The economic potential of district heating under climate neutrality: the case of Austria

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District Heat Generation, Austria

- Share of district heating in Austria, 2019: 20% of final energy consumption for space and water heating
- Future evolution and potential?

![Graph showing district heat generation in Austria from 2005 to 2018 with various sources like CHP, renewable DH, gas boilers, oil boilers, biomass boilers, and waste incineration.]

- Share CHP (%)
- Share Renewable DH (%)

[Legend: Other renewables (Solar, HP, Deep geothermal), Biomass boilers, Waste incineration boiler, non-renewable, Gas boiler, Oil boiler, Biomass CHP, CHP waste incineration, non-renewable, CHP gas, CHP oil, CHP coal]
Motivation and research question

- Energy Efficiency Directive – Art 14: Promotion of efficiency in the supply of heating and cooling
- "Comprehensive assessment of the potential for an efficient heating and cooling supply" is to be carried out by Member States every 5 years (starting in 2015)
- Project on behalf of the Austrian Federal Ministry of Climate Action to fulfill the reporting obligation of Art. 14 & Annex VIII of the EED

Research questions for this presentation:
- What is the economic potential of renewable district heating under different scenarios for the case of Austria?
  - Which types of areas can/should be supplied by district heating?
  - What is an economically viable district heating supply mix in different types of district heating systems and in Austria in general?
  - What are drivers for the uptake of future district heating potentials?
- How do decarbonisation targets affect the way how cost-benefit analyses foreseen in the comprehensive assessment should be applied?
Focus on space heating and hot water preparation (industrial process heating only for consideration of industrial waste heat supply)

„Efficient district heating“: according to the EED currently under revision => considered under the light of achieving climate targets

According to the current Austrian government programme, we assumed climate neutrality to be achieved in 2040.
Methodology for identifying economic potential of DH

**Step 1**

- **$C_{DH}$** ... DH supply cost [EUR/MWh]
- **$K_{WV}$** ... Costs of heat distribution
- **$K_{WE}$** ... Costs of heat generation

**Step 2**

- Within the region types
  - Similar supply option potentials
  - Similar size (DH potential)

**Step 3**

- For various scenarios
  - 2030/2050
  - Demand scenarios (saving scenarios)
  - DH connection rates
  - Energy and CO2 prices
  - Private and public points of views

**Step 4**

- **$C_{DE}$** ... Cost of decentralized supply option [EUR/MWh]
- **$K_{OE}$** = $\sum (...)$
  - CAPEX
  - OPEX
  - Energy
  - CO2
Step 1:
Identification of regions that could potentially be suitable for district heating
(based on heat distribution costs)
Step 1: Identification of regions that could potentially be suitable for district heating

Scenarios & characteristics of the portfolios
(with different characteristics in different types of regions and depending on the need to meet the needs)

- **WEM** – With existing measures (includes already implemented measures, May 2016)
- **Transition Scenario** – a 80% reduction of CO2-Emissions till 2050 compared to 1990
  
  Further assumptions for full decarbonisation of the gas supply to meet the objective of climate neutrality

Step 1: Identification of regions that could potentially be suitable for district heating

Resulting regions

- Identified regions in the maximum scenario:

- Impact of different scenarios on the size of district heating areas:

  Scenario: WEM / transition
  Year: 2030 / 2050
  Connection rate: 45% / 90%
  max. heat distribution costs: 30/40/50€/MWh
Step 2:
Clustering of regions with similar characteristics (size, resource availability and existing infrastructure).
Clustering of potential district heating regions

- Individual consideration of the 4 major DH regions.
  - Types 1-4: Vienna, Graz, Linz, Salzburg

- Clustering of all other regions into 6 remaining district heating region types.
  - according to heat supply potentials (gas availability, geothermal potential, waste heat potential, river size)
  - and existing heat networks
Step 3:
Calculation of costs for heat supply
(District heat supply and object-related supply)
Methodology district heating supply

- Use of the Hotmaps - DH dispatch - stand-alone model
- Minimization of running costs of heat supply to the district heating network
- Calculation for all 8760 hours of a representative year
- COP of heat pumps depending on relevant temperatures (flow, return, heat sources)
- Predefined technology park
- Calculation of numerous variants per region type

1https://hotmapsdispatch.readthedocs.io/en/latest/
### Scenarios for district heating supply

<table>
<thead>
<tr>
<th>Scenario Type</th>
<th>No.</th>
<th>Description</th>
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</table>
| Region types               | 10  | 4 specific regions (Vienna, Graz, Linz, Salzburg)  
6 typical regions (demand / supply potential)  
For each type of region::  
  • Temperatures (air, system, heat sources)  
  • Irradiation  
  • Load profile  
  • Resource availability |
| Year                       | 2   | 2030 / 2050                                                                                                                                  |
| Assessment method          | 2   | Financial (BW) / economic(VW)                                                                                                               |
| Heat demand                | 2   | Two demand levels                                                                                                                             |
| Energy carrier and CO2 prices | 2   | Low vs. high prices                                                                                                                          |
| Technology Portfolios      | 3   | A. predominantly gas  
B. Gas with renewables and excess heat  
C. Predominantly renewables and excess heat, almost no gas |
| Total                      | 480 |                                                                                                                                              |
Results

Exemplary result of DH supply:

Cluster 7 (Regions with existing DH grids, gas infrastructure and high potential for river water source heat pump)
Step 4:
Identification of the economic potential for efficient heat supply.
(Comparison of costs for district heating and object-related supply).
Step 4: Identification of the economic potential for efficient heat supply

Methodology

\[ C_{DH} \quad \text{Cost of supply from district heating} \quad \text{EUR/MWh} \]

\[ C_{DE} \quad \text{Cost of decentralized supply} \quad \text{EUR/MWh} \]

**Comparison:**

- For each district heating potential area:
  - \[ C_{DH} < C_{DE} \] District heating is economical
  - \[ C_{DH} > C_{DE} \] District heating is not economical

Total district heating potential [GWh/yr] in all areas where district heating is economic = Economic potential.

Sum of heat supply from the different technologies [GWh/yr] in all areas where district heating is economical = Economic potential per technology.
Results

Share of economic DH supply from total heat supply

2050, socio economic point of view

<table>
<thead>
<tr>
<th>Transition</th>
<th>WEM</th>
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<tr>
<td>Useful energy demand, all buildings</td>
<td>Max distribution costs [EUR/MWh]</td>
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<tr>
<td>Useful energy demand, district heating potential</td>
<td>Connection rate [%]</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Prices</th>
<th>High prices</th>
<th>Low prices</th>
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<tr>
<td>45%</td>
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</table>
Results

Result of heat supply 2050, socio economic point of view

- Biomass: still significant share; without high efficiency gains, increasing pressure on biomass resources
- Heat pumps: strongly increasing contribution also in district heating
- Geothermal energy is very relevant when available locally
- Large solar thermal systems: depending on size and remaining generation portfolio
Conclusion

- Carrying out the cost-benefit analysis foreseen in the EED under the target of climate neutrality means to exclude all fossil based systems.

- Thus, assuming full decarbonization (gas from 100% green gas), gas is not a cost-effective option in the space heating sector (neither for district heating nor decentral).

- Thermal storage systems are becoming increasingly important (uncertainty regarding costs).

- Achievable connection rates have a major impact on the economic potential of district heating.

- The heat demand scenarios have less of an impact on the district heating potential than the achievable connection rates.
Outlook and open questions

- Parameter variation for different scaling of thermal storage in different types of district heating grids and for different generation portfolios

- Analyses for different system temperatures and on district level

- Extension of the approach to an EU-wide set of representative district heating grids (Tender for the EC)

- Granularity and system boundaries in district heating sector modelling?
  - Low level of granularity in full energy system models vs.
  - High level of granularity in our bottom-up consideration without considering feedback loops, e.g. on electricity price

- Comparison of method and results among different countries?
Thank you for your attention!

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