FTI Initiative Energy Model Region

Publishable final report

Programme control:
Climate and Energy Fund

Programme management:
The Austrian Research Promotion Agency (FFG)

Final Report
created on
31.08.2025

AbSolut
ABSORPTION

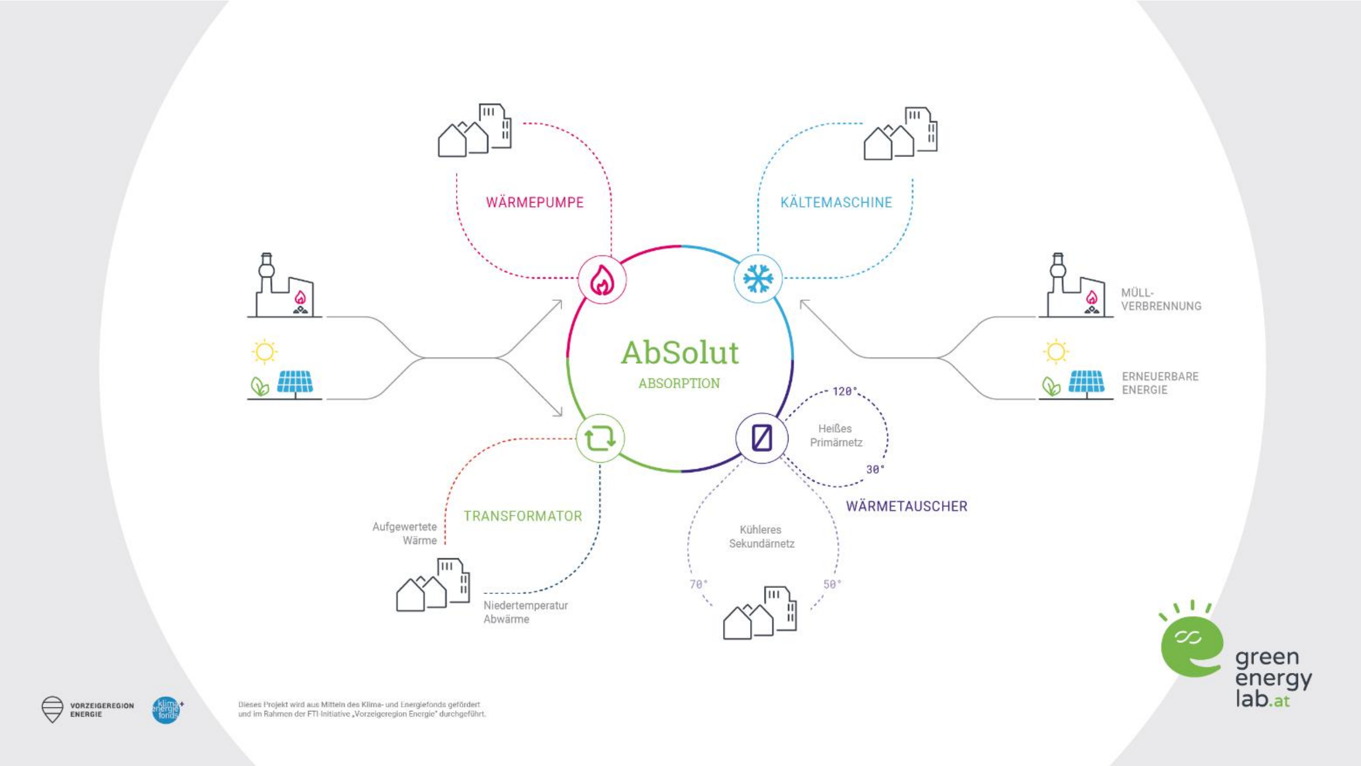
Integration of absorption technologies in district heating and cooling systems

Project number:
880765

Call	4. Call FTI Initiative Energy Model Region
Project Starting Date	01.04.2021
Project Ending Date	30.09.2024
Total duration of project (in months)	42 Months
Project holder (Institution)	AEE – Institute for Sustainable Technologies
Contact person	Carina Seidnitzer-Gallien
Postal address	Feldgasse 19, 8200
Telephone	+43 3112 5886-266
Fax	+43 3112 5886-18
E-mail	c.seidnitzer-gallien@aee.at
Website	www.aee-intec.at https://greenenergylab.at/projects/absolut/?lang=en

AbSolut

Integration of absorption technologies in district heating and cooling systems



Dieses Projekt wird aus Mitteln des Klima- und Energiefonds gefördert und im Rahmen der FTI Initiative „Vorzeigeregion Energie“ durchgeführt.

Authors:
AEE – Institut für Nachhaltige Technologien: Carina Seidnitzer-Gallien, Gerald Zotter
Carles Ribas Tugores
Wien Energie GmbH: Heinrich Ondra, Martin Höller, Sophie Zeiger
StepsAHead: Harald Blazek, Wilhelm Schmidt
Linz Strom Gas Wärme GmbH: Simon Glaser, Christoph Greitner, Hubert Pauli
Equans Energie GmbH: Christoph Walla, Markus Salzmann,

1 Table of content

2 Introduction

Within this chapter a brief introduction into the main content and challenges is given and the applied overall methodology is explained. Furthermore, a first indication and the structure of the work is included.

2.1 Background and Motivation

District heating and cooling (DHC) systems are considered a key element of Europe's strategy to decarbonize the heating and cooling sector. They offer the potential to integrate multiple renewable and waste heat sources efficiently and at scale. In Austria, DHC provides heat to over **28,3% of households** and delivers more than **22 TWh of thermal energy annually**, accounting for roughly **6,6% of total final energy consumption**[1]**.** Demand is expected to increase further, not only for heating but also for cooling, due to rising urban density and climate-induced temperature peaks.

However, most DHC networks in Central and Northern Europe operate at high supply and return temperatures (typically 80–130 °C), which prevents the efficient use of low-exergy thermal sources such as: industrial waste heat, ambient heat (e.g. geothermal, river water), and solar thermal energy.

- These limitations lead to systemic challenges[2][3]:
- High return temperatures reduce solar collector and storage efficiency.
- Fossil-fueled peak load boilers remain in use.
- Expansion is constrained by pipeline capacity and investment intensity.
- Decentralized cooling is growing (e.g. split units), but often inefficient and emission intensive.

At the same time, EU-level analysis (e.g. *Heat Roadmap Europe*) shows that available waste heat exceeds total DHC demand in many urban regions[4].

Absorption technologies such as absorption heat pumps (AHPs), absorption chillers (ACs) and heat exchangers (AHXs) are thermally driven and can lift low-temperature heat to usable levels or provide cooling without electric compression. While widely used in East Asia and in industrial process heat recovery, they remain underutilized in European DHC networks[5][6] Key advantages include:

- **Minimal electricity demand** (typically <1% of useful output),
- **High adaptability** to different temperature regimes and working pairs,
- **Integration flexibility**: in storage, source or consumer side.

---

[1] **BMK (2024)**. *Energie in Österreich: Zahlen, Daten, Fakten*. Bundesministerium für Wissenschaft, Forschung und Wirtschaft. https://www.bmwet.gv.at/Services/Publikationen/publikationen-energie/zahlen.html

[2] **Revesz, A. et al. (2020)**. *Critical review of heating and cooling decarbonization pathways*. Renewable and Sustainable Energy Reviews, 121. https://doi.org/10.1016/j.rser.2019.109658

[3] **Werner, S. (2017)**. *International review of district heating and cooling*. Energy, 137, 617–631. https://doi.org/10.1016/j.energy.2017.04.045

[4] **Paardekooper, S. et al. (2018)**. *Heat Roadmap Europe: Identifying strategic heat synergy regions*. Energy Policy, 117, 335–348. https://doi.org/10.1016/j.enpol.2018.03.027

[5] **Mayer, F. et al. (2022)**. *Absorption heat pump integration in low-temperature district heating*. Energy Reports, 8, 10784–10797. https://doi.org/10.1016/j.egyr.2022.08.136

[6] **IEA SHC Task 65 (2024)**. *Solar Cooling for Regions with High Solar Irradiation*. International Energy Agency – Solar Heating and Cooling Programme. https://task65.iea-shc.org

The main barriers to wider adoption include[7]:

- Lack of standardized planning and simulation tools,
- Few successful demonstrators in European climates,
- Unclear regulatory and business model frameworks,
- Higher upfront costs compared to compression systems.

Austria's *Mission2030* and the EU's *REPowerEU* plan explicitly promote the integration of renewable and waste heat into urban energy systems, with DHC seen as a central enabling infrastructure. Therefore, the *AbSolut* project was initiated to close these gaps and to enable a broader application of absorption-based solutions in Austria and beyond.

2.2 Project vision and objectives

The AbSolut project aims to pave the way for the broad integration of absorption technologies into sustainable DHC systems. Its vision is to enable a new generation of infrastructure that is more flexible, more compatible with low-exergy sources, and capable of providing both heating and cooling efficiently.

To achieve this **vision**, the project pursued several interrelated sub-goals:

- Strengthen technological understanding of absorption systems at component and system level, especially their performance under dynamic conditions and low-to-medium temperature regimes.
- Develop robust and practical system concepts for the integration of absorption technologies into new and existing DHC networks—focusing on increasing flexibility, decarbonization, and system efficiency.
- Quantify performance and techno-economic viability of these system configurations using standardized indicators, including COP, CO_2 reduction, lifecycle costs, and temperature efficiency.
- Generate empirical data through experimental testing of absorption systems under varying load and temperature conditions, forming a solid foundation for further planning and replication.
- Design market-oriented business models that reflect real-world boundary conditions and incentives—for example, in district cooling or seasonal waste heat recovery.
- Derive best-practice knowledge that is applicable to planners, operators, and municipal decision-makers through transferable guidelines and case-specific insights.

2.3 Methodological Approach

The project follows an integrated approach combining simulation, experimentation, system analysis, and stakeholder co-design. At the conceptual level, existing absorption technologies and system configurations were surveyed, analyzed, and developed into **integration concepts** tailored to real-world

---

[7] **Rehault, N. et al. (2021)**. *Business models and policy frameworks for renewable heating and cooling*. EASME, Horizon 2020 Project REPLACE. https://www.replace-project.eu

heat and cold supply settings (e.g. urban substations, low-temperature networks, industrial interfaces). For quantitative evaluation, **simulations** were conducted using physics-based models (e.g. energy balances, characteristic curve methods) in tools such as Ebsilon or Modelica/Dymola. These simulations allowed the comparison of various configurations under different operating conditions. To ensure realistic system behavior, **experimental validation** was performed using a flexible laboratory test setup. Key performance parameters—such as coefficient of performance (COP), and behavior under temperature fluctuations—were measured to refine and calibrate the simulation models. To assess feasibility, a **techno-economic analysis framework** was applied across different integration scenarios. This included investment and operating cost comparisons, lifecycle cost assessments, return on invest, and sensitivity analyses. Finally, **qualitative synthesis methods (radar method)** were used to derive practical recommendations from case-specific results, covering not only technology and system design, but also operational, organizational, and business model aspects. Through this comprehensive methodological framework, *AbSolut* delivers scientifically grounded, practically tested, and economically evaluated insights into how absorption technologies can contribute to a resilient and decarbonized heat and cold infrastructure in Europe.

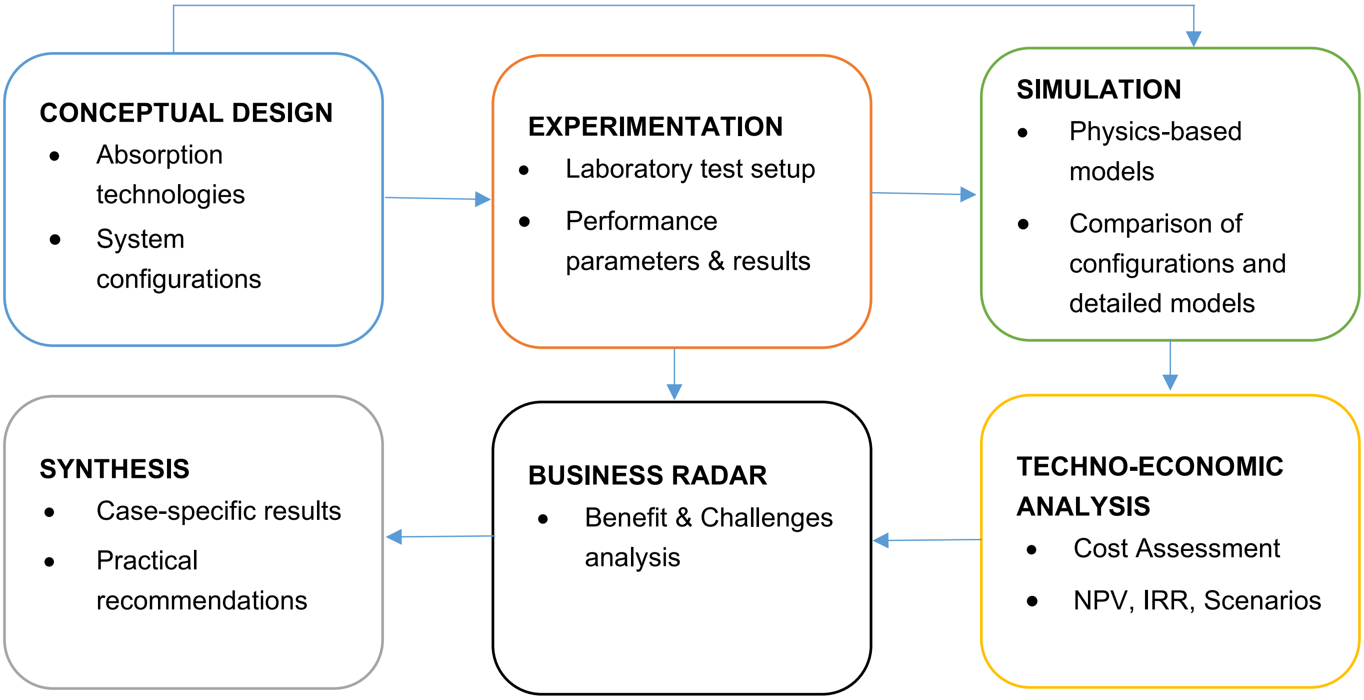


Figure 1: Methodology approach

2.4 Structure of the report

This report is structured to reflect the comprehensive approach of the *AbSolut* project. Following this introduction, **Chapter 3** presents the core content of the project, including the technological foundation of absorption-based solutions, the modeling and simulation approaches applied, and the development of practical system concepts and business models. **Chapter 4** synthesizes the replication potential of the project and overall exploitation routes. **Chapter 5** provides an outlook on future research and development needs, policy recommendations, and replication potential. This structure aims to serve both technical readers—such as energy system planners and technology developers—and decision-makers seeking strategic guidance on the integration of absorption technologies into future-ready district heating and cooling systems.

3 Absorption technologies and testing and modelling approaches

3.1 Overview of absorption technologies

Absorption heat pumps (AHPs) and absorption chillers (ACs) are **thermally driven heat pump technologies**. Their working principle relies on refrigerant evaporation under low pressure and subsequent absorption into a liquid solution, enabling the transfer of heat across temperature levels and the utilization of low-grade waste heat sources[8][9].

A typical case is the **single-stage LiBr/H_2O system**, consisting of an evaporator, absorber, generator, and condenser, supported by an internal heat exchanger for efficiency improvement. Operation requires driving temperatures around 100 °C or higher in heat pump mode, while chillers can work at lower levels. Typical COP values are **~1.7 for AHPs** and **~0.7 for ACs**. The systems run under vacuum conditions, which demands strict tightness but results in very low electricity consumption (<1 % of delivered thermal output).

Two working fluid pairs dominate:

- **LiBr/H_2O**: widely used in district heating and cooling, limited by corrosivity and maximum operating temperatures (~160 °C).
- **NH_3/H_2O**: capable of very low chilled-water temperatures (down to –60 °C), but requiring high pressures (>20 bar), making them less relevant for district heating.

Beyond these conventional fluids, research on **ionic liquids** explores options to extend operating ranges and reduce corrosion risks[10].

Absorption systems are particularly attractive in **district energy networks**, as they make use of industrial waste heat, CHP, solar thermal or geothermal energy, while minimizing electricity demand. This supports grid relief and contributes to decarbonization.

---

[8] **Herold, K., Radermacher, R., Klein, S. (2016):** *Absorption Chillers and Heat Pumps*. CRC Press.

[9] **Ziegler, F. (2014):** *Absorption Heat Pump Technology in District Heating*. Energy Procedia 61, 1960–1964.

[10] **Kazi, S. N. et al. (2021):** *Ionic liquids as absorbents in absorption refrigeration systems*. Renewable and Sustainable Energy Reviews 135.

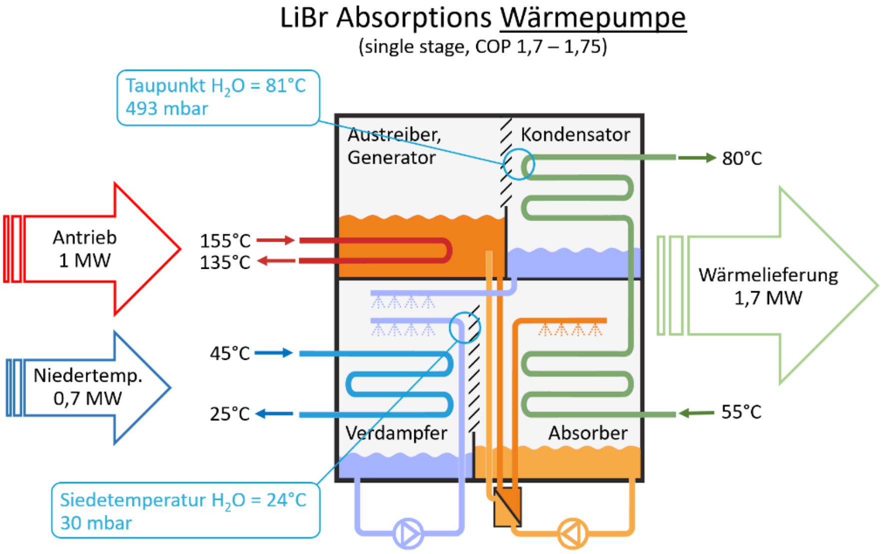


Figure 2: Simplified schematic of a single-stage absorption machine operated as a heat pump, with indicative operating temperatures and heat flows, Source: StepsAhead

For operation as a heat pump, driving temperatures of around 100 °C or higher are typically required. In chiller mode, lower driving temperatures may suffice. The **Coefficient of Performance (COP)** of single-stage LiBr absorption heat pumps is typically about 1.7, while absorption chillers reach around 0.7.[11][12]
Since water evaporates under vacuum conditions, LiBr systems always operate below atmospheric pressure, which imposes strict requirements on system tightness. The electrical demand is limited to pumps and control units and typically accounts for less than 1 % of the provided thermal output.[13]
A key advantage lies in the **very low electricity consumption**: apart from auxiliary components, LiBr absorption machines require less than 1 % of the transferred heat output in electric power.
The following summarizes the most relevant applications for absorption technologies in district heating and cooling. A comprehensive overview, including case studies and simulation results shows the *Best Practice Guide* (2025).

3.1.1 Absorption Heat Pumps (AHPs)

The most established application of AHPs in district heating is **active flue gas condensation** in biomass plants and combined heat and power (CHP) stations. In this process, the latent heat of water vapor in the flue gas is recovered and transferred to the network. This allows **fuel utilization efficiencies exceeding 110 %**, far beyond conventional boilers. Performance improvements of **20–30 %** are common, effectively increasing the available heating capacity without major infrastructure expansion.

Two main configurations exist:

- **High-temperature AHPs (~150 °C driving heat):** maximize condensation efficiency, achieving cold-water temperatures up to 30 K below network return.

---

[11] **Ziegler, F. (2002)**: *Comparative evaluation of thermally driven heat pumps and chillers*. Int. J. Refrigeration 25, 450–464.
[12] **Herold, K., Radermacher, R., Klein, S. (2016)**: Absorption Chillers and Heat Pumps. CRC Press.
[13] **Ziegler, F. (2014):** *Absorption Heat Pump Technology in District Heating*. Energy Procedia 61, 1960–1964.

- **Low-temperature AHPs (~105 °C):** suitable for smaller plants (< 5 MW), technically simpler and exempt from the EU Pressure Equipment Directive, though with somewhat lower performance.

A specific design, the **Double-Lift AHP**, addresses networks with very high return temperatures. It achieves supply temperature directly, avoiding additional post-heating, though at the expense of a lower COP (~1.3).

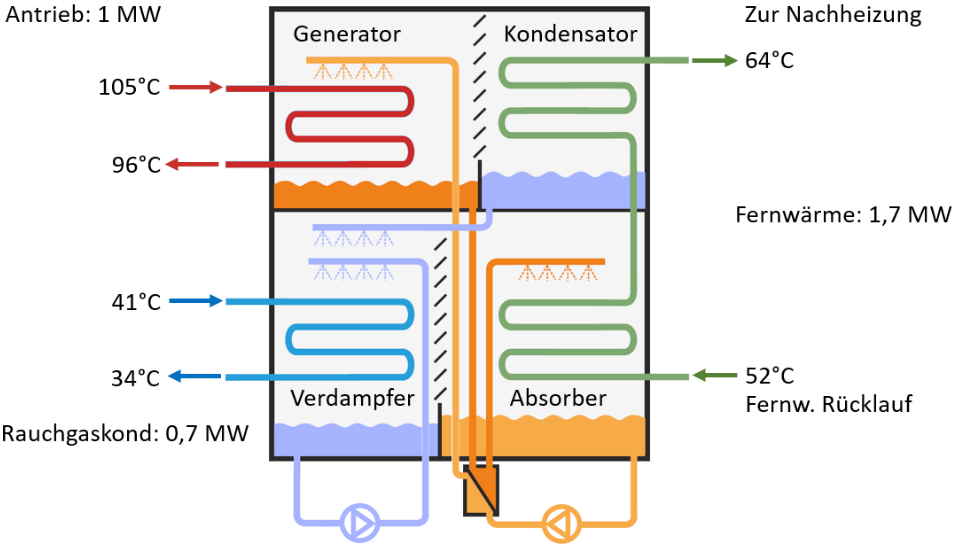


Figure 3: Absorption heat pump in flue gas condensation (schematic with typical temperature levels). Source: StepsAHead

Beyond flue gas applications, AHPs can recover **industrial waste heat streams** (e.g., cooling water, low-temperature exhausts). Their ability to upgrade waste heat to network-compatible temperature levels makes them a **key option for industrial integration**, especially when high driving heat (steam, hot water) is readily available.

3.1.2 Absorption Chillers (ACs)

Absorption chillers are widely applied in **district cooling systems**, particularly where **continuous low-cost driving heat** is available (industrial processes, solar thermal plants, waste heat from CHP). Their role is often to provide **base load cooling**, reducing reliance on electricity-intensive compression chillers.

A typical **single-stage AC** has a COP of about 0.7, i.e., 1 MW of driving heat yields 0.7 MW of cooling. While less efficient than compression systems, their extremely low electricity consumption (< 1 % of delivered cooling) makes them advantageous in regions with high electricity prices or stressed power grids.

Key aspects include:

- **Cooling tower sizing:** ACs require approximately double the cooling tower capacity of compression chillers, which must be considered in planning.
- **Low chilled-water applications:** With advanced designs, chilled-water supply down to ~1–2 °C is possible (e.g., pilot projects in Poland and Italy).
- **Double-Lift ACs:** extend operation to even lower chilled-water levels but with reduced COP, limiting their economic feasibility.

In district cooling, **every Kelvin reduction in supply temperature** can significantly enhance transmission efficiency and reduce pipe diameters. Thus, absorption chillers are particularly valuable where large loads must be transferred over long distances.

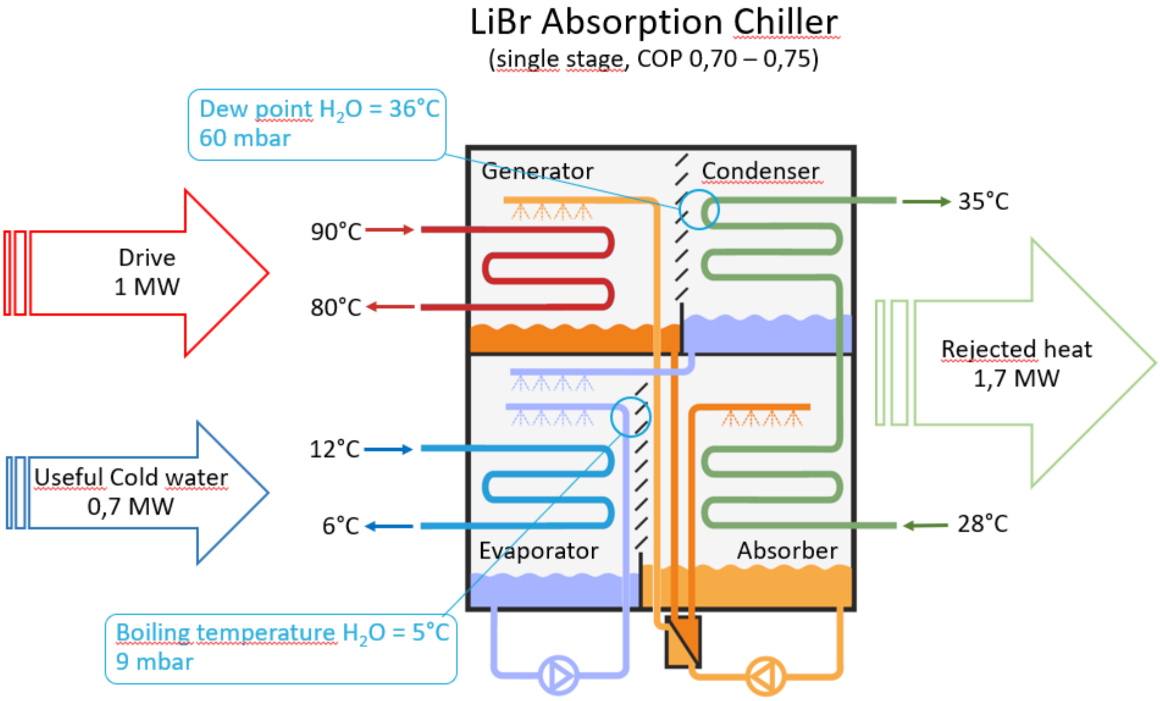


Figure 4: Performance ranges of single-stage absorption chillers (typical COP and chilled-water temperatures). Source: StepsAhead

3.1.3 Double-Stage Absorption Machines

Double-stage absorption systems improve efficiency by regenerating the solution in two steps, using steam from the high-temperature generator (HTG) to drive the low-temperature generator (LTG).

- In **double-stage chillers**, this leads to higher COP values and lower chilled-water temperatures than single-stage designs, making them relevant where high driving heat (~150–160 °C) is continuously available.
- In **double-stage heat pumps**, the relevance is limited, as they usually provide only up to 60 °C on the heating side, restricting their application to low-temperature district heating networks.

Detailed process diagrams are provided in the *Best Practice Guide* (2025).

3.1.4 Absorption Heat Exchangers (AHXs)

AHXs represent a **strategic network optimization tool**. By coupling an external heat exchanger to the absorption cycle, the primary return temperature can be reduced below the secondary return level.

This yields two central advantages:

- **Capacity increase:** existing pipes can transport up to ~30 % more heat without reinforcement.
- **Efficiency gains:** lower return temperatures improve the performance of CHP and geothermal plants, where extraction temperatures directly influence efficiency.

The technology is therefore particularly relevant in existing networks that are facing capacity limits due to increasing connection densities or planned network extensions.

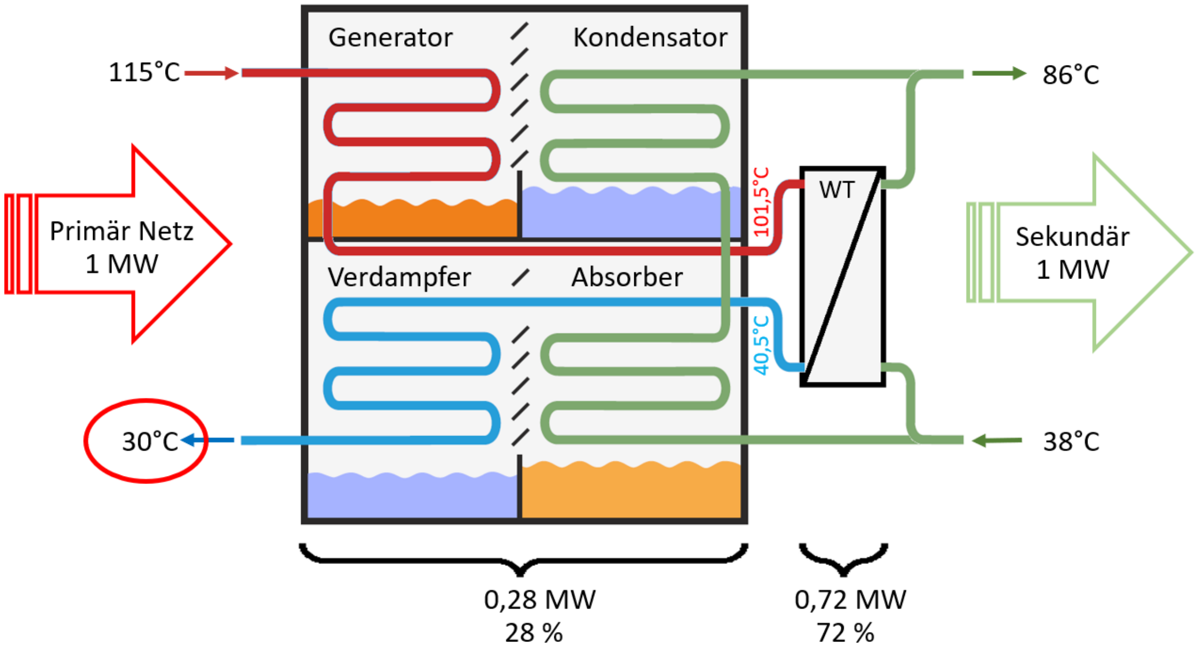


Figure 5: Absorption heat exchanger principle and effect on return temperature reduction. Source: StepsAHead

3.1.5 Heat Transformers (Category II AHPs)

Heat transformers are a specific variant of absorption systems in which **waste heat itself serves as the driving energy**, allowing part of it to be lifted to a higher temperature.

Typically, around **48 % of the input waste heat** is upgraded, while ~52 % must be rejected at a lower level. This makes the technology highly relevant for **industrial process integration**, where steam recovery is required.

A notable hybrid concept is the **"155 % boiler"**, where direct fuel combustion in the generator is combined with absorption-based recovery of flue gas heat. This results in **fuel utilization efficiencies of up to 155 %**, far beyond what is achievable with conventional boilers.
Detailed information and process charts are provided in the *Best Practice Guide* (2025).

3.2 Simulation and modelling approaches

Modelling and simulation play a relevant role in the definition of optimal energy concepts as it allows the estimation by means of static and/or dynamic simulations of the expected performance of the energy concept. It allows the evaluation of different designs and operational strategies for the given case (boundary conditions, requirements, etc.) and provides a solid basis to assist the decision-making processes during different project phases.

In regards of the modelling of absorption heat pumps, the modelling approaches can be grouped in two categories (Glück, C.[14]), namely:

1. **Characteristic curve or map models:** This type of model uses predefined operational points (derived from measured data, technical sheet, …) to calculate the machine's behaviour for different operating conditions, e.g. TRNSYS type 107. This modelling approach does obtain good matching with the operating behaviour of real machines, if there is enough data to calibrate the model[15]. Statistics models such as a black-box Modell[16] with a self-learning algorithm are also included in the first group. The applicability and accuracy of the calibrated model outside the known operating points depend on the model itself and the available data.
2. **Balance and hybrid models:** The second group does include physical based balance models. Here the so-called basic energy models such as the one presented in [17] are included. This model is based on the solution of the enthalpy balance equations at the four main heat exchangers. The ΔΔt method, presented in[18] and [19], is also included. The method has been further developed several times[20] and can after some modification be applied to carry out quasi stationary simulations of single stage absorption machines[21]. Furthermore, there is a concept to account for variable mass flow rates at the heat exchangers[22,23]. The ΔΔt method can be used to model absorption heat transformer (AHT) with good agreement[24,25].

In regards of the energy concept evaluation, TRNSYS[26] and Modelica[27]-based simulations software such as Dymola[28] are flexible environments (multi-domain and possibility to add custom models) widely used for transient simulations. Tools like EBSILON® Professional[29] focus on evaluation of thermodynamic cycles plants (e.g. conventional heating plants) and are utilized by the Stepsahead to analyze integration energy concepts that include absorption heat pumps.

In the AbSolut project, static and dynamic simulations are carried out in both software, Dymola[28] and Ebsilon, to assist the different use cases, see chapter 4.

---

[14] Generische Simulationsmodelle für Sorptionswärmepumpen zum Heizen und Kühlen. Glück, C. 2015. DOI: 10.5445/IR/1000046924.

[15] Absorption chiller modelling with TRNSYS – requirements and adaption to the machine EAW Wegracal SE 15. Witte et.al. EuroSun2008. ISBN: 9781617822285.

[16] Simulation of an Adsorption Chiller using artificial neural networks, Döll, Jochen OTTI – 4th International Conference Solar Air Conditioning, Zypern, 2011.

[17] Sorptionswärmepumpen, Ziegler, 1997. ISBN-13: 978-3932715600.

[18] Simple absorption heat pump modules for system simulation programs, Hellmann and Ziegler, 1999.

[19] The characteristic equations of absorption chillers, Hellmann et.al, in Proceedings of the International Sorption Heat Pump Conference. 1999. Munich, Germany.

[20] Comparison of a similar control strategy for ab- and adsorption chillers, Albers et.al, 2013.

[21] Advanced control of solar driven adsorption chillers, Dalibard et.al, 2013.

[22] Einfluss variabler Volumenströme auf charakteristische Gleichungen für Absorptionskälteanlagen, Albers and Ziegler, 2009.

[23] Heat transfer calculation for absorption heat pumps under variable flow rate conditions, Albers and Ziegler, 2011.

[24] Absorption heat converter and the characteristic equation method. Falk, C. and Ziegler, F. 2015.

[25] Experimental results of an absorption heat transformer. Falk, C. et al. 2017. in Proceedings of 12th IEA Heat Pump Conference – ISBN 978-90-9030412-0.

[26] TRNSYS. https://www.trnsys.com/

[27] Modelica. https://modelica.org/

[28] Dymola Version 2024x Refresh 1. URL: https://www.3ds.com/products/catia/dymola.

[29] EBSILON® Professional. https://www.ebsilon.com

In the case of Modelica, after the review of available open-source models and modelling approaches, intensive work has been done to improve the available open-source models to be able to model and perform dynamic simulations of absorption technologies. The main work carried out is reported in the following subchapters.

3.2.1 Review of open-source Modelica models

The literature review carried out on open-source Modelica models consisted in the review and testing of available models aiming to evaluate the suitability to be used directly on the planned worked within the project. Models available within commercial libraries and in-house models were excluded from the review. The review identified three primary libraries (ThermoSysPro[30], Buildings[31] and District Cooling Open-Source Library (DCOL) [32]). The specifics of each library are summarized in a publication[33]. The review of open-source models for absorption machines yields the following conclusions[33]:

- Compatibility with other Modelica libraries: The use of standardized interfaces (e.g. fluidPort) enables a modelling approach that leverages validated models from multiple sources and facilitate interoperability. This approach has been utilized in the project to enhance the usability of the newly implemented models within the broader Modelica ecosystem.
- Object-oriented modelling approach: The DCOL library[32] adopts an object-oriented approach, with separate models for key components (e.g. absorber, generator), which supports modularity, ease of development, and maintainability. The same approach is followed in the Absolut project, with DCOL models serving as a reference for the implementation of the dynamic models.
- Initialization Challenges: Some evaluated models encountered difficulties during initialization and execution, highlighting the importance of a robust model structure and well-defined initial values to improve usability. The models implemented within the project have in most cases a runnable example to showcase the use of the model. The models might also serve as a reference for troubleshooting newly created or modified models.
- Fluid Property Implementation: Although fluid property correlations are available, inconsistencies in their implementation may lead to numerical instabilities. It was concluded that existing libraries would benefit from a more consistent and reliable representation of fluid properties.

3.2.2 Implemented absorption technology models

Models for absorption technologies have been implemented step by step. It includes fluid property library for the H_2O/LiBr working pair, basic (zero-order) models for rough assessments, static models to model a

---

[30] EDF LAB CHATOU PRISME Department (2024). Thermosyspro. Thermosyspro. URL: https://thermosyspro.com/index.html.

[31] Wetter, Michael et al. (2014-07-04). “Modelica Buildings library”. In: Journal of Building Performance Simulation 7.4, pp. 253–270. ISSN: 1940-1493, 1940-1507. DOI: 10 . 1080 / 19401493.2013.765506. URL:http://www.tandfonline.com/doi/abs/10.1080/19401493.2013.765506 (visited on 2024-12-06).

[32] Febres, Jesus et al. (2017). District Cooling Open Source Library (DCOL). Version 4.1. URL: https://zenodo.org/records/1215665.

[33] Absolut Modelica library. Carles Ribas Tugores, Gerald Zotter, Carina Seidnitzer-Gallien, 16th International Modelica & FMI Conference. Lucerne, Switzerland, Sep 8-10, 2025.

large set of thermodynamic cycles and dynamic models focusing on the absorption heat exchanger. The models are made open source via GitHub[34].

Fluid properties: The static and dynamic models use pure water as a refrigerant, specifically employing the implementation based on the IAPWS/IF97 standard provided in the Modelica Standard Library[35]. The thermodynamic correlation for the working pair H_2O/LiBr is based on the formulation from Yuan, Z. and Herold K.E.[36] and has been implemented[37].

The correlation from Yuan, Z. and Herold K.E. follows a global approach to ensure improved consistency across properties. Rather than fitting individual thermodynamic properties separately, a fundamental function - in this case Gibbs free energy - is selected. All relevant properties are derived from this function using thermodynamic relationships (e.g. entropy is obtained from the partial derivative with respect to the temperature of the Gibbs free energy). The correlation expresses the Gibbs free energy as a function of temperature, pressure, and lithium bromide mass fraction. All available thermodynamic data are then used simultaneously to determine the main coefficients of the fundamental function. The correlation obtained gives good accuracy[36] over the full range of liquid concentrations from pure water up to the crystallization line and from 5°C to 250°C.

Implemented functions are verified directly, by comparing functions output results with reference values (e.g. calculated values obtained for specific heat capacity has been compared with measurements published by Yuan, Z. and Herold K.E.[36] with satisfactory results, see Figure 6), and indirectly, by evaluating results of implemented static component and absorption cycles models.

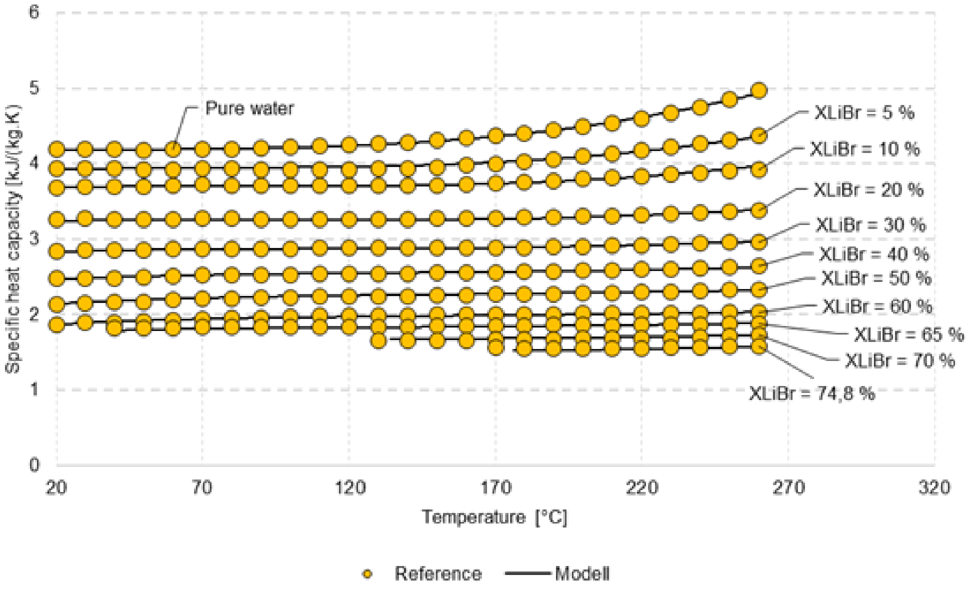


Figure 6: Comparison of values of specific heat capacity obtained by implemented functions and reference values as a function of temperature for different concentrations of lithium bromide.

---

[34] Absolut library. https://github.com/carlesRT/Absolut

[35] Modelica Association (2024). Modelica Standard Library. URL:https://github.com/modelica/ModelicaStandardLibrary.

[36] Yuan, Zhe and Keith E. Herold (2005-07). “Thermodynamic Properties of Aqueous Lithium Bromide Using a Multiproperty Free Energy Correlation”. In: HVAC&R Research 11.3, pp. 377–393. ISSN: 1078-9669, 1938-5587. DOI: 10.1080/10789669.2005.10391144. URL:https://www.tandfonline.com/doi/full/10.1080/10789669.2005.10391144.

[37] https://github.com/carlesRT/Absolut/tree/main/Absolut/Media/LiBrH2O

Basic models:

Most of the models included in the Basic package[38] are based on the Carnot cycle (reversible process). By combining the Carnot cycle for power generation with a refrigeration cycle, the efficiency of a single effect absorption heat pump can be derived. The derivation can be found in chapter 2.7 of book Absorption chillers and heat pumps[39]. The Carnot-based functions are further refined to account for the primary source of irreversibility in absorption cycles, which is associated with heat transfer between the cycle and its surroundings (Herold, Radermacher, and Klein 2016)[39]. This refinement is achieved by introducing a thermal resistance between the external and internal temperatures, resulting in a temperature difference. It is important to note that the internal cycle of the AHP is still assumed to be reversible. This assumption, along with the assumption that the temperature difference between the condenser and the generator is equal to that between the condenser and the evaporator, forms the basis of the so-called zero-order models (Herold, Radermacher, and Klein 2016)[39].

Static models:

Static models have been implemented for valves, solution pump, and main heat exchangers (absorber, generator, evaporator and condenser). This can be (and are) used to model various thermodynamic absorption cycles (e.g. single and double effect absorption heat pump, absorption heat transformer, absorption heat exchanger and resorption cycle). The implemented models can be found within the Static package[40]. Most of the models implemented have been verified using examples from (Herold, Radermacher, and Klein 2016)[39] and partially reported in [33]. Exemplary results for the single-effect absorption heat pump static model are shown in Table 1.

Table 1: Comparison of calculated and reference values for heat flow rates and COP for an absorption heat pump. Deviation results are given in kW and %. Calculated as the difference between reference values from Table 6.1 in (Herold, Radermacher, and Klein 2016) [39] and the simulation results from model AHP_se_UAfix_eps.

Heat flow rate at…	Deviation	
	in kW	in %
Absorber	0.09	0.62
Generator	0.09	0.62
Evaporator	0.07	0.61
Condenser	0.07	0.60
Solution heat exchanger	-0.03	-0.84
COP for cooling	0.00	-0.06

Dynamic models:

The dynamic models have been focussed on the single effect absorption heat pump, which serves as the core component of the AHE. This model is extensively explained in a dedicated publication[33] which also presents the Absolut library.

---

[38] https://github.com/carlesRT/Absolut/tree/main/Absolut/Basic

[39] Herold, Keith E., Reinhard Radermacher, and Sanford A. Klein (2016). Absorption Chillers and Heat Pumps. Second edition. London New York; Boca Raton: CRC Press. ISBN: 978-1-4987-1435-8. DOI: 10.1201/b19625.

[40] https://github.com/carlesRT/Absolut/tree/main/Absolut/FluidBased/Static

3.2.3 Validation of absorption heat exchanger model

An AHE model has been developed based on the PlateHeatExchangerEffectivenessNTU model of the Buildings library for the external heat exchanger and the Dynamic.AHP.AHP_pump_hex_extended model of the Absolut library for the AHP. This model has been validated using experimental measurements obtained within the framework of this project. Detailed information about the experimental test rig, the reader is referred to (Eberhöfer 2022)[41]. The validation work (details about the model, calibration process, and validation work) is extensively explained in a dedicated publication[33]. For the sake of completeness, a brief description of the validation work and main results are summarized below.

For the validation work, measurements (one very minute) from (Eberhöfer 2022)[41] at the inlet position of the absorption heat exchanger (position 11, 13, and 20, see Figure 8) are used as model inputs. The values utilized are shown in Figure 7.

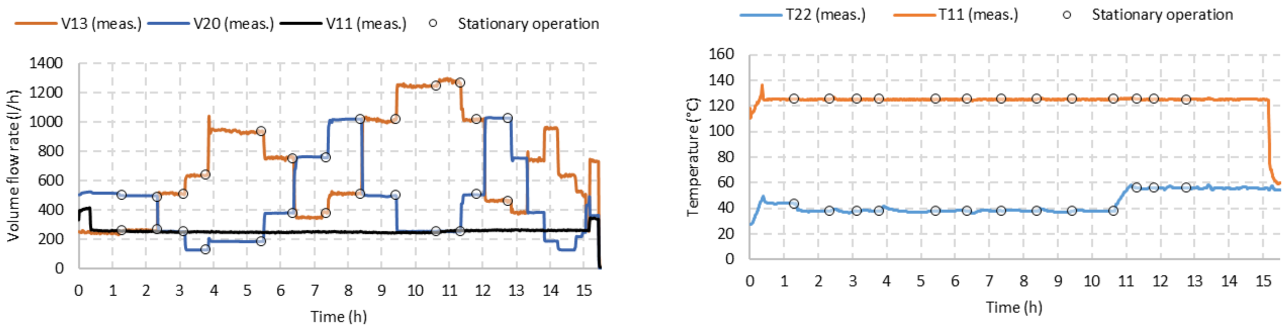


Figure 7: Measured data (meas.) used as boundary conditions for the model validation. Volume flow rates (left) and temperatures (right). Volume flow rate and temperature entering the generator V_{11} and T_{11}. Volume flow rate entering the absorber V_{13} and the external heat exchanger (secondary side) V_{20} and their temperature T_{22}. Positions are indicated in Figure 8. Circles markers are used to indicate a point at which quasi-stationary operation is reached.

The model is then able to predict the dynamic behaviour of the machine and estimate the evolution of temperatures in the AHE. The outlet temperatures at the main heat exchangers (positions 12, 14, 15, 17, 19 and 21, see Figure 8) are the compared to the reference (measurement) values to carry out the model validation.

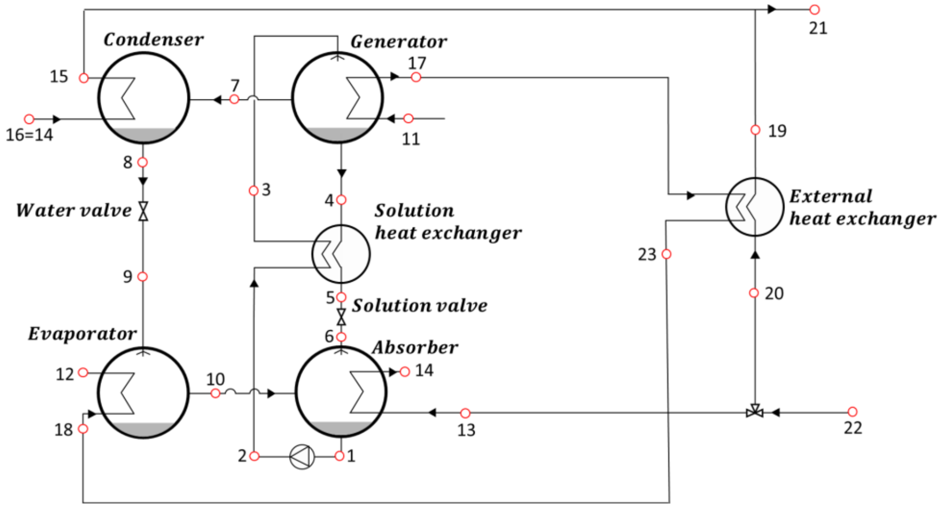


Figure 8: Schematics of an absorption heat exchanger. Numbers indicate the positions of referenced variables.

---

[41] Eberhöfer, Damian (2022-10). Adaption und Untersuchung eines Absorptionswärmetauschers zur Rücklauftemperaturreduktion in Fernwärmenetzen.

The comparison is done for a whole 14-hours experiments (841 values) well as for selected measurements defined as quasi-stationary[42]. In Regards of the evaluation of the absorption heat exchanger, the outlet temperature at the evaporator is a critic value as it is used to evaluate subcooling (temperature below the return temperature of the secondary line, i.e. the temperature difference T_{22}-T_{12}) which represents the added value of the application. The obtained results during the validation work indicates a deviation for the outlet temperature at the evaporator in the range of -0.6 K to 3.1 K with an average temperature deviation for the 14-hour period of 1.2 K, i.e. a slight overestimation of the AHE potential. The measurement uncertainty is estimated[41] in ±0.2 K.

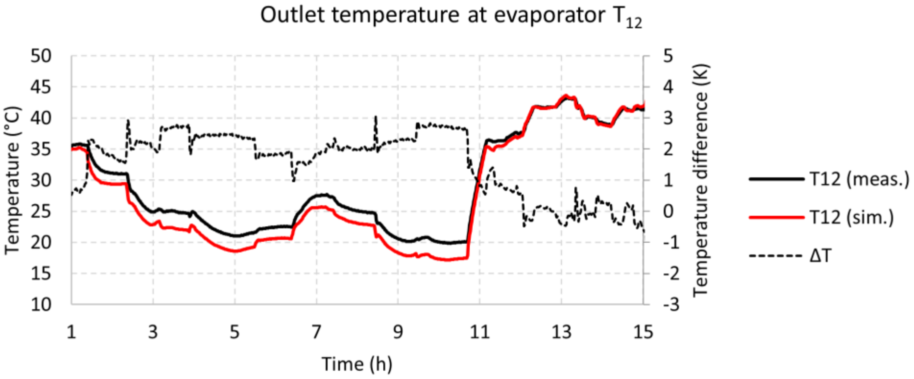


Figure 9: Temperature difference (ΔT) in K between measurements (meas.) and simulation results (sim.) at outlet of the evaporator (position 12, see Figure 8).

The deviations under quasi-stationary operation are summarized in Table 2.

Table 2: Average, maximum and minimum temperature deviations (in Kelvin) defined as the reference value (measurement) minus the calculated values (simulation result) for monitored positions under steady-state operating conditions.

Temperature	Temperature deviation in K		
	Average	Maximal	Minimal
T_{14}	-0.29	0.53	-2.11
T_{15}	-0.43	0.7	-1.66
T_{12}	1.2	2.61	-0.79
T_{17}	1.72	2.74	-0.01
T_{19}	2.58	5.49	0.74
T_{21}	0.0	0.0	-0.05

3.3 Laboratory test bench and experiments

The experimental evaluation of the absorption heat exchanger (AHE) concept was carried out at the laboratories of AEE INTEC in Gleisdorf. A dedicated test bench was designed and operated to validate the thermodynamic behavior, subcooling capacity, and efficiency of the system under realistic boundary conditions. The experimental campaign provided over 100 measurement points is in detail presented in

---

[42] These points correspond to periods in which the system operation is assumed to have stabilized.

the HPC 2023 full paper[43] and an diploma thesis[44]. The results are summarized in the following sub-sections.

3.3.1 Test Bench of the Pilot-Scale Absorption Heat Exchanger (AHX)

For this research, a pilot-scale absorption heat exchanger (AHX) was developed and installed at the AEE INTEC laboratory. The system combined a **single-stage absorption chiller** (nominal cooling capacity of 15 kW, using the water/lithium bromide working pair H_2O–LiBr) with a **plate heat exchanger** (heat transfer surface area of 2.46 m²) in a counterflow configuration. This configuration was specifically designed not to operate as a conventional chiller or heat pump, but as an exergetically optimized transfer substation.

The pilot unit was fully equipped with calibrated measurement instrumentation and embedded into the laboratory's thermal infrastructure, which provided heat sinks and sources for flexible operation (see **Figure 10**).

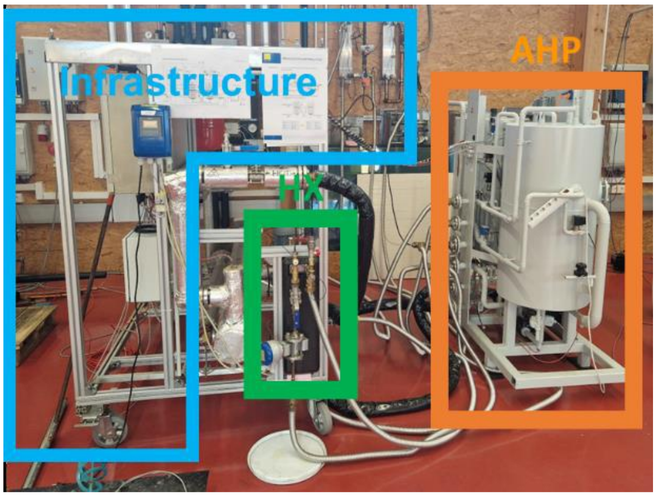


Figure 10: Picture of the AHX test bench at AEE INTEC, consist of an AHP (in orange) and a HX (in green) integrated in the infrastructure of the laboratory[45]

The operating conditions were systematically varied with respect to:

- the **primary supply temperature**,
- the **secondary return temperature**,
- the **general volume flow ratio (GVR)**, defined as the ratio between secondary and primary volume flows,
- and the **secondary volume flow ratio (SVR)**, defined as the fraction of secondary flow directed through the plate heat exchanger relative to that through the absorption chiller.

---

[43] **Zotter, G., Eberhöfer, D., Seidnitzer-Gallien, C. (2023):** An energetical, exergetical and experimental analysis of an absorption-heat exchanger used as transfer sub-station in an already existing district heating grid, 14th Heat Pump Conference 15-18 May 2023, Chicago.

[44] **Eberhöfer, Damian (2022-10)**. Adaption und Untersuchung eines Absorptionswärmetauschers zur Rücklauftemperaturreduktion in Fernwärmenetzen.

[45] **Zotter, G., Eberhöfer, D., Seidnitzer-Gallien, C. (2023):** An energetical, exergetical and experimental analysis of an absorption-heat exchanger used as transfer sub-station in an already existing district heating grid, 14th Heat Pump Conference 15-18 May 2023, Chicago.

Table 3: Parameter (and values) for measurement matrix of AHX Name of parameter[46]

Name of parameter	Values	Measurement uncertainties
$t_{S,Pr}$ in °C	145, 125, 105	± 0.2 K
$t_{R,Se}$ in °C	38, 44, 50, 56	± 0.2 K
$\dot{V}_{Pr}$ in m³/h	250	± 0.5% of the measured value
GVR in -	3, 4.5, 6	$\pm\sqrt{((\pm 0.5\%\mathrm{MVSE} /_{\pm 0.5\%\mathrm{MVPR}})^{2} + (\pm 0.5\%\mathrm{MVPR}' /_{\pm 0.5\%\mathrm{MVPR}'}))}$
SVR in -	2, 0.5, 0.2	$\pm\sqrt{((\pm 0.5\%\mathrm{MVHX} /_{\pm 0.5\%\mathrm{MVAHP}})^{2} + (\pm 0.5\%\mathrm{MVAHP}' /_{\pm 0.5\%\mathrm{MVHX}'}))}$

Table 3 summarizes the measurement matrix, which includes three primary supply temperatures (145 °C, 125 °C, 105 °C), four secondary return temperatures (38 °C, 44 °C, 50 °C, 56 °C), and multiple GVR and SVR values.

For safety reasons, the primary circuit was operated with thermal oil rather than pressurized hot water (which would have required pressures up to 20 bar at 145 °C). While this measure avoided cavitation risks, it reduced the maximum achievable capacity of the AHX to approximately 10 kW due to the lower specific heat capacity and different heat transfer coefficients of thermal oil compared to water. Instrumentation uncertainties were minimized through calibration: ±0.2 K for temperature sensors and ±0.5% of the measured value for flow meters. For each operating point, steady-state conditions were defined as stable asymptotic values of flows, temperatures, and pressure levels. Energy balances were conducted to account for convective and radiative heat losses, which were estimated at about 10% due to missing thermal insulation. These losses were further validated using infrared thermography (see **Figure 11**).

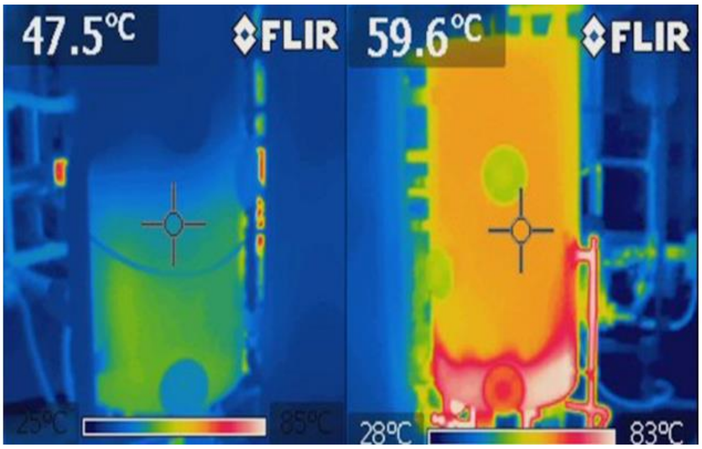


Figure 11: Infrared photograph of the evaporator-absorber reactor (left) and the condenser-generator reactor (right); to determine the heat losses[47]

---

[46] **Zotter, G., Eberhöfer, D., Seidnitzer-Gallien, C. (2023):** An energetical, exergetical and experimental analysis of an absorption-heat exchanger used as transfer sub-station in an already existing district heating grid, 14th Heat Pump Conference 15-18 May 2023, Chicago.

[47] **Zotter, G., Eberhöfer, D., Seidnitzer-Gallien, C. (2023):** An energetical, exergetical and experimental analysis of an absorption-heat exchanger used as transfer sub-station in an already existing district heating grid, 14th Heat Pump Conference 15-18 May 2023, Chicago.

3.3.2 Measurement Results

The experimental campaign focused on determining the maximum achievable **subcooling of the primary return temperature below the secondary return temperature (∆TSub-R,Pr/Se)**. In total, **36 measurement points** were evaluated across the parameter space defined in Table 2. Transient responses were also recorded but are not the focus of this report.

The results confirm that subcooling performance depends strongly on the interaction of supply and return temperatures as well as flow ratios.

- **Influence of Primary Supply and Secondary Return Temperatures (Figure 12):**
  Subcooling increased with higher primary supply temperatures and lower secondary return temperatures. The maximum subcooling of 20.7 K was achieved at a primary supply of 145 °C and a secondary return of 38 °C (GVR = 4.5, SVR = 0.2). Even at a reduced primary supply of 105 °C, the system achieved about 12 K subcooling, provided the secondary return temperature was ≤44 °C. However, no subcooling occurred when both primary supply temperature was low and secondary return temperature high.

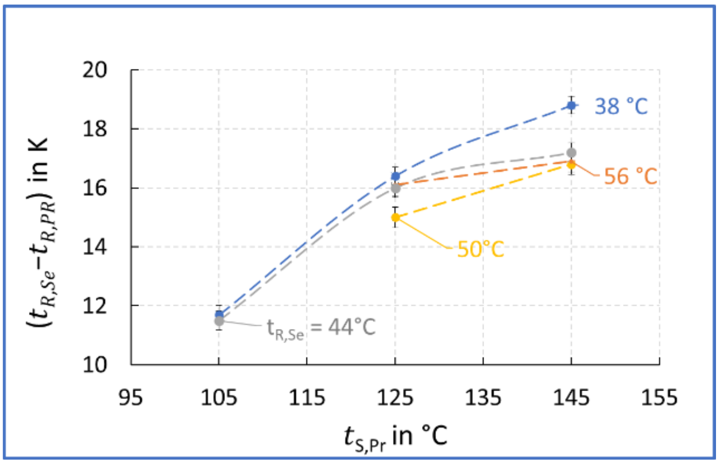


Figure 12: Subcooling of the primary return temperature below the secondary one ($t_{R,Se}-t_{R,PR}$) depending on primary supply temperature at different $t_{R,Se}$ and constant V_{Pr}=250 m³/sh; GVR =4.5, SVR = 0.2[48]

- **Influence of Secondary Flow Distribution (SVR, Figure 13):**
  At constant primary flow (250 m³/h) and high GVR (6), subcooling improved as more secondary flow was routed through the absorption chiller (low SVR). This confirmed that higher chiller-side flow enhances subcooling.

---

[48] **Zotter, G., Eberhöfer, D., Seidnitzer-Gallien, C. (2023):** An energetical, exergetical and experimental analysis of an absorption-heat exchanger used as transfer sub-station in an already existing district heating grid, 14th Heat Pump Conference 15-18 May 2023, Chicago.

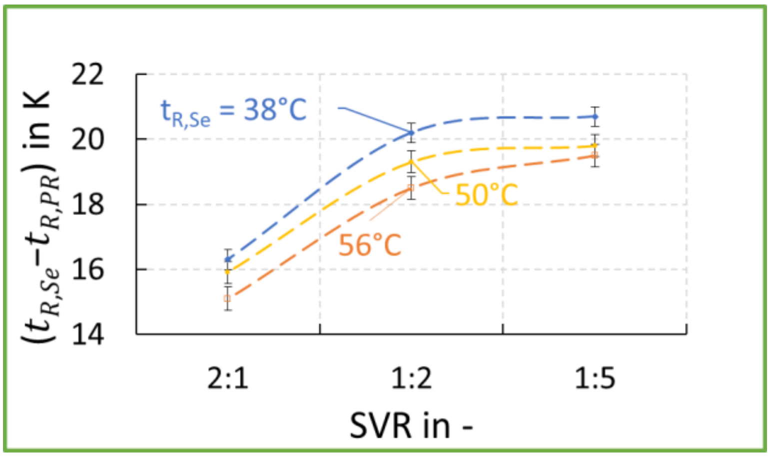


Figure 13: Subcooling of the primary return temperature below the secondary one ($t_{R,Se}-t_{R,PR}$)depending on SVR at different $t_{R,Se}$ and constant V_{Pr}=250 m³/h and GVR of 6[49]

- **Influence of General Volume Flow Ratio (GVR, Figure 14):**
  Higher GVR values, i.e., higher secondary-to-primary flow ratios, significantly increased subcooling. This is because the larger secondary mass flow ensured that the increased heat capacity could be transferred without raising the secondary supply temperature, thereby maintaining the exergetic driving potential of the AHX.

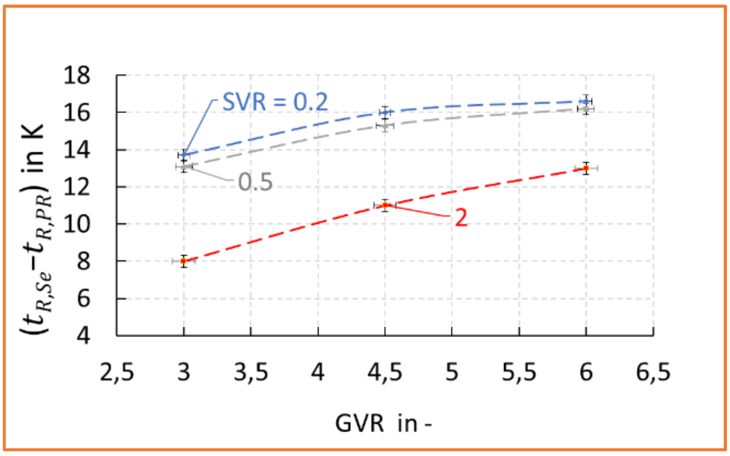


Figure 14: Subcooling of the primary return temperature below the secondary one ($t_{R,Se}-t_{R,PR}$) depending on GVR at different SVRs and constant V_{Pr}=250 m³/h; $t_{R,Se}$ = 44°C[50]

Nevertheless, several **technical limitations** were identified:

- Increased pump power requirements at high flow ratios,
- Additional cooling demand at the generator before the evaporator stage,
- High heat losses due to insufficient thermal insulation,
- Control limitations of the absorption chiller, particularly concerning the solution pump and throttle valves.

---

[49] **Zotter, G., Eberhöfer, D., Seidnitzer-Gallien, C. (2023):** An energetical, exergetical and experimental analysis of an absorption-heat exchanger used as transfer sub-station in an already existing district heating grid, 14th Heat Pump Conference 15-18 May 2023, Chicago.

[50] **Zotter, G., Eberhöfer, D., Seidnitzer-Gallien, C. (2023):** An energetical, exergetical and experimental analysis of an absorption-heat exchanger used as transfer sub-station in an already existing district heating grid, 14th Heat Pump Conference 15-18 May 2023, Chicago.

Potential **design improvements** include enhancing thermal insulation, optimizing the control of internal hydraulic components, and reconfiguring the absorber and condenser in parallel instead of serial operation.

The results of the experimental measurement series show that a high primary supply temperature, a low secondary return temperature and a high secondary-to-primary mass flow rate are required for a high subcooling performance. The partitioning of the secondary mass flow between the absorption chiller and the heat exchanger also had an effective effect, with a high mass flow through the chiller increasing subcooling. At tS,Pr of 145 °C and tR,Se of 38 °C, a SVR of 0.2 and GVR of 6 the highest subcooling with 20.7K could be achieved within the pilot scaled AHX. But even under suboptimal conditions, like low primary supply temperatures of 105 °C the AHX subcooled the primary return temperature below the secondary of 12.4K, but for that a low return temperature on the secondary side below 44 °C is required. For tR,Se higher than 50 °C a minimal tS,Pr of 125 °C is required.

From an economical point of view, a further dynamic year-round simulation is essential for the economic evaluation in order to determine by how much the primary return can be supercooled. The further investigations are shown in Chapter 4.

3.4 Business radar approach

To systematically evaluate technologies and their techno-economic implications, the project applied the **Business Radar** as a central analytical tool. The methodology is designed to capture and visualize both the **benefits (opportunities)** and the **challenges (barriers)** of innovative energy technologies in a single framework. Unlike purely financial models, which provide quantitative but often highly case-specific results, the Business Radar emphasizes **systemic interactions** and the **relative economic relevance** of key factors.

3.4.1 Conceptual Structure

The Business Radar is a circular diagram divided into two halves.

- The **upper half (green)** represents **benefits**, i.e., positive effects and added value of the technology.
- The **lower half (orange)** visualizes **challenges**, i.e., risks, barriers, or constraints.

Within this circular space, factors are further differentiated along three **system dimensions**:

- **Network:** impacts on infrastructure, grid operation, and system-wide efficiency,
- **Generation:** impacts on production assets and the integration of energy sources,
- **Consumption:** impacts on end users, customer installations, and demand-side flexibility.

This systematic structuring allows each identified factor to be clearly allocated to its **systemic level of impact**.

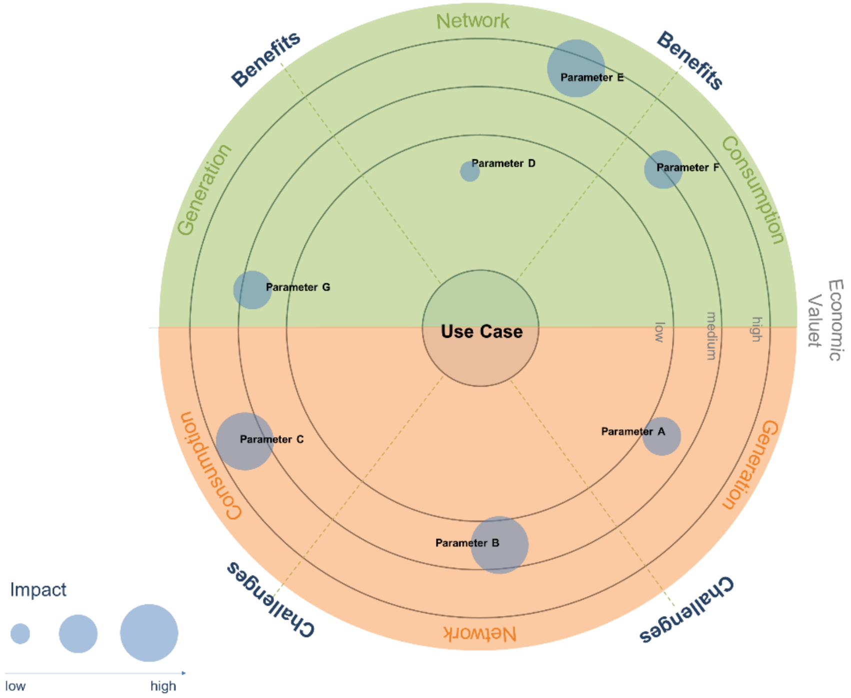


Figure 15: Schematic overview of the business radar method

3.4.2 Evaluation Parameters

Each identified factor is visualized as a **circle (bubble)** in the radar. Two parameters define its representation:

- **Vertical position:** reflects the **economic value**. Higher placement corresponds to higher economic relevance (e.g., significant cost savings or major investment requirements).
- **Bubble size:** represents the **systemic impact** of the factor, i.e., its relative importance for the energy system as a whole. Larger bubbles indicate greater systemic relevance.

The horizontal alignment indicates the factor’s assignment to the network, generation, or consumption dimension.

3.4.3 Development Process

The creation of the Business Radar follows a structured, multi-step process:

1. **Identification of factors:** Relevant benefits and challenges are identified through project results, simulation data, laboratory experiments, and expert consultation.
2. **Categorization:** Each factor is assigned to one of the three systemic dimensions (network, generation, consumption).
3. **Assessment:** Factors are qualitatively and semi-quantitatively assessed according to economic value and systemic impact. This step is usually conducted through expert panels or partner evaluations.
4. **Visualization:** The results are plotted in the radar, with benefits in the upper half, challenges in the lower half, and positioning/size reflecting economic value and systemic impact.
5. **Interpretation:** The radar provides a holistic representation of where the technology creates the most significant economic and systemic advantages and where the most critical barriers arise.

3.4.4 Role in the Use Case Assessment

In the context of the project's use cases, the Business Radar represents the optimal instrument to illustrate the techno-economic interdependencies of the absorption technology based use cases. A classical economic assessment (e.g., based on net present value or internal rate of return) can only provide results that are highly dependent on the specific technical and operational boundary conditions of an individual use case. Hence, such approaches cannot yield generally valid conclusions for broader technology deployment. By contrast, the Business Radar makes it possible to highlight the relative importance of systemic and economic factors across different contexts, providing a transparent and transferable assessment that supports strategic decision-making.

3.4.5 Complementary Evaluation by Project Partners

While the Business Radar served as the primary cross-case instrument, the individual partner use cases were evaluated additionally using classical economic methods. These included:

- **Net Present Value (NPV)** calculations,
- **Internal Rate of Return (IRR)** as a measure of project profitability, and evaluations of integration into the planned generation portfolios of large utilities

This dual approach ensures that both the case-specific financial feasibility and the generalizable systemic implications of the technology are comprehensively assessed.

3.4.6 Relevance for Business Case Analysis

The Business Radar thus complements classical economic methods by providing a qualitative, systemic, and comparative perspective. While NPV or IRR results remain indispensable for project-specific investment decisions, the radar enables stakeholders to understand the broader value proposition and constraints of the technology, thereby bridging the gap between detailed financial analysis and strategic innovation planning. The results for each use case are shown in chapter 4.

4 Case Studies & Results Discussion

4.1 Absorption Heat Exchanger Vienna

Wien Energie supplies many consumers via the connected secondary district heating network. DH substations ("Gebietsumformerstationen") are available in the power range from 2 MW_{th} to 20 MW_{th}. This DH substations transfer heat from the high temperature (primary) DH grid to the "low" temperature (secondary) DHN. They are designed with 2 to 5 heat exchangers for reasons of supply security and partial load behaviour. A schema of a typical DH substations in Wien with exemplary temperatures is shown in Figure 16. They are mainly installed in shafts[51], which are designed to be just as large as necessary for reasons of investment costs and the limited space available in inner-city areas.

---

[51] Zoidl, Franziska (2024). Die Fernwärme-Abfahrt ist unter der Litfaßsäule. Der Standard. https://www.derstandard.at/story/3000000212128/die-fernwaerme-abfahrt-ist-unter-der-litfasssaeule (accessed on 08.08.2025).

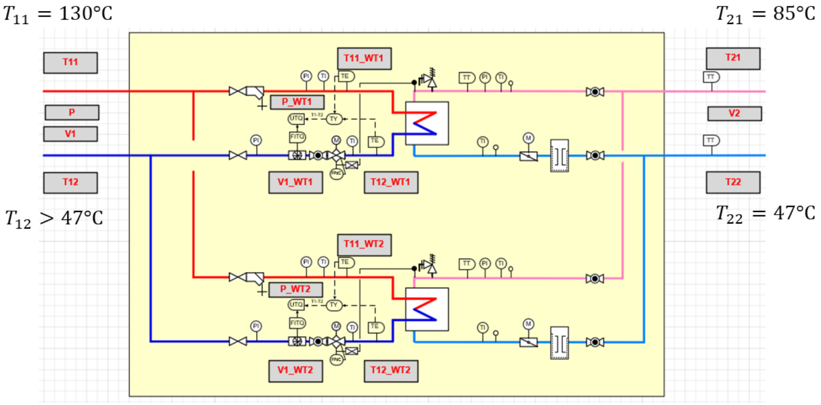


Figure 16: Schematics of a DH substation with two heat exchangers with exemplary temperatures. Source: Wien Energie.

The Vienna district heating system is expanding every year, the integration of new customers requires an increase in capacity for the existing infrastructure. As investments in existing primary grid infrastructure are expansive, and the primary grid is operated at very high temperatures the absorption heat exchanger is identified as potential solution for the Viennese district heating system to provide an increase of transport capacity without the need of DHN refurbishment. Absorption heat exchangers as introduced in 3.1.4, are able to lower the return temperature in the primary side when “low” supply temperature are provided in the secondary side. Schematics of the energy concept are provided in Figure 17.

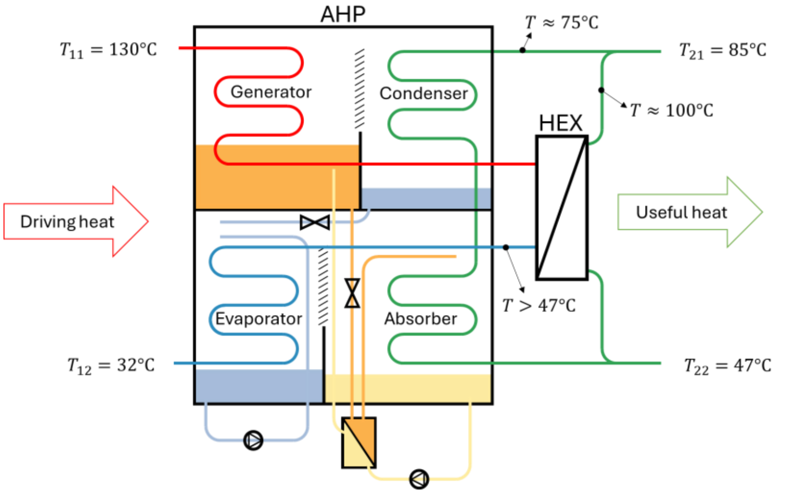


Figure 17: Schematics of an absorption heat exchanger with exemplary temperatures. Modified from source: Stepsahead.

The further definition of the use case includes the selection of appropriate and representative DH substations. First, a 2.8 MW_{th} DH substations was selected and analyzed, yielding promising results but boundary conditions were considered not representative enough, thus a further DH substation was selected and analyzed. The results are included in the publishable report. Because the change in location, the boundary conditions need to be updated as well. The load profile has been downscaled to match the thermal capacity of the previously designed 2,8 MW_{th} AHE, see Figure 18. In regard of the temperatures, the evaluation has been conducted for two different cases, a first cased based on the actual operating temperatures (status quo. The temperatures are shown in Figure 19) and secondly, assuming that the supply temperatures on the primary side are reduced (planned future operating situation).

To analyse the system, the AHE model presented in chapter 3.2 is used. The model parameters (e.g. UA values) are increased to up-scale the AHE from the AHE in ~kW range used in the lab and during the validation work up to a larger AHE of 2.8 MW_{th} that matches the requirement of the DH substation. A few operating points provided by the technology provide Stepsahead are used as a reference for the calibration process.

In regards of the boundary conditions, the secondary side of the heat exchanger (consumer side) are based on measured data, return temperature T_{22} and mass flow are used as input variables (the return temperature T_{22} is in the range 44 to 60°C, see Figure 19). The flow temperature of the primary side T_{11} is either based on measured data (case 1: status quo) or is calculated using a function between the outside air temperature and the minimum flow temperature at the consumer (case 2: planned future operating situation). The most important control parameter of the model is the mass flow on the primary side, which is set so that the outlet temperature on the secondary side (flow) T_{21} reaches its setpoint (setpoint for T_{21} is in the range 62 to 73°C). The distribution of the mass flow between the external heat exchanger and the absorption chiller is divided equally (50-50) and kept constant, i.e. no optimization is carried out.

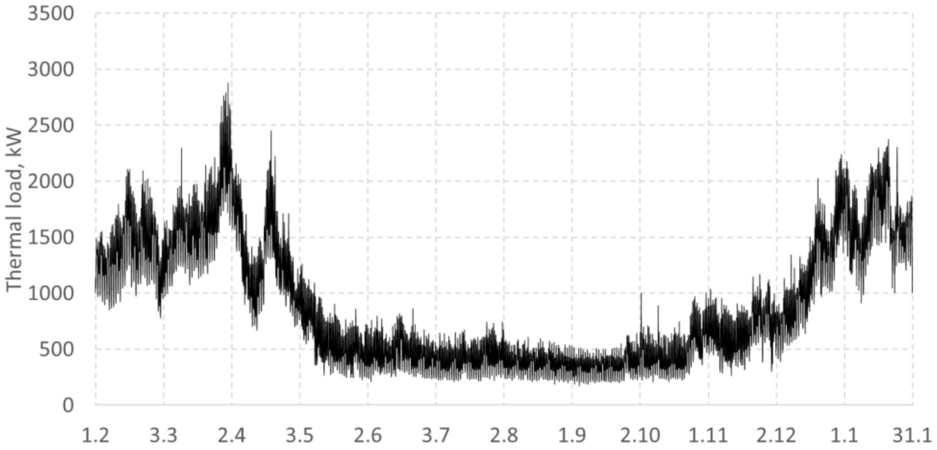


Figure 18: Downscaled load profile for second location. Source: Wien Energie.

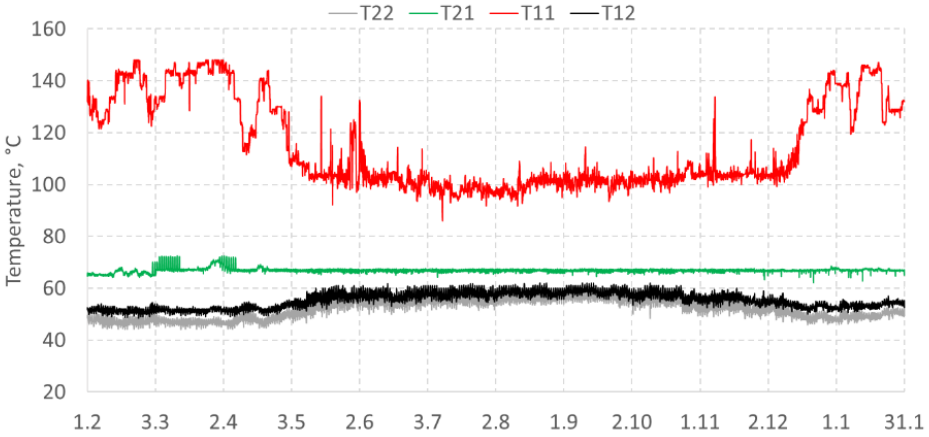


Figure 19: Status Quo supply and return temperatures at the primary and secondary for second location. Source: Wien Energie.

4.1.1 Technical results

The results of the simulation studies carried out for the Vienna use case, which boundary conditions and methodology is introduced in chapter 4, are here presented.

The temperatures for the status quo (case 1) with high flow temperatures on the primary side (T_{11}) are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**. The results show how the return temperatures on the primary side (T_{12}) can be lowered below the return on the secondary side (T_{22}) with the AHE. The highest subcooling[52] effect occurs in winter, when the temperature T_{11} is high. During the course of the year, the temperature difference between T_{12} with and without AHE varies between 9 and 29 K.

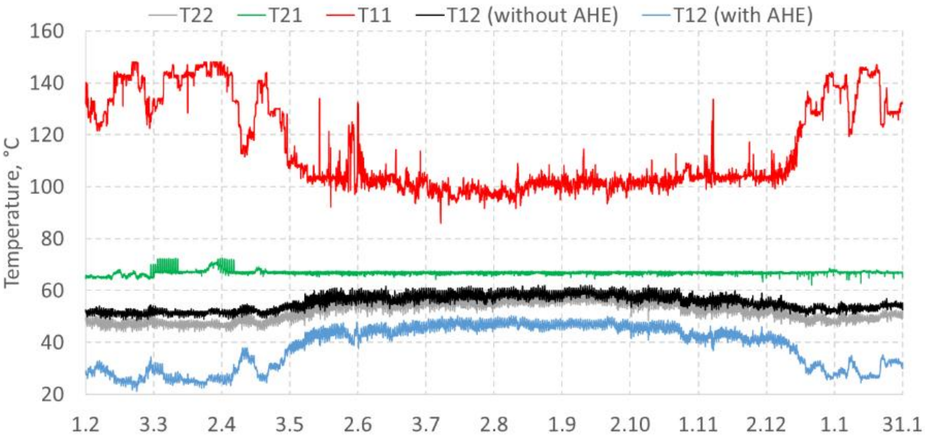


Figure 20: Results and boundary conditions for case study with current (status quo) high flow temperature of the primary side T11.

The temperatures for the planned future situation (case 2) with reduced flow temperatures on the primary side (T_{11}) are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**. Lowering the flow temperatures on the primary side has a negative effect on the operation of the AHE; it reduces the subcooling effect. As in the previous case (status quo), the highest subcooling effect occurs in winter or better said, when the driving temperature T_{11} is high. The added value of the concept when the AHE driving temperature T_{11} is below 80°C (summer time) is barely noticeable. Over the course of the year, the temperature difference between T_{12} with and without AHE is between 0 and 20 K.

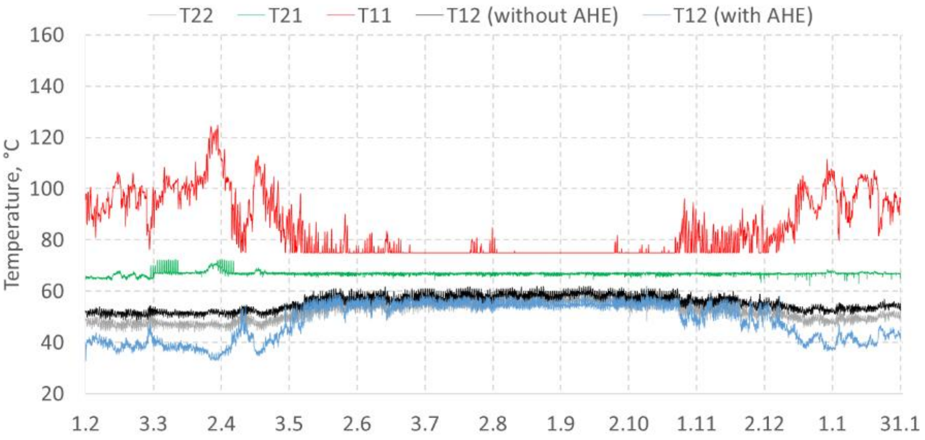


Figure 21: Results and boundary conditions for case study with planned future flow temperature of primary side T11.

The results show the added value of the AHE an how the driving temperature T_{11} has a large influence on the achieved subcooling. Aware that the validity of the results is limited to the specific case the hourly values of the results are used to generate a correlation. The correlation is put in context with other publications in this topic. To do so, the key performance indicator efficiency ε is utilized, see **Fehler!**

---

[52] Subcooling effect is defined as the temperature difference between return temperature at the secondary side (T_{22}) and return temperature at the primary side (T_{12}).

Verweisquelle konnte nicht gefunden werden.. The efficiency is defined as the temperature ratio between the difference of the supply and remperature at the primary side T_{11} and T_{12} respectively and the temperature difference between T_{11} and the return of the secondary side T_{22}.

$$\varepsilon = \frac{T_{11} - T_{12}}{T_{11} - T_{22}} \qquad \text{Equation 1}$$

As the supply temperature T_{11} is not the only factor afecting the performance of the absorption heat exchanger, the results are presented as a function of the difference between the supply (driving) temperature T_{11} and the supply temperature of the secondary side T_{21}. See **Fehler! Verweisquelle konnte nicht gefunden werden.**. The labels indicate the dataset source[53] and supply and return temperatures of the secondray side T_{21} and T_{22}.

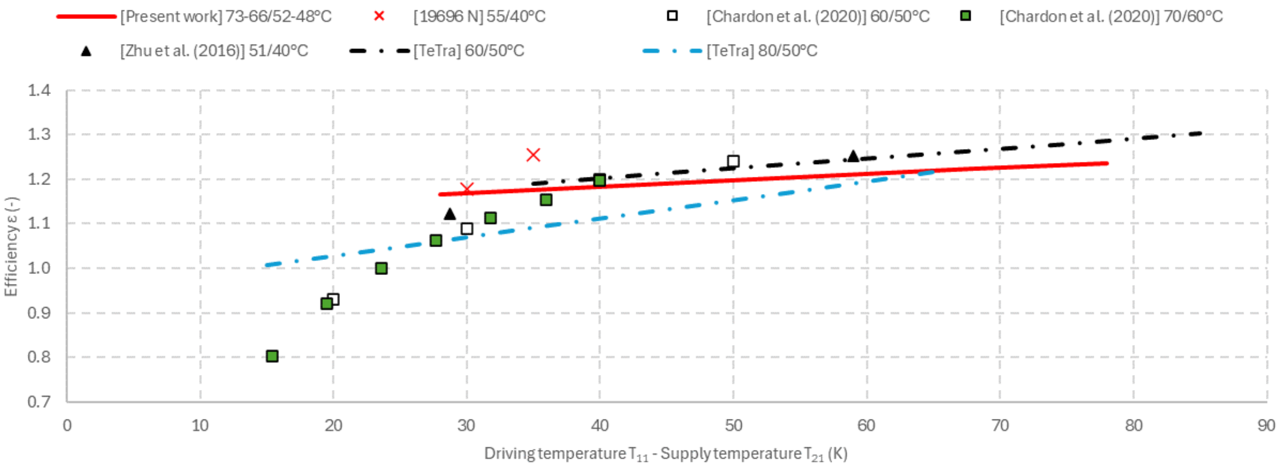


Figure 22: Efficiency of AHE of the current study (red line) compared to literature values as a function of temperature difference between supply (driving) temperature T_{11} and supply temperature at the secondary side T_{21}. Labels indicate operating temperatures T_{21} and T_{22} at the secondary side.

Note that a efficiency $\varepsilon = 1$ represents the physical limit value of an infinite counter-current heat exchanger where T_{12} is equal to T_{22}. From the results it can be observed, that with a driving temperature T_{11} 20 to 30 K higher than the supply temperature T_{21} the AHE start to obtain higher efficiencies than the possibles with a standard DH substation (counter-current heat exchanger). These values provides a reference value to understand under which operating conditions an AHE provides an added value on such application and thus worth considering. Furthermore the values can be used to roughly estimate the expected efficiency of an AHE DH substation (assuming similar temperature boundary conditions).

Part of the above results have been presented at the 10th edition of the Smart Energy Systems conference in Aalborg, Denmark. A video recording is available in YouTube[54].

Further, based on the reults, the integration of AHE in the viennesse DH system is discussed.

---

[53] List of external references utilized in **Fehler! Verweisquelle konnte nicht gefunden werden.**:
[TeTra] Thermische Energietransformation zur Wärme- und Kälteauskopplung sowie Effizienz Steigerung in Nah- und Fernwärmenetzen. Projektnummer: 865.023.
[Chardon] Chardon, G. et al. On the opportunity to integrate absorption heat pumps in substations of district heating networks. Thermal Science and Engineering Progress 2020. https://doi.org/10.1016/j.tsep.2020.100666.
[Zhu] Zhu, C. et al. A multi-section vertical absorption heat exchanger for district heating systems. International Journal of Refrigeration 2016. https://doi.org/10.1016/j.ijrefrig.2016.08.010.
[19696 N] Project n°: 19696 N. Potenziale von Absorptionswärmepumpen in zentralisierten Wärmeversorgungsnetzen. 2020.

[54] Presentation of Enabling Return Temperature Reduction in Austrian District Heating System. SESAAU 2024 Conference. https://www.youtube.com/watch?v=izDfpzIVHYY&t=10s (last visited 11.08.2025)

- A key challenge observed are the space requirements of the solution. The proposed technical solution of the AHE based DH substation requires the utilization of a higher space than “classical” HEX based DH substations. This challenge is especially relevant for the refurbishment of DH substations. The existing DH substations do have limited space so that the development of compact absorption heat pumps and/or AHE is key for the AHE to be a really feasible solution. Otherwise the deployment of AHE might be limited to few cases where the space is available or, in the case of new DH substation, the situation/location allows to consider the utilization of a large space during the design phase.

Given the situation in Vienna, most potential of the AHE has been identified for,

- Increase the transport capacity: In DH network sections where the (primary) transport infrastructure is already at full capacity; the use of an absorption heat exchanger could create new capacity without the need to expand the infrastructure (pipeline construction or enlargement). The use of this technology could offer an alternative, particularly where this is not possible or only possible with great difficulty for structural or historical reasons (e.g. listed buildings).
- Network sections with higher flow temperature: In network sections that, for certain reasons, have to be operated with a flow temperature that is higher than the rest of the network, the absorption heat exchanger could derive additional benefit from these high temperatures.

Further, as Wien Energie is working and plans a temperature reduction of the supply temperature at the primary side, the AHEs can be an enabler on the temperature reduction, a sweet spot could be found that allows a feasible temperature reduction while keeping the temperature high enough (e.g. > 90°C) to not only maximize the benefits caused by the reduction at the primary side of the supply temperature but also consider the benefits cause by the AHE on the reduced return temperature at the primary side, i.e. defining additional technical guidelines on technical design conditions (TR-TAB) for areas were an AHE would be installed.

Finally report that the analysis and simulation studies have focused on demonstrating and assessing the expected performance of the AHE for given uses cases in Vienna. Details about the integration (hydraulics) and optimal operation have not been investigated. A few points must be given especial attention in subsequent analysis towards a more concrete energy concept. These are,

- The mass flow of the AHE at the primary side goes through three heat exchangers (instead of one). Higher pressure drops are therefore expected so that a thoughtful consideration of this new situation is necessary to ensure a proper design and thus a smooth operation.
- The addition of an absorption heat pump on existing DH substations, implies that the new device needs to be maintained and operated. Furthermore, a new technology is introduced so that the personnel responsible needs to be properly trained.
- The heat supply security plays a major role in the DH operation at Wien Energie. The robustness and operability of the AHE need to be further analyzed (e.g. by means of a pilot project) to ensure a smooth operation.

4.1.2 Economic results and business radar

The use of an absorption heat exchanger (AHE) in district heating networks has positive impacts on several economic factors. However, these benefits are counterbalanced by higher investment and operating costs compared to standard heat exchangers. Potential savings have been identified in particular in the following areas:

- **Network costs:** Due to the higher temperature spread enabled by reducing return temperatures, the same thermal output can be achieved with a lower mass flow. This leads to reduced costs for repairs, maintenance, and network operation.
- **Pumping electricity costs:** Lower mass flow also decreases the electrical energy required for operating network pumps.
- **Increased transport capacity of existing primary networks:** When connecting new consumers would otherwise require the installation of additional pipelines, an AHE can under suitable conditions serve as a transfer station and eliminate the need for new pipe installations.
- **Efficiency gains:** The reduction of return temperatures can increase overall system efficiency (depending on technology, operation mode, and plant-specific parameters).
- **Reduced heat losses:** A lower transported water volume may reduce thermal losses across the network, which has further positive economic effects.

Despite these advantages, several technical and economic challenges also arise:

- **Space requirements:** AHEs require up to 50% more space than standard heat exchangers. In existing district heating substations, this space is often unavailable since shafts are typically designed for standard exchangers.
- **Pressure losses:** The chosen design entails higher pressure losses (primary side: at least 1 bar differential pressure required; secondary side: approx. 20–35 kPa for shell-and-tube heat exchangers). Additionally, mixing options must be implemented on the primary side, as supply temperatures in district heating networks can reach 160–180 °C, while AHEs are only rated up to 130 °C. These measures increase pumping power demand and must be factored into the economic assessment.

Business Radar Results

The Business Radar analysis confirms the aspects outlined in the economic discourse. Particularly strong advantages are observed at the network level: lowering return temperatures increases transport capacity, reduces mass flow and associated pumping costs, and decreases heat losses. In addition, the integration of renewable heat sources and the efficiency of existing plants can be improved.

On the consumer side, lower connection costs and potential impacts on heat tariffs are evident. On the downside, increased investment costs for customer installations, additional space requirements, higher technical complexity, and the need for knowledge transfer represent barriers.

Overall, the Business Radar highlights that the economic and systemic benefits clearly outweigh the drawbacks. However, their realization depends on accompanying measures such as targeted investment incentives and structured knowledge transfer.

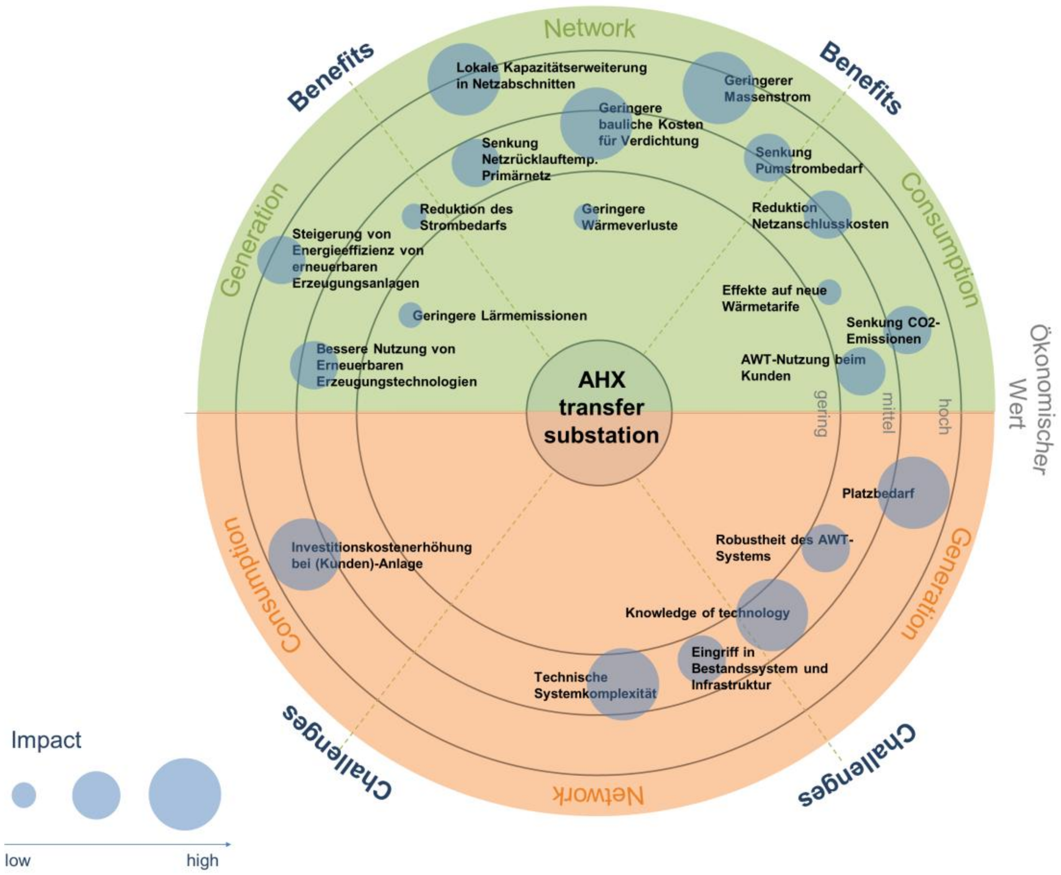


Figure 23: Business radar assessment of the absorption heat exchanger

4.1.3 Conclusion

Absorption heat exchangers (AHEs) are not a universal solution for district heating networks but offer strong potential in specific applications:

- **Targeted use cases:** They are particularly effective in network sections with capacity bottlenecks where infrastructural expansion is difficult (e.g., due to historical or spatial constraints).
- **Integration with renewables:** Combining AHEs with geothermal plants can enhance system performance, though operational interactions (e.g., with downstream heat pumps) must be carefully assessed.
- **High-temperature segments:** In areas with elevated supply temperatures, AHEs can operate especially efficiently.

Overall, AHEs provide added value for decarbonization and flexibility in urban district heating when applied selectively. The technology shows promise as a complementary solution, especially in highly loaded network areas and in combination with renewable sources. Future research and pilot projects are required to address technical challenges (space demand, pressure losses), exploit economies of scale, and demonstrate economic viability on a larger scale

4.2 Absorption Chiller in District Cooling Linz

4.2.1 Background and objectives

The integration of absorption chillers into district cooling networks has become increasingly relevant for urban areas with growing cooling demand and ambitious decarbonisation targets. Absorption chillers (AC) operate on the LiBr–H_2O cycle and make use of surplus or low-cost thermal energy as the driving input. Their main advantage lies in the ability to provide cooling services while consuming only minimal amounts of electricity, thereby relieving urban power grids during summer peak load periods.
This case study investigates the planned deployment of an absorption chiller in Linz (Austria), designed to provide cooling to a data centre and adjacent office buildings. The aim was to demonstrate the feasibility of absorption-based district cooling under Austrian boundary conditions and to compare it with conventional compression-based systems.

4.2.2 Technical concept and system integration

The absorption chiller was dimensioned for a **nominal cooling capacity of 700 kW**, with a minimum load of 70 kW. It operated with chilled water temperatures of **14.5 °C (inlet) to 5.5 °C (outlet)** at a mass flow of 66.8 m³/h. The cooling water circuit, based on a glycol-water mixture (33%), was designed for **27 °C (inlet) to 37 °C (outlet)** at 153 m³/h. The driving circuit, supplied from the district heating grid, was dimensioned for **80 °C (inlet) to 70 °C (outlet)** with a flow of 79.3 m³/h.

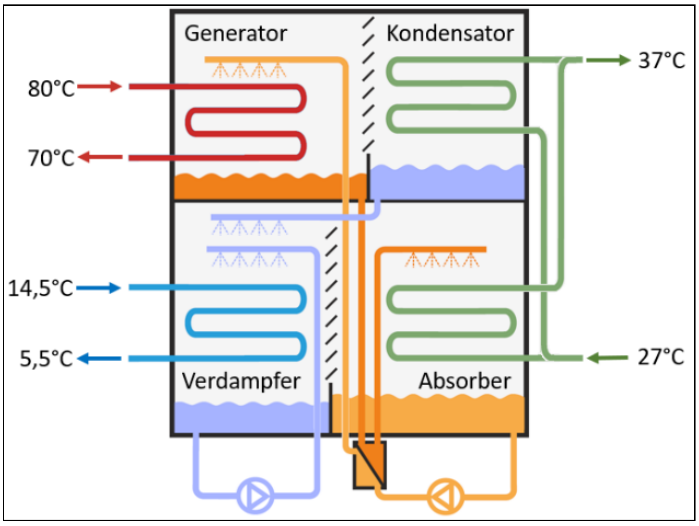


Figure 24: Scheme of absorption cooling system for Use Case Linz

Table 4: Technical details of the absorption chiller for the use case Linz

Technische Daten Absorptionskälteanlage			
Kaltwasser	Kälteleistung	kW	700
	Min. Kälteleistung	kW	70
	Temperatur (Eintritt -> Austritt)	°C	14,5->5,5
	Volumenstrom	m³/h	66,8
	Max. Druckverlust	kPa	76
	Anschluss	DN (mm)	100

Kühlwasser **(33% Glykol)**	Temperatur (Eintritt -> Austritt)	°C	27->37
	Volumenstrom	m³/h	153
	Max. Druckverlust	kPa	165
	Anschluss	DN (mm)	150
Antriebswasser **(Fernwärmenetz)**	Antriebsleistung	kW	900
	Temperatur (Eintritt -> Austritt)	°C	80->70
	Volumenstrom	m³/h	79,3
	Max. Druckverlust	kPa	94
	Anschluss	DN (mm)	125
	COP		0,78±5%
	Abmaße LxBxH	mm	6400x1850x3300
	Betriebsgewicht	t	17,9
	Elektroanschluss		400VAC 20A

The absorption chiller achieved a **COP of 0.78 ± 5%** under nominal conditions. It required only minor auxiliary electricity demand (20 A, 400 V AC), confirming its low electrical footprint. The dimensions of the machine were **6,400 × 1,850 × 3,300 mm**, with a weight of 17.9 tonnes.

The integration concept for the Linz case consisted of a **hybrid cooling centre** with multiple technologies:

- **Free cooling** during favourable outdoor conditions,
- **Three electric compression chillers** to secure peak load and flexibility,
- **One absorption chiller** to provide base load cooling, driven by district heating.

A wet cooling tower was designed to reject heat, with a temperature spread of 37 °C → 27 °C. The chilled water was distributed to both the data centre and office buildings.

From a technical perspective, the absorption chiller demonstrated several advantages. The use of LiBr–H_2O as the working pair allowed chilled water supply down to 5.5 °C without efficiency loss, and even as low as 1 °C when operated with slightly saline brine. The machine was able to cover base loads stably, with part-load operation feasible down to 20% of nominal capacity. The system operated with very low vibration and noise emissions, which is particularly relevant for urban environments.

Despite the promising technical design, the Linz project was not implemented in practice. The decisive factor was the lack of surplus thermal energy during summer months. Without access to free or very low-cost driving heat, the absorption chiller could not demonstrate an economic advantage over compression systems, which are more flexible in adapting to variable loads.

4.2.3 Economic assessment and business radar findings

The economic evaluation highlights the fundamental dependence of absorption chillers on boundary conditions. Investment costs are higher compared to compression units, primarily due to the larger machine dimensions and the required cooling tower infrastructure. However, operating costs are very low, as electricity demand is negligible.

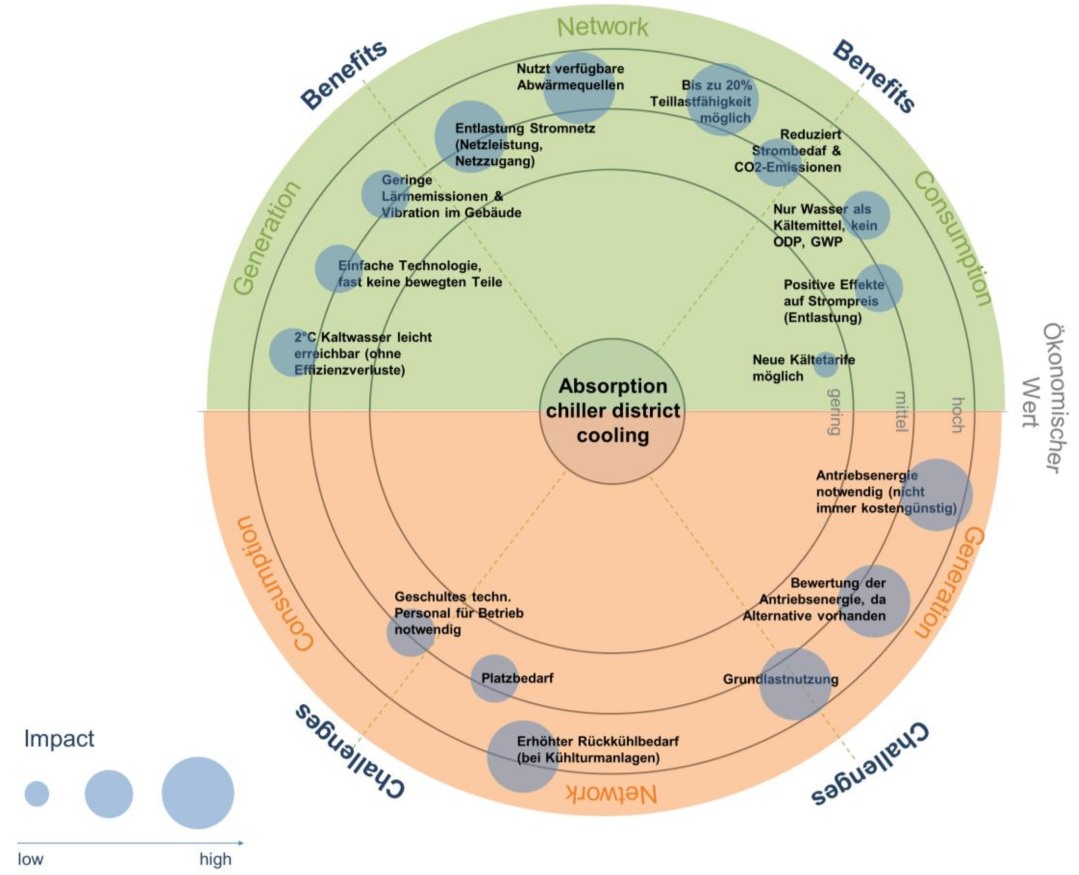


Figure 25 Business Radar assessment for absorption chiller in district cooling grids

The **Business Radar** confirmed the systemic strengths of absorption chillers:

- They enable the **use of surplus heat**, thereby increasing overall resource efficiency and reducing primary energy consumption.
- By shifting cooling production to the thermal sector, they **relieve the electricity grid** and reduce summer peak loads.
- They contribute to **CO_2 emission reductions**, as every megawatt-hour of electricity replaced by surplus thermal energy avoids indirect emissions.
- They show high acceptance in urban contexts due to **silent and low-vibration operation**.

On the downside, the Business Radar also identified significant challenges:

- Absorption chillers require **continuous base load demand** to be economically viable.
- The **driving heat must be available at low cost**; otherwise, the technology is not competitive with compression-based systems.
- **Cooling water demand** is high, approximately 2.3 times the cooling output.
- The technology requires **larger installation space** and skilled operators.

4.2.4 Discussion and conclusions

The Linz case study illustrates both the opportunities and limitations of absorption-based cooling. From a technical perspective, the absorption chiller is a robust and environmentally friendly technology, capable of providing reliable base load cooling with minimal electricity use. It is especially attractive in contexts where surplus or waste heat is available continuously, such as waste incineration, industrial processes, or cogeneration plants.

However, the project also demonstrated that the absence of low-cost driving heat can severely limit viability. Under Austrian conditions, where summer availability of surplus heat is restricted, compression chillers remained the more flexible and economically favourable option.

In summary, absorption chillers represent a useful solution for urban district cooling, most effective when integrated into hybrid systems that combine multiple technologies. Their role is to stabilize base loads, exploit surplus thermal energy, and reduce reliance on electricity-based cooling. The Linz case showed that while technically feasible, their economic competitiveness is highly site-dependent and requires specific local conditions.

4.3 Absorption Heat Pump for the Utilization of Waste Heat from Secondary Cooling Water Linz

4.3.1 Background and Objectives

The improvement of energy efficiency is a key pillar in ensuring prosperity, security of supply, and long-term climate goals. A largely underestimated potential lies in the utilization of waste heat from power plants. In addition to well-known flue gas streams, significant amounts of thermal energy are generated in the cooling and lubrication systems of gas turbines, steam turbines, generators, and compressors. Today, this heat is typically dissipated into rivers and thus remains unused.

Absorption heat pumps (AHPs) offer a promising solution by upgrading this low-temperature waste heat (40–70 °C) to the temperature levels required for district heating networks. This allows fossil-based heat producers to be substituted, CO_2 emissions to be reduced, and the overall efficiency of the energy system to be significantly increased.

The objective of this case study was to evaluate the technical feasibility, system integration challenges, and economic implications of implementing an AHP system that harnesses secondary cooling water in an existing power plant environment.

4.3.2 Technical Concept and System Integration

Absorption heat pumps use thermal rather than electrical energy to drive the refrigeration cycle, typically employing a lithium-bromide/water ($LiBr/H_2O$) solution. Their key advantage is the ability to utilize low-temperature heat sources, provided that sufficiently high driving temperatures (90–120 °C) are available.

Case Study Setup Linz

- **Waste heat source:** Oil cooling loops with inlet temperature of 62 °C and outlet of 52.9 °C.
- **District heating integration:** Return flow lifted from 55 °C to 70 °C.
- **Driving heat source:** District heating supply line with 97 °C cooled to 87 °C.

- **Heat output capacity:** 8.63 MW.
- **Coefficient of Performance (COP):** 1.86.
- **Physical specifications:** 48 t unit, dimensions 7.8 m × 3.1 m × 4.2 m.

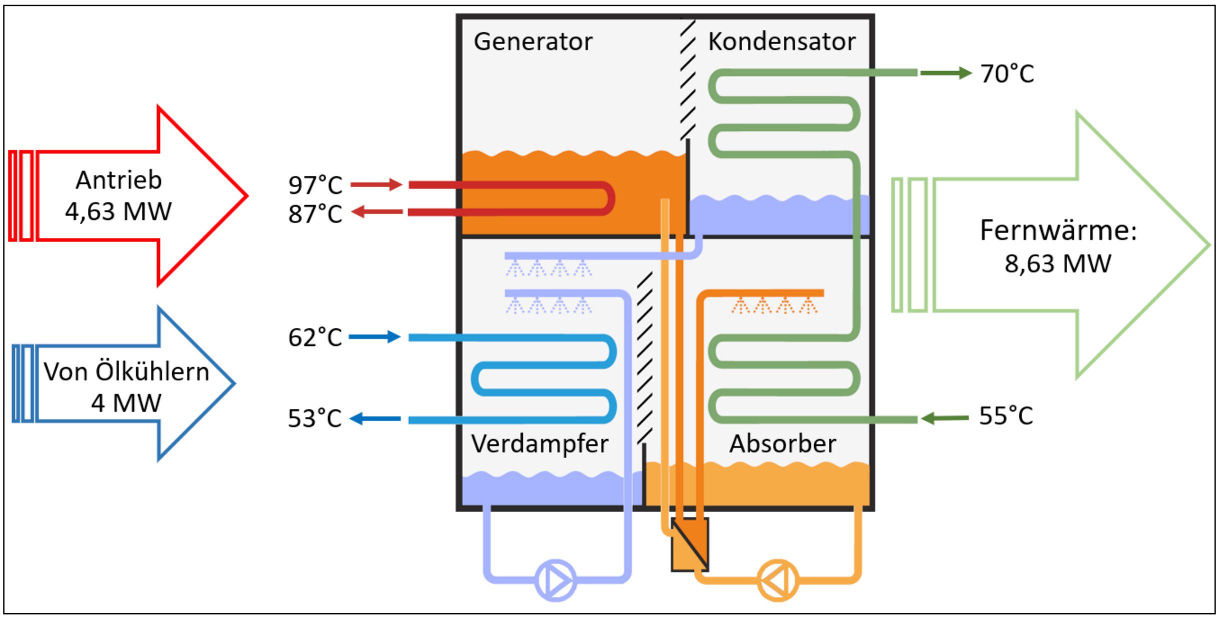


Figure 26: Process flow diagram of AHP integration

Table 5: Technical specifications of the designed AHP

Technische Daten LiBr - Absorptionswärmepumpe			
Fernwärme (Vorwärmung des Rücklaufs)	Wärmeleistung	kW	8630
	Min. Wärmeleistung	kW	863
	Temperatur (Eintritt -> Austritt)	°C	55->70
	Massenstrom	t/h	495
	Max. Druckverlust	kPa	120
	Anschluss	DN (mm)	300
Kühlwärme Öl	Temperatur (Eintritt -> Austritt)	°C	62->52,9
	Massenstrom	t/h	378
	Max. Druckverlust	kPa	89
	Anschluss	DN (mm)	250
Antriebswasser (Vorlauf des Fernwärmenetzes)	Antriebsleistung	kW	4630
	Temperatur (Eintritt -> Austritt)	°C	97->87
	Massenstrom	t/h	396
	Max. Druckverlust	kPa	60
	Anschluss	DN (mm)	250
	COP		1,86
	Abmaße LxBxH	mm	7800x3100x4200
	Betriebsgewicht	t	48
	Elektroanschluss		400VAC 48,7A

Integration Challenges

- **Systemic modifications:** Hydraulic coupling of several cooling loops requires redesign and adjustments.
- **Compatibility issues:** Coordination with turbine manufacturers is required, particularly regarding warranty conditions.
- **Competing uses:** Driving heat sourced from the district heating supply may alternatively be used for electricity generation in turbines.

Although technically feasible, the relatively low driving temperature of 97 °C proved limiting. A higher driving temperature would have enabled a more robust configuration, resulting in higher COP values and improved economic viability. While more than 20 MW of additional waste heat could theoretically be recovered in the secondary cooling water system, this potential could not be fully harnessed under the given boundary conditions.

4.3.3 Economic Assessment

The economic viability of AHP systems depends on both technical conditions and system context. Key considerations include:

- **Free waste heat source:** Heat from oil coolers is available at no cost, providing a major advantage compared to fossil fuels.
- **Value of driving heat:** Driving heat from district heating or steam must be accounted for as opportunity costs, since it could otherwise be used for electricity production.

Business Radar findings:

- **Advantages:** Unlocks unused heat sources, improves CO_2 footprint, diversifies heating sector, and uses water as a refrigerant without environmental risks. It also relieves stress on the electricity grid due to its thermal-driven operation.
- **Challenges:** High space requirements, complex integration into existing plant structures, lack of harmonized EU standards, and uncertain economics if driving heat has high market value.

In practice, the profitability of AHPs fluctuates significantly. When driving heat comes from low-cost or renewable sources (biomass, solar thermal), AHPs can outperform fossil-based alternatives. Conversely, if driving heat is priced at levels comparable to gas or electricity, profitability decreases. Still, ecological benefits remain significant, with every substituted MWh of gas reducing emissions by ~200 kg CO_2. International experience (e.g., IEA-DHC, 2021) confirms that AHPs can play a pivotal role in industrial waste heat recovery when properly embedded in system contexts and supported by policy frameworks. Subsidies and incentives are essential to mitigate investment risks and ensure wider market uptake.

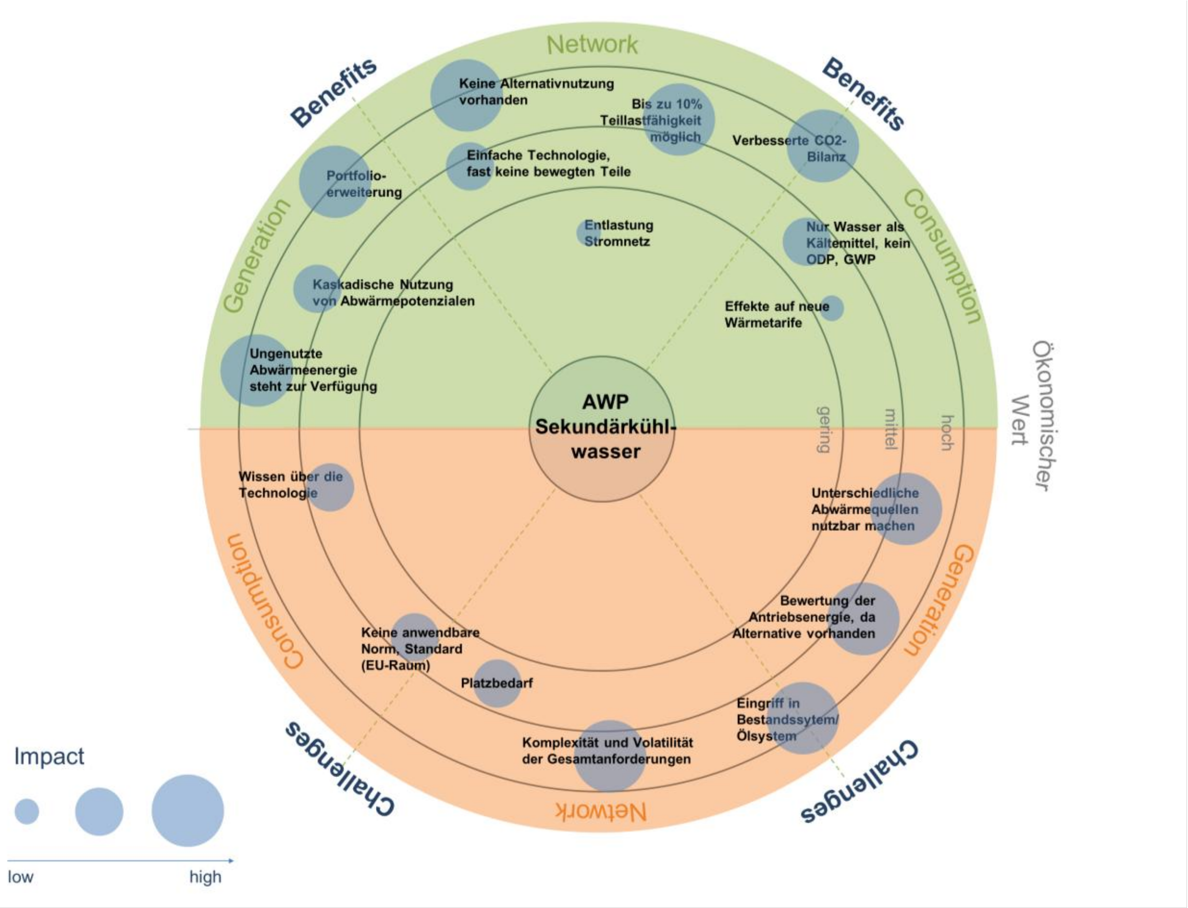


Figure 27: Business Radar assessment for absorption absorption heat pump for the Utilization of Waste Heat from Secondary Cooling Water

4.3.4 Conclusion

The analysis demonstrates that utilizing waste heat from secondary cooling water circuits through absorption heat pumps offers substantial technical and ecological potential. By upgrading cooling circuit temperatures to district heating levels, fossil-based heating can be displaced, leading to considerable CO_2 reductions. With COP values of 1.6–1.9 and low operational costs, AHPs are a mature and reliable technology.

However, key limitations were identified:

- High driving temperatures are necessary and not always available without trade-offs with power generation.
- Integration requires complex retrofits and coordination with turbine manufacturers.
- Profitability is highly site-specific and depends on local energy prices, seasonal demand, and supportive policy measures.

Next steps should include detailed feasibility studies at suitable sites, pilot projects, hybrid solutions with high-temperature heat pumps, biomass or solar thermal integration, and development of dedicated funding schemes to reduce investment risks.

4.4 Absorption Heat Pumps for Flue Gas Condensation in Biomass District Heating

4.4.1 Background and Objectives

One of the main challenges in biomass-based district heating networks is increasing the overall efficiency of existing plants. A substantial share of thermal energy is lost through the flue gas stream, which contains not only sensible heat but also significant latent condensation energy. Traditional heat exchangers recover mainly the sensible fraction, while the latent share often remains unused.
Absorption heat pumps (AHPs) offer a highly efficient solution to utilize this untapped potential. Instead of consuming electricity like compression heat pumps, AHPs are thermally driven (using hot water or steam from the biomass boiler). This enables the recovery of both sensible and latent heat while keeping additional electricity demand to a minimum (<1 % of the delivered heat).
Main objectives are:

- Increase fuel utilization rate by 20–30 %.
- Reduce biomass consumption and related transport/logistics costs.
- Lower CO_2 emissions and strengthen the sustainability of district heating.
- Ensure compliance with new funding schemes (e.g. Austrian environmental subsidies effective since July 2024).

4.4.2 Technical Concept and System Integration

The AHP is integrated between the biomass boiler, the flue gas treatment unit, and the district heating network.

- **Heat Source:** Condensation stage or flue gas scrubber water (20–40 °C typical).
- **Heat Sink:** District heating return line (50–90 °C).
- **Driving Heat:** Hot water (105 °C) or steam (up to 150 °C) extracted from the boiler system.

Key technical parameters

Absorption heat pumps applied in biomass district heating plants typically operate with a coefficient of performance (COP) of around 1.7, which corresponds to a 170 % efficiency gain compared to the supplied driving heat. In practical terms, this means that for every 1 MW of driving heat, about 0.7 MW of additional heat from the flue gas can be recovered, resulting in a total of 1.7 MW of usable district heating output. The technology requires only minimal electricity input, primarily for pumps and auxiliary systems, which remains well below one percent of the delivered heat. Depending on the system configuration, single-lift and double-lift absorption heat pumps can be applied. While standard systems achieve higher COP values, double-lift configurations allow lower return temperatures and higher output temperatures, though at a slightly reduced COP of about 1.3.

Integration aspects:

The integration of absorption heat pumps into biomass-based district heating systems involves a careful alignment between the boiler, the flue gas treatment unit, and the district heating network. The flue gas stream, or water from the flue gas scrubber, serves as the low-temperature source at typical levels between 20 and 40 °C. The recovered heat is transferred into the return line of the district heating network, generally raising its temperature into a range of 50 to 90 °C. As driving heat, either hot water at about 105 °C or steam up to 150 °C can be applied, depending on the boiler design and local requirements. In systems with boiler outputs below 10 MW, hot-water-driven absorption heat pumps are often favored, since their operation avoids the regulatory requirements of steam boiler supervision. At the same time, the cooling of the flue gas stream requires close consideration of emission behavior, as lower stack temperatures can alter pollutant dispersion and, in some cases, necessitate a reheating step to comply with emission control standards.

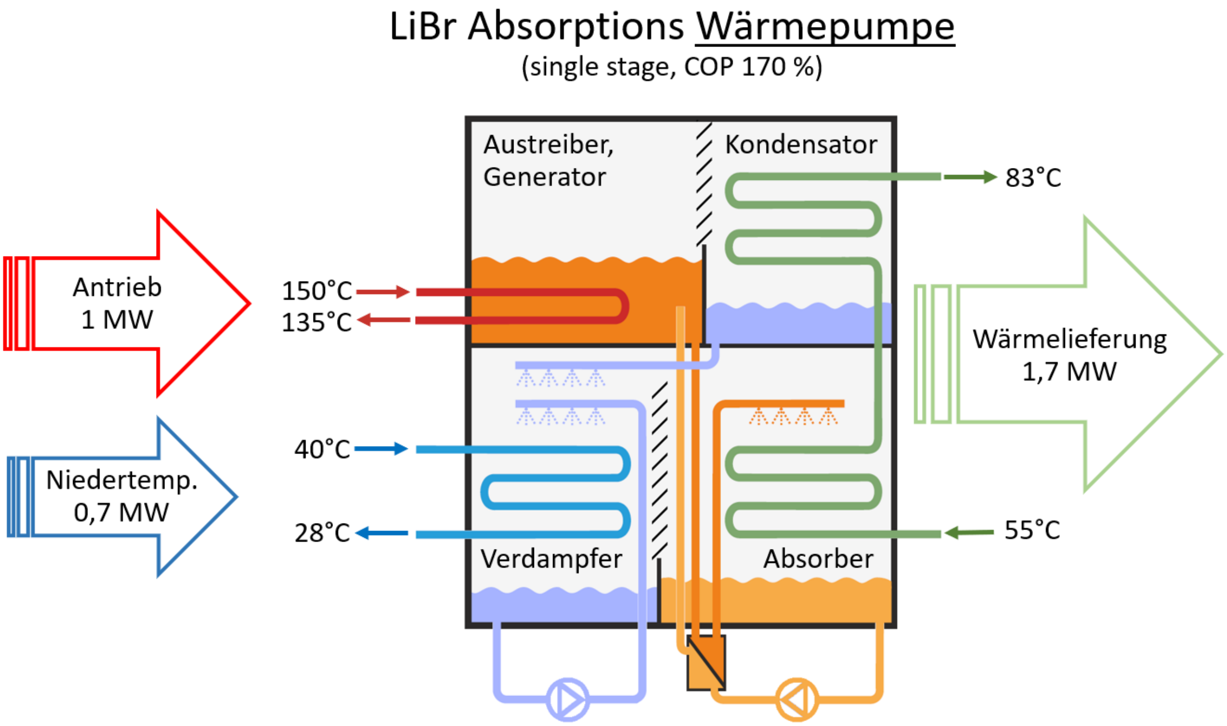


Figure 28: Functional principle of LiBr absorption cycle (schematic)

4.4.3 Economic Assessment

Implementing an AHP requires higher upfront investment compared to a standard condenser. However, the economic benefits outweigh these costs due to:

- **Fuel cost savings:** 15–25 % reduction depending on fuel water content.
- **Operational costs:** Minimal electricity use; O&M mainly hydraulic integration.
- **Supportive policies:** Austrian federal funding supports investments with proven efficiency gains, shortening payback times.
- **Amortisation:** Typically, 5–8 years, depending on plant size and fuel price trends.

Business Radar Results

The Business Radar analysis underlines the strong efficiency gains achievable with absorption heat pumps, identifying a 20 to 30 percent increase in fuel utilization as the most important benefit. This improvement not only reduces fuel demand but also lowers storage and transport costs while creating space for more competitive heat tariffs and portfolio expansion. A further co-benefit is the enhanced performance of flue gas cleaning, since deeper cooling of the exhaust improves de-dusting and desulphurization, contributing to better local air quality.

At the same time, several challenges need to be considered, such as the requirement for specialized know-how, additional space in existing plants, and the resilience of the system under varying fuel and return temperature conditions. Furthermore, limited awareness of the technology among operators highlights the need for targeted information and training.

Overall, the analysis shows that the benefits clearly outweigh the constraints. Efficiency improvements, fuel savings, and reduced ancillary costs provide a strong case for absorption heat pumps as a forward-looking investment with both ecological and economic advantages.

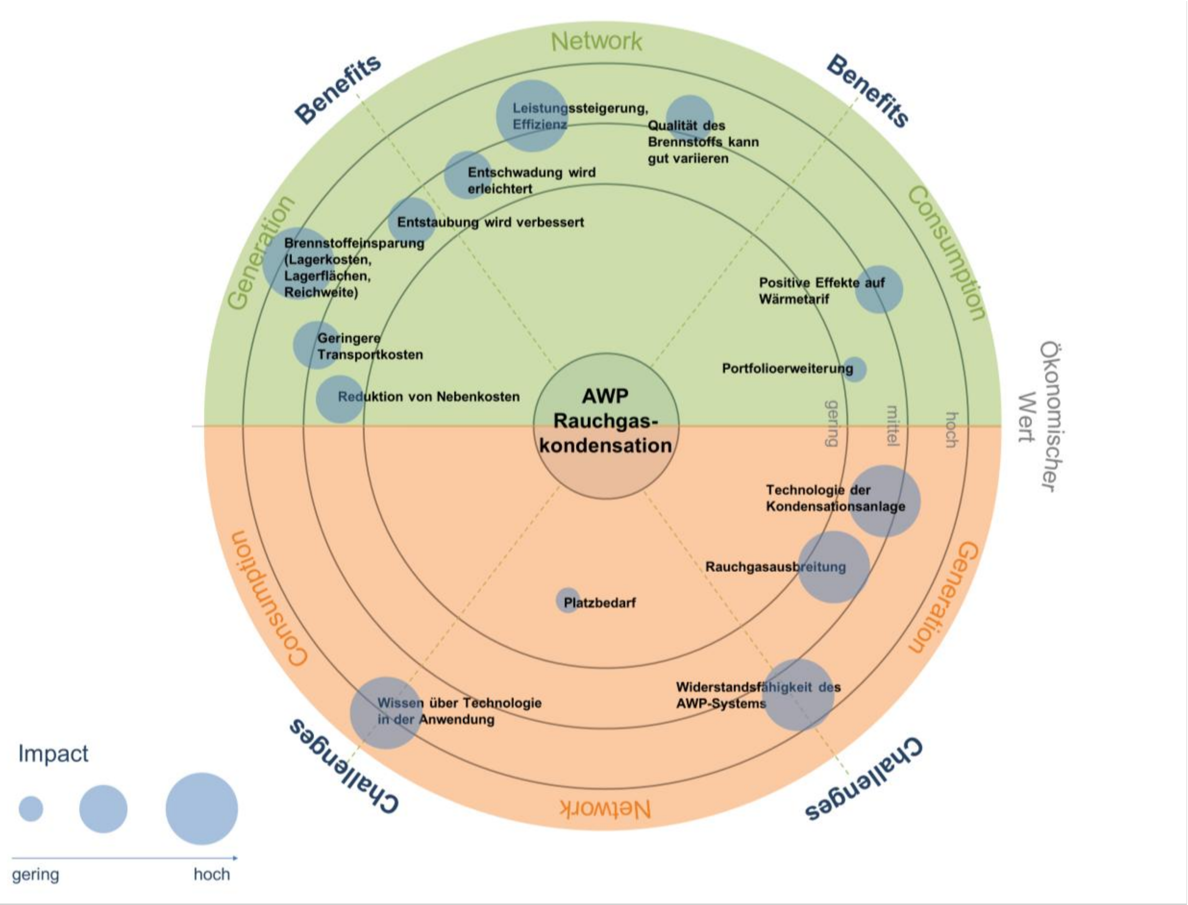


Figure 29: Business Radar assessment – efficiency, cost savings, emission reduction vs. challenges

4.4.4 Case Studies and References

Case Study 1 – Heating Plant Montafon

- 2×4 MW boilers, 11.2 MW district heating output.
- Integration of a 5.7 MW AHP with 150 °C hot water drive.
- COP: 1.7.
- Result: Achieved 115 % efficiency (based on Hu), significant additional heat recovery without added electricity demand.

Case Study 2 – Heating Plant Haid

- AHP driven by 105 °C hot water (below DGRL classification).
- 1.76 MW heat recovery, COP 1.77.
- Result: Lower regulatory requirements, still substantial efficiency gain.

Detailed information about the use case and their results can be found in the concerning Factsheet.

4.4.5 Conclusion

Absorption heat pumps for flue gas condensation are a **proven, mature, and efficient technology** to significantly increase the utilization rate of biomass heating plants. They unlock both sensible and latent heat in the flue gas, achieving efficiency gains of 20–30 % while keeping electricity consumption negligible.

- **Ecological impact:** Reduced CO_2 emissions and more sustainable use of scarce biomass resources.
- **Economic impact:** Lower fuel costs, short payback periods supported by subsidies, improved competitiveness of district heating operators.
- **Technical impact:** Reliable technology, flexible integration, and broad applicability for both retrofitting and new plants.

Field examples confirm the robustness and scalability of the concept. While not every biomass plant can be easily retrofitted, the market potential in Austria and beyond is significant, making this technology a key enabler of the heat transition.

5 Conclusion and Outlook

The AbSolut project has demonstrated that absorption technologies – specifically absorption heat pumps (AHP), absorption chillers (AC) and absorption heat exchangers (AHX) – can play a decisive role in decarbonising and increasing the efficiency of district heating and cooling systems.

Technical investigations

The technical investigations (Chapter 3) and the case studies (Chapter 4) provide clear evidence of their potential. Absorption heat pumps proved capable of upgrading low-temperature industrial waste heat streams to district heating levels. In the Linz case study (Chapter 4.3), a capacity of 8.6 MW with a COP of 1.86 was achieved, demonstrating both technical feasibility and significant CO_2 savings. Absorption chillers, investigated in the Linz cooling case (Chapter 4.2), showed that they can provide stable base load cooling with a COP of 0.78 while requiring only minimal electricity input – an important advantage for relieving stressed power grids in summer peaks. Absorption heat exchangers, tested in the Vienna case (Chapter 4.1), achieved a reduction of return temperatures by up to 20 K, effectively increasing the transport capacity of existing pipelines without additional grid expansion.

Economic discussion

From an economic perspective, the analyses underline both the opportunities and the challenges. The Business Radar evaluations (Chapters 3.4 and 4) highlighted clear systemic benefits: lower return temperatures improve network efficiency, pumping costs can be reduced, and additional capacity is created in existing grids. At the same time, higher investment costs, larger space requirements, and additional complexity in system integration represent barriers that must be addressed. Payback periods of between 5 and 10 years are achievable, particularly where inexpensive driving heat or industrial waste heat is available. In terms of climate impact, reductions of up to 200 kg CO_2 per MWh are possible when fossil-based generation is substituted[55][56].

These results also translate into viable business models. Waste-heat-to-heat concepts allow utilities to purchase surplus industrial heat and feed it into their networks via AHPs, turning an unused by-product into a marketable commodity. Cooling-as-a-Service models, based on ACs, open new opportunities for urban developers and utilities to deliver cooling flexibly while reducing electricity demand. Dual-use configurations, where the same machine provides heat in winter and cooling in summer, are particularly relevant for dense urban quarters with strongly seasonal energy needs. Finally, the use of AHXs offers utilities the possibility of extending their networks without costly or disruptive grid reinforcement – an option of particular importance in historic city centres.

Replication potential

The replication potential of these solutions has been confirmed across different contexts. AHXs are especially valuable in network sections with high return temperatures or bottlenecks, ACs can be replicated in urban district cooling systems where continuous surplus heat is available, and AHPs offer broad opportunities for the utilisation of industrial waste heat, especially in combination with biomass and geothermal systems. Lessons learned from the project underline that technical design must focus on compactness and minimised pressure losses, while from an economic perspective supportive policies such as investment subsidies and CO_2 pricing are critical to improving profitability, that's also mentioned in Lund et al., 2022[57]. On the organisational side, the introduction of these technologies requires early coordination with operators and manufacturers as well as targeted training for plant personnel.

Exploitation pathways and further activities

The exploitation pathways are equally clear. The project has produced factsheets, guidelines and transferable assessment methods such as the Business Radar that can support planners, utilities and decision-makers in adopting absorption technologies. The pathway towards broad deployment is expected to follow a stepwise process: pilot installations will build operational experience, demonstration projects will validate performance at larger scales, and subsequent commercial rollouts will enable a wider market penetration. For this to succeed, supportive policy frameworks are required. Instruments

---

[55] IEA-DHC (2021): *State-of-the-Art Report on Absorption Heat Pumps for District Heating*. International Energy Agency.

[56] Barker, T., et al. (2022): *Hybrid Thermal Energy Storage in Urban District Systems*. Energy Reports.

[57] Lund, H., et al. (2022): *4th Generation District Heating: Implementing Advanced Low-Temperature Networks*. Renewable Energy.

such as **Carbon Contracts for Difference**, investment grants for waste heat integration, and clear regulatory frameworks for waste heat injection into district heating systems can significantly accelerate uptake.

Looking ahead, several fields of action emerge. On the **technological side**, further development should focus on compact and modular machine designs, improved thermal insulation and optimised hydraulic integration. Advanced control strategies such as Model Predictive Control (MPC), already explored in Chapter 3.2, hold promise for operating absorption units flexibly in combination with other heat sources, storage systems and electricity markets. Hybrid solutions that combine absorption technologies with high-temperature heat pumps, thermal storage or solar thermal generation represent an important step towards integrated, resilient urban energy systems.

From a **policy perspective**, the integration of industrial waste heat into national and regional heating plans is a pruiority. This aligns with European strategies such as the **Green Deal**, the **Fit-for-55 package** and the **REPowerEU plan**[58], all of which explicitly call for the systematic use of renewable and waste heat sources. Harmonisation of technical standards for absorption technologies within district heating networks would further ease market entry.

In terms of **research and development**, long-term demonstration projects at Technology Readiness Levels (TRL) 6–7 are needed to validate the performance and reliability of absorption-based solutions under real operating conditions. Open-source simulation libraries (e.g. Modelica, TRNSYS) should be further developed to become standardised planning tools for engineers and utilities. Finally, linking absorption-based solutions with energy markets could unlock new value streams: for example, operating absorption chillers or heat pumps not only as heat providers but also as flexibility assets that support electricity grid stability.

In conclusion, absorption technologies are not a one-size-fits-all solution, but they can create substantial added value in specific contexts. Absorption heat pumps are particularly effective for waste heat recovery, absorption chillers reduce electricity peaks in urban cooling systems, and absorption heat exchangers provide a cost-effective way to expand network capacities. Together, these technologies can help deliver on Austria’s **Mission2030** targets and support the EU’s strategic ambitions under the **REPowerEU** and **Green Deal** frameworks. With targeted policy support, further pilot and demonstration projects, and closer collaboration between utilities, industry and research, absorption technologies can move from niche applications to becoming a cornerstone of sustainable district heating and cooling in Europe.

---

[58] European Commission (2022): *REPowerEU Plan*. Brussels.

6 List of Figures and Tables

6.1 List of Figures

6.2 List of Tables

7 Appendix

7.1 Factsheets

7.1.1 Anwendung von Absorptionswärmepumpen zur Nutzung der Abwärme aus dem Sekundärkühlwasser (extra sheet)

7.1.2 Anwendung von Absorptionskälteanlagen für Kältenetze (extra sheet)

7.1.3 Anwendung eines Absorptionswärmetauschers im Fernwärmenetz (extra sheet)

7.1.4 Anwendung von Absorptionswärmepumpen zur Rauchgaskondensation in Biomasse-Nahwärmenetzen (extra sheet)

7.2 Best-practice Guide Absorptionstechnologien für Fernwärme und -kälte (extra sheet)

8 Contact details

Project manager
Carina Seidnitzer-Gallien
c.seidnitzer-gallien@aee.at,
Phone: +43 3112 5886 266
https://greenenergylab.at/projects/absolut/?lang=en

Institute
AEE – Institute for Sustainable Technologies (AEE INTEC)
Feldgasse 19, 8200 Gleisdorf, Austria
Phone: +43 3112 5886 0
www.aee-intec.at

Project partners (in alphabetic order)
Equans Energie GmbH
Linz Strom Gas Wärme GmbH
StepsAhead
Wien Energie GmbH