Transformation Scenarios for High Temperature District Heating Networks with Different Levels of Retrofitted Building Stock: Potential and System Performance Analysis

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Motivation

To attain climate neutrality , it is imperative to decarbonise the heating sector which represents about one third of the final energy demands. One of the recognized strategies for decarbonisation of the heating sector is the reduction of building energy demands. In the case of a neighbourhood with reduced energy demands it makes an interesting case to investigate if the existing high temperature district heating network (HTDN) can be operated as a low temperature district heating network (LTDN).

Problem statement:

Transforming an existing HTDN to a LTDN focusing on the thermal performance of the network, keeping the hydraulic parameters of the pre existing network unaltered. Further investigating the possibility of replacing the combined heat and power plant (CHP) by a centralised heat pump and estimating the emission performance of the system.

Methodology

The methodology followed in this study has been shown in fig 1.

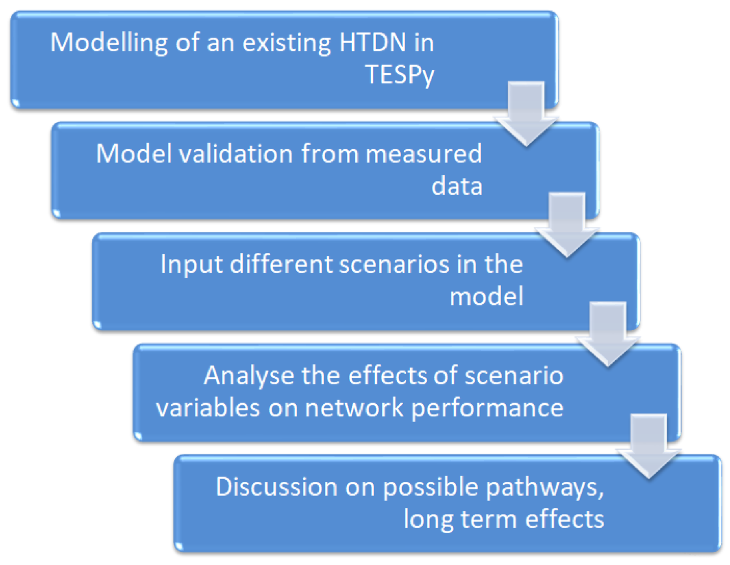

Fig 1: Overview of the methodology

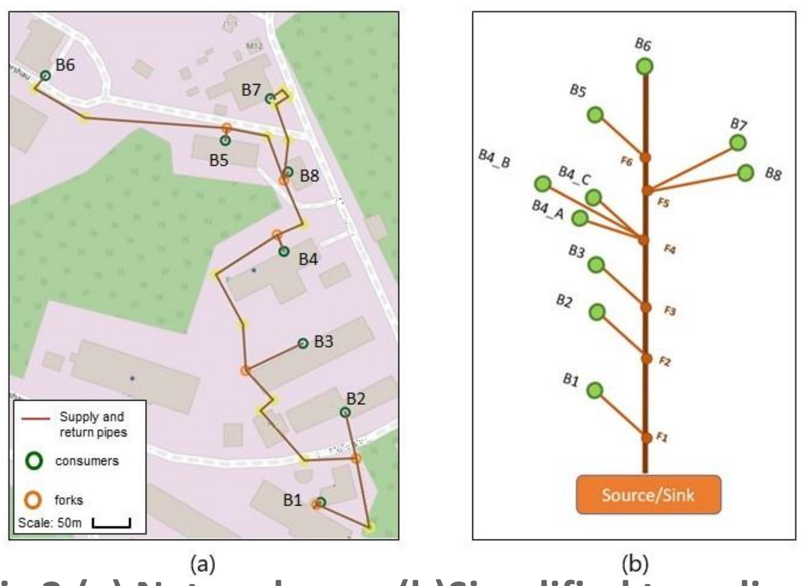

Fig 2:(a) Network map (b)Simplified tree diagram

Modelling of an existing district heating network (DHN)

TESPy (Thermal Engineering Systems in Python), a python based tool was used to develop steady state model of the DH system in hand. The physical characteristics of the network and mass flow were used as input variables to evaluate the thermal parameters of the system.

Results

Development and Validation of Existing Network Model

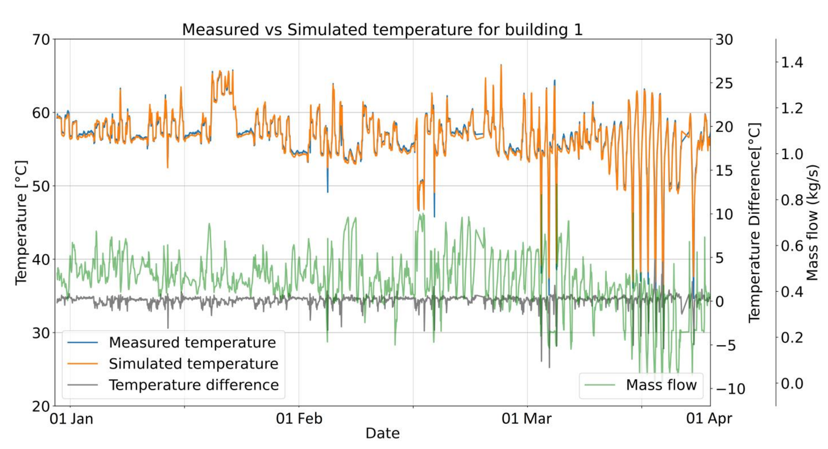

Fig 3: Measured and simulated supply temperatures for building 1

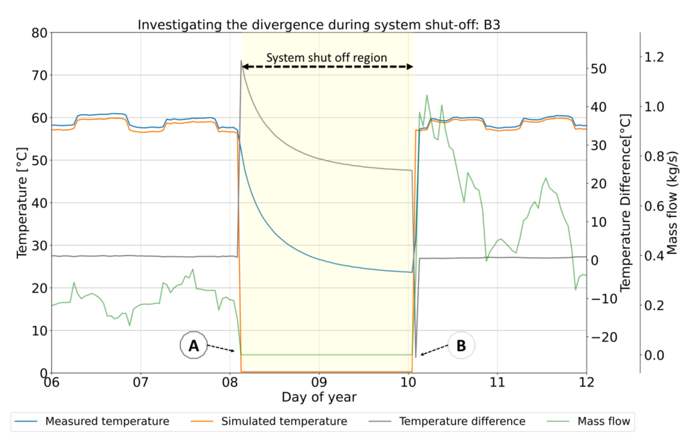

Fig 4: Investigating model divergence during system shutoff.

With the help of physical parameters available, a model of the entire network was developed. The flow temperatures at respective buildings were used as reference to validate the results from the model. It was seen that the model failed to converge when mass flow was zero. To eliminate this, pre-processing of data was done.

Scenario 1: Keeping the supply source (CHP)

In this scenario, the HTDN was supplied with a constant temperature of 45 °C from the source keeping the mass flow unchanged.
The network performance is shown in fig 5(a) & 5(b).

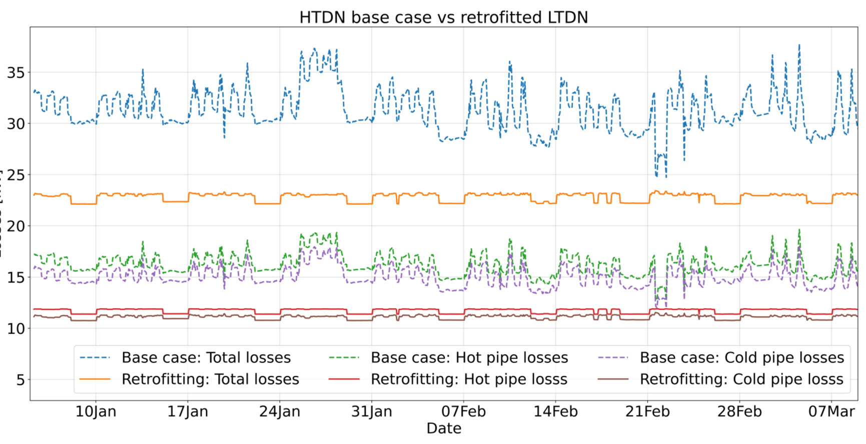

Fig 5(a): Comparison of losses

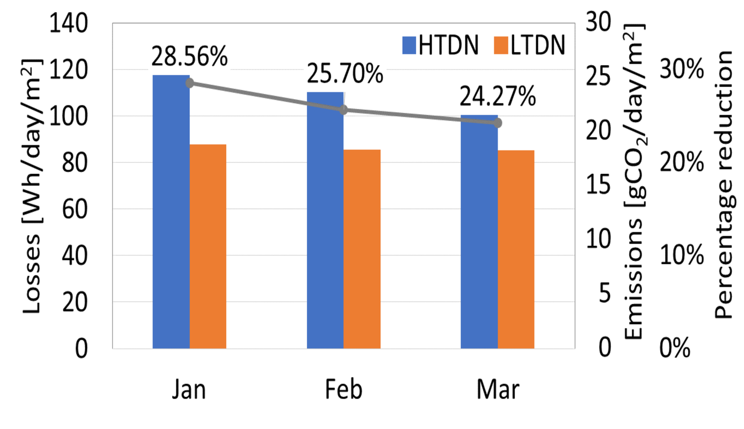

Fig 5(b): Network performance over Q1 22

Scenario 2: Changing Supply Source to heat pump

In this scenario, the CHP was replaced by an air sourced heat pump using HPLib (heat pump library). The COP values of heat pump were used to calculate corresponding electrical power input. The system performance and reduction in losses is shown in fig 6 (a) and 6 (b).

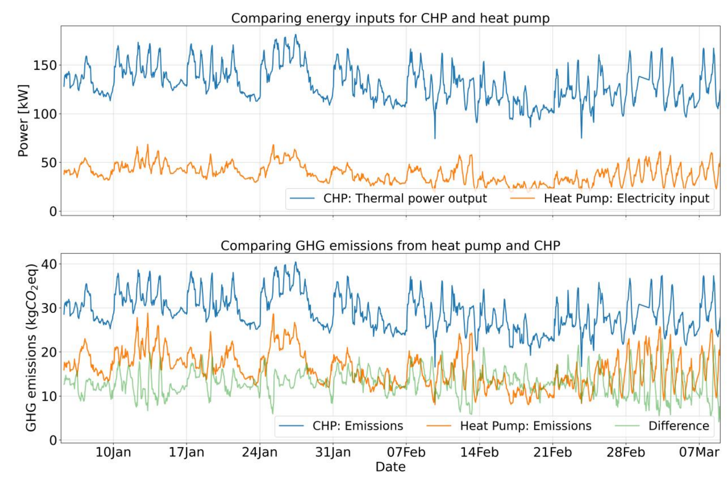

Fig 6(a): Comparison of CHP vs heat pump

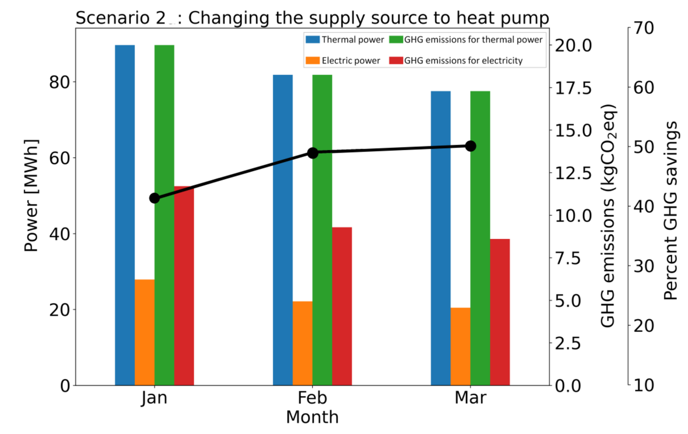

Fig 6(b): Network performance over Q1 22

Scenario 3: Emulating Pulsating Behavior

In this scenario, the network was operated at its measured maximum mass flow. With this, network was operated in a pulsed manned keeping the total demands unaffected.

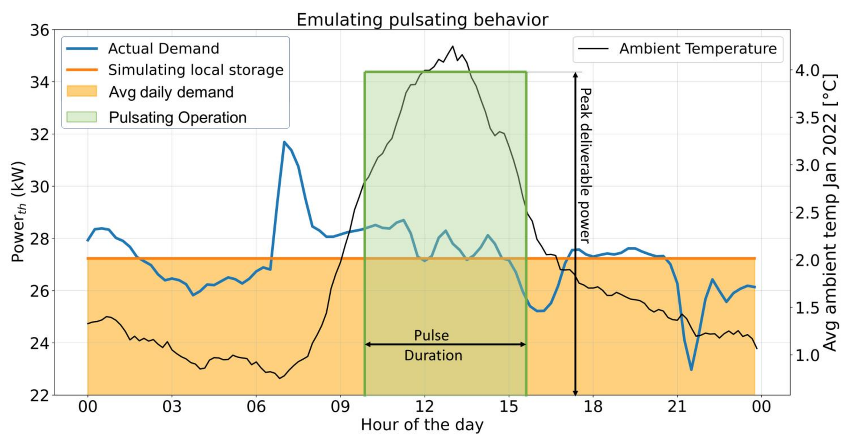

Fig 7(a): Pulsating operation for a given day

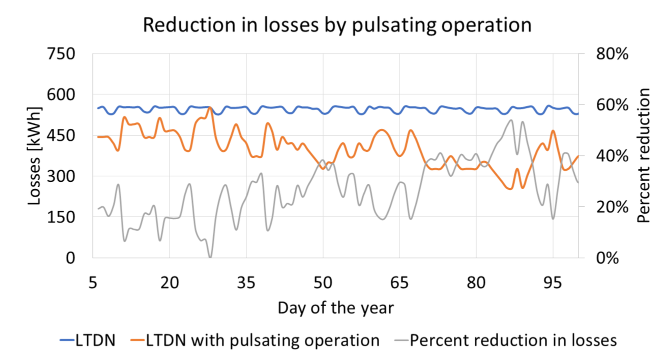

Fig 7(b): Network performance after pulsating operation

Summarising the main findings in this study:

The network performance has been summarised in fig 8(a) and 8(b).

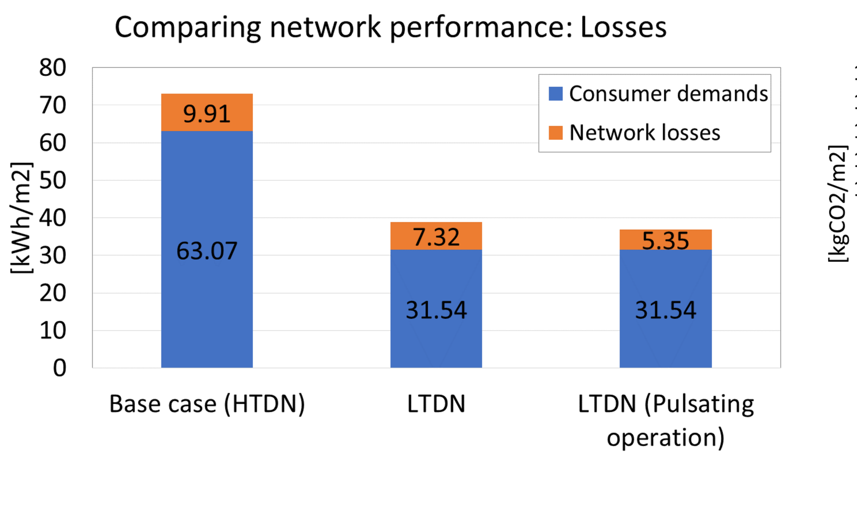

Fig 8(a): Network performance considering transmission losses in different scenarios

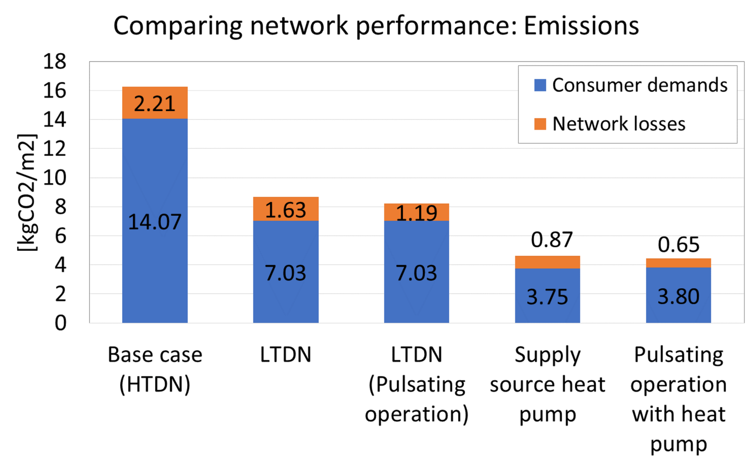

Fig 8(b): Network performance considering CO_2 emissions in different scenarios

Conclusions

This study shows that it is possible to transform an existing HTDN to an LTDN. Operating the network at lower temperatures leads to reduction in losses and in-turn the emissions associated with space heating.

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