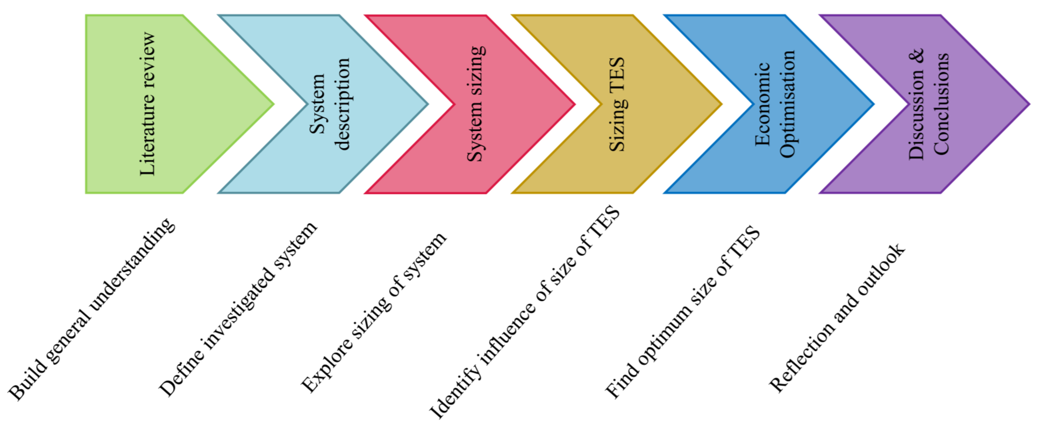
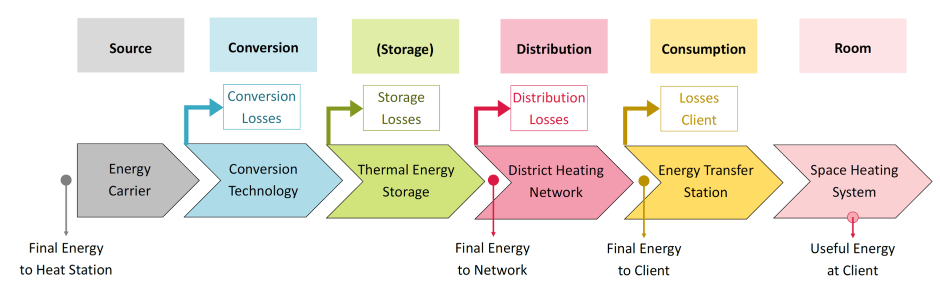
HSLU Hochschule Luzern

Technik & Architektur
Master of Science in Engineering
Energy & Environment

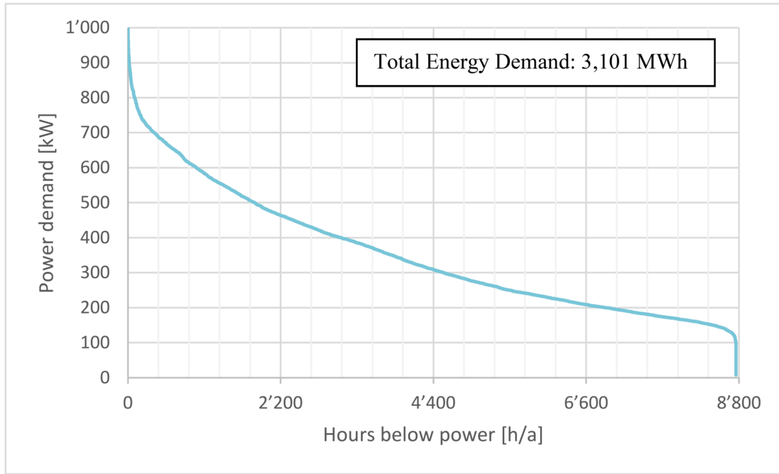
Decarbonisation of District Heating by Thermal Energy Storage



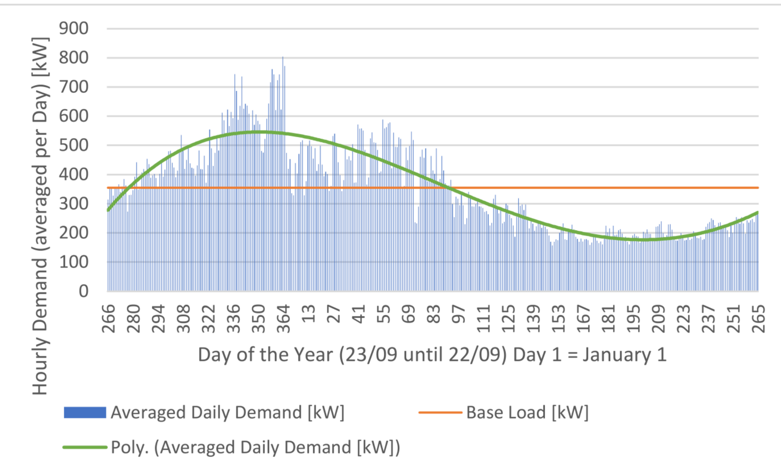
Methodological approach



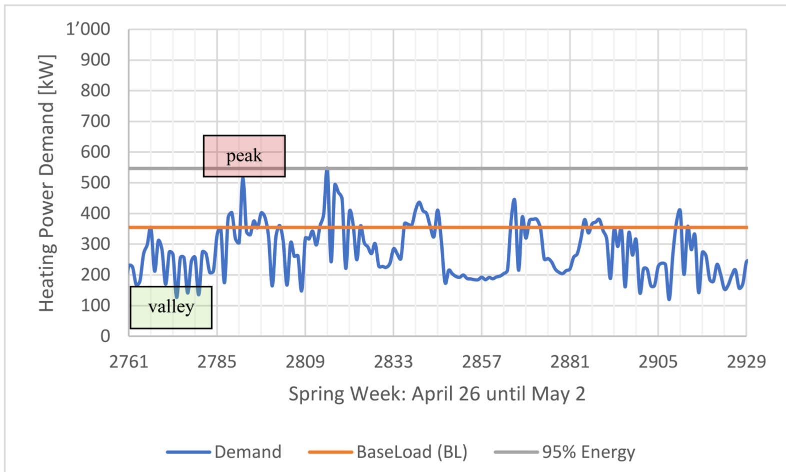
System categorisation and occurring losses



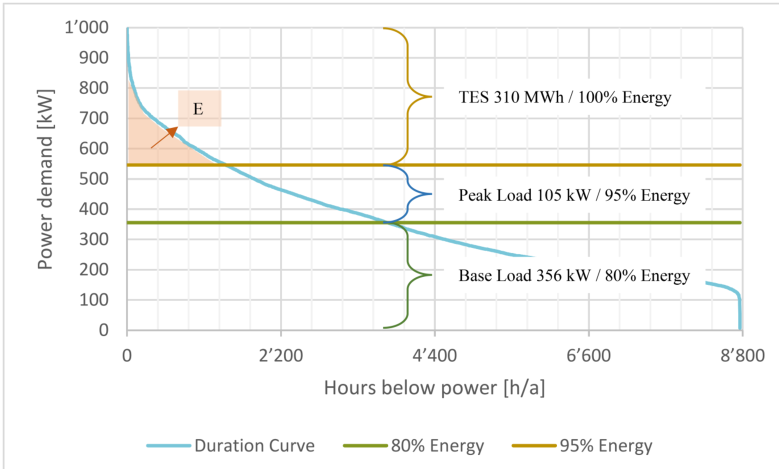
Duration curve of use case



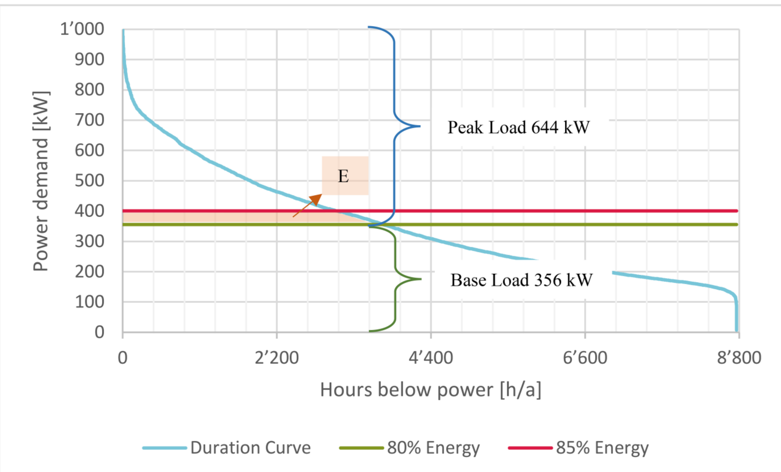
Daily average demand and base load



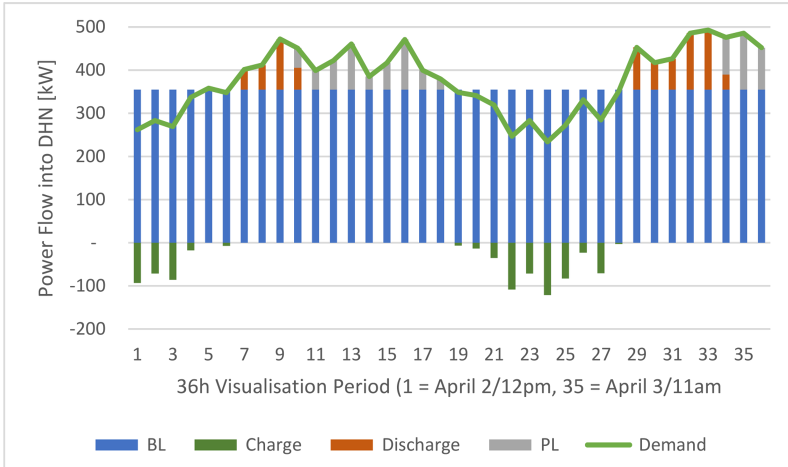
Valleys and subsequent peaks in spring



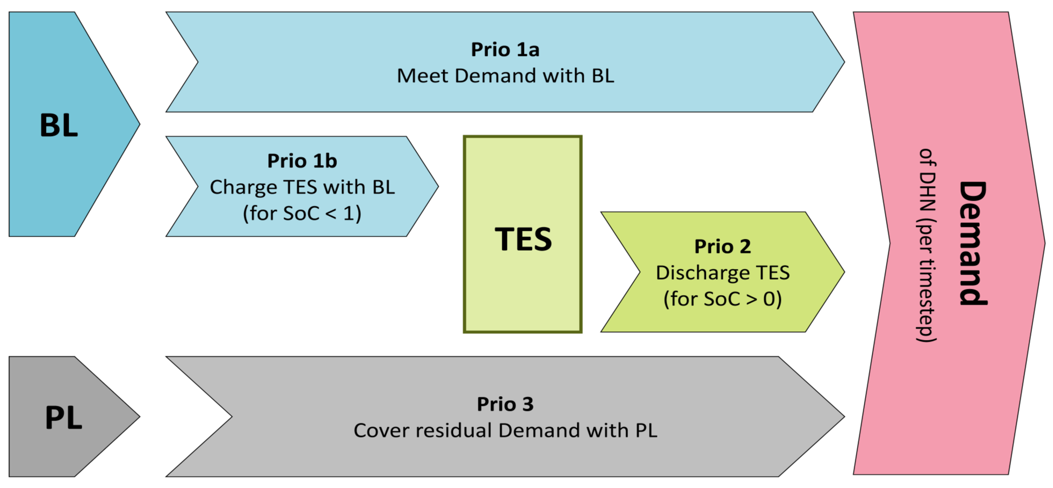
Approach peak shaving reducing peak load



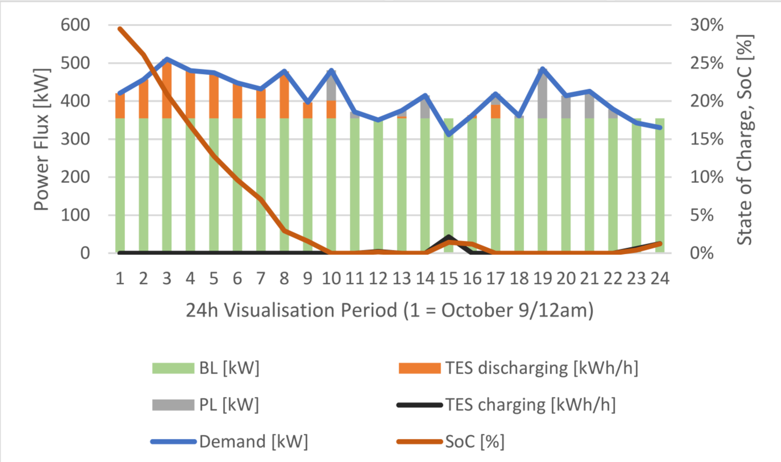
Approach load shifting reducing size of TES



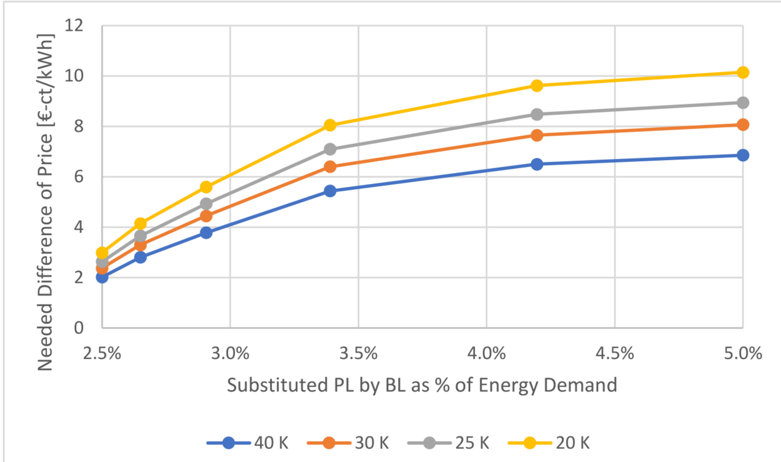
Valleys and peaks used in thermal storage



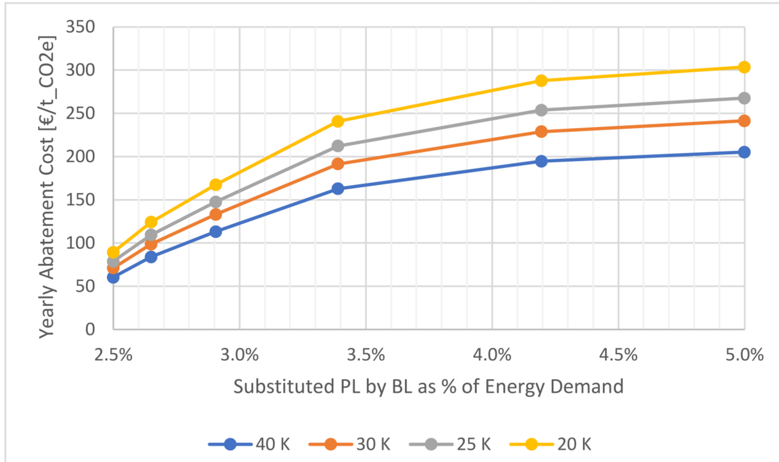
Fixed order control of energy coverage



Energy coverage by BL, PL, and TES



Economic analysis and price difference



Carbon analysis and abatement cost needed

Challenge

It is an inconvenient truth that society faces the general challenge of decarbonisation. Specifically concerning district heating systems, Hangartner and Hurni have revealed that the majority of consumers still rely on fossil-fuelled peak load coverage. Ködel and Hangartner further-more showed that many existing district heating systems are soon to be refurbished, and suitable strategies to decarbonise heating energy demand are needed. This offers the opportunity to integrate thermal energy storage to serve as a substitute for fossil fuels.

Research Question

This work strives to present ways to decarbonise district heating networks (DHN) by substituting carbon intensive peak load with more eco-friendly base load by means of the integration of thermal energy storage (TES).
Thus, the primary research questions are:
How can TES help decarbonise DHN?
Which strategy allows moderate size?

Approach

Based on a given energy demand dataset, a power split is used to investigate different sizes of TES integration. For two different approaches (peak shaving and load shifting, see figures), the sizing is scrutinised. Furthermore, for the more promising load shifting approach, economic and carbon analysis are carried out to analyse main drivers for change.

Results

Making use of an energy balance model accounting for state of charge and following a fixed order control, the effect of different sizes was defined. The comparison between the chosen peak shaving and load shifting is provided below. It is apparent that the higher the shifted energy demand, the lower the difference between shaving and shifting becomes. At the same time, shifting as little as 3%, carbon emissions drop by 6 to 10%.

Substituted Energy Demand	**2.5%**	**2.6%**	**2.9%**	**3.4%**	**4.2%**	**5.0%**
Substituted Carbon (CH/UK)	5.5% / 8.2%	5.9% / 8.7%	6.4% / 10%	7.5% / 11%	9.3% / 14%	11% / 16%
Shaving Capacity [MWh]	772	822	901	1'051	1'301	1'551
Shifting Capacity [MWh]	25	50	100	250	500	750
Sizing: Shaving to Shifting [-]	**31**	**16**	**9.0**	**4.2**	**2.6**	**2.1**

Outlook

Further work may include: (i) Improvement of the analysis of the "oscillating" period. Hypothesis: There is a more favourable power split for TES integration than 80%/20%. (ii) Application of the methodology in a case study. Hypothesis: The confrontation with a real-world problem takes this concept study to the next level. (iii) Varying the technology options. Hypothesis: More technology options will reveal opportunities for DHN.

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