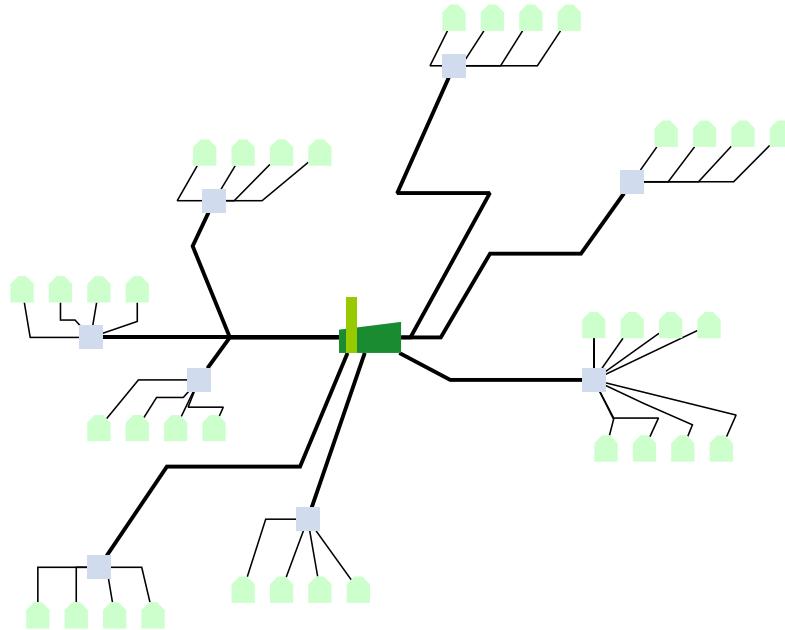

Open models of optimal system operation in central vs. decentral heat supply

— *Jann Launer, Marcus Schluzy,
Jakob Wolf, Silke Köhler,
Christoph Pels Leusden*
2019-09-10 Copenhagen



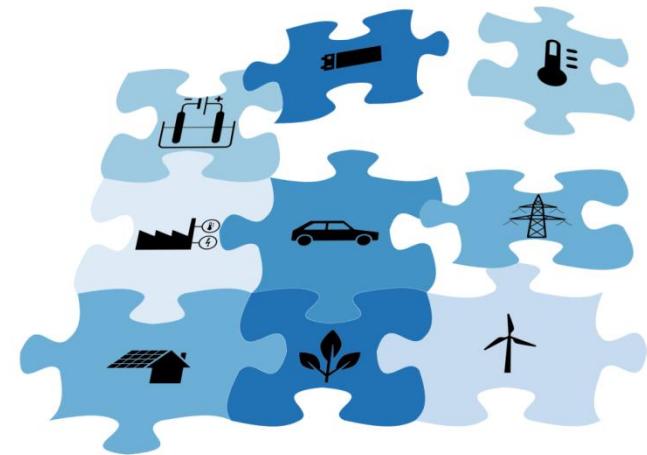
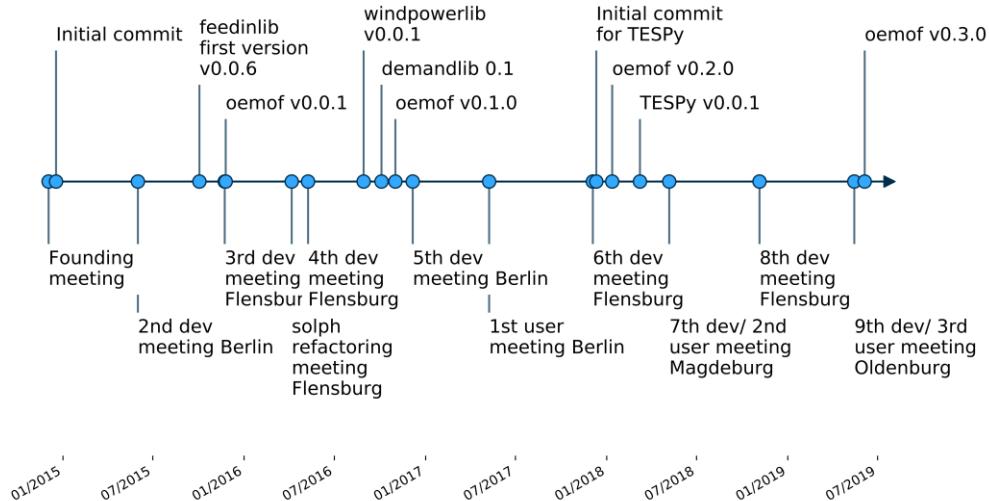
- ▶ Central fossil (natural gas) CHP,
- ▶ central peak load boiler
- ▶ central thermal storage,
- ▶ 1 primary,
- ▶ 8 sub-networks.



“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

Project funded by BMWi

Duration: 3 years (2017-2020)

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



Gefördert durch:
 Bundesministerium
für Wirtschaft
und Energie
aufgrund eines Beschlusses
des Deutschen Bundestages



Developing heat components
for simulation and optimization models

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

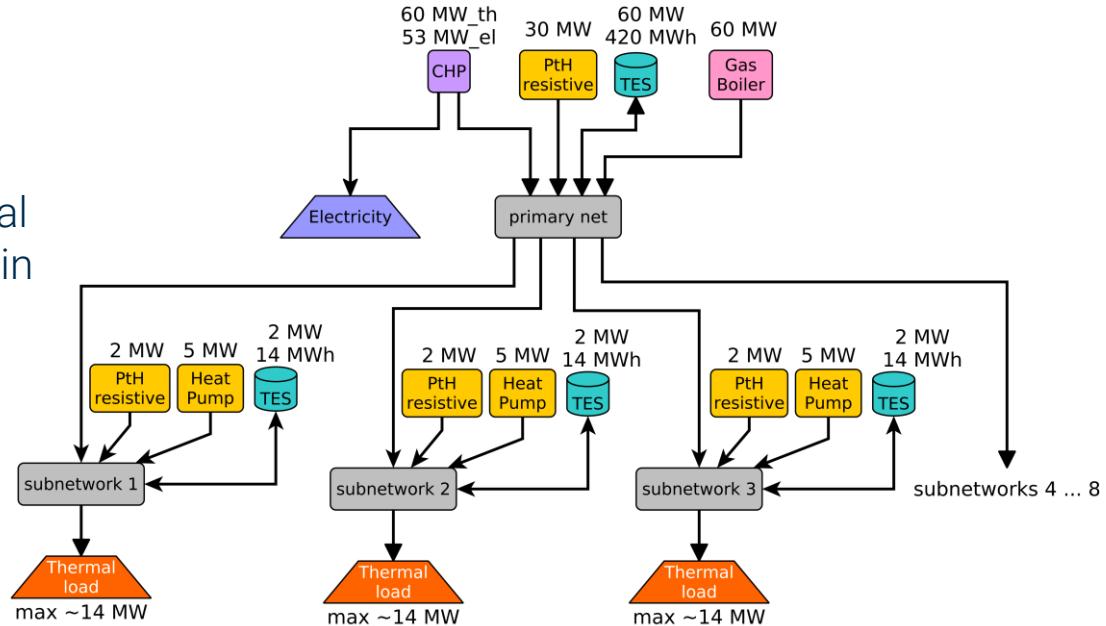
Case study

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.

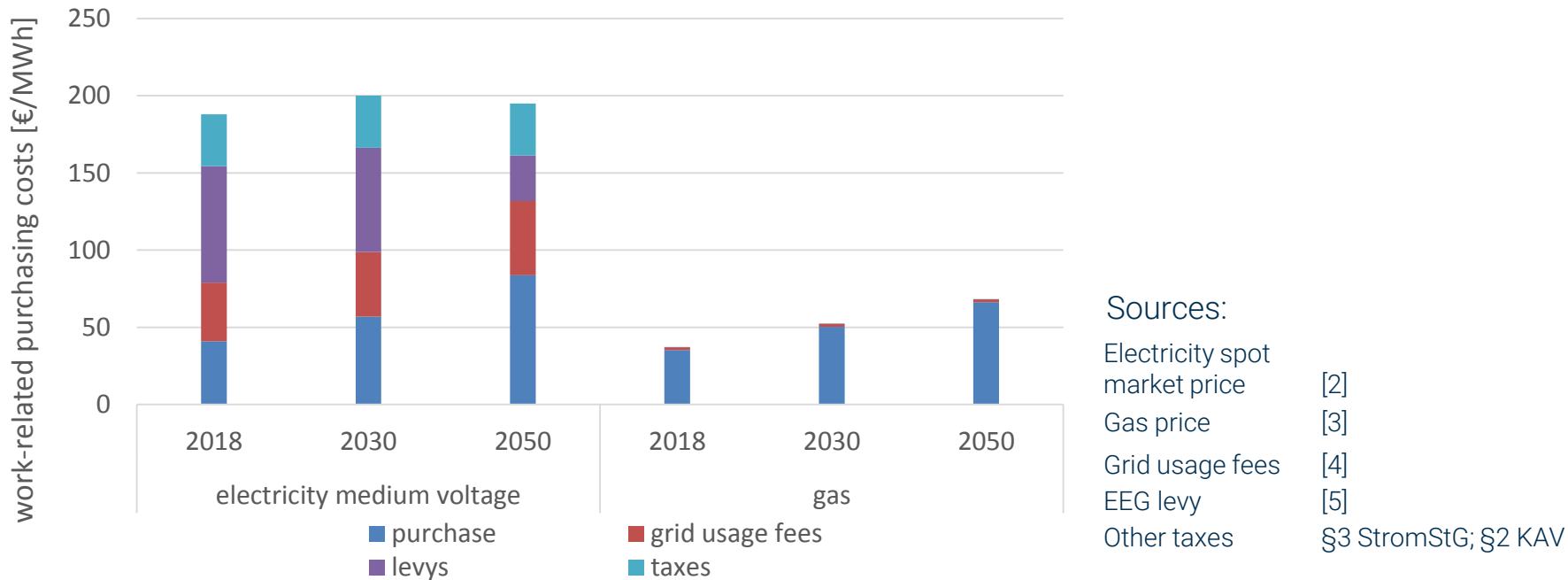
Scenario overview

Setup scenarios along three main axes:

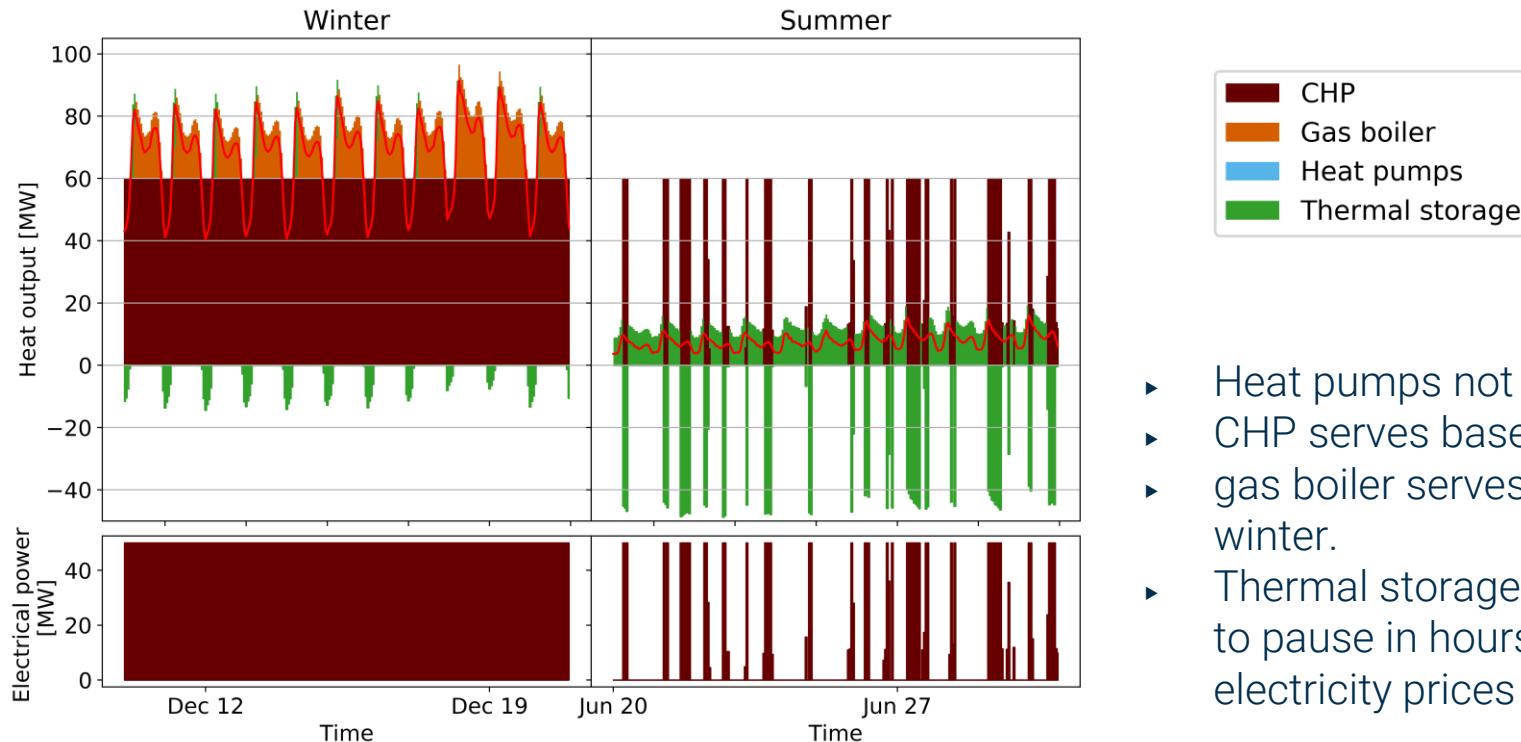
System configuration	Regulatory framework	Year
Decentral heat pumps	Status quo	2018
(Central resistive PtH)	Flex Friendly	2030
(No PtH)		2050

Scenario: Status Quo – Energy carrier prices

Scenario: Status Quo – Energy carrier prices



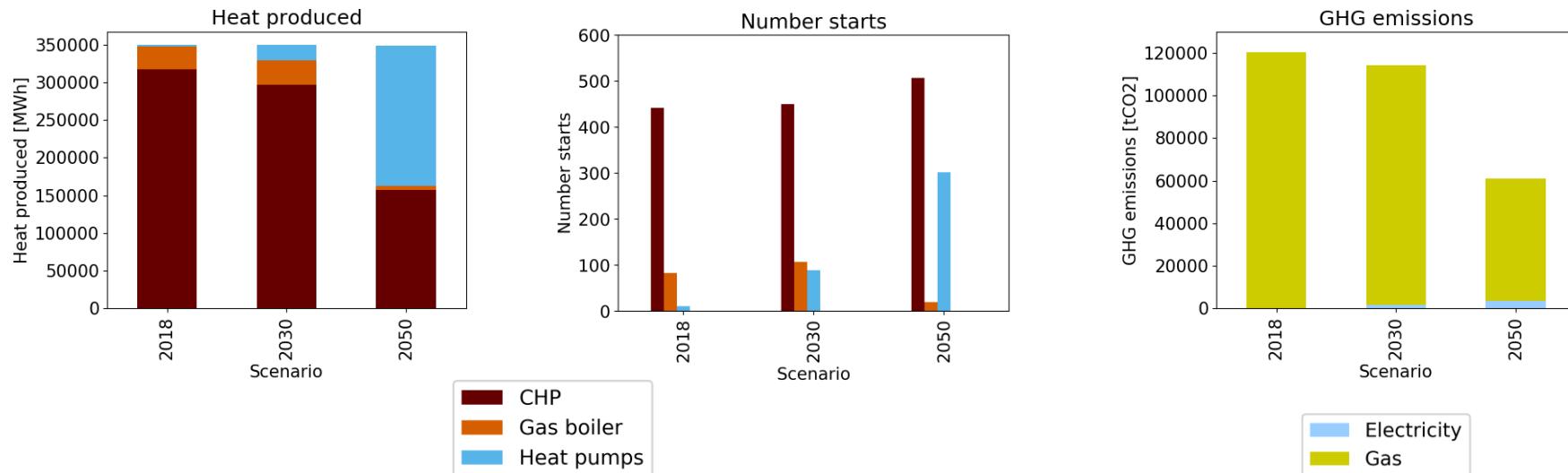
Scenario: Status quo | 2018



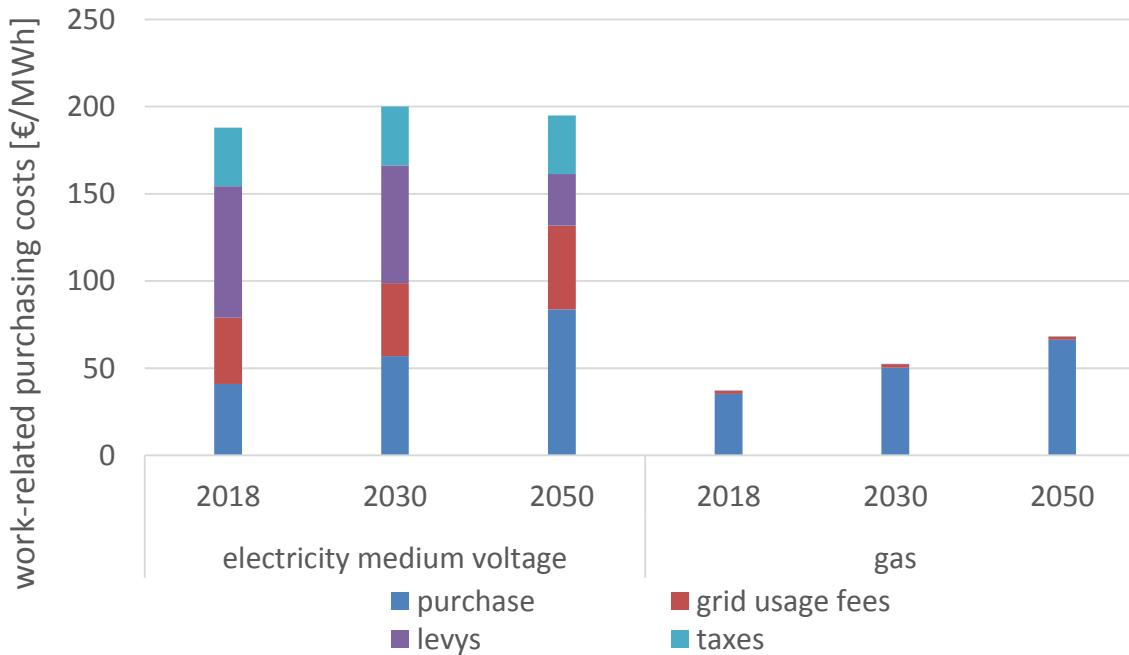
- ▶ Heat pumps not used.
- ▶ CHP serves base load,
- ▶ gas boiler serves peak load in winter.
- ▶ Thermal storage allows CHP to pause in hours of low electricity prices in summer.

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

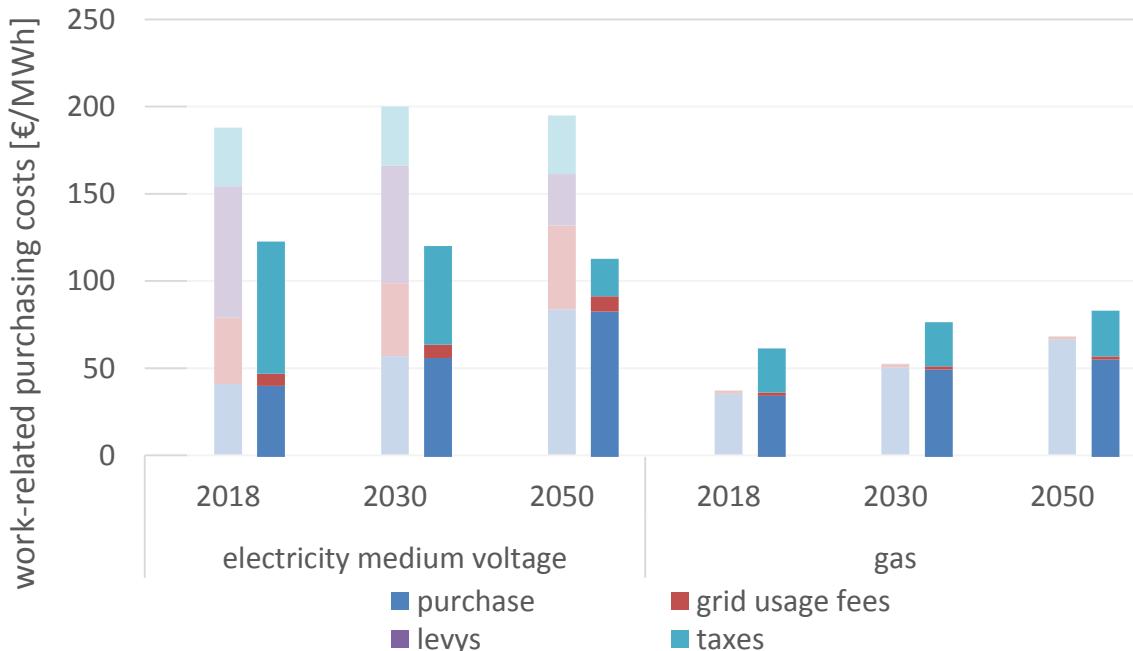


Status quo

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



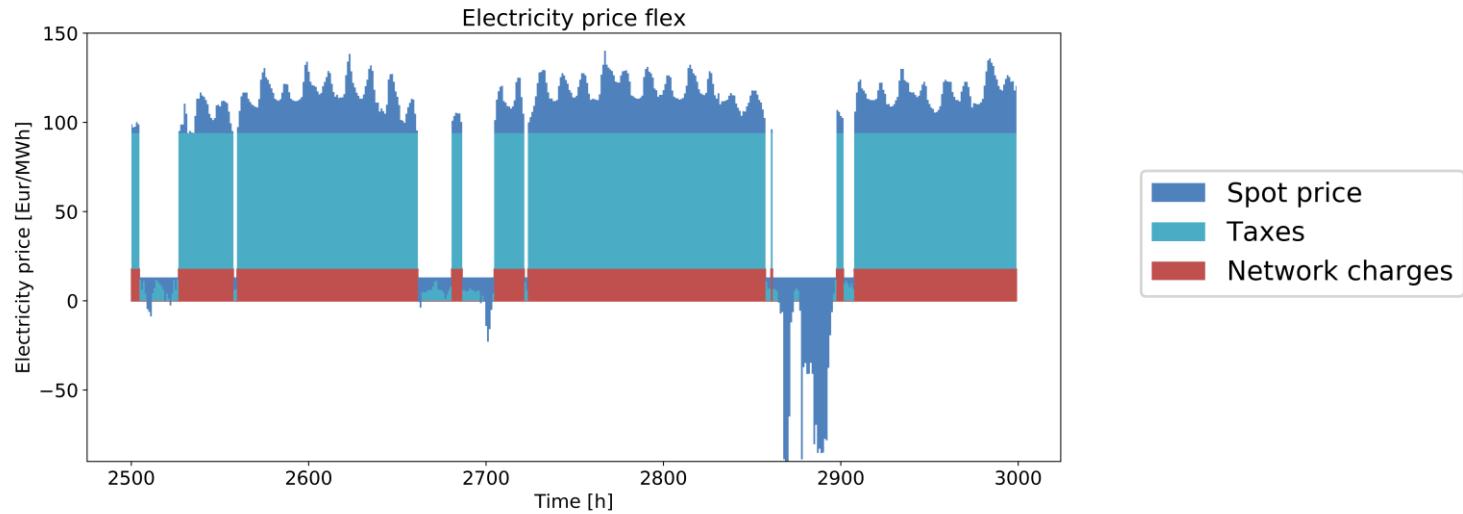
Status quo
Flex
friendly

Sources:

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

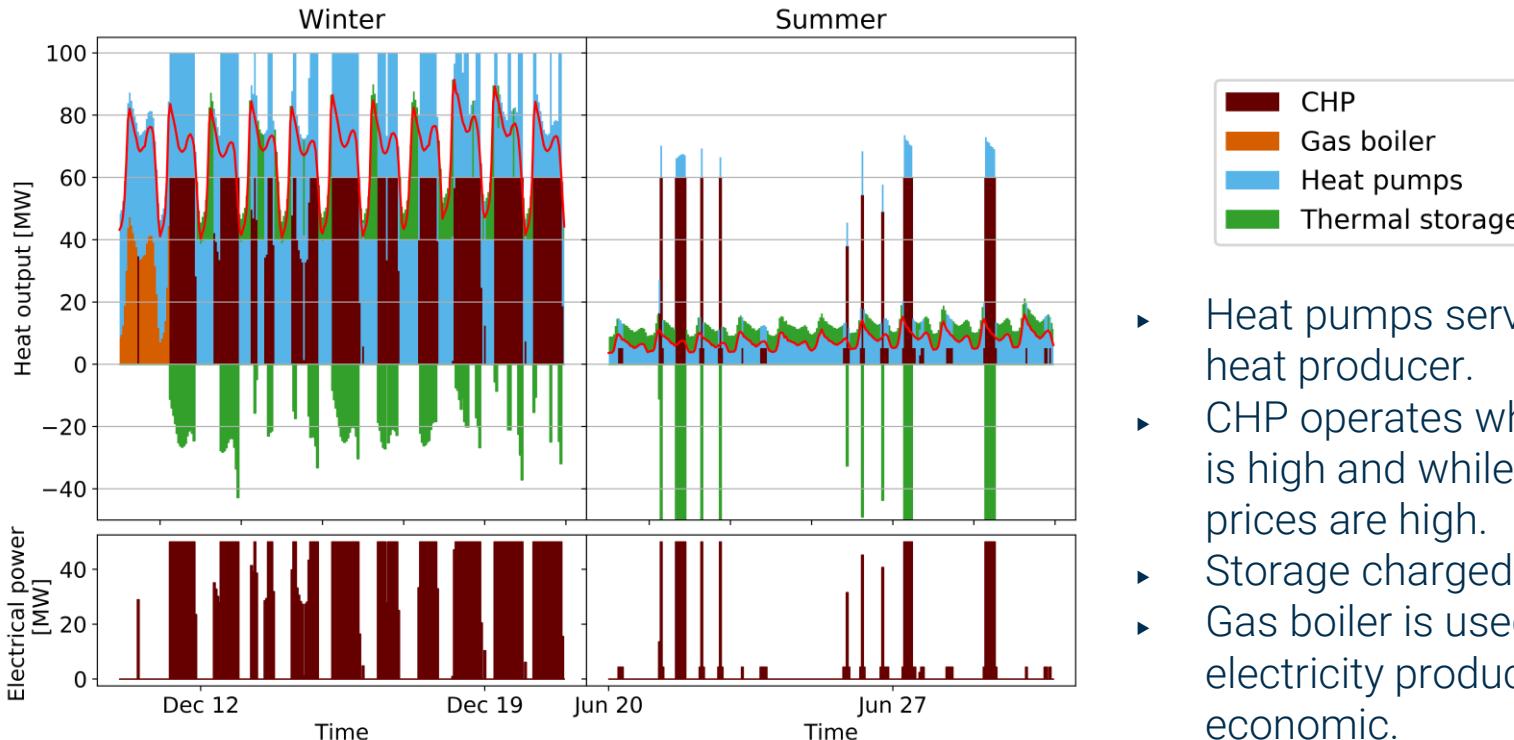
No levies and lower grid usage fees,
introduce CO2-tax.

Scenario: Flex friendly – Energy carrier prices



When spot price < 0
Taxes significantly reduced.
Network charges = 0.

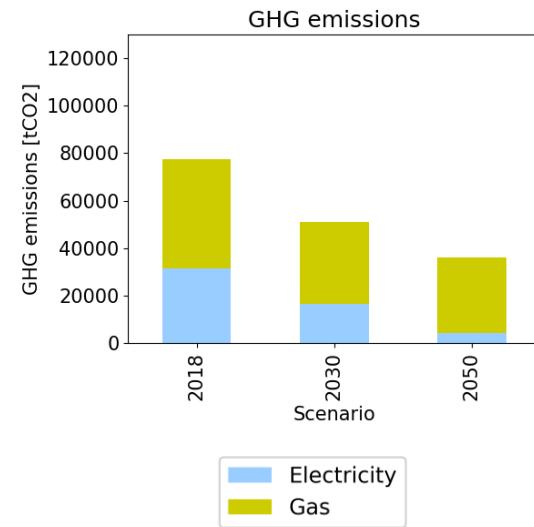
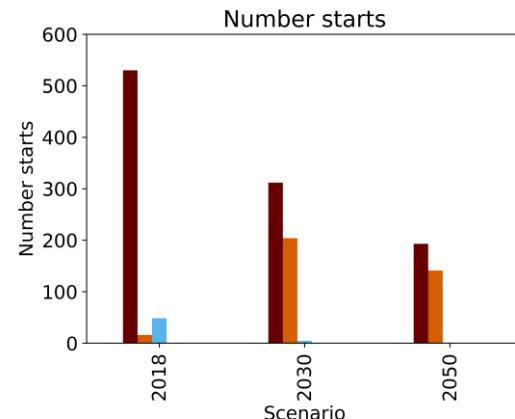
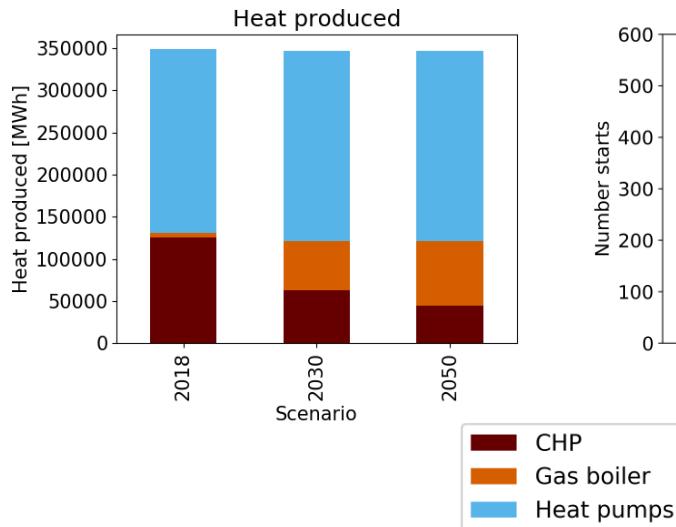
Scenario: Flex friendly | 2018



- ▶ 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!

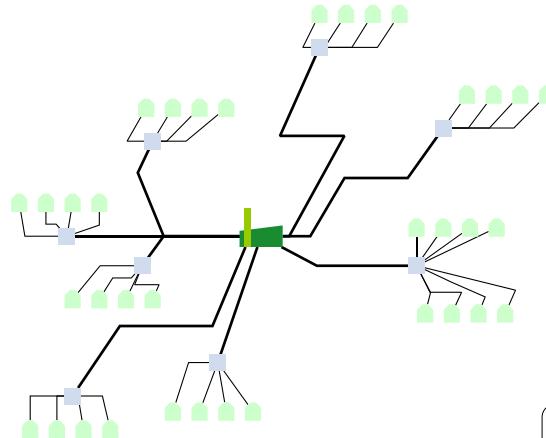


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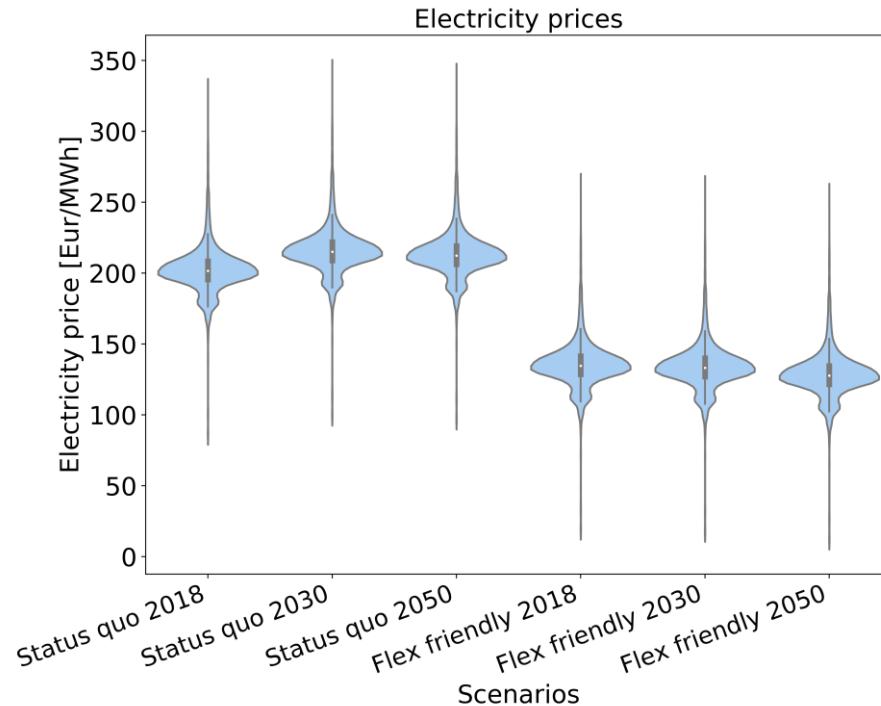
E-Mail: jann.launer@rl-institut.de

Web: <http://www.rl-institut.de>

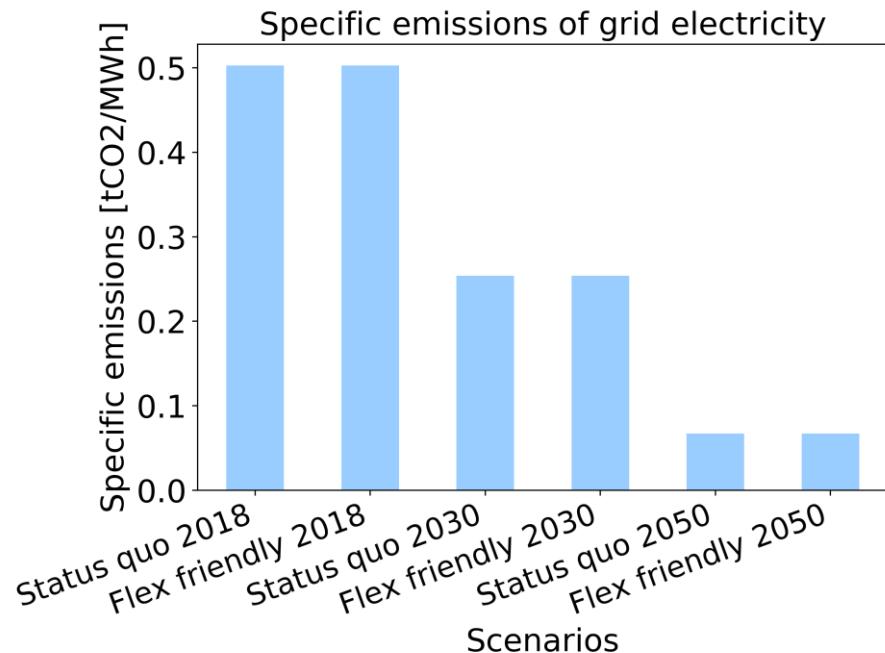
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Electricity prices

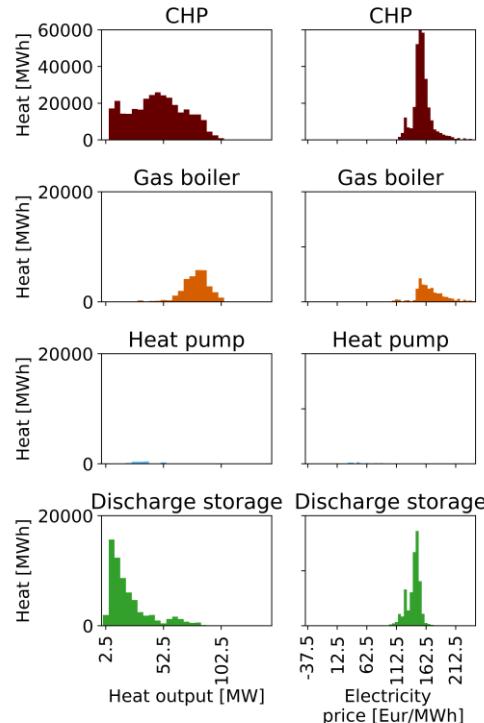


Specific emissions

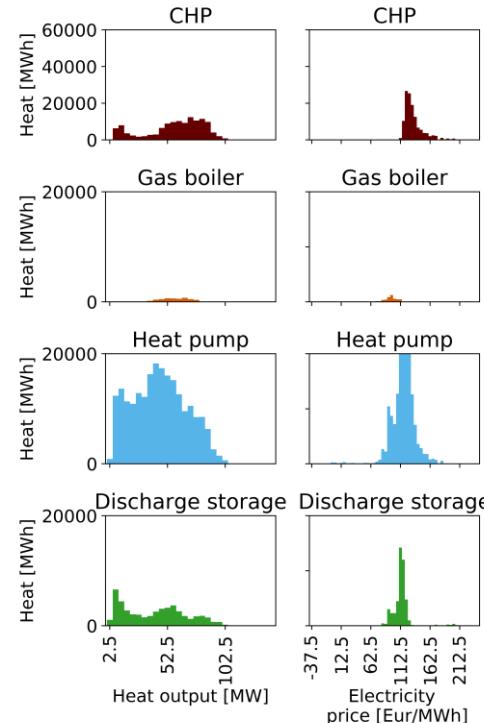


Scenario: Status quo/Flex friendly | 2018

Status quo 2018

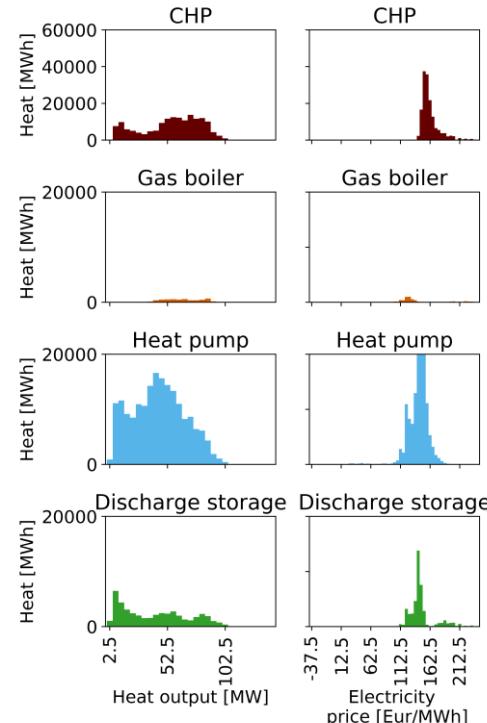


Flex friendly 2018



Scenario: Status quo/Flex friendly | 2050

Status quo 2050



Flex friendly 2050

