OptHySys

Optimisation of Hybrid Energy Systems

Olatz Terreros, Daniele Basciotti, Edmund Widl, Henein Sawsan
AIT Austrian Institute of Technology GmbH
Background

Why hybrid energy grids?

- Increase integration of renewable sources
- Improve supply-demand balance
- Increase energy savings
- Reduce CO₂ emissions

Challenges

- Thorough investigation needed on the real impact and benefits of hybridisation
- Absence of tools for the cooperative simulation of multiple grids
Background

OptHySys - Optimisation of Hybrid Energy Systems

• **Objective**
  Assessment of synergy potentials in the operation of electric distribution grids and district heating networks, on the basis of a relevant scenario in Austria.

• **Period**
  From 01.06.2015 to 31.05.2016

• **Funds**
  Climate and Energy Funds

• **Programme**
  Energieforschungsprogramm 2014
Case study
Case study

Innsbruck
Case study
Gas boiler 630 kW
Gas boiler 865 kW
Gas boiler 80 kW
Biomass boiler 950 kW
PV system 160MWh/year
CHP 257 kW th./ 200 kW el.
Heat pumps
Goal

• Design and operational optimisation of a hybrid energy system in Innsbruck.

• The following goals have guided the optimisation process:
  • maximisation of the local consumption of on-site PV generation for thermal production
  • minimisation of on-site CO₂ production
  • minimisation of electricity imported from the external grid

• Methodology:
  1. Development of the controller.
  2. Modelling of the thermal and electric grid.
  3. Coupling of the thermal, electric grid and controller (co-simulation)
Controller

Operational strategy

• Sufficient PV production?
  (1) Run heat pumps with the highest priority.
• Heat pumps cannot cover the demand?
  (2) Run biomass boiler.
• Demand still cannot be covered entirely?
  (3) Run the CHP.

Implementation

• The formulation of the goals from above is programmed as a linear optimisation problem.
• Optimal heat flows are calculated in real-time.
• System operational constraints are taken into account.
Co-simulation setup

Thermal network model

Electric network model

Dymola

PowerFactory

Controller

FMU

OutputAdapter

FileWriter2

FileWriter
Design optimisation variations

- Storage volume

<table>
<thead>
<tr>
<th>Address</th>
<th>Variation 1</th>
<th>Variation 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rossaugasse 2</td>
<td>15 m³</td>
<td>20 m³</td>
</tr>
<tr>
<td>Rossaugasse 4</td>
<td>25 m³</td>
<td>30 m³</td>
</tr>
</tbody>
</table>

- Heat pump size

<table>
<thead>
<tr>
<th>Address</th>
<th>Variation 1</th>
<th>Variation 2</th>
<th>Variation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste water</td>
<td>100 kW</td>
<td>150 kW</td>
<td>200 kW</td>
</tr>
<tr>
<td>Ground water</td>
<td>50 kW</td>
<td>50 kW</td>
<td>50 kW</td>
</tr>
</tbody>
</table>

Assessment of the potential of HP integration

The ground water HP is used as backup due to its lower efficiency compared to waste water HP.
Design optimisation

System configurations

heat pumps

maximize usage of local PV generation

assessment of the potential for heat pump integration

thermal storages

• basically same performance w.r.t. thermal KPIs
• slightly worse performance w.r.t. electrical KPIs
• needs more actuation of production plants

config4  config5  config6
Design optimisation

Sizing of the heat pumps

Exploitation of local production from PV:

- **small size** heat pump configuration (*config4*) → limited by maximal electrical consumption
- **large size** heat pump configuration (*config6*) → limited due to high operational production threshold
- **medium size** heat pump configuration (*config5*) → optimal compromise between *config4* and *config6*
Design optimisation

Sizing of the heat pumps

Heat pump yearly energy production (MWh/year)

Config. 6
- Waste water HP
- Ground water HP
- Total

Config. 5

Config. 4

0 50 100 150 200 250
## Design optimisation

### Sizing of the heat pumps

<table>
<thead>
<tr>
<th>Thermal storages</th>
<th>Small size configuration</th>
<th>Medium size configuration</th>
<th>Large size configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WWHP: 100 kW, GWHP: 50 kW</td>
<td>WWHP: 150 kW, GWHP: 50 kW</td>
<td>WWHP: 200 kW, GWHP: 50 kW</td>
</tr>
<tr>
<td>Small size</td>
<td>config1</td>
<td>config2</td>
<td>config3</td>
</tr>
<tr>
<td>RG 2: 15 m³, RG 4: 25 m³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large size</td>
<td>config4</td>
<td>config5</td>
<td>config6</td>
</tr>
<tr>
<td>RG 2: 20 m³, RG 4: 30 m³</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Goals achieved?

Integration of renewable sources increased?

Electricity coverage (%)

![Graph showing electricity coverage for Baseline and Hybrid scenarios](image_url)
Goals achieved?

Energy savings increased?

Weighted heat production costs (€/MWh)

Baseline scenario

Weighted heat production costs per plant (%)

Baseline scenario

Hybrid scenario
Goals achieved?

CO₂ emissions decreased?

![CO₂ emissions graph]

**Baseline scenario**

**Hybrid scenario**
Conclusions

- The methodology presented enables the evaluation of the synergies between multiple energy grids.
- Development of a cosimulation environment to simulate multiple grids.
- Increase of PV integration (13%).
- Reduction of CO₂ emissions (60%).
- Further demonstration projects would allow to verify the potential of hybridisation.
Thank you for your attention.

Olatz Terreros
AIT Austrian Institute of Technology GmbH
olatz.terreros@ait.ac.at
+43 50550 6359