SET HEAT

Programme for the Environment and Climate Action

LIFE Clean Energy Transition sub-programme

# SET_HEAT_RIVER Project

## Industrial heat pump utilising river water as a heat source

Project number
**101119793**

Project acronym:
**LIFE22-CET-SET_HEAT**

Call:
**LIFE-2022-CET**

Topic:
**LIFE-2022-CET-DH**

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# Agenda



— Introduction

— Project concept

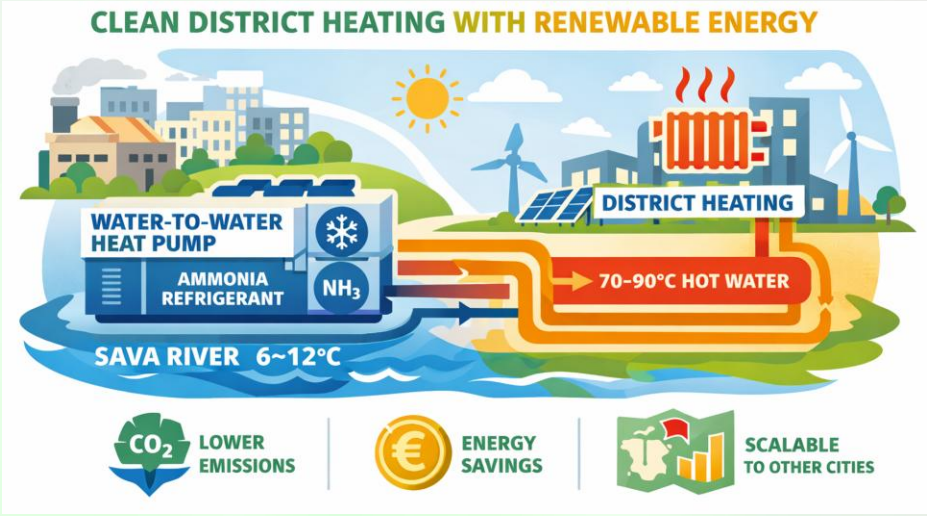
— Location, integration and key data

— Heat pump technology

— Modelling results

— Preliminary profitability assessment

— Conclusions

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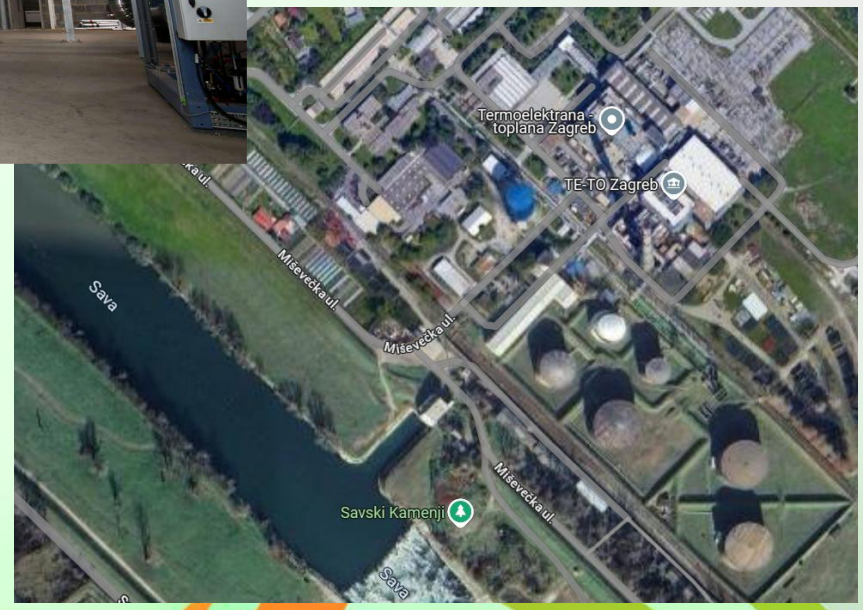
# Introduction

This project is an important initiative for the decarbonisation of the city of Zagreb. It includes a 21 MW water-to-water heat pump system that uses the Sava River as a renewable heat source, reducing dependence on natural gas.





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# Project concept



- The heat pump facility will be integrated with with the TE-TO Zagreb combined heat and power plant.
- 21 MW water-to-water heat pump (WSHP) system will be installed.
- Use of the Sava River as a renewable heat source.
- The heat pump covers the base load demand.
- Six cascade ammonia-based heat pumps.
- Supply temperature up to 90°C.
- Gas boilers are used exclusively to cover peak loads.

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# Point of departure

- Zagreb district heating relies 100% on natural gas
- Yearly heat production of the TE-TO plant is around 210.6 GWh.
- TE-TO plant is already using Sava river water for condenser cooling.
- Min river temperature is 4 °C.
- Buffer energy storage (TTES) of 750 MWh capacity is already in place.



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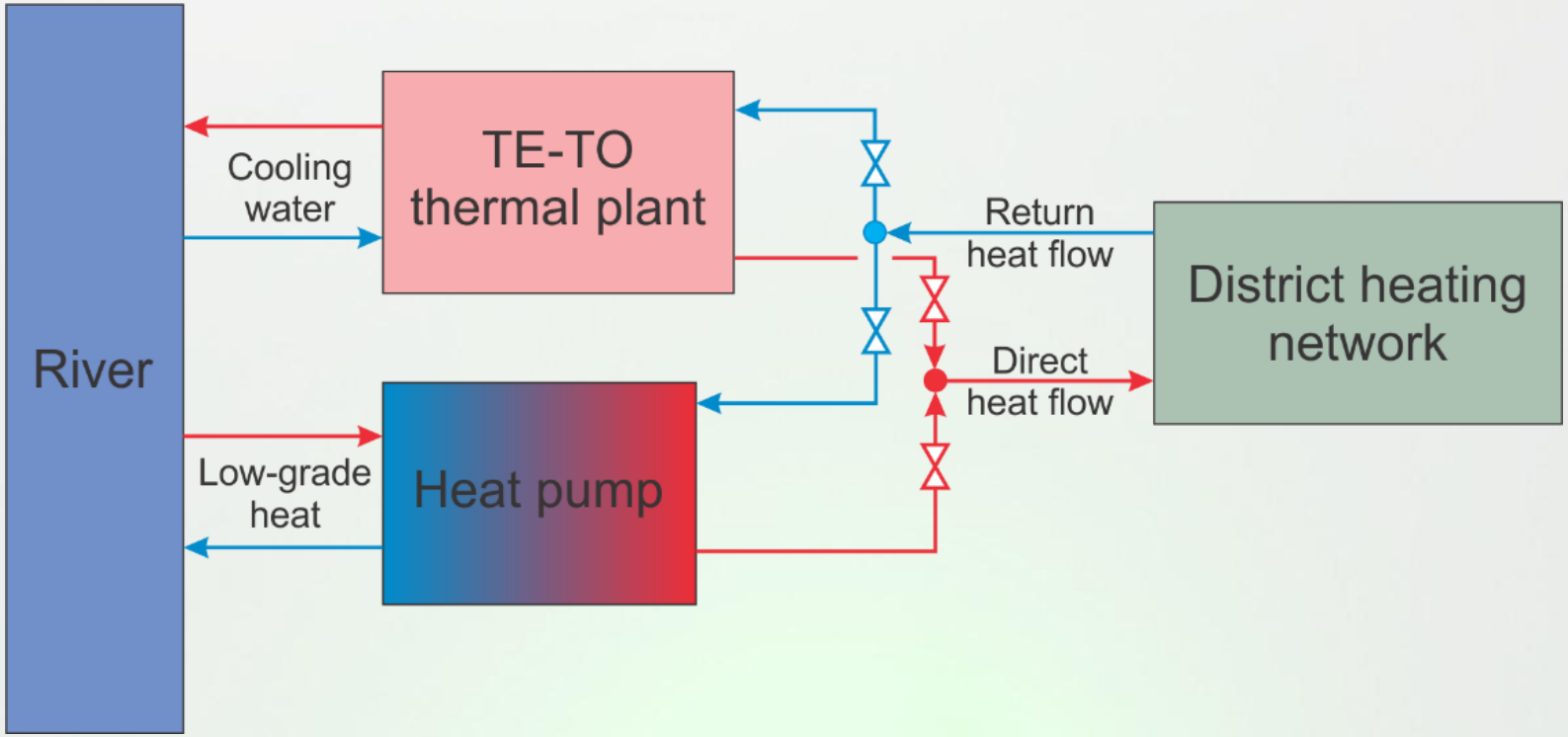
# Integration




- The reduction in electricity production at the TE-TO combined heat and power plant can be compensated for by the EL-TO combined heat and power plant, which has lower costs (with modern CCGT unit).



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# WWHP location

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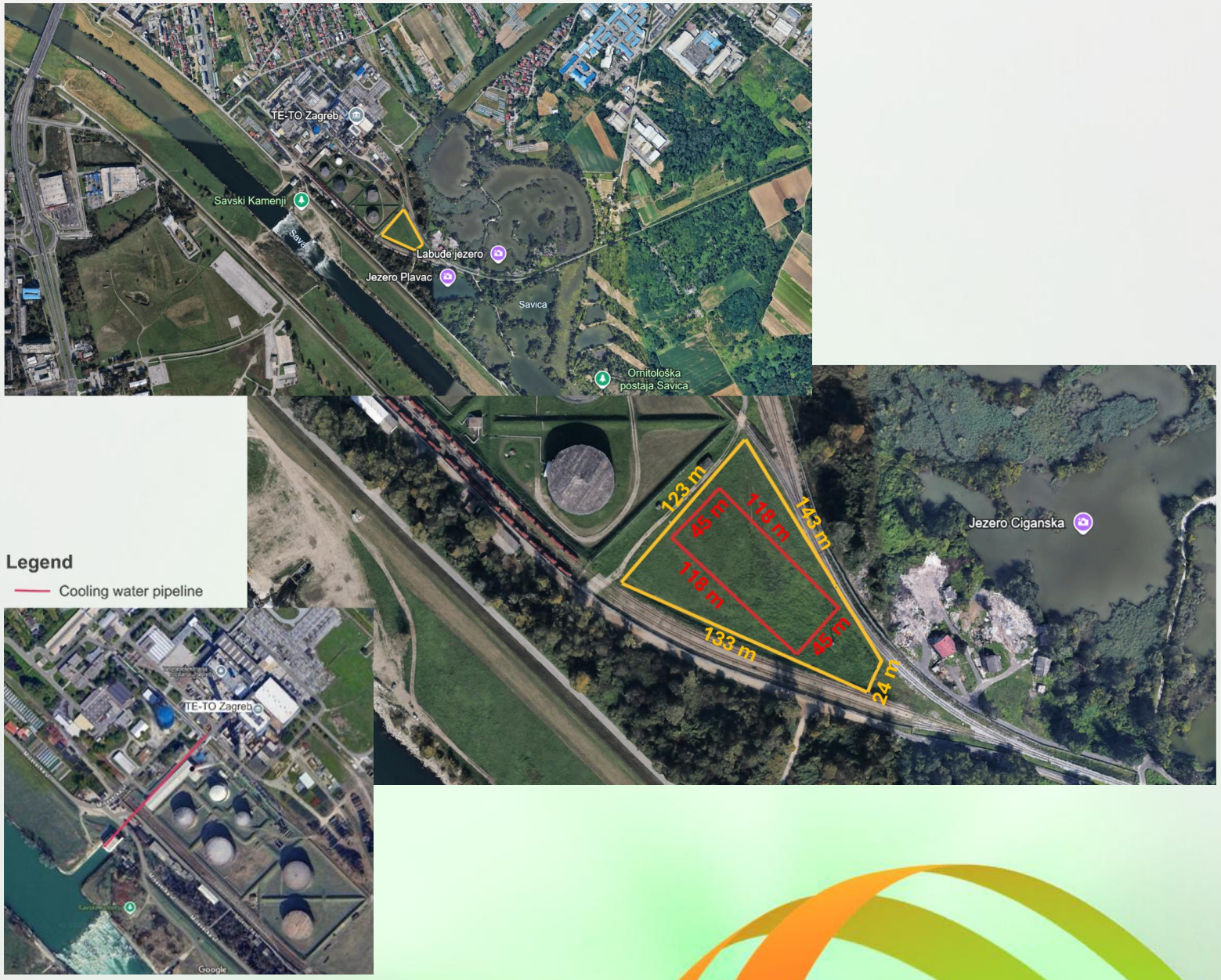


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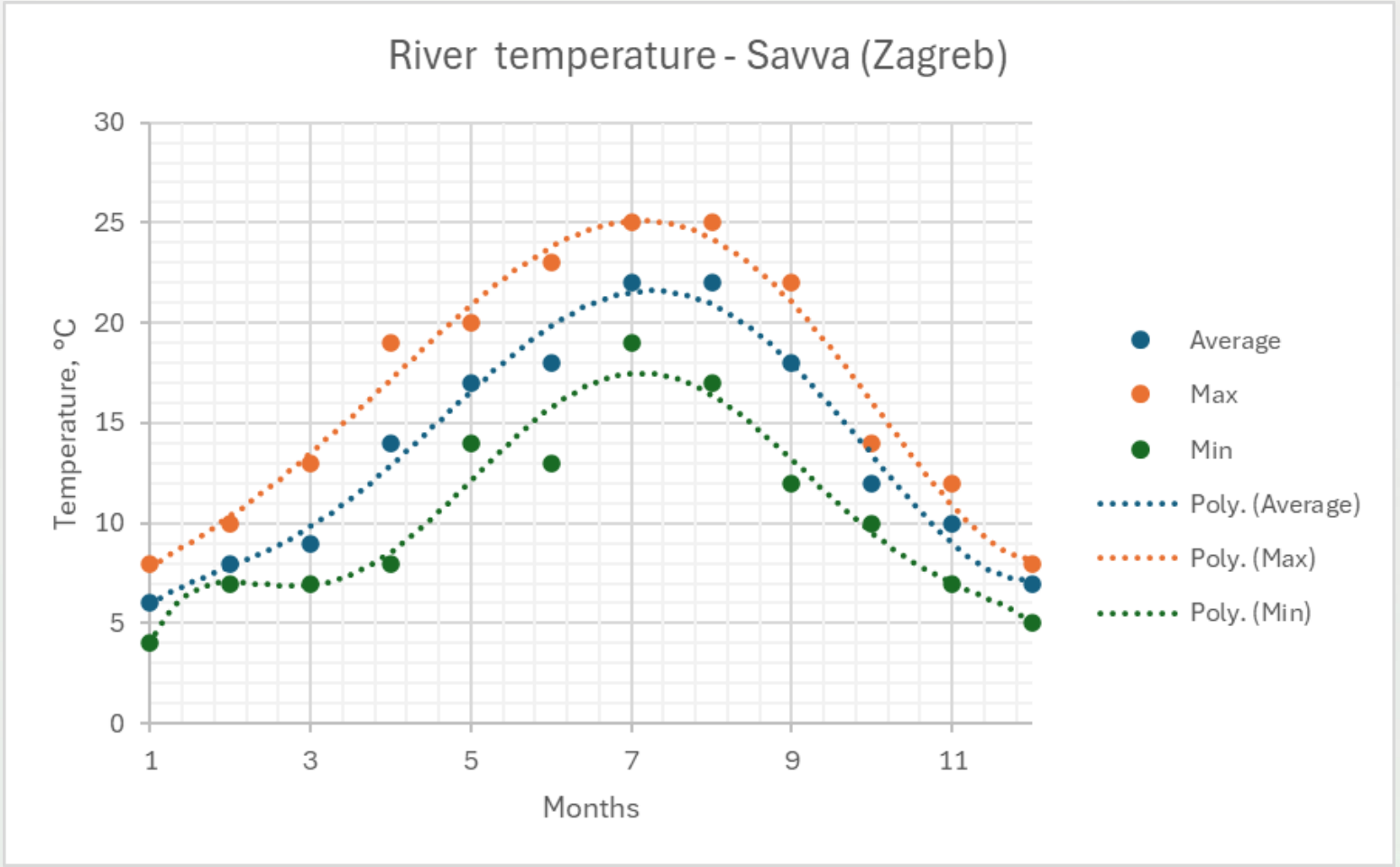
# Key data



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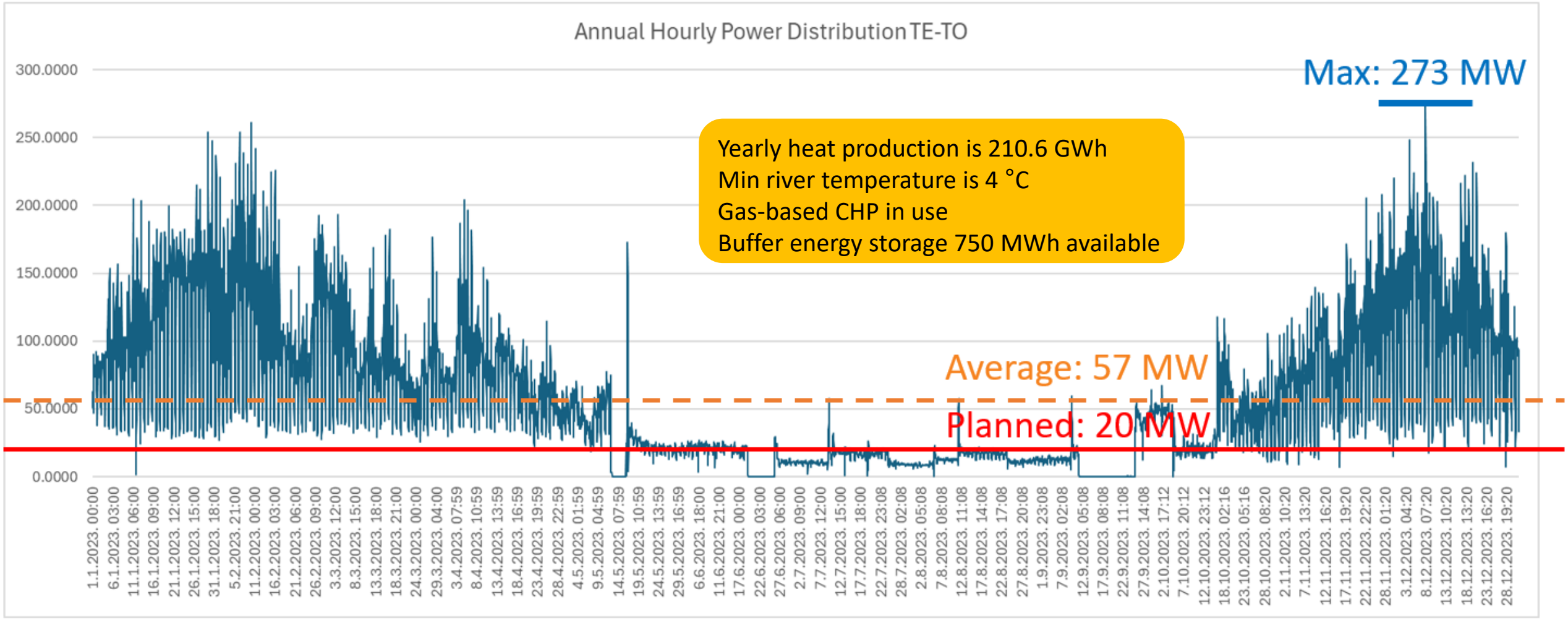


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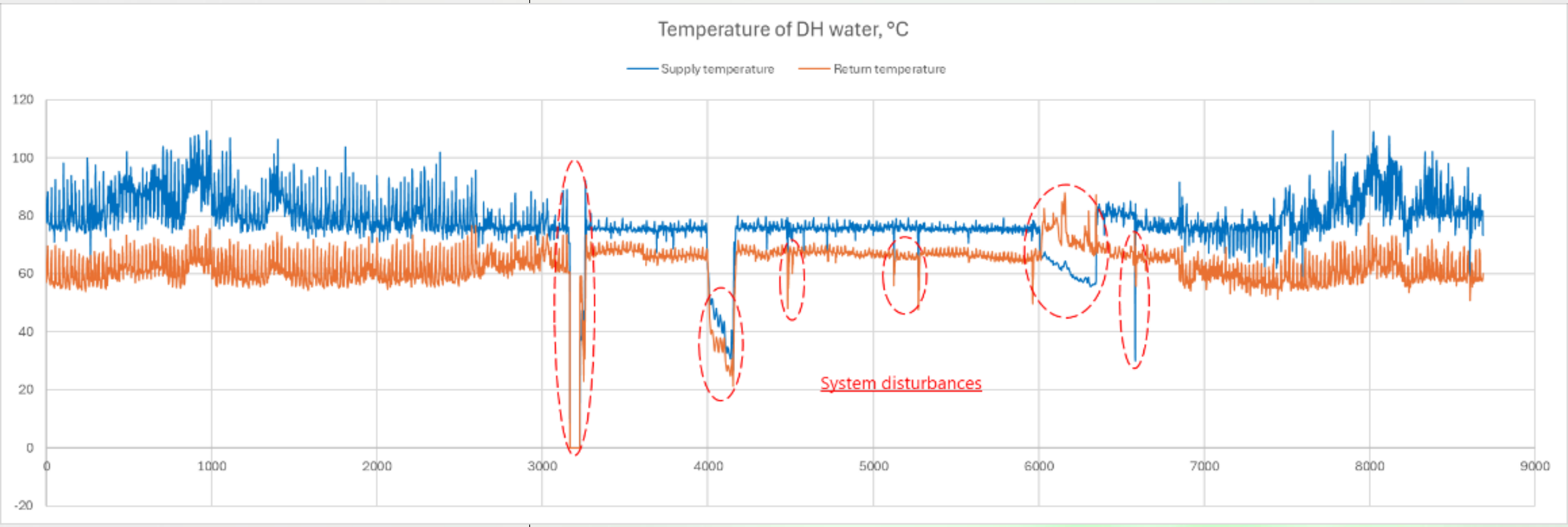


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# WWHP technology considered



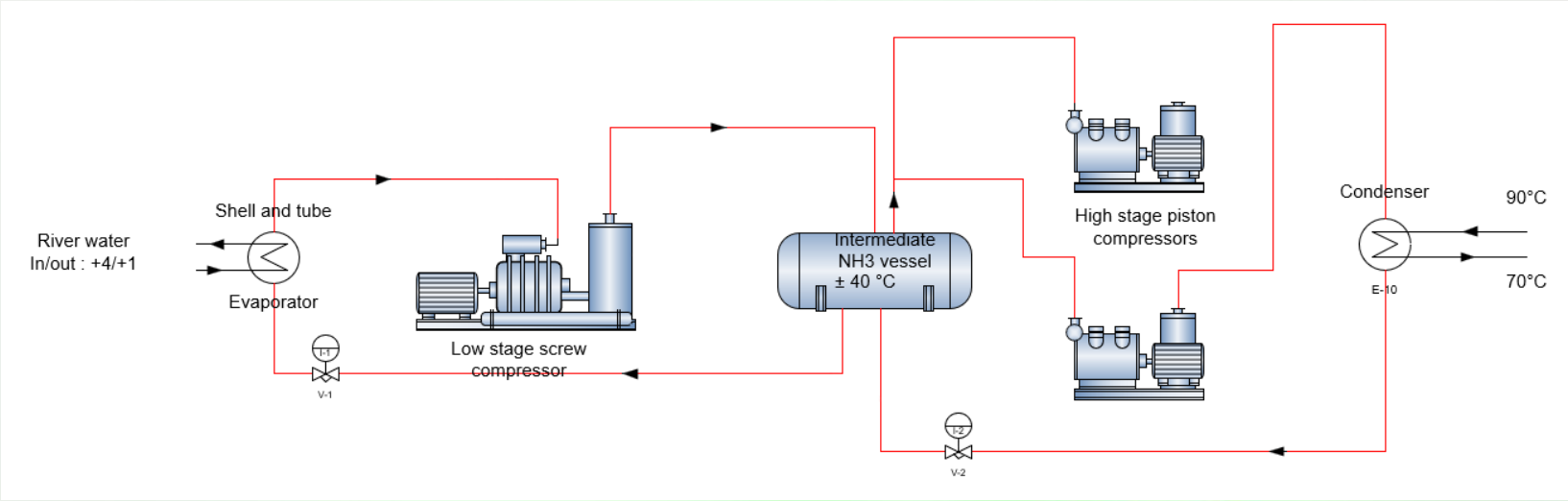
— 2-stage heat pump.

— Refrigerant: ammonia.

— GEA 3500 kW GSHP heat pump solution.

— Modular solution: 6 units providing 20 MW.

— Boundary conditions: max network water return temperature is 70 °C; min river water temperature is 4 °C

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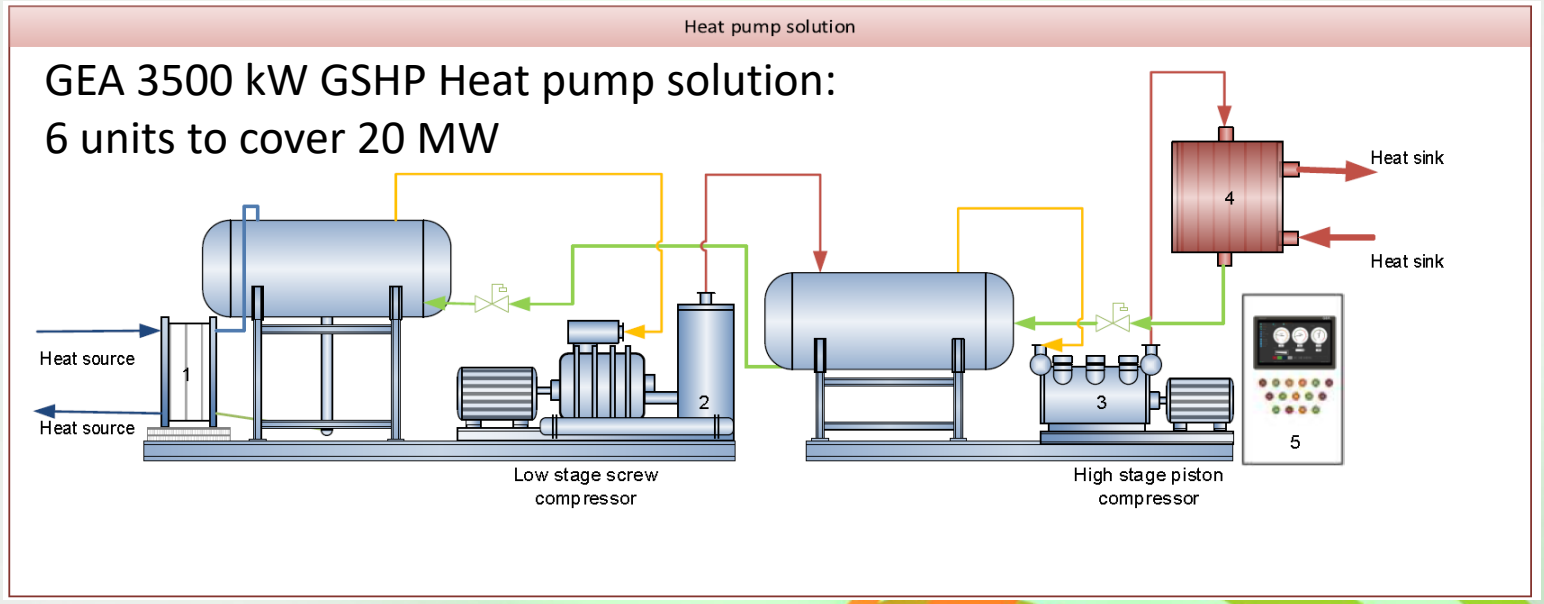
# Key components

- Semi welded plate and frame evaporator (Heat source) !!! shell-and-tube is preferred
- Low stage screw compressor
- High stage piston compressor
- Fully welded shell and plate De-superheater/condenser/Sub-cooler (Heat sink)
- GEA OMNI control system



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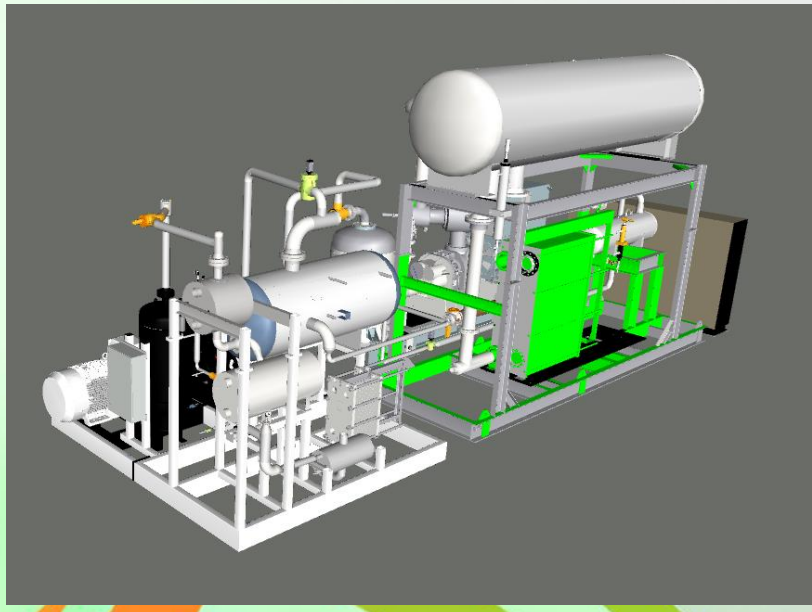
# Technology

- Dimensions: 13695 × 4545 × 5587 mm
- Heating capacity: 3.5 MW × 6
- Target temperature: 90 °C
- Source min temperature: 4 °C
- Source temp. range: 4-20  °C
- Pressure level 1: 1.5 MPa
- Pressure level 2: 5.5 MPa
- Drive motor: 630 + 800 kW
- Low to medium voltage
- 3-phase current





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# Heat pump characteristics



A. Heating temperature:

Outgoing temperature: 90°C

Return temperature: 70°C

| Heat source temperature [°C] | | Absorbed power [kW] | Heating capacity [kW] | Cooling capacity [kW] | Heating COP |
|---|---|---|---|---|---|
| out | in | | | | |
| 0 | 5 | 1085 | 3064 | 2021 | 2.82 |
| 5 | 10 | 1206 | 3500 | 2398 | 2.90 |
| 7 | 12 | 1174 | 3500 | 2428 | 2.98 |
| 10 | 15 | 1125 | 3500 | 2472 | 3.11 |
| 15 | 20 | 1054 | 3500 | 2537 | 3.32 |
| 20 | 25 | 1002 | 3500 | 2585 | 3.49 |

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# Heat pump characteristics



B. Heating temperature:

Outgoing temperature: 80°C
Return temperature: 60°C

| Heat source temperature [°C] | | Absorbed power [kW] | Heating capacity [kW] | Cooling capacity [kW] | Heating COP |
|---|---|---|---|---|---|
| out | in | | | | |
| 0 | 5 | 976 | 2947 | 2025 | 3.02 |
| 5 | 10 | 1051 | 3427 | 2421 | 3.26 |
| 7 | 12 | 1065 | 3500 | 2527 | 3.29 |
| 10 | 15 | 1013 | 3500 | 2574 | 3.46 |
| 15 | 20 | 939 | 3500 | 2642 | 3.73 |
| 20 | 25 | 885 | 3500 | 2692 | 3.95 |

C. Heating temperature:

Outgoing temperature: 70°C
Return temperature: 50°C

| Heat source temperature [°C] | | Absorbed power [kW] | Heating capacity [kW] | Cooling capacity [kW] | Heating COP |
|---|---|---|---|---|---|
| out | in | | | | |
| 0 | 5 | 880 | 2884 | 2029 | 3.28 |
| 5 | 10 | 932 | 3323 | 2426 | 3.57 |
| 7 | 12 | 959 | 3500 | 2598 | 3.65 |
| 10 | 15 | 910 | 3500 | 2668 | 3.85 |
| 15 | 20 | 832 | 3500 | 2739 | 4.21 |
| 20 | 25 | 776 | 3500 | 2791 | 4.51 |

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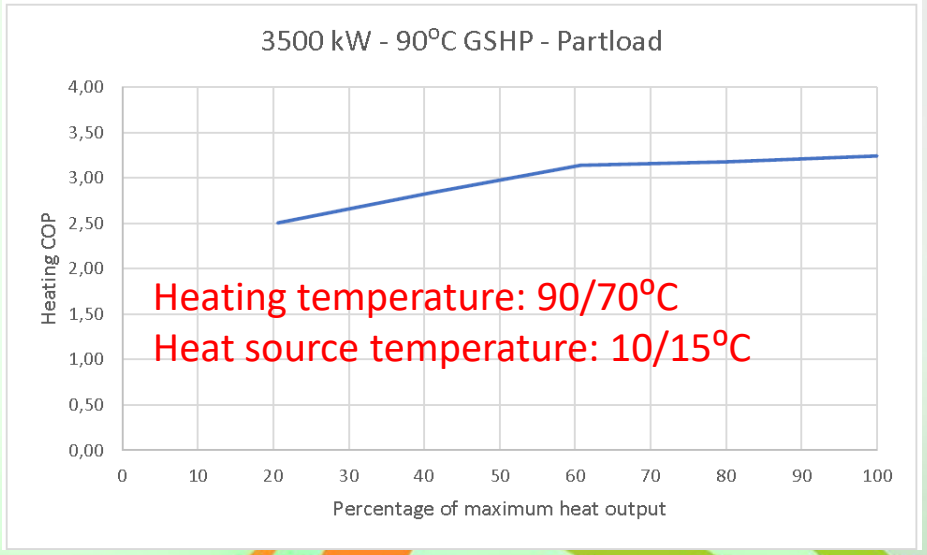
# Heat pump characteristics



C. Heating temperature:

Outgoing temperature: 70°C
Return temperature: 50°C

| Heat source temperature [°C] | | Absorbed power [kW] | Heating capacity [kW] | Cooling capacity [kW] | Heating COP |
|---|---|---|---|---|---|
| out | in | | | | |
| 0 | 5 | 880 | 2884 | 2029 | 3.28 |
| 5 | 10 | 932 | 3323 | 2426 | 3.57 |
| 7 | 12 | 959 | 3500 | 2598 | 3.65 |
| 10 | 15 | 910 | 3500 | 2668 | 3.85 |
| 15 | 20 | 832 | 3500 | 2739 | 4.21 |
| 20 | 25 | 776 | 3500 | 2791 | 4.51 |

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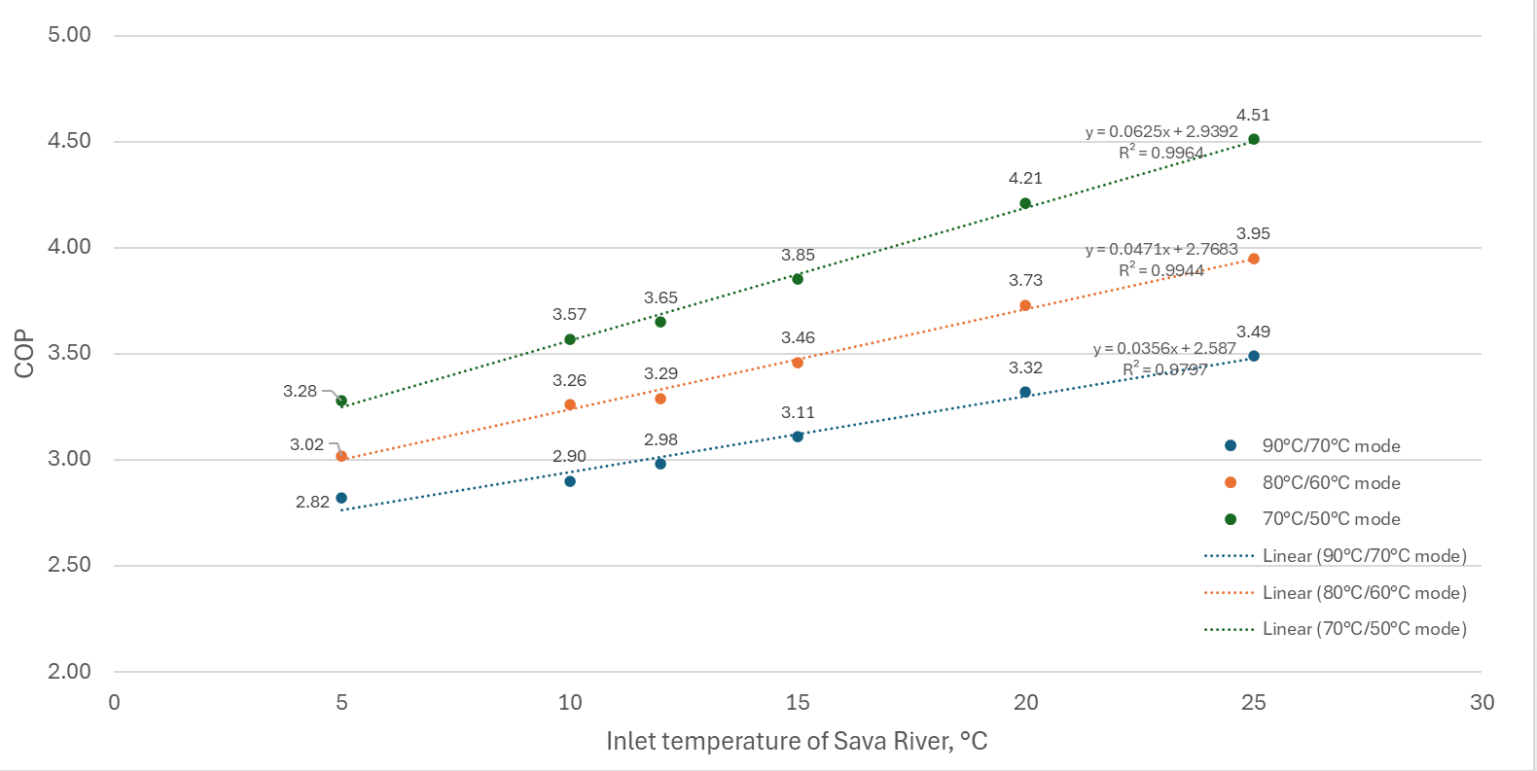
# Heat pump modelling






| | TE-TO plant | Heat pump |
|---|---|---|
| Energy delivered to DHS (MWh/year) | 167,404 | 167,404 |
| Seasonal COP | - | 3.11 |
| Energy use, (MWh/year) | $167,404_t$ | $53,908_e$ |
| Primary energy, MWh/year | 244,744 (nat. gas) | 87,007 (nat. gas) |
| $CO_2$ emissions, (t/y) | 57,885 | 12,658 |

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# CAPEX assessment



HP unit budget price 10,500,000.00 €, which covers:

- Design
- Project management and engineering
- Delivery on site of the equipment
- Assembly on site  (due to the size it needs to be transported in sections)
- Insulation of the units
- Refrigerant and oil charge
- Testing and commissioning

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# CAPEX assessment



Additional cost 9,500,000 €, which covers:

- Offloading and cranage
- All civil works (building , foundation etc.)
- All required permits
- All local taxes, levies,  etc.
- All water Pumps and their starter panels & controls
- Ammonia gas detection
- Heating of the engine room

Total indicative CAPEX: EUR 20,000,000.00 (21 $MW_{th}$)

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# Keay economic data



- Electricty price 103 €/MWh
- Heat price 36 €/MWh
- Natural gas price 41 €/MWh
- $CO_2$ price 65 €/ton
- Saving by reducing $CO_2$ 2,939,736 €
- Annual operation and maintenance 200,000 €
- Private Equity 20%
- Interest Loan 6%
- Discount rate 7 %
- Corporate Income Tax18 %
- Loan 10 years

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# Preliminary profitablility assessment

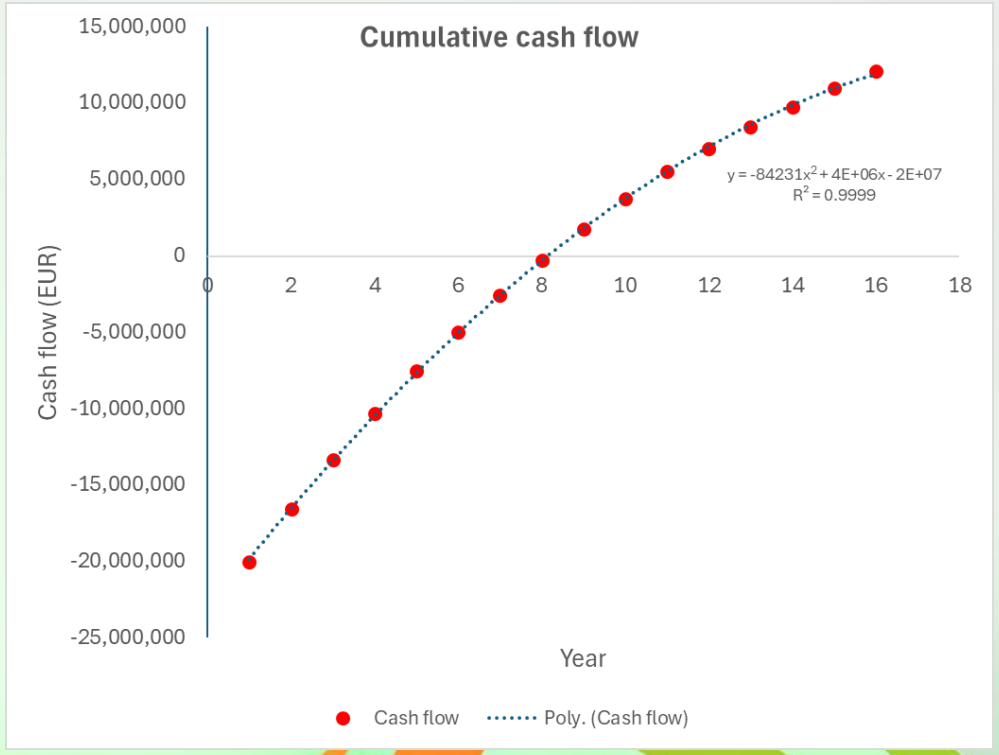


— Indicative CAPEX: €20 million

— Net Present Value (NPV): €5.5 million

— Internal Rate of Return (IRR): 13%

— Payback period: ~7 years




Note: loss of revenue from electricity sales not included.

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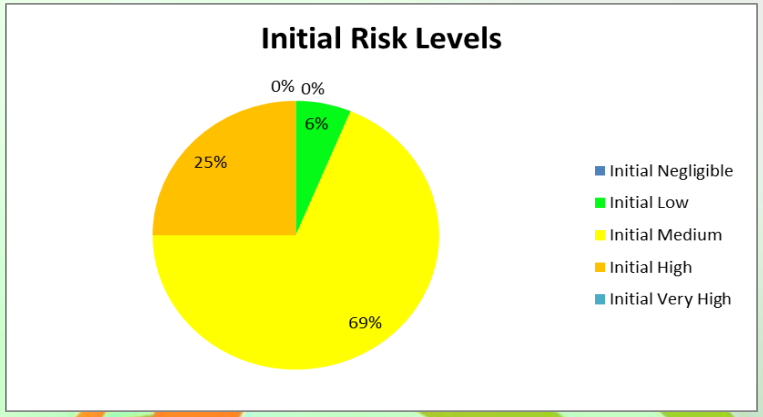
# Risks and mitigation

Key risks include potential underperformance of heat pump components, efficiency losses during peak or low Sava River temperatures, and failures in compressors, heat exchangers, and river-water intake infrastructure.

Mitigation emphasises rigorous system design, continuous monitoring, redundancy in critical components, preventive maintenance schedules, and the adoption of digital control systems for predictive operation.

While several risks are classified as high severity, the analysis shows that none are unmanageable.

| Impact ↓ / Likelihood → | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 8 | 0 | 0 |
| 4 | 0 | 1 | 2 | 0 | 0 |
| 5 | 0 | 2 | 2 | 0 | 0 |



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# Conclusions



- The pre-feasibility study clearly demonstrates technical feasibility, economic viability and environmental benefits.
- Sensitivity analysis confirms that profitability remains robust under ±20 % variations in energy prices and investment costs. However, economic performance is particularly sensitive to electricity price increases, reinforcing the importance of renewable electricity supply.
- No single risk poses a critical threat to technical feasibility or financial viability.
- With robust engineering, renewable electricity integration, and strong stakeholder coordination, the project represents a low-to-moderate risk investment with significant environmental and strategic benefits for Zagreb and the wider region.

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# Final recommendations



- Proceed to detailed feasibility and design phase.
- Comprehensive hydraulic and thermal simulations of the integration between the Sava River, the heat pump system and the district heating network are required.
- Secure blended financing and EU grant support.
- Integrate renewable electricity supply.
- Establish a smart operation and digital monitoring platform.
- Trigger institutional and stakeholder collaboration.
- prepare permits and environmental impact assessments (EIA) in accordance with Croatian and EU water and environmental regulations
- Based on this project establish a “Zero-Carbon Heat Hub” in Zagreb.

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# Contact information



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