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

DECARBONIZED ELECTRICITY
- Lower CO₂
- Lower NOₓ
- Lower PM

CENTRALIZED Vs INDEPENDENT H&C
- ECONOMIES OF SCALE
- LONGER LIFE
- ELECTRICITY TARIFF

THERMODYNAMIC ADVANTAGE
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 m²)
  Heating: 100 kWh/m²,y
  Cooling: 75 kWh/m²,y

QUESTIONS:

COMPONENT SIZING AND CONTROL?

OVERALL PLANT EFFICIENCY IN THE MW SCALE?

COST COMPETITIVE Vs INDEPENDENT AIR-SOURCE HEAT PUMPS?
**WEATHER (2017, MILANO)**

- **Air-source HP**
- **Seasonal Performances**
- **SCOP = 2.41 (*)**
- **SEER = 3.27**

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

(*) air-source HP
- ENERGY MODELLING AND SIMULATION (1 YEAR, HOURLY TIME STEP)

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

- 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

\[ [H] \text{SCOP}_{\text{sys}} = 3.16 \]
\[ [C] \text{SEER}_{\text{sys}} = 3.51 \]
## RESULTS

### PV GENERATED ON-SITE (480 kWp)

<table>
<thead>
<tr>
<th>LCOHC</th>
<th>Base case (€/MWh)</th>
<th>+ PV (€/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPEX contribution</td>
<td>45.2</td>
<td>61.2</td>
</tr>
<tr>
<td>OPEX contribution</td>
<td>44.7</td>
<td>34.6</td>
</tr>
<tr>
<td>Annual benefit</td>
<td></td>
<td>-16.8</td>
</tr>
<tr>
<td>Total</td>
<td>89.9</td>
<td>79.0</td>
</tr>
</tbody>
</table>

- **Investment in PV**: 61.2 €/MWh
- **Self-consumption**: 34.6 €/MWh
- **Sales to grid**: -16.8 €/MWh
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!