VON ABWÄRME BIS ANERGIE

wie eine effiziente und resiliente (Fern-)Wärmeversorgung aussehen kann

1. Nahwärmetagung am 5.12. in Innsbruck, Tirol

Riel Blakcori, Tobias Forster, Klara Maggauer, Nicolas Marx, Bernhard Mayr, Ralf-Roman Schmidt, Stefan Strömer, Gerhard Totschnig

Challenges for District Heating

CHALLENGES

Climate Change
- less heating in winter, more cooling in summer?

Deep Decarbonization
- More Wind and PV, less CHP
- Competition for Biofuels with hard-to-abate sectors

Global Energy Security
- Unpredictable energy prices
- Threat of shortcuts

Seasonal Mismatch
- of the heat source availability and demand

Missing Proximity
- Many heat sources are outside the city

High Network Temperatures
- reduce potential for decarbonization

Economic Barriers
- high investment costs
- Competitor individual HPs

Customer Requirements
- want to participate
- Price stability

Regulative Barriers
- Missing centralization obligation
- What to do with the CO_2 in waste incineration?

CHALLENGES

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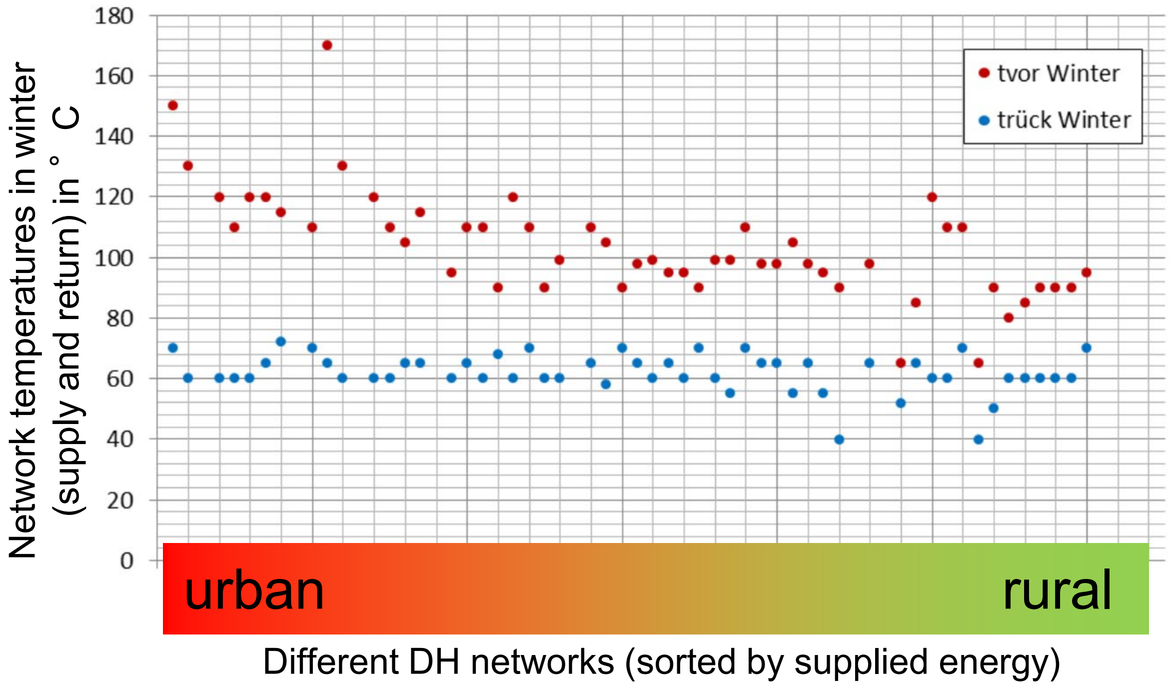
Selected Solutions and Case Studies

Challenge:
High network temperatures

CHALLENGE:
HIGH NETWORK TEMPERATURES

Example: supply and return temperatures of different DH networks in Austria



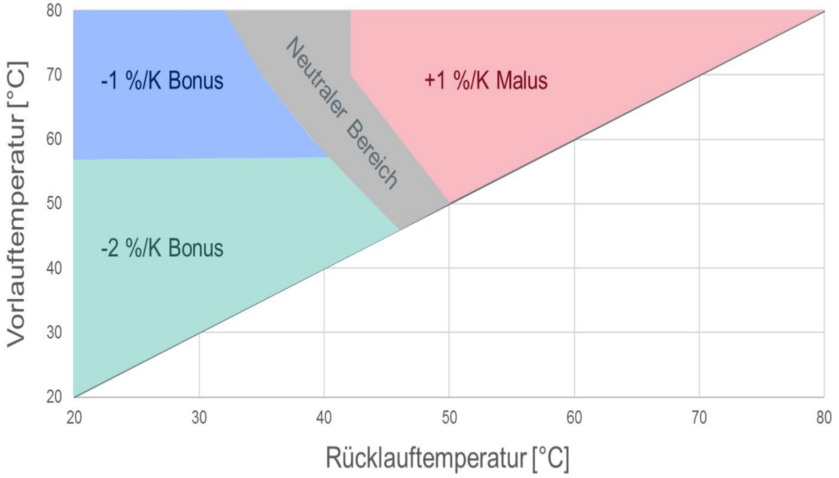
- **High DH network temperatures** create a fatal lock-in effect and significantly reduce the potential for decarbonization
- high heat **losses**
- low **storage** capacities
- Limited **network extension** possibilities
- **Low cost-efficiency** when integrating waste heat, heat pumps, solar- and geothermal energy

http://www.austrian-heatmap.gv.at/fileadmin/user_upload/FW_KWK_Endbericht.pdf

→ SOLUTION (EXISTING SYSTEMS)

- **Reducing DH networks temperatures can be done by optimizing buildings heating systems** towards lower return temperatures and lower (peak) heat demand.
- Therefore **suitable business models are required** considering investor/ user dilemma, contractual terms as well as issues related to responsibilities and ownership
- **Outlook**: the project DeRiskDH will look into those business models including the DH network operators in Vienna, Salzburg, Linz, Graz and Klagenfurt

Example for a business model for reducing the return temperatures: motivational tariffs



Diget T/ Frederiksberg, Danish Board of District Heating (DBDH), 2019, pp. 19-22.

Roman Geyer, et al. 2021, https://doi.org/10.1016/j.segy.2021.100011
Paolo Leoni, et al. 2020, https://doi.org/10.1016/j.energy.2020.116963

→ SOLUTION (NEW SYSTEMS)

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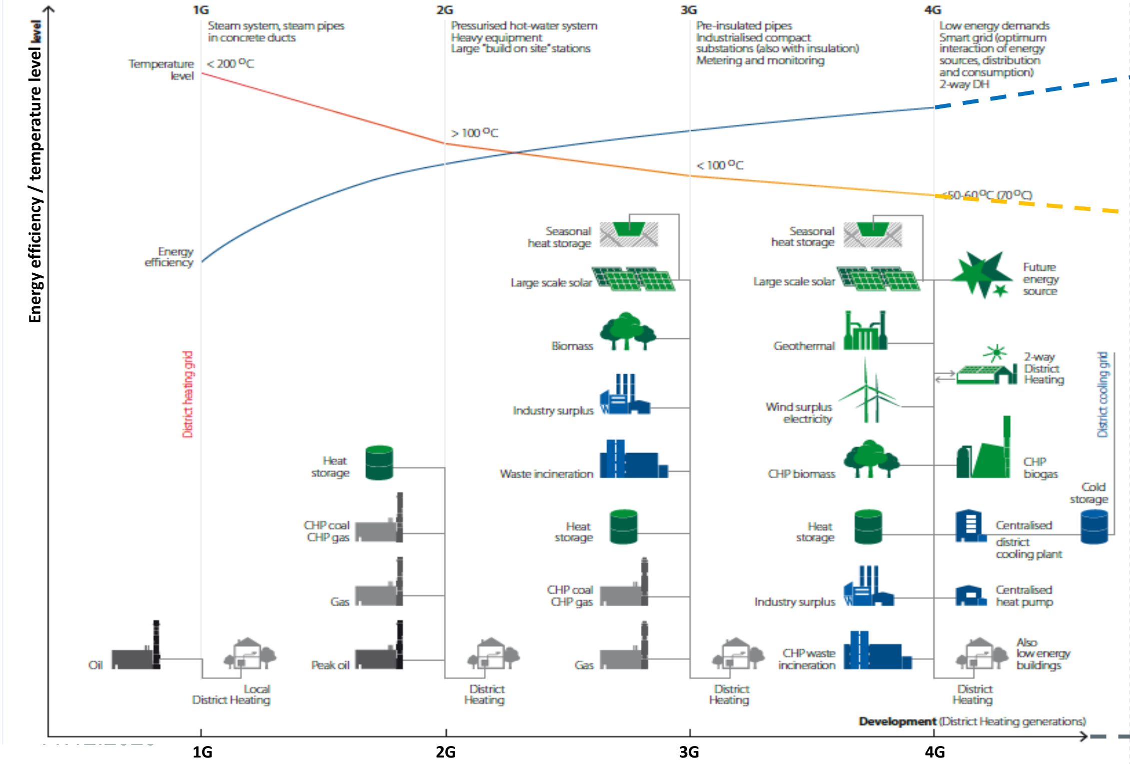
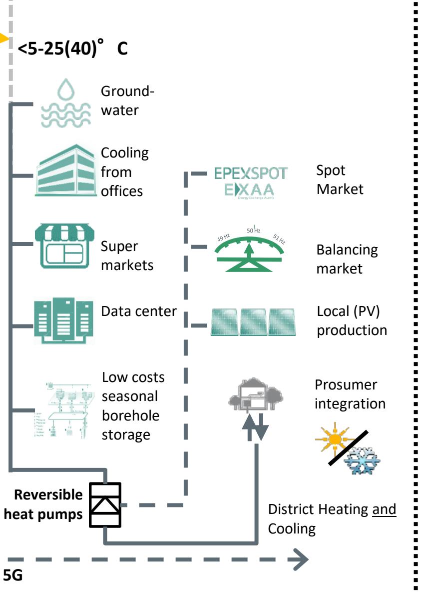
a) **Initial concept for the 1st to 4th DHC generation**
(Lund, Werner et. al; Energy 68, 2014)



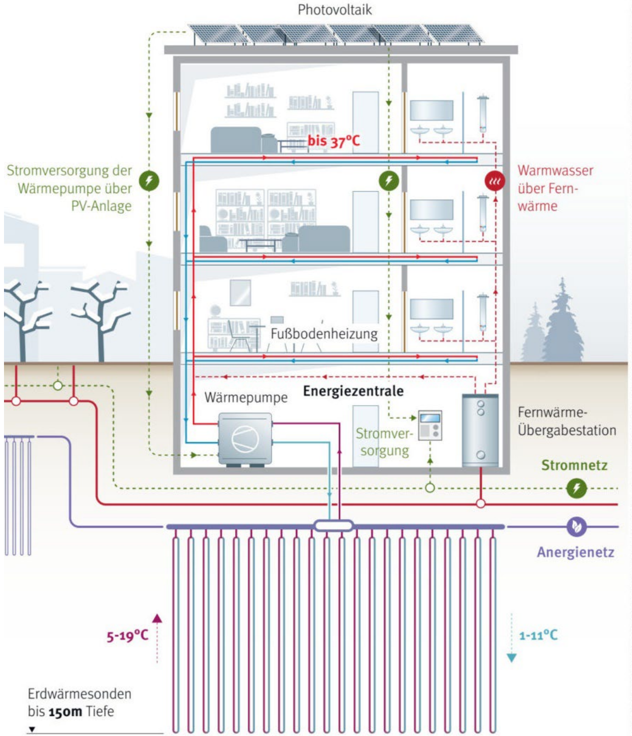
b) **"5th generation"** heating and cooling networks are operating around ambient temperatures, together with consumer-side heat pumps. Thus, waste heat from data centers can be directly utilized.



→ SOLUTION (NEW SYSTEMS)

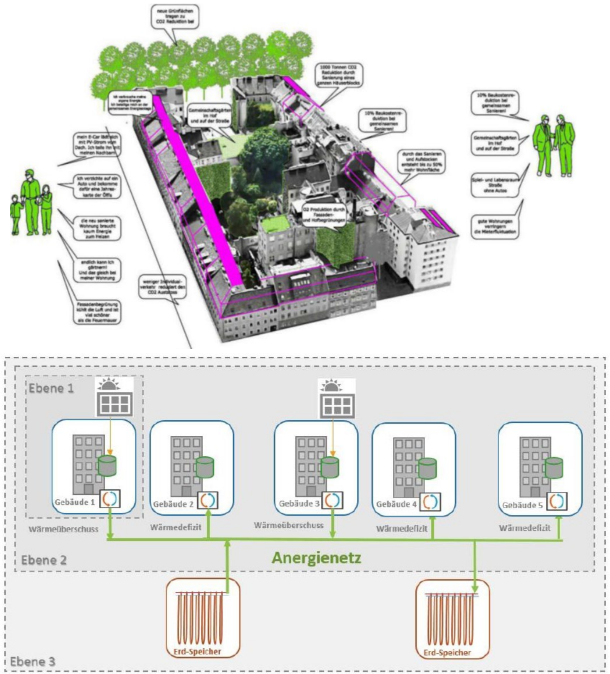
- **Examples** of 5GDHC networks (so called „Anergy“ networks

"Village im Dritten", Vienna



https://positionen.wienenergie.at/projekte/waerme-kalte/village-im-dritten/?utm_source=mailpoet&utm_medium=email&utm_campaign=energiepolitisches-update_21

"Smart Block Geblergasse", Vienna



https://www.proholz.at/fileadmin/proholz/media/bauholz/2020/003_Modul1_JZeininger.pdf
https://www.tsb-energie.de/fileadmin/Redakteure/Veranstaltungen/Energiewende_und_Klimaschutz/2021/Referentenbeitraege/Johannes_Zeininger_-_Zeininger_Architekten.pdf

Challenge:
seasonal mismatch

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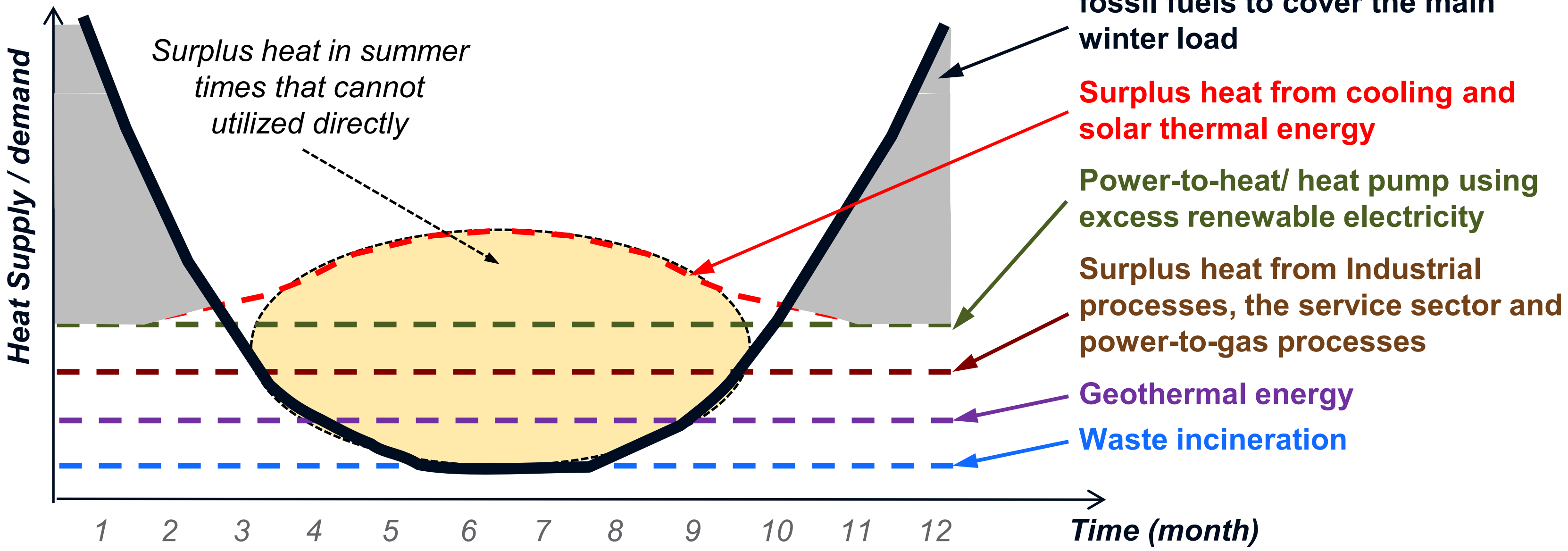
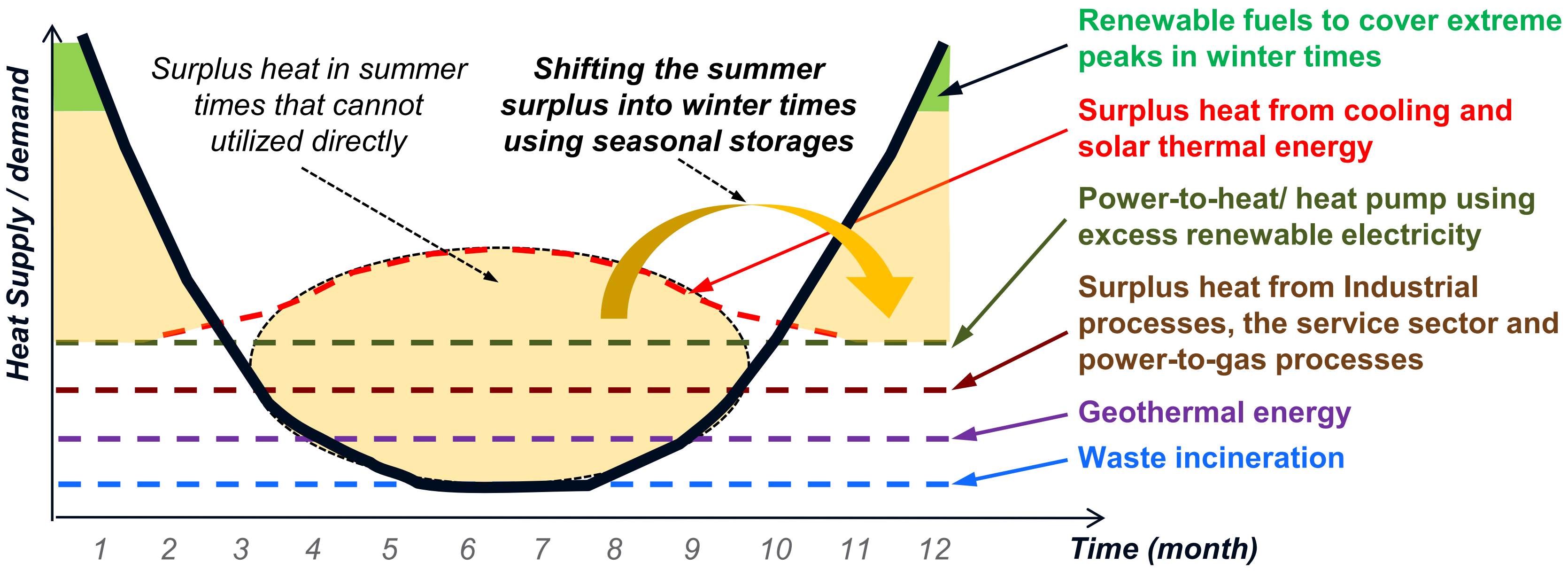
CHALLENGE:
SEASONAL MISMATCH

temporal mismatch of the waste heat availability and heat demand, including a **supply competition** to most of the renewable heat sources in summer times.



→ **SOLUTION**: SEASONAL STORAGE

operational optimization and multi-use of the storage can reduce payback periods. Considering new types, e.g. **Cavern Thermal Energy Storage** (mines, tunnels …)

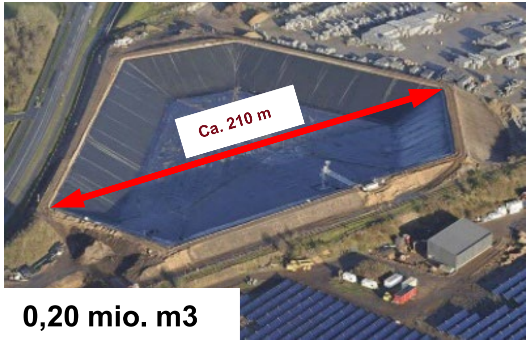


→ **SOLUTION**: SEASONAL STORAGE EXAMPLES

Tank thermal energy storage

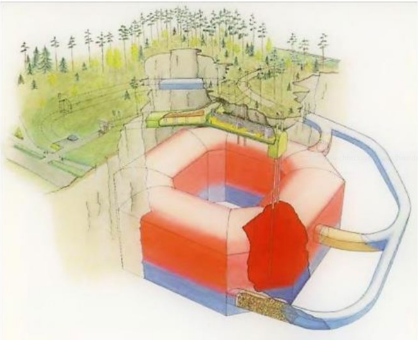
0,05 mio. m3

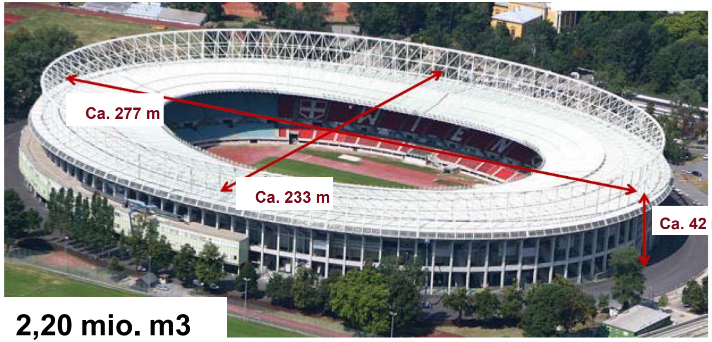
PTES - Pit thermal energy storage



0,20 mio. m3

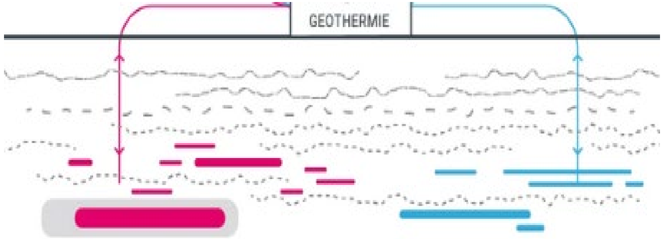
CTES - cavern thermal energy storage





2,20 mio. m3

ATES - Aquifer thermal energy storage



Example. Vienna: possible capacity; 10 GWh, temp. 40 ° C)

https://www.geothermie.de/bibliothek/lexikon-der-geothermie/u/utes.html
https://www.newcaets.org/wp-content/uploads/2021/12/NATF-Inter-seasonal-heat-storage.pdf
https://www.saisonalspeicher.de/
https://greenenergylab.at/projects/ates-vienna-aquifer-thermal-energy-storage-vienna/

CASE STUDY: OPTIMIZED STORAGES INTEGRATION FOR DH DECARBONIZATION

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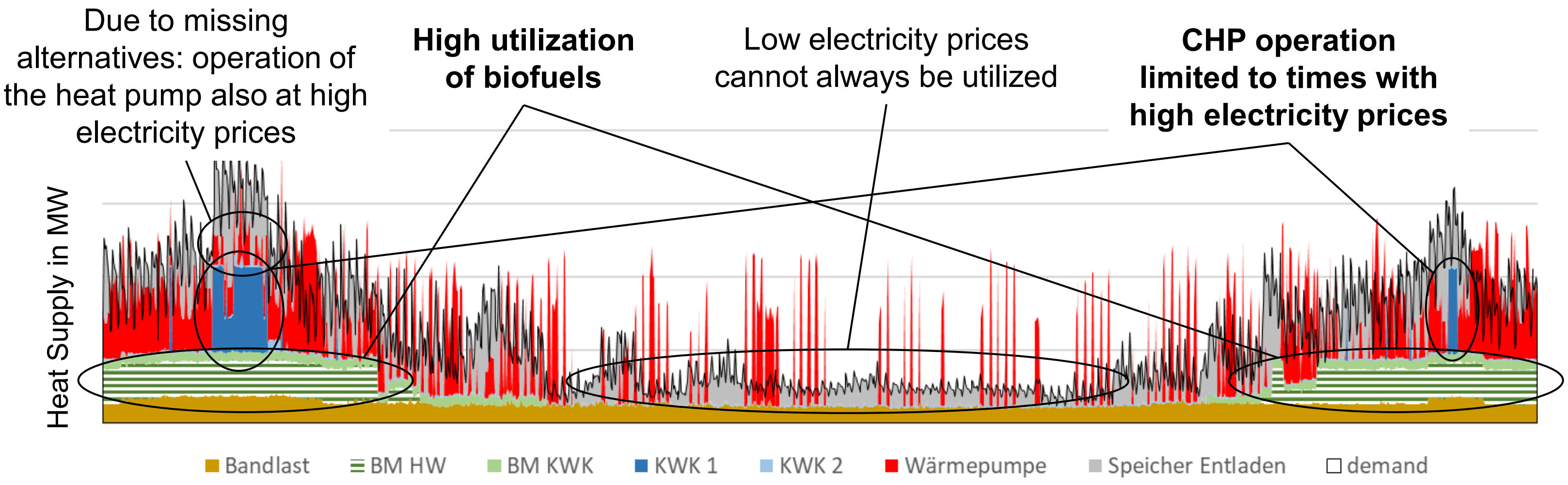
- **For a medium size DH network in Austria a decarbonization strategy for the heat supply was developed**

  - Realistic **boundary conditions** were set together with the DH utility
    - Investment costs for new units (incl. seasonal energy storages)
    - Future energy costs / limites for biofuels, electricity, methane, waste heat …

  - A model-based **optimization tool** was customized and used
    - considering different scenarios (low/high energy prices, low/high heat demand …)
    - Evaluating the time horizon until 2040 (considering 2025, 2030, 2035)
    - Calculating the optimized investment pathway
    - Including a “return line heat pump”, allowing to cool the seasonal storage

RESULS: WITHOUT SEASONAL STORAGE

Hourly heat supply in 2040



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RESULS: WITH SEASONAL STORAGE

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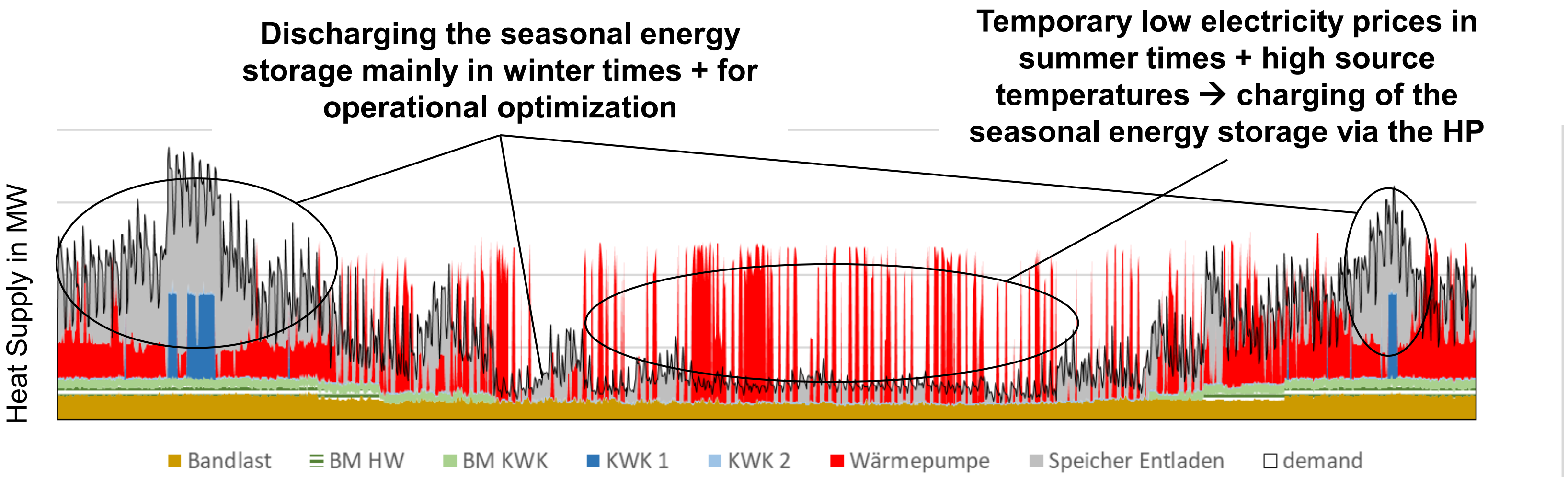
Hourly heat supply in 2040



-2% levelized cost of heat-
comparing to the scenario without seasonal storage

Challenge:
locational mismatch

CHALLENGE:
LOCATIONAL MISMATCH

missing proximity of the DH network to the location of waste heat sources

https://www.colocationamerica.com/blog/rural-data-center-benefits

→ SOLUTION

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- **Interregional heat transmission networks (HTNs)** allow the interconnection of
  - several industrial waste heat
  - and renewable heat sources,
  - local district heating networks,
  - industrial process heat sinks and storage

- The **NEFI Project „HeatHighway** (running from 03/21 - 08/24) is investigating concrete HTN in Austria and push them towards realization: "Zentralraum", "Linz" and Styria + four "follower" regions
- https://www.nefi.at/de/projekt/heat-highway
- https://www.ait.ac.at/themen/integratedenergysystems/projekte/heat-highway

powered by klima+ energie fonds

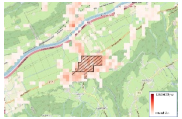
NEW ENERGY FOR INDUSTRY

LAND OBERÖSTERREICH

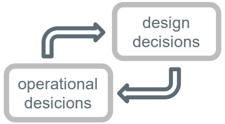
CASE STUDY:
HYPOTHETICAL HTN IN TYROL

Data gathering and preparation
- Market data
- Supply data
- Demand Data
- Economic parameters
- Model parameters

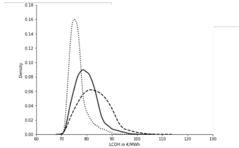
Hotmaps – Toolbox
- GIS-based feasibility calculation of DH share
- Based on maximum allowed distribution costs

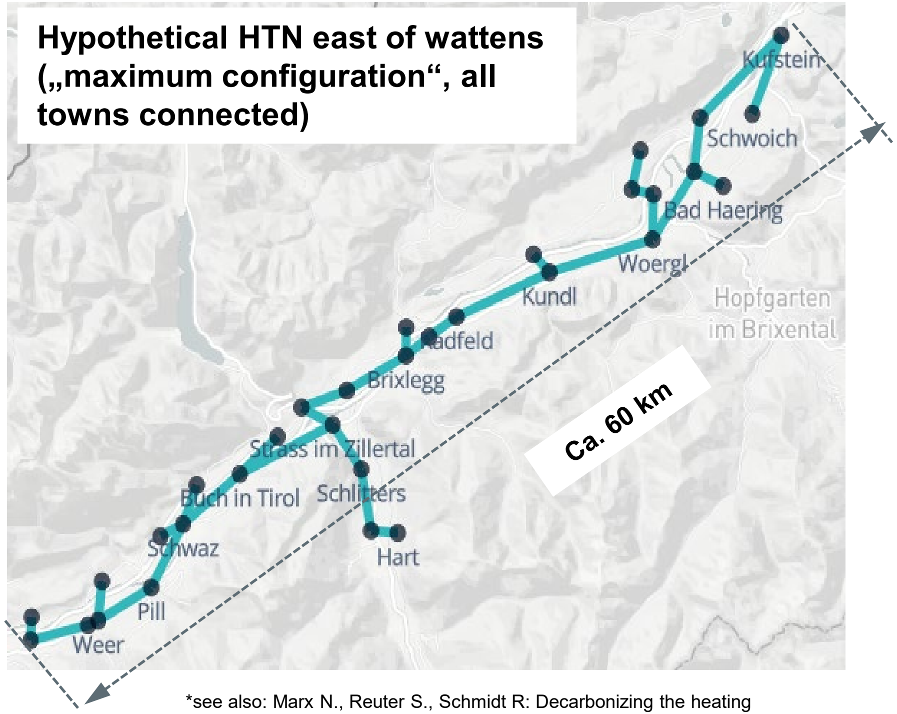


AIT IESopt
- Deterministic optimization model
- Design & operational decisions
- Based on average price scenario



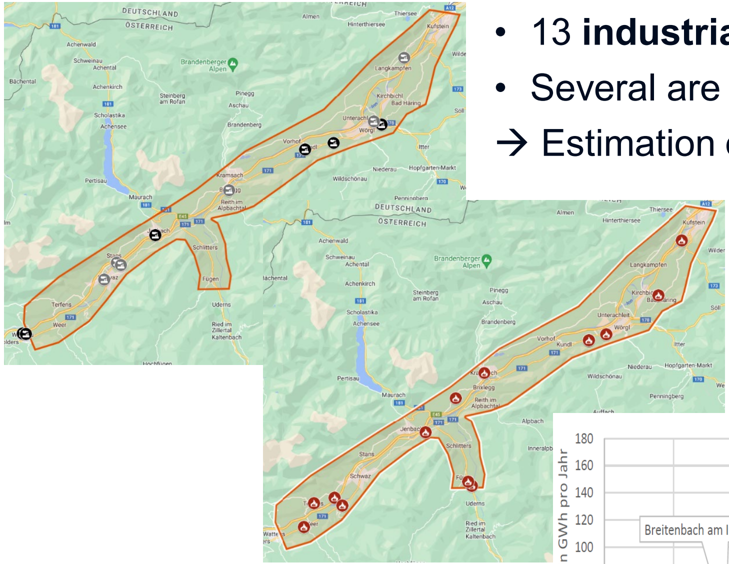
AIT SEEET
- Monte Carlo Simulation for robustness testing
- Considering different uncertain factors
- > 10 000 Runs





*see also: Marx N., Reuter S., Schmidt R: Decarbonizing the heating supply via regional district heating networks - Status-Quo for a case study in Tyrol; 8th International Conference on Smart Energy Systems, 13-14 September 2022; Aalborg, Denmark

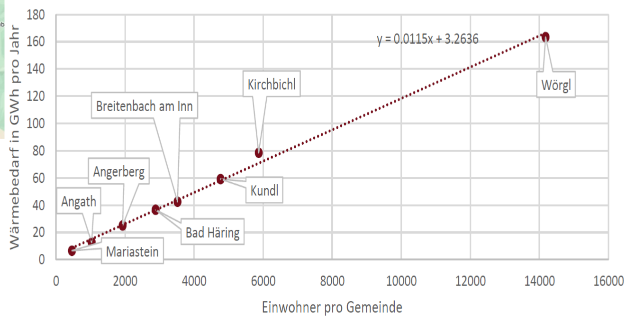
DATA GATHERING AND PREPARATION



- 13 **industral sites** in the area
- Several are supplying into local DH networks

→ Estimation of waste heat potential

- Heating in Inn Valley is mainly biomass-based
- 13 exisiting **biomass heating** plants identified



- The total residential and tertiary **heating demand** of the individual municipalities in the region is considered

Sources:

- Austrian Heat Map
- Company websites
- Sustainability reports
- Tyrolean Energy Monitoring
- Waste heat register Tyrol
- Energiemosaik.at
- oerok.gv.at
- OIB 6
- „Wie heizt Tirol 2050“
- Interviews with industrial sites
- TABULA WebTool
- Eurostat
- ..

HOTMAPS TOOLBOX* HOTMAPS

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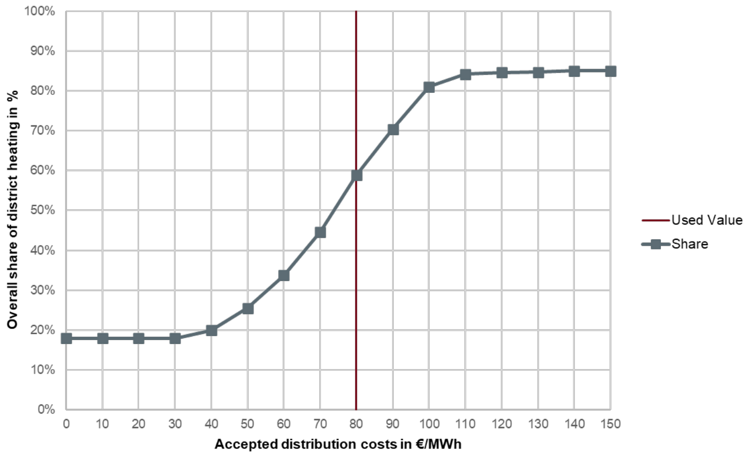
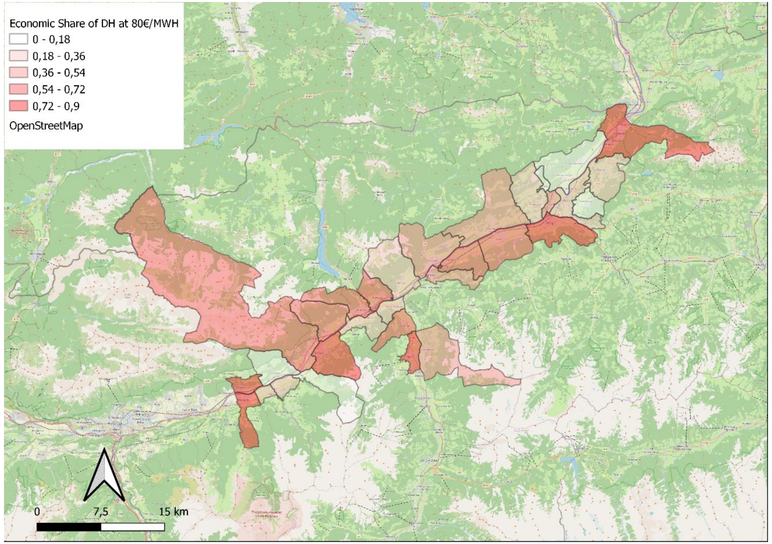
GIS-based feasibility calculation of local DH share

a) Overall share of DH at different heat distribution costs**



b) Resulting share of DH in municipalities***



*see also: Mostafa Fallahnejad, Michael Hartner, Lukas Kranzl, Sara Fritz, Impact of distribution and transmission investment costs of district heating systems on district heating potential, Energy Procedia, Volume 149, 2018, Pages 141-150, ISSN 1876-6102, https://doi.org/10.1016/j.egypro.2018.08.178.

** Assumption: 80 €/MWh are accepted costs
*** Other share assumed to be covered by 50% biomass and 50% heat pumps

“OPTIMUM” CONNECTION?

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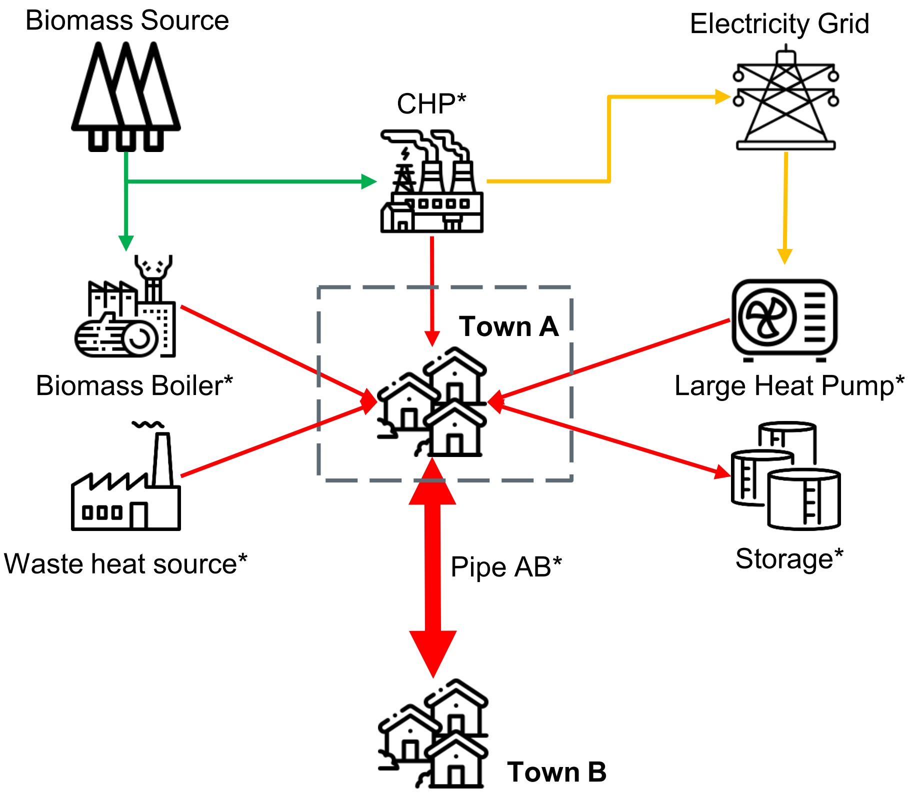
Deterministic optimization model

- Find the solution with the **minimum system costs** based on:
  - Heating demand
  - CAPEX & OPEX
- Seasonal (3 months) timesteps
  - Average energy prices
- Decision to build or enlarge:
  - Biomass boiler
  - Waste heat
  - CHP
  - Large heat pump
  - Connection to other towns

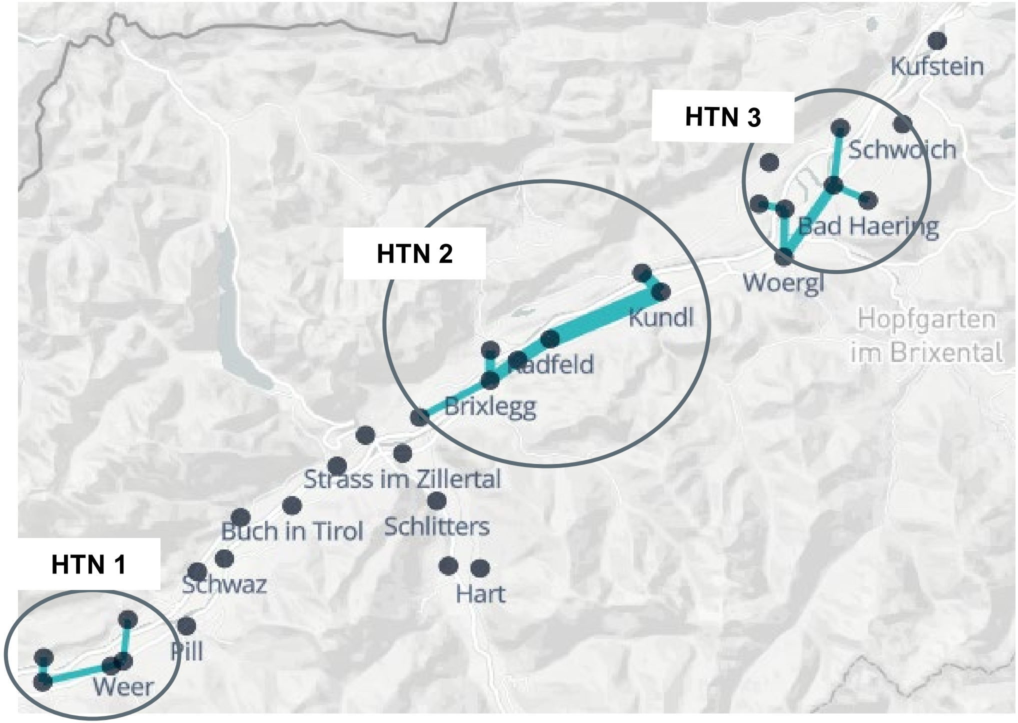


*Highlights components with decisions

"OPTIMUM" CONNECTION?

Deterministic optimization model

- In the test run, 3 separate HTNs are build
- Depending on energy prices & local DH share different components are built
  - CHPs (high energy prices)
  - heat pumps (low energy prices) are built
- Large scale / seasonal thermal storages are built in all HTN'S



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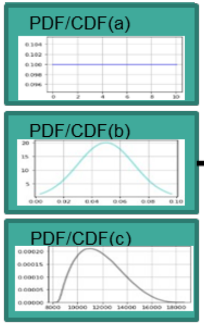
TESTING FOR THE ROBUSTNESS

Monte Carlo Simulation

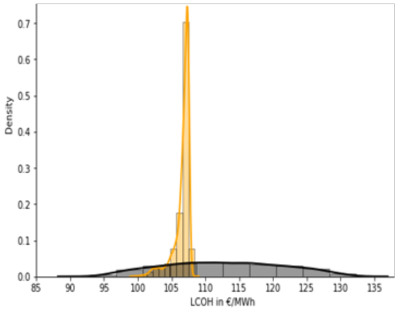


Generating random samples a_i, b_i, c_i

+

Scenario definition

SEEET - Seasonal Energy Economics Evaluation Tool



Assignment of probability density functions (**PDF**) and cumulative density functions (**CDF**) for key uncertainty parameters

Monte Carlo simulation: conduct i trials (repeat steps i times)

Calculating seasonal energy balances, derive levelized cost of heat for each trial i over period considered

Assembly of all trial results into output distribution and calculate the risk

*see also: Marx N., Blakcori R., Forster T., Maggauer K., Schmidt R: Risk Assessment in District Heating: Evaluating the Economic Risk of Inter-Regional Heat Transfer Networks with regards to Uncertainties of Energy Prices and Waste Heat Availability using Monte Carlo Simulations; Smart Energy https://doi.org/10.1016/j.segy.2023.100119

TESTING FOR THE ROBUSTNESS

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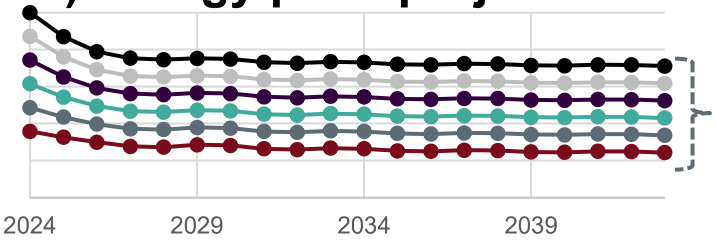
Uncertainty factors

a) Energy price projections

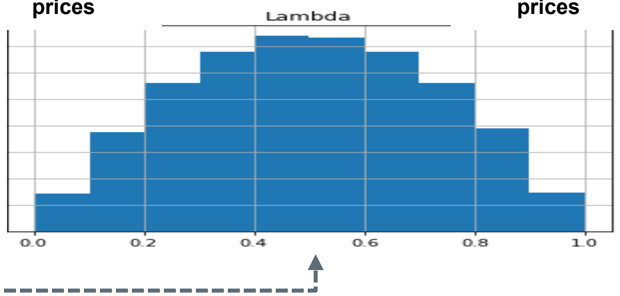


- Hourly Electricity prices
- Monthly biomass prices

Quellen: Gaspreise: EU Energy Outlook 2060, Strompreise: öffentlich verfügbare Studien, Schwankungen: VAR-Model, Biomassepreise: Biomasseverband

Lambda = 0 → Scenarios with low energy prices

Lambda = 1 → Scenarios with high electricity prices



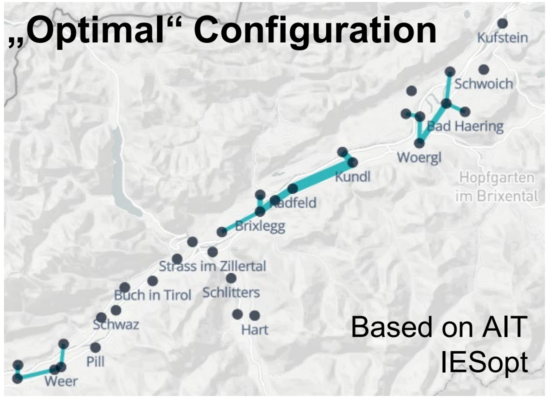
Lambda Drawing

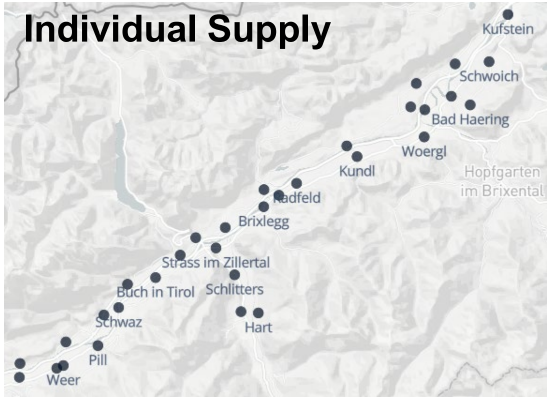
- The distribution of the energy price scenarios is described by a beta distribution
- $Price = Lambda \cdot Price_{max} + (1 - Lambda) \cdot Price_{min}$

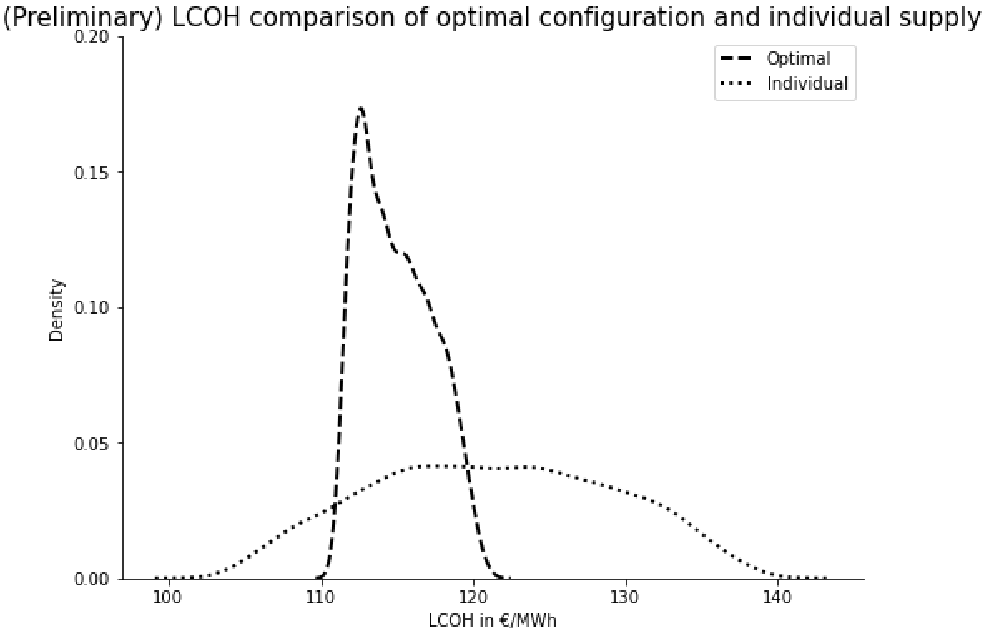
b) Waste heat availability

- Little data available when and under what conditions the supply of waste heat fails
- Here: Use of statistics on corporate insolvencies, calculation of mean probability per year.

PRELIMINARY RESULTS







Further refinement of the input data (heat demand, waste heat potential …), required

More variants could be calculated

THANK YOU!

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