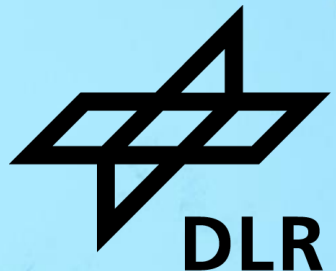
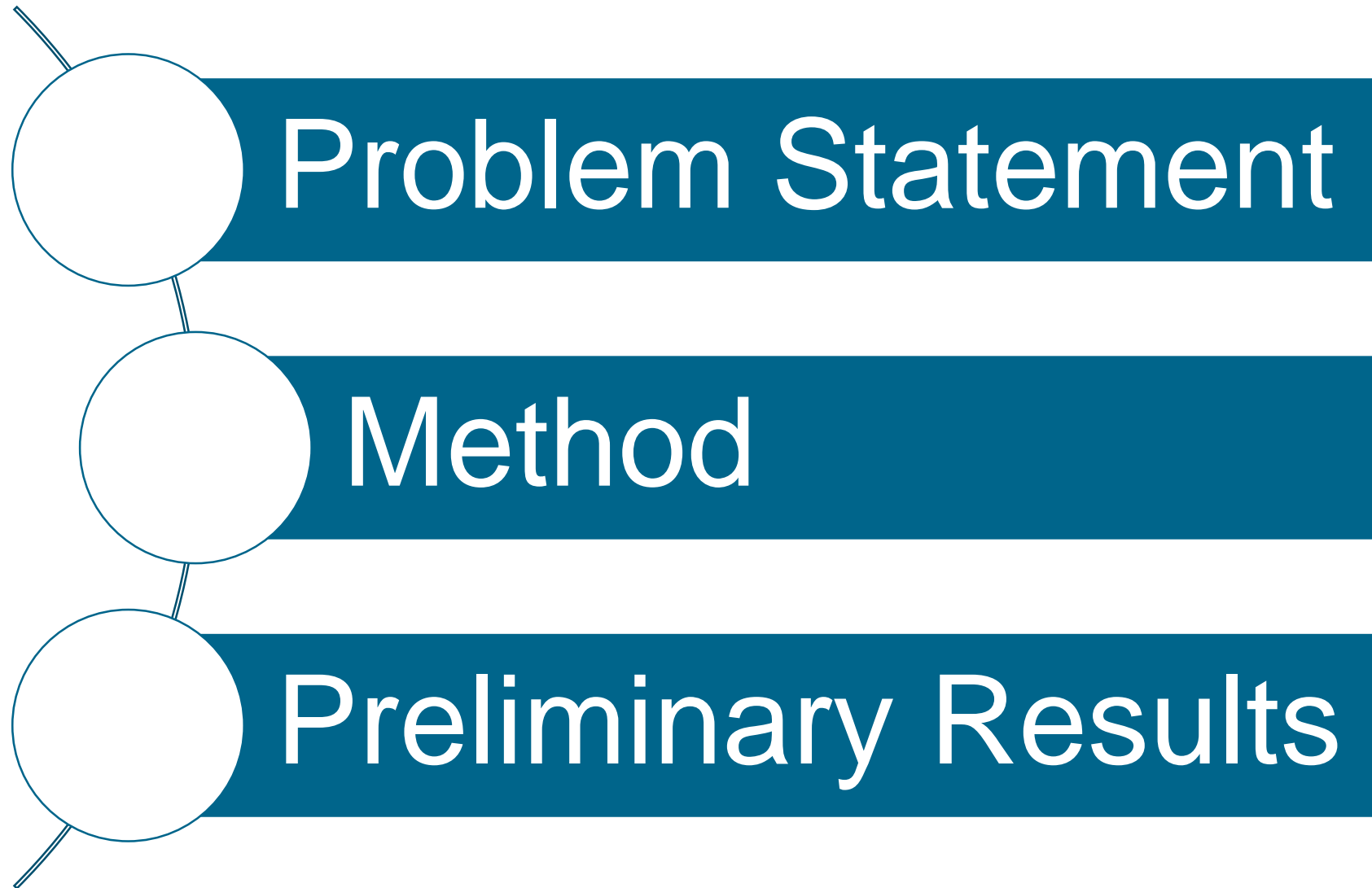


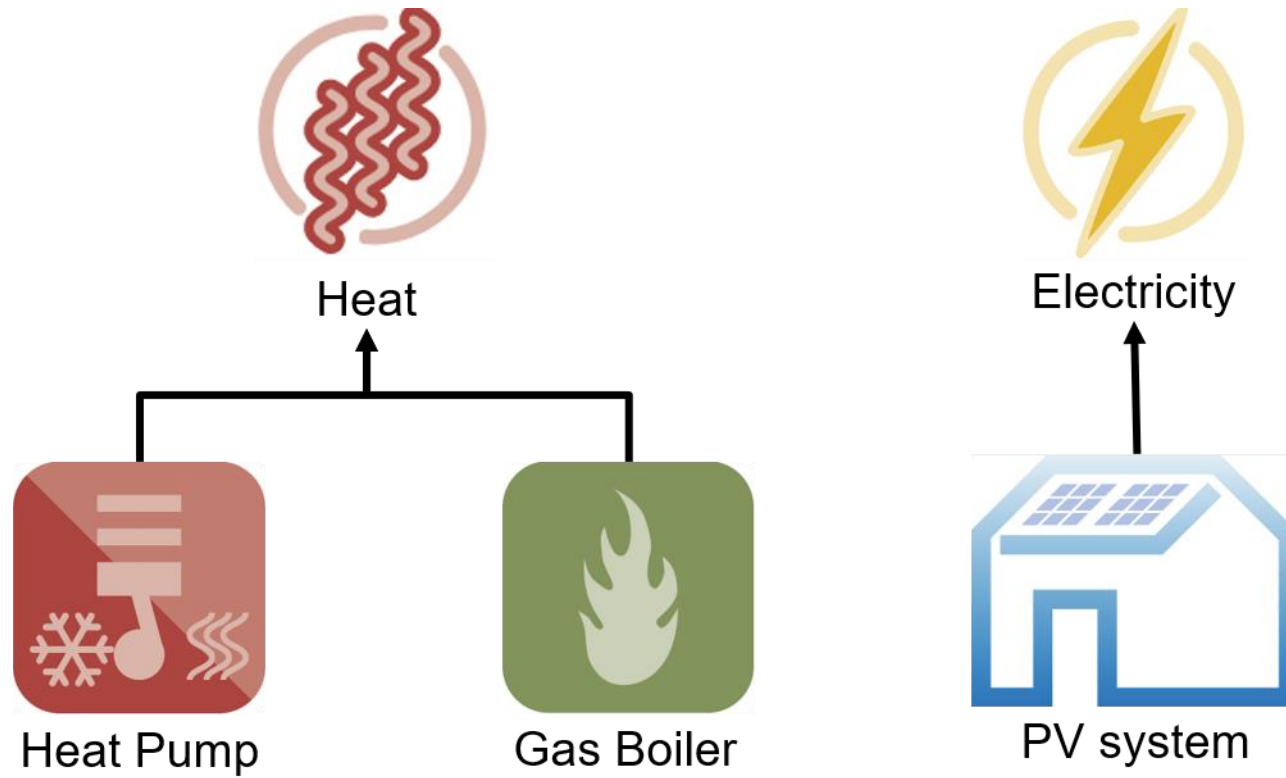
DEVELOPMENT PATHS FOR DECENTRALIZED ENERGY SYSTEMS IN THE RESIDENTIAL SECTOR

Carlos Muñoz

DLR Institute of Networked Energy Systems, Oldenburg





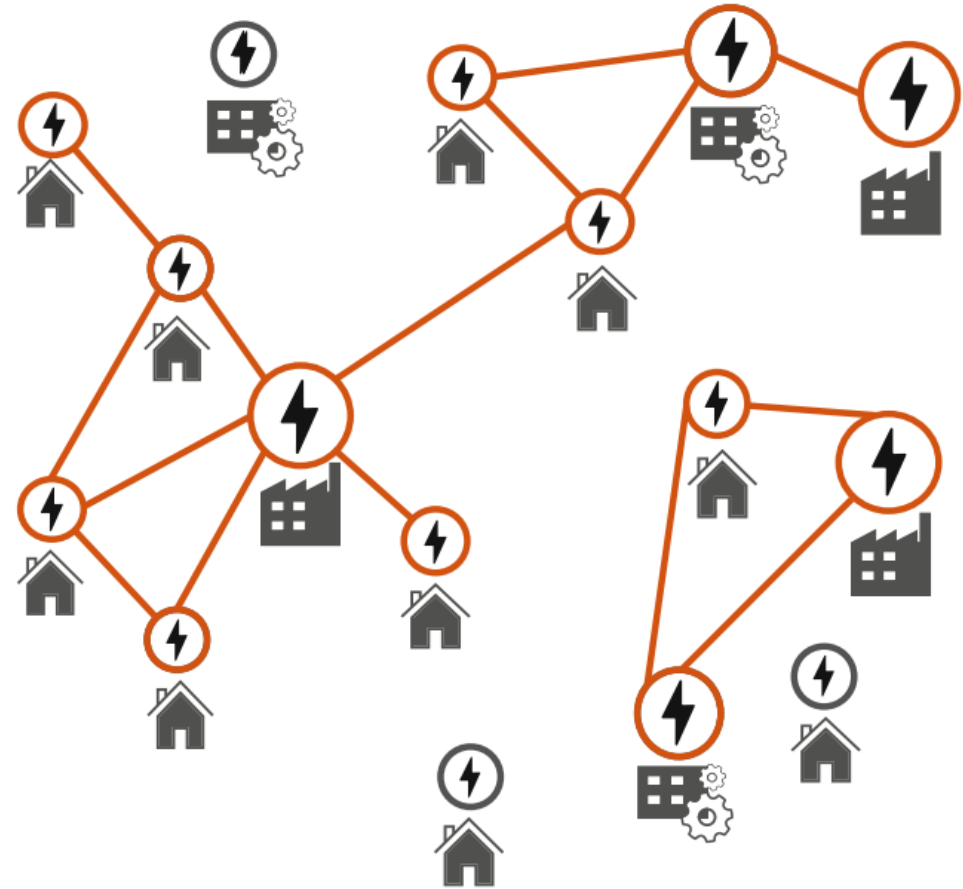


PROBLEM STATEMENT

Decentralized/Distributed Energy System (DES)

Residential DES

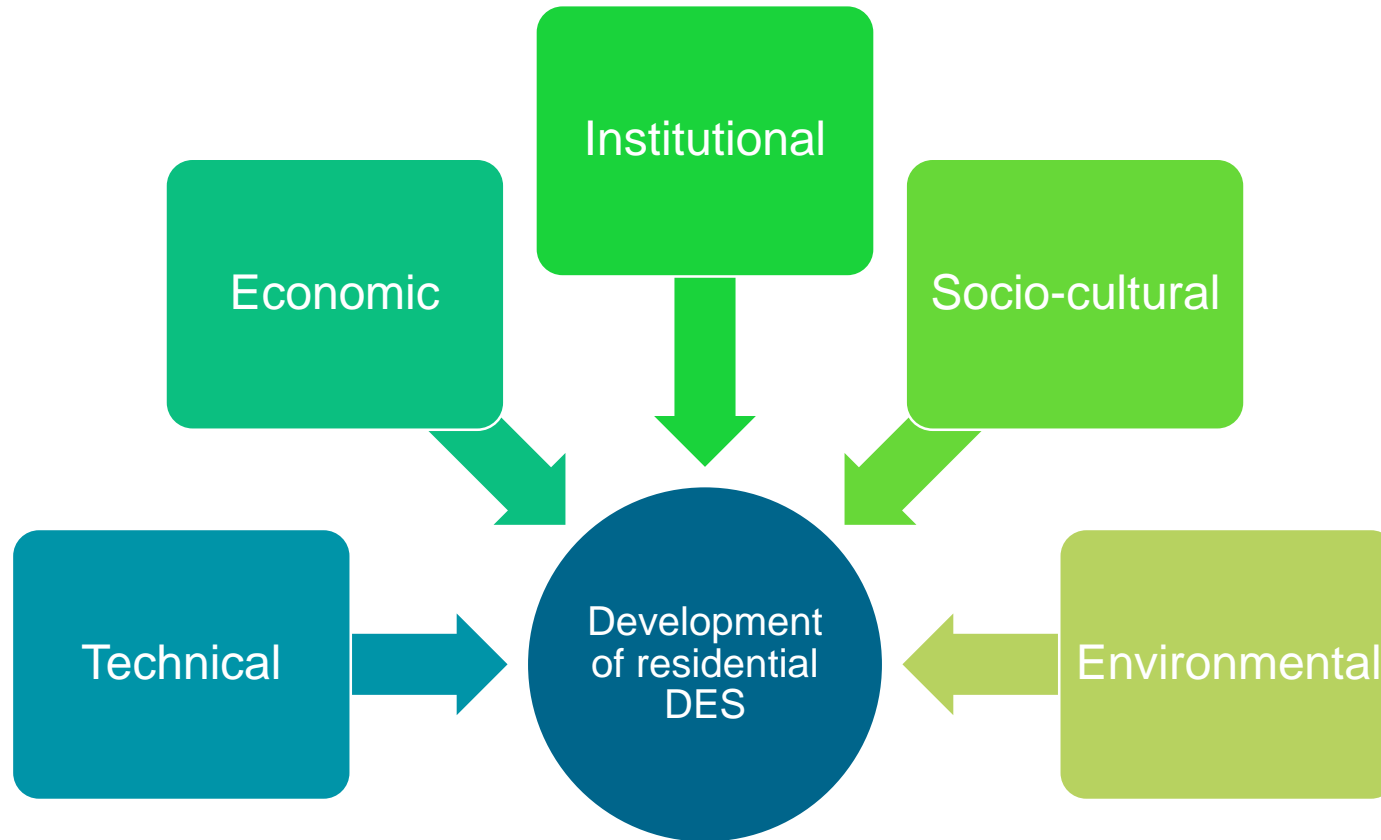
- Development depends on **individual choices** made by private users



Adapted from [1]

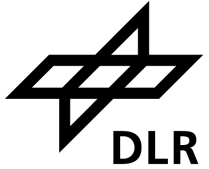
[1] C. Vezzoli, *Designing sustainable energy for all: Sustainable product-service system design applied to distributed renewable energy* / Carlo Vezzoli [and six others] ; with Mary Suzan Abbo [and eleven others]. Cham, Switzerland: Springer, 2018

Factors that influence the development of residential DES



Adapted from: C. Vezzoli, *Designing sustainable energy for all: Sustainable product-service system design applied to distributed renewable energy* / Carlo Vezzoli [and six others] ; with Mary Suzan Abbo [and eleven others]. Cham, Switzerland: Springer, 2018

Research gap, research question and relevance



Knowledge gap

- Effect of factors on the development of residential DES for private users

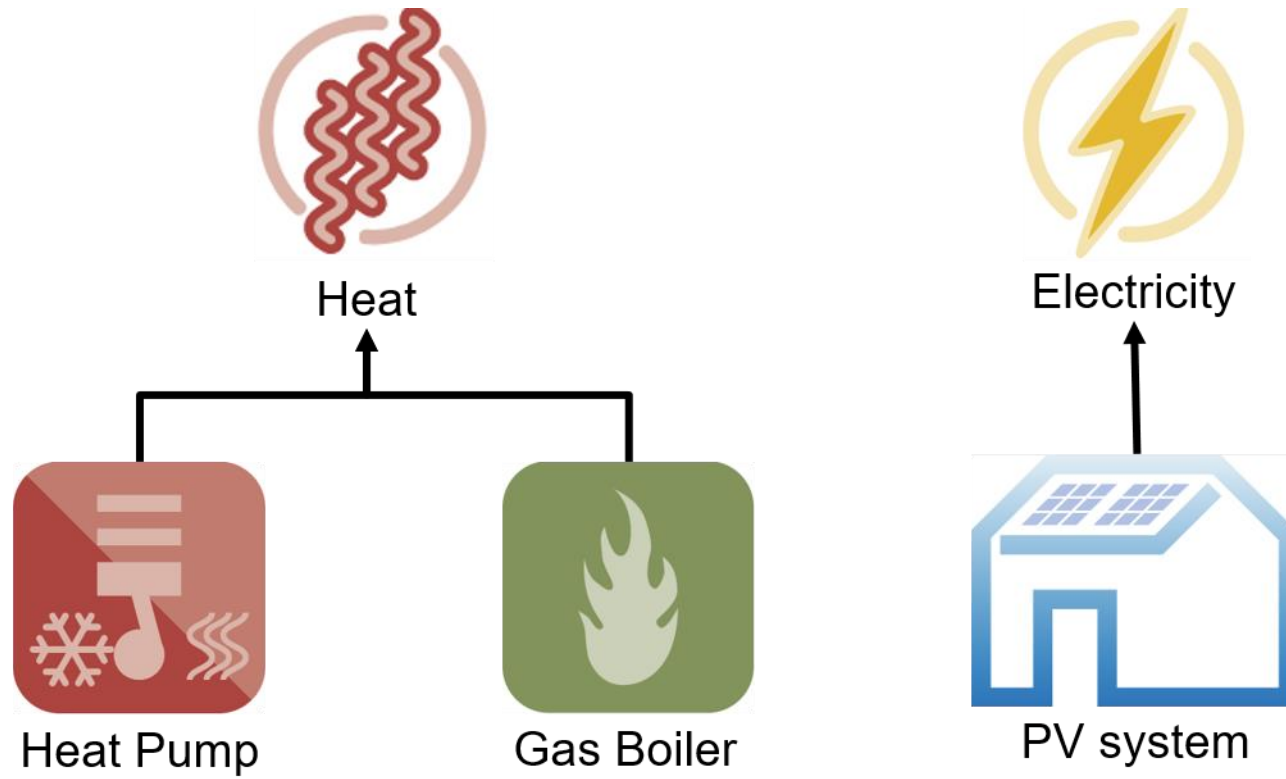
Main research question

- *What effects do incentives, policies and starting situations for residential users have on the evolution of residential energy demands from 2022 until 2030?*

Relevance

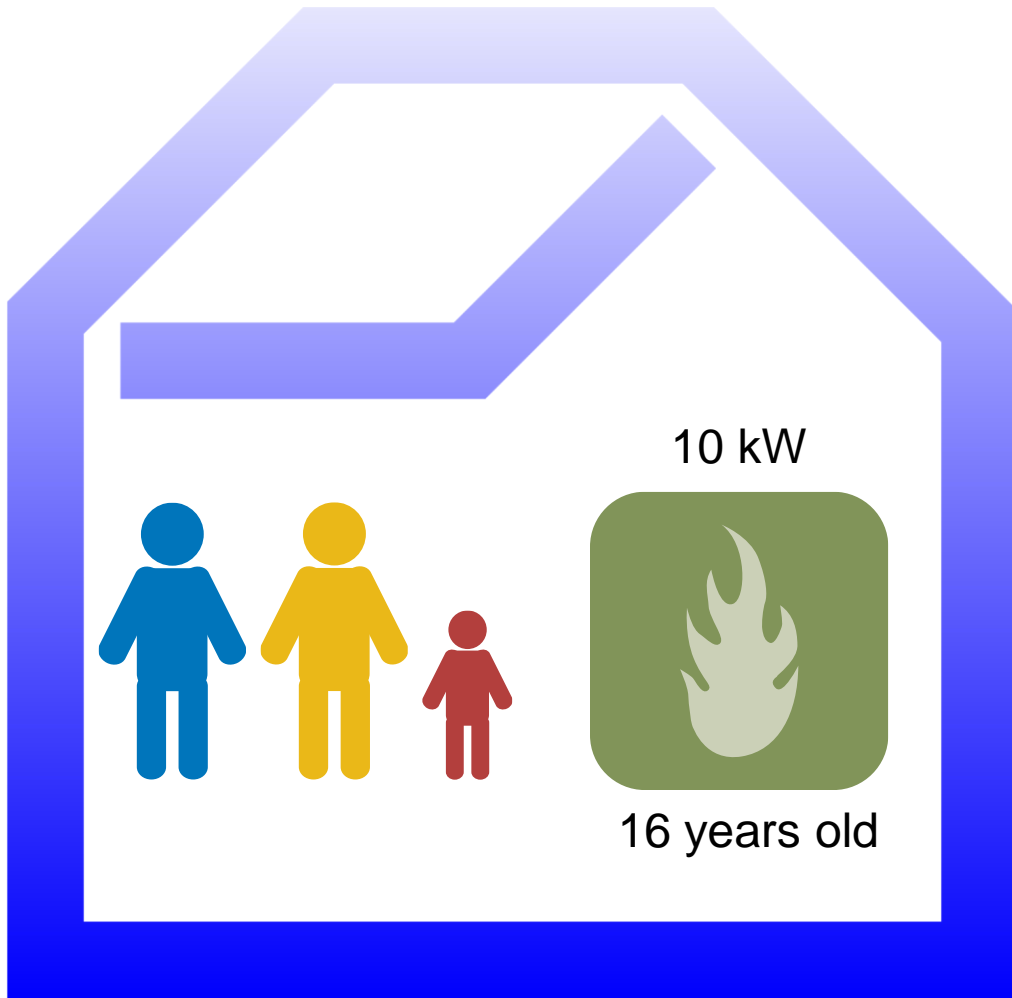
- 65% reduction of emissions by 2030
- Climate neutrality by 2045
- Possible regulation in 2024: 65% of RE sources for heating in residential [1]
 - Ban on new oil or gas heaters, except if supplemented with new technologies
 - Strong incentives might be needed

[1] Federal Ministry for Economic Affairs and Climate Action and Federal Ministry for Housing, Urban Development and Building, *65 Prozent erneuerbare Energien beim Einbau von neuen Heizungen ab 2024: Konzeption zur Umsetzung*, 2022. [Online]. Available: https://www.bmwsb.bund.de/SharedDocs/downloads/Webs/BMWSB/DE/veroeffentlichungen/bauen/konzeptpapier-65-prozent-ee.pdf?__blob=publicationFile&v=5%20.

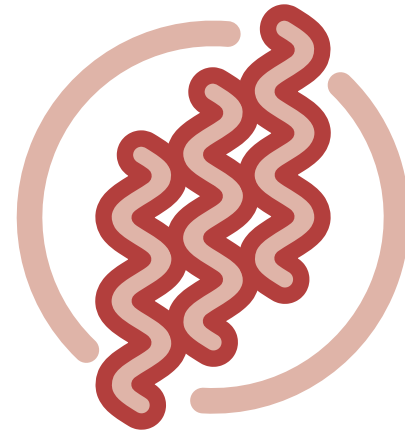


METHOD

Archetype household in 2021



21402 kWh



Hourly heat demand



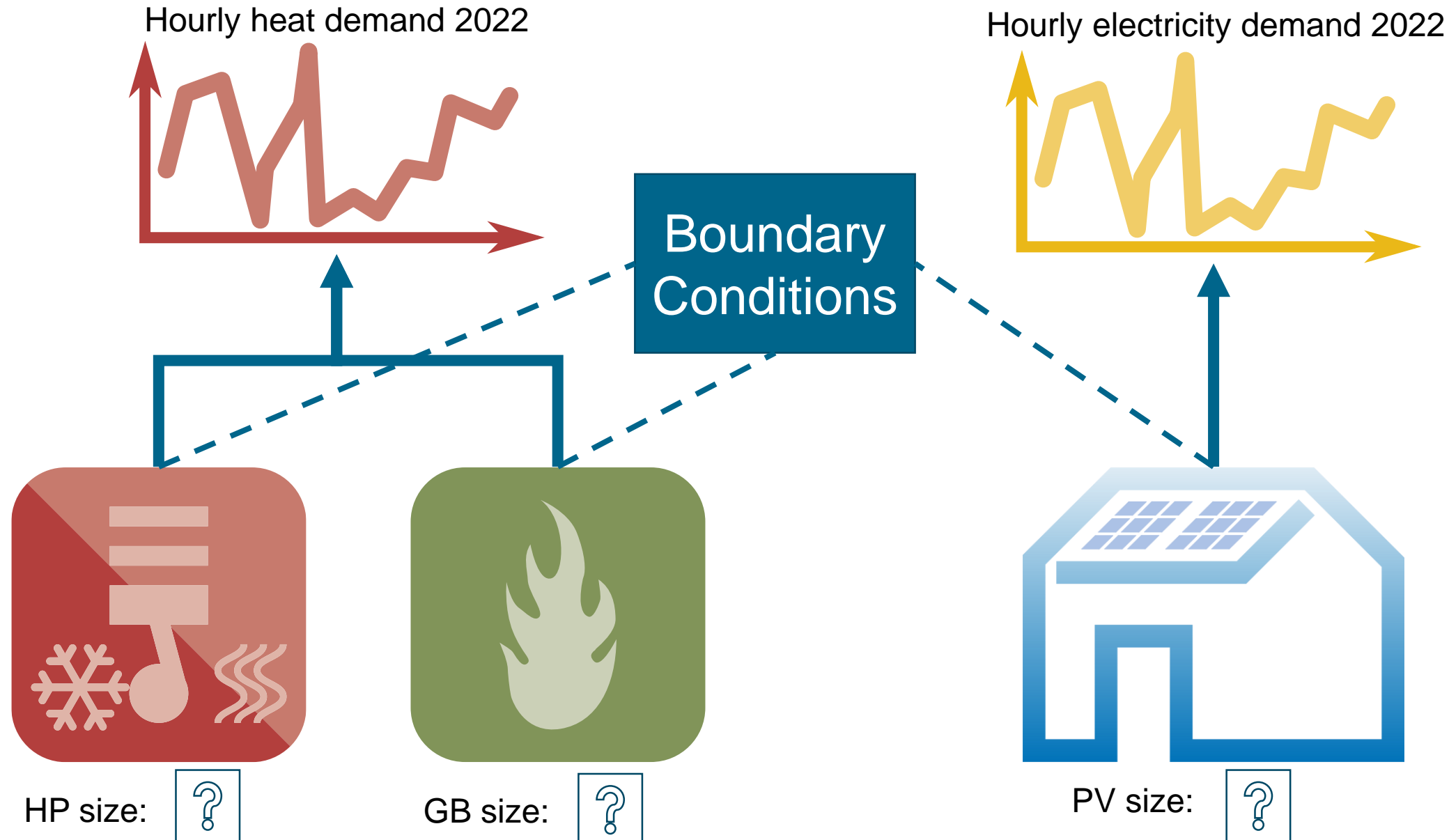
4919 kWh



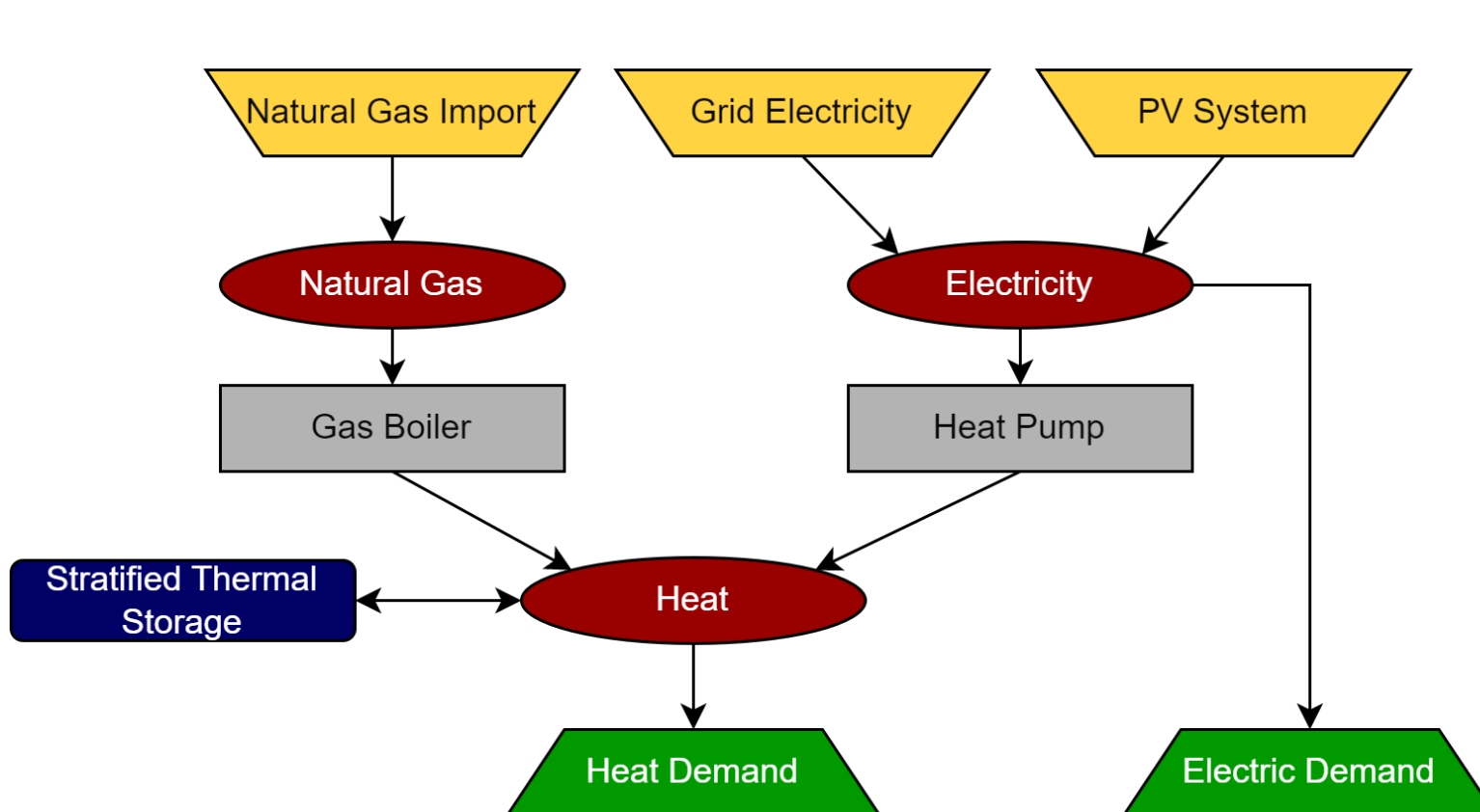
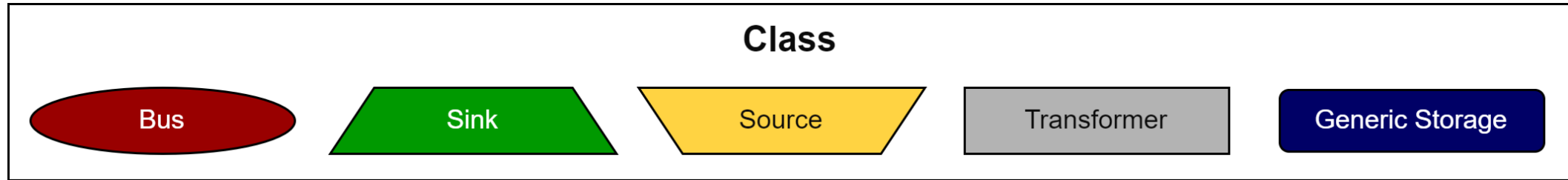
Hourly electricity demand



Investment for residential technologies in 2022

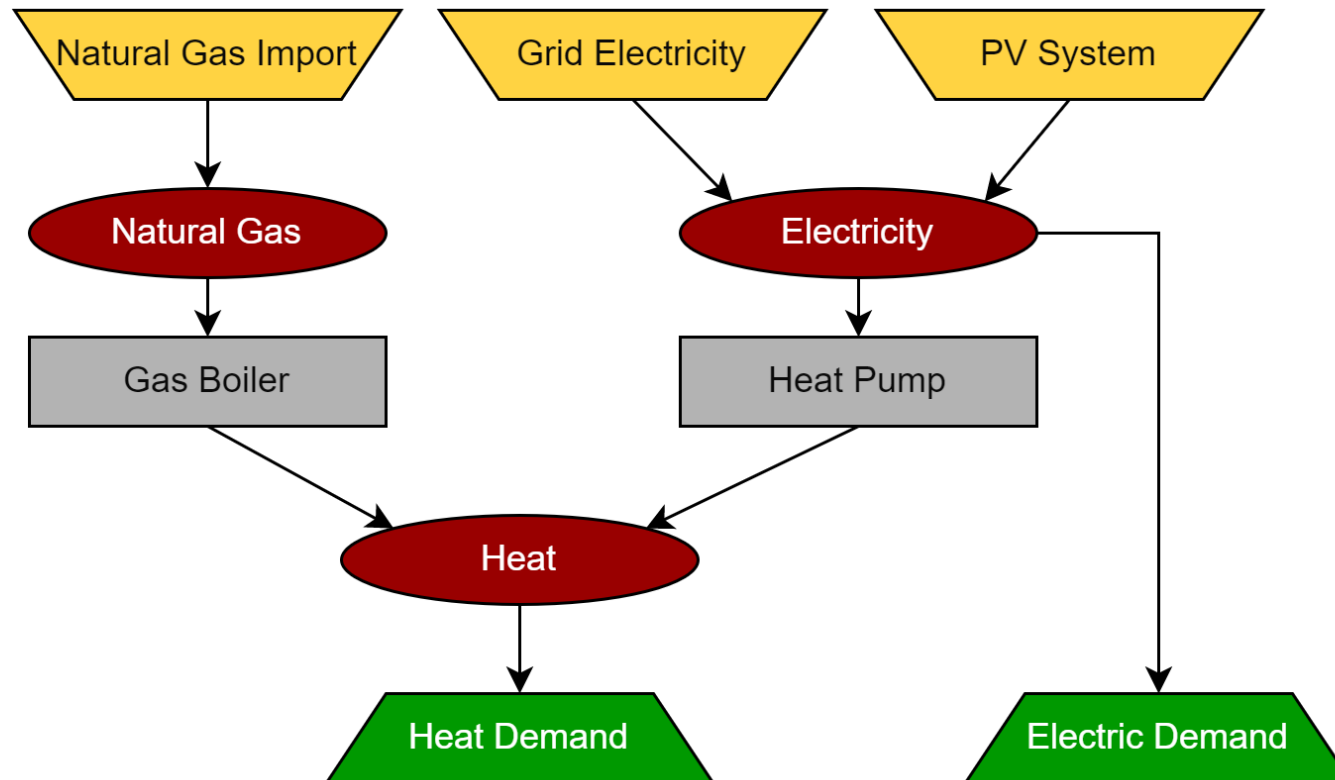
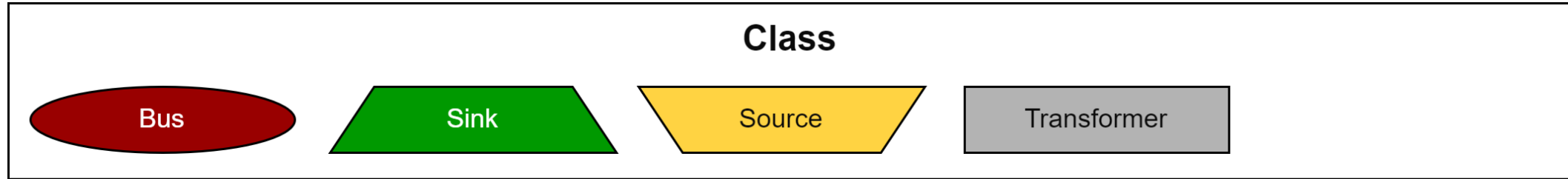


Household energy system model with oemof.solph



- Electricity Price Markov chain
- Gas Price
- Status of Gas Boiler
- Investment and incentives for technologies
- $COP(T_{env})$
- Offset for Investment
- Price Exp. Curves
- Compliance with Policy

Household energy system model with oemof.solph

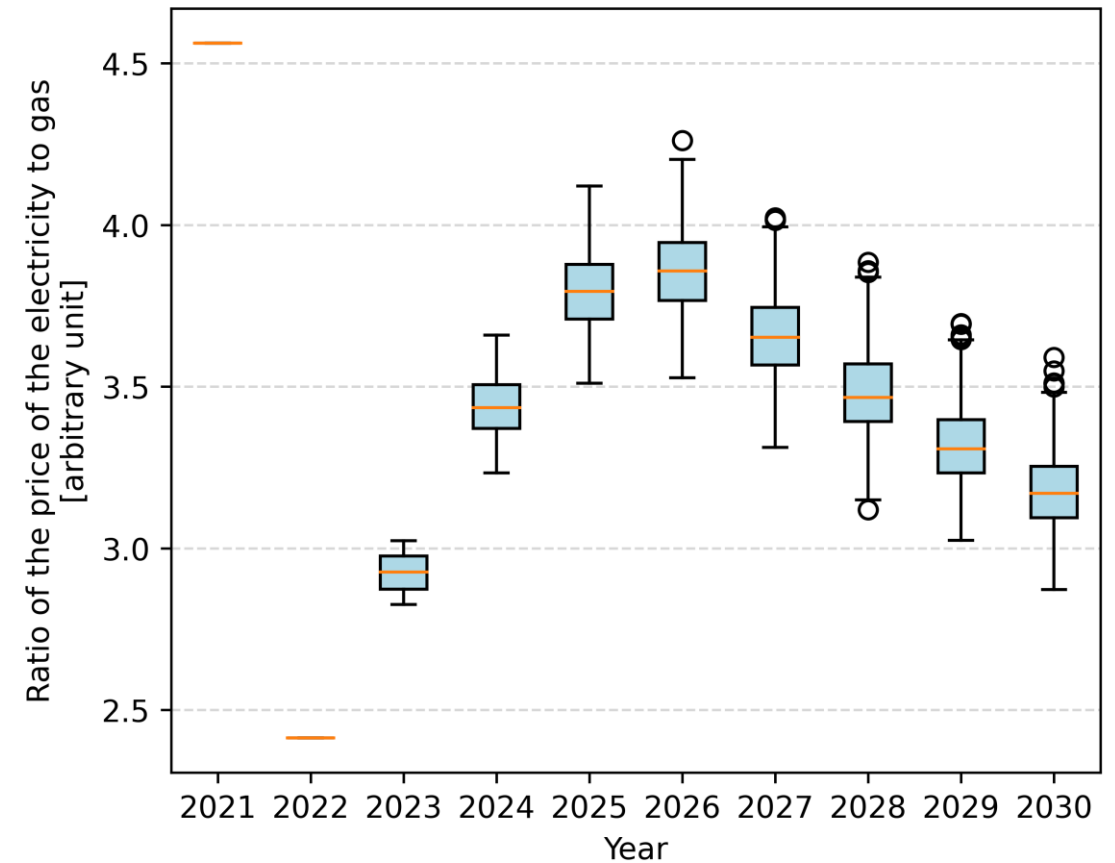
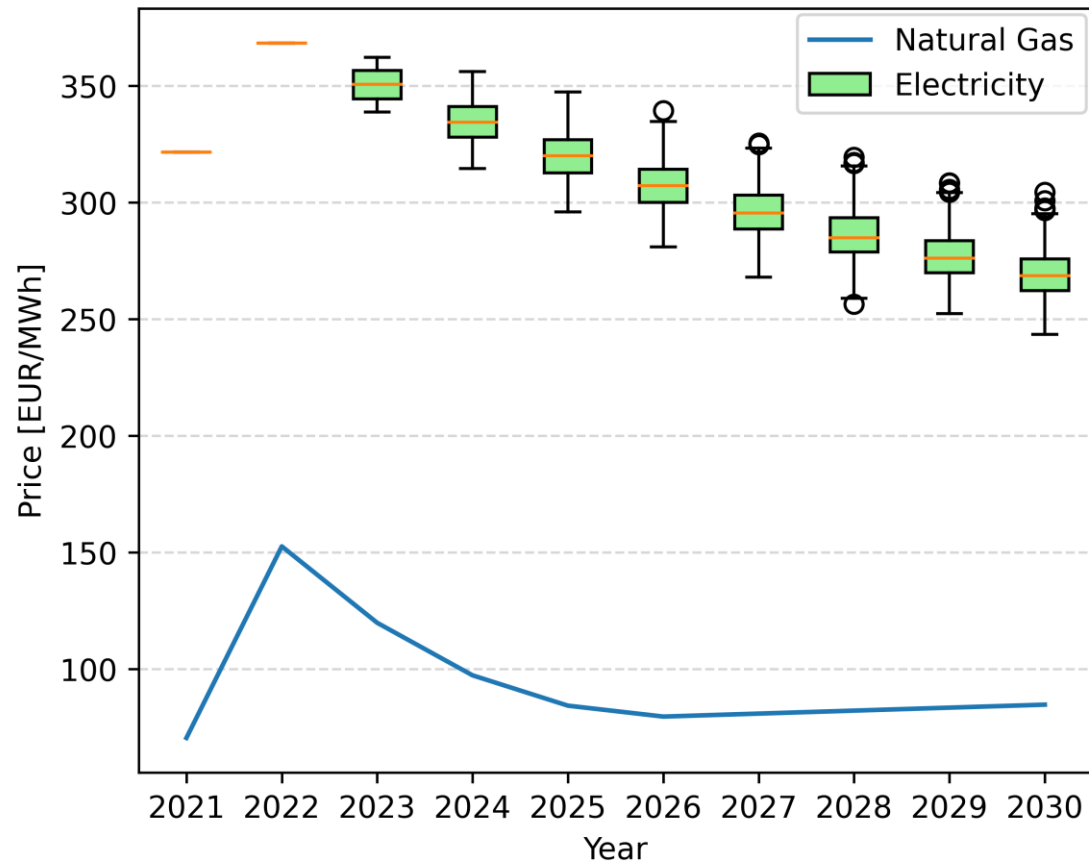


Boundary Conditions

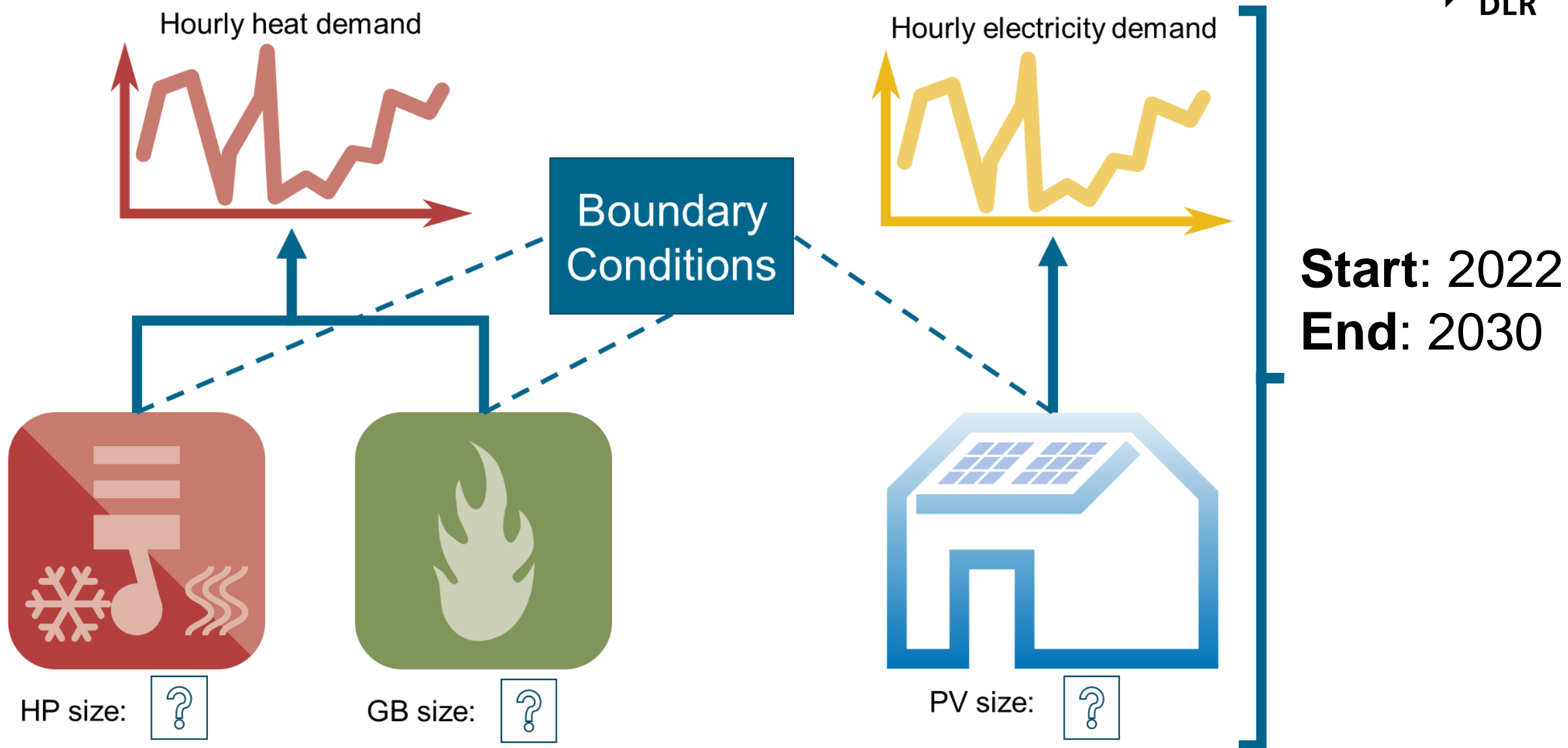
- Electricity Price Markov chain
- Gas Price
- Status of Gas Boiler
- Investment and incentives for technologies
- $COP(T_{env})$
- Offset for Investment
- Price Exp. Curves
- Compliance with Policy

Pilot Study

Forecast of the residential electricity and gas price

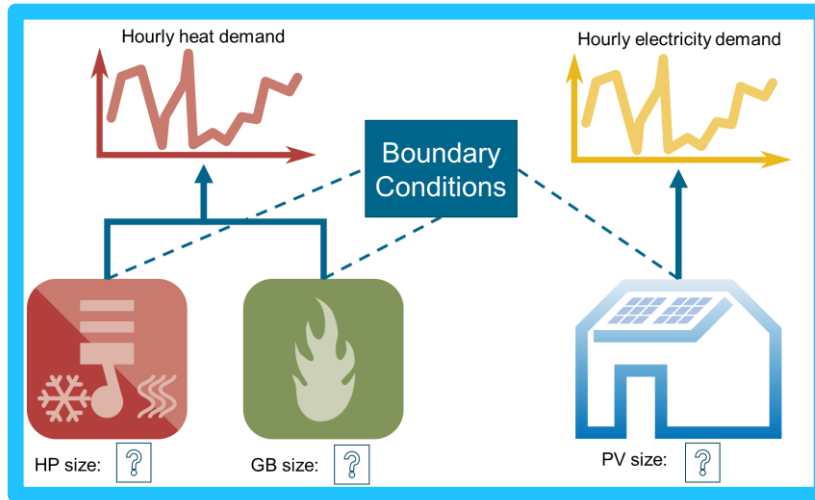


Investment for residential technologies during 2022-2030

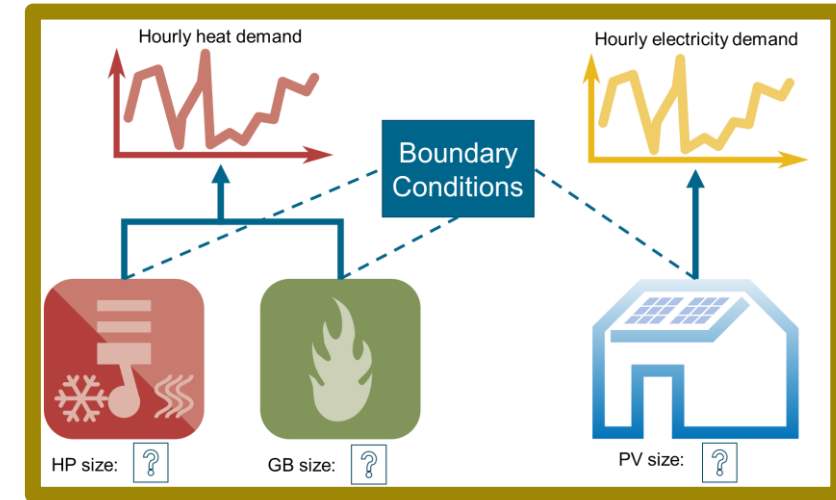


Investment for residential technologies during 2022-2030

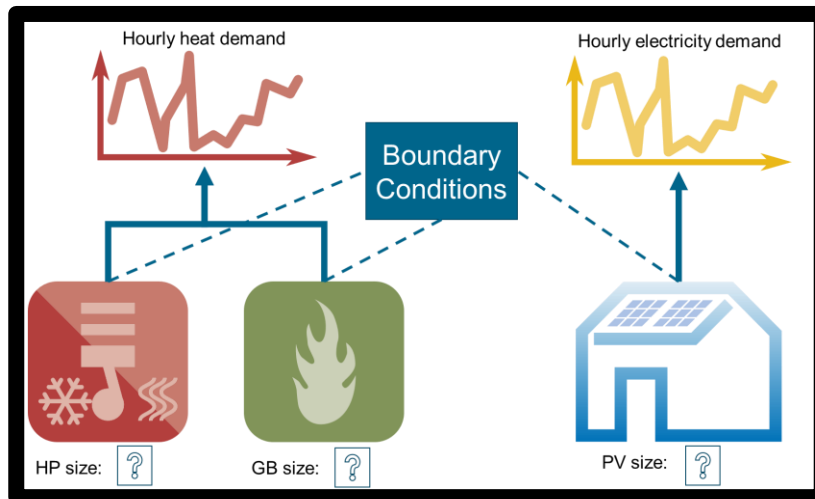
Scenario with no incentives



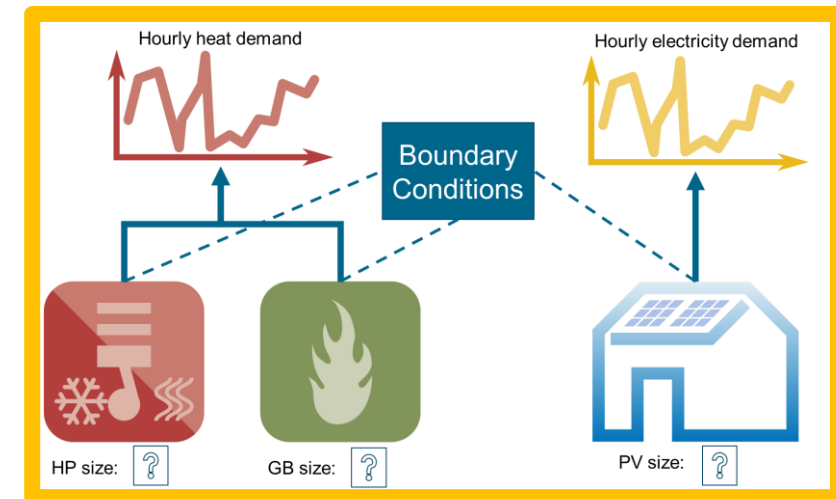
Scenario with only PV feed-in

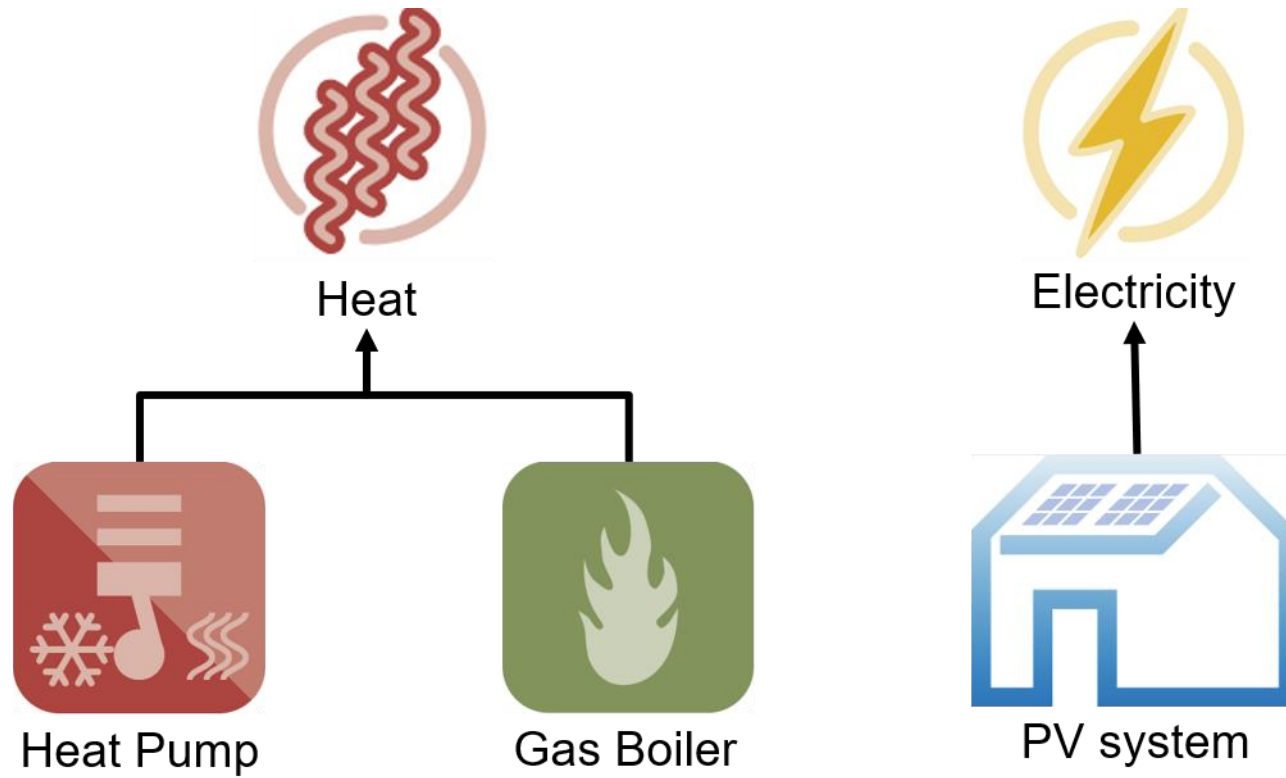


Scenario with only heat pump subsidy



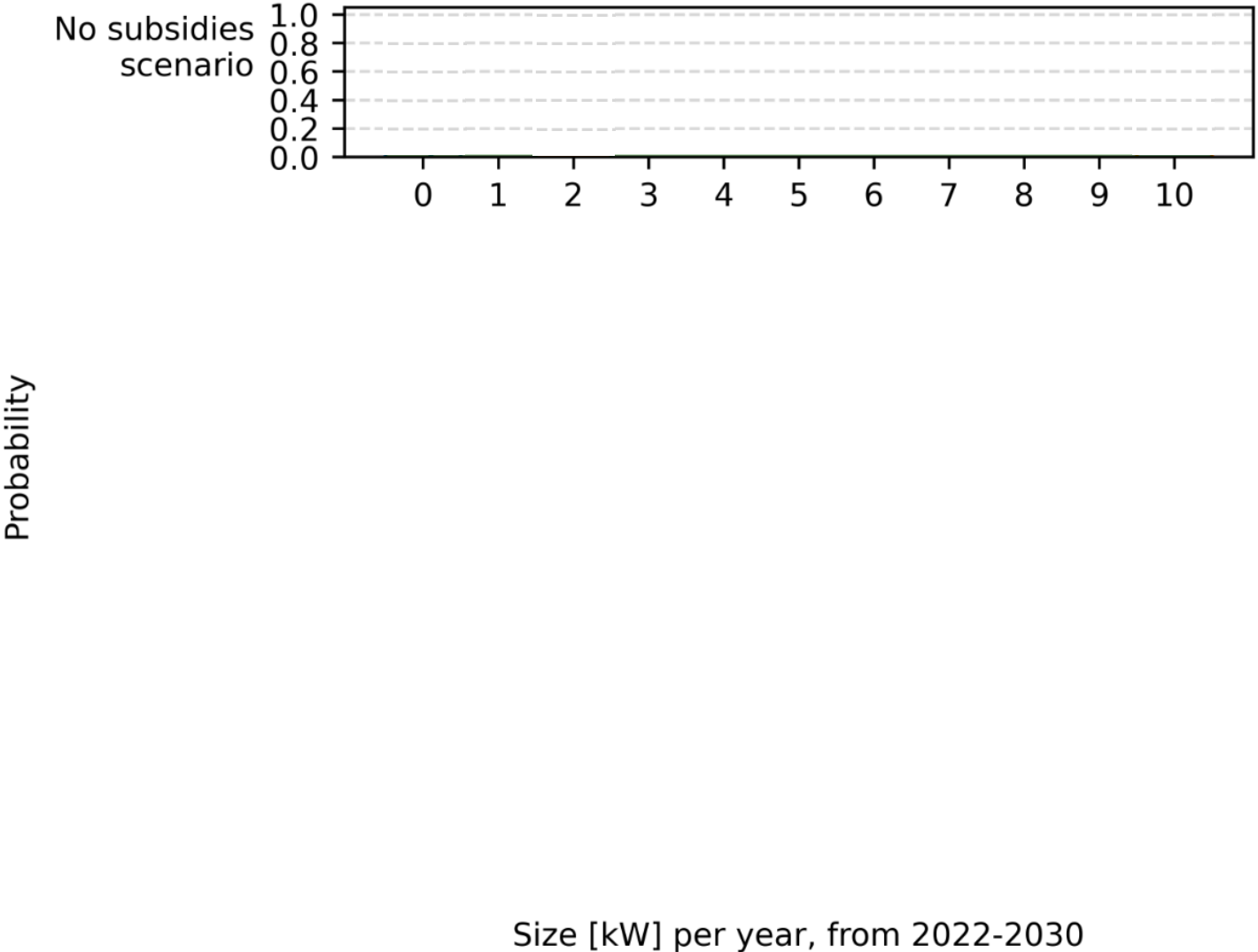
Scenario with all incentives



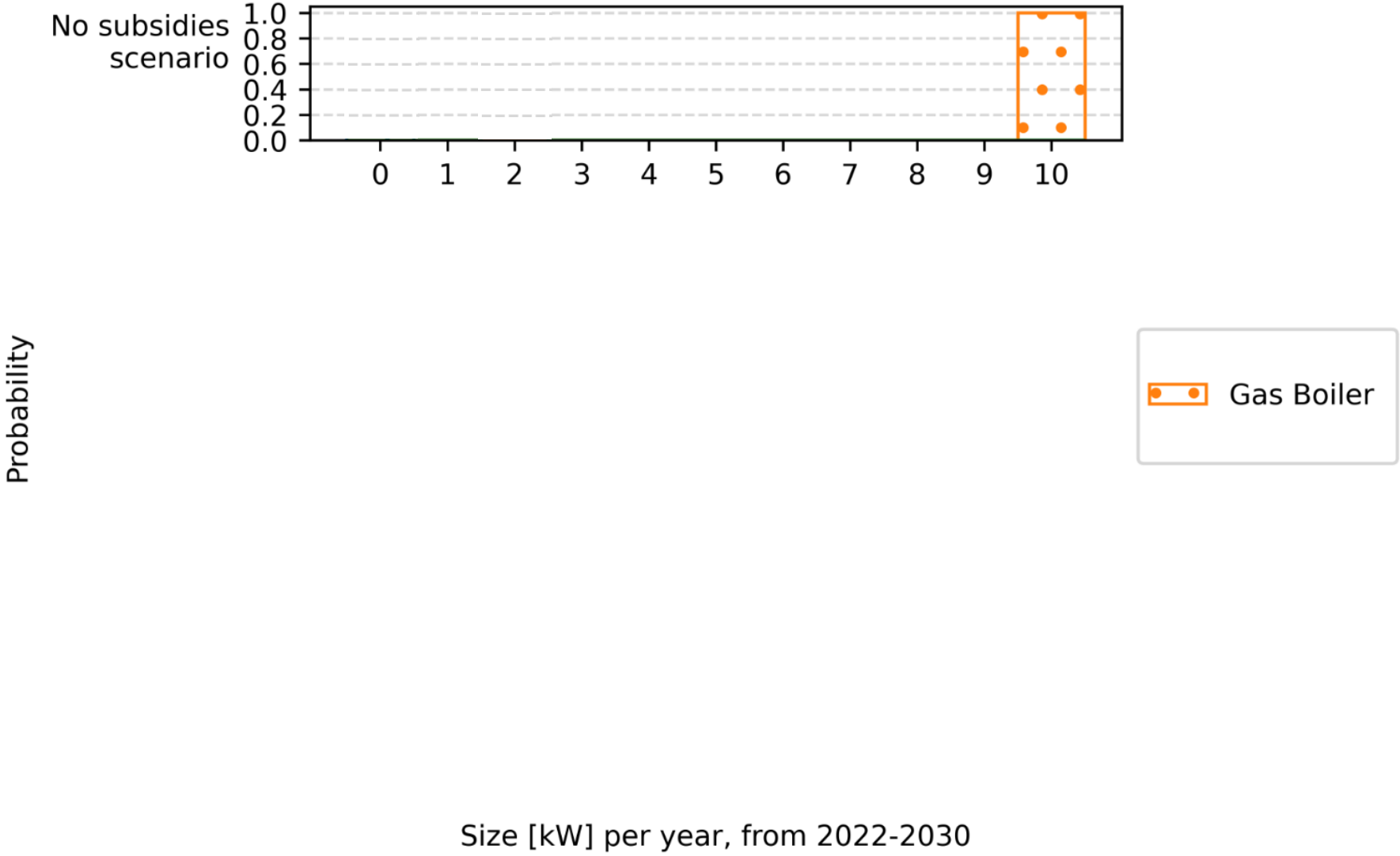


PRELIMINARY RESULTS

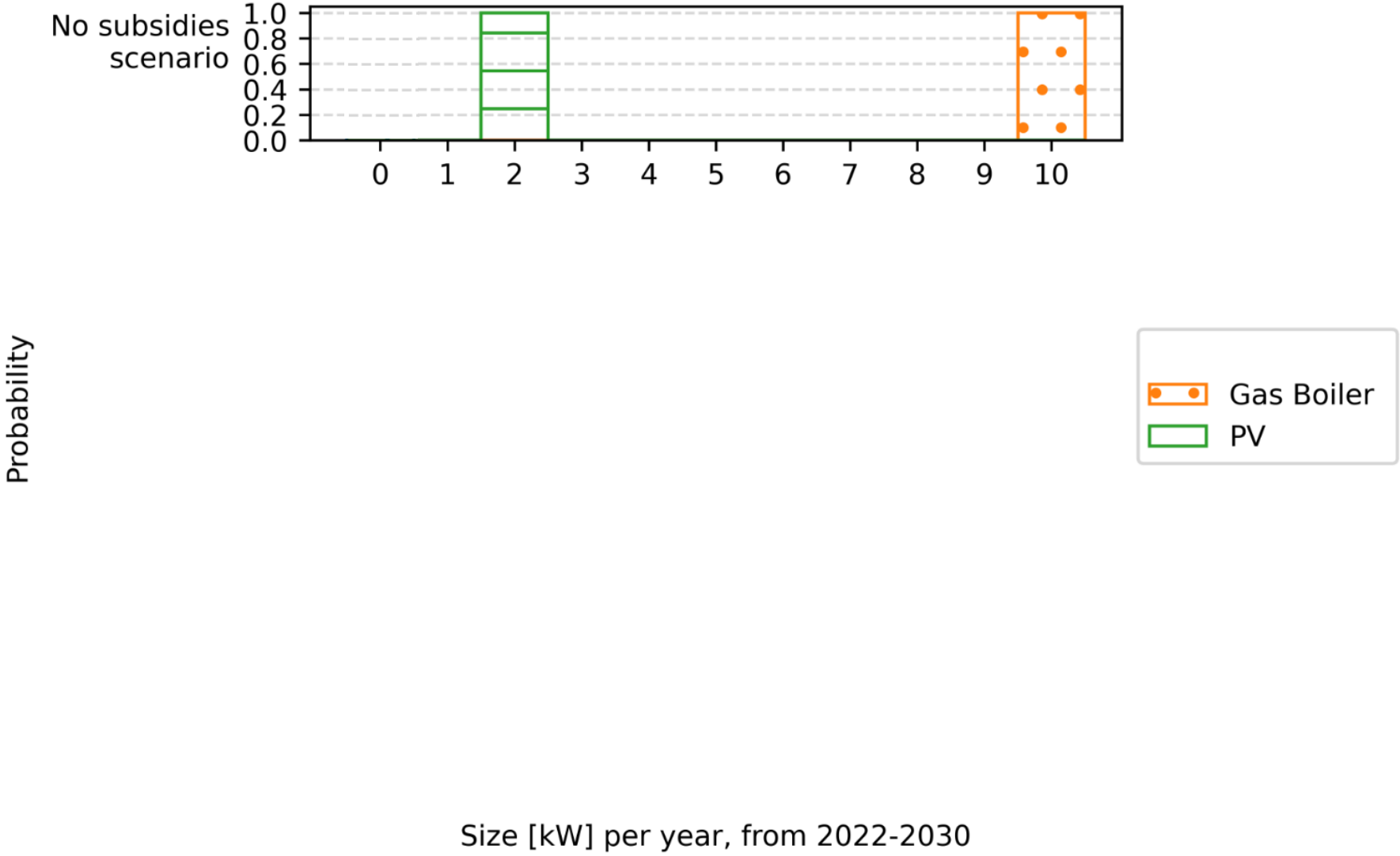
Operational gas boiler cases



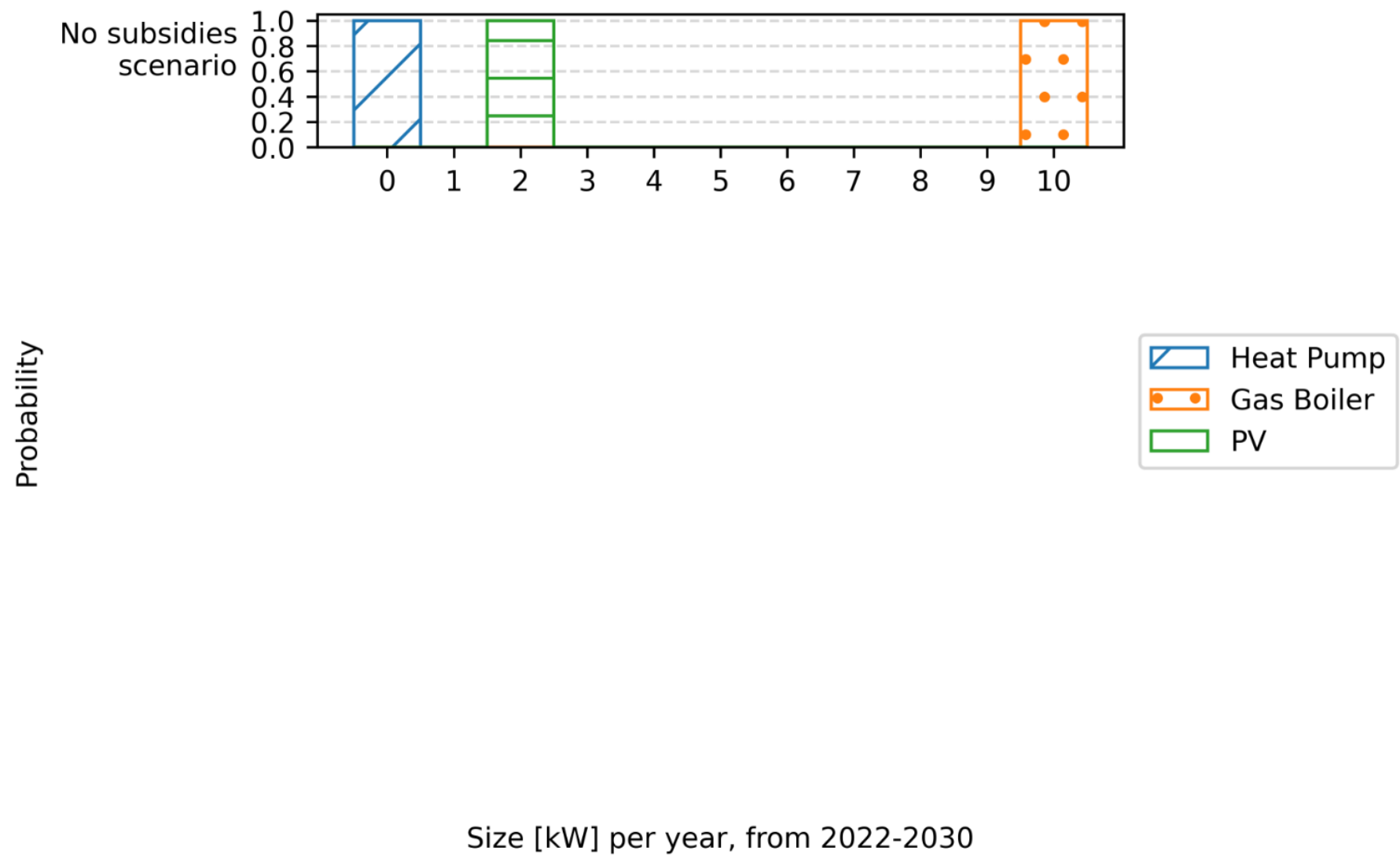
Operational gas boiler cases



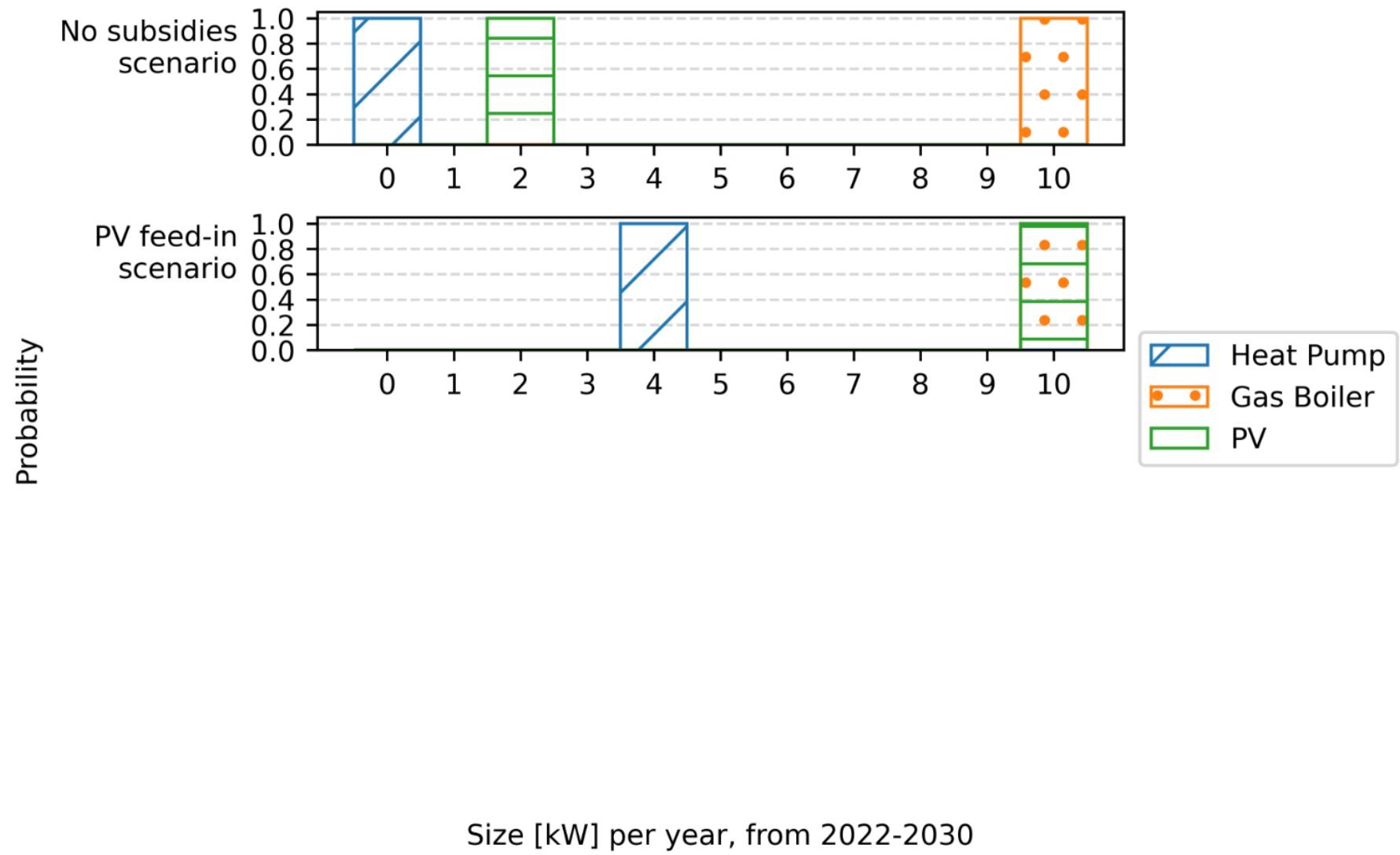
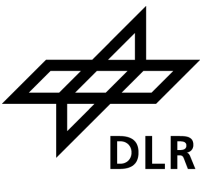
Operational gas boiler cases



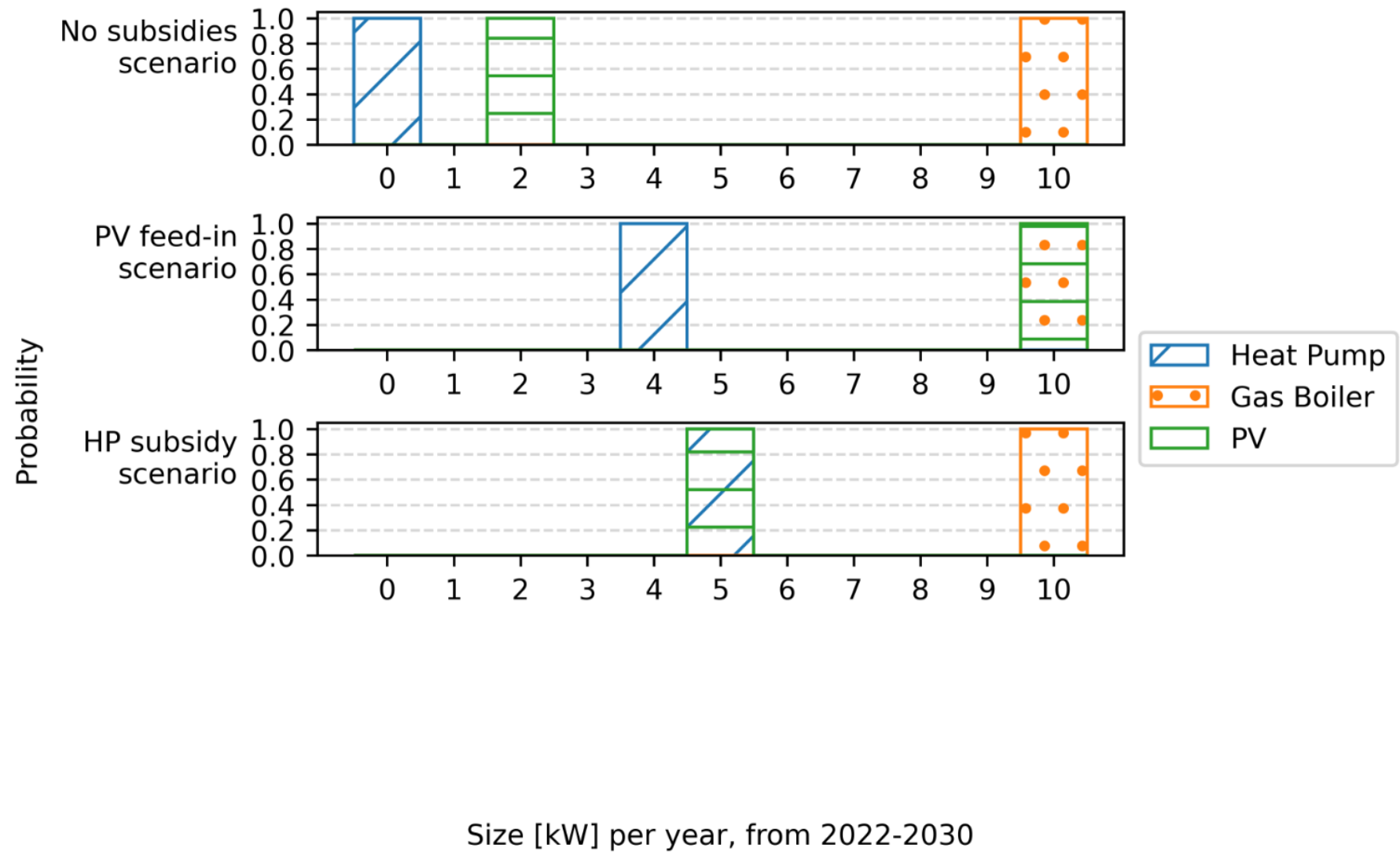
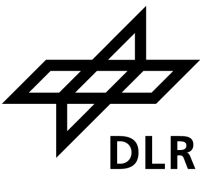
Operational gas boiler cases



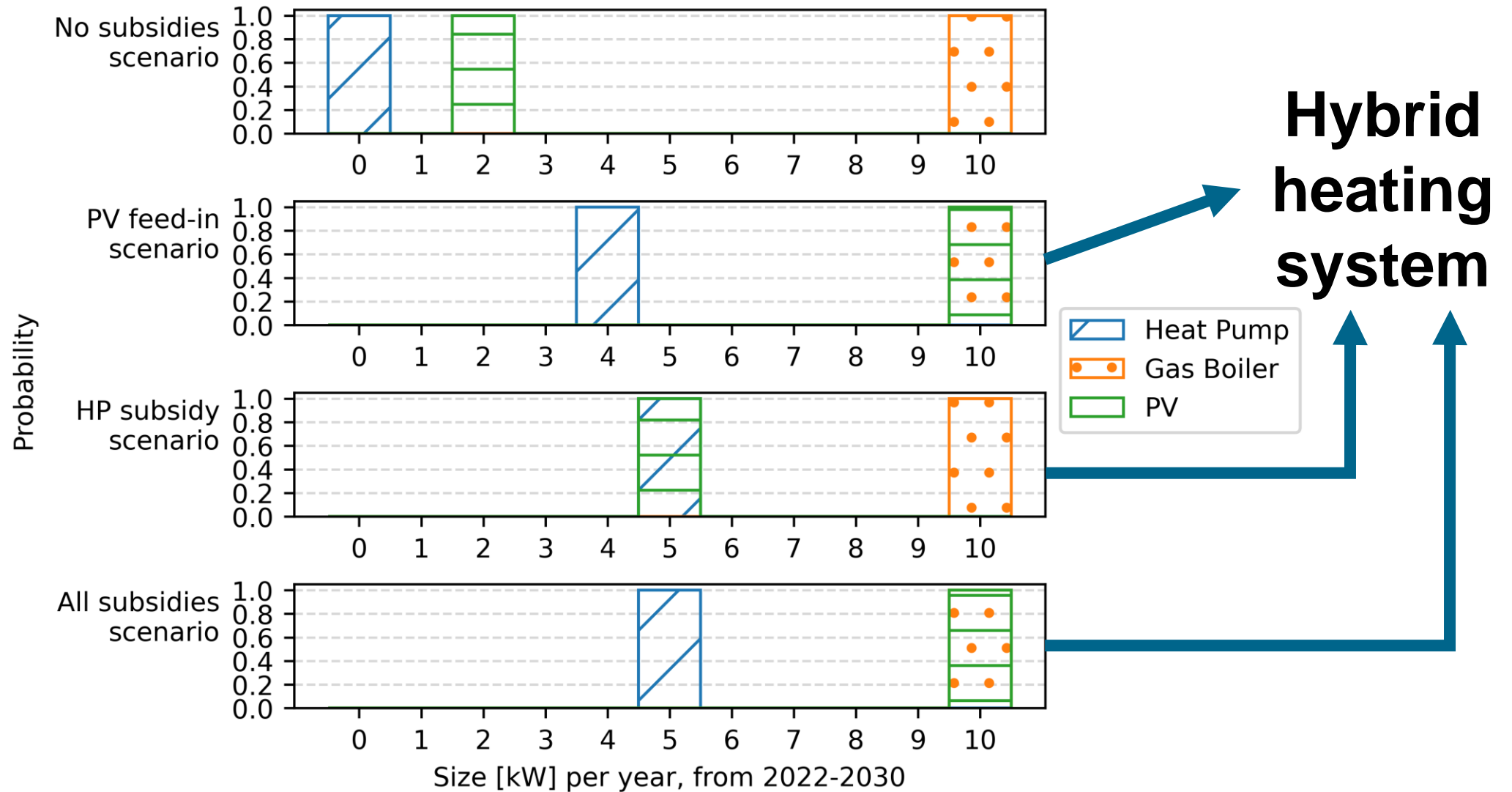
Operational gas boiler cases



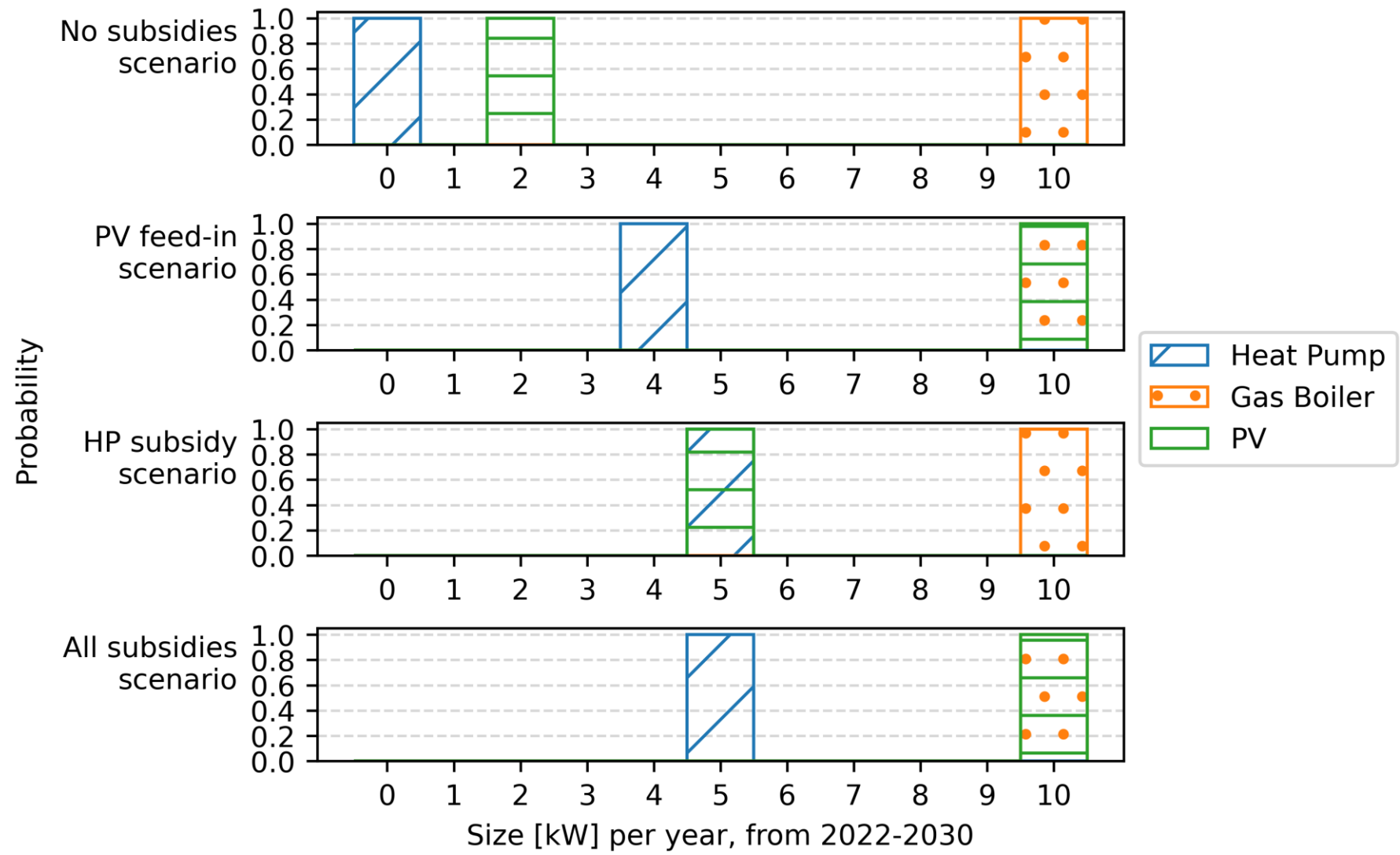
Operational gas boiler cases



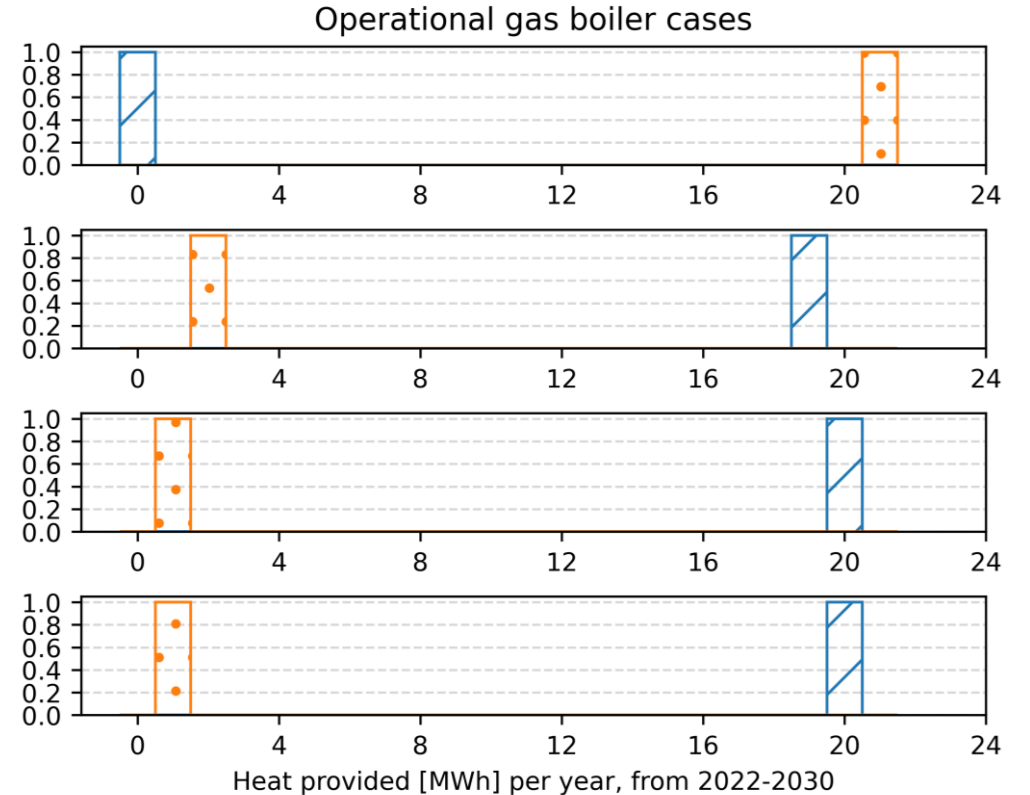
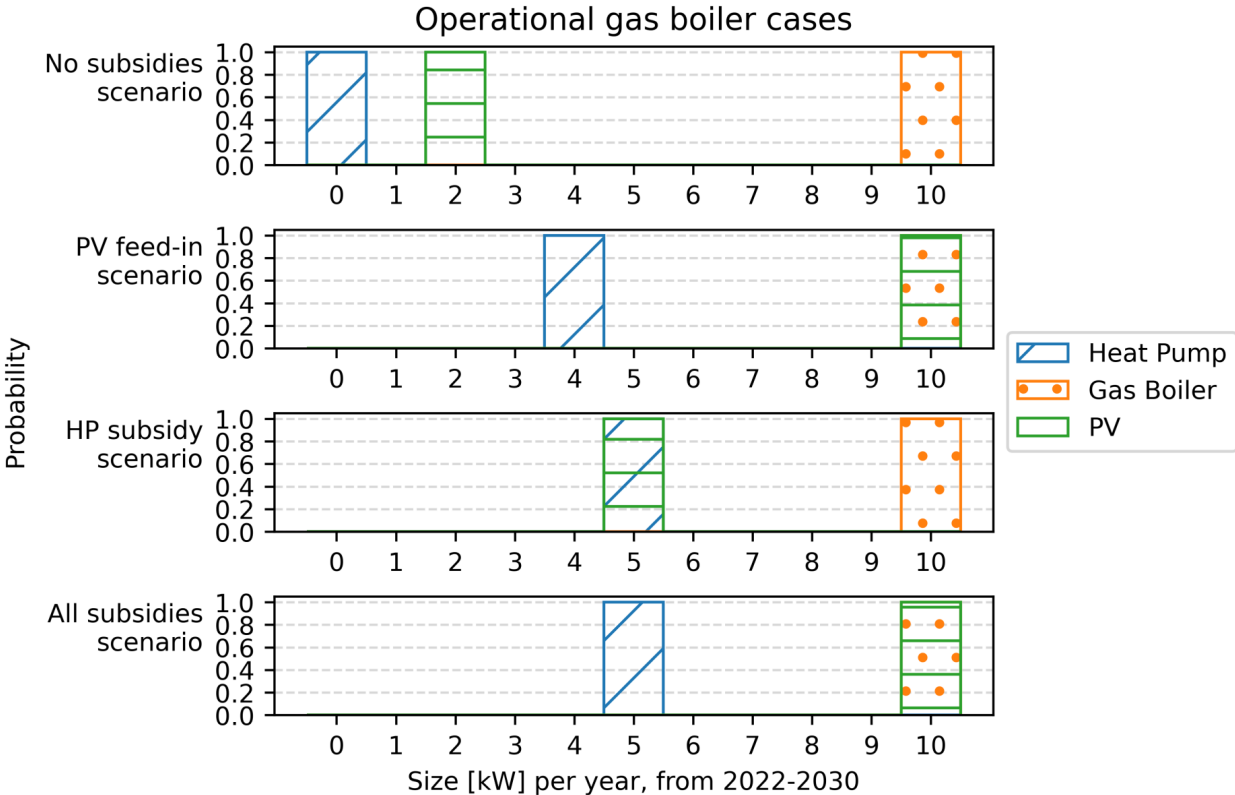
Operational gas boiler cases



Operational gas boiler cases



Operational gas boiler cases






Analysis of the final situation up to 2030

Answer to the research question: *what effects do incentives, policies and starting situations for residential users have on the evolution of residential energy demands from 2022 until 2030?*

Probability distribution			
Scenario			
No subsidies			




Analysis of the final situation up to 2030

Answer to the research question: *what effects do incentives, policies and starting situations for residential users have on the evolution of residential energy demands from 2022 until 2030?*

Probability distribution			
Scenario			
No subsidies	22%	78%	0%







Analysis of the final situation up to 2030

Answer to the research question: *what effects do incentives, policies and starting situations for residential users have on the evolution of residential energy demands from 2022 until 2030?*

Probability distribution			
Scenario			
No subsidies	22%	78%	0%
Only PV feed-in	21%	0%	79%




Analysis of the final situation up to 2030

Answer to the research question: *what effects do incentives, policies and starting situations for residential users have on the evolution of residential energy demands from 2022 until 2030?*

	HP	GB	Hybrid	Probability distribution		
						
Scenario						
No subsidies	22%	78%	0%			
Only PV feed-in	21%	0%	79%			
Only heat pump subsidy	79%	0%	21%			







Analysis of the final situation up to 2030

Answer to the research question: *what effects do incentives, policies and starting situations for residential users have on the evolution of residential energy demands from 2022 until 2030?*

Probability distribution			
Scenario			
No subsidies	22%	78%	0%
Only PV feed-in	21%	0%	79%
Only heat pump subsidy	79%	0%	21%
All subsidies	83%	0%	17%

Analysis of the final situation up to 2030

Answer to the research question: *what effects do incentives, policies and starting situations for residential users have on the evolution of residential energy demands from 2022 until 2030?*

	HP 	GB 	Hybrid 
	Probability distribution		
Scenario			
No subsidies	22% 100%	78% 100%	0%
Only PV feed-in	21% 100%	0%	79% 90%
Only heat pump subsidy	79% 100%	0%	21% 93%
All subsidies	83% 100%	0%	17% 93%

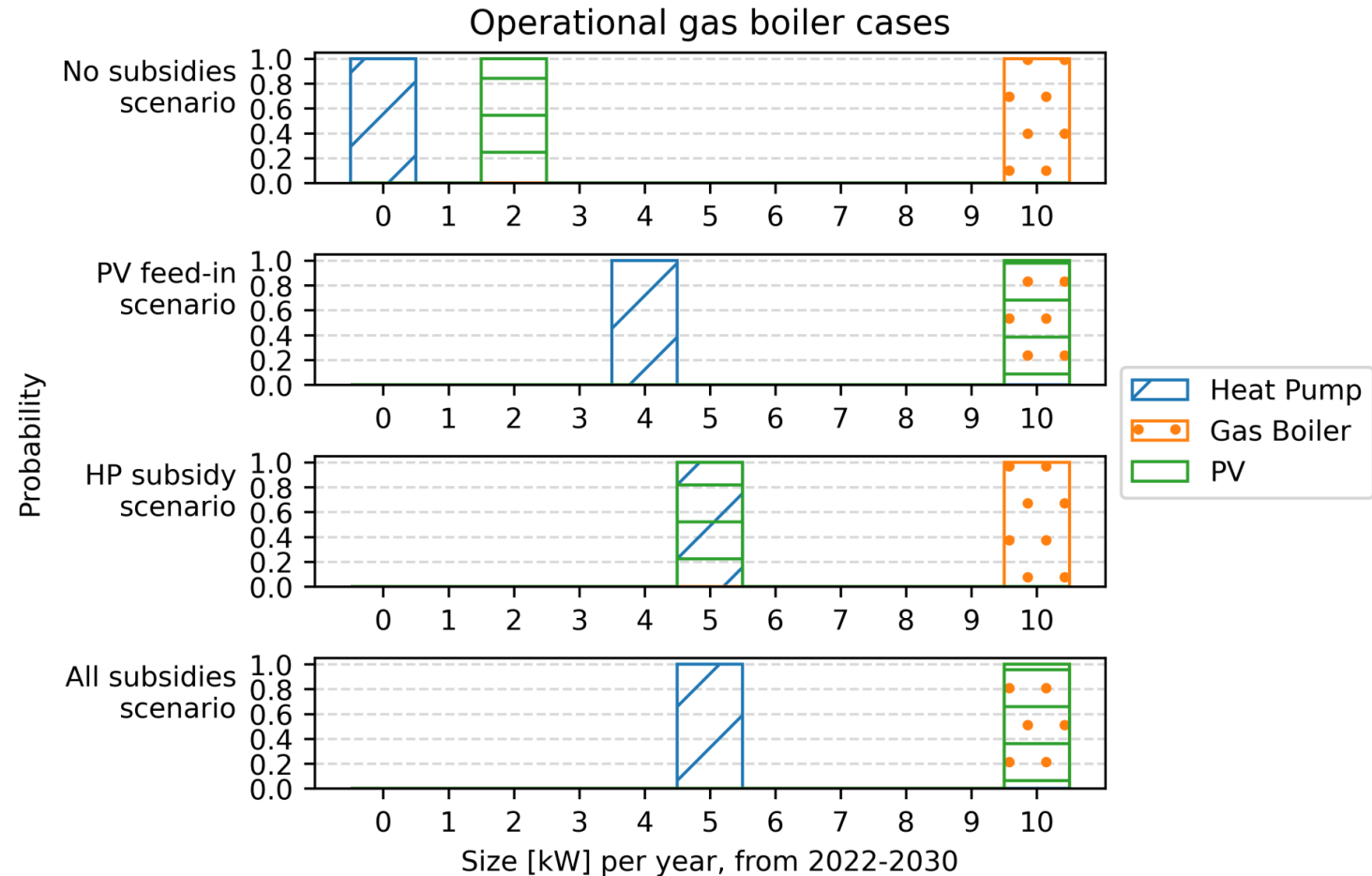
Interdependencies and Technology Lock-ins

Interdependencies

- With at least one incentive, PV system promoted heat pump, in cases of operational and broken
- In broken gas boiler cases, sum of heat pump and gas boiler sizes equaled the heat demand

Technology lock-ins

- With no subsidies: gas boiler was replaced by another one when it broke
- Always there was a likelihood for gas boiler to be present, either alone or in hybrid system



Summary for Pilot Study



No incentives:
gas boiler
prevalence

Only PV feed-in:
hybrid
prevalence

Only heat pump
subsidy: heat
pump
prevalence

All subsidies:
heat pump
prevalence

Incentives
decreased the
presence of gas
boilers

Incentives as
drivers of
heating from RE