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TOMORROW TODAY

RISK MINIMIZATION FOR DECARBONIZING HEATING NETWORKS VIA NETWORK TEMPERATURE REDUCTIONS: OPPORTUNITIES AND CHALLENGES, EXPERIENCE FROM AUSTRIA AND OUTLOOK

SÉMINAIRE ÉNERGIE – ENVIRONNEMENT, Conférences 2022 – 2023

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Ralf-Roman Schmidt, AIT Austrian Institute of Technology GmbH

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- District heating in Austria, status and challenges

- DH temperatures as a key element for decarbonisation
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  - How to identify reasons for high return temperatures?

- Seasonal energy storages

- Risk assessment using monte-carlo-simulations

- Outlook

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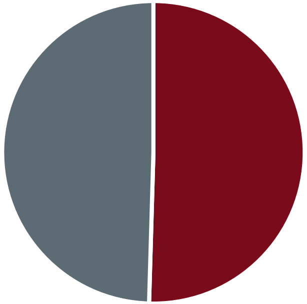
OWNERSHIP STRUCTURE



49.54 %

FEDERATION OF AUSTRIAN INDUSTRIES

(through VFFI)

50.46 %

REPUBLIC OF AUSTRIA

Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology

1.400

EMPLOYEES

167 m EUR

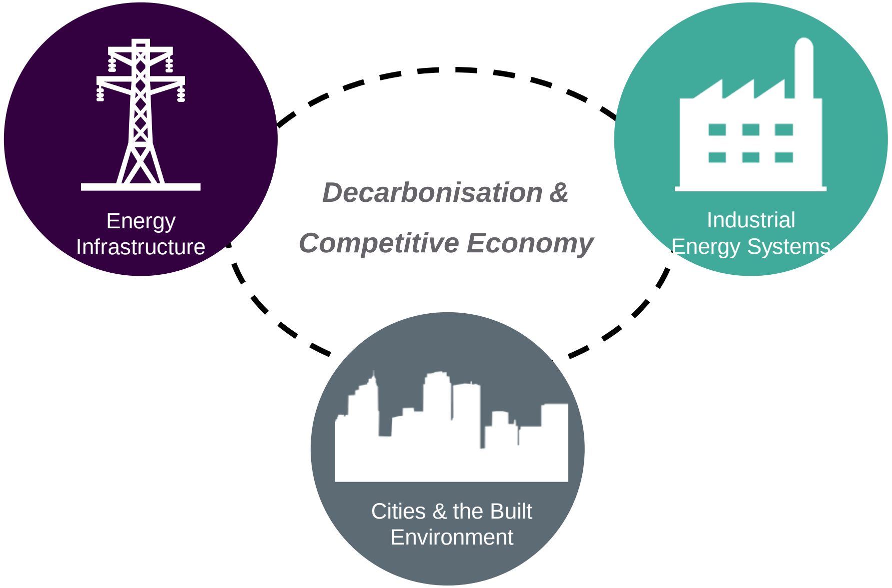
TOTAL REVENUES
as of YE 2019

90,4 m EUR	Contract research revenues (incl. grants)
49,8 m EUR	BMK funding
22,8 m EUR	Other operating income, incl. Nuclear Engineering Seibersdorf
4,0 m EUR	Profactor (51% of 7,9 m EUR)

AIT CENTER FOR ENERGY – FACT & FIGURES

- 240+ researchers & scientists
- Diverse competence fields & teams
  - 25+ nationalities
  - engineering, physics, architecture, IT …
- 9 Research Fields
- 145+ scientific publications per year

- 3 Strategic research domains



CENTER FOR ENERGY: TOPICS

ENERGY CONVERSION & HYDROGEN

- Sustainable Technologies for a hydrogen based energy system
- Functional coatings for energy conversion technologies
- Digital material development based on processing and AI
- Performance & reliability of renewable energy technologies
- Digital operation & maintenance of photovoltaic systems

CLIMATE-RESILIENT URBAN PATHWAYS

- Framework for climate-resilience
- Urban climate models
- Nature-based solutions
- Modelling and design of infrastructure interventions
- Climate resilience pathways
- Visualisation and co-creation in City Intelligence Lab (CIL)

SMART & CARBON NEUTRAL URBAN DEVELOPMENT

- City analytics and monitoring platforms
- Urban energy and green house gas emission models
- Upscaling of smart city solutions
- Impact assessment of Energy, Mobility and ICT
- Visualisation and co-creation in City Intelligence Lab (CIL)

CENTER FOR ENERGY: TOPICS

INTEGRATED ENERGY SYSTEMS

- Energy markets
- Flexibility
- Hybrid energy systems (District heating and cooling, Industrial energy systems, Hydrogen)
- Integrated transport optimization

POWER SYSTEM PLANNING & OPERATION

- Power grids as part of an integrated energy infrastructure
- Grid planning and operation with distributed generation, flexibility, e-mobility, storage
- Low inertia systems, hybrid AC/DC Systems

EFFICIENCY IN INDUSTRIAL PROCESSES & SYSTEMS

- Industrial Heat Pumps
- Industrial thermal energy storage
- Simulation and optimisation of industrial processes
- Decarbonisation pathways for industry

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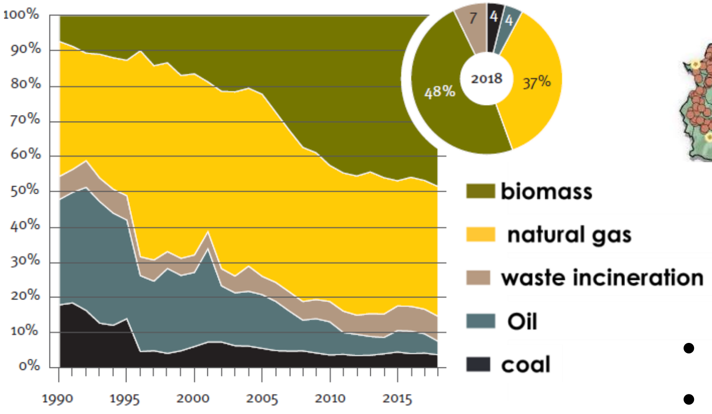
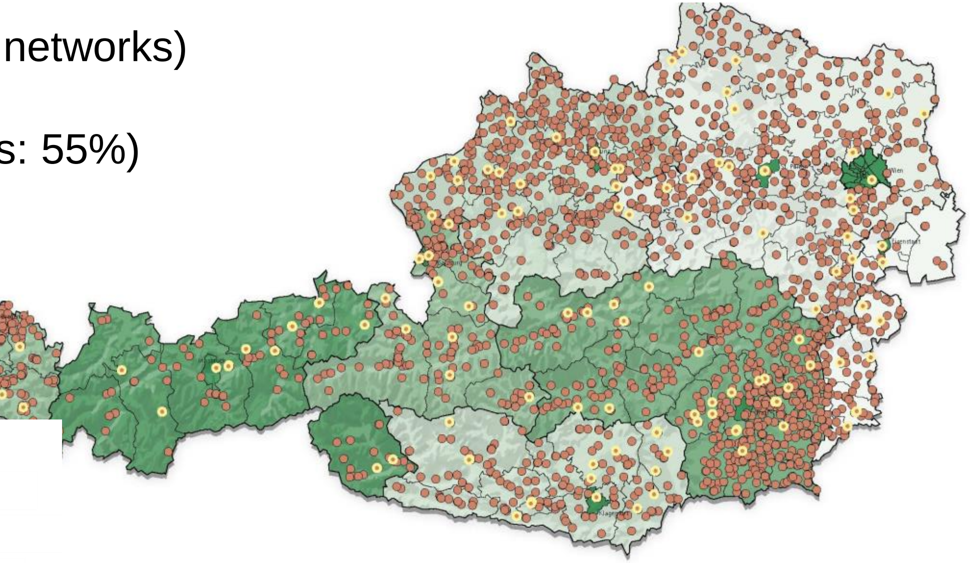
DISTRICT HEATING IN AUSTRIA

DISTRICT HEATING IN AUSTRIA

- > 2,400 systems (incl. many rural networks)
- DH share = 27%
- (for buildings with > 20 apartments: 55%)

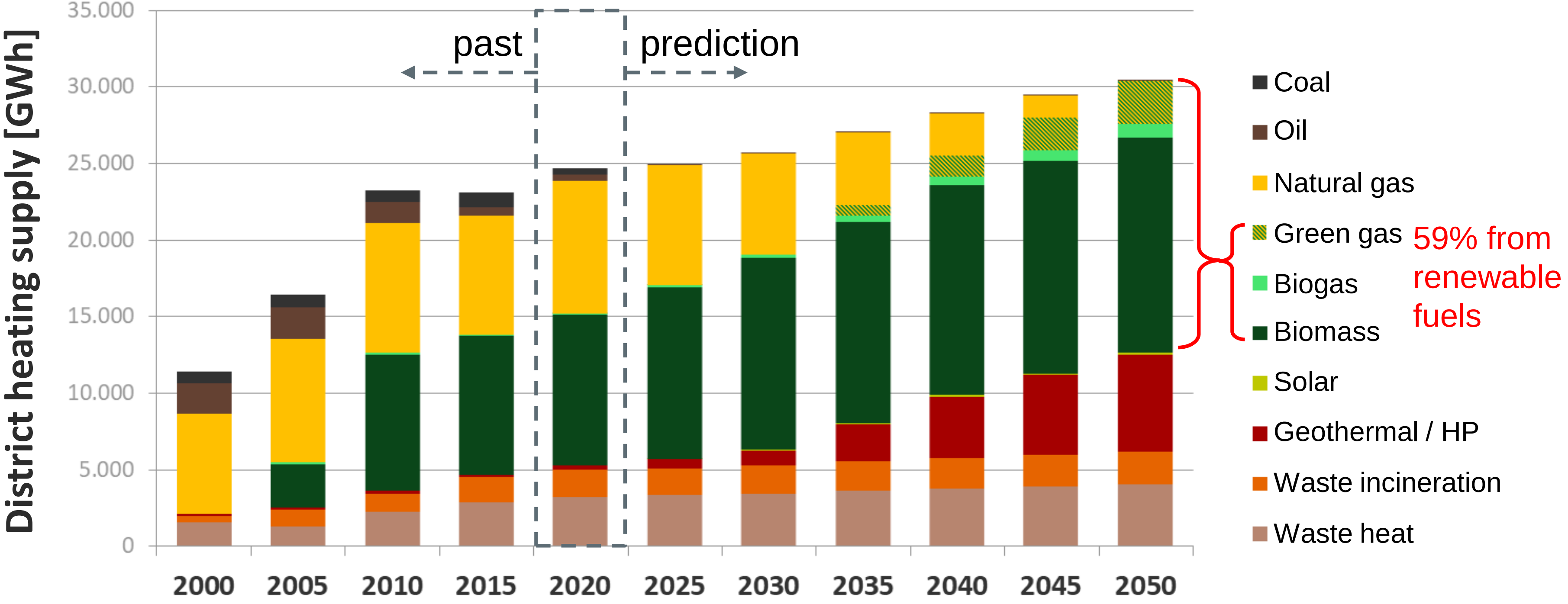




- heat delivery = 24 TWh (hereof 15 TWh from CHP)
- Growing demand in district cooling (192 GWh)

https://www.gaswaerme.at/media/medialibrary/2019/09/zasp19_endversion.pdf
https://www.biomasseverband-ooe.at/uploads/media/Downloads/Publikationen/Bioenergie_Atlas/Bioenergie-Atlas_Oesterreich_2019_klein.pdf

DISTRICT HEATING DECARBONIZATION SCENARIO



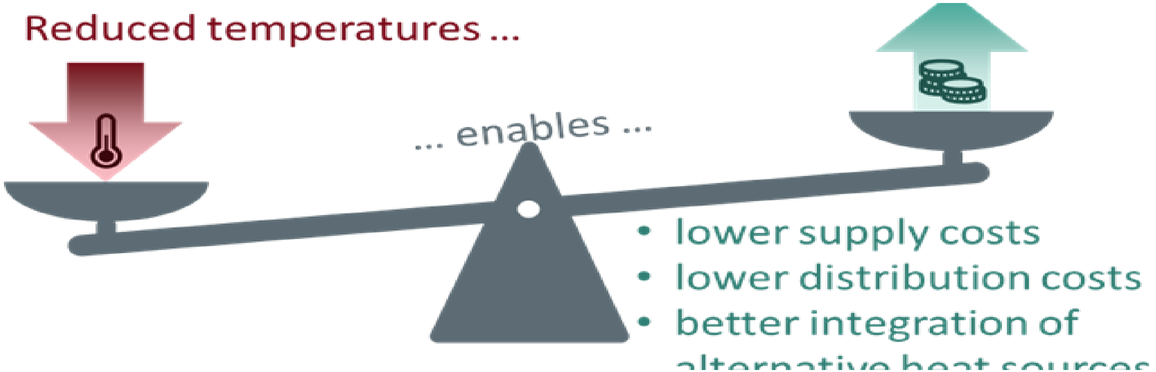
Herbert Lechner: Szenario zur Dekarbonisierung der Fernwärme in Österreich, Fernwärmetage, 9. März 2020
https://eventmaker.at/uploads/16600/downloads/lechner_vortrag.pdf

TRENDS AND DRIVERS: LESS CHP, NEW HEAT SOURCES REQUIRED

- The role of **CHP as a dominant heat source will significantly change**
  - Declining role of fossil fuels, strong competition for renewable fuels
  - Less CHP based electricity required due to more PV and wind

- **Other heat sources are required** (stable demand in DHC can be expected), e.g.
  - Cooling of data centres, office buildings, super markets etc.,
  - Waste heat from (future) industrial processes, tunnels, or electrolyses processes,
  - Power-to-heat from excess electricity (e.g. avoiding curtailment in areas with weak el. network),

- However, those sources often have **low temperatures**, appear in **decentralized** locations, is owned by **third parties** + have a **seasonal mismatch**
  - In turn, the use of Biomass (and synthetic fuels on H2-basis) is a solution currently preferred by many (Austrian) DHC operators (stick to the "Business-as-usual" scenario)



- lower supply costs
- lower distribution costs
- better integration of alternative heat sources

Assessment based on:

- Geothermal
- Heat pump
- Waste heat
- Solar thermal
- Flue gas condensation
- Combined heat and power
- Storage
- Distribution

POSITIVE EFFECTS OF REDUCED SYSTEM TEMPERATURES

This part of the presentation is an extract from
https://www.iea-dhc.org/the-research/annexes/2017-2021-annex-ts2
and
https://energieforschung.at/projekt/transformation-von-konventionellen-waermenetzen-in-richtung-niedertemperaturnetze-durch-sekundaerseitige-massnahmen/

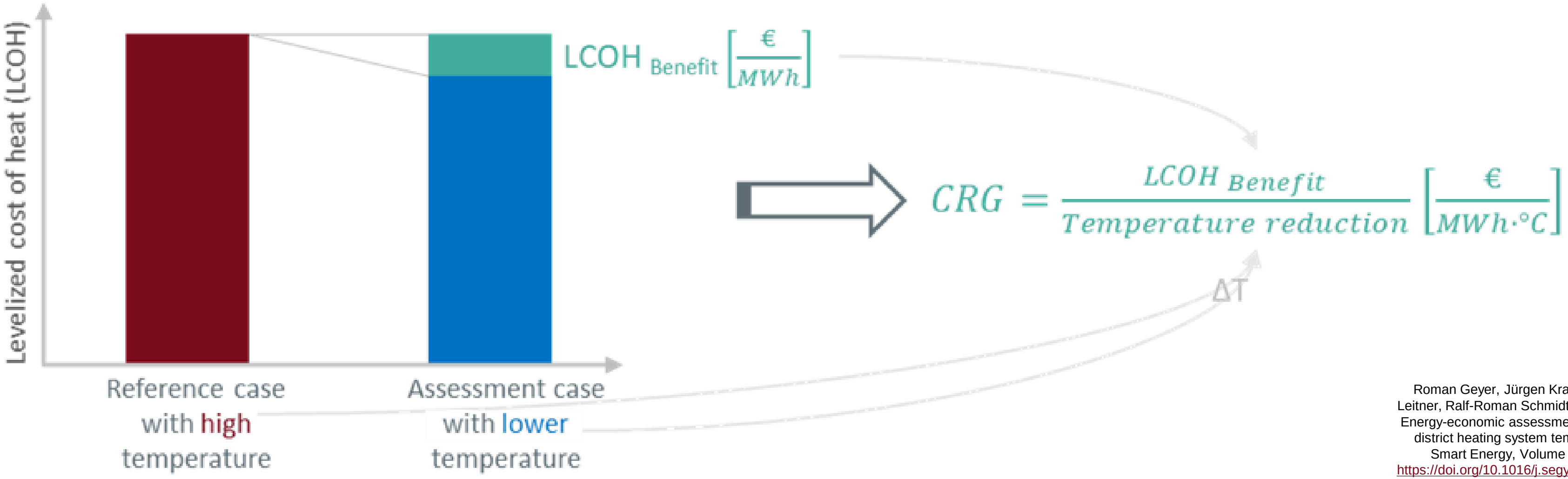
POSITIVE EFFECTS OF REDUCED SYSTEM TEMPERATURES

- More **geothermal heat** extracted from wells since lower-temperature geothermal fluid can be returned to the ground.
- Less electricity used in **heat pumps** when extracting heat from heat sources with temperatures below the heat distribution temperatures since lower pressures can be applied in the heat pump condensers.
- More **industrial excess** heat extracted since lower temperatures of the excess heat carrier will be emitted to the environment.
- More heat obtained from **solar collectors** since their heat losses are lower, thereby providing higher conversion efficiencies.

POSITIVE EFFECTS OF REDUCED SYSTEM TEMPERATURES

- More electricity generated per unit of heat recycled from **steam CHP** plants since higher p-t-h ratios are obtained with lower steam pressures in the turbine condensers
- More heat recovered from **flue gas condensation** since the proportion of vaporised water (steam) in the emitted flue gases can be reduced.
- Higher **heat storage** capacities since lower return temperatures can be used in conjunction with high-temperature outputs from high-temperature heat sources.
- Lower **heat distribution losses** with lower average temperature differences between the fluids in heat distribution pipes and the environment.
- The ability to **use plastic pipes** instead of steel pipes to save cost.

EVALUATION METHODOLOGY

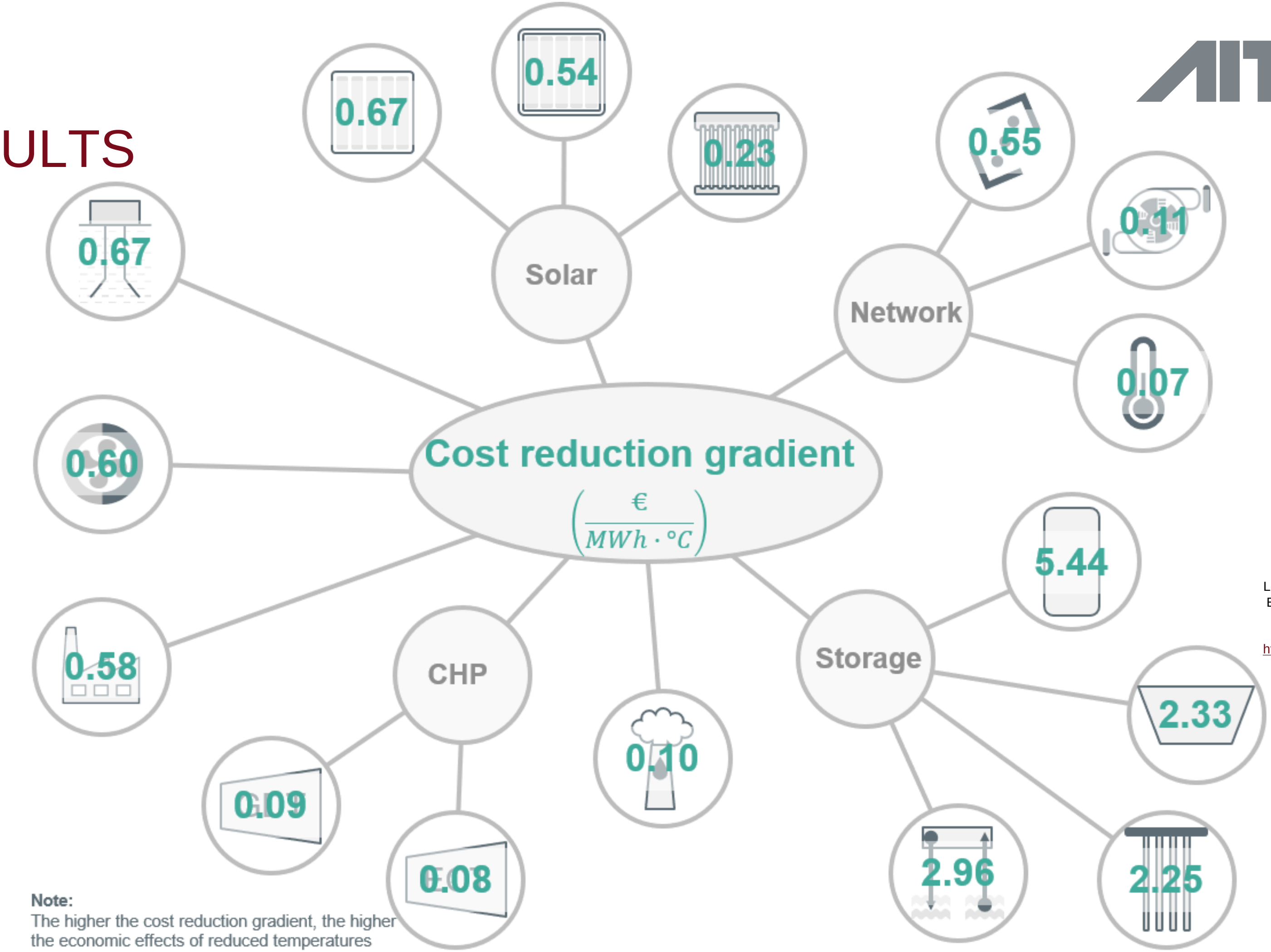


$$CRG = \frac{LCOH_{Benefit}}{Temperature\ reduction} \left[\frac{€}{MWh \cdot °C}\right]$$

Roman Geyer, Jürgen Krail, Benedikt Leitner, Ralf-Roman Schmidt, Paolo Leoni, Energy-economic assessment of reduced district heating system temperatures, Smart Energy, Volume 2, 2021, https://doi.org/10.1016/j.segy.2021.100011

- **Thermodynamic models** have been used to investigate capacity and efficiency improvements.
- cost data were derived from extant **literature**, with indicative cost estimations from **manufacturers**
- → calculate the **levelized cost of heat (LCOH)** determined for both reference and assessment cases.

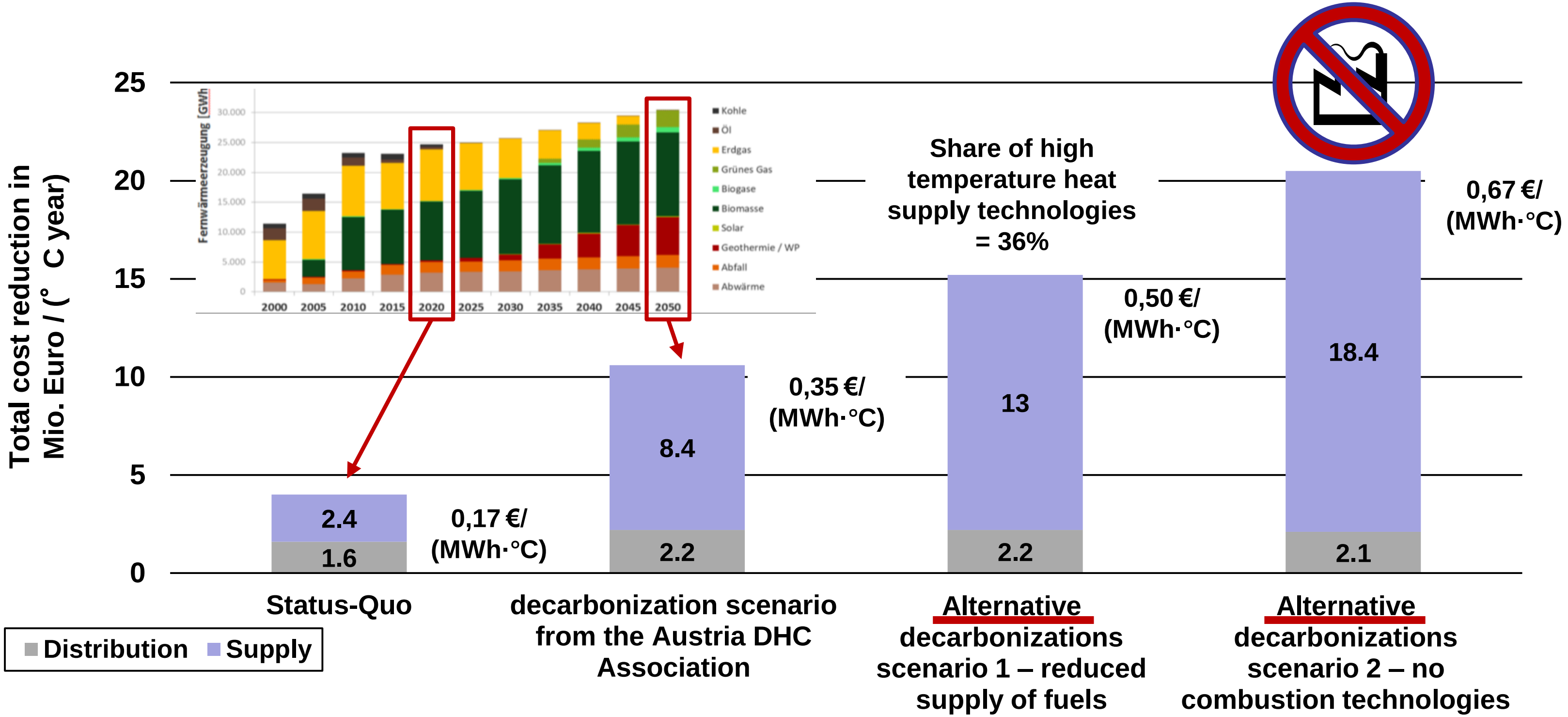
RESULTS



Note:
The higher the cost reduction gradient, the higher the economic effects of reduced temperatures

Roman Geyer, Jürgen Krail, Benedikt Leitner, Ralf-Roman Schmidt, Paolo Leoni, Energy-economic assessment of reduced district heating system temperatures, Smart Energy, Volume 2, 2021, https://doi.org/10.1016/j.segy.2021.100011

ESTIMATION OF THE MONETARY EFFECTS FOR AUSTRIA



0,17 €/(MWh·°C)

0,35 €/(MWh·°C)

0,50 €/(MWh·°C)

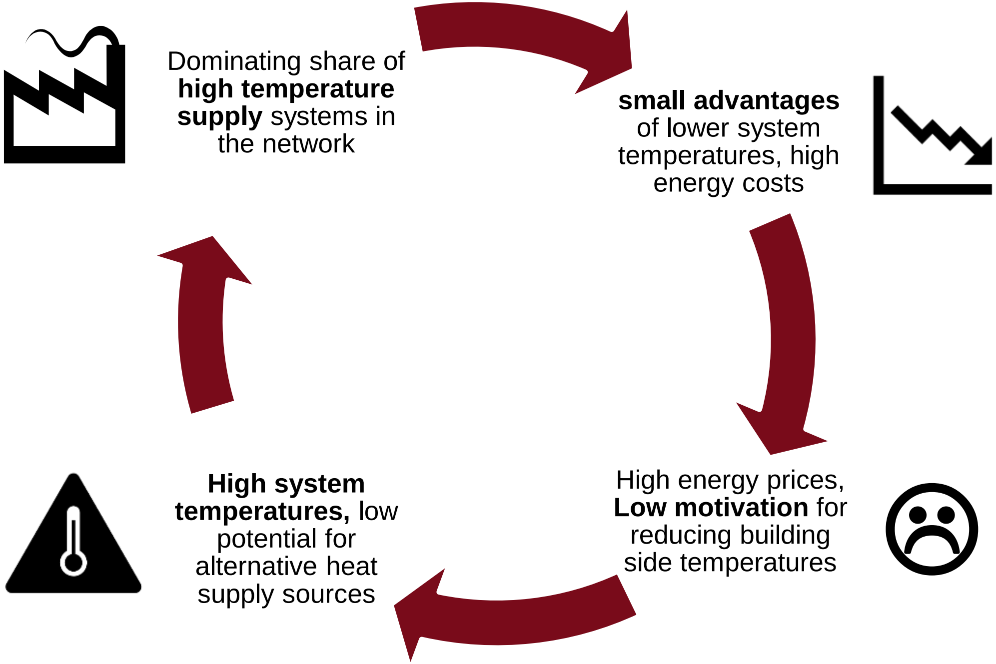
0,67 €/(MWh·°C)

Share of high temperature heat supply technologies = 36%

BUSINESS MODELS FOR REDUCING DISTRICT HEATING RETURN TEMPERATURES

This part of the presentation is an extract from
https://energieforschung.at/projekt/transformation-von-konventionellen-waermenetzen-in-richtung-niedertemperaturnetze-durch-sekundaerseitige-massnahmen/

VICIOUS CIRCLE OF HIGH SYSTEM TEMPERATURES



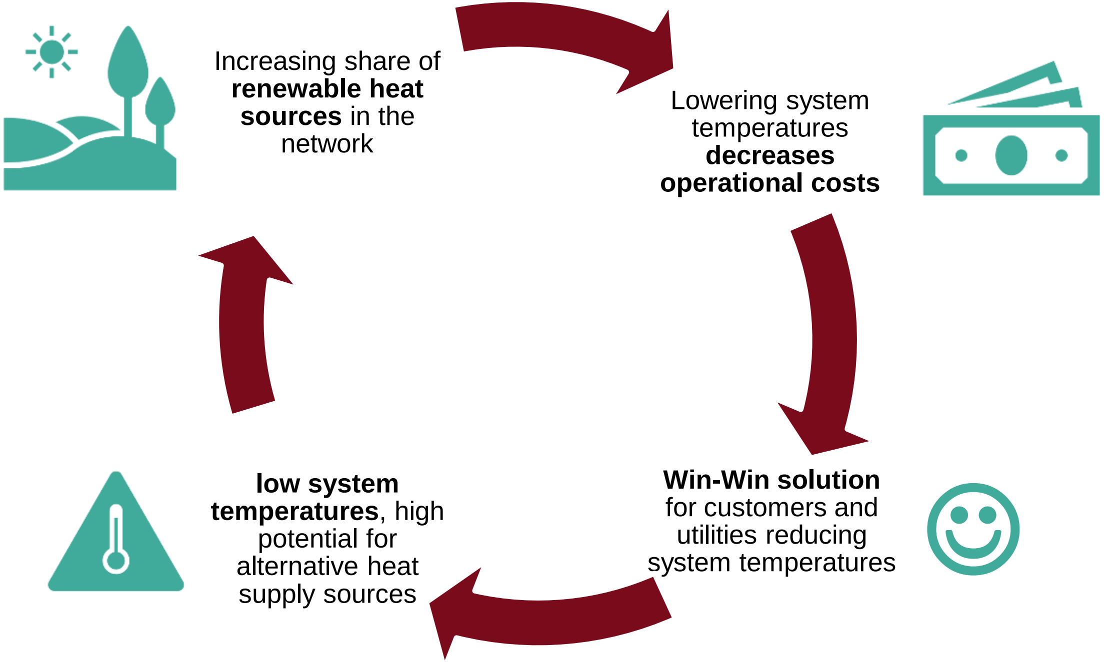
Dominating share of **high temperature supply** systems in the network

small advantages of lower system temperatures, high energy costs

High energy prices, **Low motivation** for reducing building side temperatures

High system temperatures, low potential for alternative heat supply sources

ADDED VALUE OF LOW SYSTEM TEMPERATURES



Increasing share of **renewable heat sources** in the network

Lowering system temperatures **decreases operational costs**

Win-Win solution for customers and utilities reducing system temperatures

low system temperatures, high potential for alternative heat supply sources

HOW TO REDUCE THE SYSTEM TEMPERATURES?

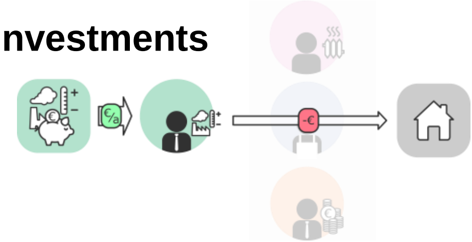
- **Counter measures** for correcting building side faults are well known and manageable

- The person supposed to bear the investment for optimization (**building owner**) is often different than person profiting from lower return temperatures (**operator**)

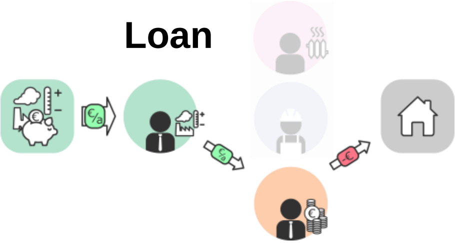
Identification of suitable business models

POSSIBLE **BUSINESS MODELS** FOR REDUCING SYSTEM TEMPERATURES

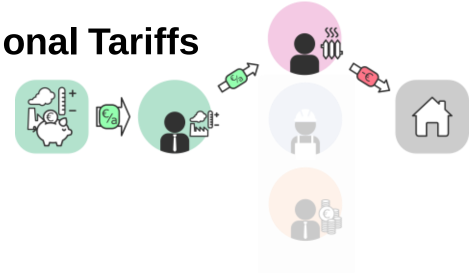
Utility Own Investments



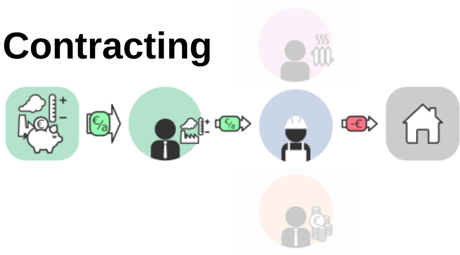
Loan



Motivational Tariffs

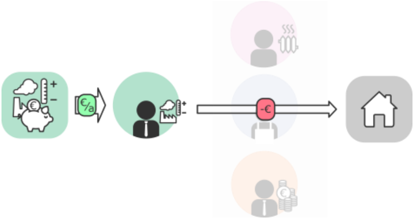


Contracting



Paolo Leoni, Roman Geyer, Ralf-Roman Schmidt, Developing innovative business models for reducing return temperatures in district heating systems: Approach and first results, Energy, Volume 195, https://doi.org/10.1016/j.energy.2020.116963

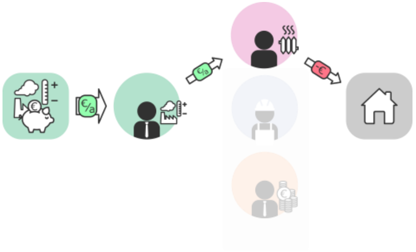
(REFERENCE)
BM-1: **UTILITY OWN INVESTMENTS**



- **The utility takes over the investment and implements the return temperature-reducing measures. Repayment via savings in operational costs.**

Strength/ Opportunities	**Weaknesses/ Threats**
• Standard model	• Availability of technical staff?
• utilities have know-how for correcting faults	• Investment risk lies with the utility
• Can be implemented directly	• Possibly access restrictions?
	• Some installations are complex
	• Lack of interest in investing in customer plants + liability issues

BM-2: **MOTIVATIONAL TARIFFS**



- **The customer takes over the investment or carries out the measures. Repayment of the investment via a bonus (malus) tariff depending on the return temperature.**

Strength/ Opportunities

- Best practice examples available
- can be implemented directly by the utility
- Easily scalable
- Encourages behavioral change
- Risks remain with the customer
- Repayment of investments via lump sum rent including heating
- Digitalisation for visualisation
- Initiation of competition between customers?

Weaknesses/ Threats

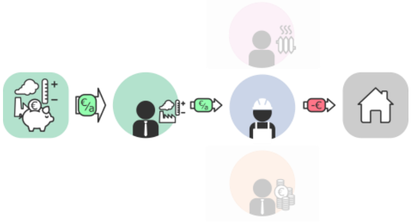
- Investor-user dilemma
- High complexity of the tariff
- Low customer satisfaction in case of malus
- Often long-term heat supply contracts
- Customer has little knowledge of and access to the system
- Billing according to temperature levels not permitted?

BM-3: **LOAN**

- **External investors (e.g. crowdfunding) take over the investment. Repayment over an agreed period of time.**

Strength/ Opportunities	**Weaknesses/ Threats**
• New financing channels for the utility	• Guarantees regarding repayments?
• Citizen participation models/ investment in environmentally friendly/ long-term projects.	• Data protection with regard to customer installations
• Use within cooperatives?	• Cannot be implemented without further ado
• Utilisation of online platform increases visibility of the utility and transparency + Additional services possible	

BM-4: **CONTRACTING**

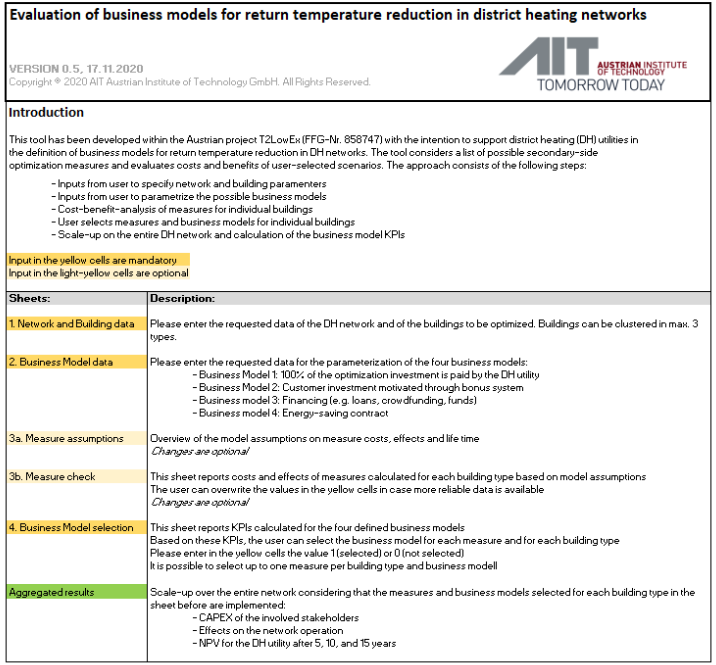


- **An external contractor implements the measures (e.g. tendering according to the best bidder principle) Repayment of the investments via sharing of the real savings.**

Strength/ Opportunities	Weaknesses/ Threats
• Measures are cost-effective due to economies of scale. • Sharing of the risk between the contractor and the utility. • Utility companies can act as contractors outside their own network area (increase in staff utilization).	• Often short-term view of the contractors • Negative relationship between utility and customer in case of failure • Complicated contract design • Measures for customer data protection • cannot be implemented easily

COST-BENEFIT ANALYSIS AND SELECTION OF SUITABLE BUSINESS MODELS

Excel Tool



Evaluation of business models for return temperature reduction in district heating networks

VERSION 0.5, 17.11.2020

TOMORROW TODAY

Introduction

This tool has been developed within the Austrian project T2LowEx (FFG-Nr. 858747) with the intention to support district heating (DH) utilities in the definition of business models for return temperature reduction in DH networks. The tool considers a list of possible secondary-side optimization measures and evaluates costs and benefits of user-selected scenarios. The approach consists of the following steps:

- Inputs from user to specify network and building paramenters
- Inputs from user to parametrize the possible business models
- Cost-benefit-analysis of measures for individual buildings
- User selects measures and business models for individual buildings
- Scale-up on the entire DH network and calculation of the business model KPIs

Input in the yellow cells are mandatory
Input in the light-yellow cells are optional

Sheets:	Description:
1. Network and Building data	Please enter the requested data of the DH network and of the buildings to be optimized. Buildings can be clustered in max. 3 types.
2. Business Model data	Please enter the requested data for the parameterization of the four business models: - Business Model 1: 100% of the optimization investment is paid by the DH utility - Business Model 2: Customer investment motivated through bonus system - Business model 3: Financing (e.g. loans, crowdfunding, funds) - Business model 4: Energy-saving contract
3a. Measure assumptions	Overview of the model assumptions on measure costs, effects and life time *Changes are optional*
3b. Measure check	This sheet reports costs and effects of measures calculated for each building type based on model assumptions The user can overwrite the values in the yellow cells in case more reliable data is available *Changes are optional*
4. Business Model selection	This sheet reports KPIs calculated for the four defined business models Based on these KPIs, the user can select the business model for each measure and for each building type Please enter in the yellow cells the value 1 (selected) or 0 (not selected) It is possible to select up to one measure per building type and business modell
Aggregated results	Scale-up over the entire network considering that the measures and business models selected for each building type in the sheet before are implemented: - CAPEX of the involved stakeholders - Effects on the network operation - NPV for the DH utility after 5, 10, and 15 years

- **Input:**
  - Data on the network, buildings, tariff
  - Measures, costs, effects (CRG), life time
  - BM specific data (interest rate, height of the bonus, duration of contract …)

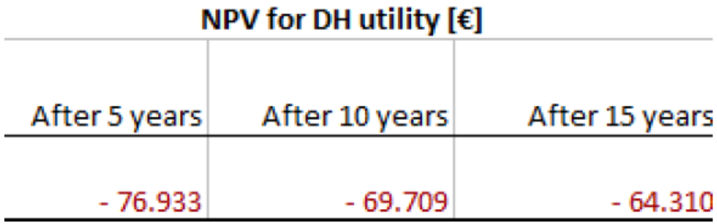
- **output:**
  - Building-specific costs and effects
  - KPI calculations, selection of BM
  - Results scaled to network level

→ Use of the tool in the case studies of the project partners

COST-BENEFIT ANALYSIS AND SELECTION OF SUITABLE BUSINESS MODELS

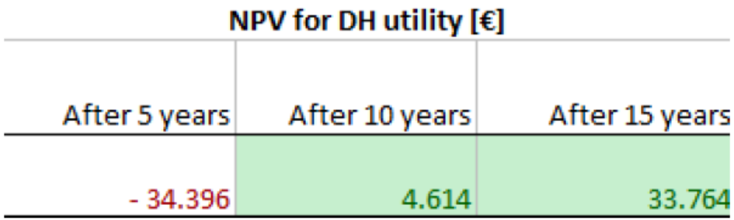
- **Example: implementation of a motivational tariff in a DH network**
  - Standard price at return temperatures between: 55,1 – 60° C
  - 1.8% / 3.5% / 5.1% reduction at: 50,1 – 55° C / 45,1° C – 50° C / < 45 ° C
  - The customer was implementing different optimization measures
- The resulting **economic effects were evaluated** using the excel tool for two different DH networks:

Network 1: CRG = 0.21 €/(MWh K)



NPV for DH utility [€]		
After 5 years	After 10 years	After 15 years
- 76.933	- 69.709	- 64.310

Network 2: CRG = 1.08 €/(MWh K)

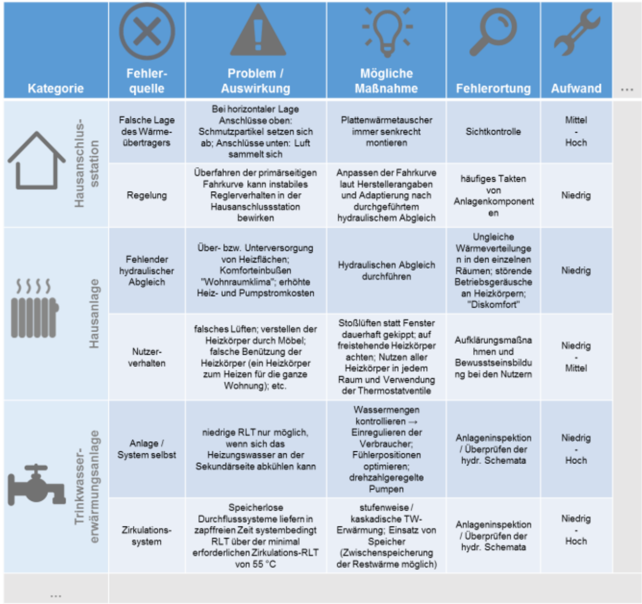


NPV for DH utility [€]		
After 5 years	After 10 years	After 15 years
- 34.396	4.614	33.764

HOW TO IDENTIFY REASONS FOR HIGH RETURN TEMPERATURES?

CHARACTERIZATION OF TYPICAL FAULTS IN BUILDING INSTALLATIONS

- The **main reason for high temperatures** lies on the secondary side: the building installations
- **Various faults can occur**, including wrong design of heat exchanger or radiators, false setpoints, sensor misplacement, valve misfunctions, unnecessary bypasses, user behaviour …
- This faults do not actually affect the thermal comfort. Thus, **customers are often unaware of them.**

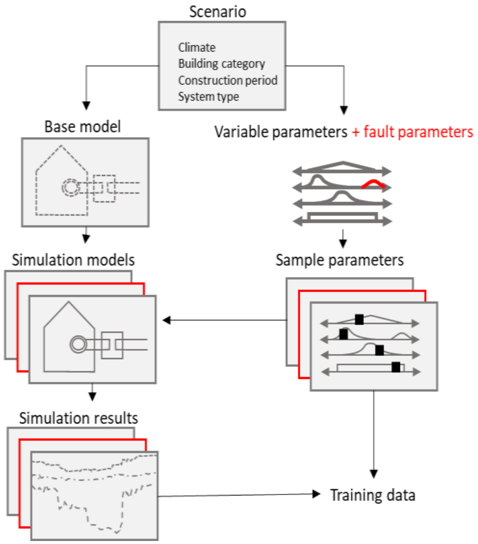


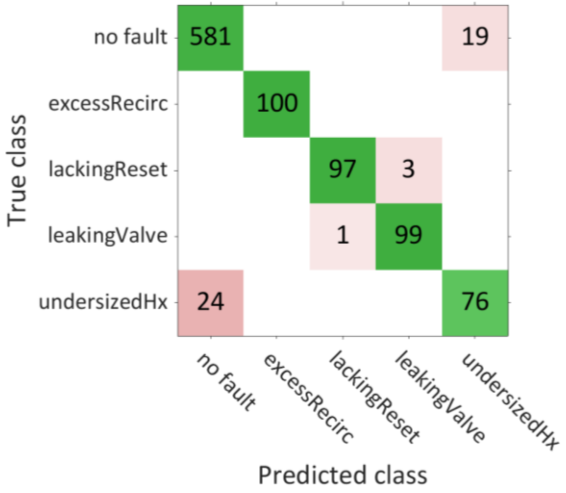
Kategorie	Fehlerquelle	Problem / Auswirkung	Mögliche Maßnahme	Fehlerortung	Aufwand	…
Hausanschlussstation	Falsche Lage des Wärmeübertragers	Bei horizontaler Lage Anschlüsse oben: Schmutzpartikel setzen sich ab; Anschlüsse unten: Luft sammelt sich	Plattenwärmetauscher immer senkrecht montieren	Sichtkontrolle	Mittel - Hoch	
	Regelung	Überfahren der primärseitigen Fahrkurve kann instabiles Reglerverhalten in der Hausanschlussstation bewirken	Anpassen der Fahrkurve laut Herstellerangaben und Adaptierung nach durchgeführtem hydraulischem Abgleich	häufiges Takten von Anlagenkomponenten	Niedrig	
Hausanlage	Fehlender hydraulischer Abgleich	Über- bzw. Unterversorgung von Heizflächen; Komforteinbußen "Wohnraumklima"; erhöhte Heiz- und Pumpstromkosten	Hydraulischen Abgleich durchführen	Ungleiche Wärmeverteilungen in den einzelnen Räumen; störende Betriebsgeräusche an Heizkörpern; "Diskomfort"	Niedrig	
	Nutzerverhalten	falsches Lüften; verstellen der Heizkörper durch Möbel; falsche Benützung der Heizkörper (ein Heizkörper zum Heizen für die ganze Wohnung); etc.	Stoßlüften statt Fenster dauerhaft gekippt; auf freistehende Heizkörper achten; Nutzen aller Heizkörper in jedem Raum und Verwendung der Thermostatventile	Aufklärungsmaßnahmen und Bewusstseinsbildung bei den Nutzern	Niedrig - Mittel	
Trinkwassererwärmungsanlage	Anlage / System selbst	niedrige RLT nur möglich, wenn sich das Heizungswasser an der Sekundärseite abkühlen kann	Wassermengen kontrollieren → Einregulieren der Verbraucher; Fühlerpositionen optimieren; drehzahlgeregelte Pumpen	Anlageninspektion / Überprüfen der hydr. Schemata	Niedrig - Hoch	
	Zirkulationssystem	Speicherlose Durchflusssysteme liefern in zapffreien Zeit systembedingt RLT über der minimal erforderlichen Zirkulations-RLT von 55 °C	stufenweise / kaskadische TW-Erwärmung; Einsatz von Speicher (Zwischenspeicherung der Restwärme möglich)	Anlageninspektion / Überprüfen der hydr. Schemata	Niedrig - Hoch	
…						

heat_portfolio (FFG-Nr. 848849), Deliverable D6.1 & D6.2, https://www.energieforschung.at/assets/project/downloads/heat-portfolio-D6.1-D6.2.pdf

FAULT **IDENTIFICATION** BY ANALYSES OF MONITORING DATA

- **Example:** Application of a **self-learning algorithm** for fault detection using monitoring data
- **Training data** based on simulation of building and technical system
- Accounting for **variability in parameters** (constructions, systems, occupancy…)





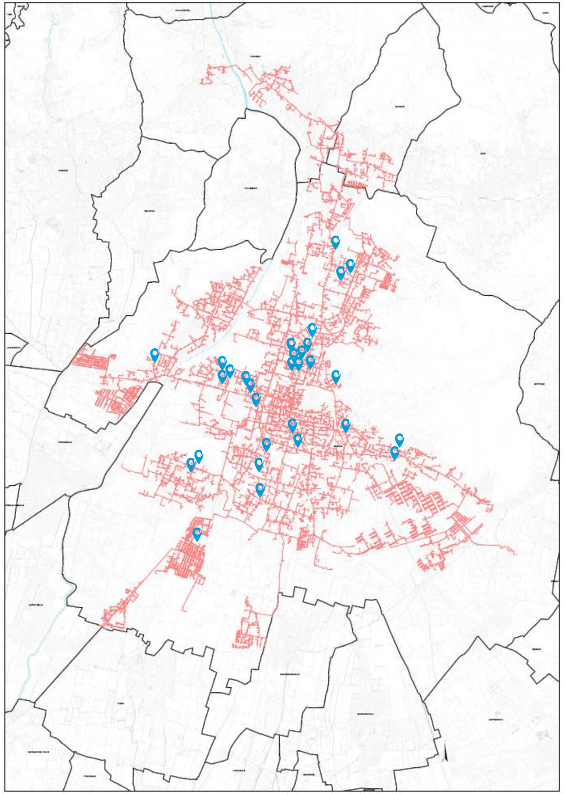
	no fault	excessRecirc	lackingReset	leakingValve	undersizedHx
no fault	581				19
excessRecirc		100			
lackingReset			97	3	
leakingValve			1	99	
undersizedHx	24				76

Aurélien Brès et al: 2019
https://doi.org/10.26868/25222708.2019.210629

*when considering data from secondary side temp. measurements using simulation models

DEMONSTRATION IN THE DH NETWORK OF BRESCIA (ITALY)

- 680 km network length
- > 21.500 customers
- 1.000 GWh supplied heat
- Supply / return temp: 90°C ÷ 130°C / 60°C;
- Supply via: Waste to Energy, CHP + heat recovery
- **Demonstration of the fault detection algorithm in 31 multi family houses (MFH) distributed in the city**



This part of the presentation is an extract from https://www.tempo-dhc.eu/wp-content/uploads/2022/03/4-TEMPO-Challenges-and-success-in-Brescia.pdf

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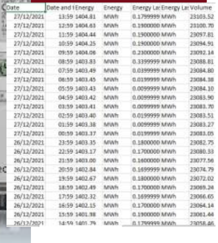
IMPLEMENTED ACTIVITIES

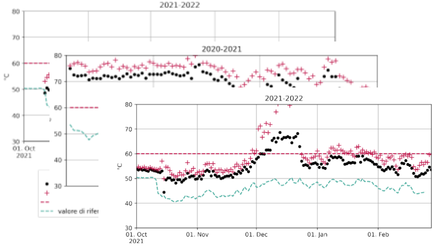
1. Extraction of monitoring data from the MFH by a2a



Date	Date and t	Energy	Energy	Energy La	Energy La	Volume
27/12/2021	13:59	1404.81	MWh	0.1799999	MWh	23103.52
27/12/2021	12:59	1404.63	MWh	0.1900000	MWh	23100.70
27/12/2021	11:59	1404.44	MWh	0.1900000	MWh	23097.81
27/12/2021	10:59	1404.25	MWh	0.1900000	MWh	23094.91
27/12/2021	09:59	1404.06	MWh	0.2300000	MWh	23092.14
27/12/2021	08:59	1403.83	MWh	0.3399999	MWh	23088.81
27/12/2021	07:59	1403.49	MWh	0.0399999	MWh	23084.80
27/12/2021	06:59	1403.45	MWh	0.0199999	MWh	23084.38
27/12/2021	05:59	1403.43	MWh	0.0099999	MWh	23084.10
27/12/2021	04:59	1403.42	MWh	0.0099999	MWh	23083.90
27/12/2021	03:59	1403.41	MWh	0.0099999	MWh	23083.70
27/12/2021	02:59	1403.40	MWh	0.0199999	MWh	23083.51
27/12/2021	01:59	1403.38	MWh	0.0099999	MWh	23083.27
27/12/2021	00:59	1403.37	MWh	0.0199999	MWh	23083.05
26/12/2021	23:59	1403.35	MWh	0.1800000	MWh	23082.75
26/12/2021	22:59	1403.17	MWh	0.1700000	MWh	23080.33
26/12/2021	21:59	1403.00	MWh	0.1600000	MWh	23077.56
26/12/2021	20:59	1402.84	MWh	0.1699999	MWh	23074.79
26/12/2021	19:59	1402.67	MWh	0.1800000	MWh	23072.02
26/12/2021	18:59	1402.49	MWh	0.1700000	MWh	23069.24
26/12/2021	17:59	1402.32	MWh	0.1699999	MWh	23066.65
26/12/2021	16:59	1402.15	MWh	0.1700000	MWh	23064.14
26/12/2021	15:59	1401.98	MWh	0.1900000	MWh	23061.44
26/12/2021	14:59	1401.79	MWh	0.1799999	MWh	23058.46

2. Fault detection by AIT

- Analysing the individual performance / possible faults
- Provide an online guide for auditing building installations
- Visualization for non-experts

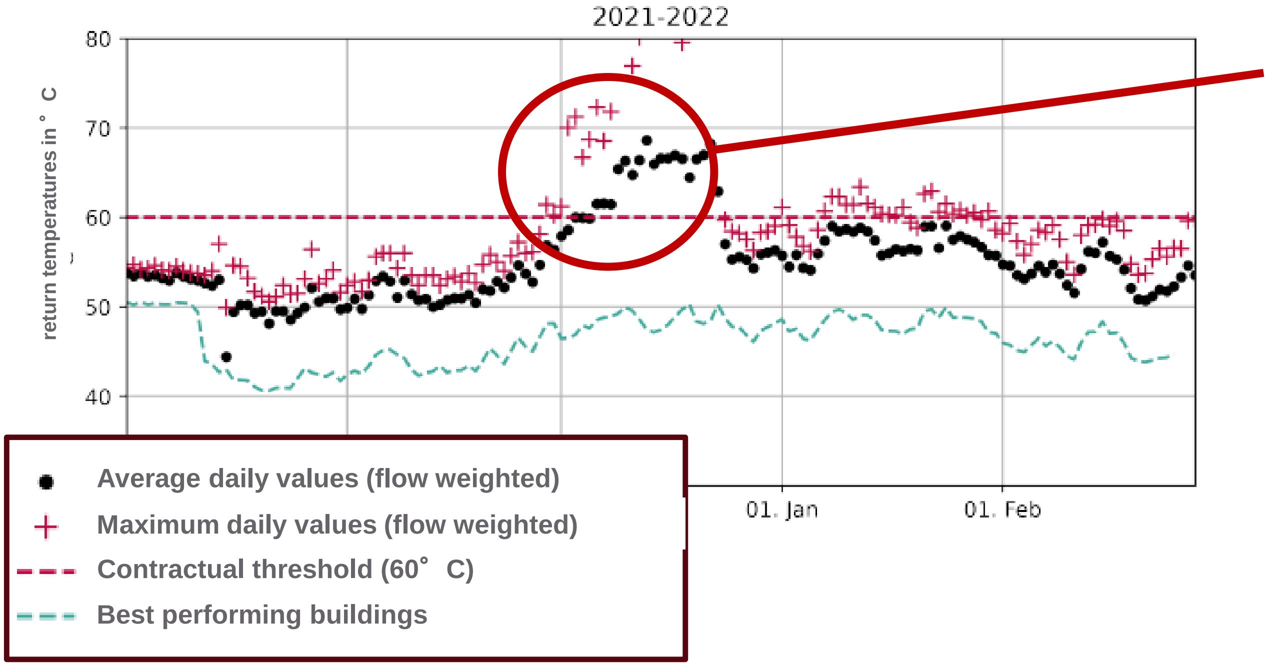


3. a2a sends simplified reports to the managers of the worst performing buildings

4. Building managers involves their technicians + Technicians (can) get in discussion with a2a on possible improvements

This part of the presentation is an extract from https://www.tempo-dhc.eu/wp-content/uploads/2022/03/4-TEMPO-Challenges-and-success-in-Brescia.pdf

EXAMPLE RESULTS



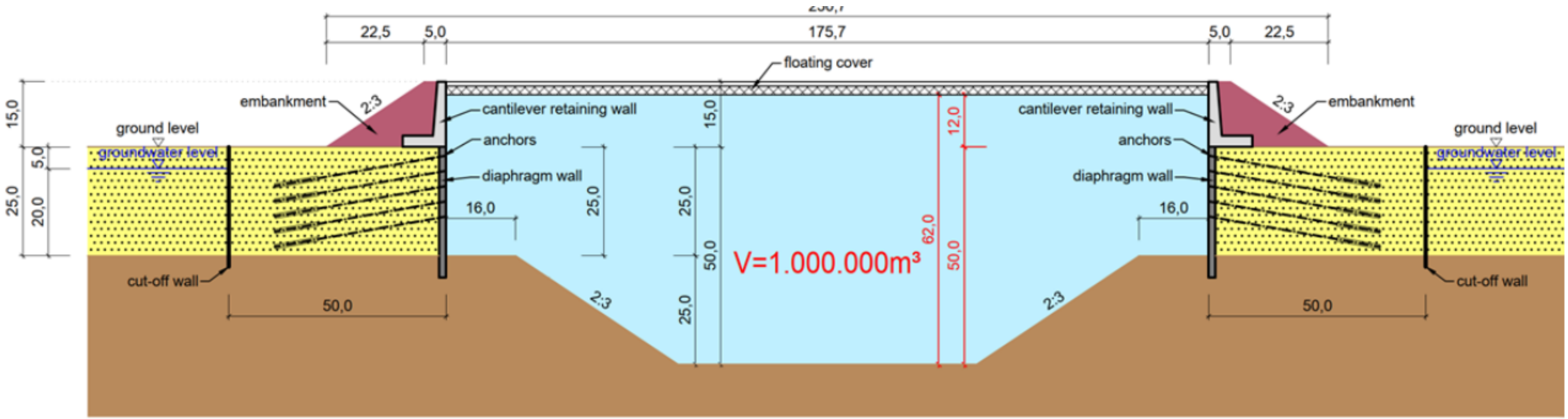
1. high return temp. have been **identified by the algorithm**

2. the **communication with the local technicians** revealed the reason for this behaviour *(heat exchanger fouling, and cleaned in Dec.)* **+ counter measures** were suggested to avoid fouling in the future

This part of the presentation is an extract from
https://www.tempo-dhc.eu/wp-content/uploads/2022/03/4-TEMPO-Challenges-and-success-in-Brescia.pdf

TEMPERATURE REDUCTIONS

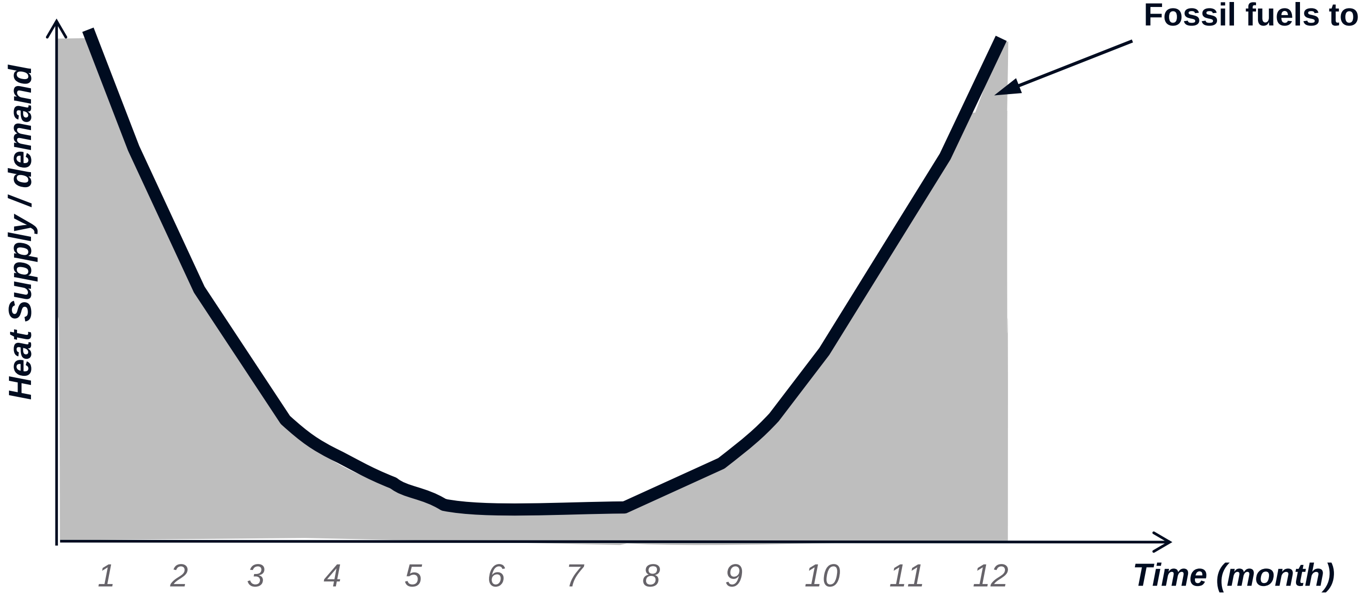
- **High DH network temperatures** create a fatal lock-in effect and significantly reduce the potential for decarbonization
- **Future prove DH networks** will be dominated by diversified, alternative heat source where **low system temperatures will have a significant benefit**
- **Digitalization and AI** can support the identification of optimization potentials and the implementation of business models
- For implementing measures to reduce system temperatures the **customer needs to be involved**, creating win-win situations
- Every **involvement and communication towards the customer** is sensitive and needs to be planned carefully;
- **Contractual terms as well as responsibilities / ownership** must be carefully evaluated when proposing activities on customers side;



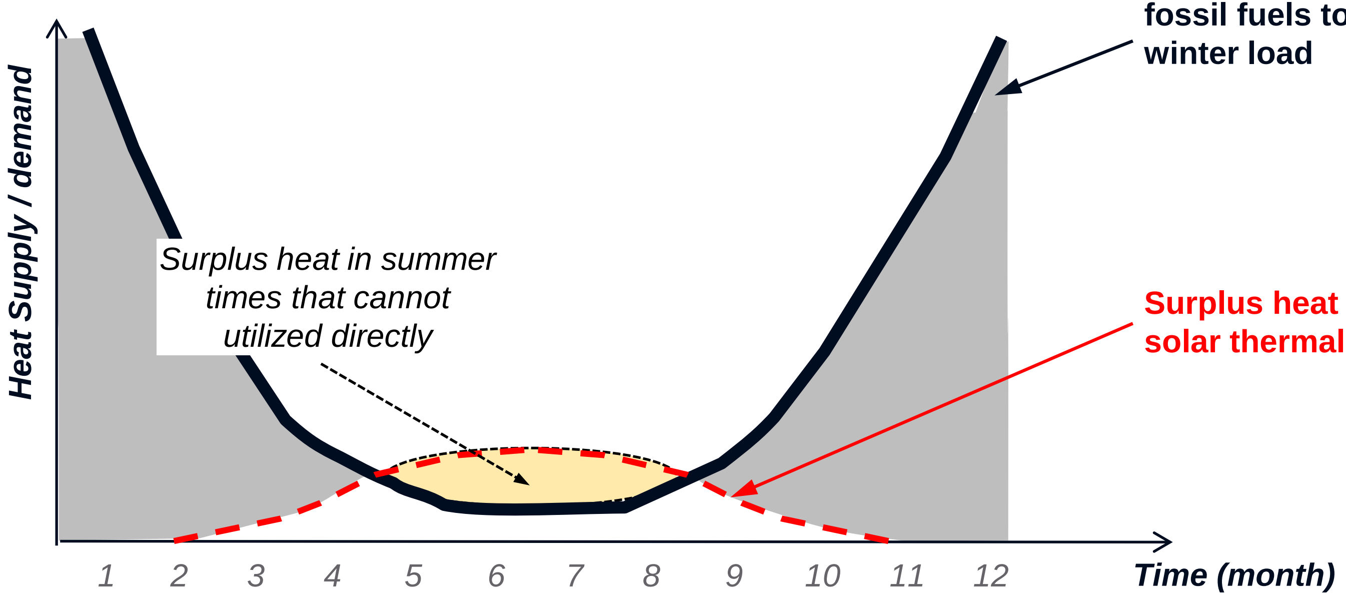
https://nachhaltigwirtschaften.at/resources/nw_pdf/events/20211123/2-2_Deix_van_Helden_WimvanHelden.pdf?m=1637609879&

SEASONAL ENERGY STORAGES

MOTIVATION:
SURPLUS HEAT IN SUMMER TIMES



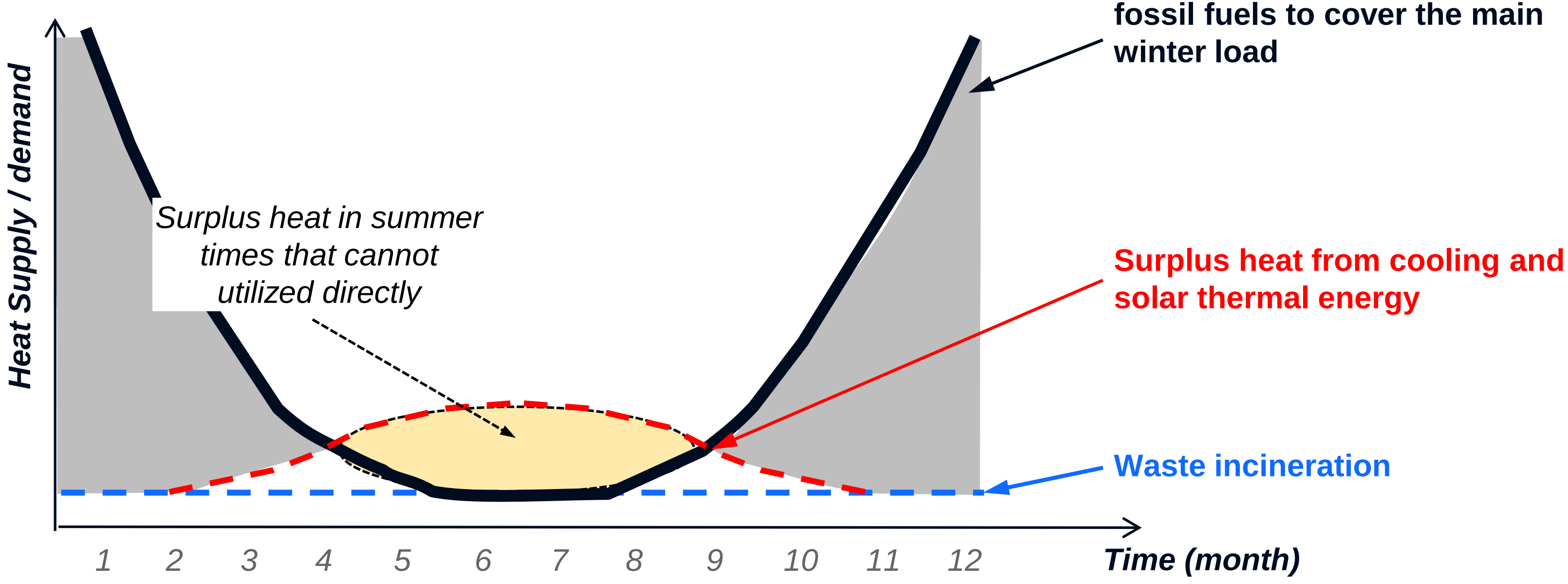
MOTIVATION:
SURPLUS HEAT IN SUMMER TIMES



fossil fuels to cover the main winter load

Surplus heat from cooling and solar thermal energy

MOTIVATION:
SURPLUS HEAT IN SUMMER TIMES

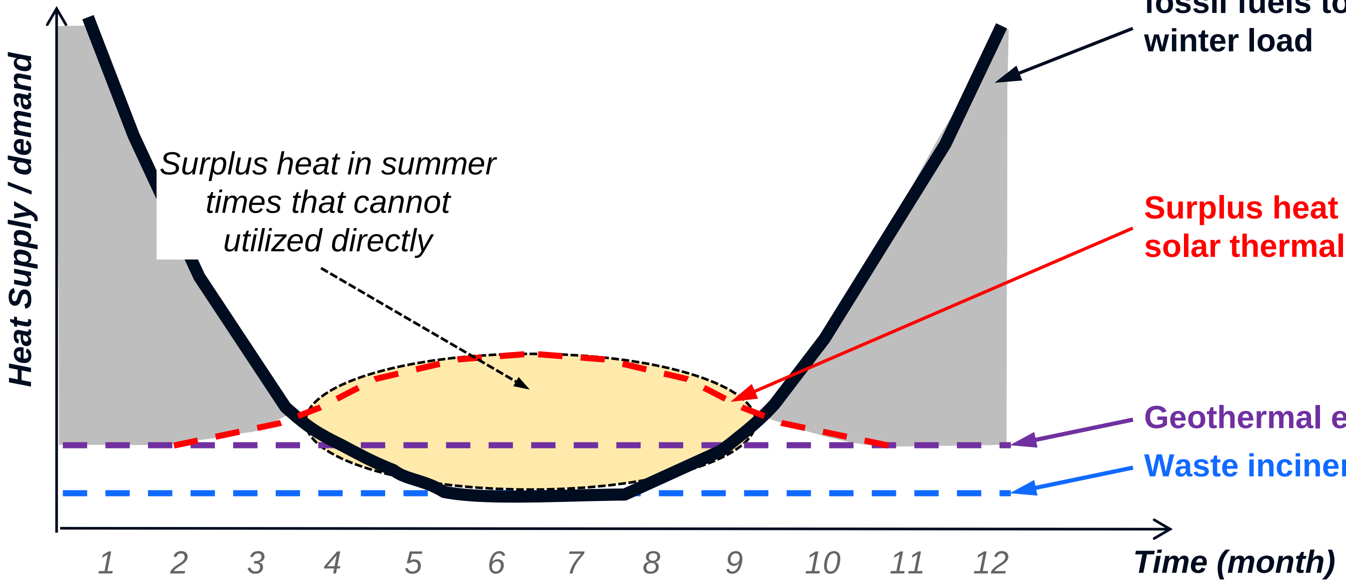


fossil fuels to cover the main winter load

Surplus heat from cooling and solar thermal energy

Waste incineration

MOTIVATION:
SURPLUS HEAT IN SUMMER TIMES



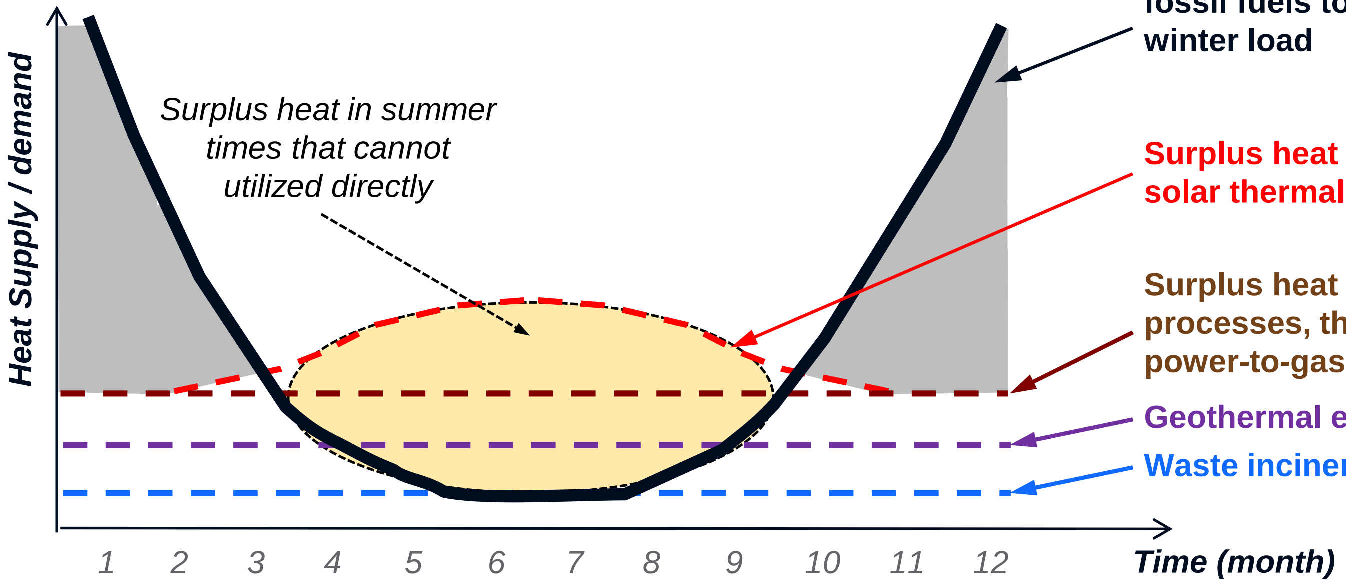
fossil fuels to cover the main winter load

Surplus heat from cooling and solar thermal energy

Geothermal energy

Waste incineration

MOTIVATION:
SURPLUS HEAT IN SUMMER TIMES



fossil fuels to cover the main winter load

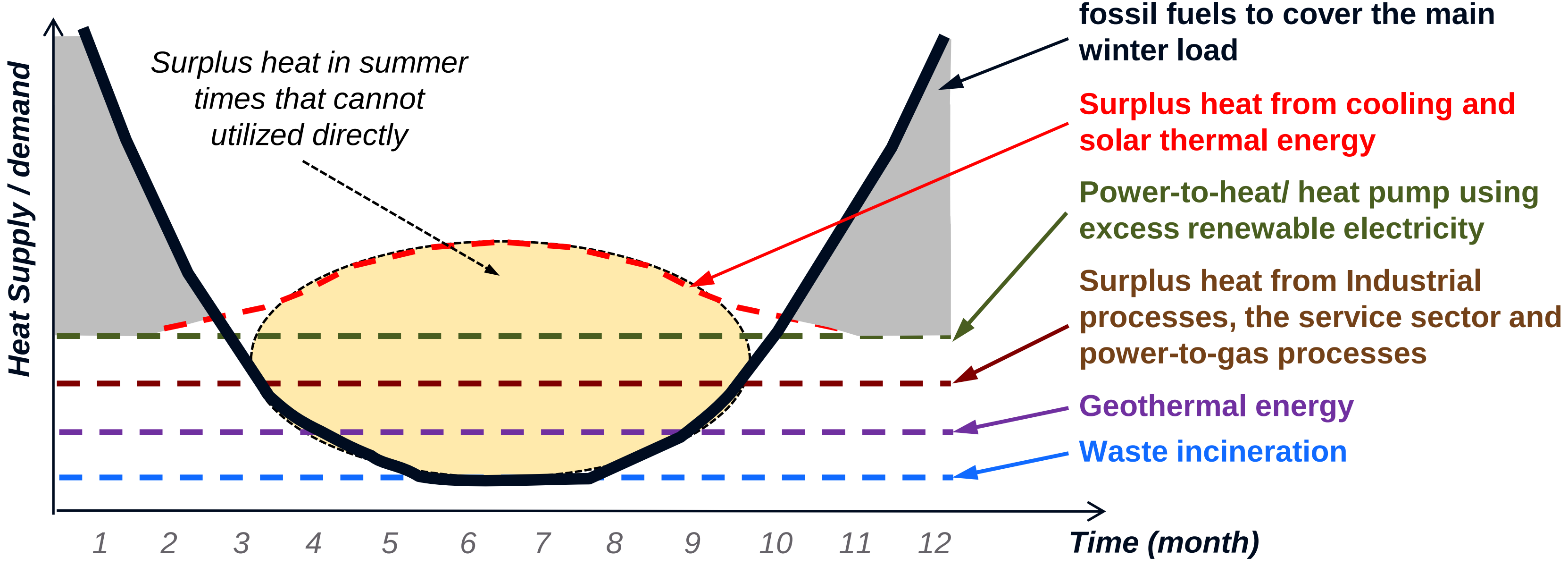
Surplus heat from cooling and solar thermal energy

Surplus heat from Industrial processes, the service sector and power-to-gas processes

Geothermal energy

Waste incineration

MOTIVATION:
SURPLUS HEAT IN SUMMER TIMES



Surplus heat in summer times that cannot utilized directly

fossil fuels to cover the main winter load

Surplus heat from cooling and solar thermal energy

Power-to-heat/ heat pump using excess renewable electricity

Surplus heat from Industrial processes, the service sector and power-to-gas processes

Geothermal energy

Waste incineration

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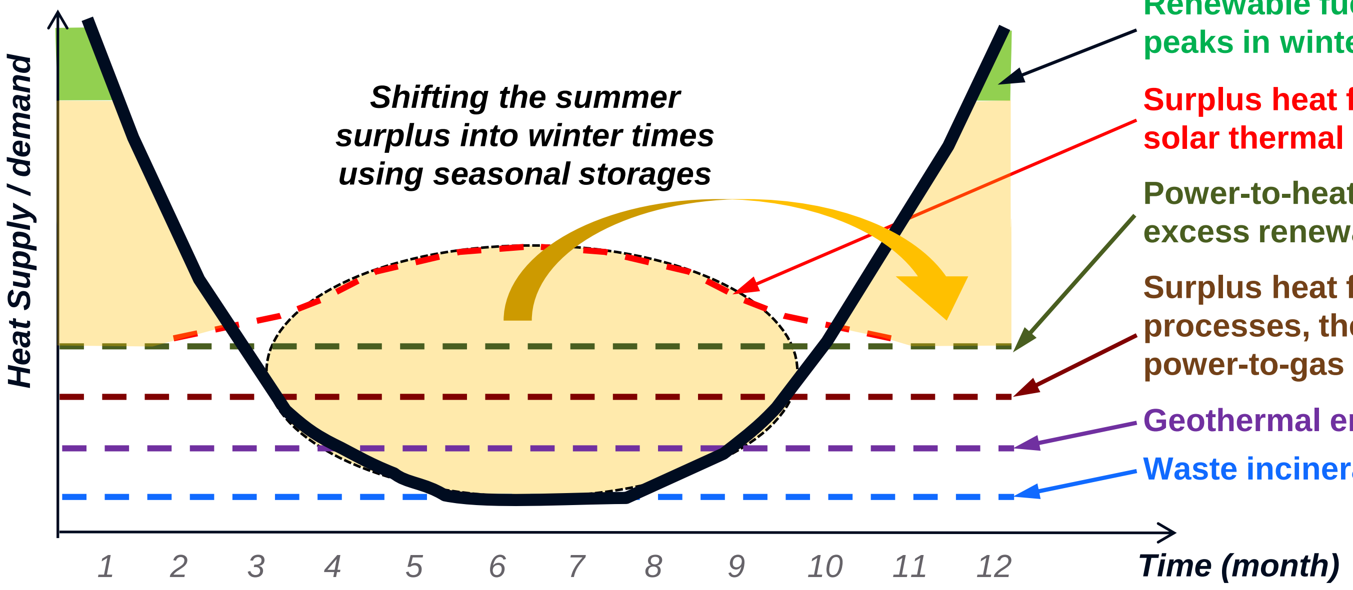
USING SURPLUS HEAT IN WINTER TIMES



Renewable fuels to cover extreme peaks in winter times

Surplus heat from cooling and solar thermal energy

Power-to-heat/ heat pump using excess renewable electricity

Surplus heat from Industrial processes, the service sector and power-to-gas processes

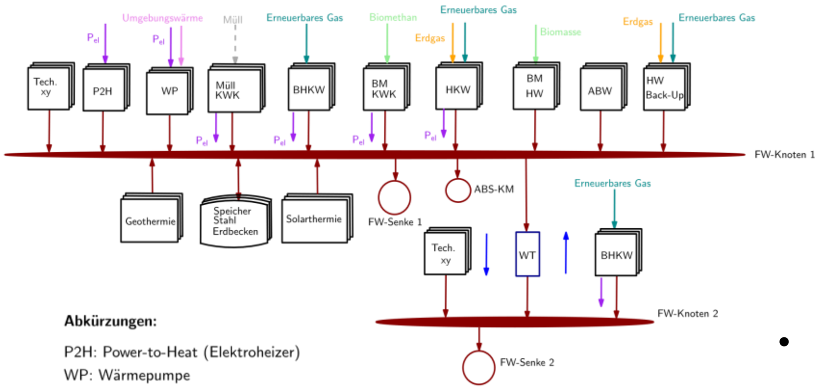
Geothermal energy

Waste incineration

EXAMPLE:

- **Model-based optimization of the future supply portfolio of a district heating network (medium-sized city) in Austria**
  - For a long-term and holistic view of the heat supply an optimised "no regrets" heat and gas strategy for the entire province was developed, including
    - supply of green biomethane & hydrogen;
    - heating demand and supply
      - rural and **urban district heating network**
      - Decentralized heating sector
      - Industrial heating / gas demand
    - Infrastructure/ gas grid

AIT DISTRICT HEATING DECARBONIZATION
MODELLING & OPTIMIZATION FRAMEWORK



Abkürzungen:

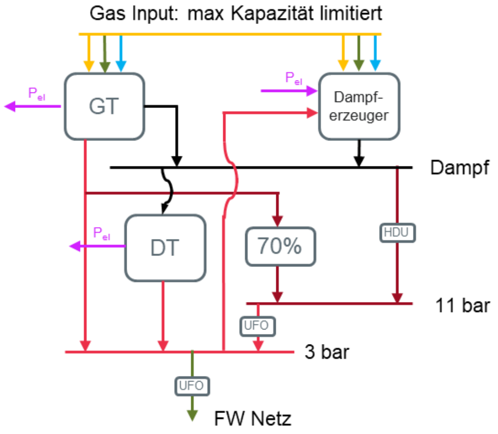
P2H: Power-to-Heat (Elektroheizer)
WP: Wärmepumpe
BHKW: Blockheizkraftwerk
KWK:Kraftwärme-Kopplung
BM: Biomasse
HKW: Heizkraftwerk
HW: Heizwerk
ABW: Abwärme
ABS-KM: Absorber Kältemaschine
WT:Wärmetauscher
FW: Fernwärme

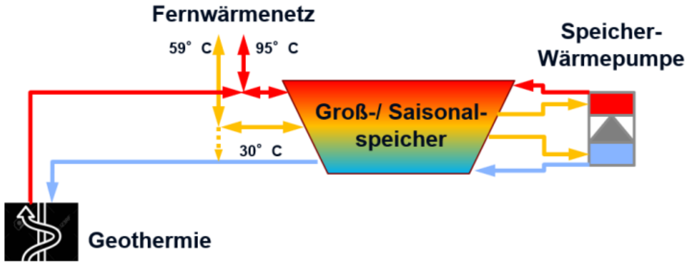
- **Method**: Mixed integer optimization, objective function: minimisation of the discounted total system costs, consideration of
  - **energy price fluctuations** (forecasts of gas and electricity prices)
  - Different degrees of district heating **expansion**
  - current and potential **new heat supply** technologies + storages
  - grid transmission **capacities**.
- **Model horizon**: from 2026 to 2050.
  - Use of four base years and 6 representative weeks; temporal resolution: 3h (achieving acceptable computation time and convergence).
- **Results**: Optimal investment path (incl. plant sizes), heat production costs etc.

CONSIDERED **TECHNOLOGY OPTIONS**

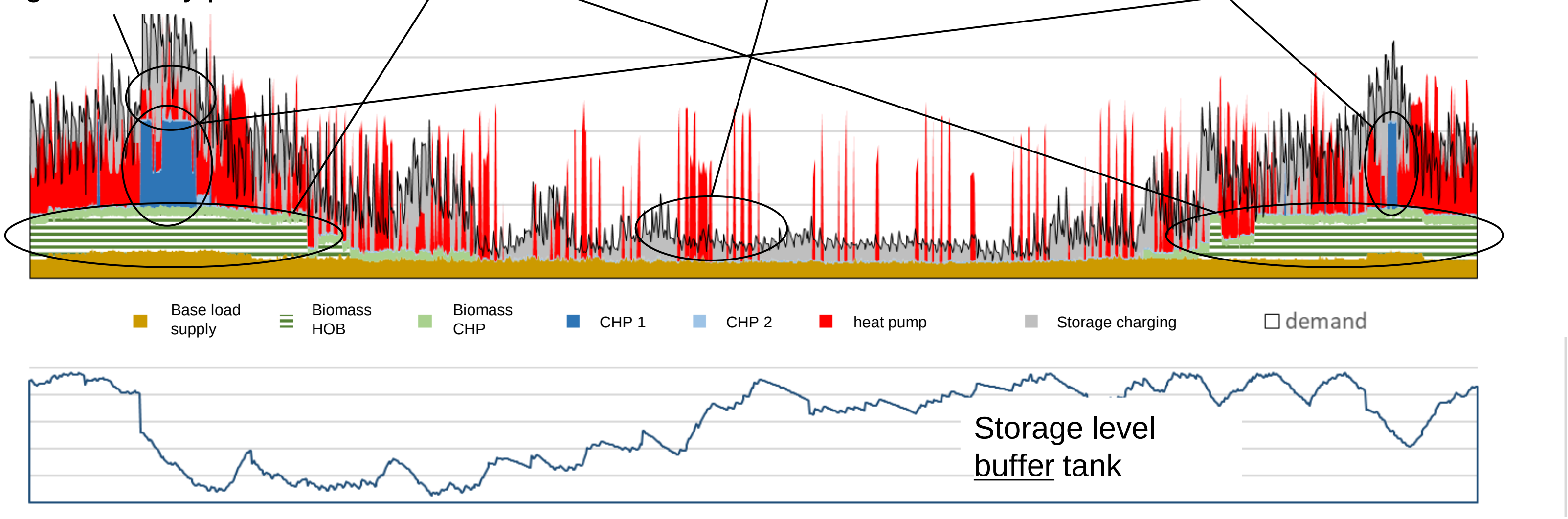
- Existing plants + possible new plants
  - CHP (extraction condensation, back pressure); heat only boilers, waste incineration
  - heat pumps, solar- + geothermal energy, waste heat
  - Large-scale storage (steel tank, PIT storage)
- Plants with multiple energy flows
- Partial load behaviour
- Various interconnected sub-grids

- **Remark heat pumps:**
  - Operation is optimised according to electricity prices
  - Cascade interconnection / Return temperature reduction
    - Better utilisation of geothermal energy
    - Increase in storage capacity
  - Different operating modes and COPs for the same heat pump





RESULTS: WITHOUT SEASONAL STORAGE



Due to missing alternatives: operation of HP also during periods with high electricity prices

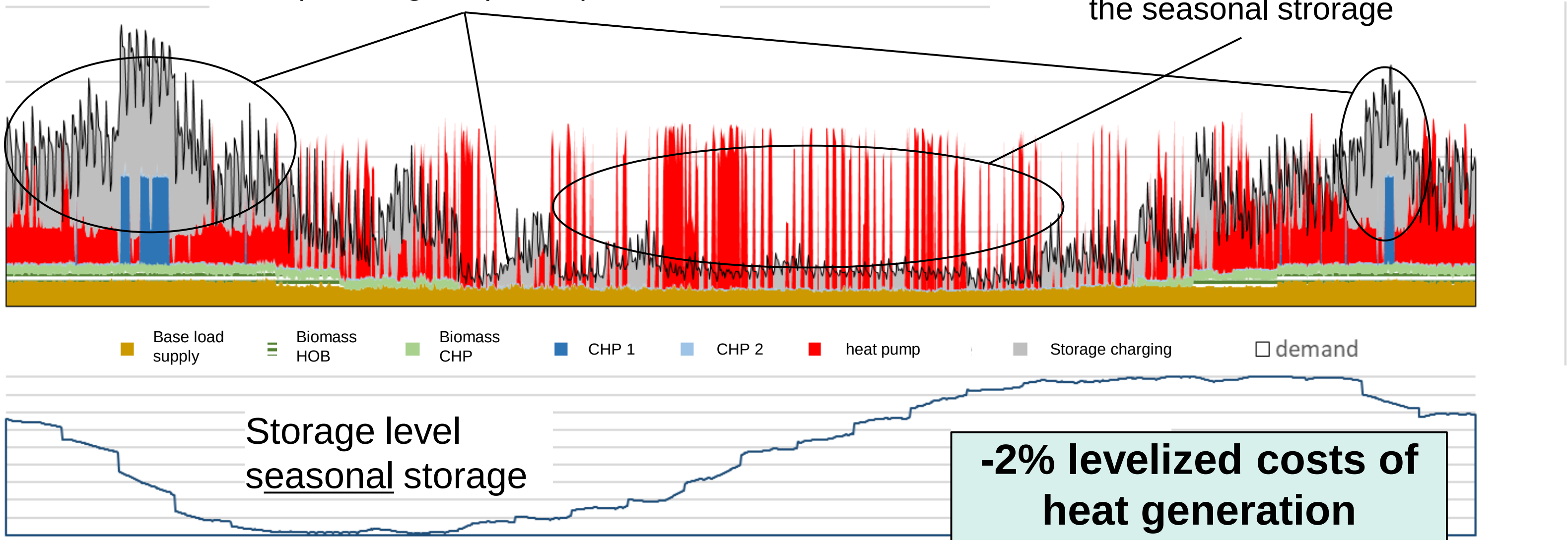
High amounts of biofuels

Limited buffer charging at low electricity prices

CHP operation due to high electricity prices in winter

Storage level
buffer tank

RESULTS: WITH SEASONAL STORAGE



Discharging of the seasonal storage mainly in winter times + for optimizing the plant operation

Low electricity prices in summer + high source temperatures → operation of the HP and charging the seasonal strorage

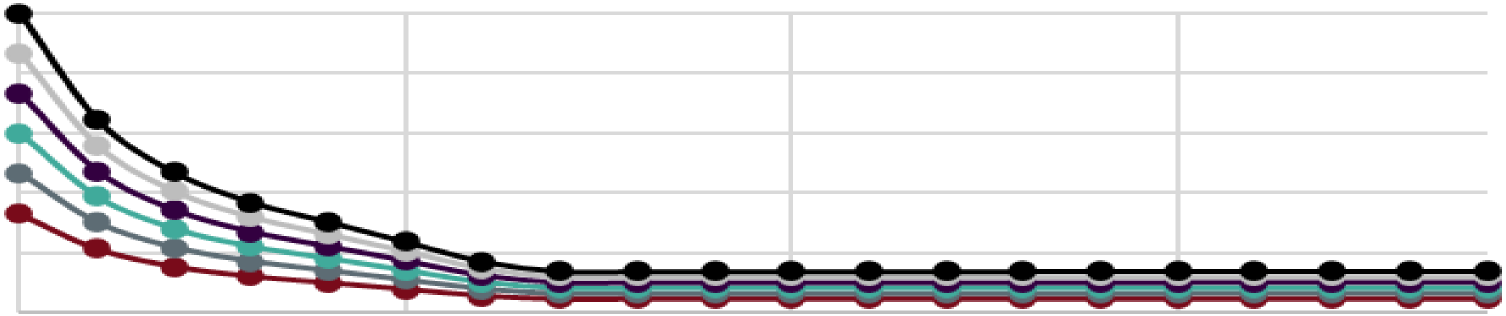
Storage level seasonal storage

-2% levelized costs of heat generation
compared to the scenario without seasonal storage

SEASONAL STORAGES

- Large-scale storages create a **seasonal balance** (move surpluses heat from the summer (waste heat, geothermal energy, HP, CHP ...) to the winter) + are also important for **short-term flexibility**
  - Optimization of use of sector coupling technologies (**HP, CHP**)
  - Reduction of **biofuel** demand
- Can be **economic feasible** if low costs of surplus heat is available, the costs of biofuels is high and long observation periods are considered

- **CONTRA:**
  - Space requirement, additional grid infrastructure may be necessary.
  - Possibly acceptance problems?
  - Technology availability (largest storage so far = 0.2 million m3) and feasible temperature levels



RISK ASSESMENT USING MONTE-CARLO-SIMULATIONS

This part of the presentation is an extract from https://iewt2023.eeg.tuwien.ac.at/download/contribution/presentation/266/266_presentation_20230223_100053.pdf

MOTIVATION

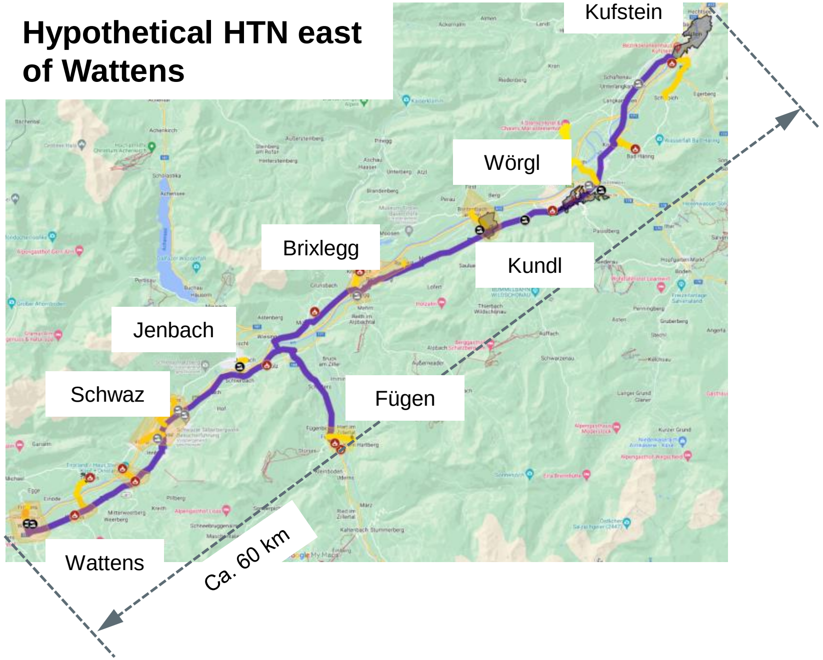
- **The development of district heating networks or their decarbonization is associated with considerable uncertainties**
  - **Electricity** prices (average values and hourly fluctuations)
  - Prices of **renewable fuels** (especially H2, biomethane and biomass),
  - Availability of alternative heat sources (especially **waste heat**, but also deep geothermal energy) and seasonal storage.

CASE STUDY: INTERREGIONAL HEAT SUPPLY NETWORK IN AUSTRIA (INN VALEY)

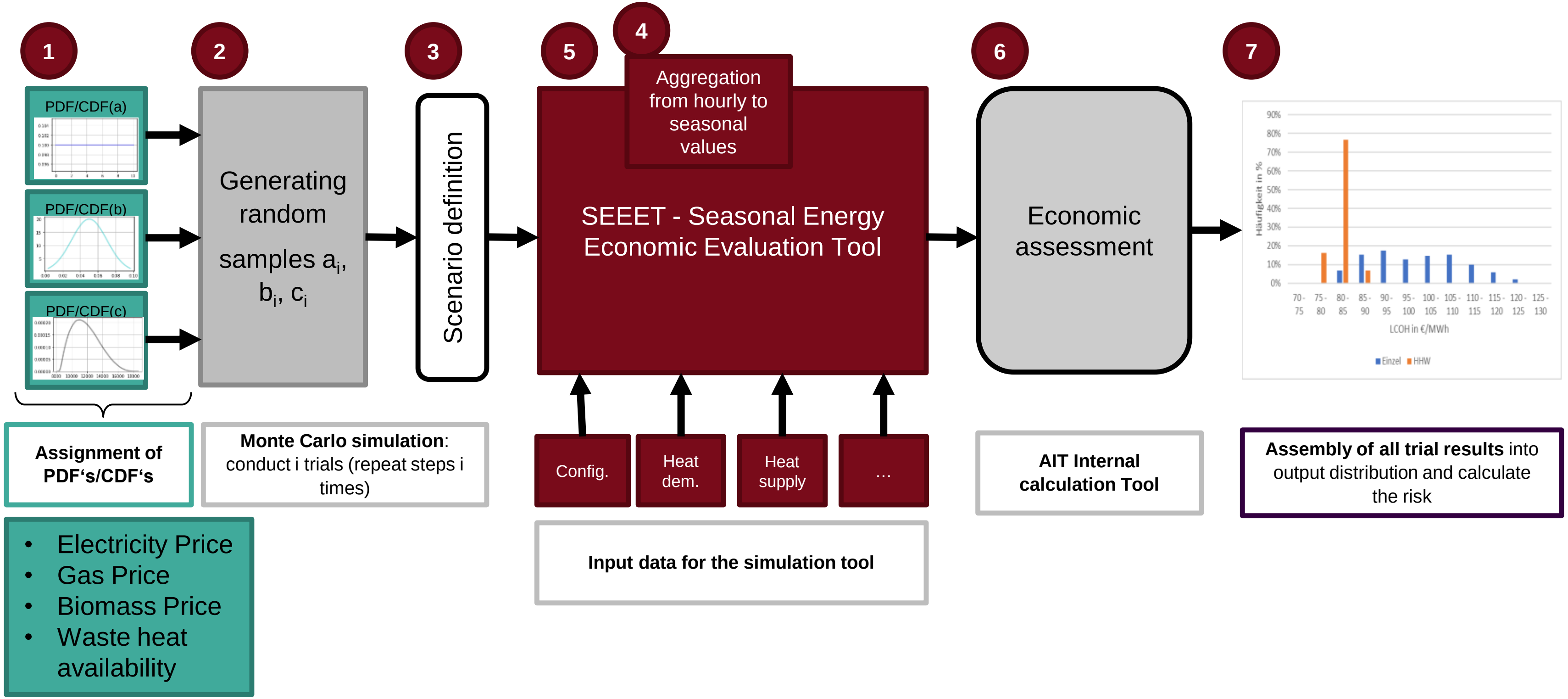
- Identification of the most promising **heat sinks and sources** (8 industrial waste heat suppliers + existing biomass heating plants).
- Elaboration of a **basic pipeline route** + costs
- Calculation of **economic efficiency** via seasonal balances (no optimisation)
- Performing a **risk analysis** in comparison to an "individual" heat supply using Monte Carlo simulation

Focus of this presentation

Hypothetical HTN east of Wattens



METHOD



Generating random samples a_i, b_i, c_i

Scenario definition

Aggregation from hourly to seasonal values

SEEET - Seasonal Energy Economic Evaluation Tool

Economic assessment

Assignment of PDF's/CDF's

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

Config.

Heat dem.

Heat supply

…

Input data for the simulation tool

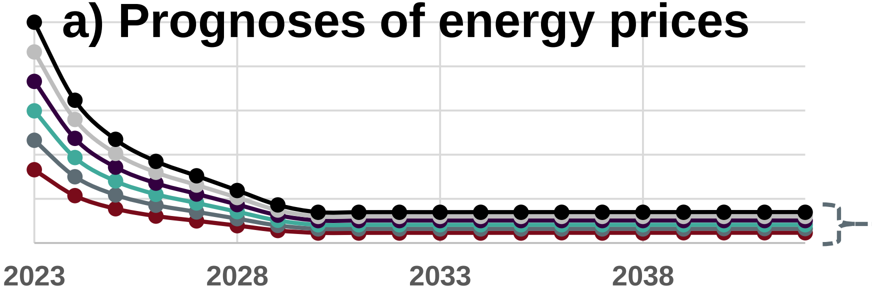
AIT Internal calculation Tool

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

- Electricity Price
- Gas Price
- Biomass Price
- Waste heat availability

1 DEFINITION OF THE UNCERTAINTY FACTORS

a) Prognoses of energy prices

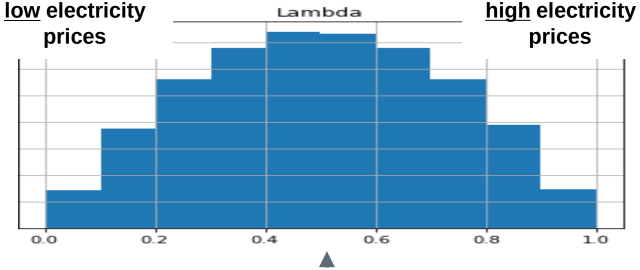


- Houerly electricity prices
- Monthly biofuel prices
- Yearly biomethane prices (= Gas price + Premium)

Source: Gas price: EU Energy Outlook 2060, electricit prices: öffentlich verfügbare Studien, Schwankungen: VAR-Model, Biomassepreise: Biomasseverband

Lambda = 0 → Scenarios with <u>low</u> electricity prices

Lambda = 1 → Scenarios with <u>high</u> electricity prices



Lambda draw

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

b) Availability of waste heat

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

2 SZENARIO DEFINITION

- Example of a draw X

		year, when waste heat is not longer available							
Scenario	**Lambda**	**Waste heat supplier 1**	**Waste heat supplier 2**	**Waste heat supplier 3**	**Waste heat supplier 4**	**Waste heat supplier 5**	**Waste heat supplier 6**	**Waste heat supplier 7**	**Waste heat supplier 8**
X	0.73	2033	-	2040	-	-	-	-	-

3
- N draws will be done and handed to the simlation tool

4
- For each draw, the economic full load hours of CHP and WPs are calculated using the hourly electricity prices + aggregated to seasonal values

5 TECHNO-ECONOMIC EVALUATION

- Using the **simulation programme „SEEET“** (developed within the project MEMPHIS 2.0)
- Consideration of seasonal differences with regard to the main influencing parameters (heat demand and generation, electricity prices, etc.)

- **Comparing two configurations**

INDIVIDUAL

- Decarbonization on municipal level
- Exchange of oil and coal heating with biomass and heat pumps
- Exchange gas heating with biomethane / biomass/ heat pump

HEAT HIGHWAY

- Connecting all municipalities via a interregional DH transmission network (90% connection rate)
- Maximizing the waste heat utilization
- Integration of large scale CHP and HP

CALCULATION OF THE LEVELIZED COSTS OF HEAT (LCOH)

LCOH INDIVIDUAL

Energy Cost
- Biomass
- Electricity
- Biomethane

CAPEX
- Individual generation plants

Depreciation
- Heating plant

OPEX
- All generation units

Reinvest
- Assumption: Existing individual plants are at 50% of the service life

LCOH HEAT HIGHWAY

Energy Cost
- Biomass
- Electricity
- Profits from electricity sales

CAPEX
- Individual generation plants

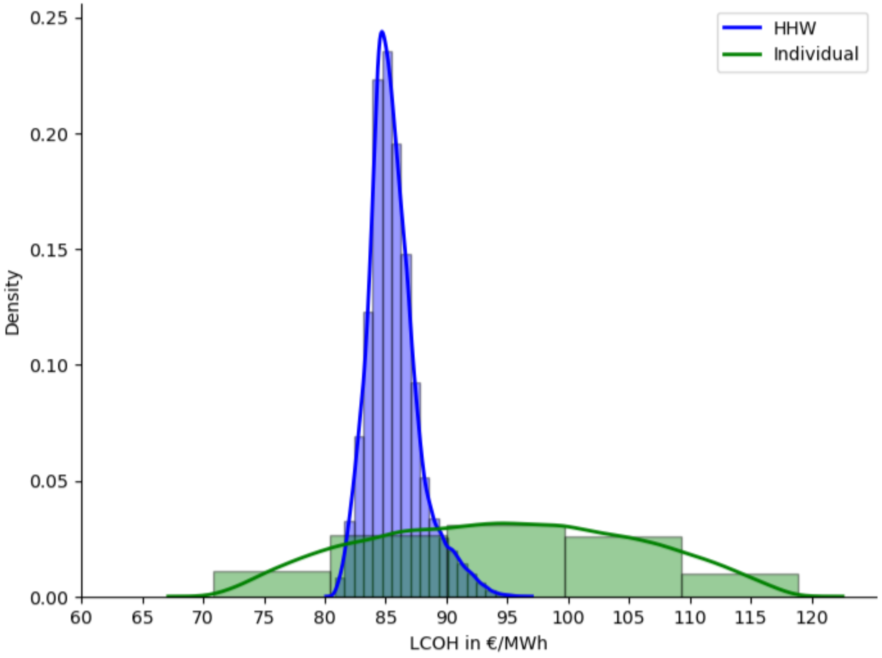
Depreciation
- Heating plant
- Networks
- CHP
- Large-scale heat pump
- Storage

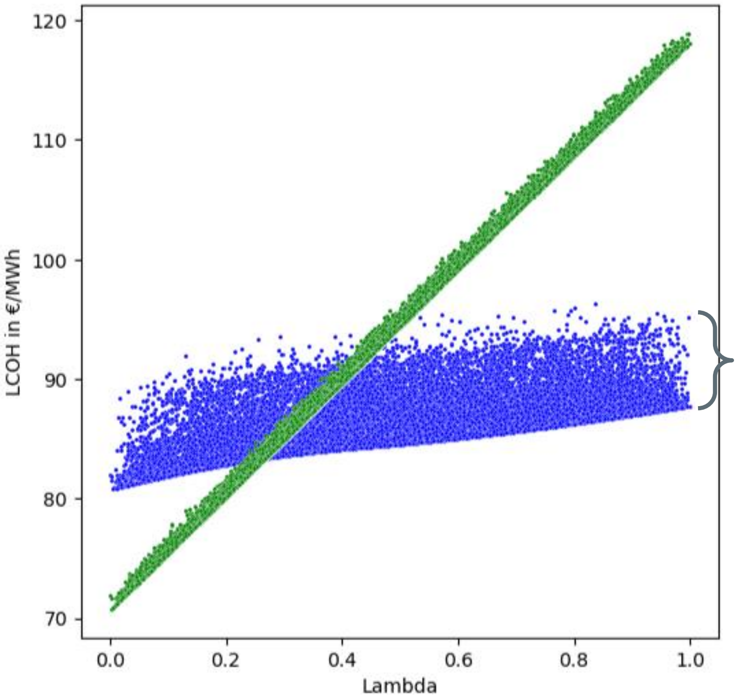
OPEX
- All generation units

Reinvest
- Assumption: Existing individual plants are at 50% of the service life

'image: Flaticon.com'. This cover has been designed using resources from Flaticon.com

7 RESULTS (PRELIMINARY)





Effect of
waste heat
outages

N = 50.000

RISK ASSESSMENT

- **Uncertainties** regarding energy prices have a considerable influence on the economic efficiency of **individual** heat supply.

- Compared to individual heat supply options, **district heating** networks can
  - optimize the use of waste heat (favorable base load), utilize
  - heat pumps (use when electricity prices are low) and
  - CHP (use at high electricity prices)

  and as a consequence, form a very **robust system**

- However, **individual heat pumps** enable the use of locally generated PV, participation in energy communities, provision of cooling, etc., which was not considered in the context of this study

OUTLOOK

OUTLOOK: DeRiskDH

"Risk minimization for decarbonizing heating networks via network temperature reductions and flexibility utilization"

- **A green energy lab project**
- **Run-time**: 15.01.2023 – 14.01.2026

Optimised buildings

- Analyse and optimize **return temperatures** and **flexibility** of DH connected buildings
- Quantify technical reasons for sub-optimal performance and **measures to improve the building performance**, understand interactions/ **interdependencies**

Innovative secondary DH networks

- Develop **robust systems** with low temperatures, **high flexibility**, high share of local heat supply
- **retrofitting** measures on a district scale
- investigate and implement **innovative control algorithms** for the buildings, network and substations

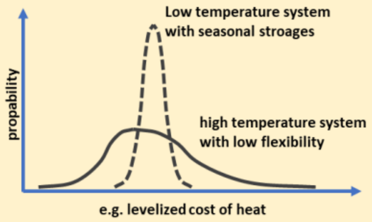
Overall DH network analysis

- Analyse **technical options** for the decarbonization of DH networks
- consider optimized **buildings**, future decentralized low temperatures **supply** units and seasonal **storages**.
- Analyse **hydraulic** constrains and heat losses

Technical analysis and demonstration

Risk minimisation for decarbonisation

- **Monte Carlo** simulations for assessing different scenarios and risks
- Evaluating interdependencies on a **national energy system** level
- considering the **effects of return temperature** reductions and **flexibility** utilization from the technical analysis
- Develop a **general understanding** of the different risks and **apply** the methodology



Economic evaluation and replication

business models and framework conditions

- **implementing** the DeRiskDH solutions
- **Cost-benefit** assessment
- **Stakeholder** involvement
- **Recommendations** (energy planning processes / regulations / subsidies)

Socio-economic perspective

THANKS FOR YOUR ATTENTION!

Dr.-Ing. Ralf-Roman Schmidt

AIT Austrian Institute of Technology GmbH
Giefinggasse 2 | 1210 Vienna | Austria
M +43(0) 664 235 19 01 | F +43(0) 50550-6679
Ralf-Roman.Schmidt@ait.ac.at | http://www.ait.ac.at