Modelling the effect of the transmitted information quality on the management of 4th Generation district heating

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CONTEXT

ENERGY EFFICIENCY POLICIES

→ Challenge for District Heating

4TH GENERATION DISTRICT HEATING:

- RES integration
- Storage integration
- Low temperature
- SMART

Sustainability & Competitiveness

NEEDS OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT):

- Which technology is the most adapted?
- What impact on the DH control?

CONTEXT

WIRELESS ICT FOR SMART DH:

• Can be a cheap solution
• Can adapted for existing and new DH

BUT

• Limited transmission time and capacity
• Limited data transmission due to encoding needs
• Non negligible information losses

Need of modelling DH functioning with limited information on demand
**METHODOLOGY**

HEATGRID: DH MODELLING AND OPTIMIZATION TOOL

- Multiple thermal sources models
- Optimization function: linear programming
- Oriented graph formalism
- Input: load demand (IDEAL OR TRANSMITTED)

Nodes: consumer/source/prosumer
Edges: distribution
CASE STUDY

1. Profile from noised HDD decomposition of monthly consumption
2. N₇ demand 2.5 times higher than N₃, N₄ and N₅

Production

<table>
<thead>
<tr>
<th>Node</th>
<th>Energy sources</th>
<th>Installed capacity [MW]</th>
<th>Cost [€/kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biomass</td>
<td>7</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>Gaz boiler</td>
<td>30</td>
<td>0.04</td>
</tr>
<tr>
<td>6</td>
<td>Gaz boiler</td>
<td>27</td>
<td>0.05</td>
</tr>
</tbody>
</table>
CASE STUDY

Optimal heat supply scenarii
(Minute wise simulation)

Merit order respected:
1. $N_1$ supply the base load (all the year)
2. $N_2$ head backup and $N_6$ local backup
CASE STUDY

LoRa (Long Range Radio)

- 36 s/hour max
- 2 s for 50 bytes messages → 18 messages/hour
- Possible information losses: ~13 messages/hour → ~5 messages/hour
  → 3 sets of 3 measured variables $(m, T_s, T_r)$/message
  → 15 powers values/hour

3 DISTRIBUTIONS OF RECEIVED MESSAGES:

1. ‘Packet’ distribution

2. Random distribution

3. Regular distribution

RESULTS AND DISCUSSION

SHIFT OF $N_6$ USE: delays in turning on/off of the local backup $N_6$ compared to the ideal case.

![Graph showing 'Packet' distribution and changes in power $P$ and differential power $dP$ over the days 20, 21, and 22 January. The graphs illustrate the comparison between the actual case and the ideal case.](image-url)
**RESULTS AND DISCUSSION**

**‘Packet’ distribution**

Maximal power differences ~ 6 MW

**Shift intervals durations:**

<table>
<thead>
<tr>
<th>Shift cumulated time</th>
<th>Mean duration</th>
<th>Max duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>7066’ (6.10 %)</td>
<td>31’5”</td>
<td>90’</td>
</tr>
</tbody>
</table>

![Graph showing 'Packet' distribution](image)

RESULTS AND DISCUSSION

Random and Regular Distribution

Maximal power differences ~ 1 MW

Shift intervals exist and last a few minutes:

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Shift cumulated time</th>
<th>Mean duration</th>
<th>Max duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random</td>
<td>1205’ (1.03 %)</td>
<td>4’20”</td>
<td>31’</td>
</tr>
<tr>
<td>Regular</td>
<td>2105’ (1.80 %)</td>
<td>6’25”</td>
<td>10’</td>
</tr>
</tbody>
</table>

Random distribution

Regular distribution
Symmetrical monotones: Over and under-productions are quite similar  

Annual energy over and under-productions comparable

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Over-production of local backup unit ((N_6)) [MWh]</th>
<th>Energy under-production of local backup unit ((N_6)) [MWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Packet’</td>
<td>642.2 (5.19 % of AP)</td>
<td>659.2 (5.33 % of AP)</td>
</tr>
<tr>
<td>Random</td>
<td>215.1 (1.74 %)</td>
<td>215.7 (1.74 %)</td>
</tr>
<tr>
<td>Regular</td>
<td>133.0 (1.07 %)</td>
<td>134.0 (1.08 %)</td>
</tr>
</tbody>
</table>
CONCLUSION & FUTURE WORK

WIRELESS ICT ARE INTERESTING FOR SMART DH

WHATEVER THE TRANSMITTED MESSAGE DISTRIBUTION:

→ LOW IMPACT OF ENERGY SYSTEMS MANAGEMENT CONNECTED TO DH

1. Regular or random distribution: $\Delta P \sim 1$ MW – shift intervals $\sim 5$ mn
2. ‘Packet’ distribution: $\Delta P \sim 6$ MW – shift intervals $\sim 30$ mn

NOW, LET’S SEE THE CONSEQUENCES CONSIDERING THE HEAT TRANSPORTATION TIMES AND INERTIA OF THE DH!
Thank you

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