GUIDELINES FOR AN OPTIMAL INTEGRATION OF WATER-WATER HEAT PUMPS IN LOW-TEMPERATURE DHNs

Lessons learnt from the analysis of three networks in France

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OBJECTIVES AND METHODOLOGY

- How to better design, install and operate centralised and decentralised Heat Pumps?
- What economic KPIs need to be considered to design cost-effective installations?

Data from the monitoring system    ||    Business plans, invoices, annual financial reports    ||    Interviews of operators, installers, technicians

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System architecture</strong></td>
<td>Centralized</td>
<td>Decentralized</td>
<td>Decentralized</td>
</tr>
<tr>
<td><strong>Heat pumps</strong></td>
<td>2 x 1092 kW(_h) for heating</td>
<td>18 HPs for heating + 18 HPs for DHW + 1 HP for swimming pool. 4640 kW(_h)</td>
<td>13 HPs. In total: 739 kW(_h) for heating + 272 kW(_h) for cooling + 94 kW(_h) for DHW</td>
</tr>
<tr>
<td><strong>Back-up</strong></td>
<td>Gas boilers</td>
<td>Gas boilers</td>
<td>Electric resistance</td>
</tr>
<tr>
<td><strong>Heat source</strong></td>
<td>Sea water</td>
<td>Geothermal doublet</td>
<td>Rejects from wastewater treatment plant</td>
</tr>
<tr>
<td><strong>Number of substations</strong></td>
<td>15</td>
<td>18 + 1 (swimming pool)</td>
<td>5</td>
</tr>
</tbody>
</table>
| **Temperature (set points)** | Forward: 63°C  
Return: 50 °C | Heating: 36 °C -27/20 °C  
DWH: 60 °C – 27 °C  | Heating: 45 - 26 °C  
Cooling: 7 °C – 12 °C  |
| **HP start-up year**     | 2013             | 2012-2013                              | 2014                                   |
HEAT SOURCE

- The heat source determines the **availability** and performance of the HP
- The availability and **quality** (flow rate, temperatures, water quality) need to be guaranteed
- **Trained** design engineers and further sharing of **return of experience** are needed to avoid project weaknesses and to face the peculiar needs of each heat source type
- Complex installations → time consuming **maintenance**
- Not to be underestimated: length and complexity of the **authorisation** process
HEAT PUMP SELECTION AND SIZING

Heat Pump selection based on: **heat demand + source / sink temperatures** and their **variations** during the year:

- Thermal capacity: to be chosen to avoid part-load operations and frequent load variations
- **COP**: to be calculated for each heat source and sink temperature → good estimation of the HP **seasonal** performances
- Seasonal COP and HP cover rate often needed to calculate possible **incentives**
- Spring/autumn: most critical operating conditions, with higher demand fluctuations

Network A:
- Winter demand: 500-2000 kWh
- Summer demand: 300-450 kWh

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COP: THE IMPACT OF AUXILIARIES

- Significantly higher impact in summer, when the heat production is lower and the HPs work at part-load

- Due to the high impact on the global COP, the consumption of auxiliaries needs to be taken into account in all the project phases

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Impact of the load rate and return temperature on production temperature:

- **Summer**: low COP (**economic** and **energy efficiency**), but production temperature maintained thanks to the high return temperature (**contractual engagement**)
- **Winter**: high COP but, because of the **HPs** not optimally chosen, the set-point production temperature cannot be reached

→ Analysis in energy AND temperature needed

**Network A**

- **Set-points:**
  - Forward: 63°C
  - Return: 50°C
ECONOMIC ANALYSIS

Investment cost:

Operating costs: components of the heat production cost (€/MWh heat produced)
CONCLUSIONS

• Carefully select and size the heat pumps according to the yearly temperature and heat demand curves and not based on maximum values.

• Do not underestimate:
  – the maintenance needs of the heat source and of the heat pumps and its impact on the overall performances – especially in decentralised systems.
  – the electricity consumption of auxiliaries required by the heat pump.
  – a continuative relationship with the HP provider: several operational issues cannot be detected and resolved at the commissioning.
  – the impact of the network and the heat source temperatures on the expected performances.
  – The importance of Variable Speed Drives and heat storage for the optimization of the HP’s operations.

• Invest on the monitoring system: good performances of heat pumps rely on an optimised control strategy and on preventive maintainance.
THANK YOU

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