TECHNISCHE UNIVERSITÄT WIEN

Energy Economics Group

Demystifying natural gas distribution grid decommissioning

IAEE Online Conference - ENERGY, COVID, AND CLIMATE CHANGE

Sebastian Zwickl-Bernhard

09.06.2021

Todays‘ agenda

- Motivation and background
- Core objective and novelties
- Methodology and open-source modeling approach
- Results
- Conclusions and outlook

Limited expectations for „green“ gas

- Gradual or complete substitution of fossil gas is a myopic approach
  - Current needs 8 billion m^3/yr in Austria
  - Independent of technically available Austrian potentials (Biomethan: 4 billion m^3/yr and hydrogen 2 billion m^3/yr)
  - Theoretically, biomethan could cocer half of the demand in the next 20 years

- Difficult that the quantities of green gas needed for all energy services will be economically available
  - Increase of the demand expected in case of profitable hydrogen production in different sectors (e.g., heavy industry, freight transportation/mobility)

- Further niche applications of hydrogen due to sector coupling and specific industry processes

Scope of this work

- Demystifying the unique/dominant position of natural gas in the provision of heat services
- Decommissioning of the existing gas distribution grid infrastructure
- Trigger emerging sustainable and high-efficient energy supply alternatives
- No continue repowering of conventional energy technologies
- No maintance of know-business models
- Costs of inaction (e.g., penalties for failing to meet climate targets)

Gasless neighborhoods in Zürich and Utrecht

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The great Dutch gas transition

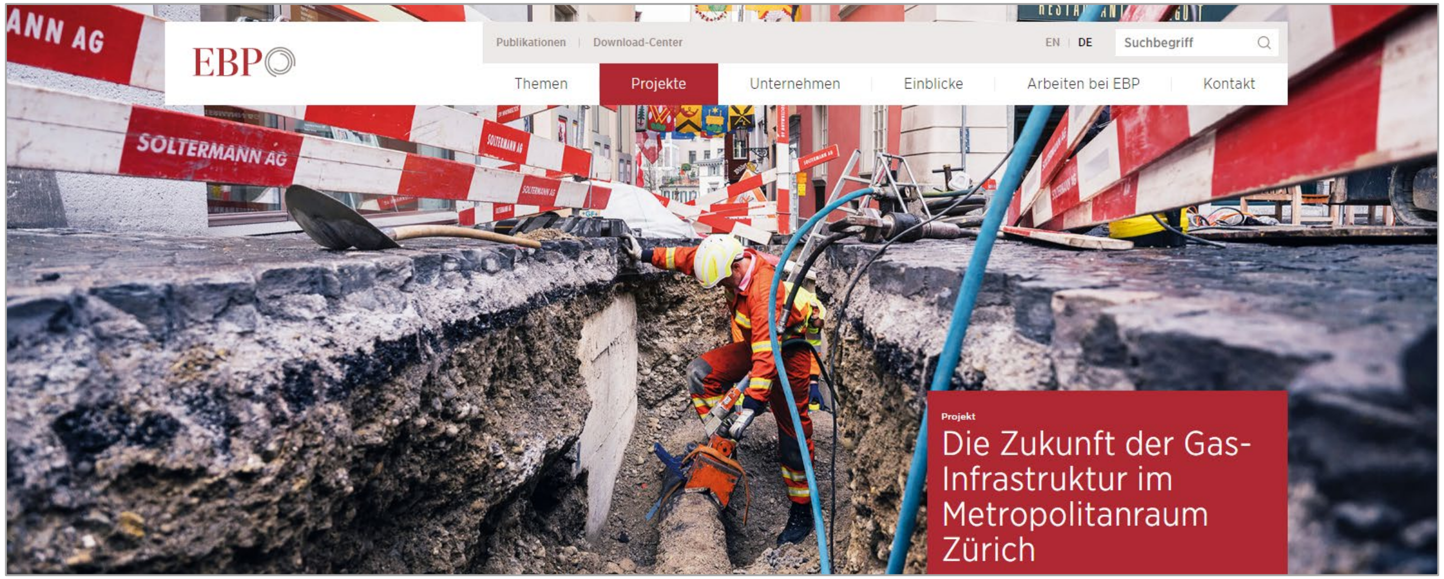
The OIES Natural Gas Programme has produced a significant amount of research over the past three years on the issue of the decarbonisation of the gas sector in Europe. This paper examines the strategy of the Netherlands, which relies more on natural gas than any other country in the EU, and which has embarked on an energy transition intended to lead to a complete phase-out of unabated natural gas consumption and production by 2050. However, despite the political consensus on climate policy goals, and the speedy realisation of a Climate Accord, there is still a great deal of uncertainty as to what shape the energy transition in the Netherlands will take and what impact it will have, especially on the future of the Dutch gas industry. This paper provides an excellent case study of the challenges, risks and costs that will be faced by the gas industry as a whole in the European Union over the next three decades.

By: Karel Beckman , Jilles van den Beukel

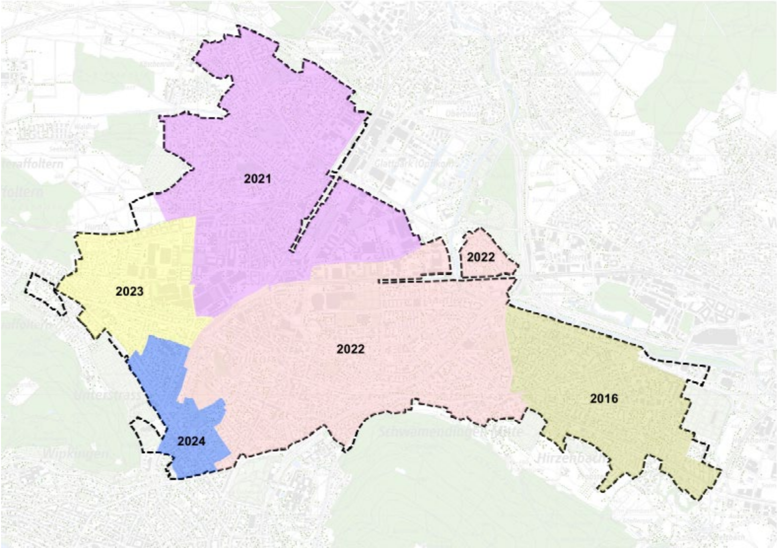
Download Publication

Categories:
Energy and the Environment , Gas , Gas Programme

Tags:
decarbonisation , Natural gas , Netherlands , transition



Gas distribution grid decommissioning in Zürich



Practical realization timeline

Zeitplan

1. Kündigung Gasanschluss durch Energie 360° — 30.6.2020
2. Antrag auf Restwertentschädigung an Energie 360° — bis 30.4.2021
3. Entfernen Gasinstallation durch konzessionierten Haustechnikbetrieb — bis 30.6.2021
4. Kontrolle Deinstallation der Geräte durch Energie 360° — bis 30.9.2021
5. Stilllegung Gasnetz durch Energie 360° — bis 31.3.2022

Remove the end-user‘s device

Submit application for remaning value compensation

Entschädigungstabelle

Remaining value compensation payments according to date of device installation

Zeitpunkt der Geräteinstallation	2002*	2003	2004	2005	2006	2007	2008	2009	2010	2011*
Entschädigung bei Netzstillegung 2021	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%

https://www.energie360.ch/de/energie-360/wissen/energieplanung/zuerichnord/

Core objective and novelties

- Decommissioning of the natural gas distribution grid and a corresponding natural gas phase-out in the heat supply of an urban neighborhood
- Alternative distribution grid capacities and sector coupling technologies are required to ensure an adequate, but sustainable development in the provision of local heat energy services (low temperature)
- Two different local deep decarbonization pathways:
  (i) High Electrification and (ii) Expansion of the district heating network
- Introduction of wide-range benefit indicators (qualitative and quantitative)
- Consideration of the increasingly important cooling demand service needs

Methodological and analytical extension

Applied Energy
Volume 282, Part A, 15 January 2021, 116166

Open-source modeling of a low-carbon urban neighborhood with high shares of local renewable generation

Sebastian Zwickl-Bernhard, Hans Auer

(c) Side by side location of *V2* (green), *UNI* (blue), *NEW* (magenta), and *STA* (yellow). Source [46]

(d) Existing distribution grid of gas (yellow), district heating (green) and electricity (red) in the urban neighborhood and its surrounding area. Source: [47]

GUSTO

enerGy commUnity SysTem mOdeling

GUSTO is a mixed-integer linear program (MILP) for energy system modeling. Thanks to the open-source energy system modeling community it is an extension of the existing open-source model (OSM) urbs[1].

Open Source ♥ | Made with Python | License GPLv3 | DOI 10.5281/zenodo.3946098

Objective and scope:

The Horizon 2020 openENTRANCE project aims at developing, using and disseminating an open, transparent and integrated modelling platform for assessing low-carbon transition pathways in Europe. openENTRANCE will analyse the new challenges of the energy transition and demonstrate the ability of the project to answer a wide range of questions linked to the energy transition by carrying out case study simulations. This model (as a merger of the two models HEROS and OSCARS) is part of case study 3, which is described as follows:

CS3: Need of flexibility – storage: Comparison of the flexibility of pumped hydro storage with batteries for future high-variability power systems caused by a large share of variable renewables. Analyses for the Iberian Peninsula and the Nordic region. Impacts on pan-European level. Key aspects covered: variability, flexibility, decentralisation

More information about the case studies of the project can be found here.

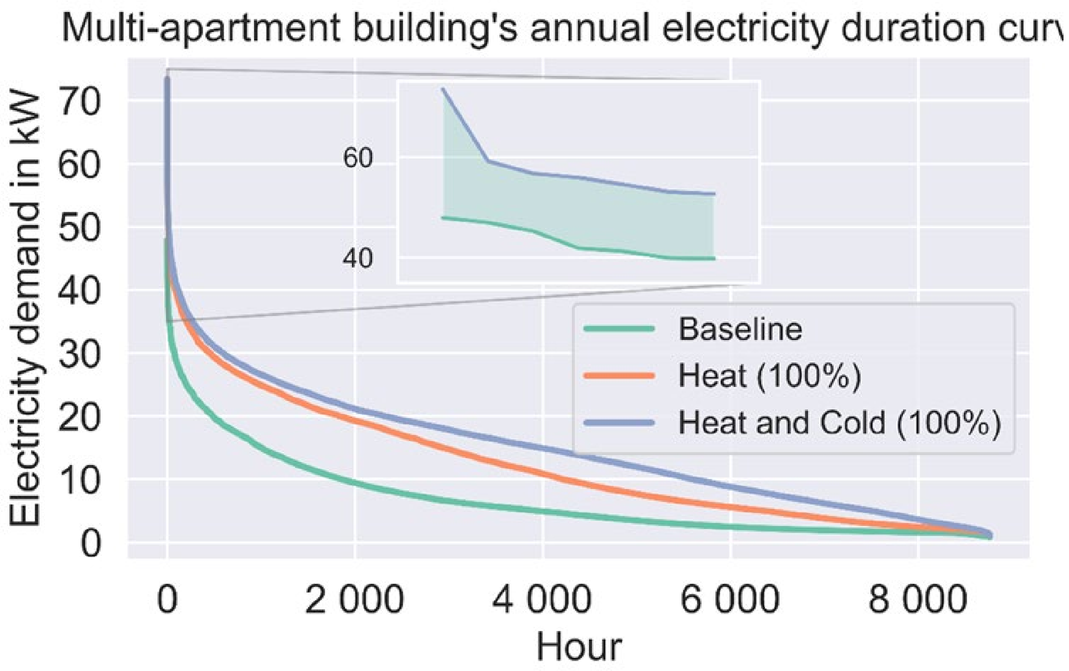
The model provides a tool for investment decisions as well as for the operational utilization of the generation units, technologies and storage units.

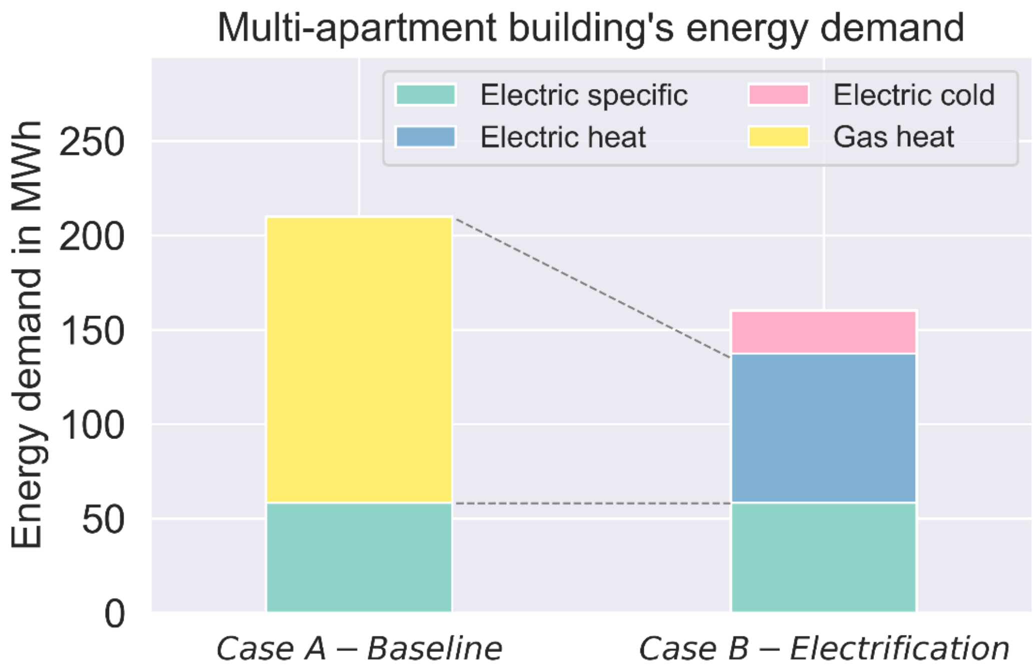
https://github.com/sebastianzwickl/GUSTO

https://doi.org/10.1016/j.apenergy.2020.116166

GUSTO enables high temporal resolution

Split existing building stock into different characteristic building types

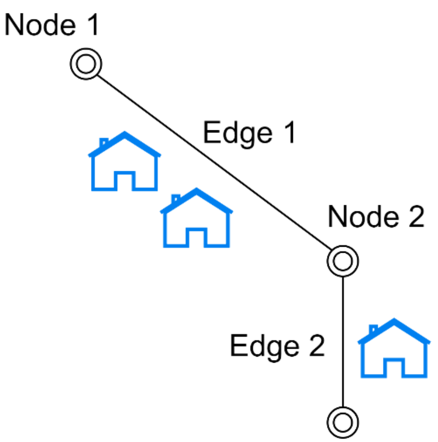


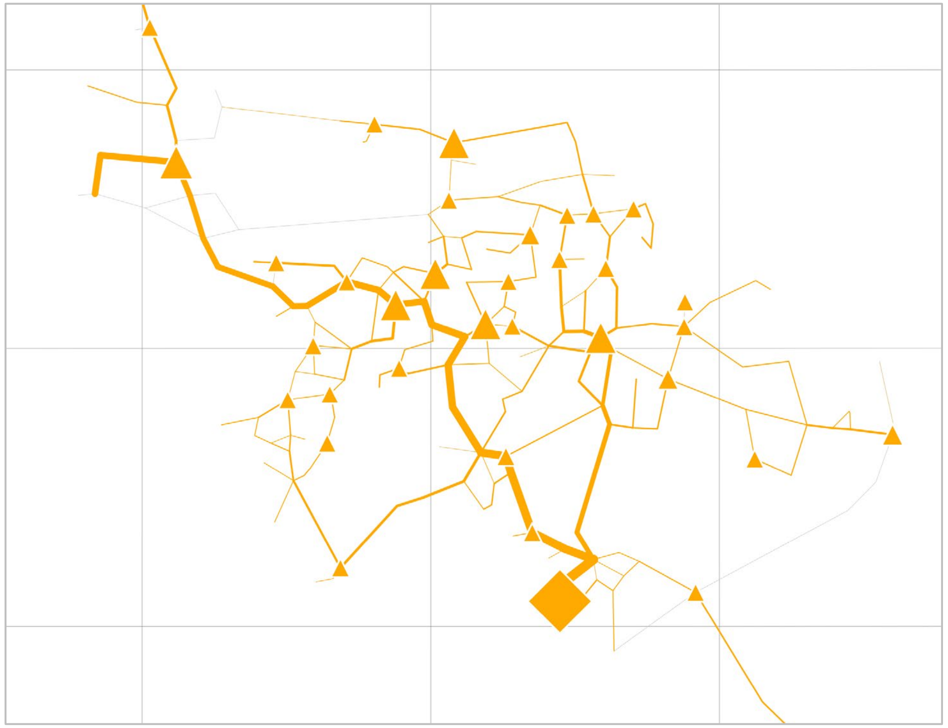


GUSTO's peak load results are inputs for *rivus*

rivus is an open-source model delevoped by Dorfner (TU Munich) available on GitHub (https://github.com/tum-ens/rivus)

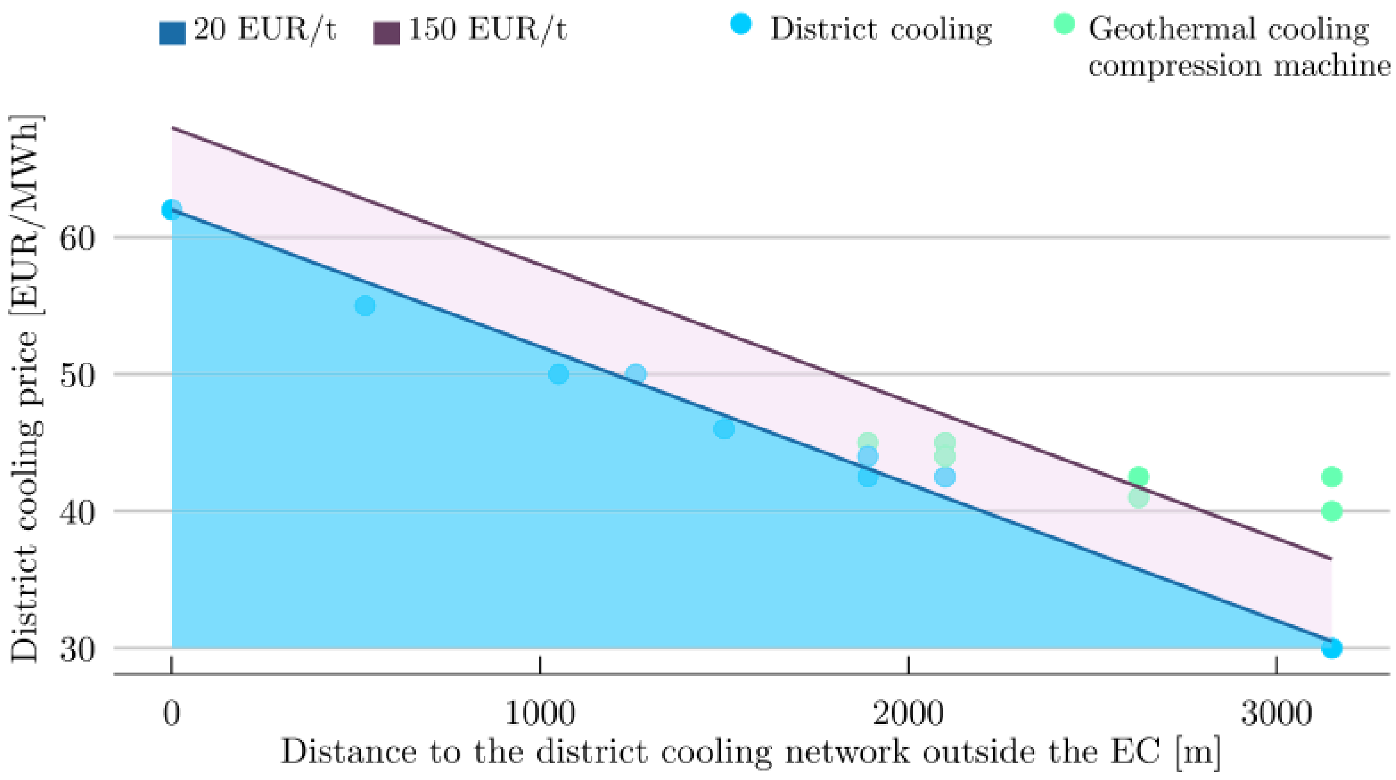
- Bases on graph theory
- Mixed-integer linear program
- Cost-minimizing multiple-energy carrier network expansion





Profitability of network-based energy supply

Consumer connection and network-based energy service provision depends significantly on the distance between consumers and existing networks

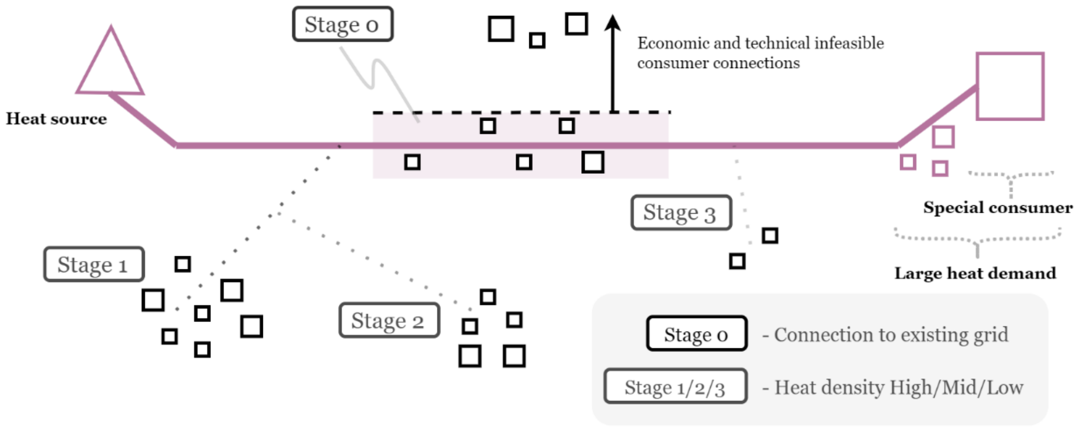


„Non-discriminatory right" to be connected

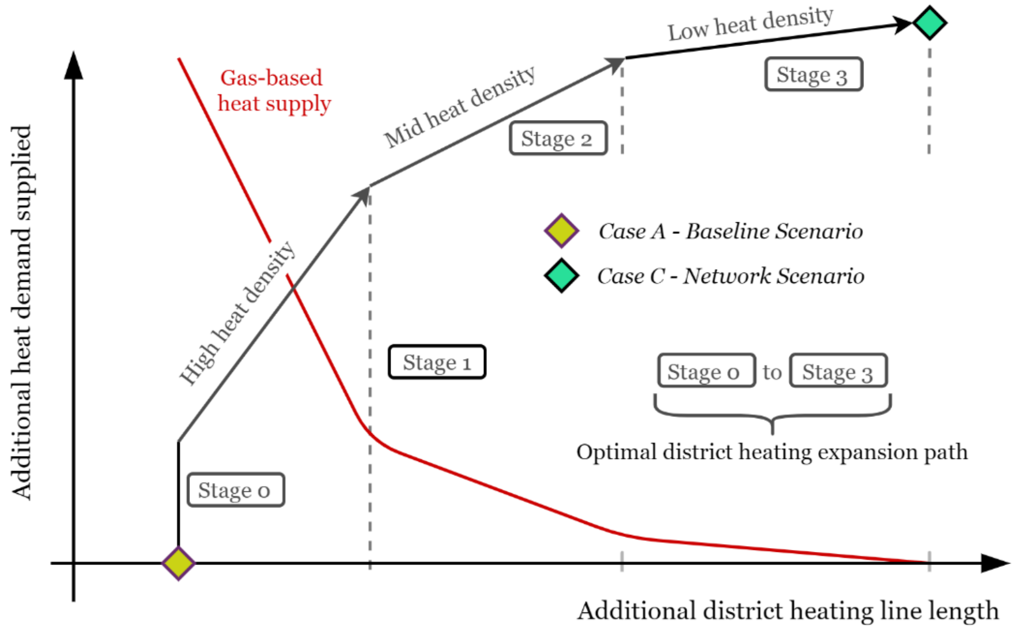
- Electricity supply: coverage and connection obligation for each consumer
- Connection costs socialized into the grid tariff and paid by all consumers

Extension: Non-linear network expansion path

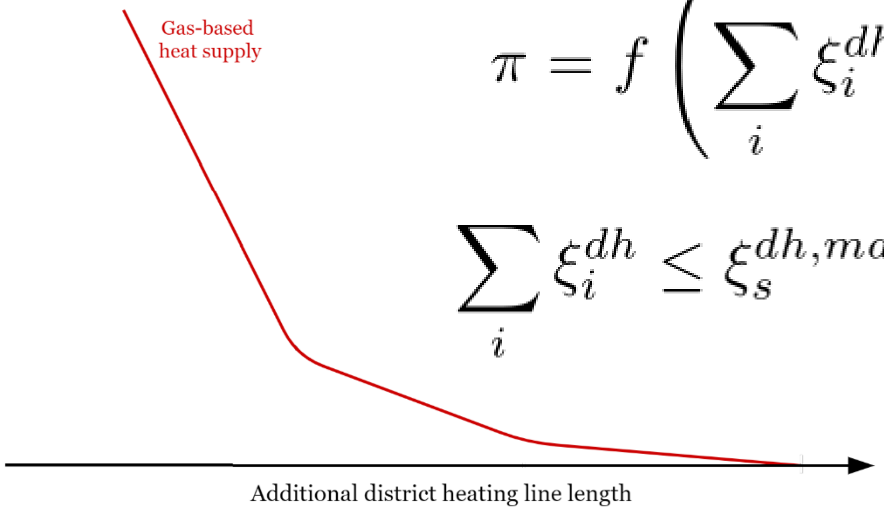
(a) District heating network expansion path depending on heat density



(b) Non-linear relation between the district heating network and gas-based heat supply



Objective function extension by penalty costs



$$\pi = f\left(\sum_i \xi_i^{dh}\right)$$

➔ Non-linear relation between district heating network and gas-based supply

$$\sum_i \xi_i^{dh} \leq \xi_s^{dh,max}$$

➔ Discrete district heating network expansion (=optimal pathway)

➔ SOS2 variables

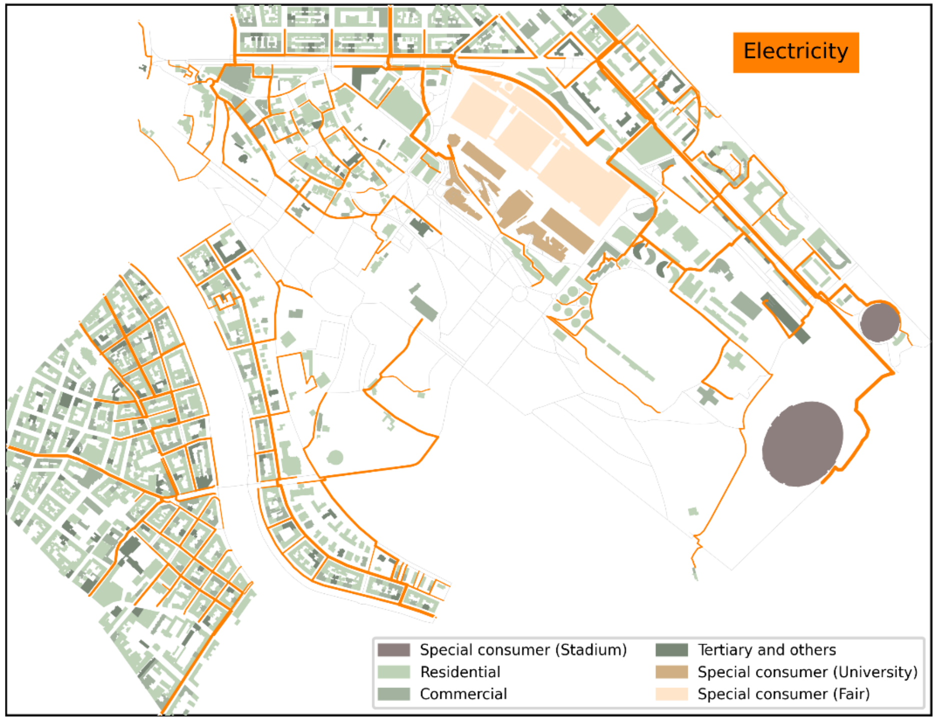
$$co\bar{s}ts = costs^{cap} + costs^{eos}$$

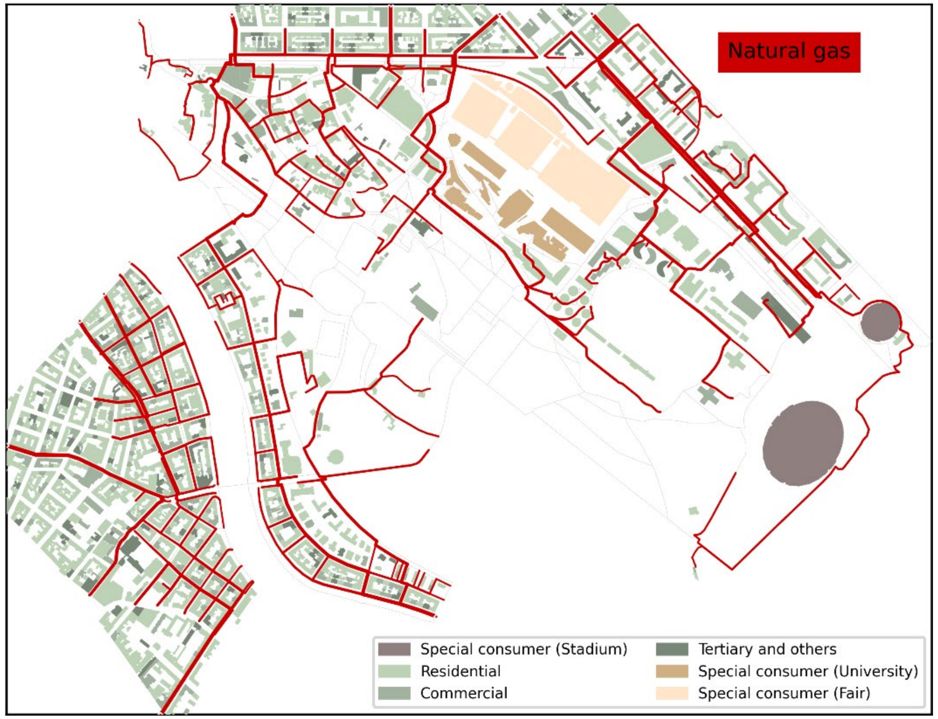
➔ Extension of the objective function by economies of scale

$$costs^{eos} = \sum_\tau \alpha_\tau \cdot \pi \cdot h \cdot r^\tau \cdot \Delta_\tau^{CO_2} \cdot p_\tau^{CO_2}$$

➔ Penalty costs for failing to meet climate targets

Result representation in the baseline scenario

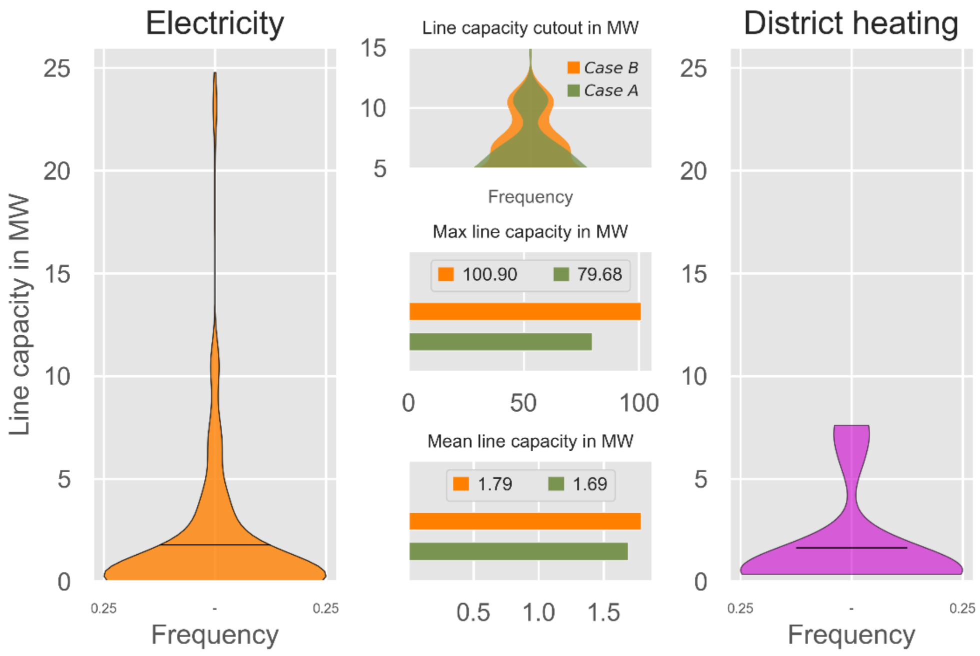




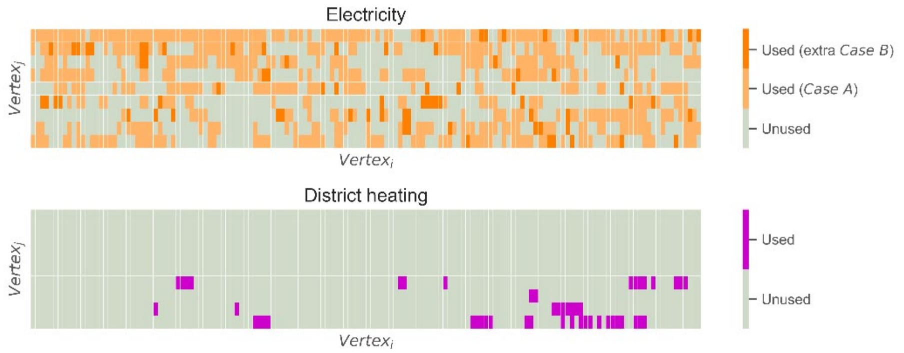
Decarbonization pathway results

Case B – High Electrification

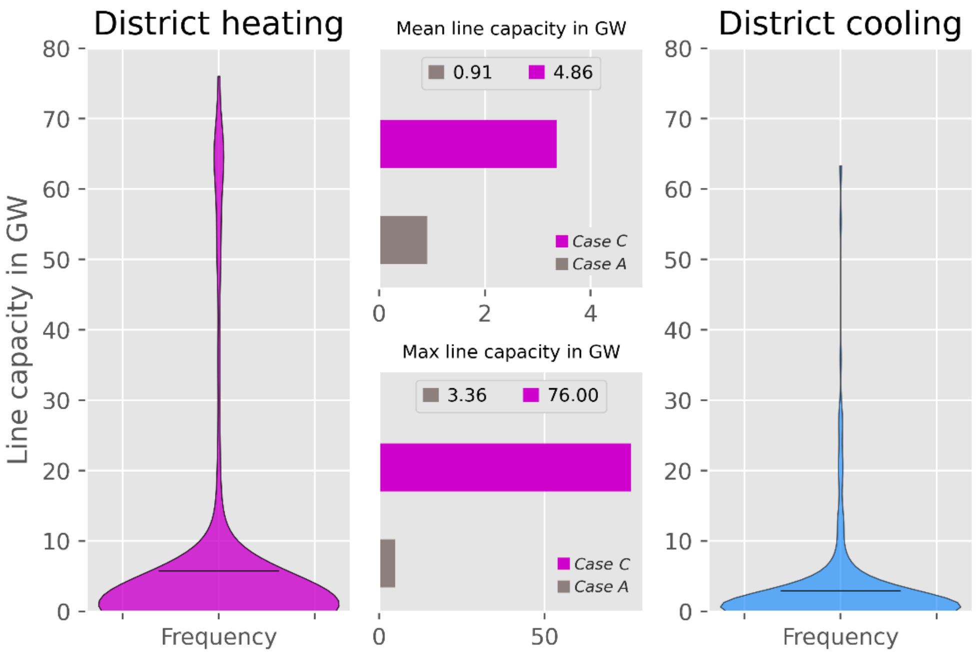
Violinplot

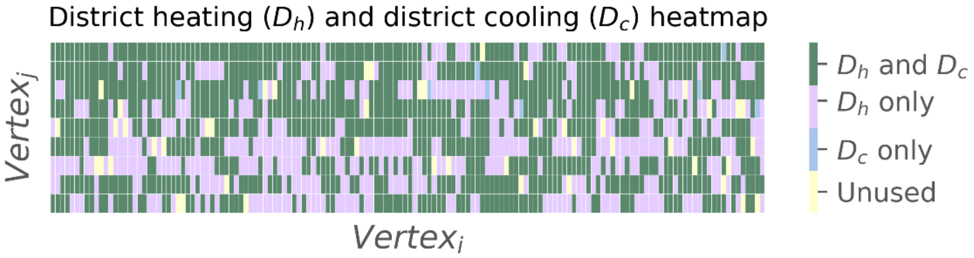


Heatmap

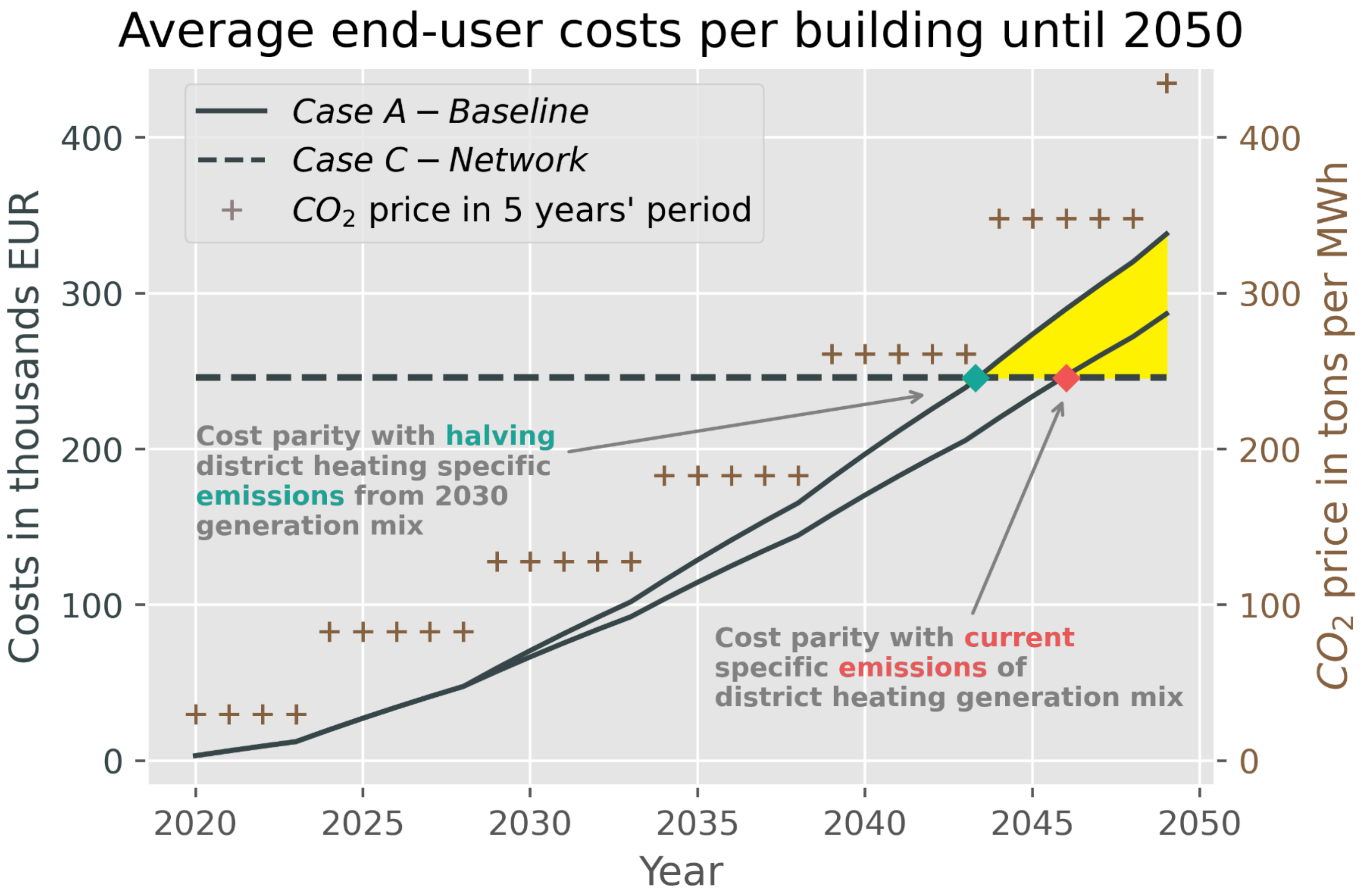


Case C - Network

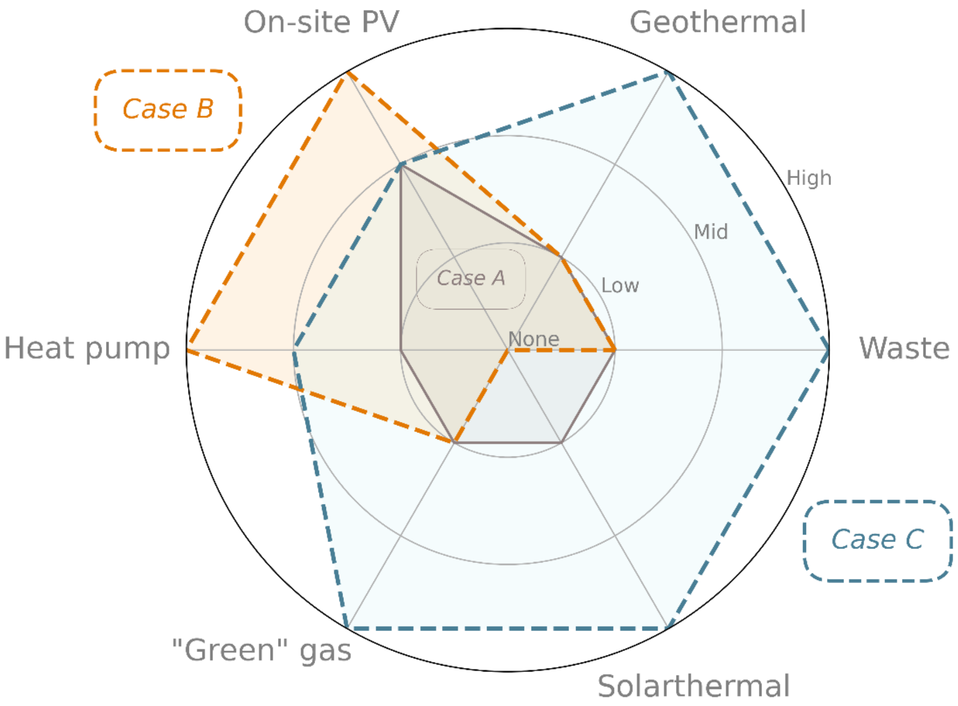


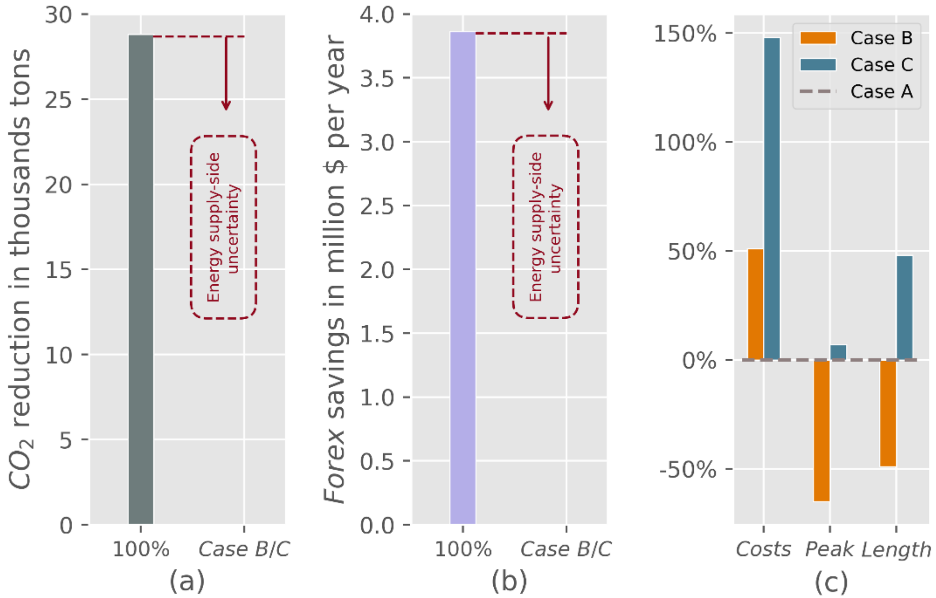


End-user cost parity between 2043 and 2046



Result comparison with benefit indicators





Conclusions and outlook

- Deep decarbonization of local multiple-energy carrier systems is possible, without being dependent on the existing gas network infrastructure
- Possible stranded assets (also at the gas end-user level) must not play a decisive role, especially since the trade-off analyses in this work show that alternative scenarios of lower/zero-emission energy service provision are even more economical in the longer term since the CO2 price is expected to increase in the next decades
- Future work: energy generation technology mix feeding into the district heating grid (waste incineration + seasonal heat storage) and the local mobility service needs

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