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1st IAEE Online Conference 2021

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The 1st IAEE Online Conference takes place on 7th – 9th June 2021

IAEE Award Ceremony

This digital conference is exceptional in many ways:

1. It offers to bring together energy economists, policymakers and business leaders from around the world in real time for 3 consecutive days. This event will allow a non-stop exchange from San Francisco to Tokyo.
2. It will feature mid-day keynote addresses to bring together a global audience in a common time zone.
3. It will address the ideal climate and energy policy regime that should simultaneously respond to potentially conflicting objectives, especially in the era of COVID: ensuring energy security, promoting universal access to affordable energy services, and fostering greener and more sustainable energy systems while taking into account geopolitical and economic dimensions.

In this context, IAEE's international online conference aims to bridge the latest scientific advances in energy economics and its relevance to practical experiences in the energy sector. It will also host 180 parallel sessions and numerous poster sessions. The digital edition reaches out to a wider global audience, regardless of time zone, and provides a unique online platform for academics, policymakers, and business leaders from around the world to present and discuss the latest economic research on pressing energy issues in an open, non-partisan setting.

News

Tweets by @IA4EE

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Thanks to @FSR_Energy's @SchTim1 and @LeonardoMeeus for citing mine and @AnneHoutman's @IA4EE Texas Power crisis article in their WP on CRMs in the EU, incl. in comp. with the US, the CEP CRM design principles, and consumers' role around resource adequacy. fsr.eui.eu/publications/?...

Capacity remuneration mechanisms in ...
In this paper, we discuss the implementati...

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POTENTIAL OF EFFICIENT HEATING AND COOLING IN THE LIGHT OF DECARBONISATION TARGETS: THE CASE OF AUSTRIA

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Marcus Hummel, David Schmidinger, e-think

IAEE 8 June 2021

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
  - What are economic potentials of efficient district heating (DH) supply in Austria by 2030 and 2050?
    - 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?

Scope and system boundaries

- 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

- The study assumes full climate neutrality of the Austrian energy system until 2040 in line with the current government programme and the European Green Deal.

Method

- **Step 1**
  - Survey of the status quo (heat demand and distribution, existing supply infrastructure, technologies and energy sources used)
- **Step 2**
  - Analysis of the potential of industrial waste heat for feeding into district heating networks
- **Step 3**
  - Identification of regions that could potentially be suitable for district heating (based on heat distribution costs).
- **Step 4**
  - Clustering of regions with similar characteristics (size, resource availability, and existing infrastructure).
- **Step 5**
  - Calculation of costs for heat supply (district heating supply and object-related supply).
- **Step 6**
  - Identification of the economic potential for efficient heat supply (comparison of costs for district heating and decentral supply).

Methodology for identifying economic potential of DH

K_{FW} … District heat supply cost

[EUR/MWh]

Step 4

Comparison …

K_{OE} … Cost of decentralized supply option

[EUR/MWh]

Step 3

Step 2

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

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

K_{WV} … Costs of heat distribution

Step 1

K_{WE} … Costs of heat generation

Step 3

$K_{WV} = \Sigma$ (…)
CAPEX
-
-
-

$K_{WE} = \Sigma$ (…)
CAPEX
OPEX
Energy
CO_2

$K_{OE} = \Sigma$ (…)
CAPEX
OPEX
Energy
CO_2

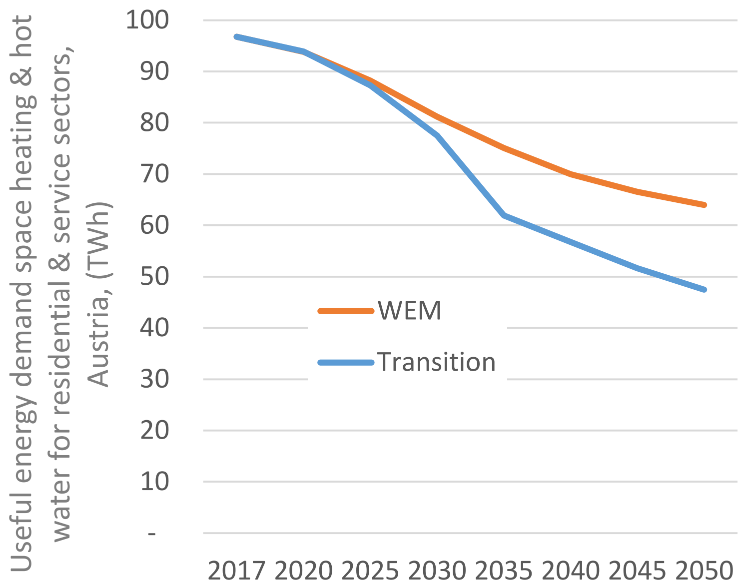
Step 1:

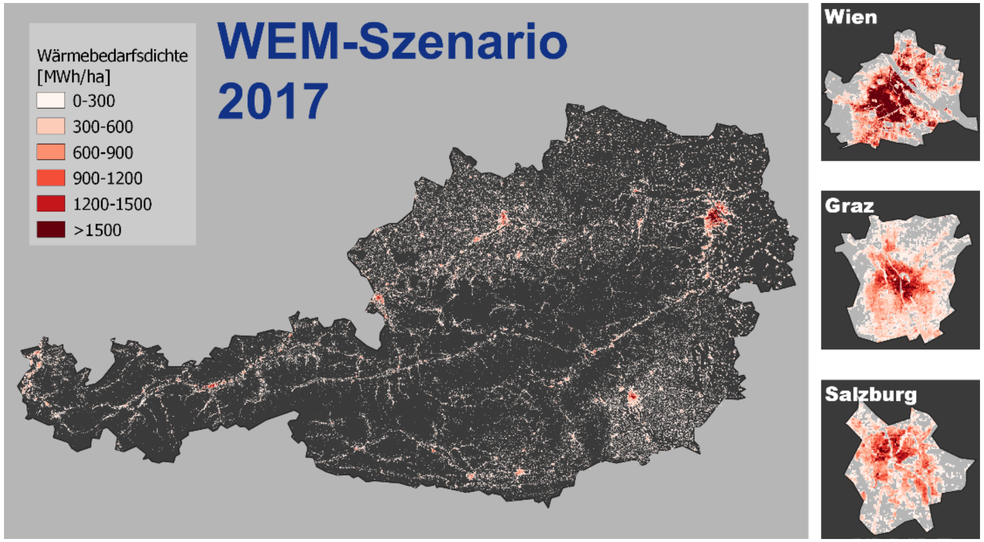
Identification of regions that could potentially be suitable for district heating

(based on heat distribution costs)

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

Scenarios of heat demand





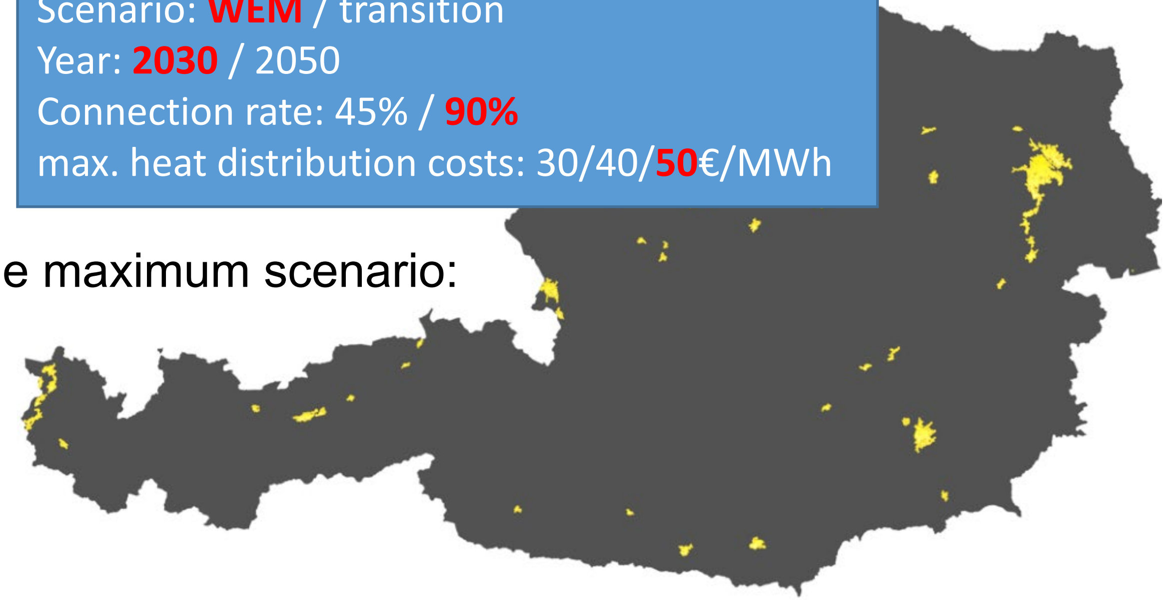
- WEM – With existing measures (includes already implemented measures, May 2016)
- Transition Scenario – a 80% reduction of CO2-Emissions till 2050 compared to 1990

Further assumptions for full decarbonisation of the gas supply to meet the objective of climate neutrality

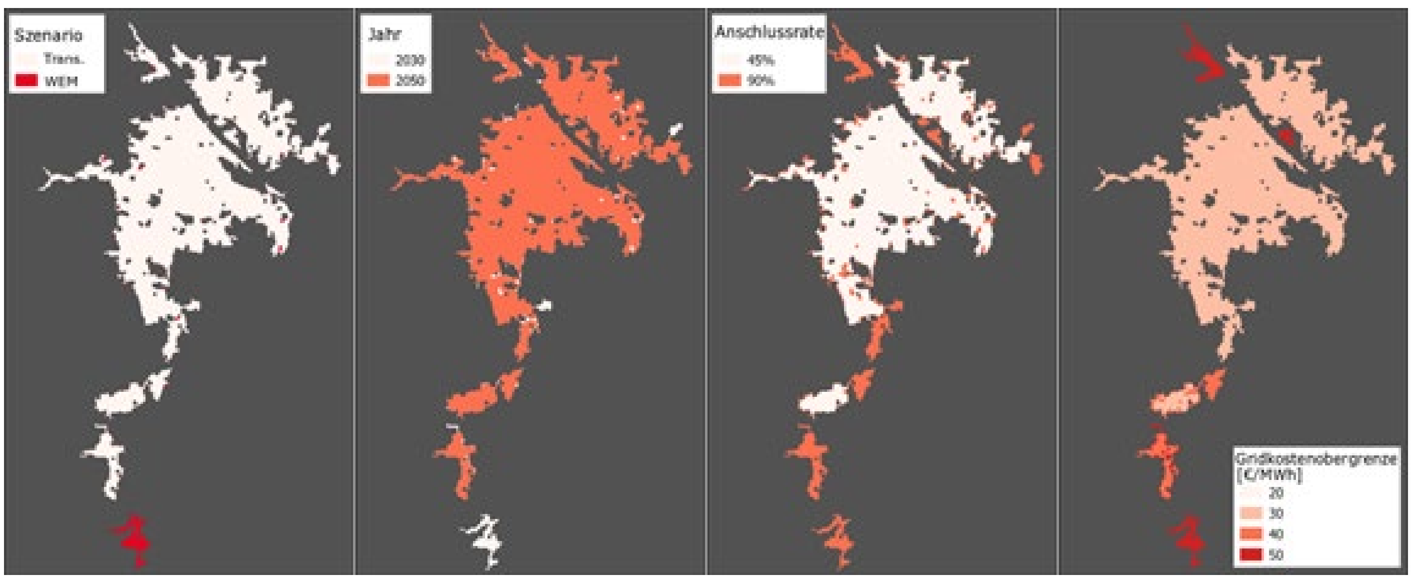
Resulting regions

Scenario: **WEM** / transition
Year: **2030** / 2050
Connection rate: 45% / **90%**
max. heat distribution costs: 30/40/**50**€/MWh

- Identified regions in the maximum scenario:



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



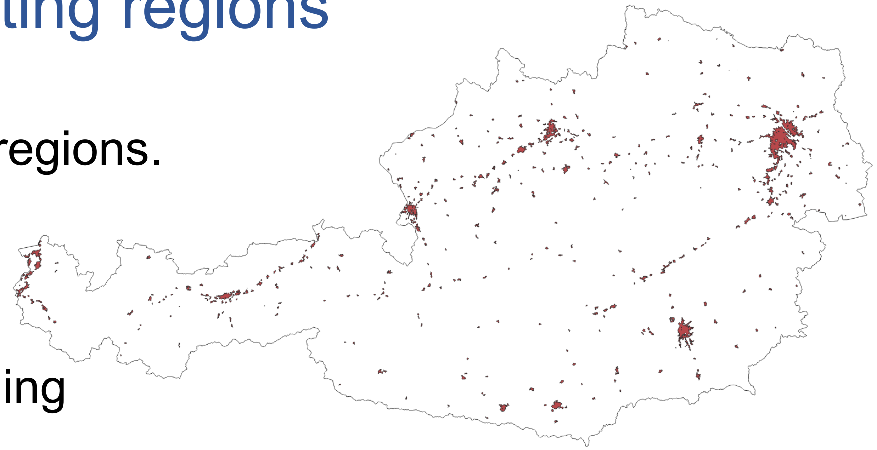
Step 2:

Clustering of regions with similar characteristics

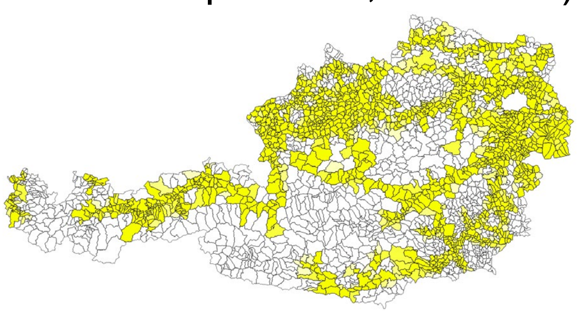
(size, resource availability and existing infrastructure).

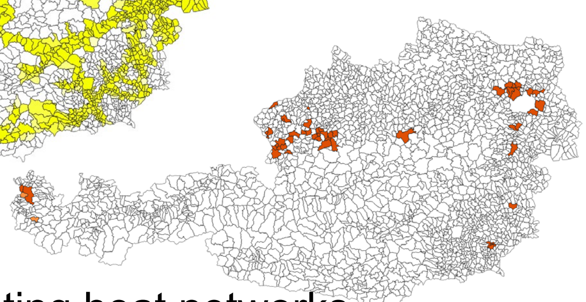
Clustering of potential district heating regions

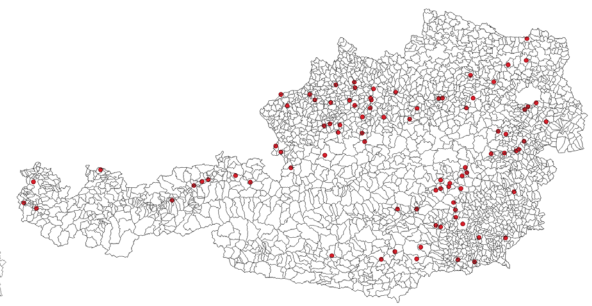
- Individual consideration of the 4 major DH regions.
  - Types 1-4:
    Vienna, Graz, Linz, Salzburg

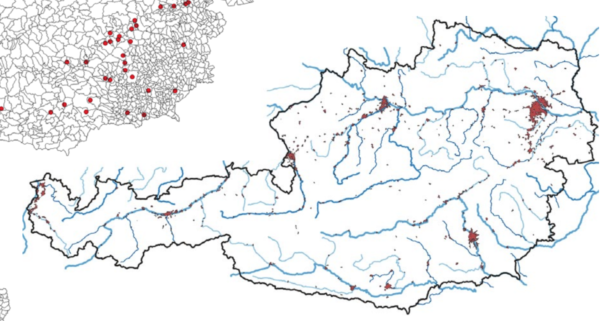


- Clustering of all other regions into 6 remaining district heating region types.
  - according to heat supply potentials (gas availability, geothermal potential, waste heat potential, river size)

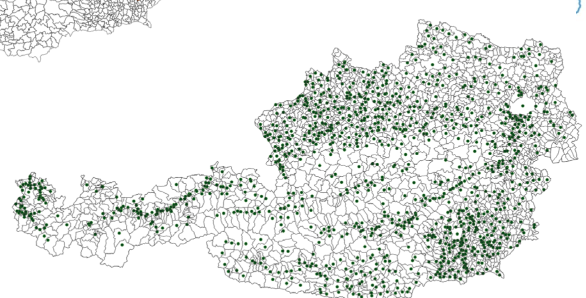






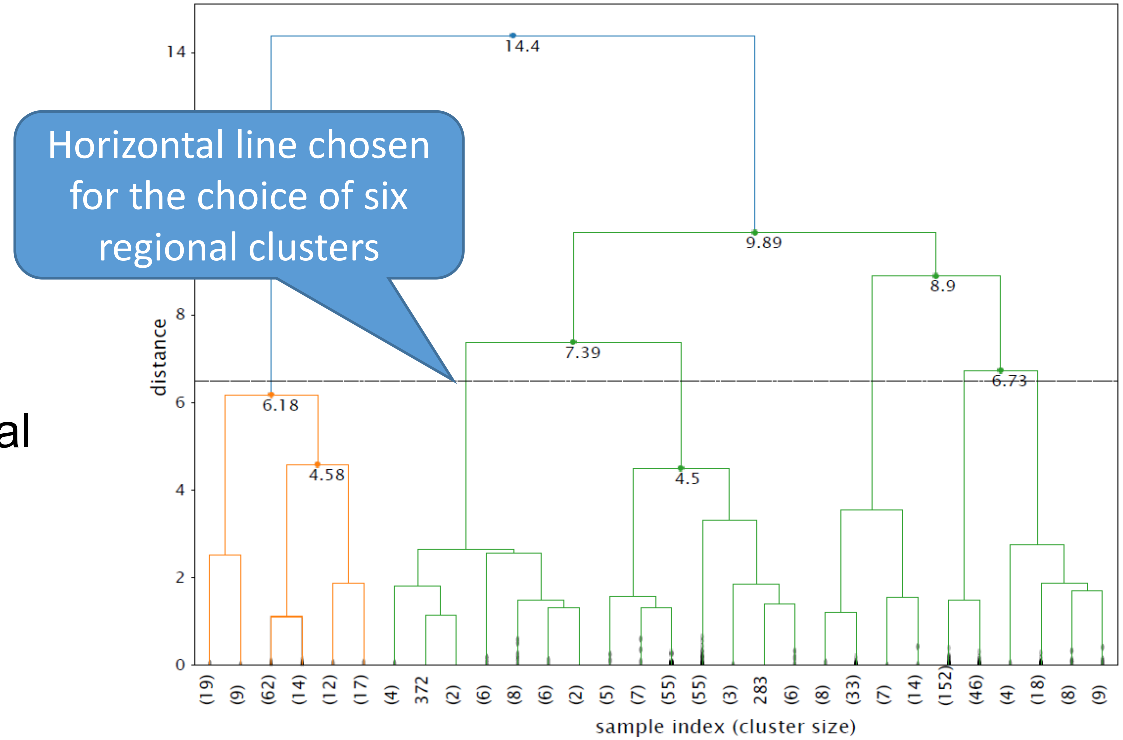


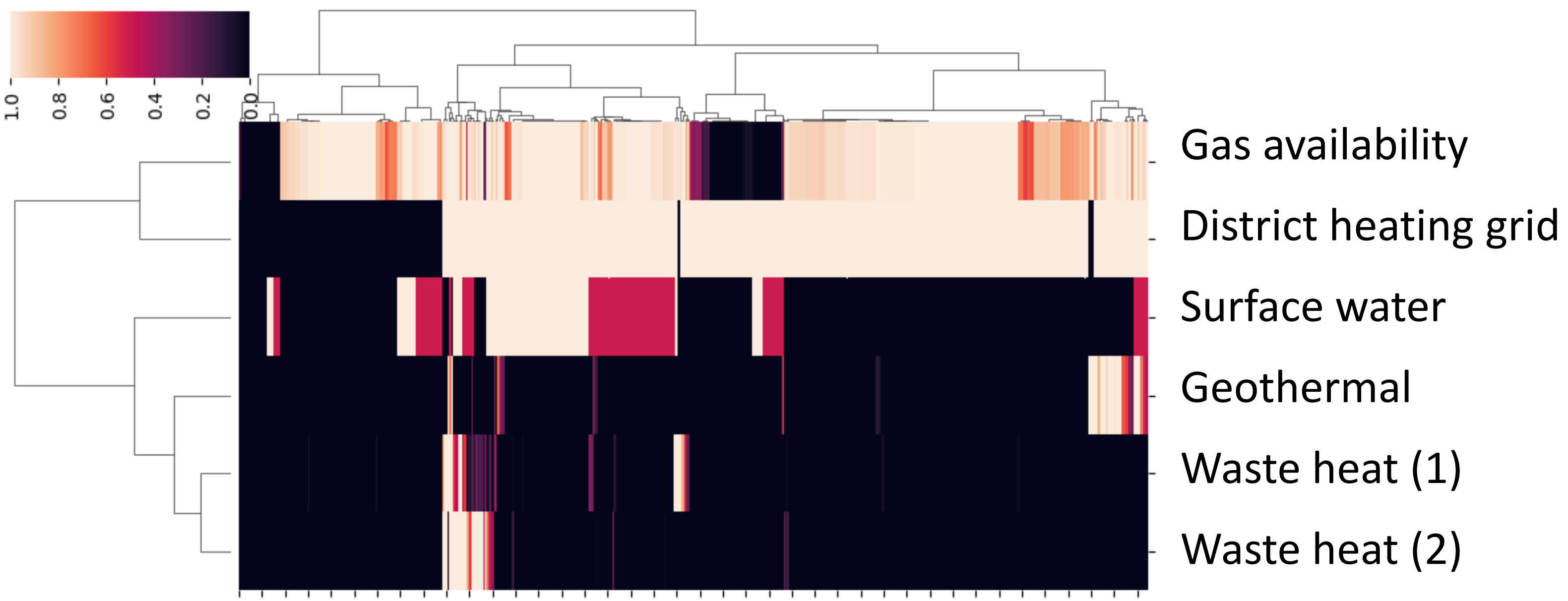
  - and existing heat networks



Clustering of potential district heating regions

- Dendogram (right hand graph) shows the „distance“ of regional clusters in terms of supply potentials and availability of a district heating grid





Step 3:

Calculation of costs for heat supply

(District heat supply and individual, decentral supply)

Hotmaps Dispatch Model

The Objective function : $\min(c_{total} - rev_{total})$

- **Components of c_{total}**
  - capital expenditures

$$CAPEX = \sum_j Cap_j \cdot i_j \cdot \alpha_j + \sum_{hs} sCap_{hs} \cdot i_{hs} \cdot \alpha_{hs}$$

$$\alpha_{j,hs} = \frac{(1+z)^{LT_{j,hs}} \cdot z}{(1+z)^{LT_{j,hs}} - z},$$

  - Operational Fix Costs

$$OPEX_{fix} = \sum_j Cap_j \cdot opex_{FIX_j} + \sum_{hs} sCap_{hs} \cdot opex_{FIX_{hs}}$$

  - Operational Costs

$$OPEX = \sum_{j,t} x_{th_{j,t}} \cdot (opex_{var_{jt}} + \frac{p_{ec_{j,t}}}{\eta_{th_j}} + \frac{f_{em_{ec_j}} \cdot p_{CO_2}}{\eta_{th_j}})$$

  - ramp costs of CHP and waste incineration plants

$$\sum_{j,t} (x_{th_{jt}} - x_{th_{j,t-1}}) \cdot 100 \frac{€}{MWh} \left| (x_{th_{jt}} - x_{th_{j,t-1}}) > 0 \right.$$

$$\forall j = \{CHP, waste\ treatment\}$$

$$\forall t = [1,8760]$$

- **Components of rev_{total}**
  - sale of electricity

$$\sum_{j,t} x_{el_{jt}} \cdot p_{s.el_{j,t}}$$

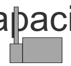
Legend		
Variable	**Description**	**Unit**
Cap_j	Capacity of the j-Generator	MW
i_j	specific investment cost of the j-Generator	$\frac{€}{MW}$
$\alpha_{j,hs}$	annuity of the j-Generator/hs-Storage	$\frac{1}{a}$
$sCap_{hs}$	Capacity of the hs-Storage	MWh
i_{hs}	specific investment cost of the hs-Storage	$\frac{€}{MWh}$
z	interest rate	1
$LT_{j,hs}$	life time of the j-Generator/hs-Storage	A
$opex_{FIX_j}$	capital cost of the j-Generator	$\frac{€}{MW}$
$opex_{FIX_{hs}}$	capital cost of the hs-Storage	$\frac{€}{MWh}$
$opex_{var_j}$	operational cost of j-Generator	$\frac{€}{MWh}$
$p_{ec_{j,t}}$	Energy carrier price for j-Generator at t-hour	$\frac{€}{MWh}$
$f_{em_{ec_j}}$	CO_2 emission factor of energy carrier for the j-Generator	$\frac{t\ CO_2}{MWh}$
p_{CO_2}	CO_2 Certificate Price	$\frac{€}{t\ CO_2}$
η_{el_j}	Electrical efficiency for the j-Generator	1
η_{th_j}	Thermal efficiency for the j-Generator	1
$x_{th_{j,t}}$	Heat generation from the j-Generator at t-hour	MWh
$p_{s.el_{j,t}}$	Electricity Sale Price for the j-Generator at t-hour	$\frac{€}{MWh_{el}}$
$x_{el_{j,t}}$	Electricity generation from the j-Generator at t-hour	MWh_{el}
$CAPEX$	capital expenditures	€
$OPEX_{fix}$	capital cost	€
$OPEX$	operational expenditures.	€

Hotmaps Dispatch Model

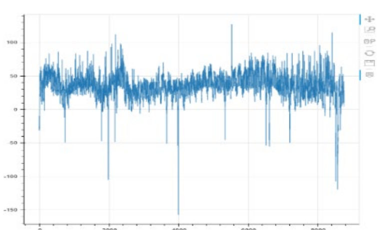
Main Inputs

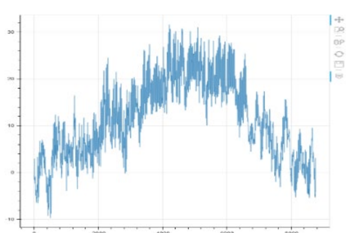
- Heat demand of the grid (d region)

- Installed capacities of heat generators



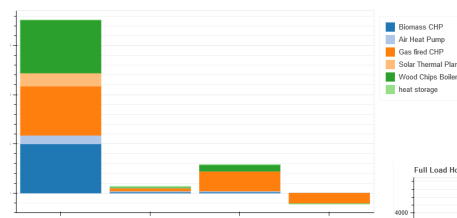
- Energy carrier prices, €
- Load Profiles,
- Radiation Profiles
- Temperature Profiles
- Electricty Price Profiles

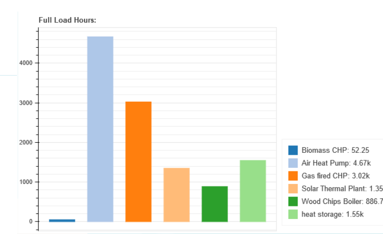




Main Outputs

- Heat generation costs
- Investment, operation and fuel costs
- Heat generation mix per heat generator
- CO2 Emissions.
- Full Load Hours, etc..





Scenarios for district heating supply

Scenario Type	No.	Description
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	2-4	Two to four demands
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**	

Characteristics of district heating generation portfolios

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

Installed capacities	Portfolio 1	Portfolio2	Portfolio 3
Local resources (Geothermal, sewage HP , excess heat heat, Waste incineration plant, Solar-thermal)	Moderate-High	Moderate-High	High
Biomass (Boiler and CHP)	Moderate	Moderate	Moderate
Gas (Boiler and CHP)	High	Moderate	Low
Air heat pump	Low	Moderate	High

Energy carrier prices and CO2 prices

year	Assessment method	CO2 Price [EUR/tCO2]	Interest Rate [%]	energy carrier prices include			
				VAT [%]	Energy tax [EUR/MWh]	Grid Cost [EUR/MWh]	Surcharge [EUR/MWh]
2030/2050	financal	81/183	7	✔	✔	✔	✔
	economic	300	3	✕	✕	✔	✔

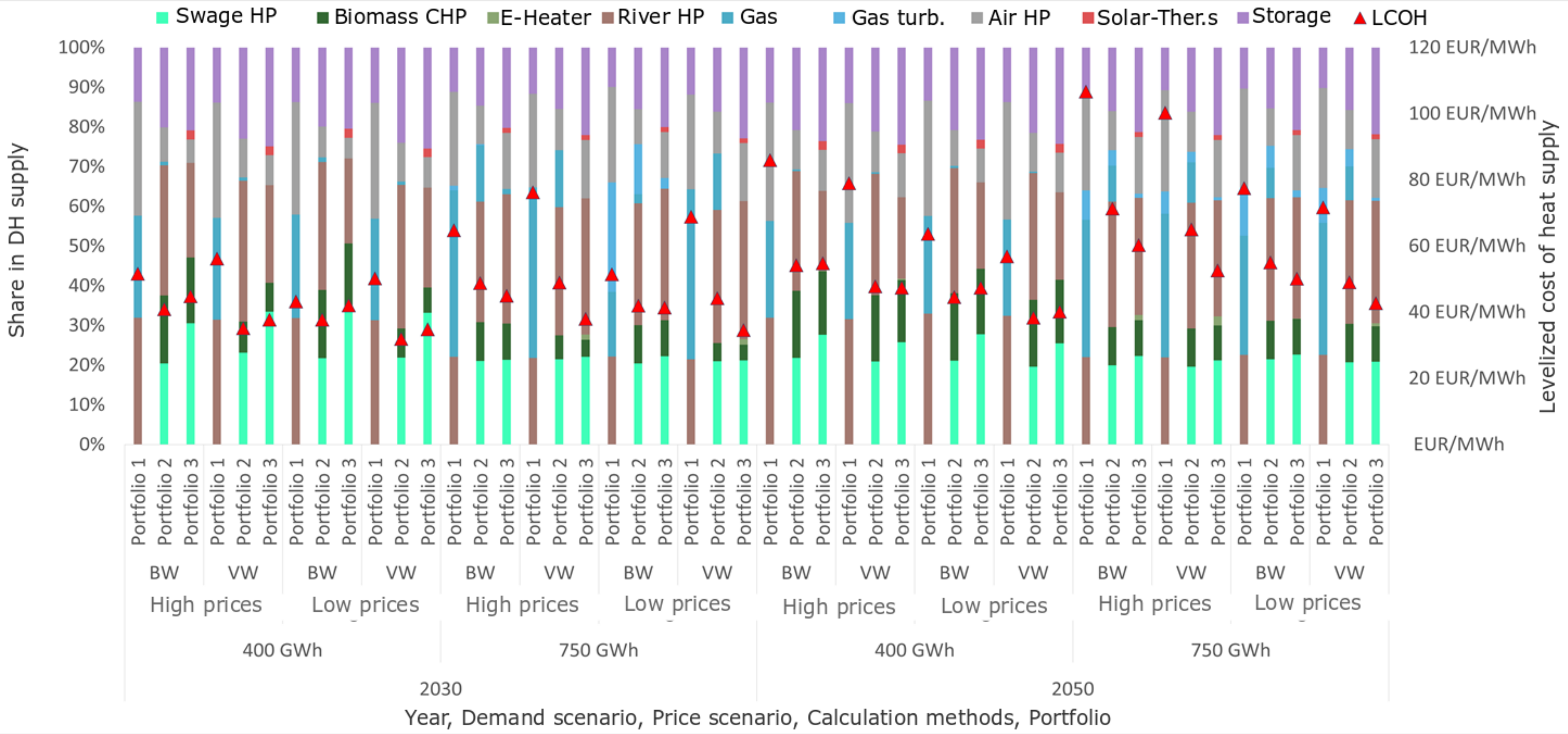
- Share of green gas (synthetic gas & biogas) in the natural gas grid in 2030 at 6%, in 2050 at 100%.
- 2030 primarily biomethane in green gas,
- 2050 mainly H2 and PtG.
- Assumptions on the mix and supply costs of green gas in 2030 and 2050.

Low Price	2030		2050	
	Share [%]	Costs [EUR/MWh)	Share [%]	Costs [EUR/MWh)
PtG	5%	150,0	40%	110,0
H2	15%	80,0	40%	70,0
Biomethan	80%	60,0	20%	80,0
Total		67,5		88,0

High Price	2030		2050	
	Share [%]	Costs [EUR/MWh)	Share [%)	Costs [EUR/MWh)
PtG	5%	210,0	40%	170,0
H2	15%	120,0	40%	100,0
Biomethan	80%	80,0	20%	100,0
Total		92,5		128,0

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).

Methodology

KFW ... Cost of supply from district heating

EUR/MWh]

Comparison ...

KDE ... Cost of decentralized supply

EUR/MWh]

... for each district heating potential area

$K_{FW} < K_{DE}$ ... District heating is economical

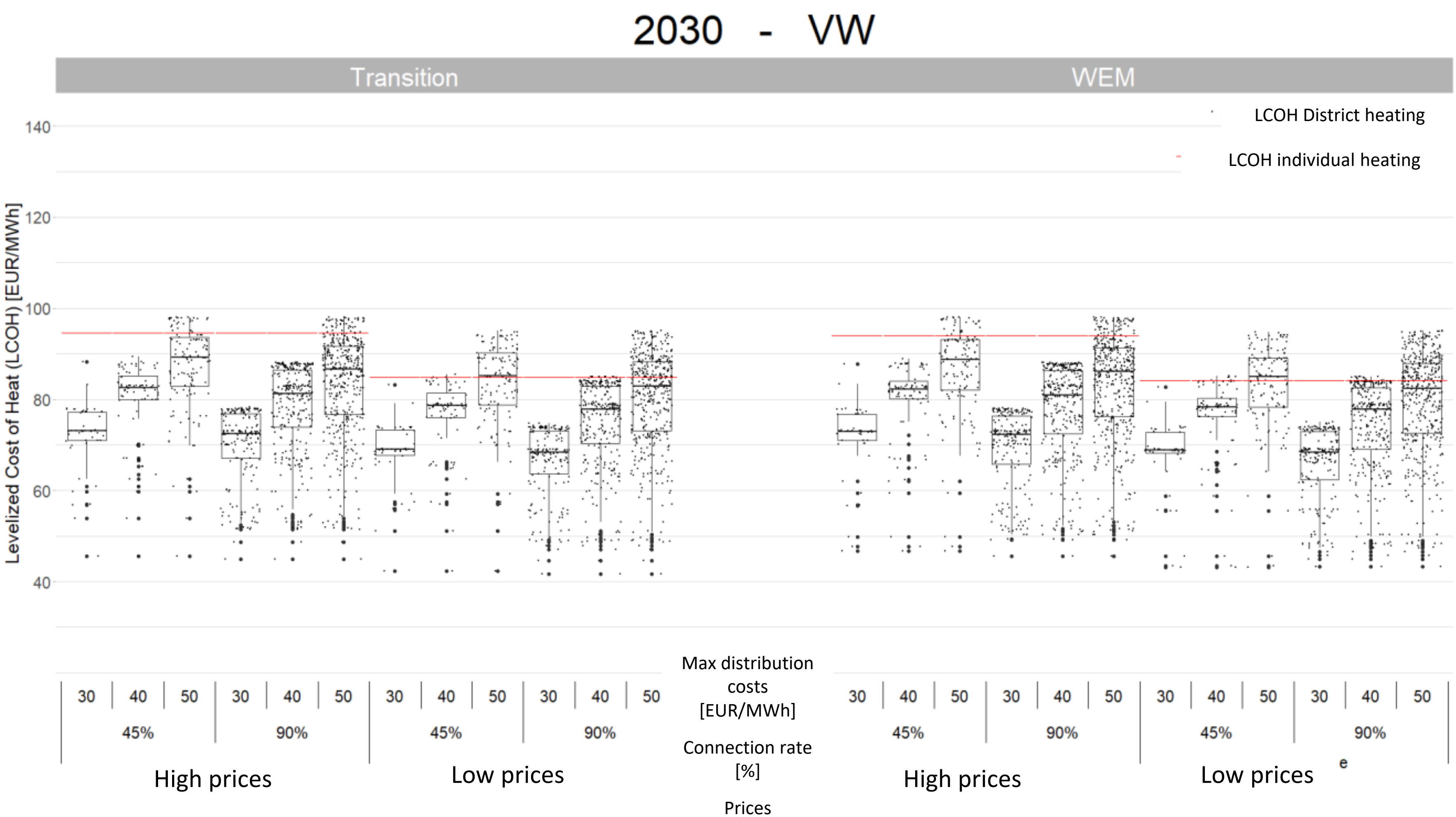
$K_{FW} > K_{DE}$ ... District heating is not economical

... for each individual scenario

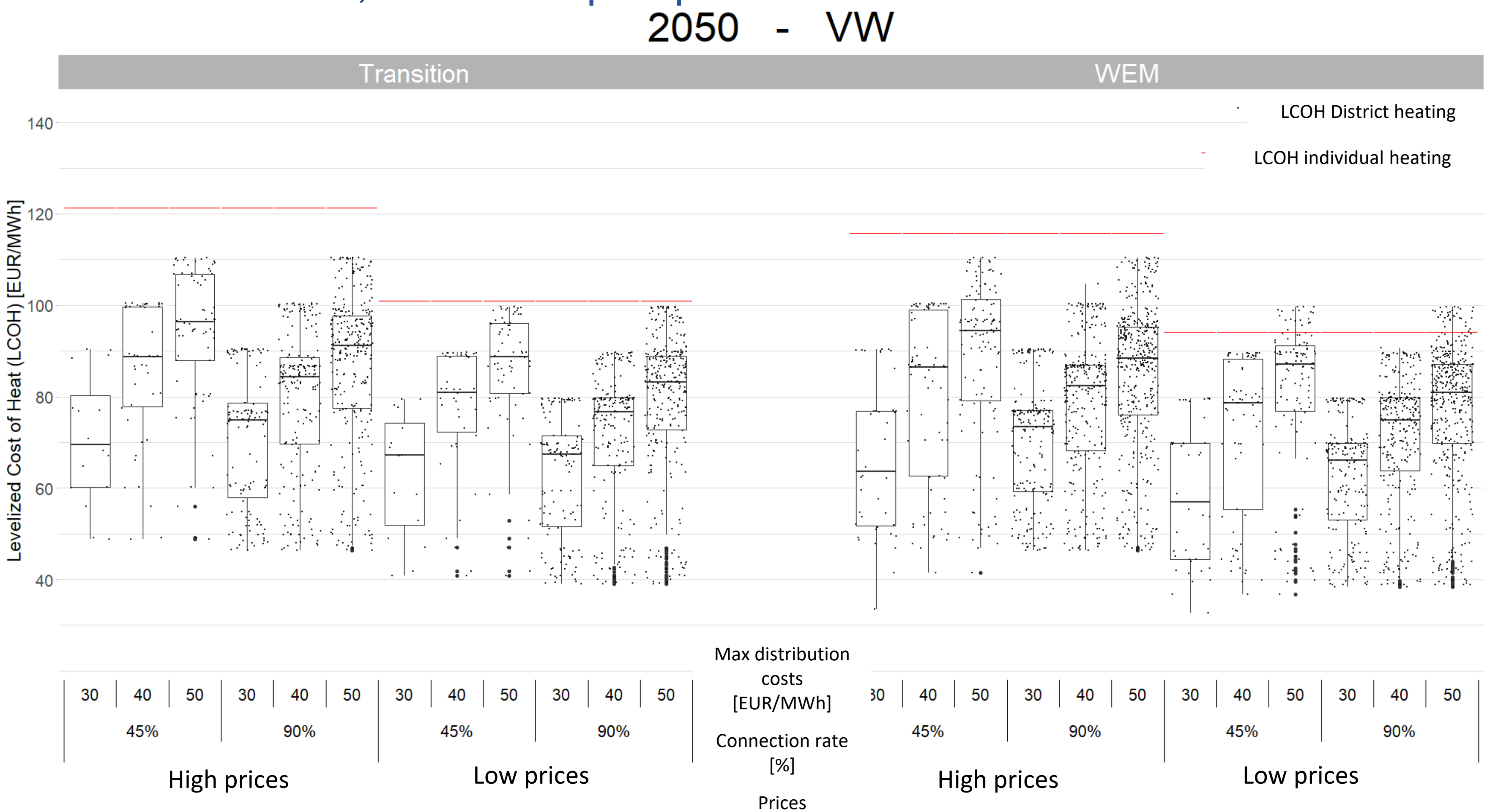
Total district heating potential [GWh/yr] in all areas where district heating is economic = Economic potential.

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

Comparison of the costs (LCOH) of decentral heat supply (red line) and the costs (LCOH) of district heating supply (boxplot) for different scenario variants in 2030, economic perspective.

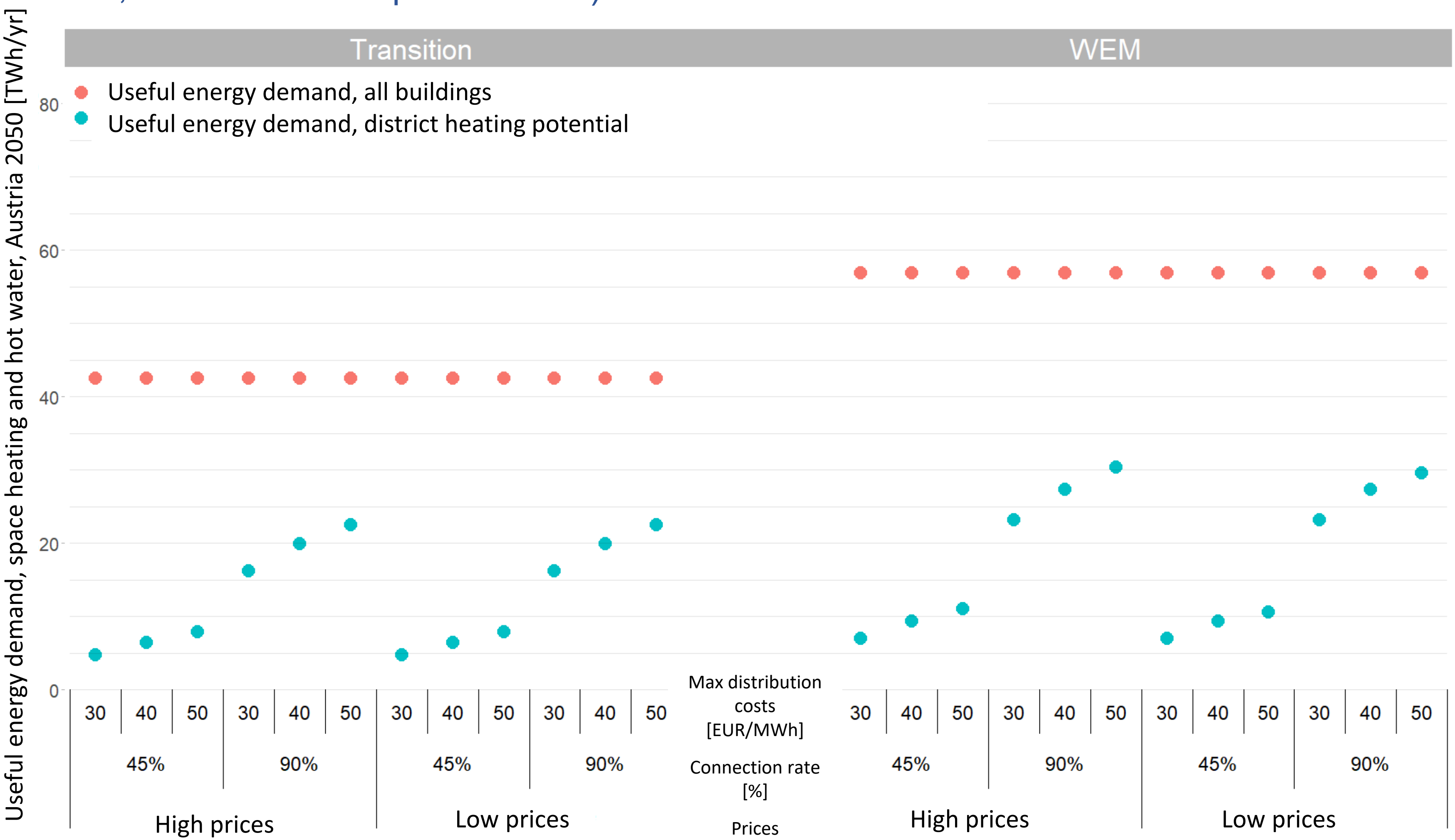


Comparison of the costs (LCOH) of decentral heat supply (red line) and the costs (LCOH) of district heating supply (boxplot) for different scenario variants in 2050, economic perspective.



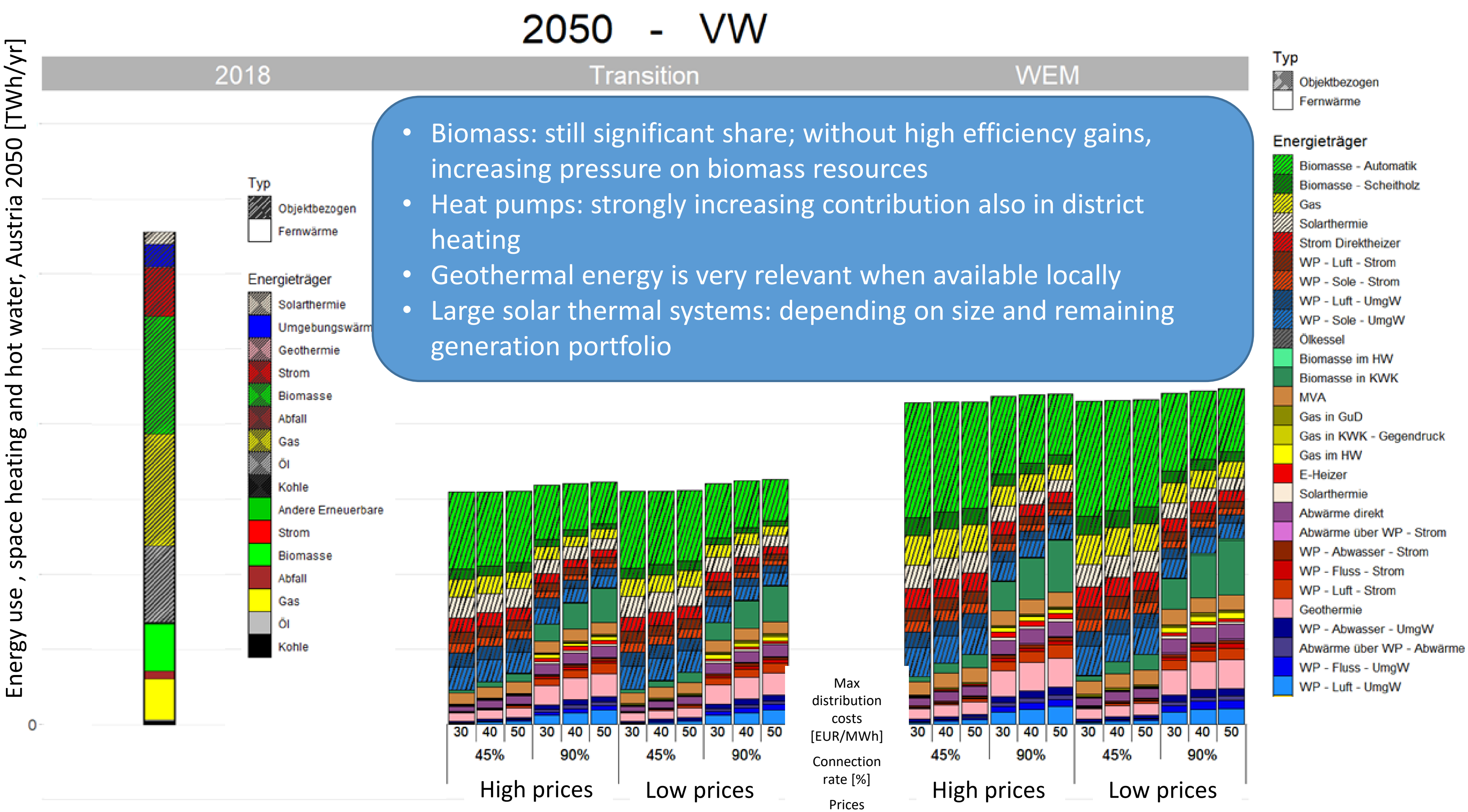
Share of economic DH supply from total heat supply

2050, socio economic point of view)



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

- 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).

- Based on our assumptions, gas-fired power plants will only have limited full-load hours by 2050. Thus, the role of CHPs for district heat supply will decrease. (However, the role of CHPs in the electricity system was not in our focus.)

- 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.

Limitations and uncertainties

- Possible cost development (including the locally existing site-specific conditions, which can lead to deviations in terms of costs), especially regarding large-scale thermal storage, solar thermal energy, costs for required land as well as deep geothermal (and the associated risks in the development).

- Technological developments and the efficiencies and corresponding technology characteristics to be expected in the future.

- Expected heat demand in district heating grids strongly depends on building renovation measures as well as on the achievable connection rates.

- Since these factors cannot be predicted in the long term, a continuously adapting planning process is required, both on the part of the heating network operators and on the part of policymakers.

Thank you!

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Orig. Photo: Patrick Stargardt