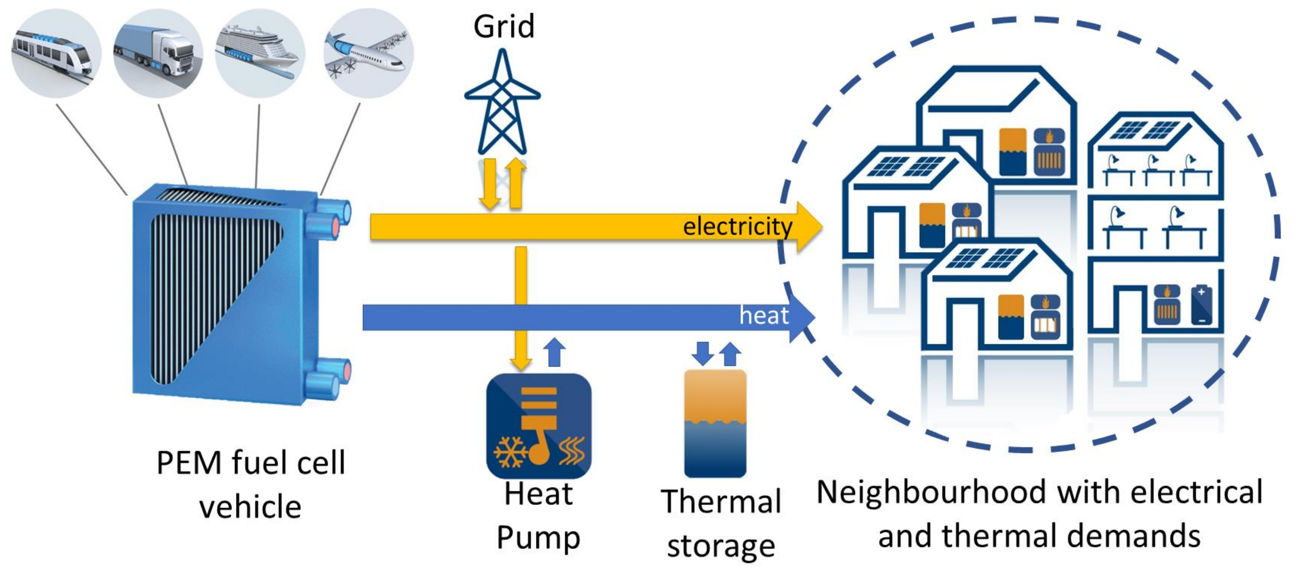
Simulative Evaluation Of High Temperature Versus Low Temperature Heating Networks To Utilise Waste Heat From Large Fuel Cells For Powering Districts

Nachiket Gaikwad[1]* , Nies Reininghaus[1], Carlos Muñoz[1], Michael Kroener[1], Martin Vehse[1], Alexander Dyck[1]

[1]Deutsches Zentrum für Luft- und Raumfahrt e.V. (German Aerospace Center, DLR), Institute of Networked Energy Systems Oldenburg
*nachiket.gaikwad@dlr.de

Motivation

Fuel cells for combined heat and power: Fuel cells generate heat as byproduct which can be used for space heating. In heavy duty fuel cells, this waste heat can potentially be used for district heating during times of low renewable generation and high demand.

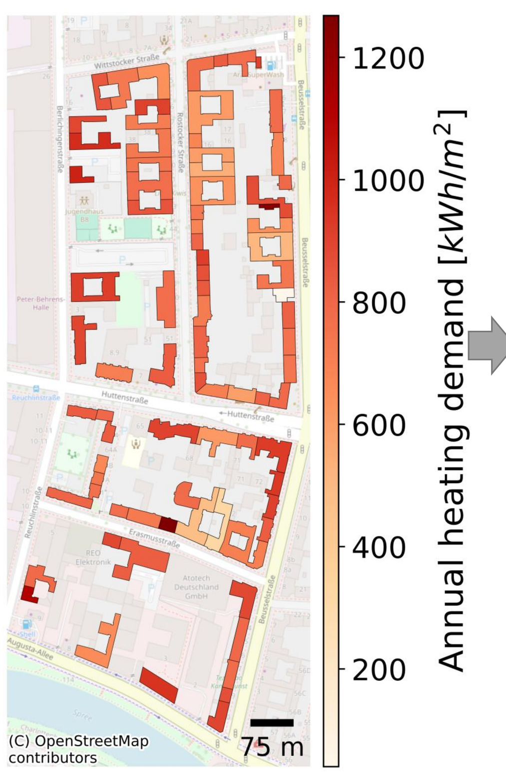


Sectorcoupling heavy duty mobility with neighbourhoods for electricity and heat.

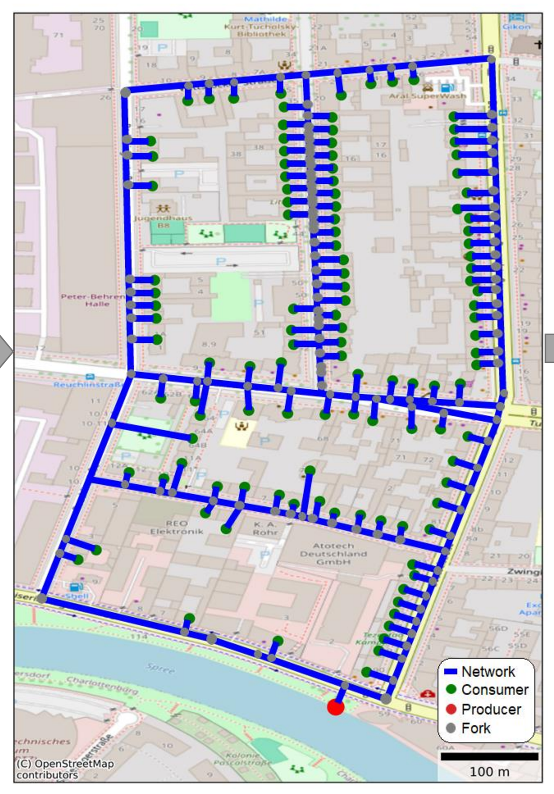
Research questions addressed

1. Can a high power heavy duty fuel cell supply electricity and heat to a district/neighbourhood?
2. How does the dispatch during peak winter demand days look?
3. How does high temperature district heating (HTDH, 80 °C) compare with low temperature district heating (LTDH, 45 °C)?

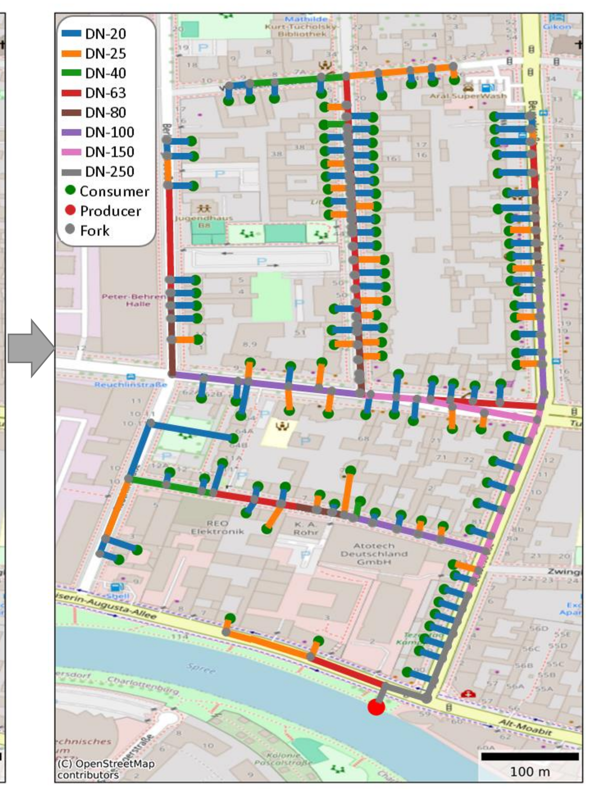
Methods



Heating demands of a sample district in Berlin.

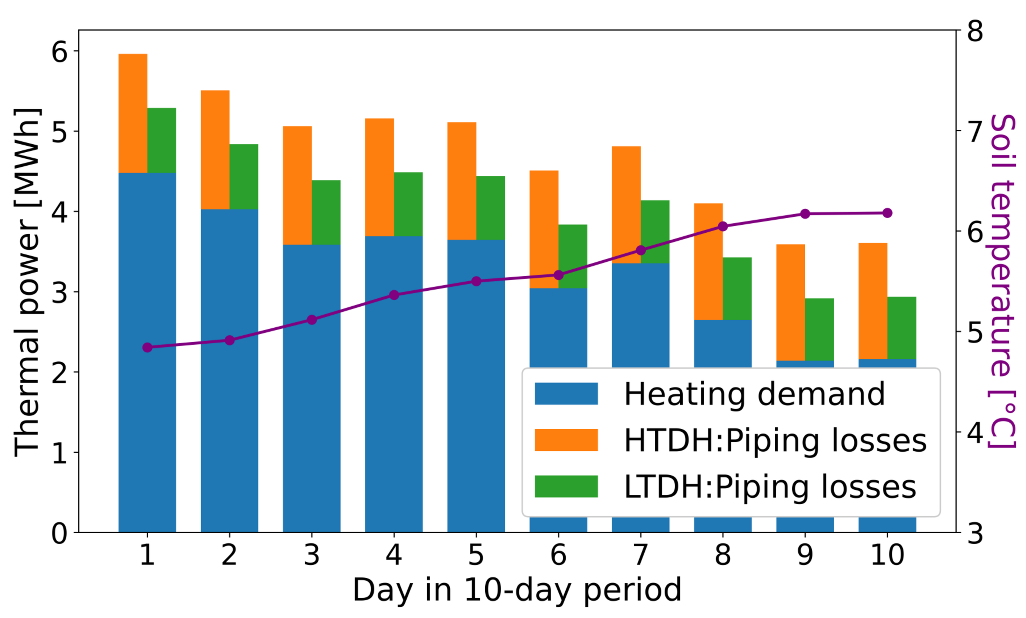


Initial model of the district heating network.



Optimised piping for district heating network using DHNx.

Virtual district heating network: Optimised heating network to supply consumers with minimum piping investment.



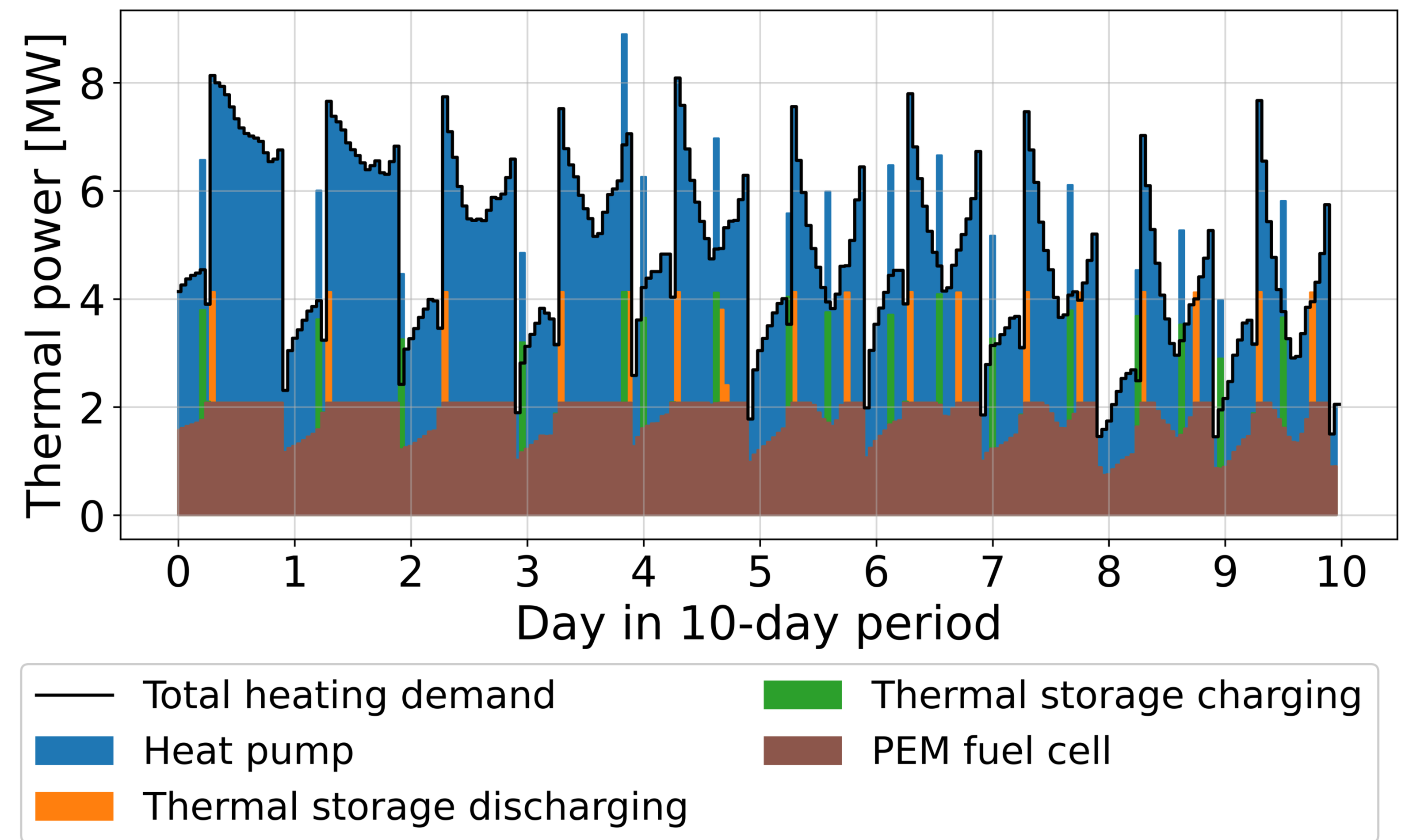
Network losses for HTDH and LTDH

10-day peak-winter period: Period when the neighbourhood has maximum heating demands.

Network simulation: Equivalent pipe method which reduces complex network to a simplified two-pipe system.

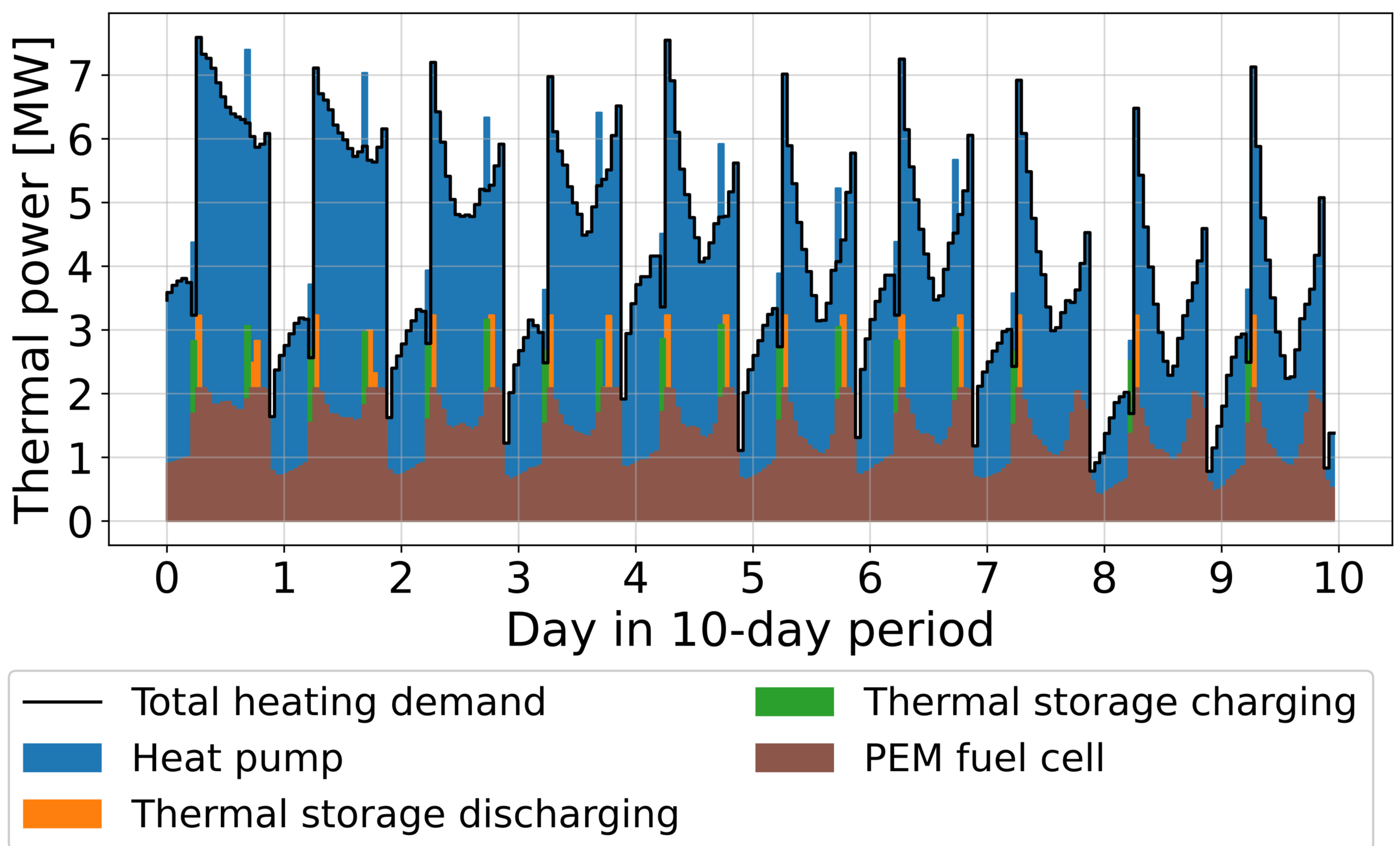
Energy system modelling: Mathematical model of the system was created using MTRESS and solved for dispatch during peak winter period.

Results



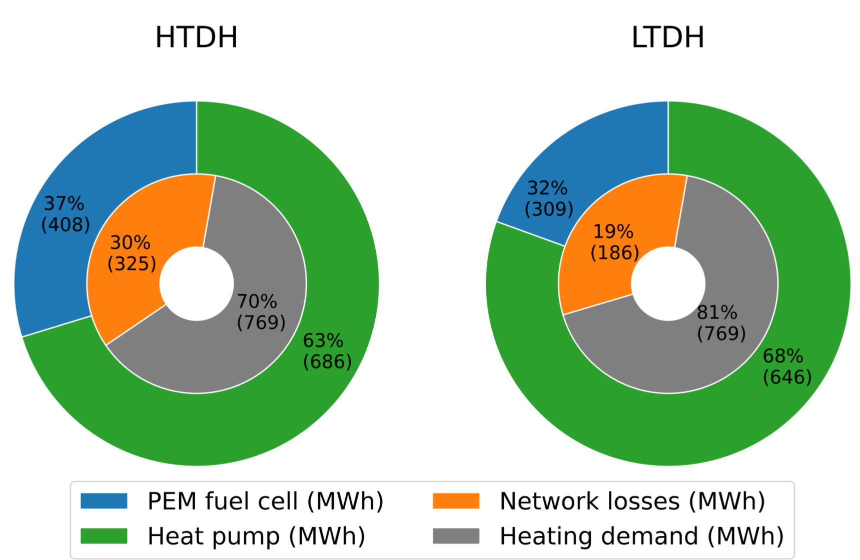
High temperature district heating (HTDH) thermal power dispatch during 10-day period.

HTDH (80 °C) thermal energy dispatch: Fuel cell thermal output is limited, the surplus is obtained from heat pump and storages. Storage discharges immediately to reduce losses to ambient. Storage capacity is 22 m³ of hot water for the whole district.



Low temperature district heating (HTDH) thermal power dispatch during 10-day period.

LTDH (45 °C) thermal energy dispatch: Fuel cell total energy demand is significantly less due to lower losses. Thermal storages shave off peak load from heat pump, which can reduce its sizing.



Summarised thermal power dispatch.

Electricity	LTDH vs. HTDH
Fuel cell	-22%
Heat pump	-94%
Grid import	-53%

Summarised electrical power comparison.

Conclusions

- Heavy duty fuel cell vehicles have a promising potential to substitute traditional combined heat and power units and provide additional flexibility through mobile applications.
- LTDH outperform HTDH in terms of lower losses and allowing better coefficient of performance for heat pumps.

Acknowledgments

The authors thank all colleagues of the DLR project PEMScale1.5 where this work took place.

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