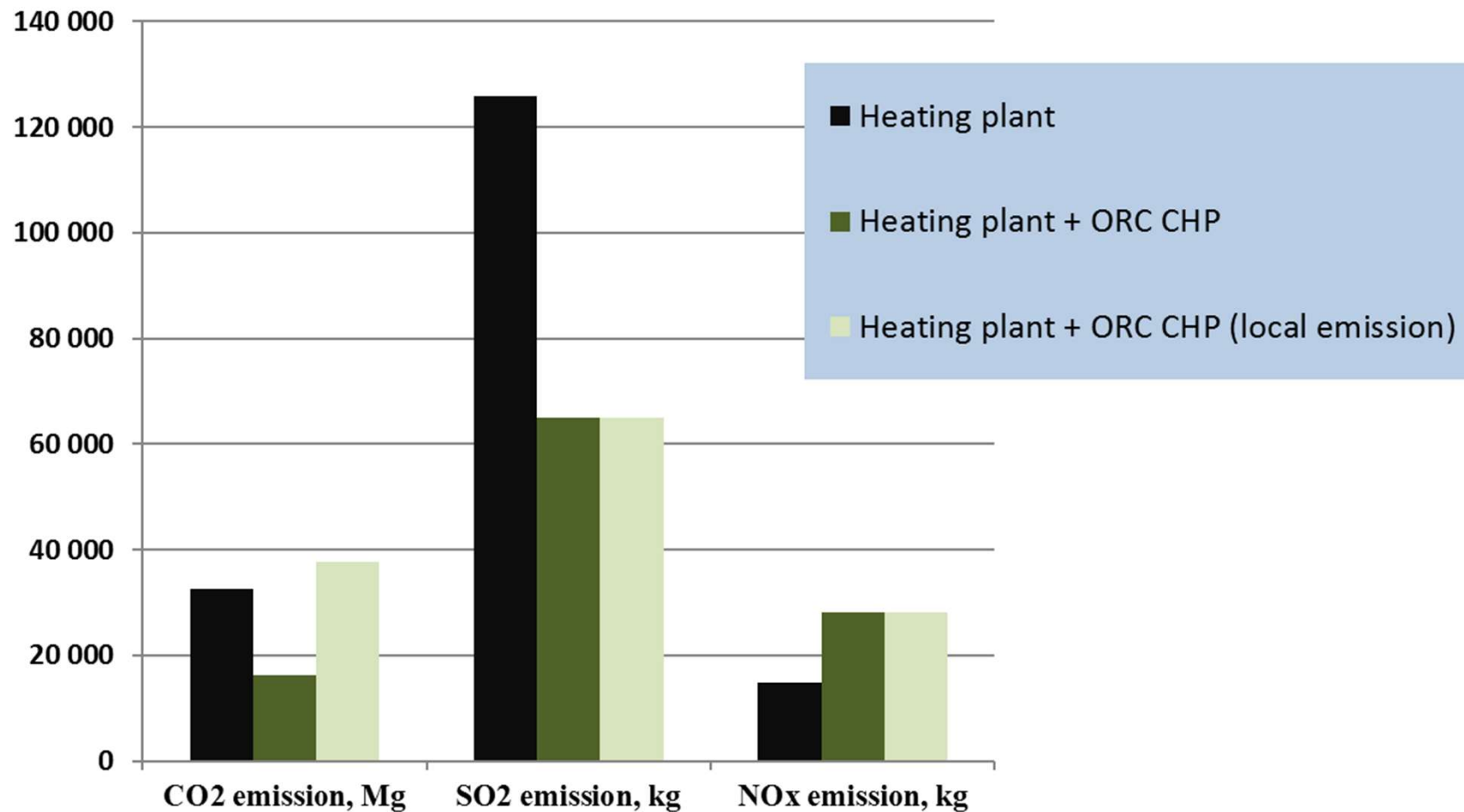
Quantity	Unit	Value
Thermal oil loop		
Nominal temperature HT oil loop (in/out)	°C	310/252
Thermal power input HT loop	kW	6310
Nominal temperature LT oil loop (in/out)	°C	250/130
Thermal power input LT loop	kW	585
Overall thermal input	kW	6715
Cooling water circuit		
Heating network water temperature (in/out)	°C	60/80
Thermal power to the water circuit	kW	5341
Performance		
Gross active electric power	kW	1317
Gross electric energy efficiency	%	19.6
Captive power consumption	kW	62
Net active electric power	kW	1255
Net electric efficiency	%	18.7
Indicative turbine isentropic efficiency	%	Up to 90
Indicative biomass consumption	kg/h	2935



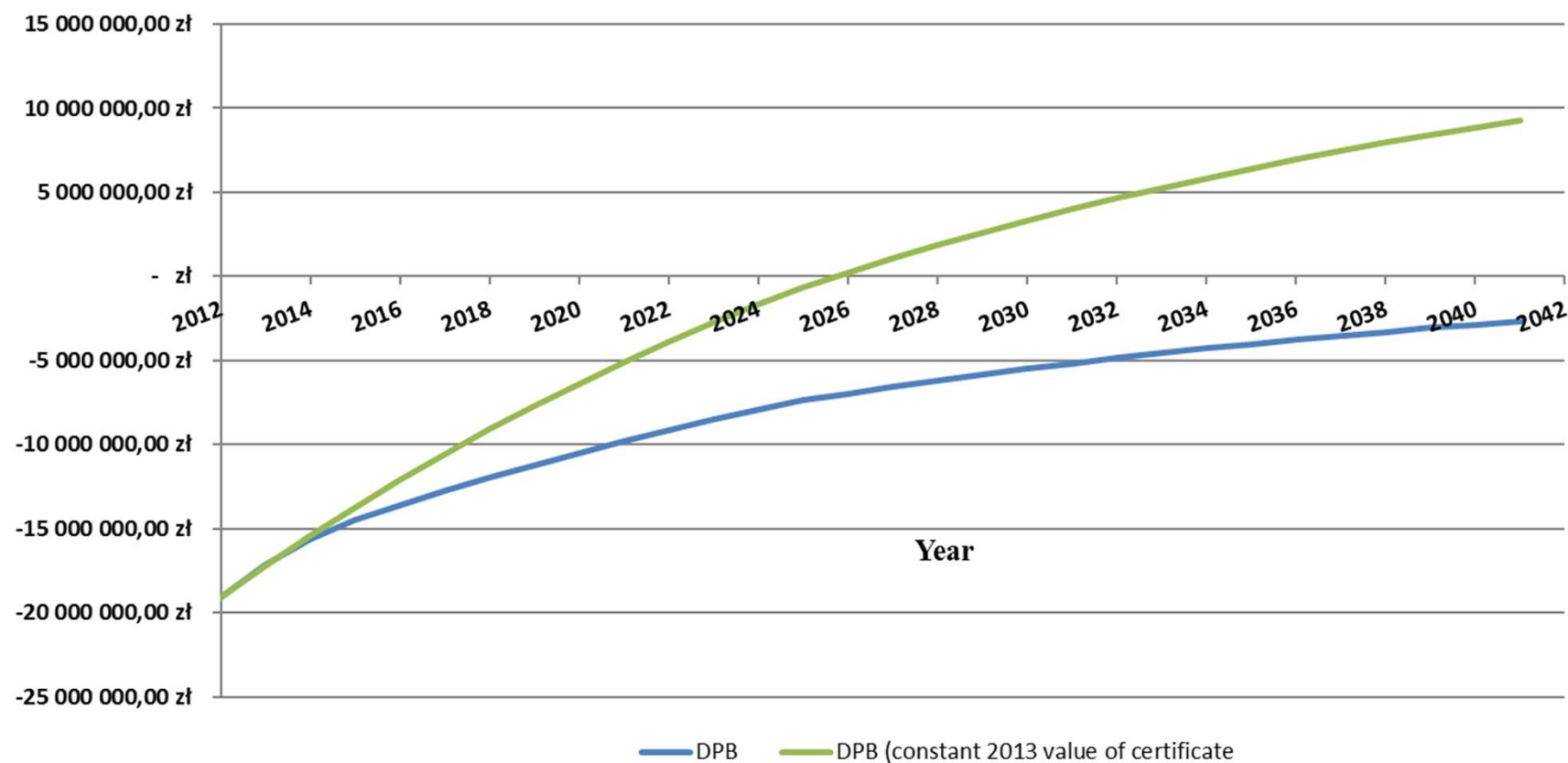


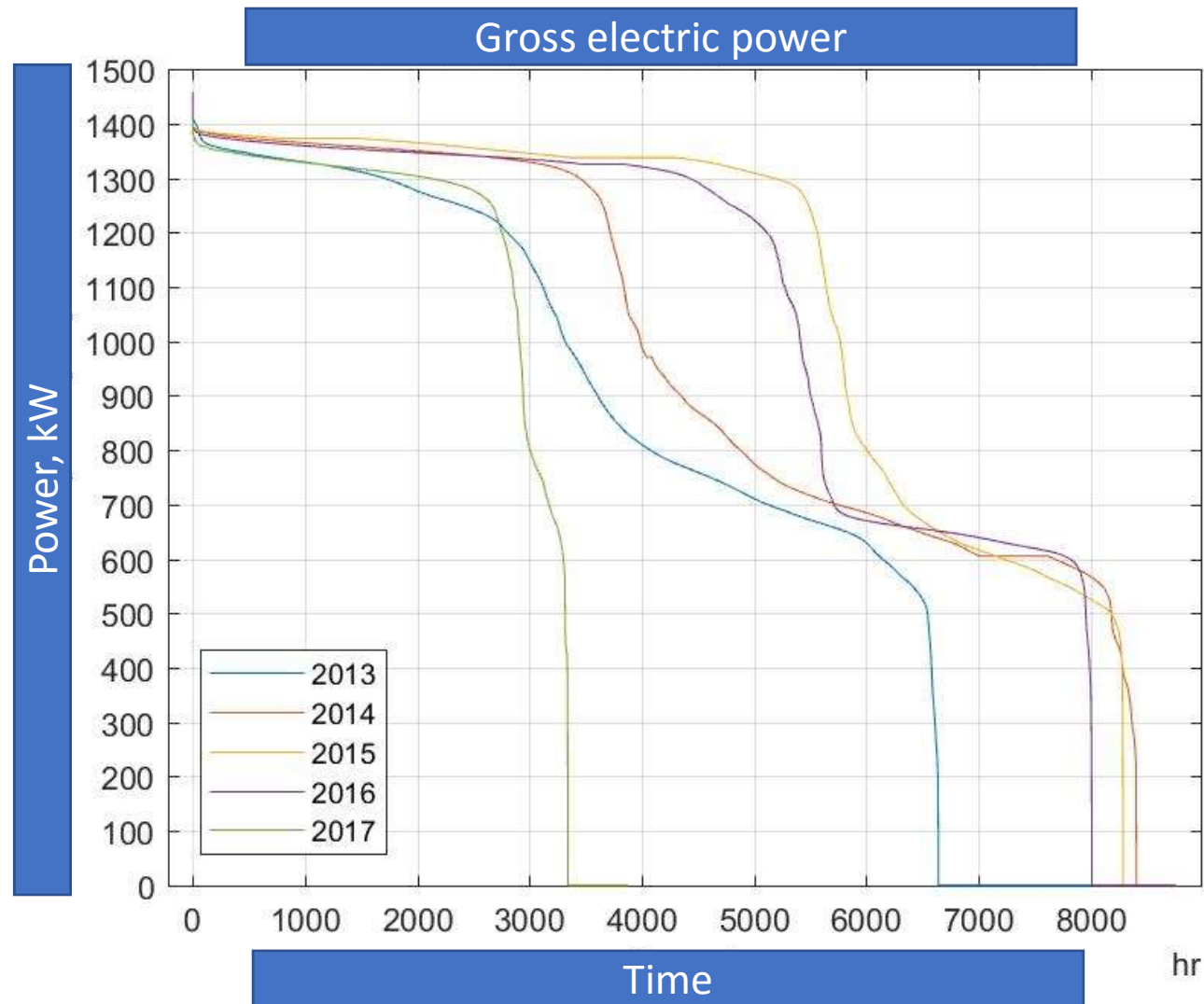
Performance indices

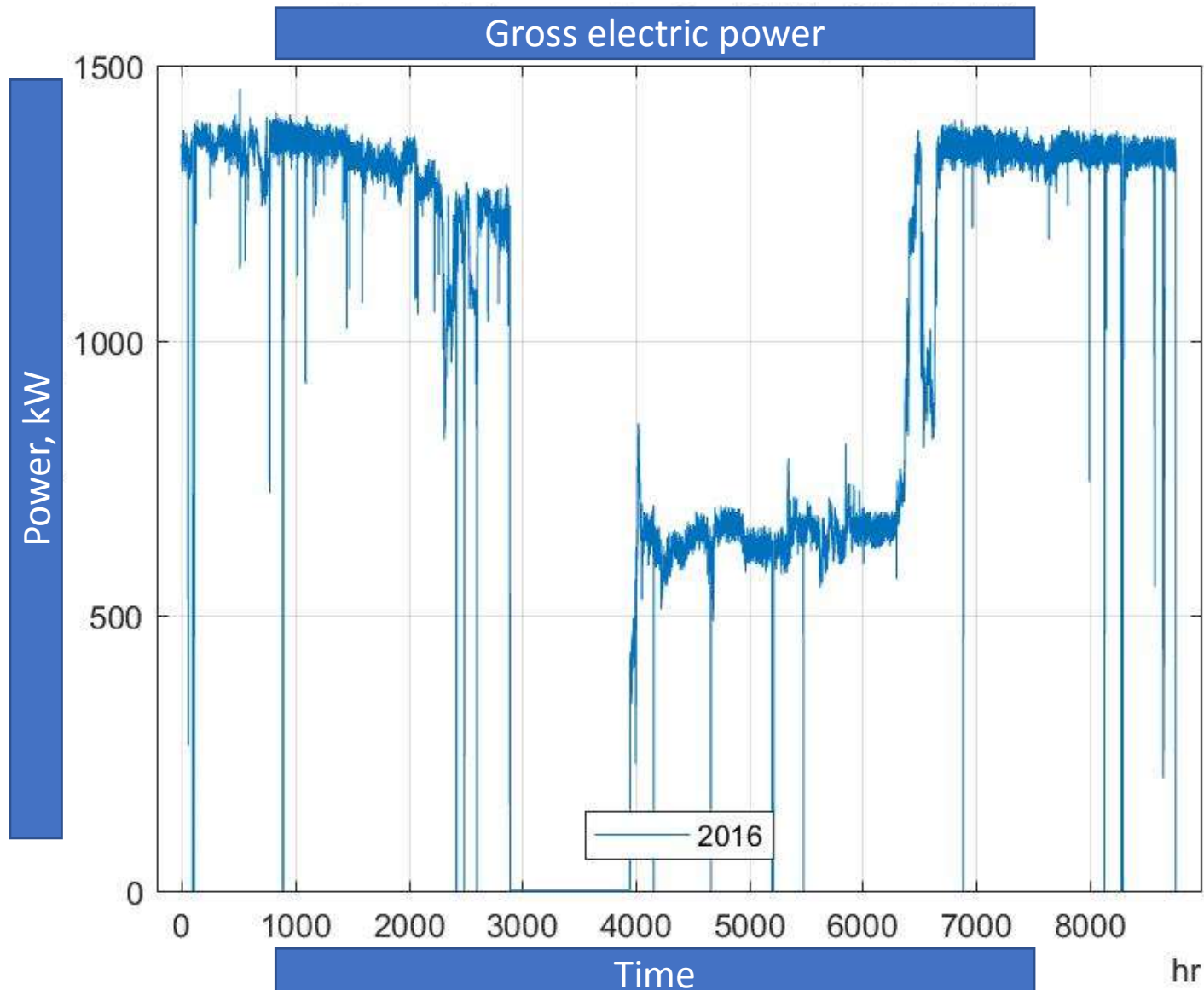
Parameter	Without ORC	With
Annual heat production		265 262 GJ
Heat from ORC	-	136 238 GJ
Heat from coal boilers	265 262 GJ	129 024 GJ
Electricity production	-	8 397,82 MWh
Biomass consumption	-	21 890 Mg
Coal consumption	14 845 Mg	7 384 Mg
Average efficiency of boiler plant	77,37%	75,78%
Average power generation efficiency	-	15,65%
Average overall efficiency	77,37%	81,31%

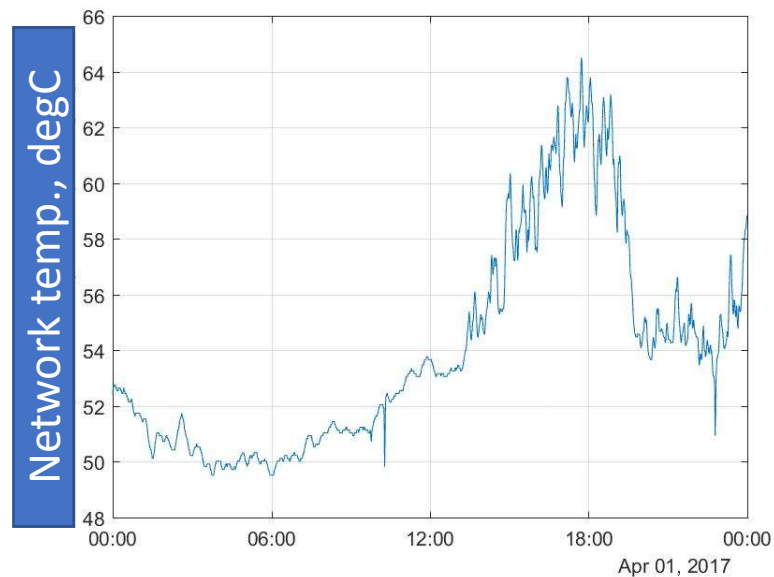
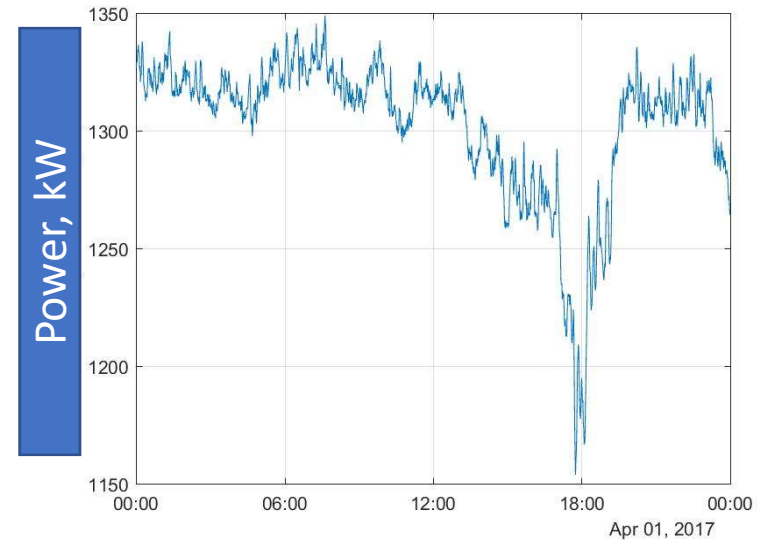
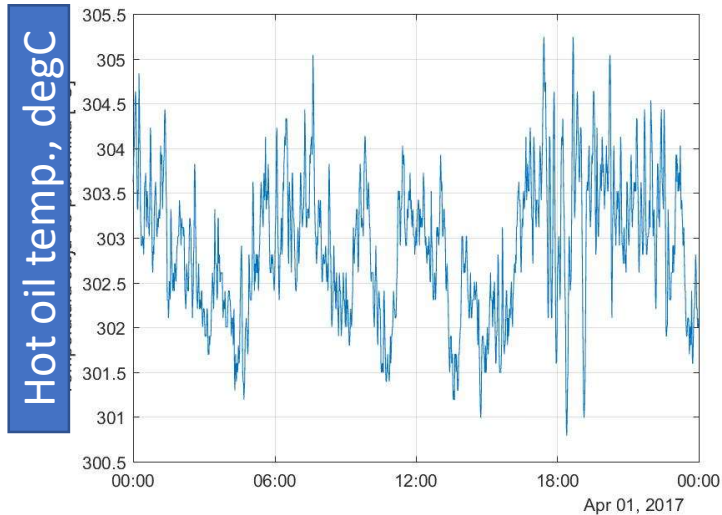


Anticipated economic results

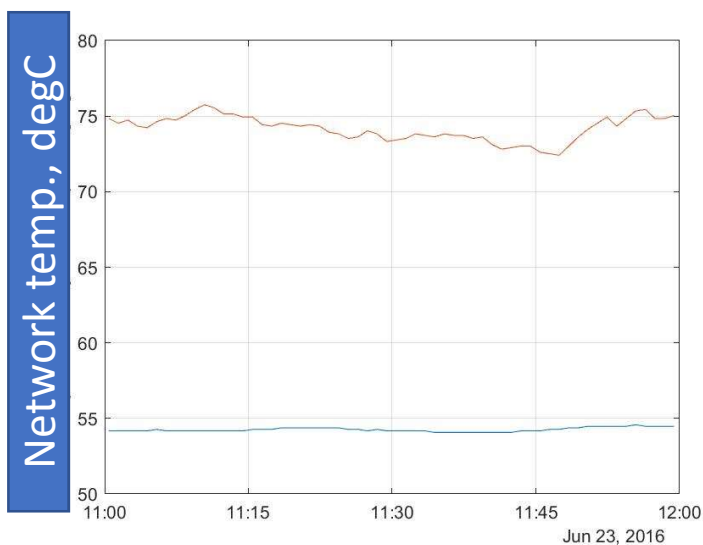
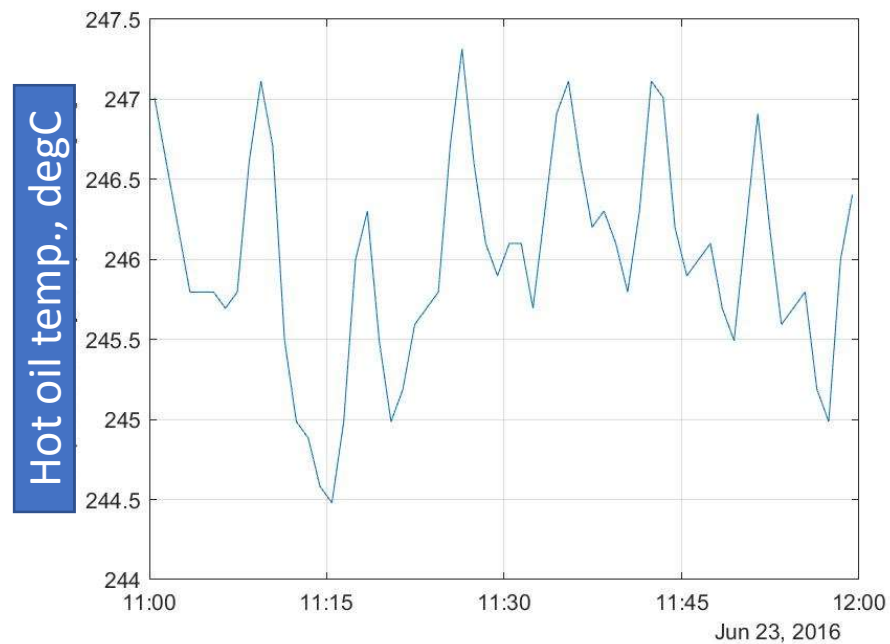
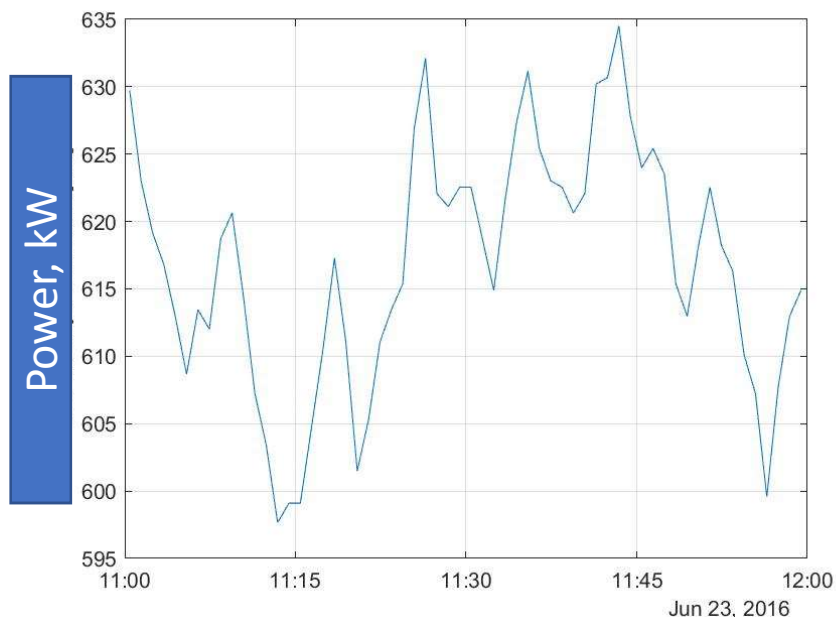


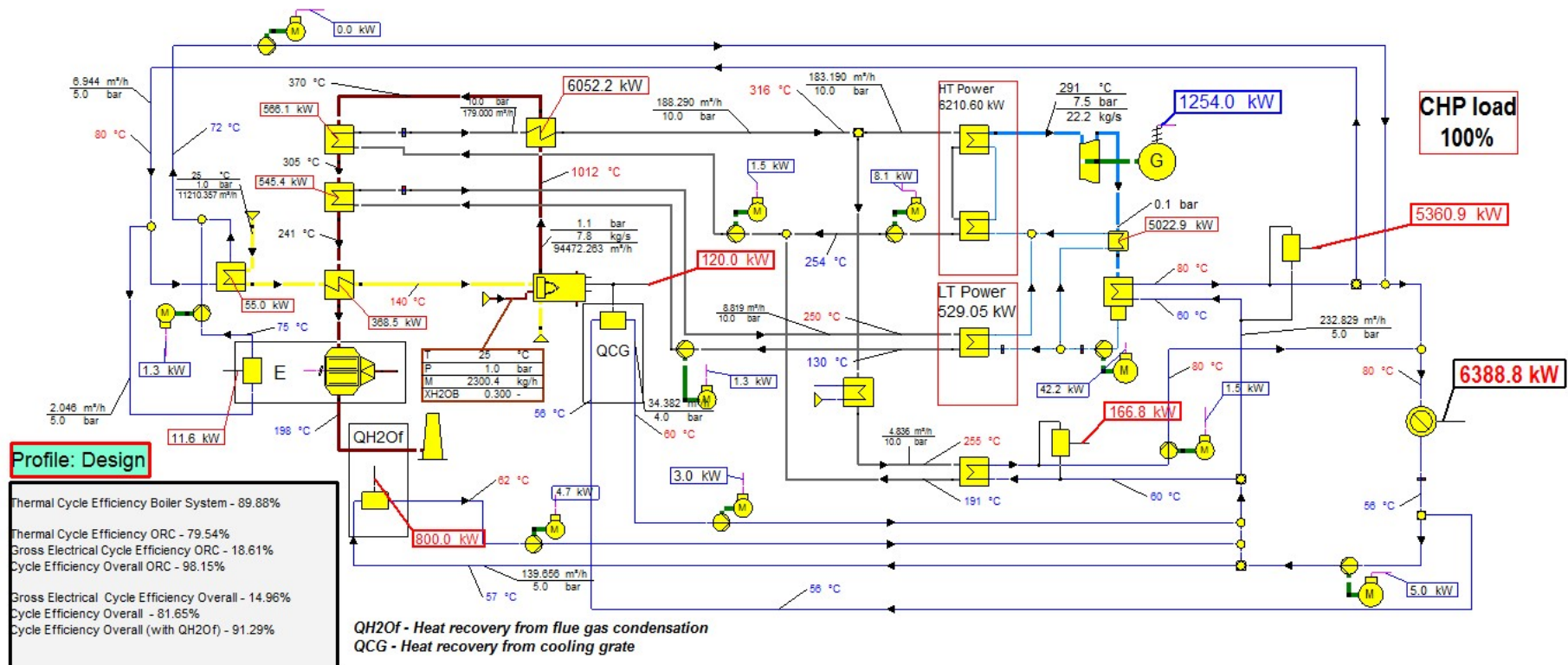


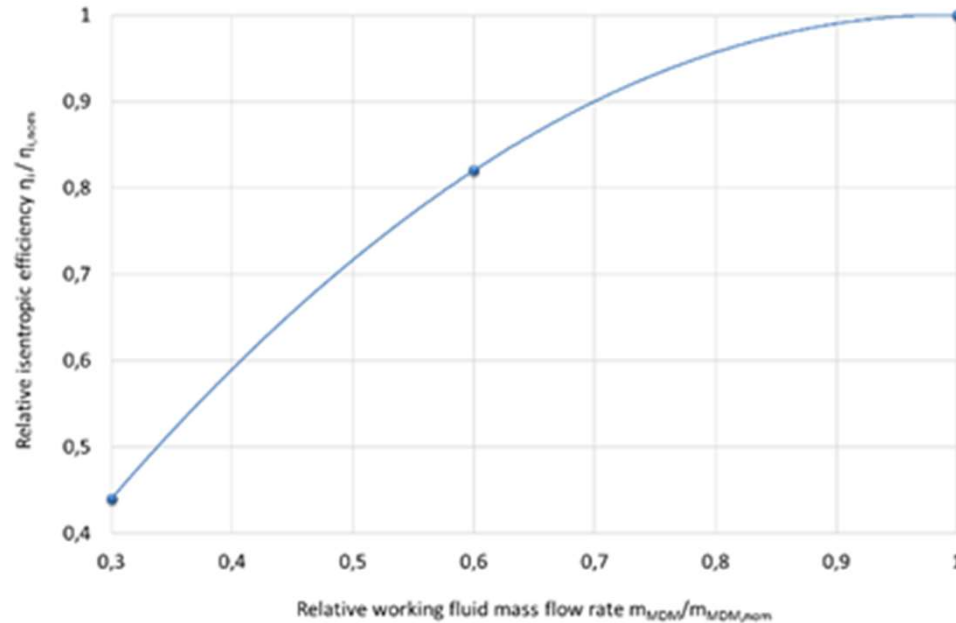




Sample hour - summer

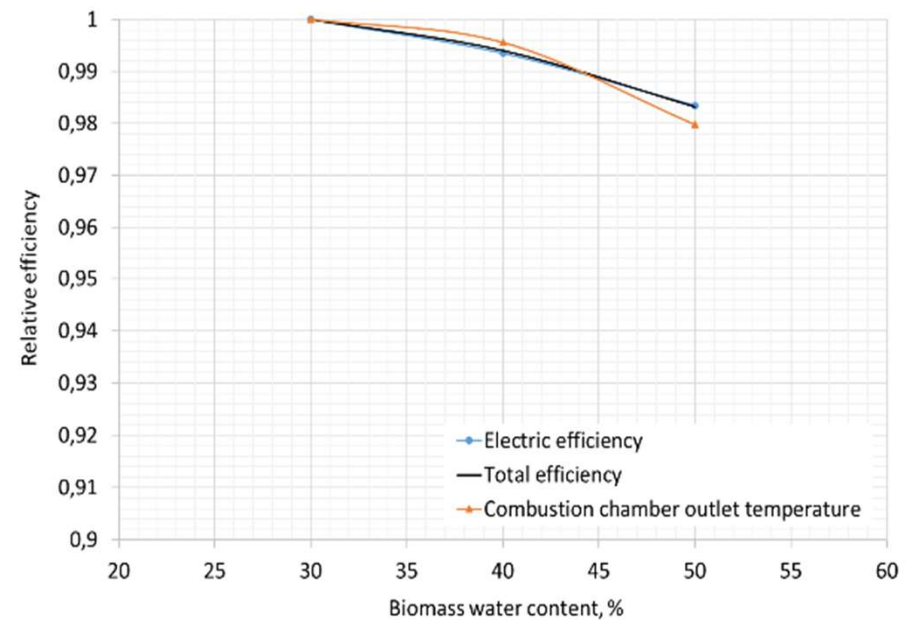
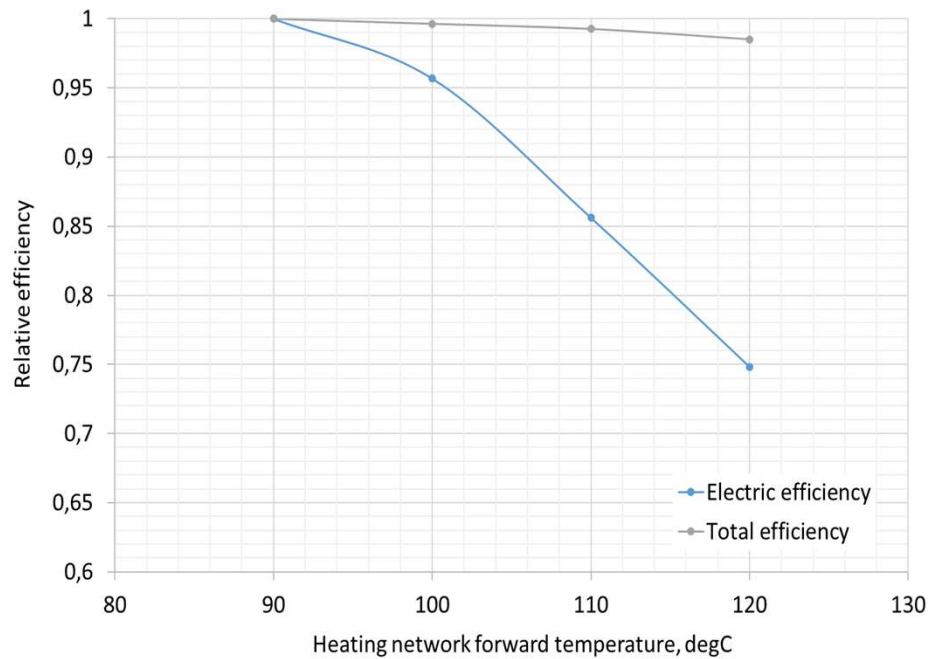




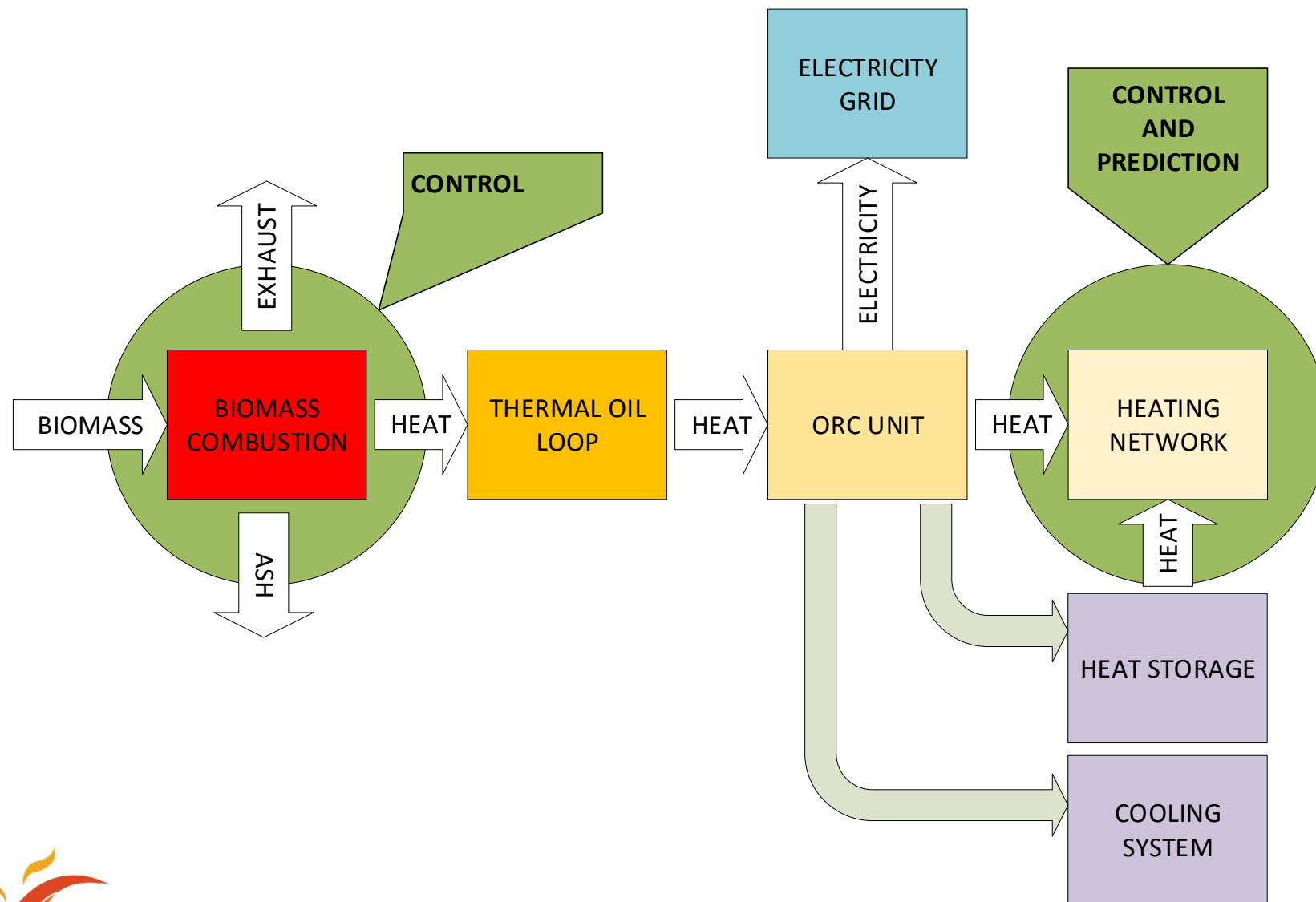


$$\frac{\eta_i}{\eta_{i,nom}} = f\left(\frac{\dot{m}_{MDM}}{\dot{m}_{MDM,nom}}\right)$$

The relation between isentropic efficiency and the working fluid mass flow rate was elaborated assuming constant turbine inlet and outlet conditions and power output as specified in the technical documentation



Possible improvements



- The technology does not bring favourable financial results
- There is a way for improvement. It consists of better system integration based on software and hardware solutions.
- Additional revenues can be generated by improved electricity generation performance (power and efficiency) and sales on balancing market.

Thank you for your attention

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