4th International Conference on Smart Energy Systems and 4th Generation District Heating
Aalborg 13-14 Nov 2018

District Power to Heat/Cool complemented by sewage heat recovery

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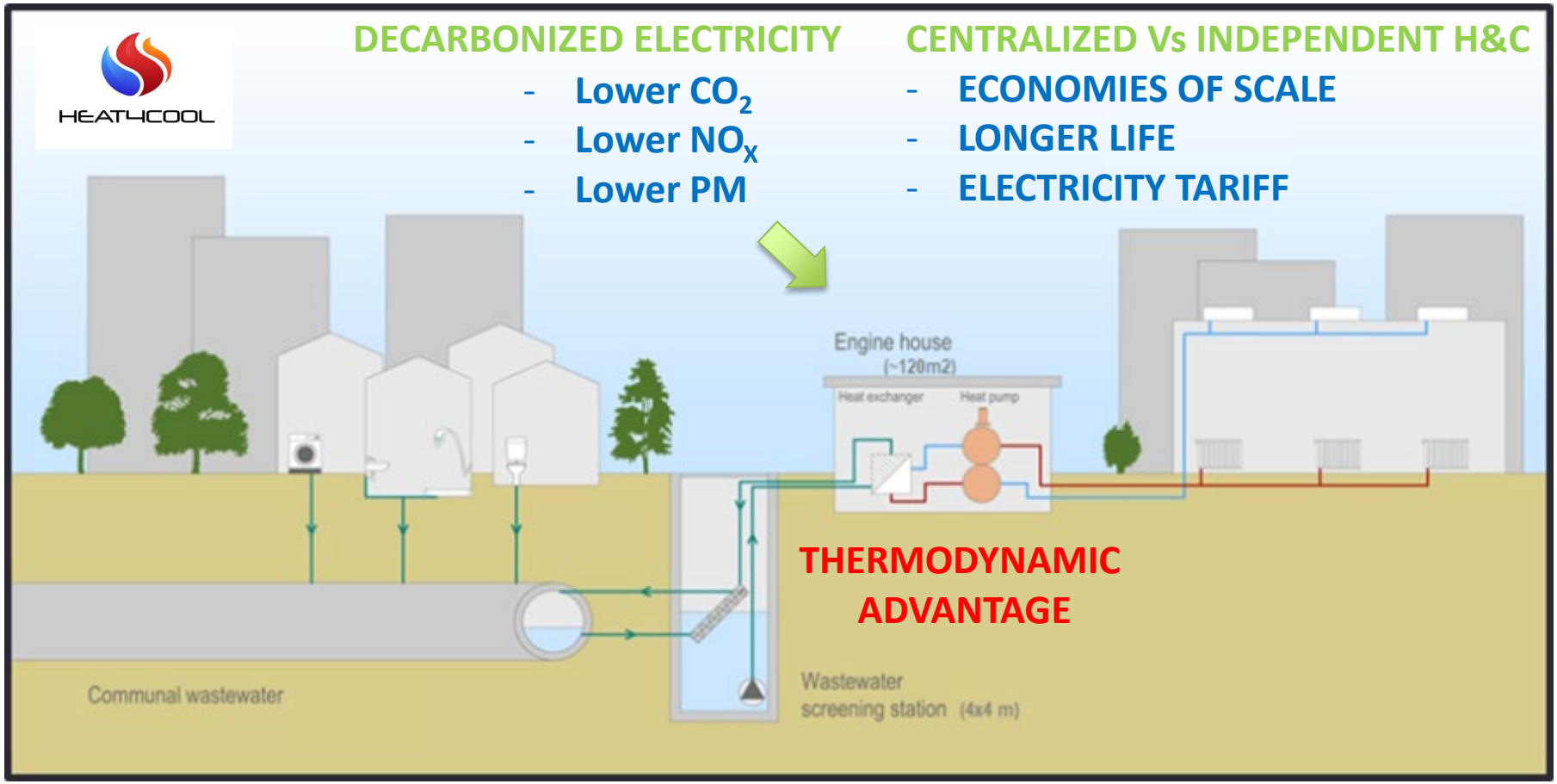
WORK STRUCTURE

- ❑ INTRODUCTION
- ❑ OBJECTIVE
- ❑ CONTEXT
- ❑ METHOD
- ❑ RESULTS
- ❑ CONCLUSION

INTRODUCTION

POWER TO HEAT/COOL COMPLEMENTED BY SEWAGE HEAT RECOVERY



OBJECTIVE

REPLICATION & OPTIMIZATION IN SOUTH EUROPE (COOLING, PV)

LOCATION: ITALY, MILANO (45 °N, SEWAGE T=13÷23°C, Q=110 MW_t)

END-USER: SHOPPING CENTER (10,000 ÷ 15,000 m^2)
Heating: 100 $kWh/m^2,y$
Cooling: 75 $kWh/m^2,y$

QUESTIONS:

- **COMPONENT SIZING AND CONTROL?**
- **OVERALL PLANT EFFICIENCY IN THE MW SCALE?**
- **COST COMPETITIVE Vs INDEPENDENT AIR-SOURCE HEAT PUMPS?**

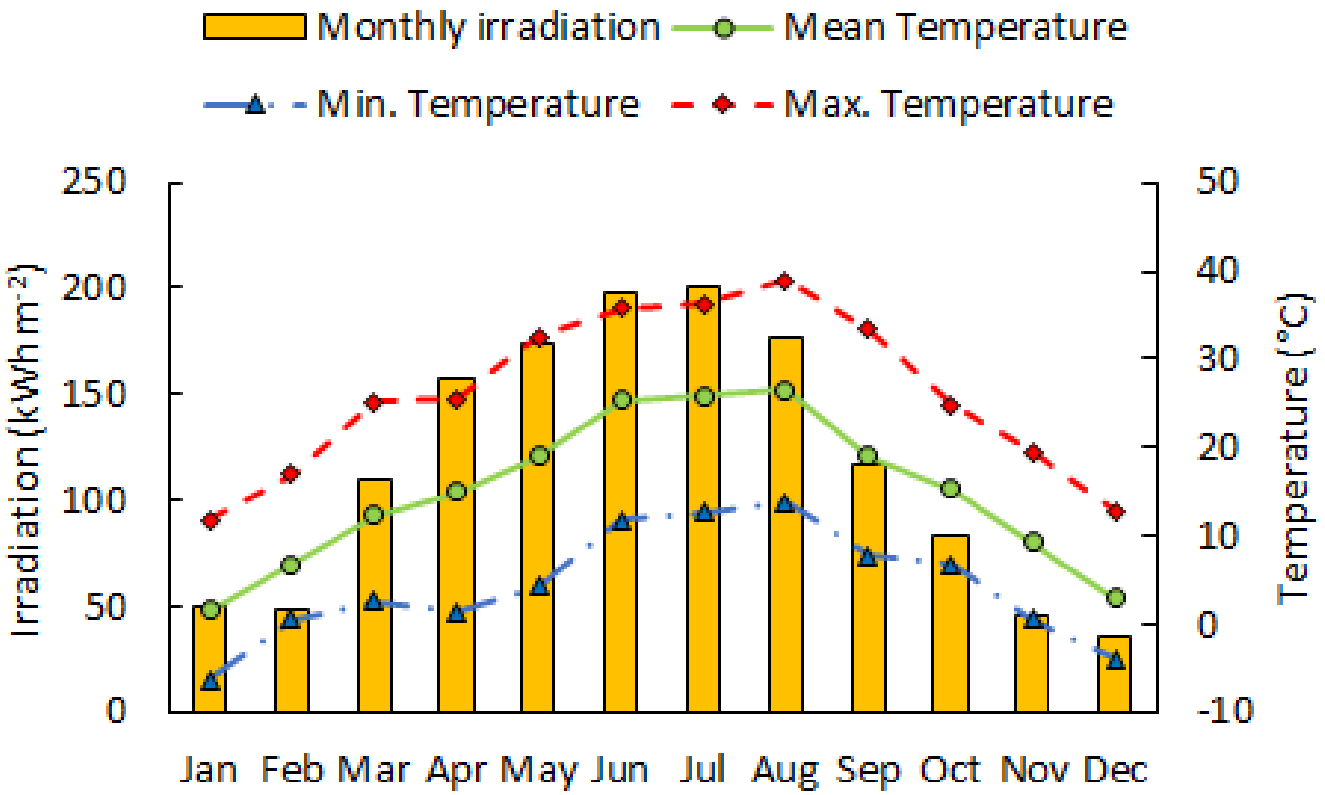
CONTEXT

WEATHER (2017, MILANO)

Air-source HP
Seasonal
Performances

SCOP = 2.41 (*)
SEER = 3.27

(*) including frosting

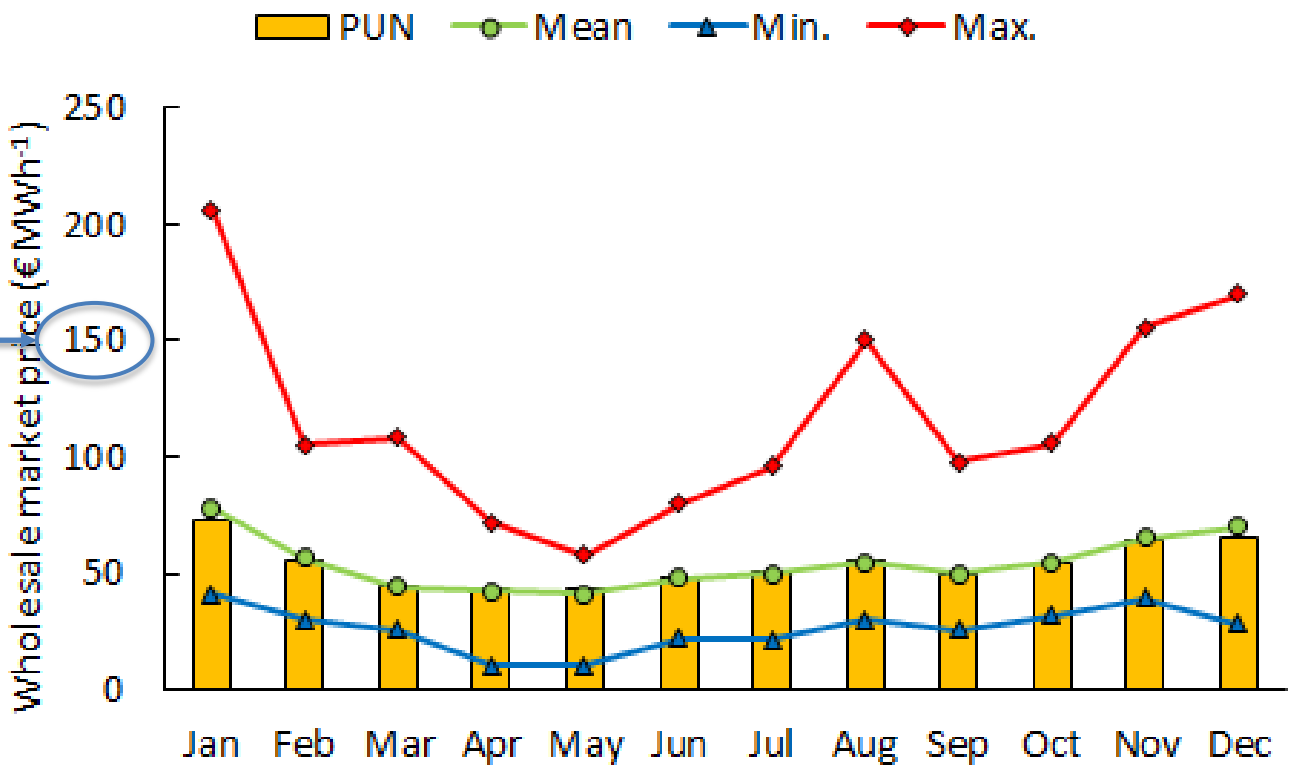


CONTEXT

ELECTRICITY MARKET (2017, NORTHERN ITALY)

Electricity price for the commercial user
LCOHC (*) = 96 €/MWh

(*) air-source HP



METHOD

- ENERGY MODELLING AND SIMULATION (1 YEAR, HOURLY TIME STEP)

- LEVELIZED COST OF HEATING AND COOLING (€/MWh)

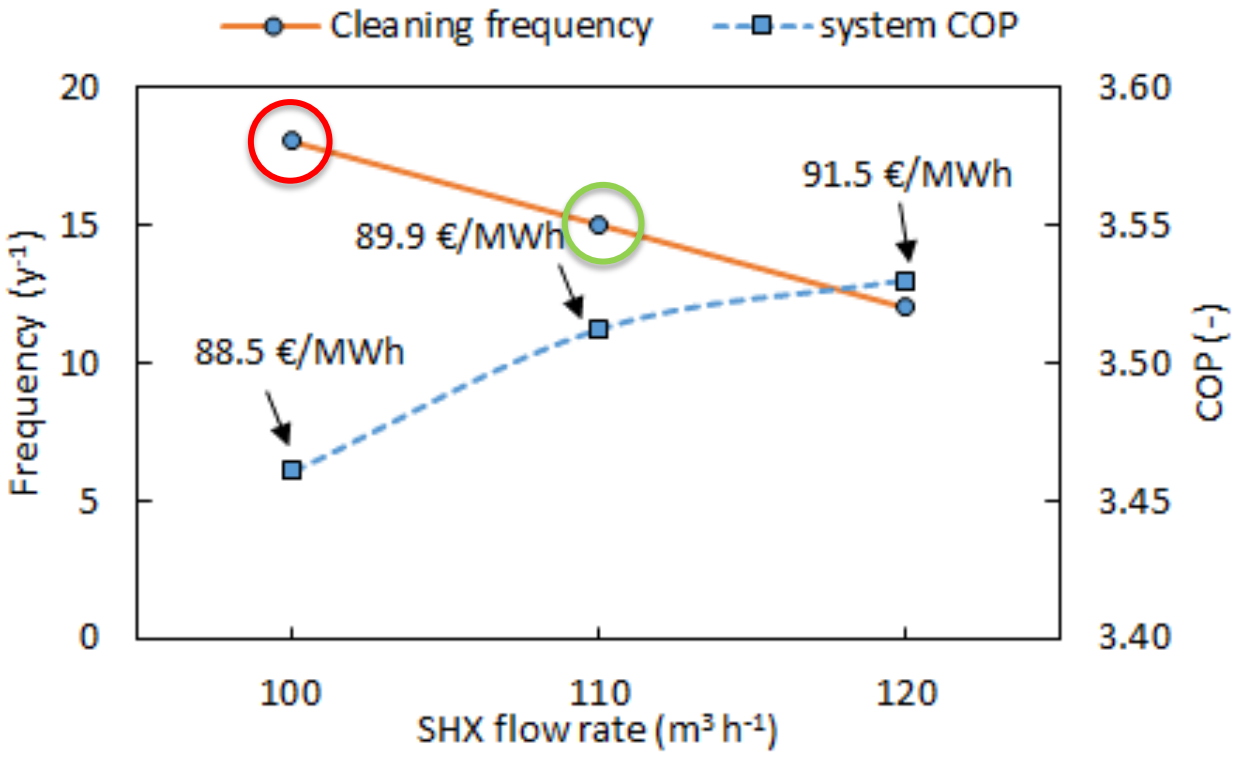
SEWAGE HEAT RECOVERY SYSTEM	ELECTRICAL HEAT PUMP	HEATING & COOLING NETWORK WITH STORAGE	HEATING AND COOLING LOADS
- DEGRADATION (decay of mass flow rate) - CLEANING (maintenance costs)	- TEMPERATURE (not constant, impact on COP, EER) - LOAD (not constant, impact on COP, EER)	- THERMAL LOSSES (sizing, insulation) - PARASITIC ENERGY (control of distribution pumps)	- TIME VARYING (from yearly demand to hourly profile: - gain and losses, - thermal capacity)

RESULTS

SIZING: SEWAGE HEAT EXCHANGER FLOW RATE

Preliminary sizing:
1100 kWt heat pump
150 m^3 storage
100 m^3/h sewage

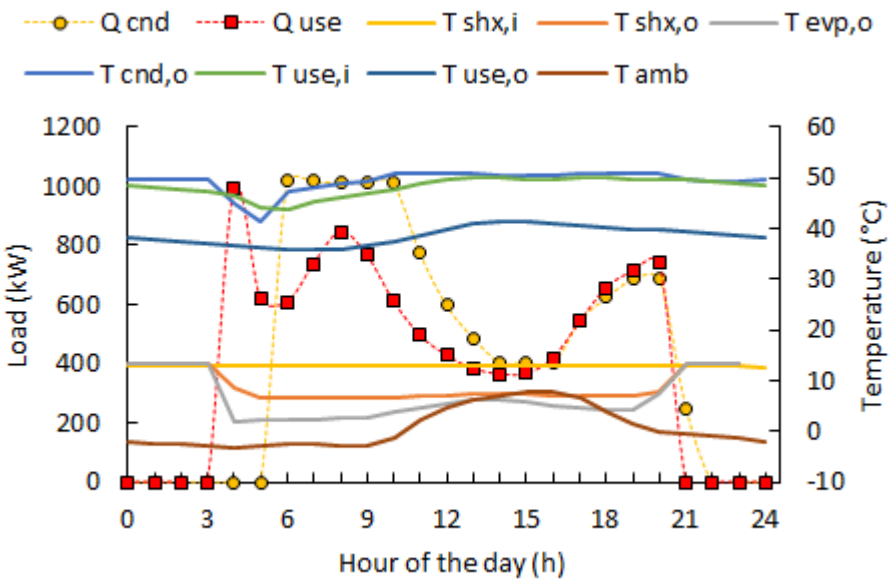
Final sizing:
1100 kWt heat pump
150 m^3 storage
110 m^3/h sewage



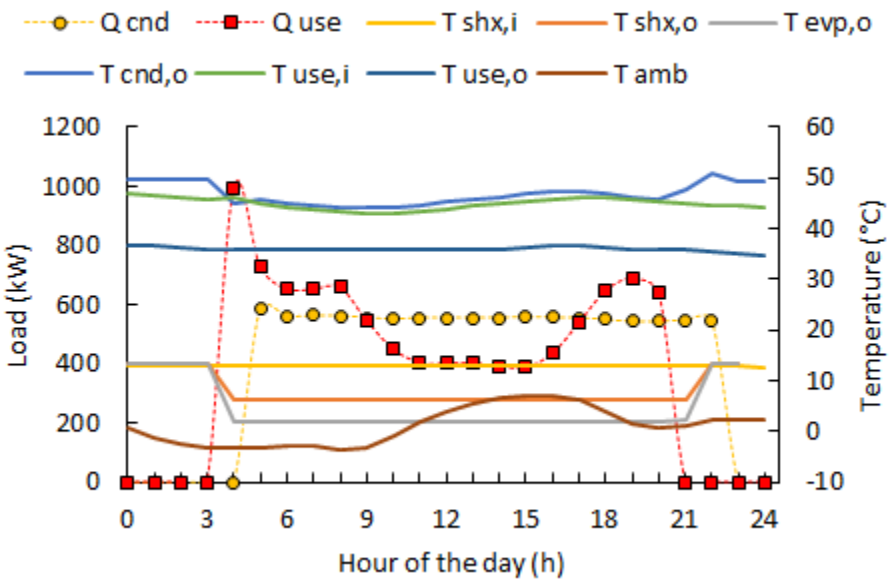
RESULTS

CLEAN Vs FOULED SEWAGE HEAT EXCHANGER

CLEAN



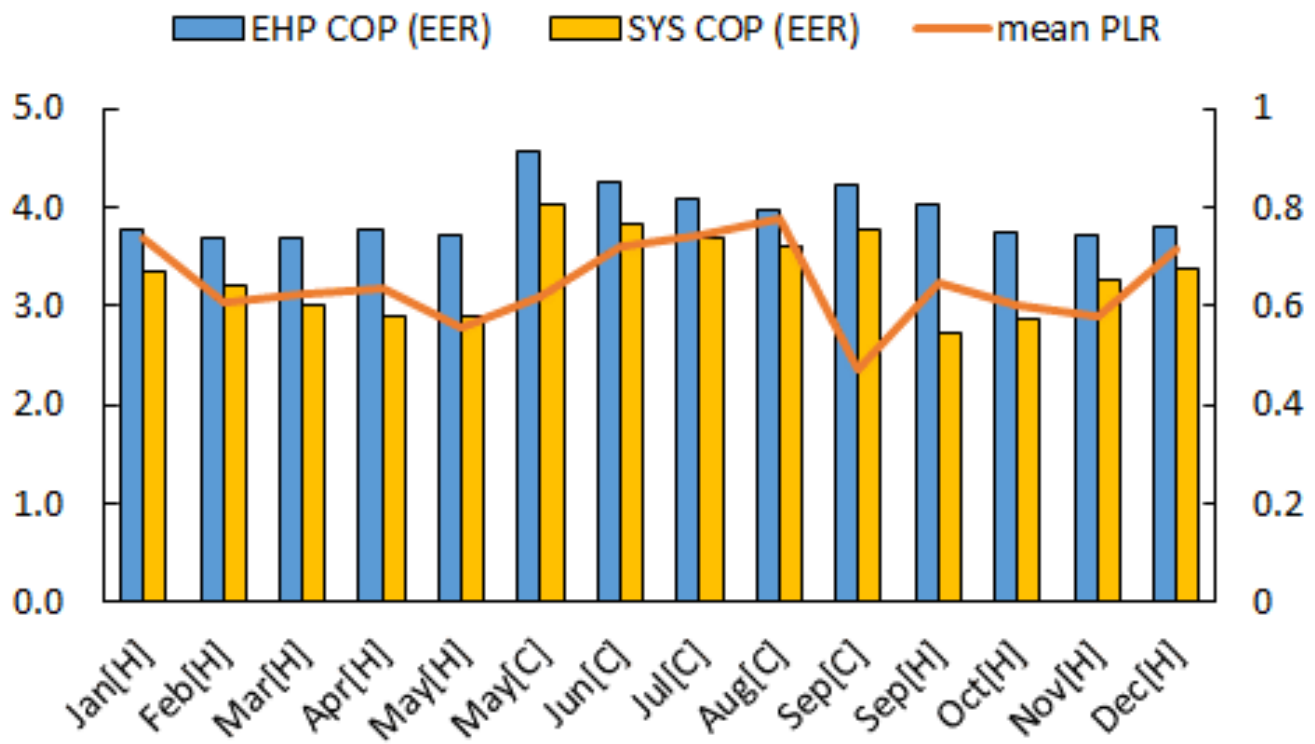
FOULED



RESULTS

HEAT PUMP AND OVERALL PLANT EFFICIENCY

[H] $SCOP_{sys}$= 3.16
[C] $SEER_{sys}$= 3.51



RESULTS

PV GENERATED ON-SITE (480 kWp)

LCOHC	Base case (€/MWh)	+ PV (€/MWh)	
CAPEX contribution	45.2	61.2	↑ Investment in PV
OPEX contribution	44.7	34.6	↓ Self-consumption
Annual benefit		-16.8	! Sales to grid
Total	89.9	79.0	

CONCLUSION

- Centralized Power to Heat/Cool cost competitive with respect to independent air-source heat pumps: LCOHC 90 (96) €/MWh
  - Superior performance: SCOP 3.16 (2.41), SEER 3.51 (3.27)
  - Economies of scale
- PV electricity generated on-site is an additional opportunity
  - LCOHC decreases from 90 to 79 €/MWh
- However, CAPEX contribution to LCOHC is high: correct sizing, specific to local boundary conditions
- Sewage Heat Exchanger degradation limits generation capacity and performance: good design of SHX, good cleaning method

THANK YOU FOR YOUR KIND ATTENTION !