Open models of optimal system operation in central vs. decentral heat supply

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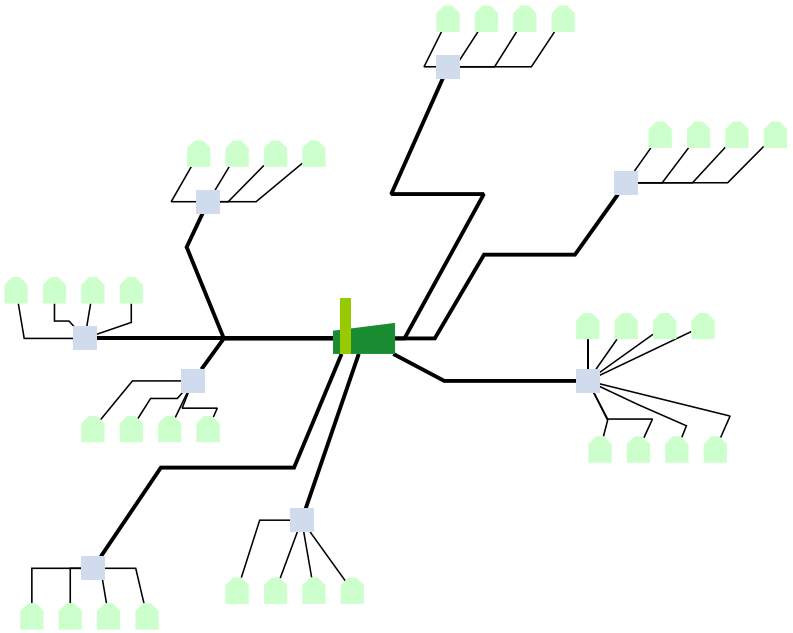
2019-09-10 Copenhagen

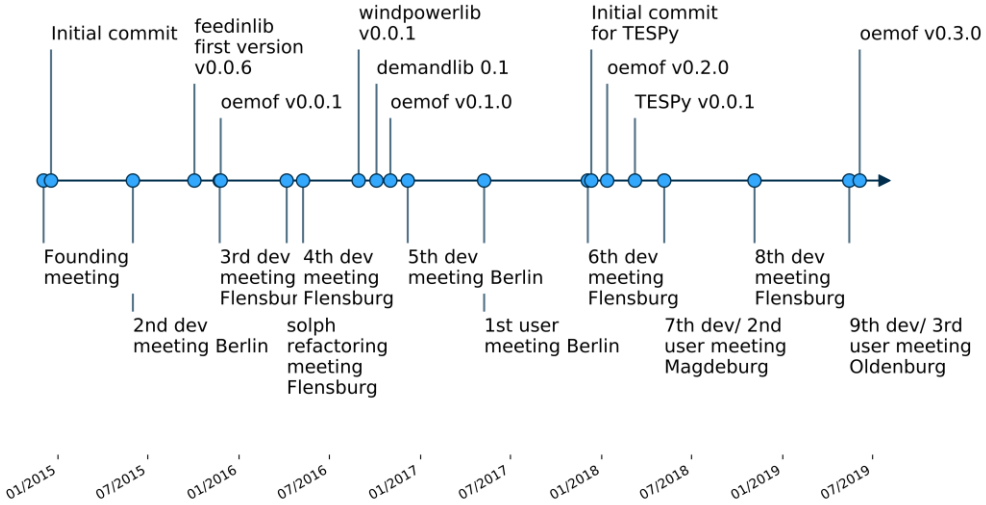
- Central fossil (natural gas) CHP,
- central peak load boiler
- central thermal storage,
- 1 primary,
- 8 sub-networks.

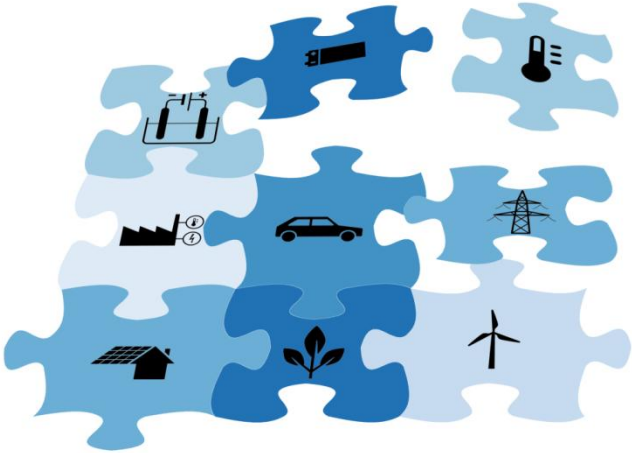


“How to include renewable heat using Power-to-Heat?“

Open energy modeling framework

Open energy modeling framework – oemof





https://oemof.org
https://github.com/oemof

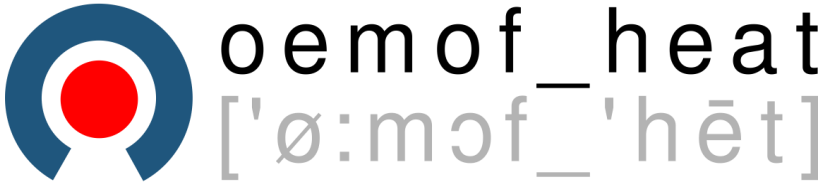
Next developer meeting
2019/12/04-06 in Berlin

oemof_heat

Project funded by BMWi

Duration: 3 years (2017-2020)

- Space heating,
- District heating networks,
- Special temperature levels.



Developing heat components
for simulation and optimization models

- Heat pumps,
- District heating networks,
- Solar thermal collectors,
- Thermal storages.

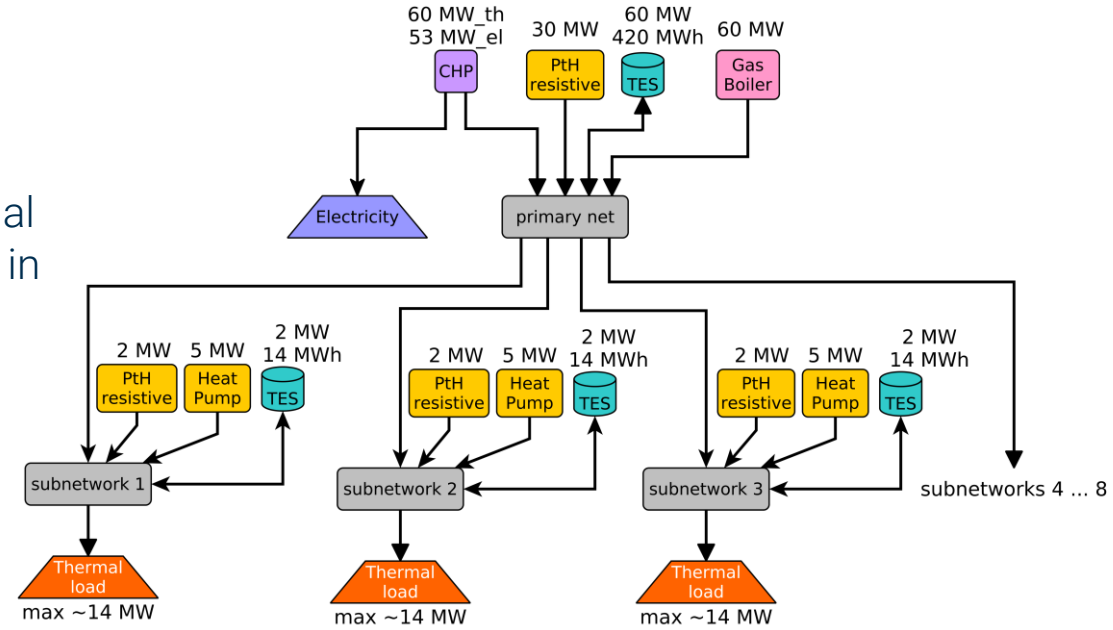
Case study

Case study – District heating system

Fictitious system

- 1 primary network,
- 8 sub-networks,
- Aggregated synthetic thermal load profiles for consumers in sub-networks.

Serve heat demand at minimal cost while maximizing revenues through electricity sale.



Assumptions

- Linear model,
- cost assumptions,
- electricity spot price timeseries,
- aggregated load profiles for sub-networks,
- constant losses in DHN pipes,
- heat source at constant temperature level 10°C,
- temperature level in subnets constant, thus constant COP for heat pumps throughout the year,
- perfect foresight,
- minimize costs, maximize revenues.

Scenario overview

Setup scenarios along three main axes:

System configuration	Regulatory framework	Year
Decentral heat pumps	Status quo	2018
(Central resistive PtH)	Flex Friendly	2030
(No PtH)		2050

Scenario: Status Quo – Energy carrier prices

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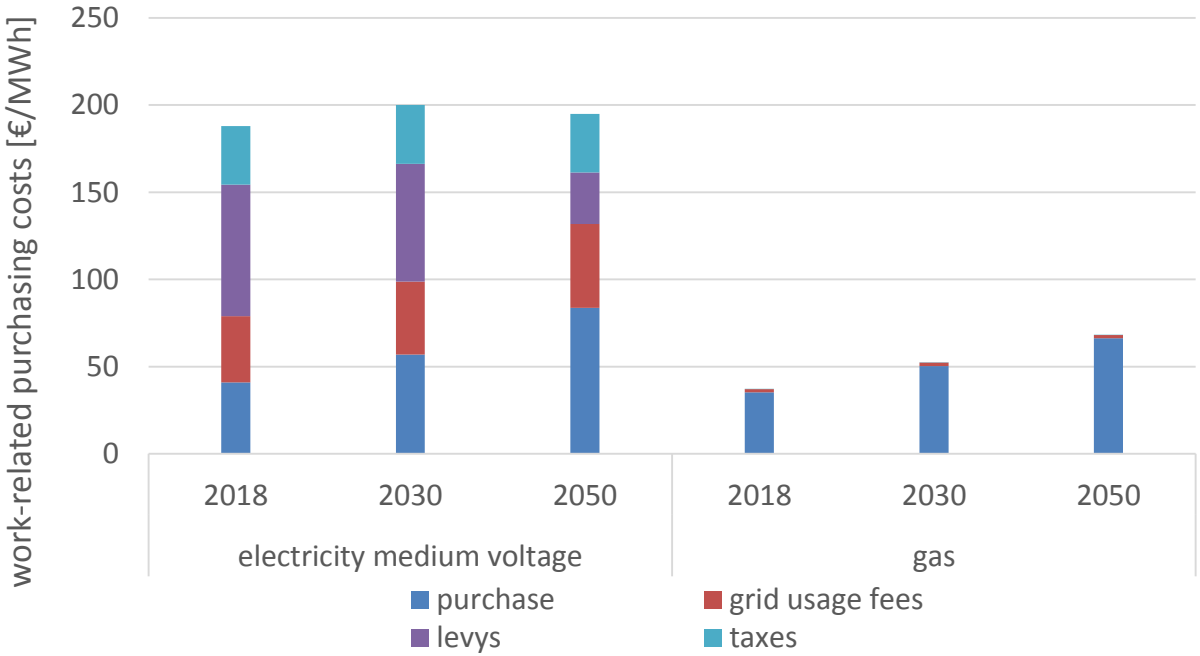
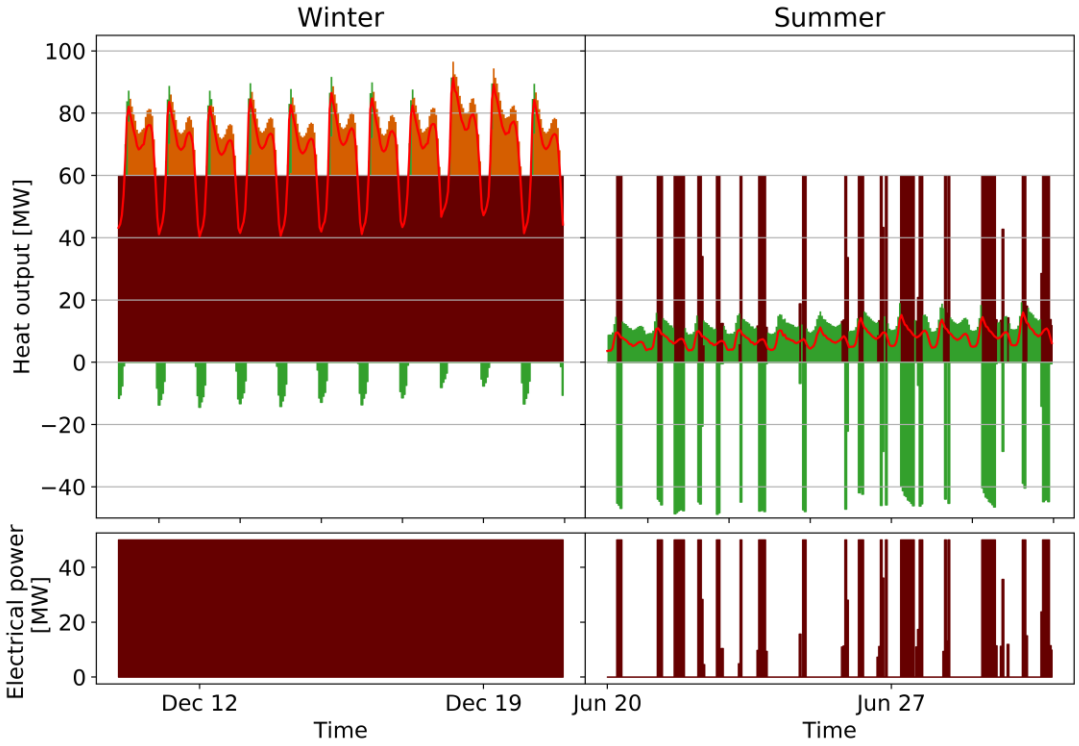
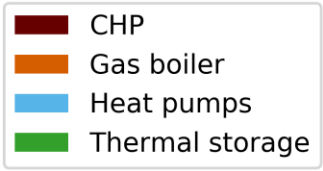


Sources:

Electricity spot market price	[2]
Gas price	[3]
Grid usage fees	[4]
EEG levy	[5]
Other taxes	§3 StromStG; §2 KAV

Scenario: Status quo | 2018

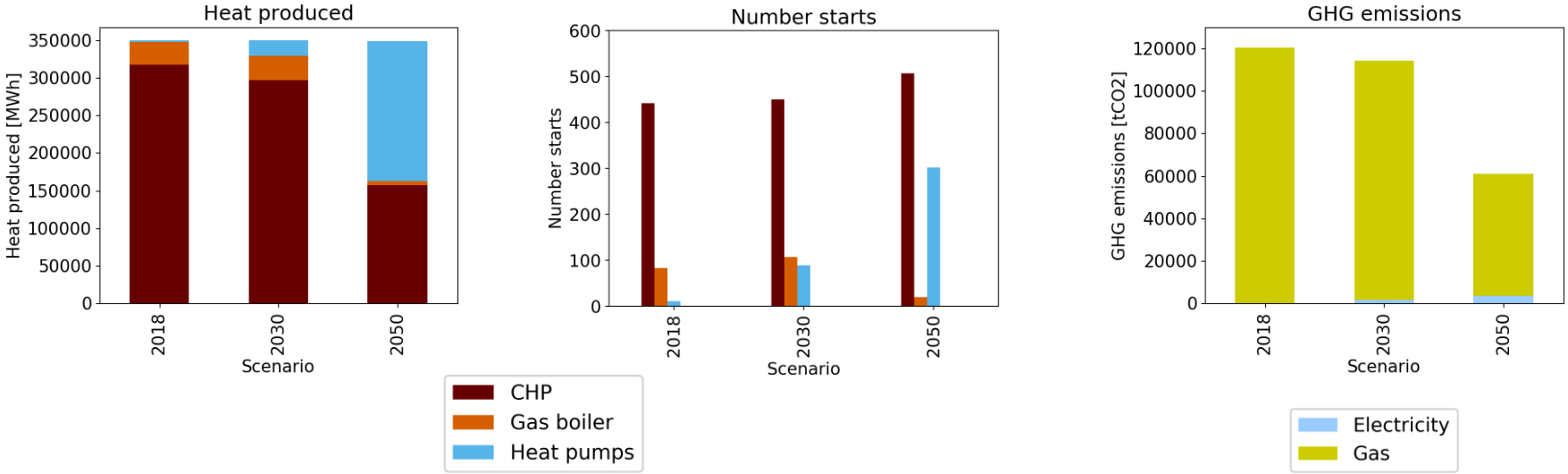




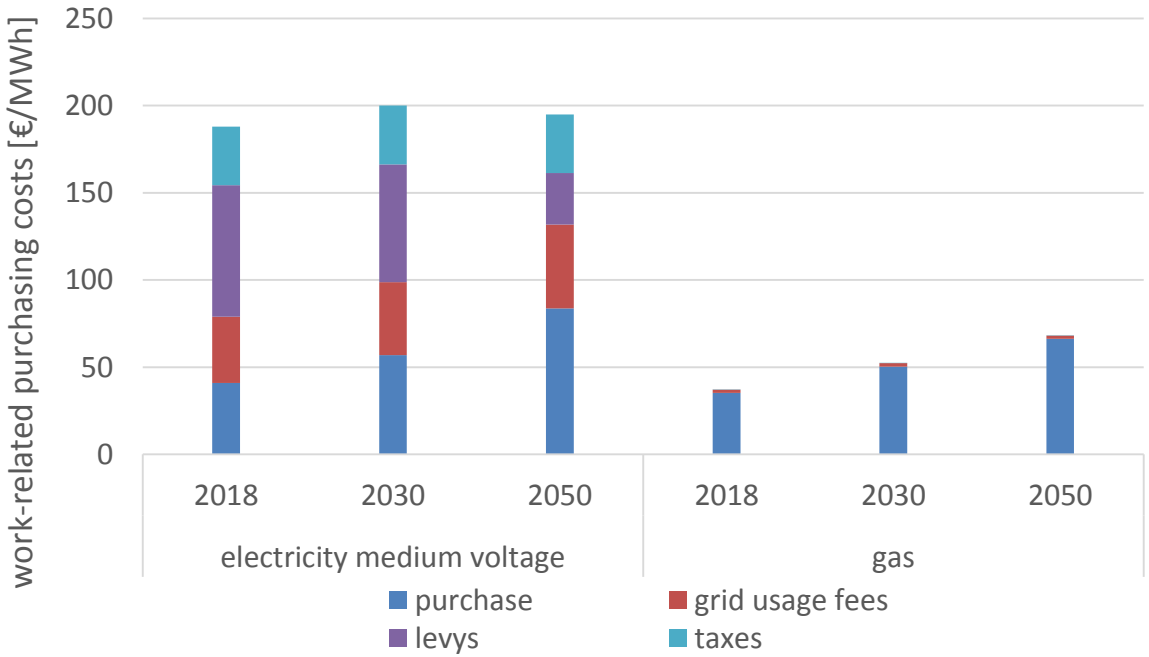
- Heat pumps not used.
- CHP serves base load,
- gas boiler serves peak load in winter.
- Thermal storage allows CHP to pause in hours of low electricity prices in summer.

Scenarios: Status quo | 2018, 2030, 2050

Economic operation of heat pumps in 2050.
~ 50% of heat produced by heat pumps in 2050,
Significant emission reduction.



Scenario: Status Quo – Energy carrier prices

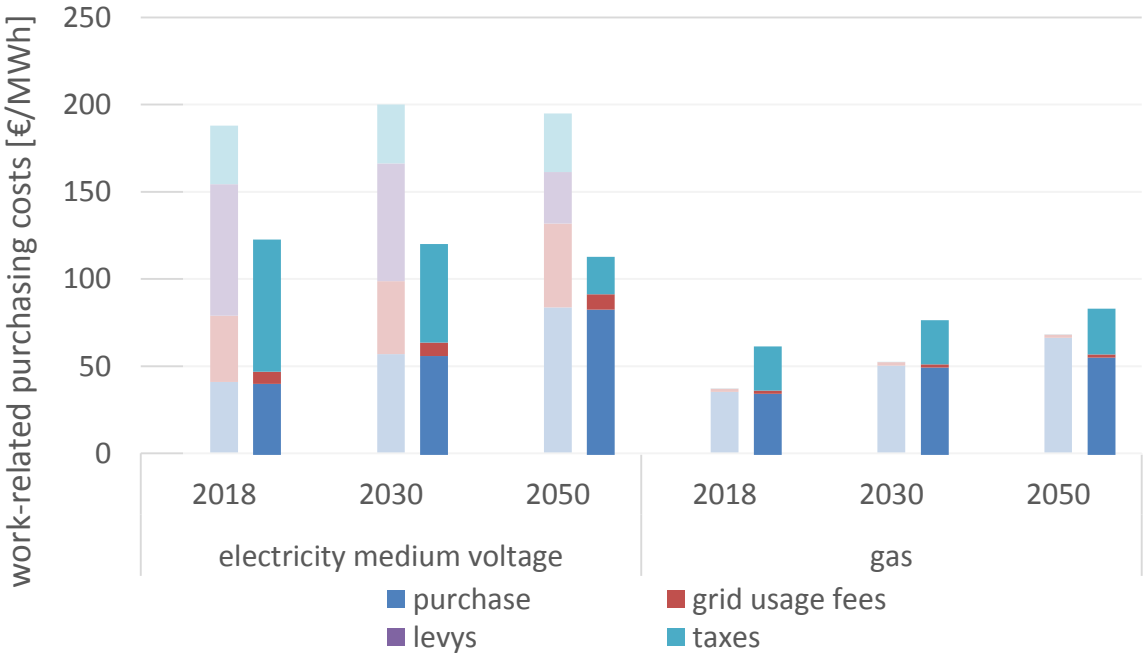


Status quo

Sources:

Electricity spot market price	[2]
Gas price	[3]
Grid usage fees	[4]
EEG levy	[5]
Other taxes	§3 StromStG; §2 KAV

Scenario: Flex friendly – Energy carrier prices



Status quo

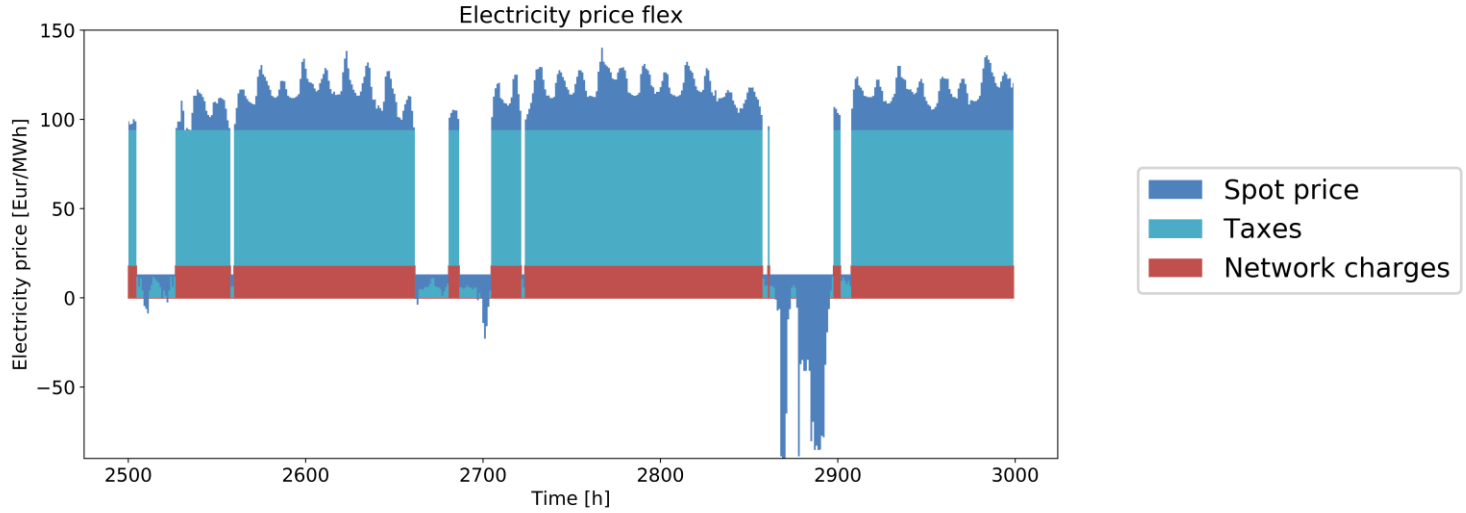
Flex friendly

Sources:

Electricity spot market price	[2]
Gas price	[3]
Grid usage fees	[4]
EEG levy	[5]
Other taxes	§3 StromStG; §2 KAV
CO2 tax	Graichen and Lenck 2018

No levies and lower grid usage fees, introduce CO2-tax.

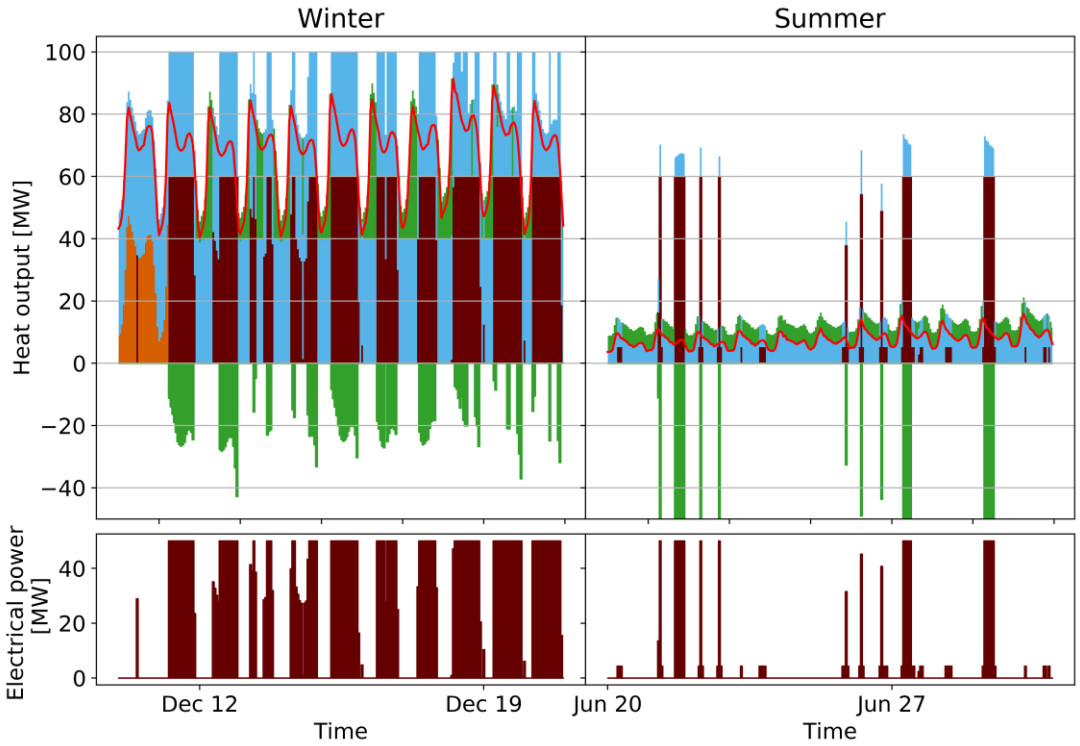
Scenario: Flex friendly – Energy carrier prices

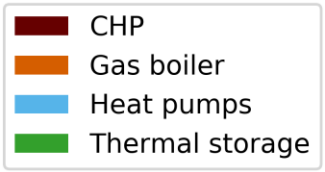


When spot price < 0

- Taxes significantly reduced.
- Network charges = 0.

Scenario: Flex friendly | 2018

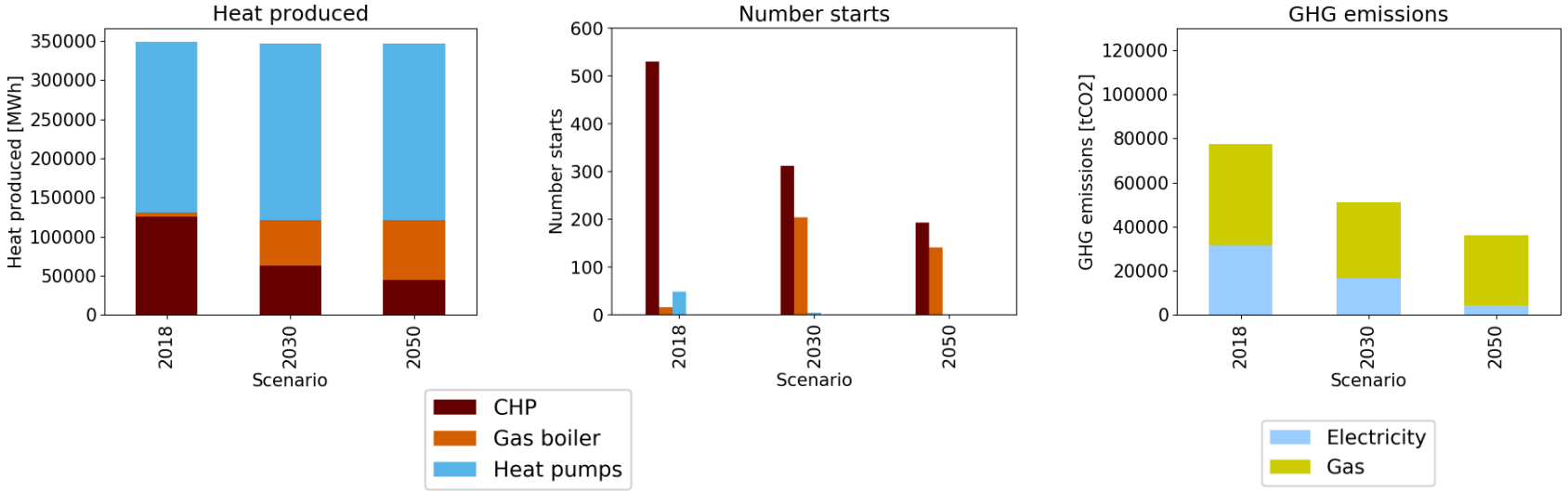




- Heat pumps serve as main heat producer.
- CHP operates when heat load is high and while electricity prices are high.
- Storage charged by CHP.
- Gas boiler is used when electricity production is not economic.

Scenarios: Flex friendly | 2018, 2030, 2050

- Heat pumps serve base load.
- CHP/Gas boiler serve peak load.
- Increasing usage of gas boiler in 2030, 2050.
- Emissions are reduced significantly.

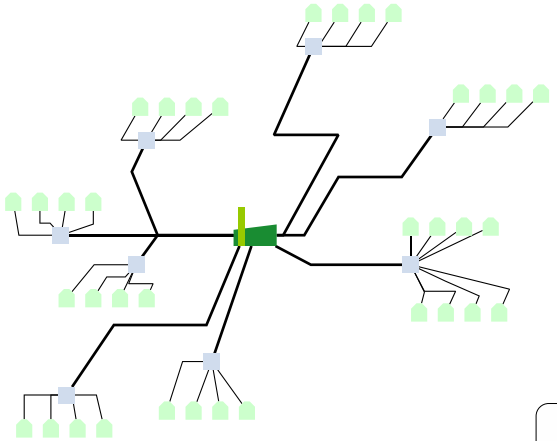


Conclusion

- Heat pumps can play an important role in district heating systems.
- Economic operation is sensitive to energy carrier price structure and revenues of electricity sale.
- Heat pumps not economic under status quo assumptions in 2018.
- Flex-friendly price structure allows economic operation.
- Roles are changed: Heat pumps serve base load, CHP switches to intermittent operation. CHP operation replaced by gas boiler at low electricity prices.
- Emissions can be reduced significantly.

Code and data will be published online together with the journal publication.

Let’s discuss!



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Sources

[1] 50 HERTZ, AMPRION, TRANSNET BW, TENNET (2019): *Netztransparenz*. Online verfügbar unter: URL: https://www.netztransparenz.de/Impressum [04.09.2019]

[2] AGORA ENERGIEWENDE, AURORA ENERGY RESEARCH (2018): 65 Prozent Erneuerbare bis 2030 und ein schrittweiser Kohleausstieg - Auswirkungen der Vorgaben des Koalitionsvertrags auf Strompreise, CO2-Emissionen und Stromhandel.

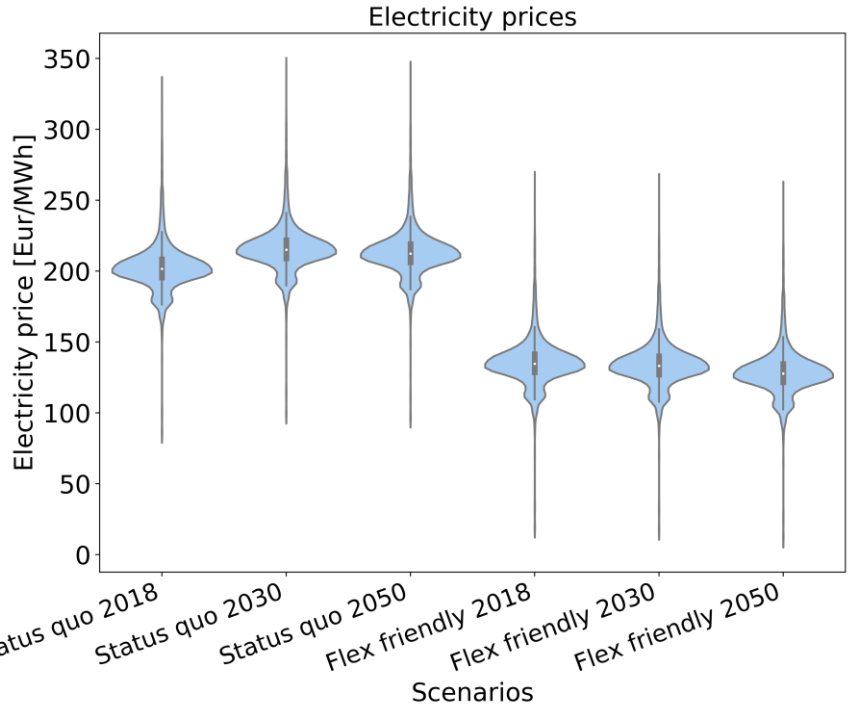
[3] DUIĆ, Neven, ŠTEFANIĆ, Nedeljko, LULIĆ, Zoran, KRAJAČIĆ, Goran, PUKŠEC, Tomislav, NOVOSEL, Tomislav (2017): Heat Roadmap Europe - EU28 fuel prices for 2015, 2030 and 2050 Deliverable 6.1: Future fuel price review. Zagreb Online verfügbar unter: URL: www.heatroadmap.eu [29.04.2019]

[4] FRAUNHOFER ISI, CONSENTEC, IFEU (2017a): Langfristszenarien für die Transformation des Energiesystems in Deutschland. Modul 3: Referenzszenario und Basisszenario. Karlsruhe, Aachen, Heidelberg Online verfügbar unter: URL: https://www.bmwi.de/Redaktion/DE/Downloads/B/berichtsmodul-3-referenzszenario-und-basisszenario.pdf?__blob=publicationFile&v=4 [18.12.2018]

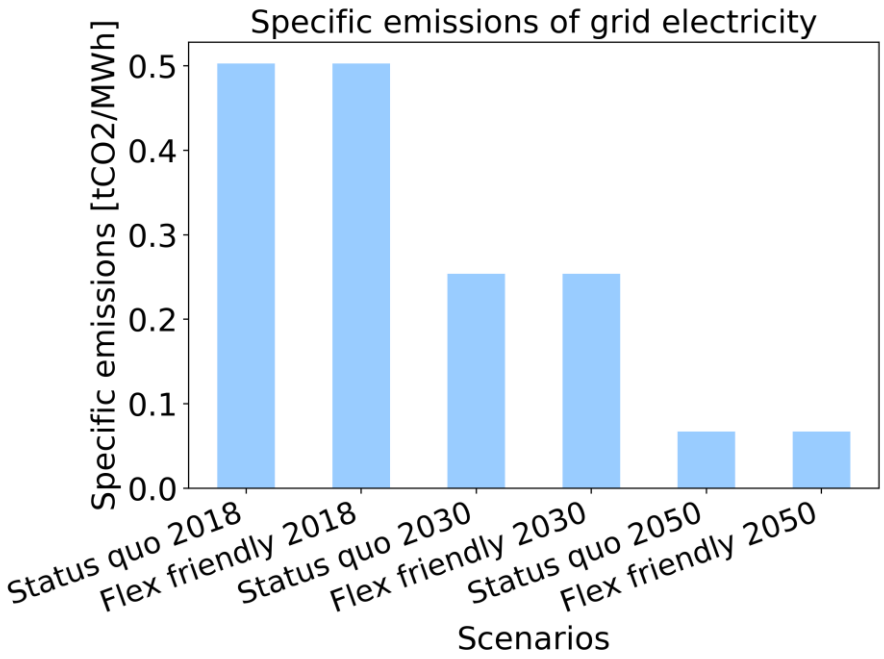
[5] ÖKO-INSTITUT (2015): Die Entwicklung der EEG-Kosten bis 2035. Berlin

GRAICHEN, Patrick, LENCK, Thorsten (2018): Eine Neuordnung der Abgaben und Umlagen auf Strom , der Abgaben und Umlagen auf Strom, Wärme, Verkehr. Berlin

Electricity prices

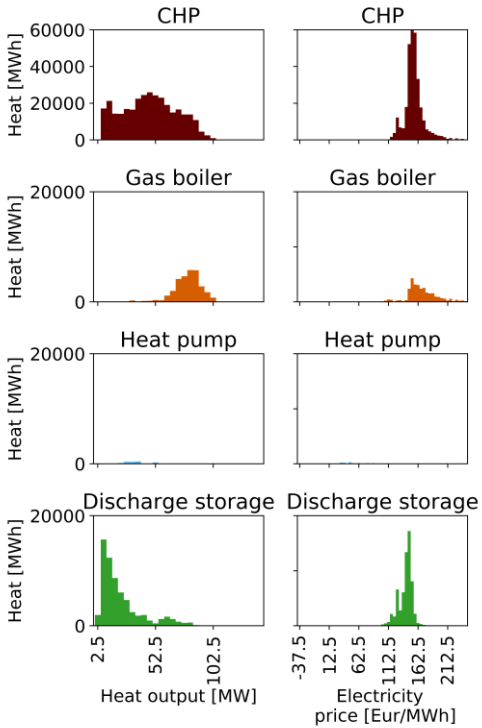


Specific emissions

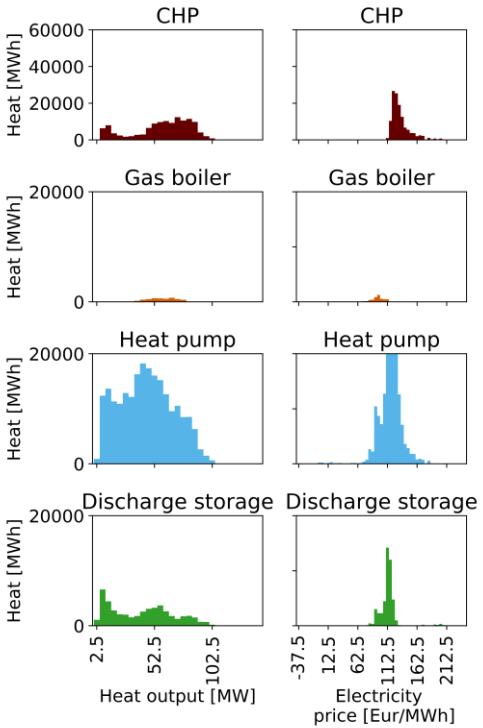


Scenario: Status quo/Flex friendly | 2018

Status quo 2018

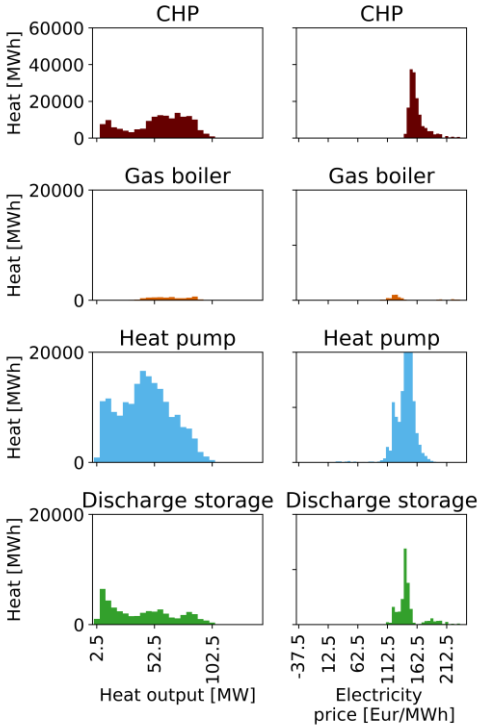


Flex friendly 2018



Scenario: Status quo/Flex friendly | 2050

Status quo 2050



Flex friendly 2050