Overview of PVP Concepts within the EU

Andreas Fleischhacker, Johannes Radl and Georg Lettner (TU Wien)

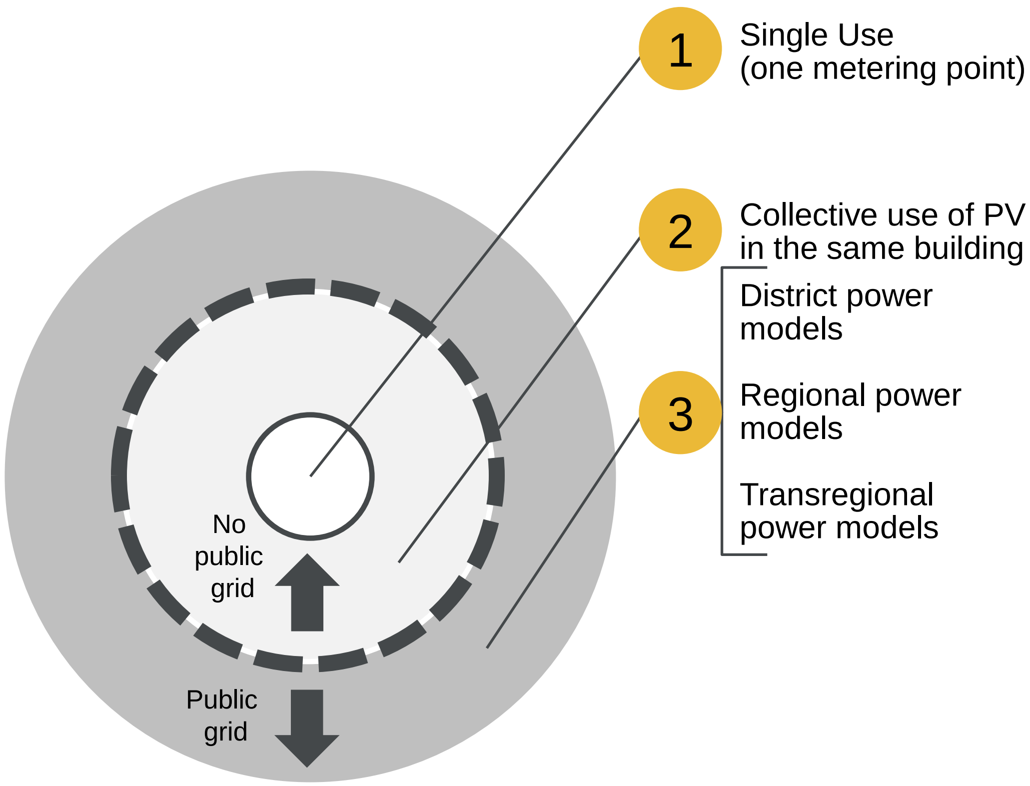
Workshop on innovation and challenges in the implementation of PV self-consumption in the EU

Brussels, 29.05.2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 764786

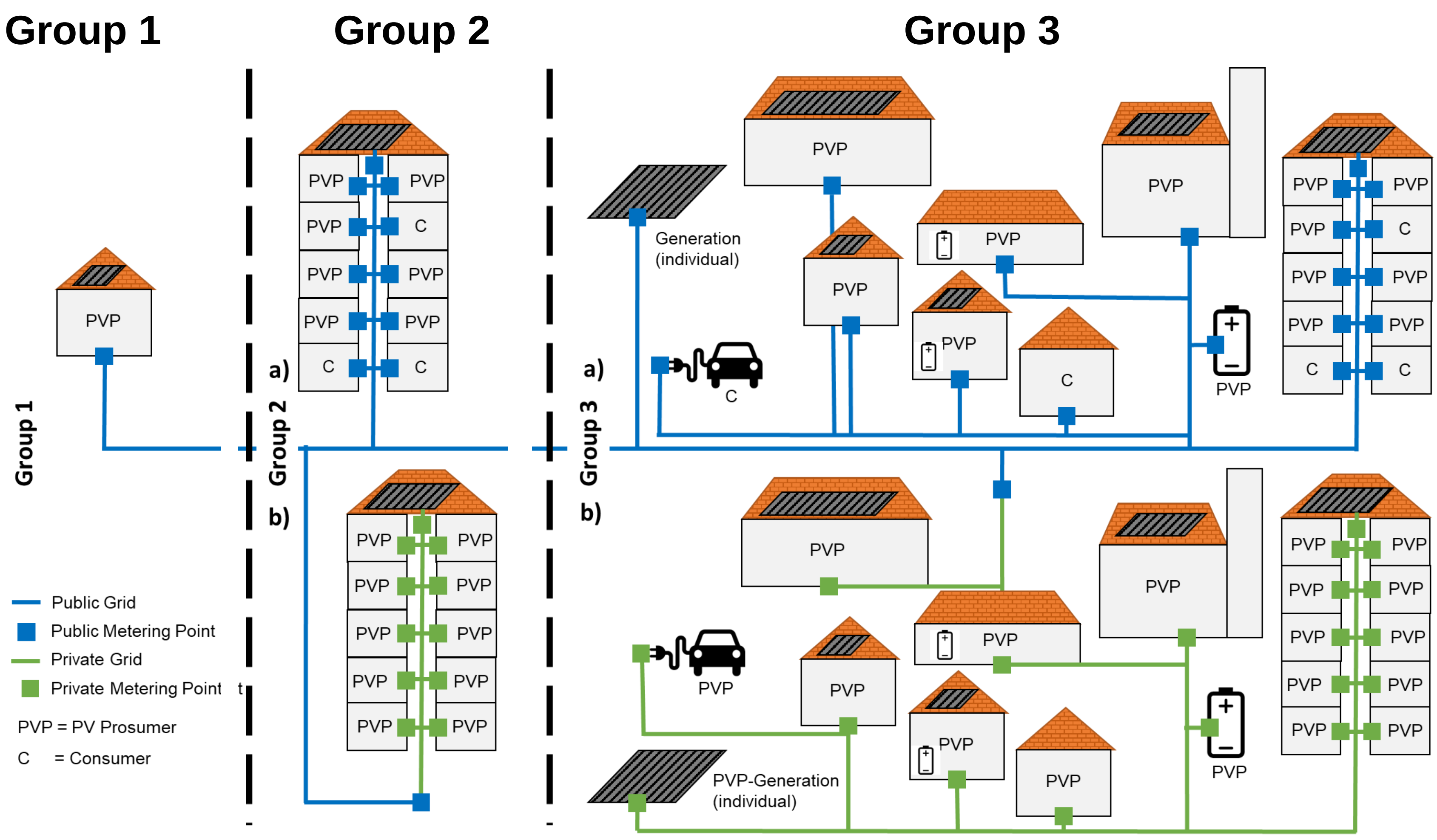
First Classification of current PVP4Grid concepts

- **Group 1:** private local (on-site) self-consumption where only one actor aims at consuming PV electricity at one place.
- **Group 2:** collective self-consumption where a group of actors aims at consuming electricity from a shared PV system.
- **Group 3:** virtual self-consumption where generation and consumption of PV happens at the same time but different locations.



Source: Lettner G., Auer H.,, et al. “D2.1 - Existing and Future PV Prosumer Concepts”, Public Report, 2018.

A more detailed view on the three groups



Source: Lettner G., Auer H.,, et al. “D2.1 - Existing and Future PV Prosumer Concepts”, Public Report, 2018.

Framework in PVP4Grid target countries

YES
YES with barriers
NO

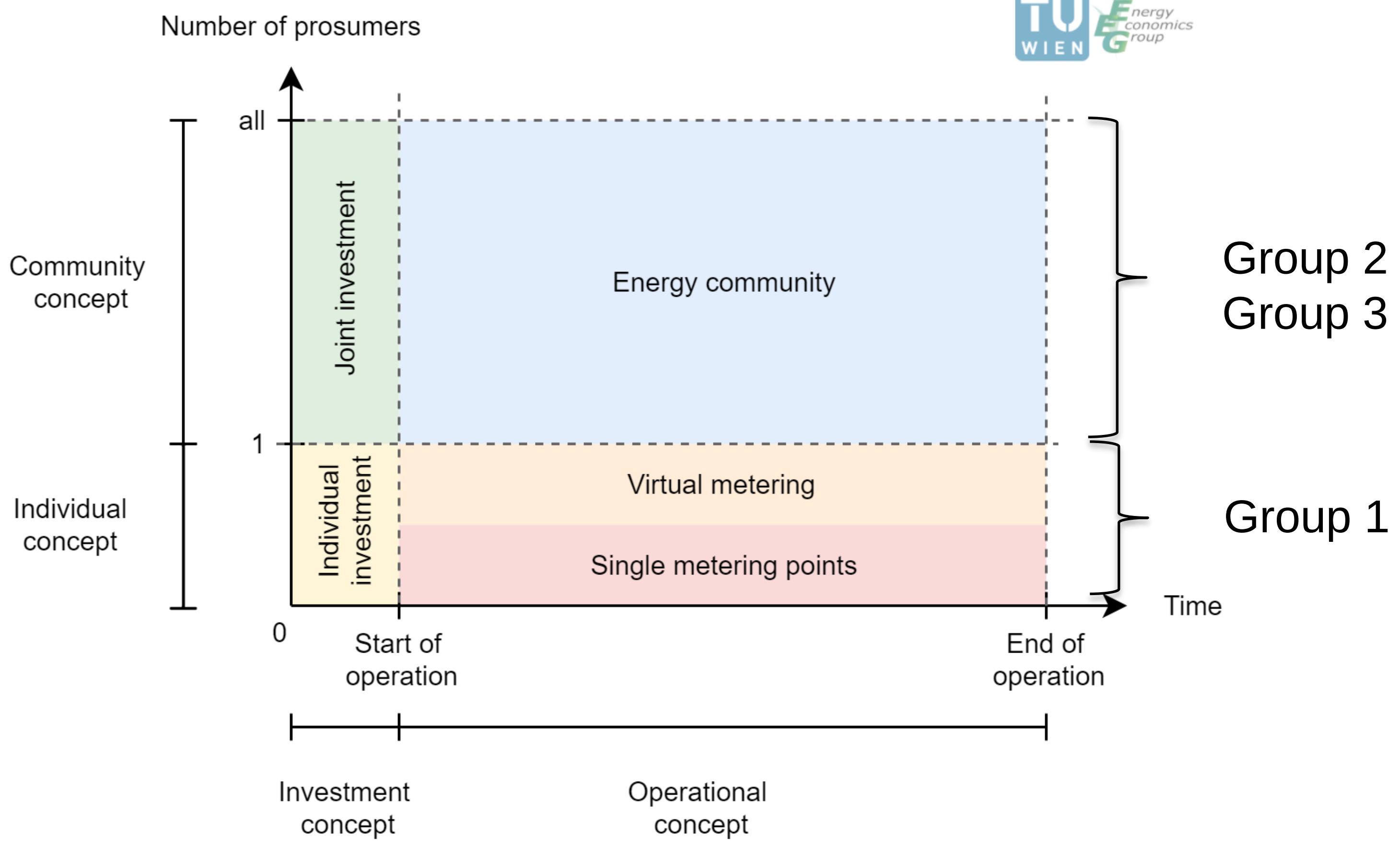
Country	Group 1	Group 2	Group 3
Austria	SC, MP, FiT, financial support	SC with two allocation methods, MP	
Belgium	SC, NM	Exceptions at reginal level	Exceptions at reginal level
France	SC, FiT, financial support	SC, VPN embedded in the public network	Limitation to the same low voltage station, but allowed
Germany	SC, FiT	SC, "Mieterstrommodelle" (neighbour solar supply model) PPA possible	Allowed, however, hardly found
Italy	(1) SC+PPA (2) NM (or NB)		
Netherlands	SC, NM	SC for apartments buildings	Postal Code Rose Policy
Portugal	SC, MP	Strong implementation barriers	Strong implementation barriers
Spain	(1) SC, no remuneration for excess (2) SC + MP		

SC: Self-consumption
NM: Net-Metering

PPA: Power purchase agreement
VPN: Virtual private network

FiT: Feed-In Tariff

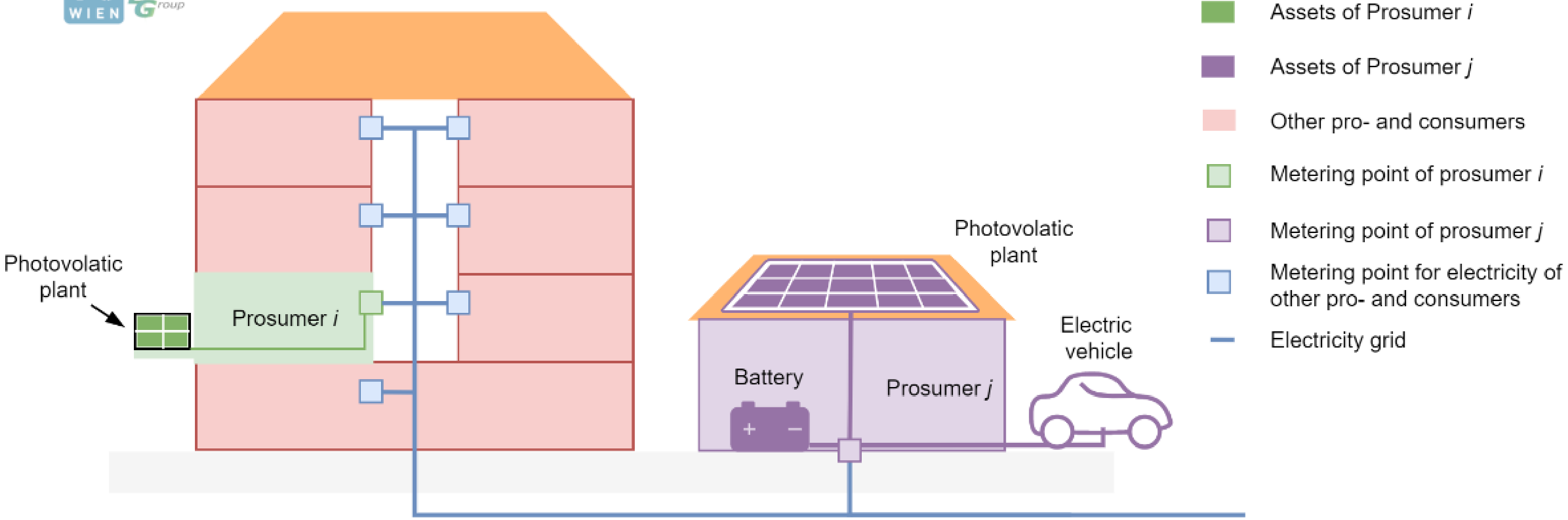
Classification of improved PVP4Grid concepts



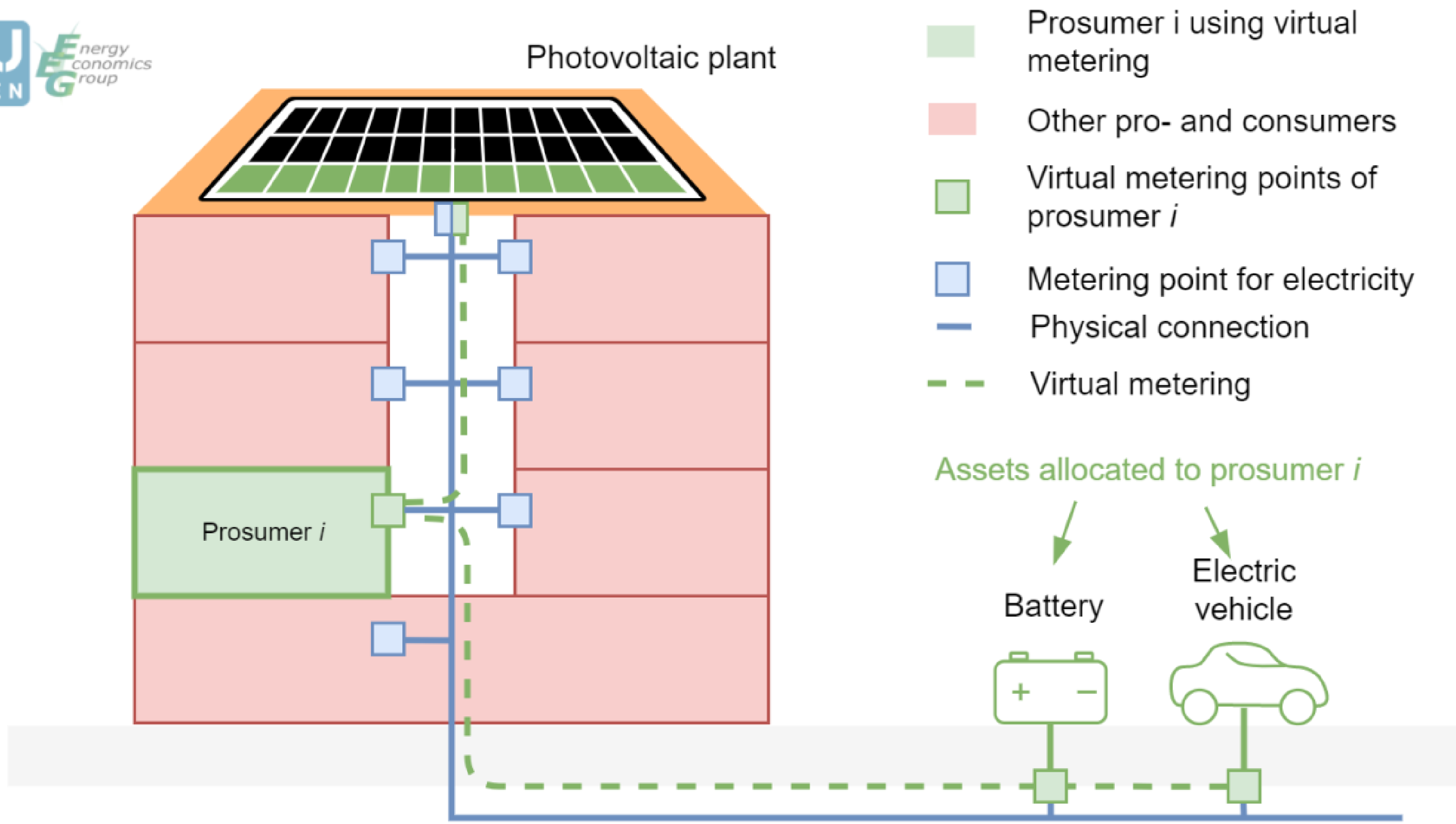
Classification of improved PVP4Grid concepts

Individual concepts	Community concepts
• Individual investment	• Joint investment
• Single metering point	
• Virtual metering	• Energy Community
Group 1	Group 2 and 3

Status Quo in all European Target Countries: Group 1

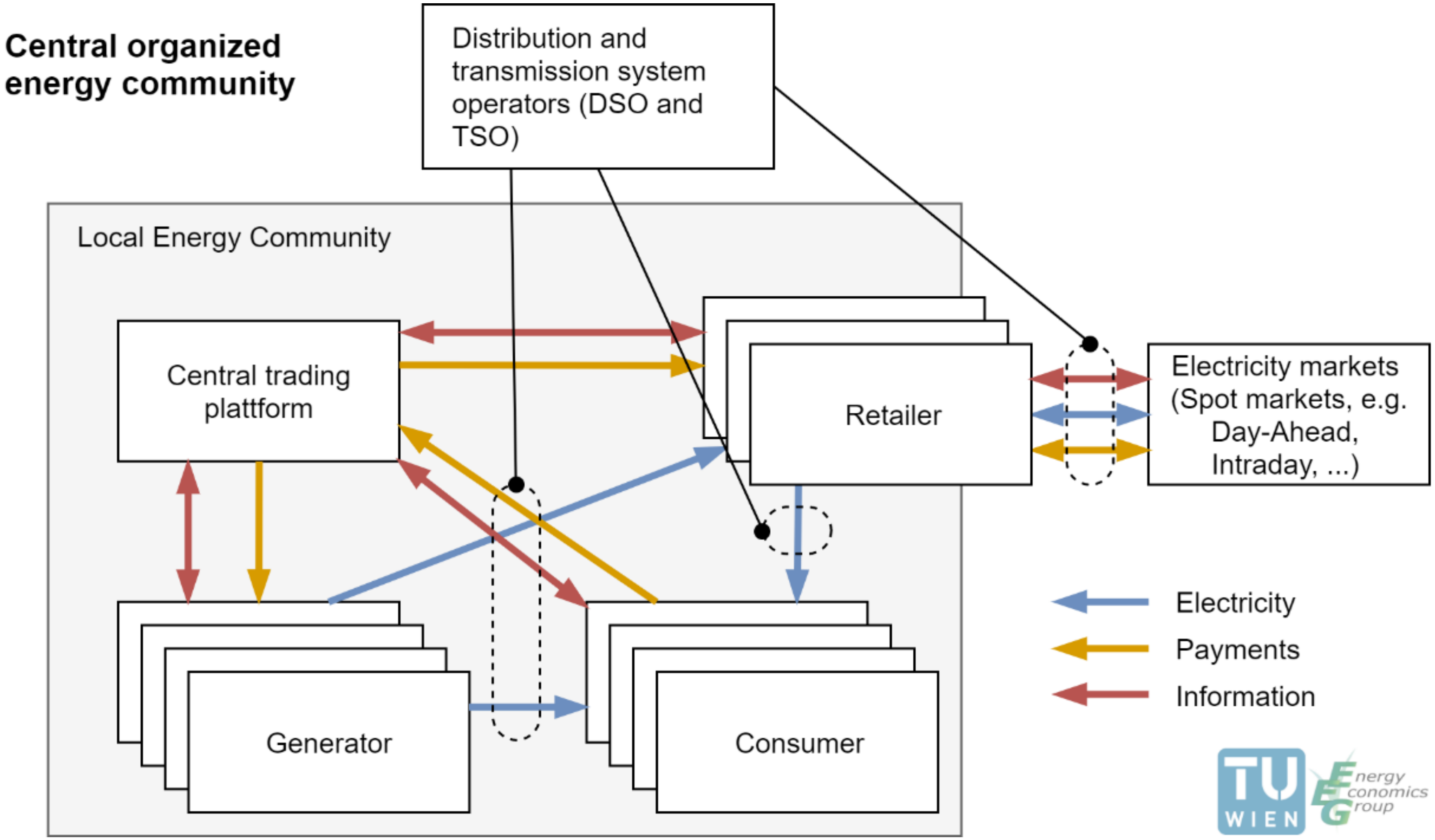


Future Concept for Group 1: Virtual Metering



Group 2 and Group 3 Concepts:

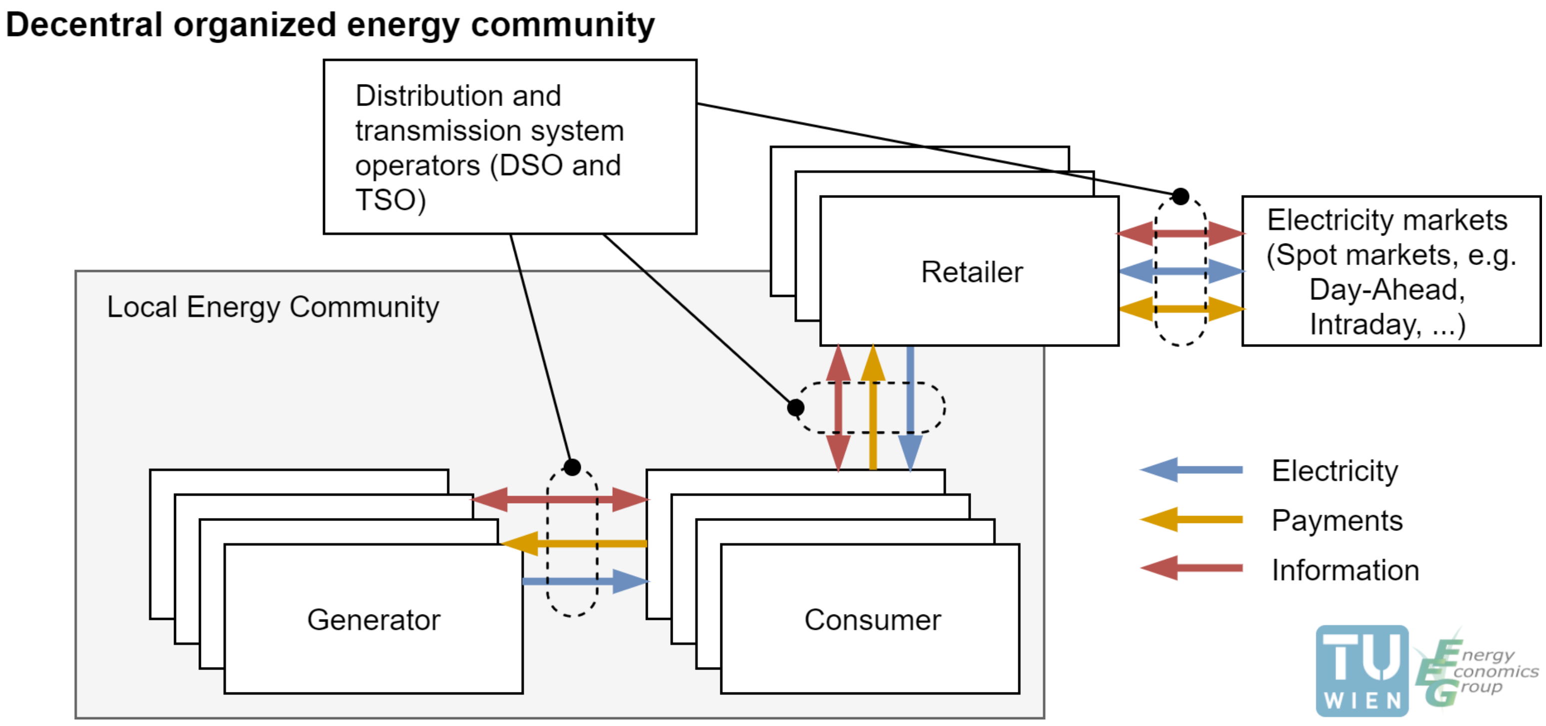
Central organized Energy Community



Adopted from: Hall, D.S., Roelich, D.K., 2015. Local Electricity Supply: Opportunities, archetypes and outcomes.

Group 2 and Group 3 Concepts:

Decentralized organized Energy Community (Peer to Peer)



Adopted from: Hall, D.S., Roelich, D.K., 2015. Local Electricity Supply: Opportunities, archetypes and outcomes.

First questions?

Future PVP Concepts

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Research Questions

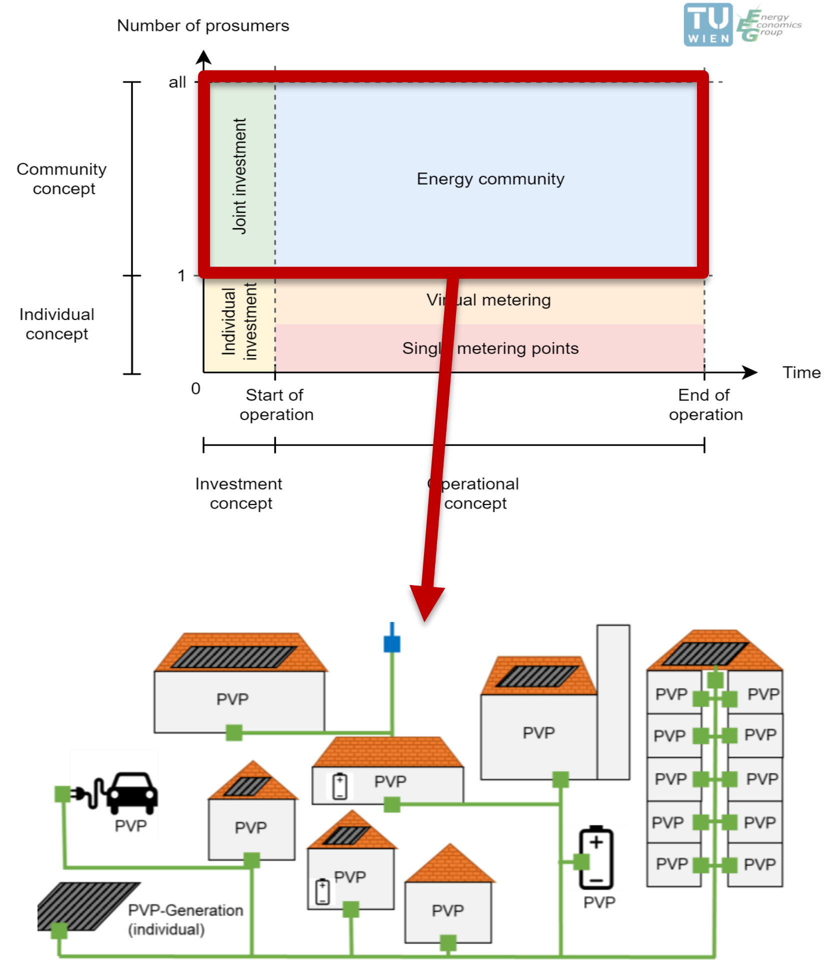
1. *What is the effect of "Future PVP Concepts" on pro- and consumers and the grid? Especially, what is the value of an Energy Community in Europe?*

> The European Commission (2018) defines an EC as
> *"Legal entity which is effectively controlled by local shareholders or members … involved in the distributed generation and in performing activities of a distribution system operator, supplier or aggregator at a local level, including across borders"*

2. *Comparison of the European target countries.*
3. *What is the effect of the tariff components (namely EUR/kWh, EUR/kW and EUR/consumer/year)?*

Assumptions

- We will present the future PVP concepts for ***Group 3*** including
  - ***Joint investment***
  - and ***Energy community***
- Method: optimization model HERO^{community} including ***investment and operational*** decision.
- Technologies: PV and battery and energy management
- Monetary gains: self-consumption, savings (energy and peak power)
- Scale: consumer, one year, 15min time resolution



Method

Pre-Processing

(collection and calculation of the input data)

Optimization

with HERO^{community}

Post-Processing

(saving and plotting results)

Target countries

Method

Pre-Processing

(collection and calculation of the input data)

Optimization

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Post-Processing

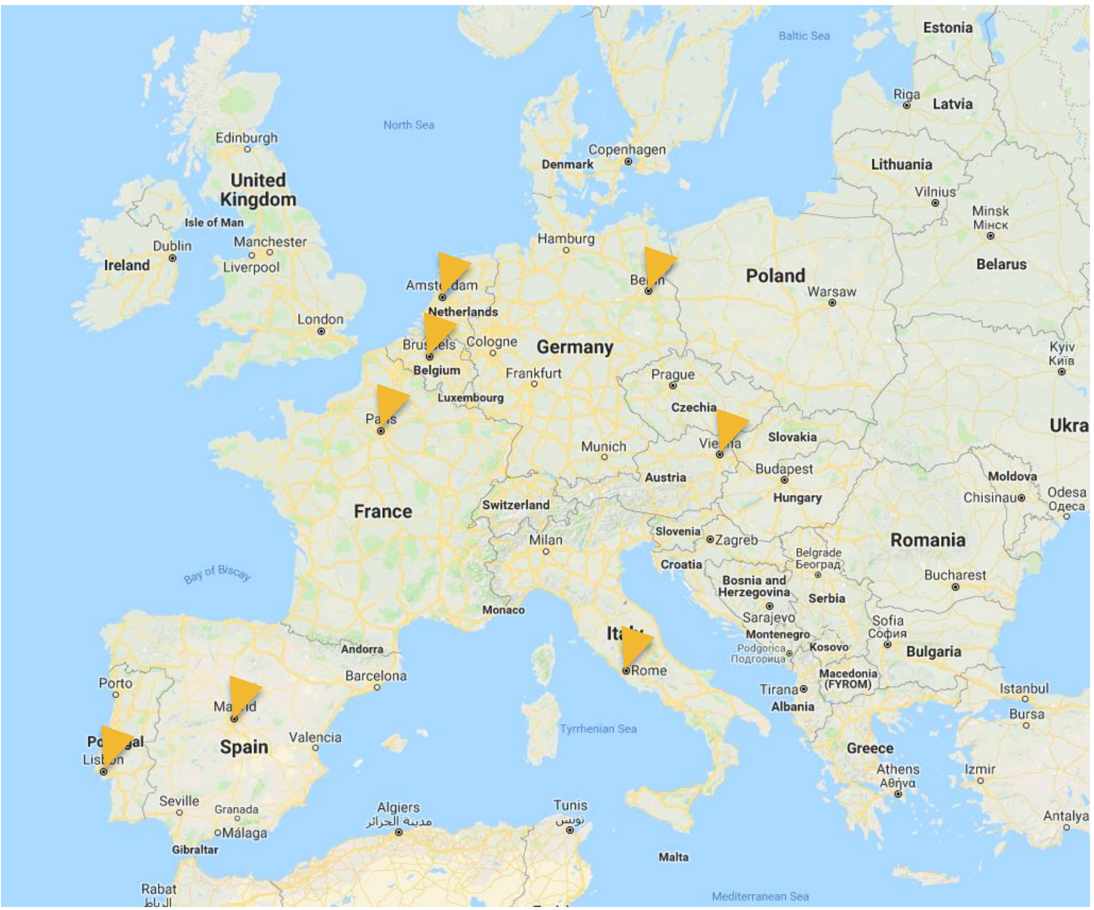
(saving and plotting results)

Target countries

Post-Processing

- The aim of post-processing is to provide the input data of the optimization model
- For the simulation, the demand is calculated (synthetic load profiles) based on measured data (e.g., outdoor temperature)
- For both groups (2 and 3) we have made assumptions based on statistical data.

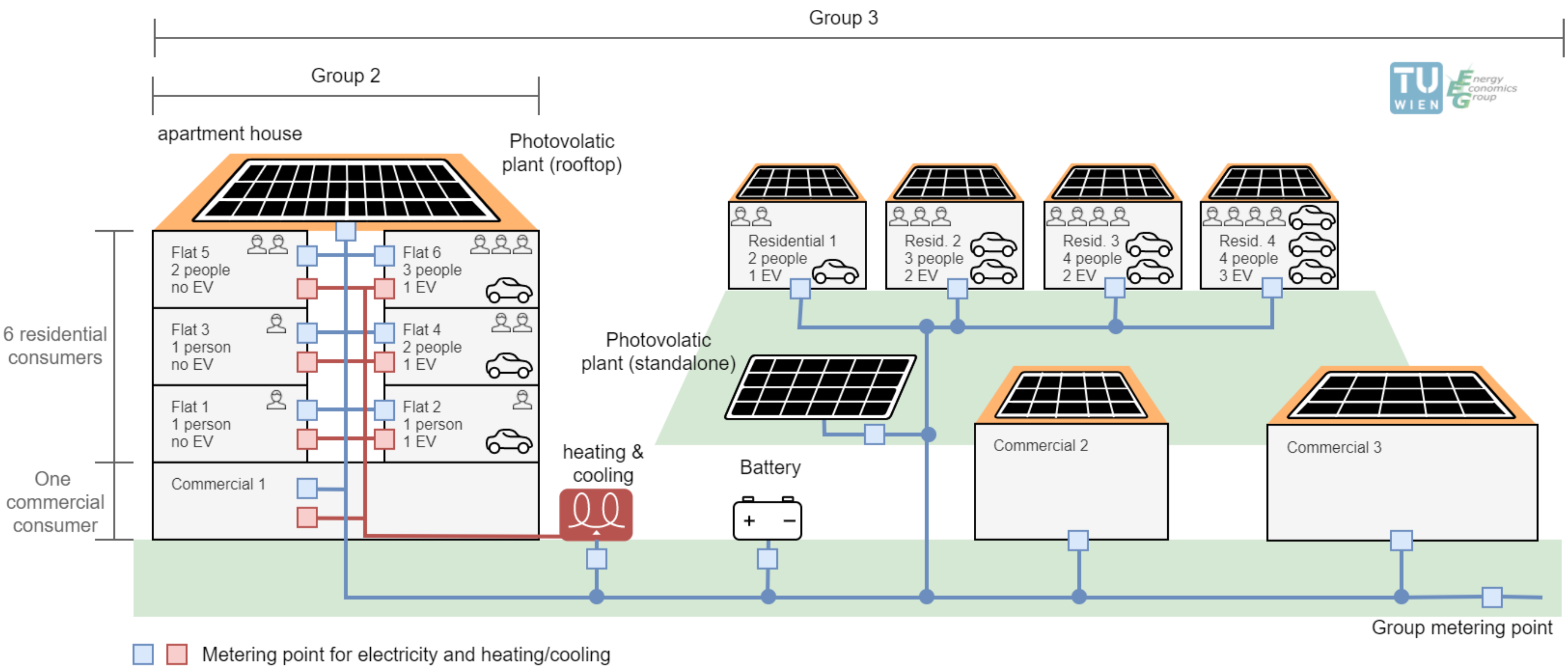
Target Countries and Reference Cities



Map data ©2019 GeoBasis-DE/BKG (©2009), Google, Inst. Geogr. Nacional, Mapa GISrael, ORION-ME United States

Target Country	Reference City
Austria	Vienna
Belgium	Brussels
France	Paris
Germany	Berlin
Italy	Rome
Portugal	Lisbon
Spain	Madrid
The Netherlands	Amsterdam

Setup for group 3



Input data – Heat and Hot Water Load

Private Households

- Hot-Water: calculated from water consumption profiles generated with *Load Profile Generator*
- European and country specific key numbers:

  Average housing size in Europe: 96 m2*

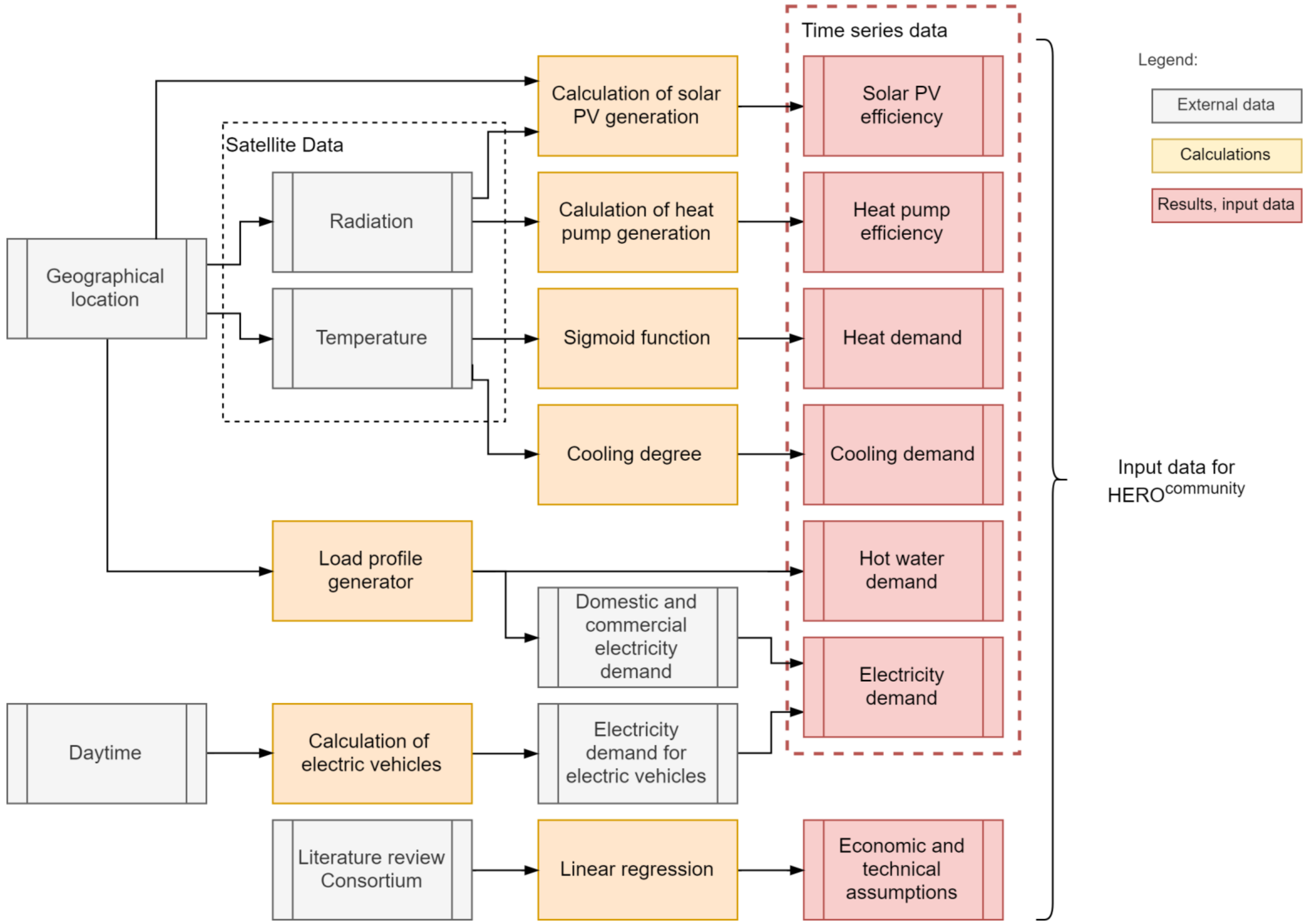
  Heating demand in Berlin: 140 kWh / m2**

  Hot water consumption per person: 2000 kWh***

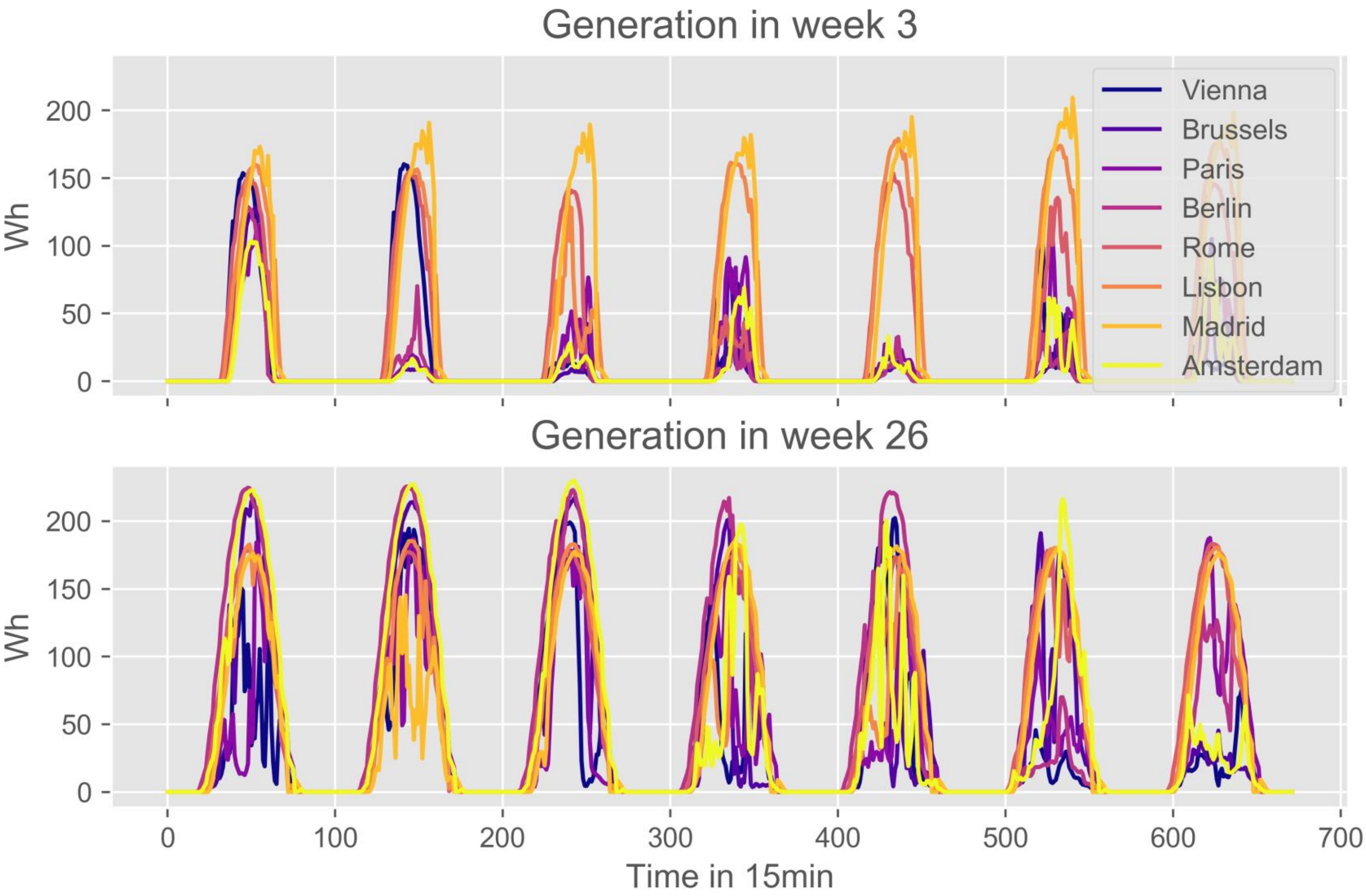
Household	People	HotWater [l]	FlatSize [m2]	HeatLoad [kWh]
Flat1	70m	2000	30	2850
Flat2	68f	2000	40	3800
Flat3	48m	2000	50	4750
Flat4	68f 71m	4000	70	6650
Flat5	23f 25m	4000	80	7600
Flat6	40f 63m 10m	6000	90	8550
Residential 1	44m 38f	4000	120	11400
Residential 2	16f 45f 48m	6000	140	13300
Residential 3	43m 9f 13m 39f	8000	160	15200
Residential 4	43f 16m 45m 14f	8000	180	17100

Source: *http://appsso.eurostat.ec.europa.eu; **https://www.heizspiegel.de; ***http://www.wilu.at/

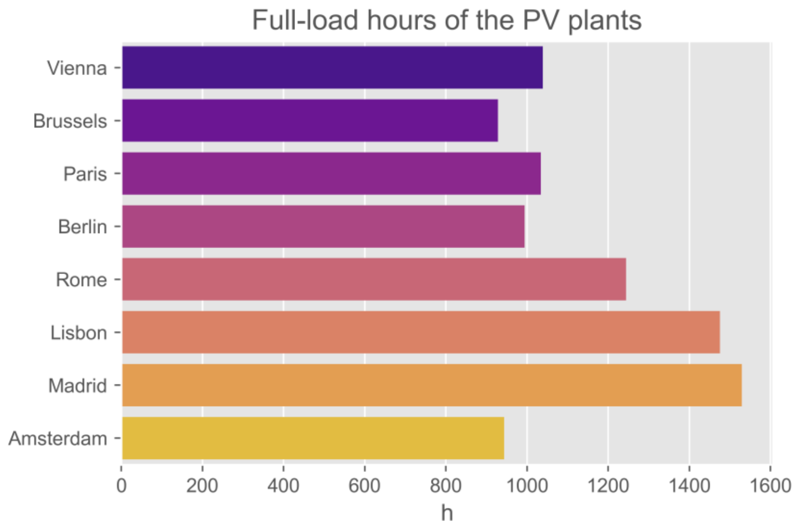
Calculation of the Input Data

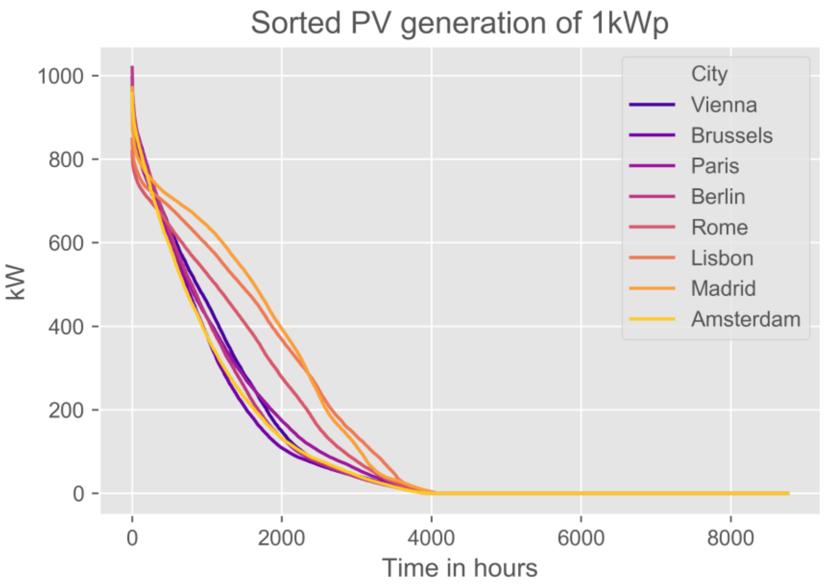


Input data – Solar Photovoltaic

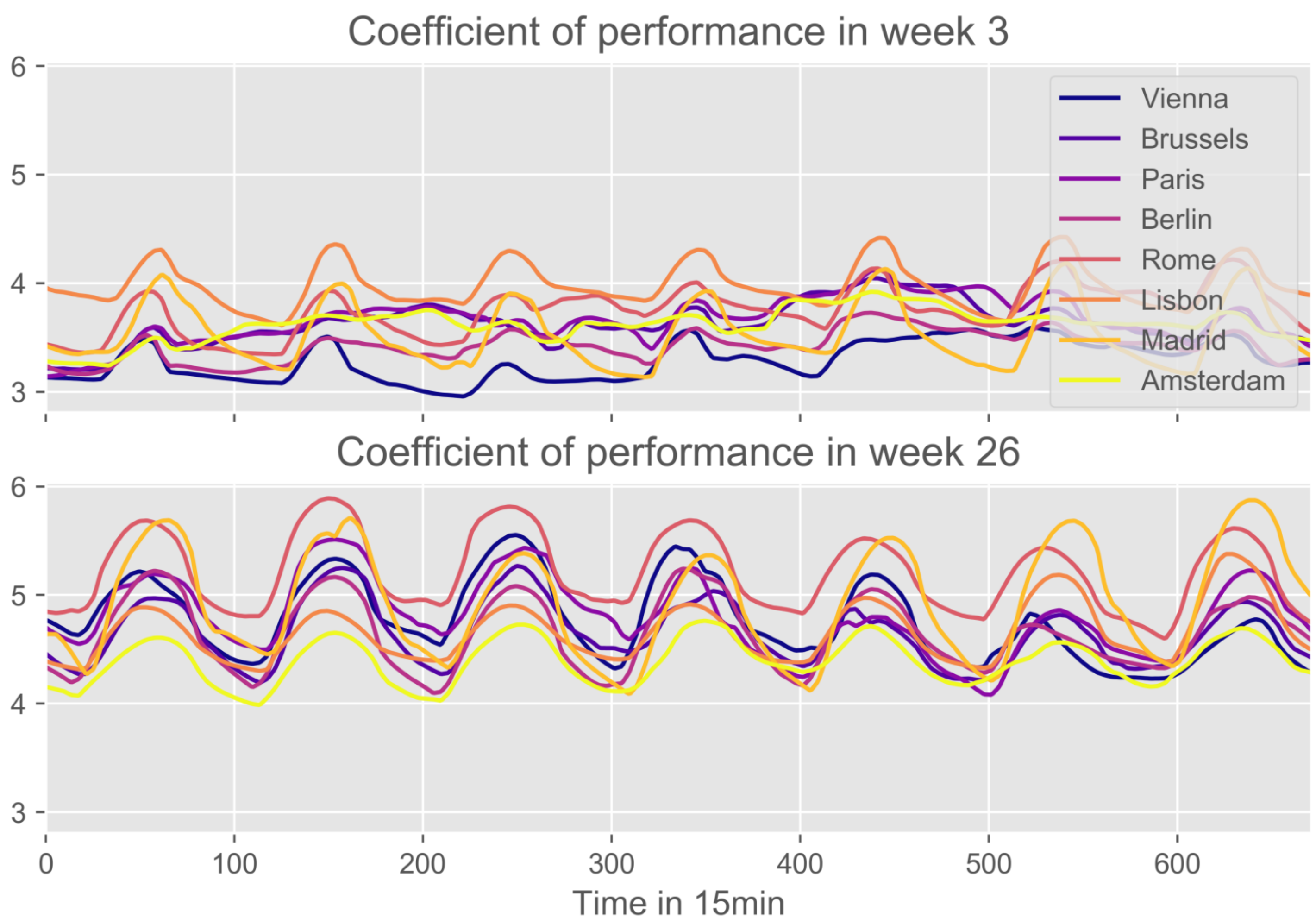


Input data – Solar Photovoltaic

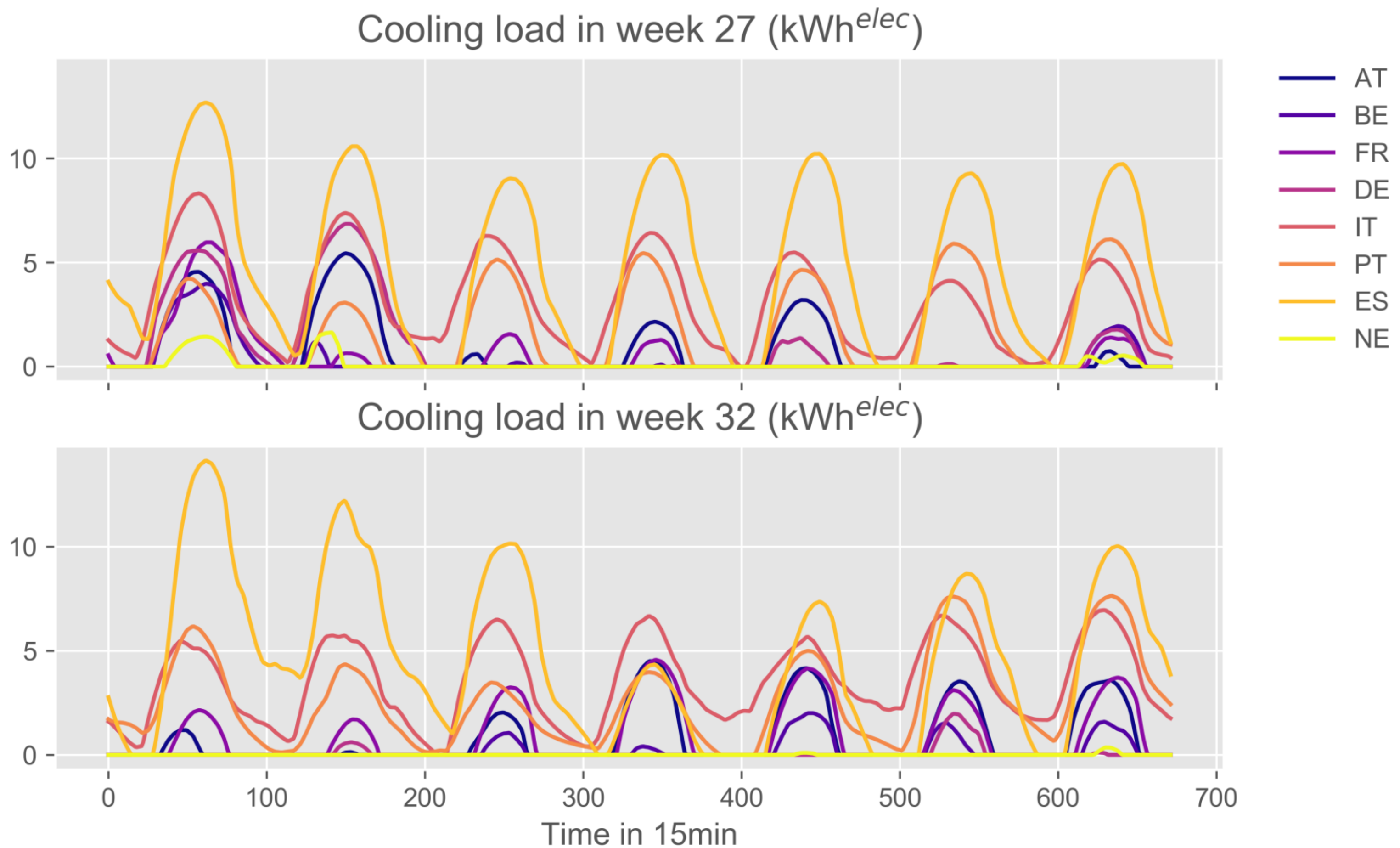




Input data – Heat Pump (air to water)

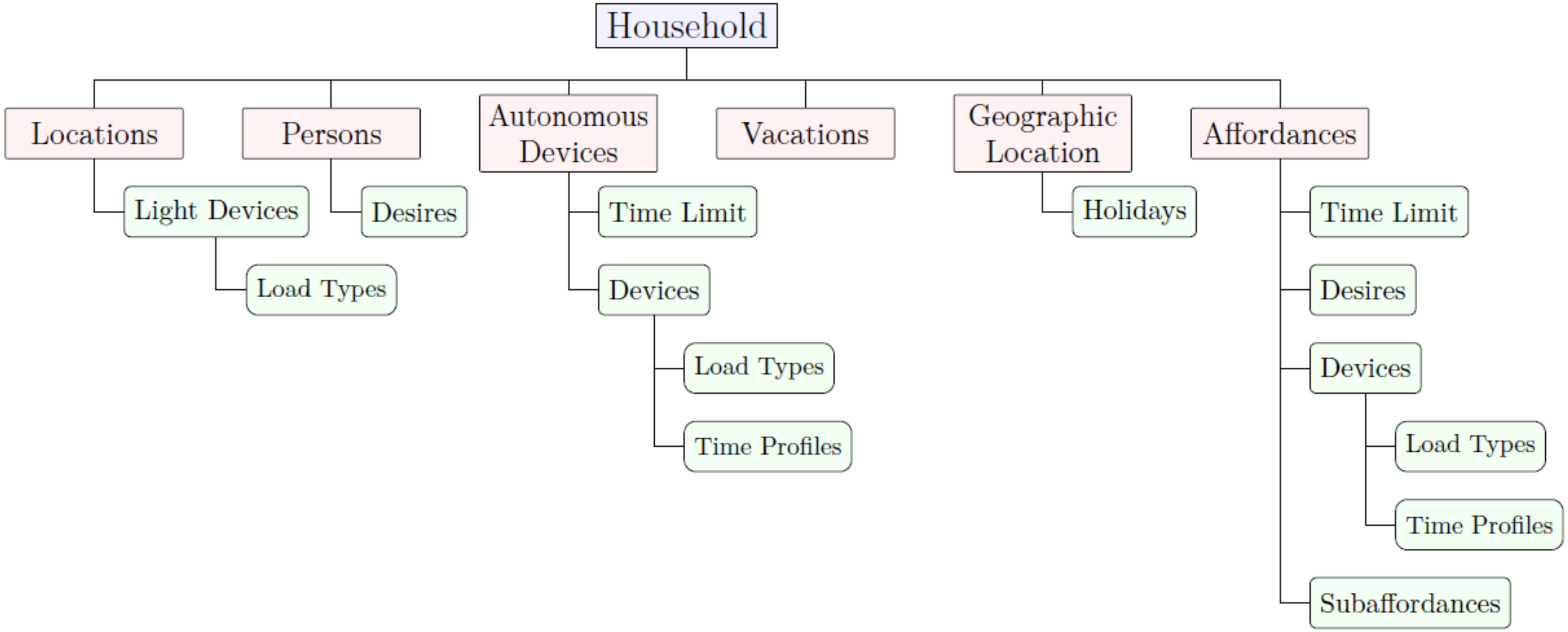


Input data – Cooling Load



Input data – Electricity demand

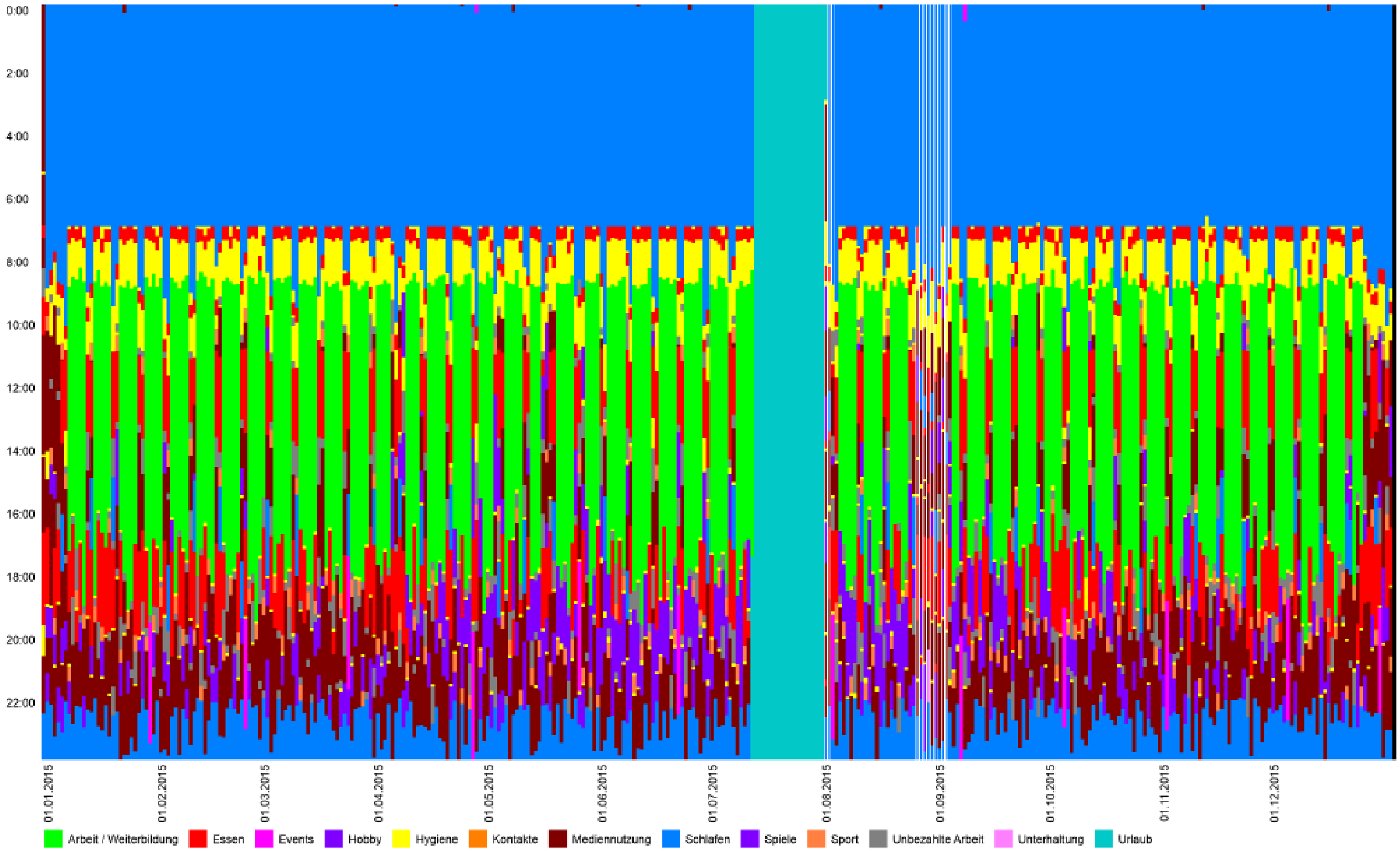
Model based on the PhD thesis Pflugradt, N.D. (2016), published on https://www.loadprofilegenerator.de/*



*Pflugradt, N.D., 2016. Modellierung von Wasser und Energieverbräuchen in Haushalten. Dissertation.

Input data – Electricity demand

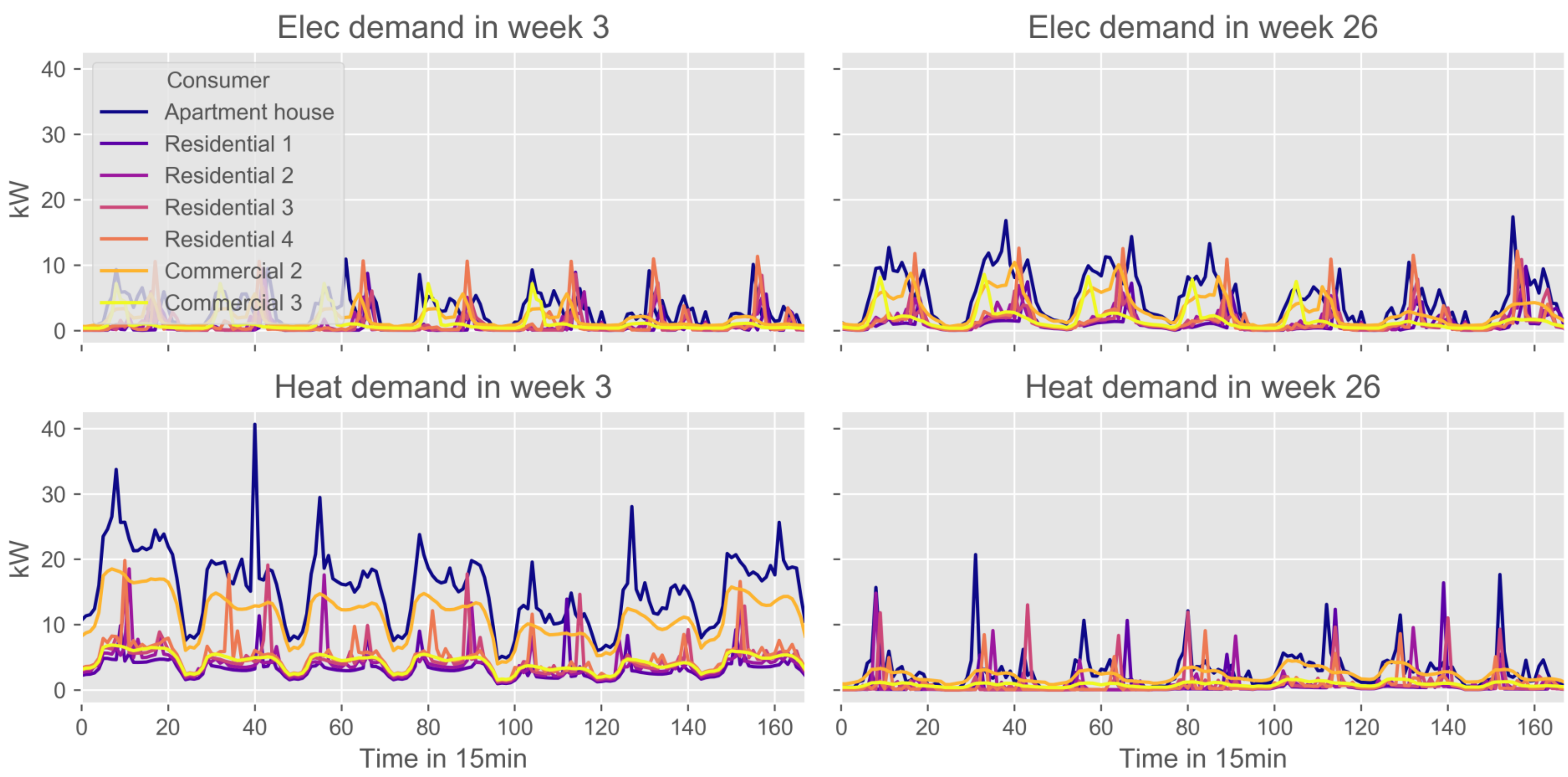
Activity of a woman (and mother) in household CHR03



Source: Pflugradt, N.D., 2016. Modellierung von Wasser und Energieverbräuchen in Haushalten. Dissertation.

Input data – Energy demand

Demand of two weeks

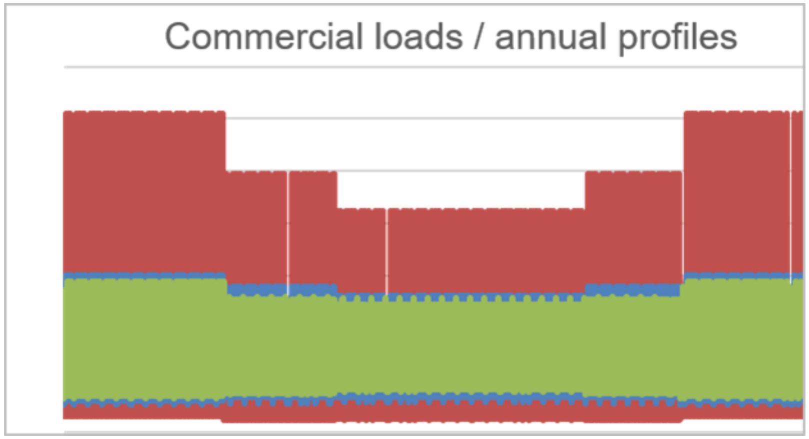


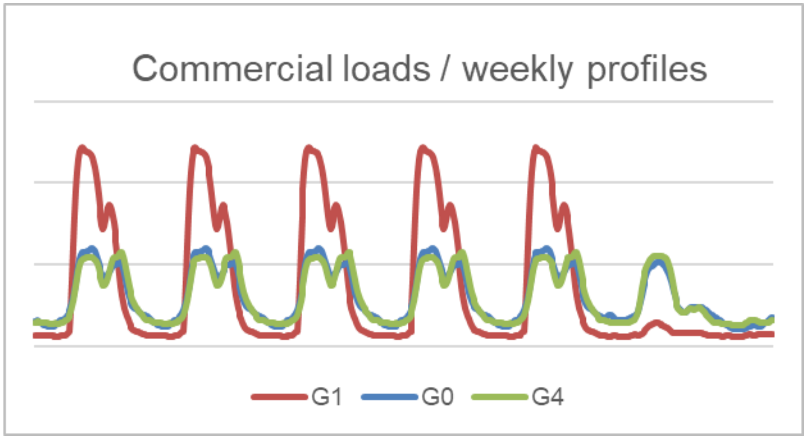
Input data – Electricity and Heat

Commercial:

- Commercial load is too individual, therefore we use Synthetic Standard Load Profiles:
  - G0 (Commercial / general)
  - G1 (Commercial / weekday)
  - G4 (Commercial / shop)
- European and country specific key numbers:

  Electricity consumption per m2 commercial building: 115 kWh*





Source: *https://de.statista.com

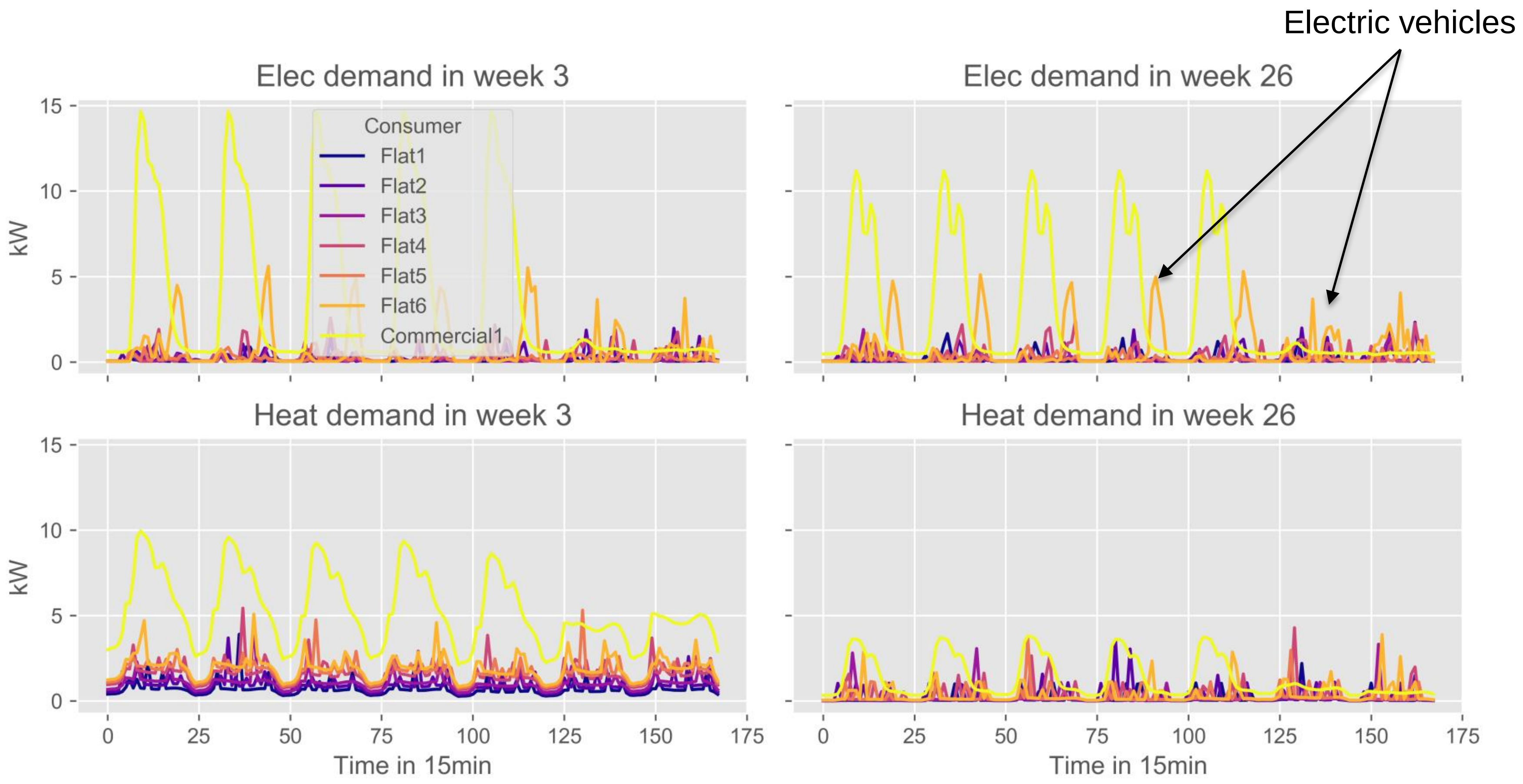
Input data – Electric Vehicles

Electric Vehicles

- European and country specific key numbers:
- Energy consumption electric vehicles (EV): 20 kWh / 100 km
- Limit of charging power: 3.6 kW
- Charging characteristics:
  - ***Car charged at home (50%)***
    - Weekdays: Charged in the evening
    - Weekends: Charged during the day and night
  - ***Car charged at commercial charging station (50%)***
    - Only on weekdays, during the day

	Number of cars per 1000 inhabitants 2016	Distance travelled per car	Weighted to 0.5 cars per person	km per car per day	Energy consumption per day [kWh]
Italy	625	9596	12,0	33	6,6
Germany	555	14107	15,7	43	8,6
Austria	555	14311	15,9	44	8,8
Belgium	503			34	6,8
Netherlands	481			34	6,8
France	479	12997	12,5	34	6,8
Spain	492	12535	12,3	34	6,8
Portugal	470			34	6,8

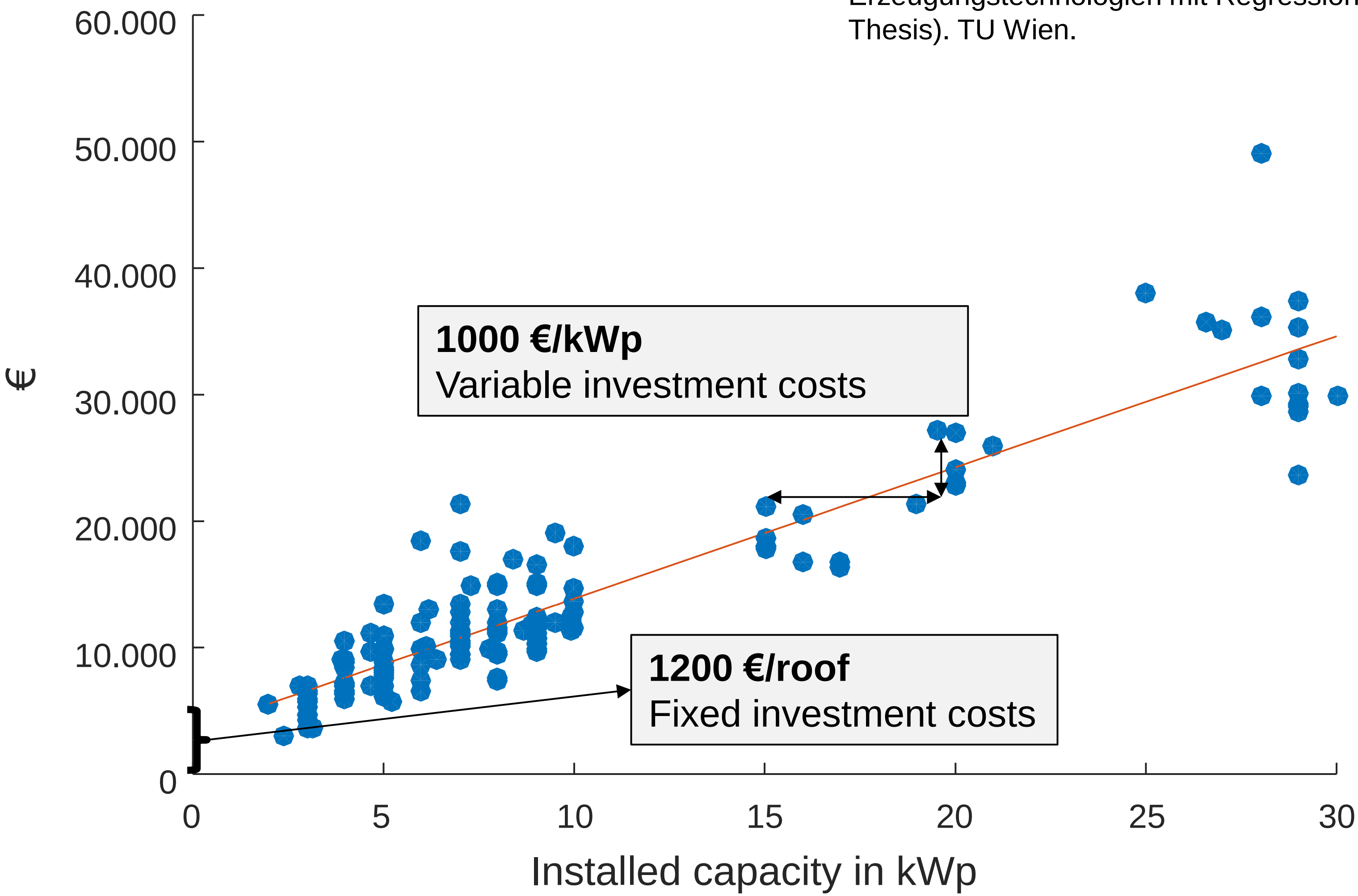
Input data – Electricity (+EV) and Heat (Space Heating + Hot Water)



Investment costs – Solar Photovoltaics

Example AT

Loschan, C., 2017. Marktanalyse von Skaleneffekten dezentraler Erzeugungstechnologien mit Regressionsanalyse (Bachelor Thesis). TU Wien.



Data requirements for simulation of PVP4Grid concepts

Economic data

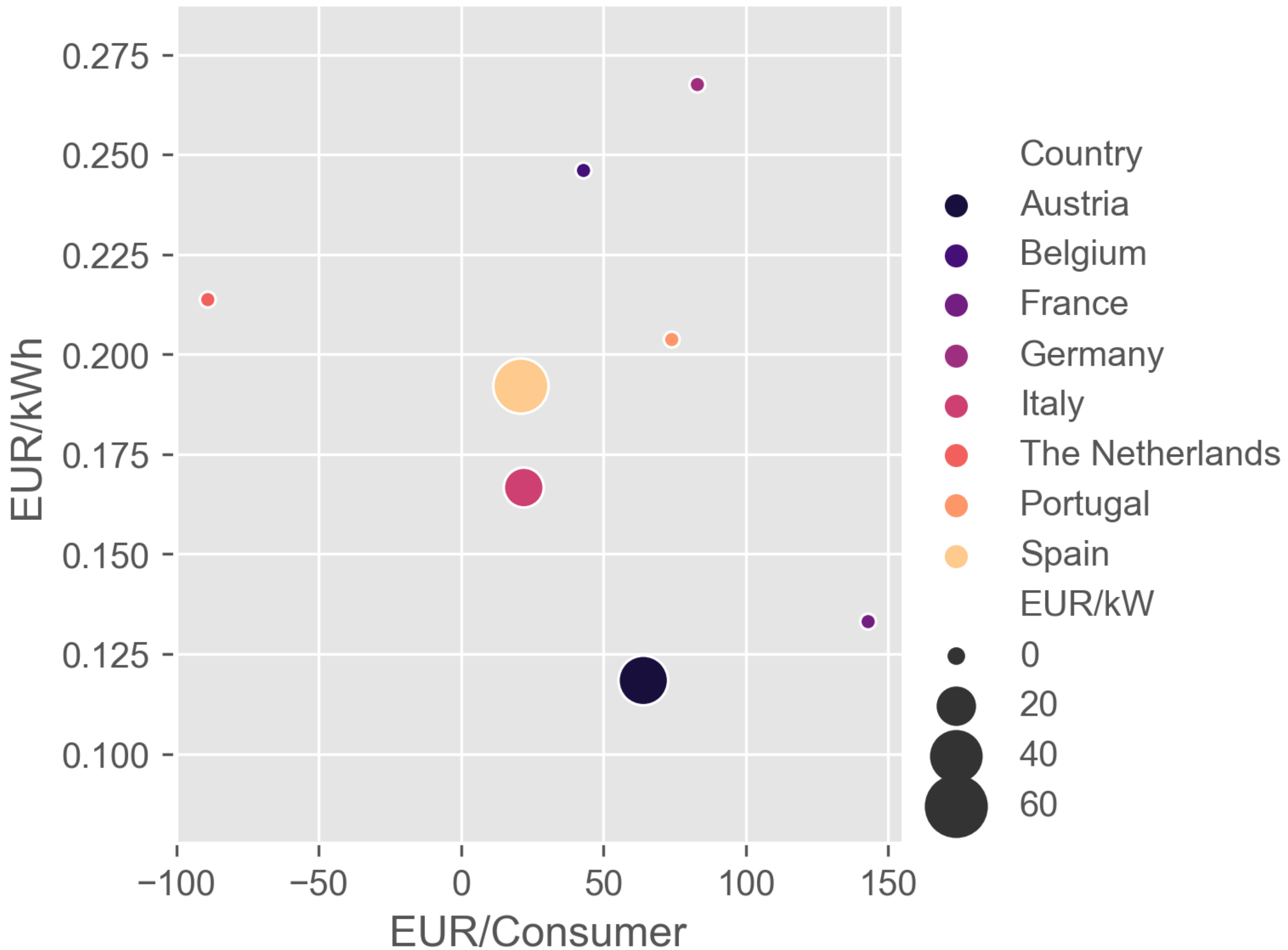
Billing components of the retail price for electricity:

- *Energy tariffs* for private, commercial and industrial consumers (electricity, gas, district heating) in €/kWh, €/kW and €/a
- *Grid or network tariffs* for electricity and gas grid and district heating network in €/kWh, €/kW and €/a
- *Taxes and fees* for private, commercial and industrial consumers in €/kWh, €/kW and €/a

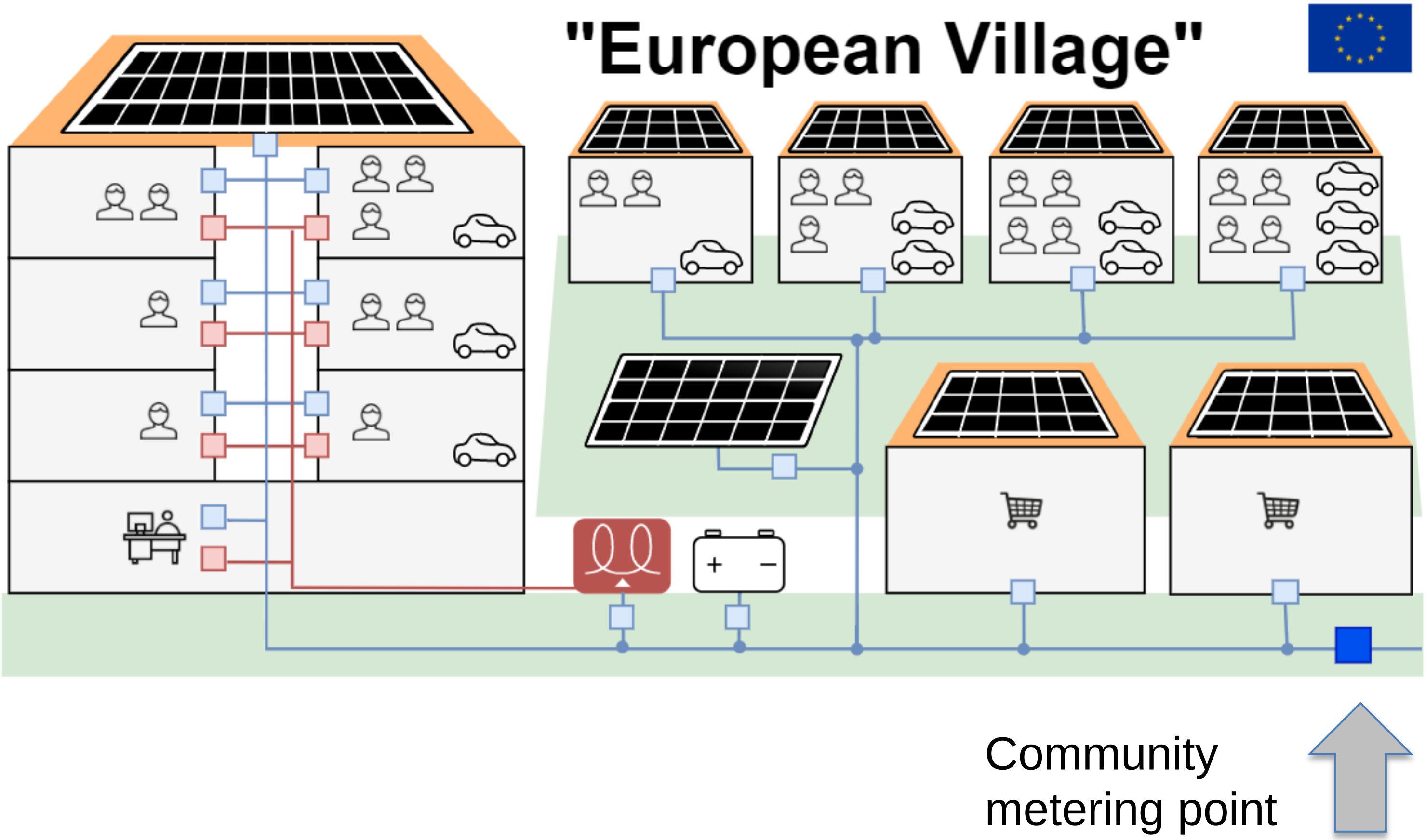
Aggregated to three components:

- EUR/kWh
- EUR/Consumer/Year
- EUR/kW

Current tariff design in the target countries



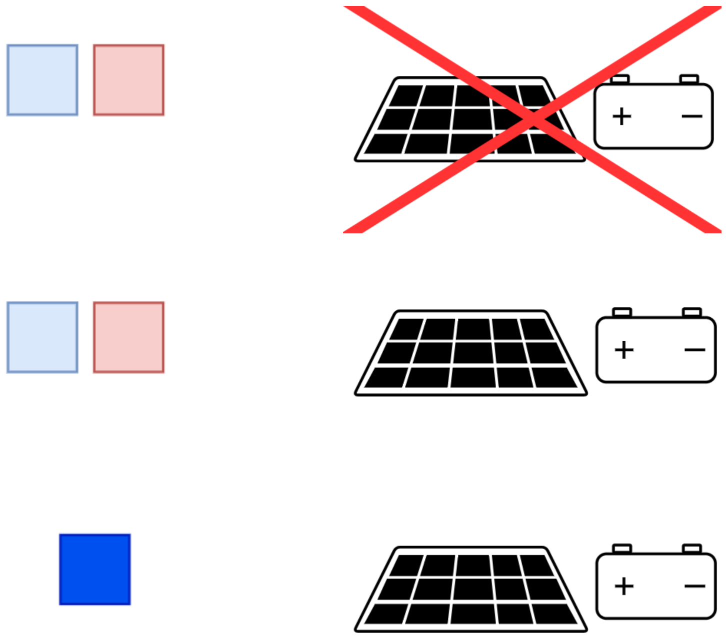
Group 3 metering points



Scenarios

Metering point ***Technologies***

- ***Grid consumption*:**
  - No investments in PV and BESS
  - Demand is satisfied via the grid
- ***No community*:**
  - Investments in PV and BESS are possible
  - Energy sharing not allowed
- ***Community*:**
  - Investments in PV and BESS are possible
  - Energy sharing allowed



Electric vehicles (EV)
Photovoltaics (PV)
Battery energy storage systems (BESS)

Method

Pre-Processing

(collection and calculation of the input data)

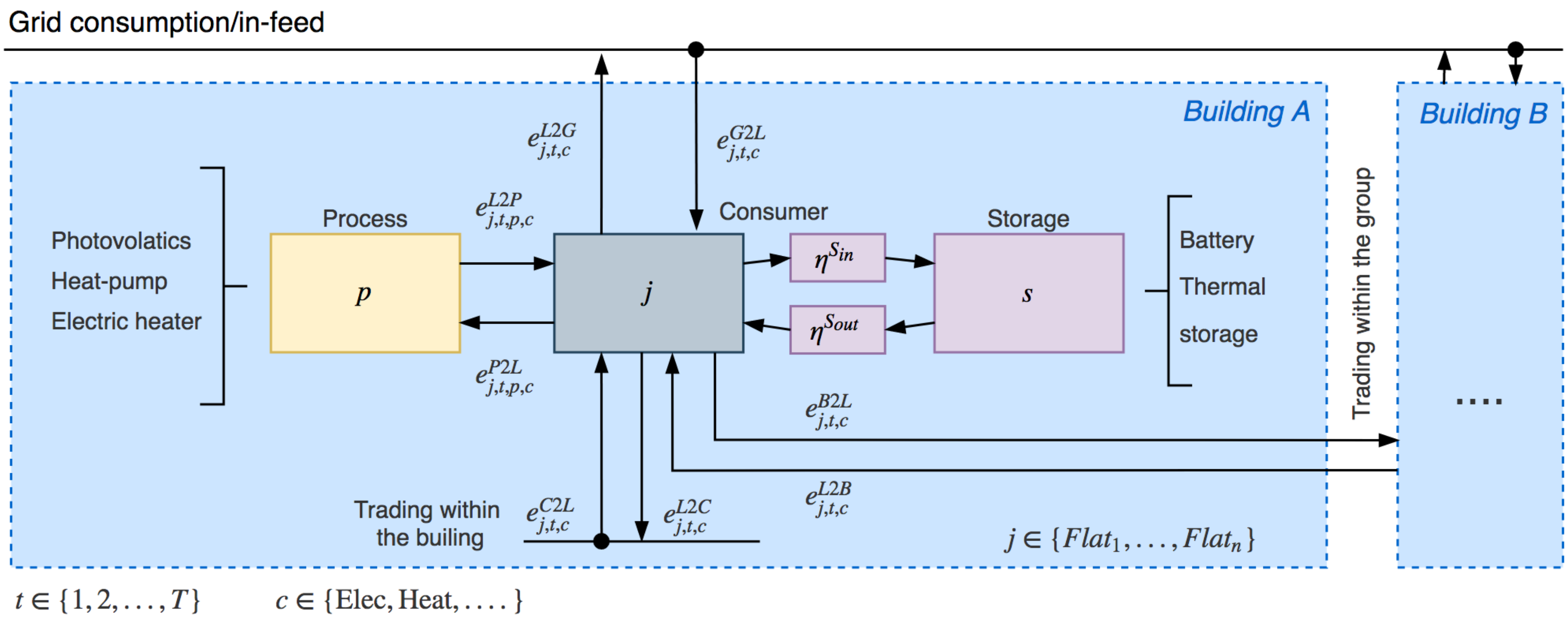
Optimization

with HERO$^{\text{community}}$

Post-Processing

(saving and plotting results)

Optimization model HERO[community]



Method for both: Simulation and Testing

Pre-Processing

(collection and calculation of the input data)

→

Optimization

with HERO$^{\text{community}}$

→

Post-Processing

(saving and plotting results)

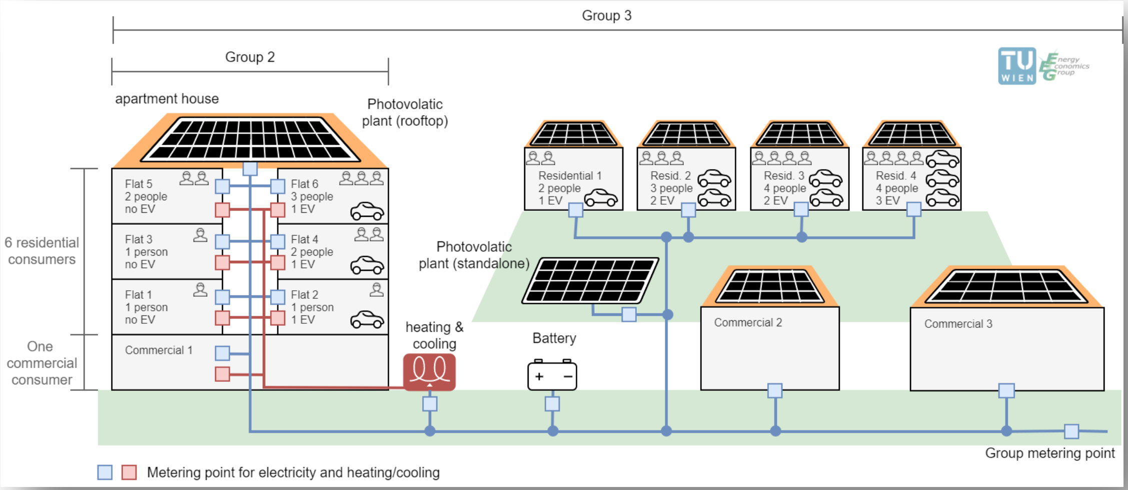
Results for Germany / Group 3

Following results will be shown:

- Total costs savings

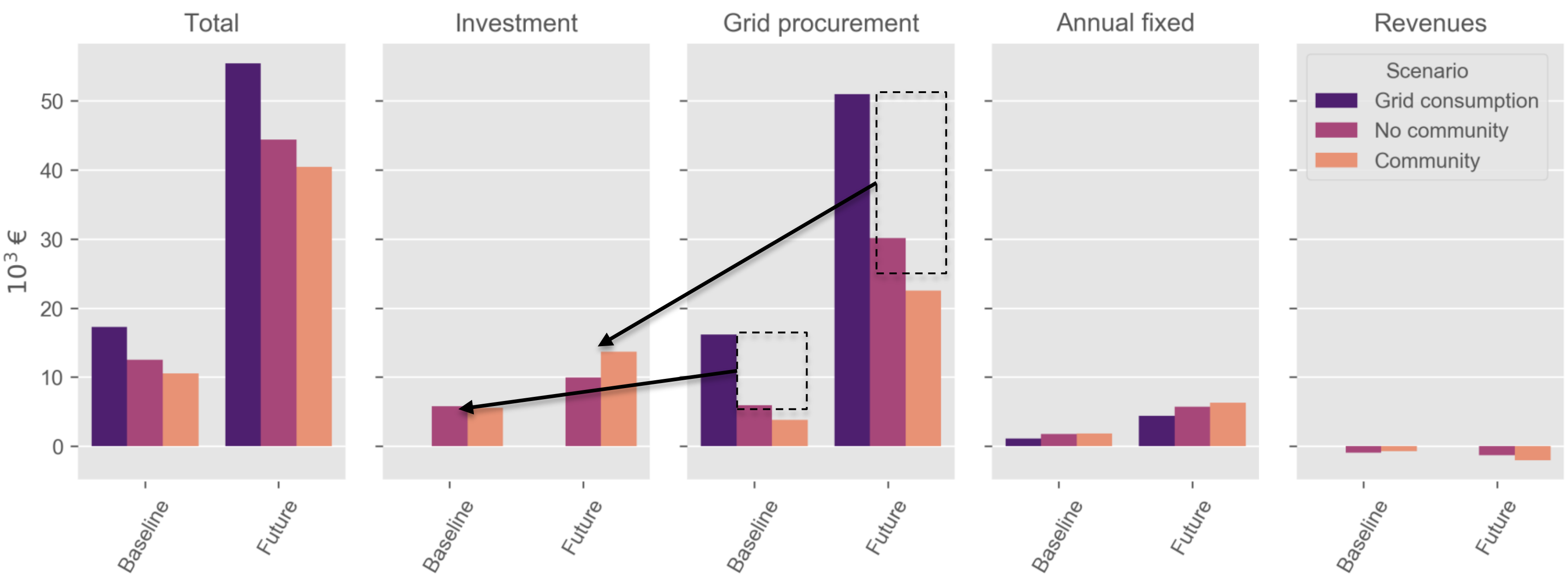
$$Total\ Costs(Year) = \alpha * Investment + Grid + Fixed + Revenues$$

- Each cost component
- Installed Capacity
  - Photovoltaic (kWp)
  - Battery (kWh)
- Sensitivity analyis



Results for Germany / Group 2

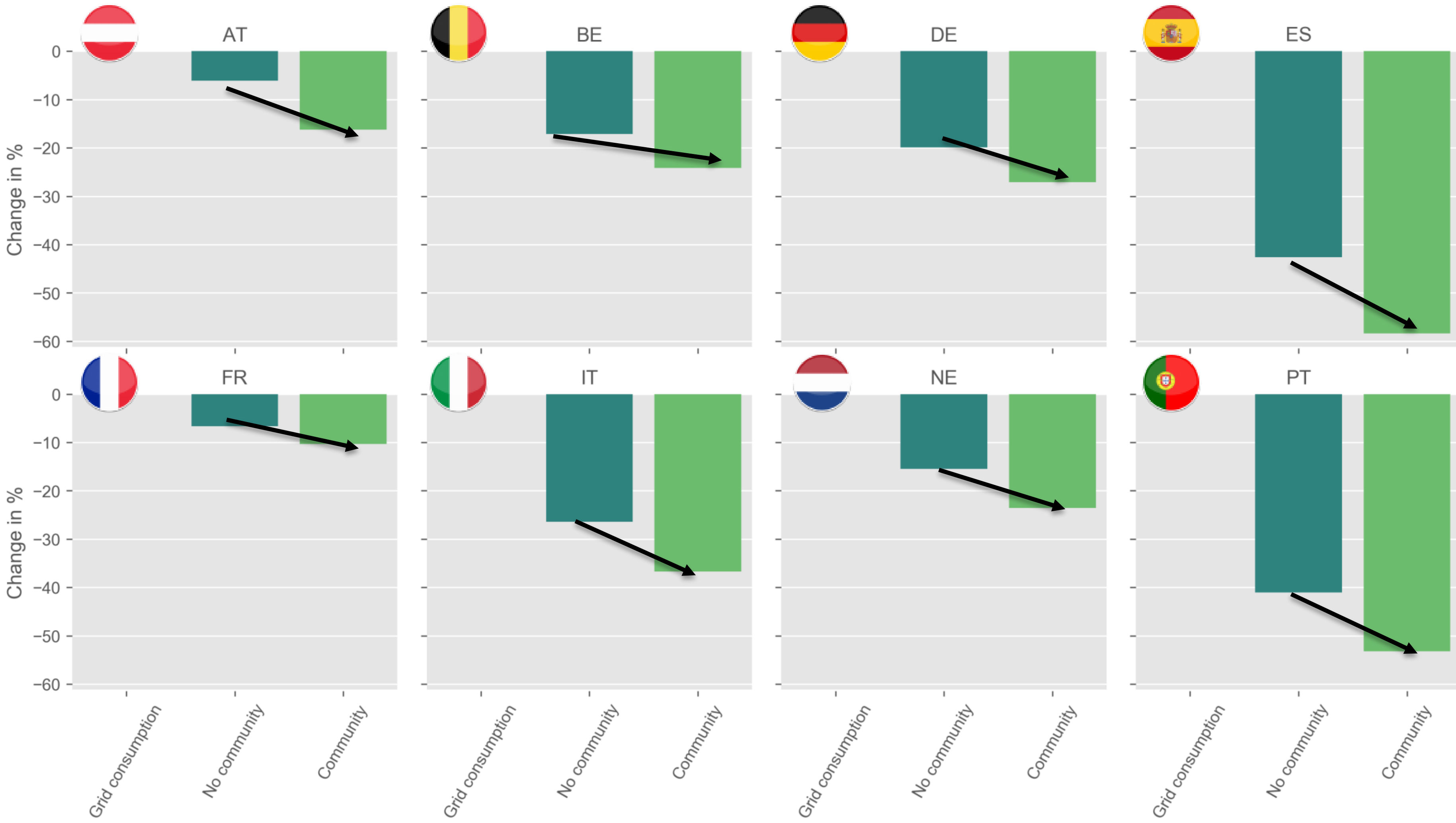
Total costs = Investment + Grid + Fixed + Revenues



OPEX → CAPEX

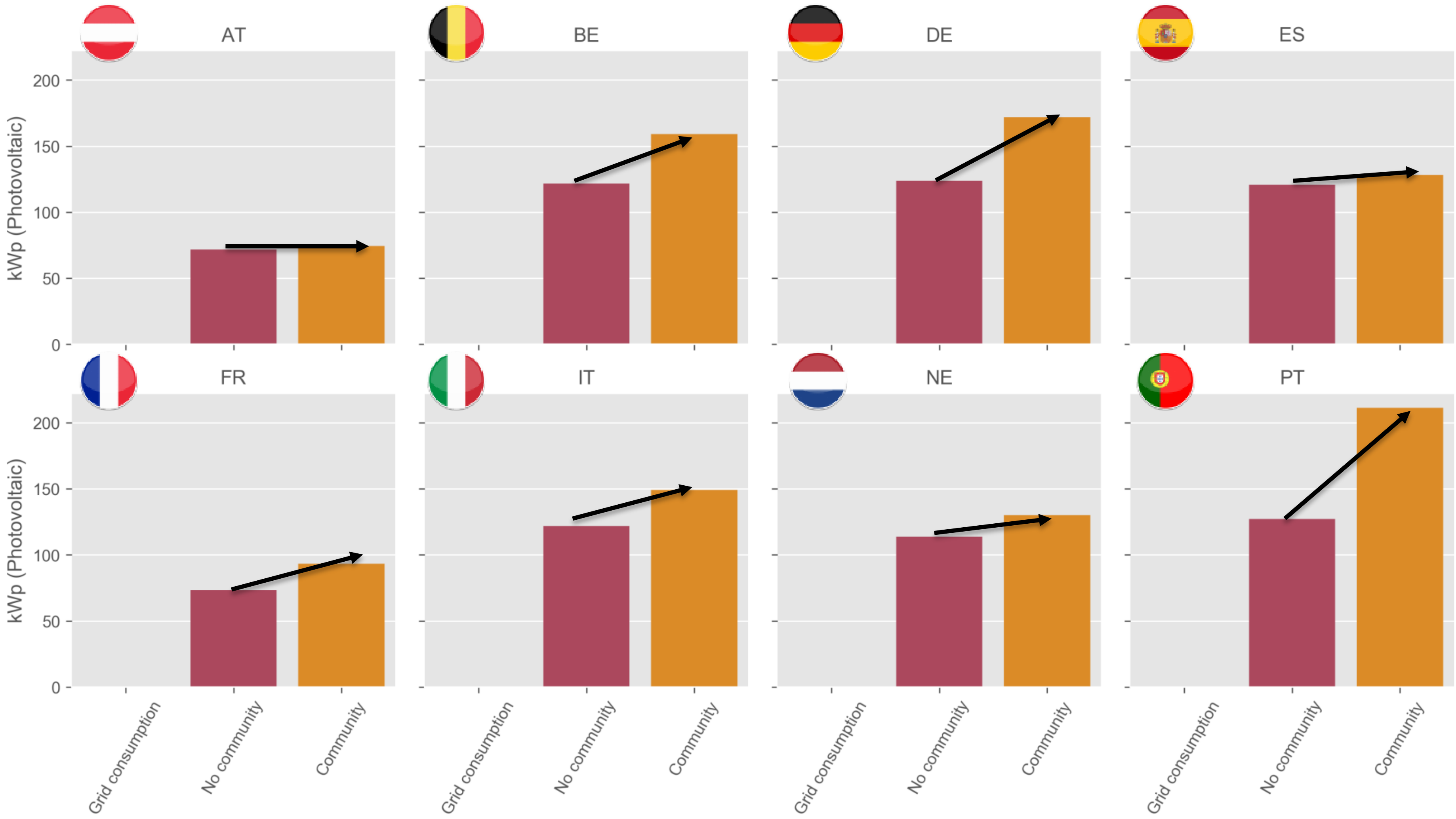
Results Group 3

Change in Total Costs



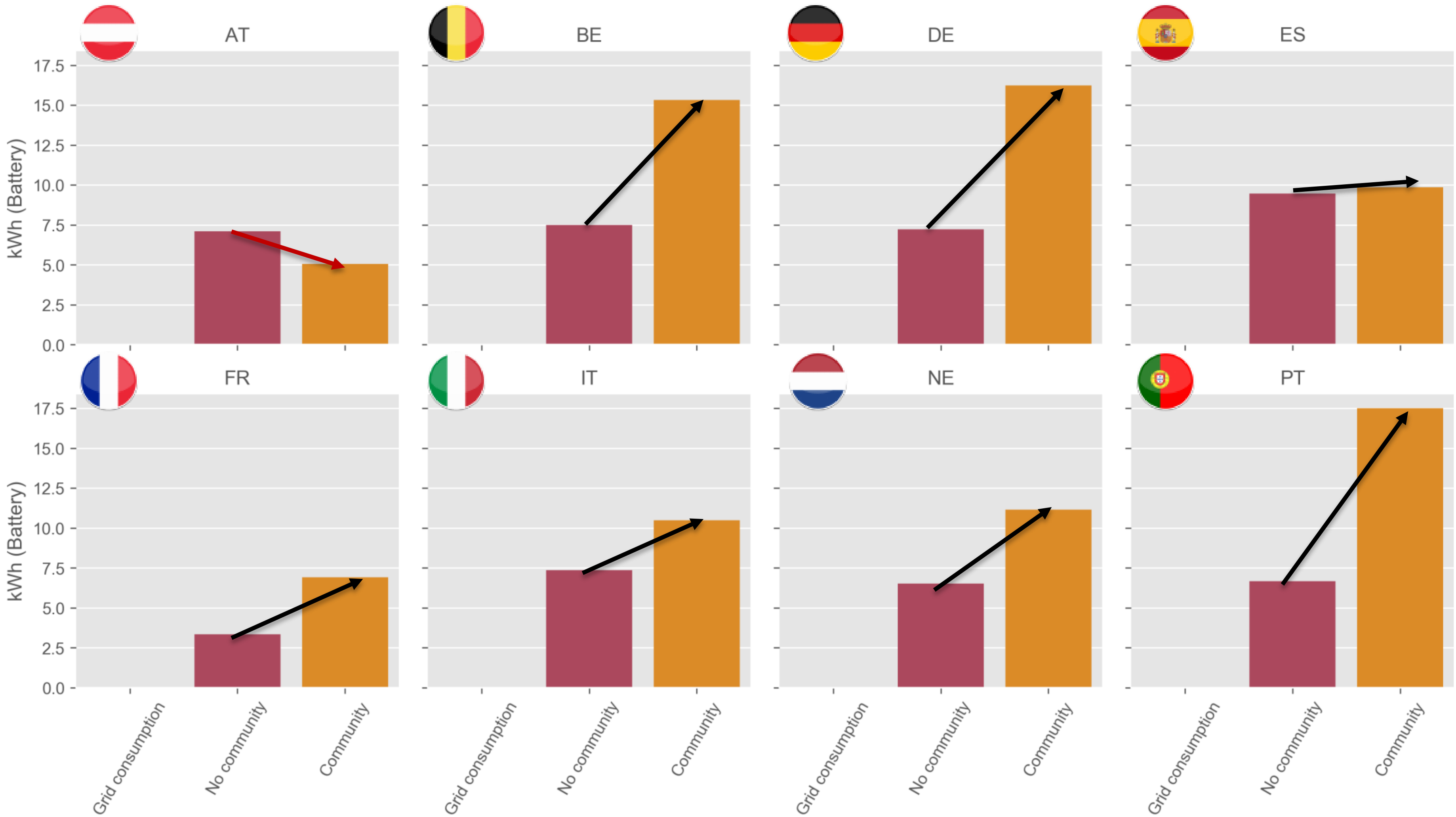
Results Group 3

Installed PV capacity in kWp

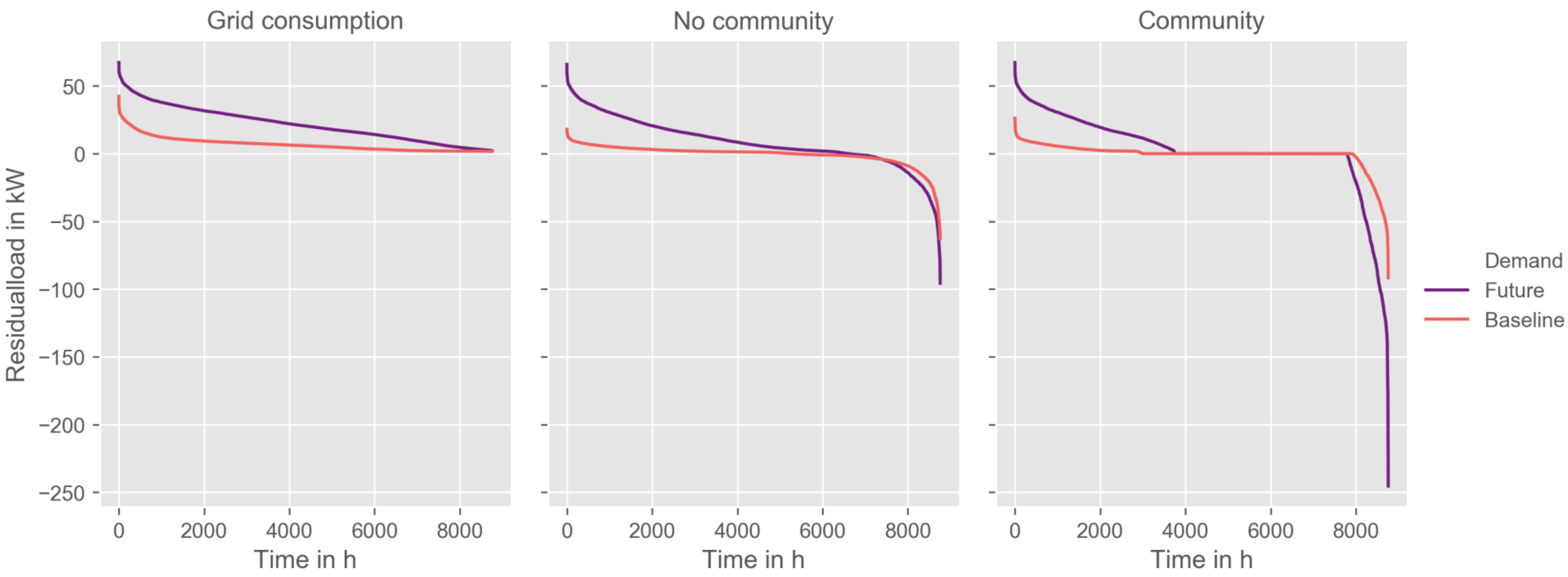


Results Group 3

Installed battery capacity in kWh

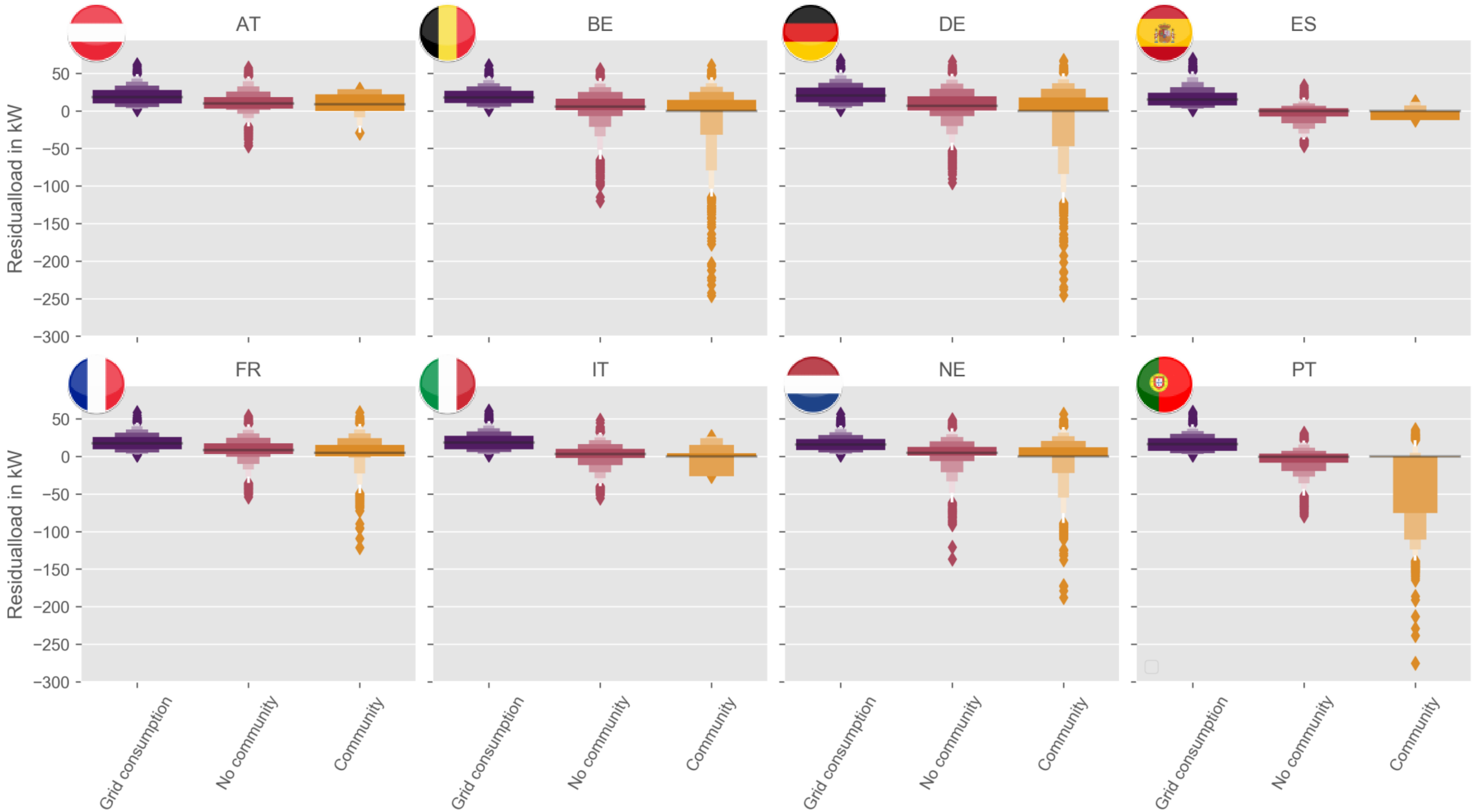


Sorted residual load (at the community metering point)



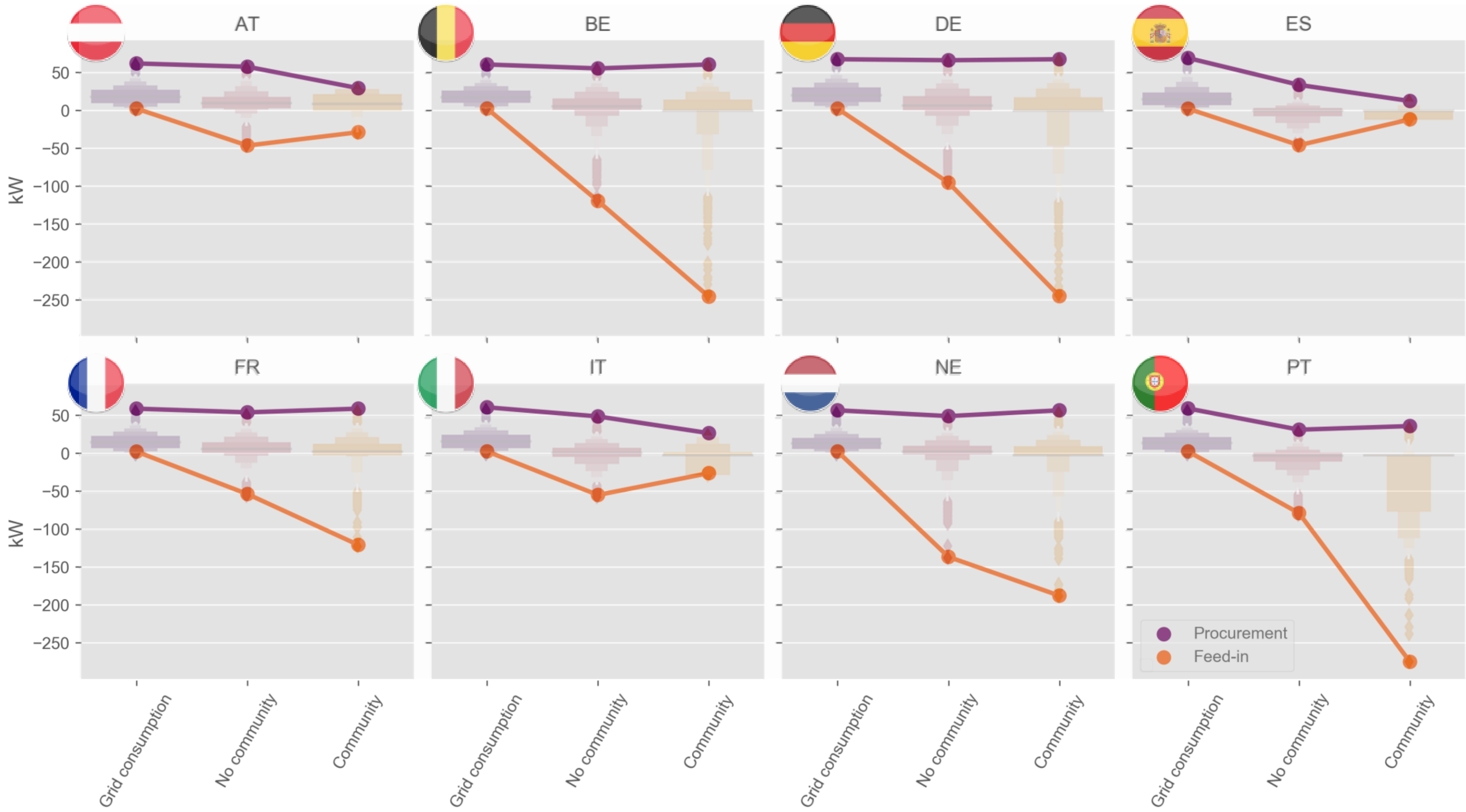
Results Group 3

Residual load in kW

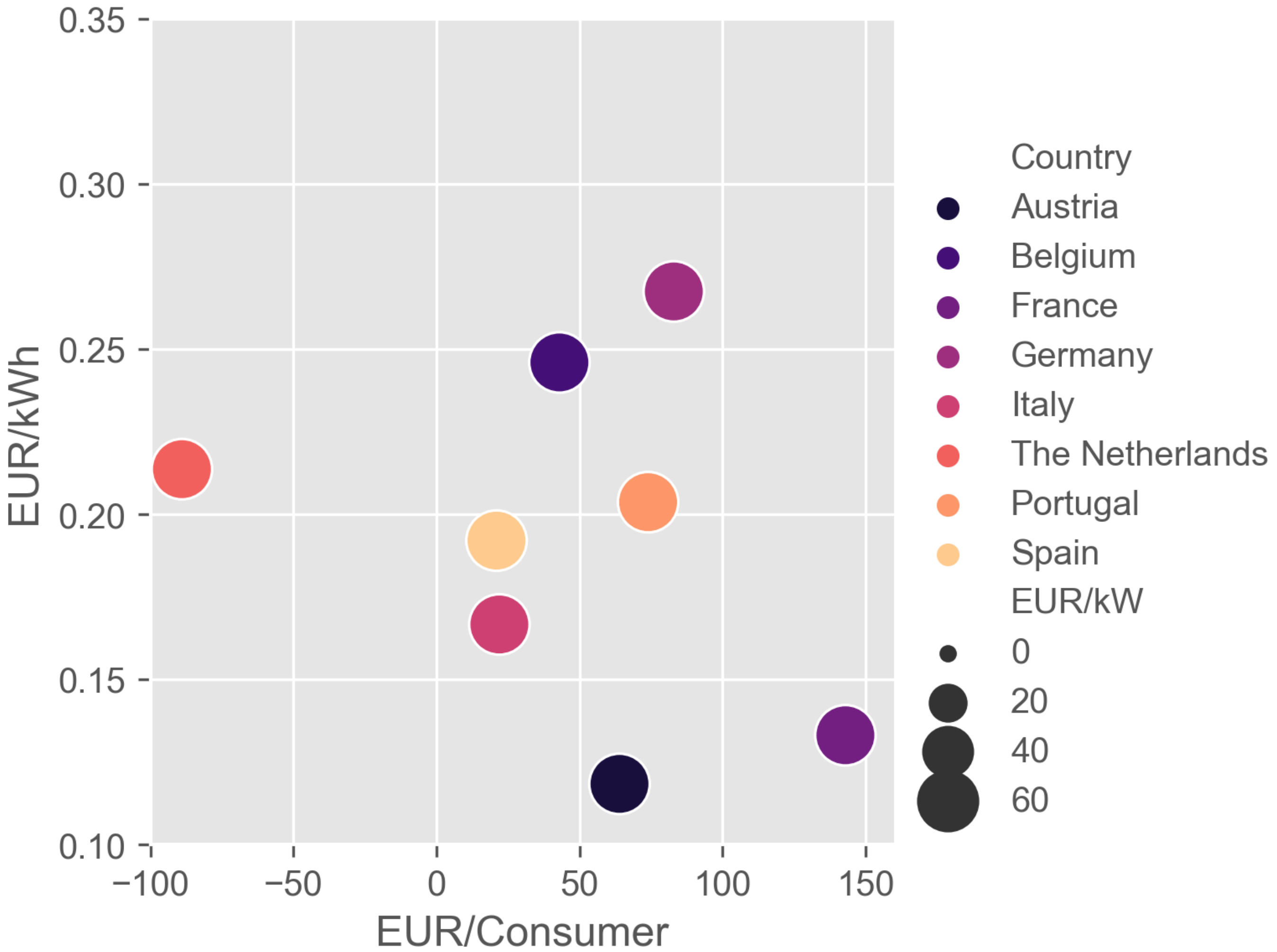


Results Group 3

Residual load in kW

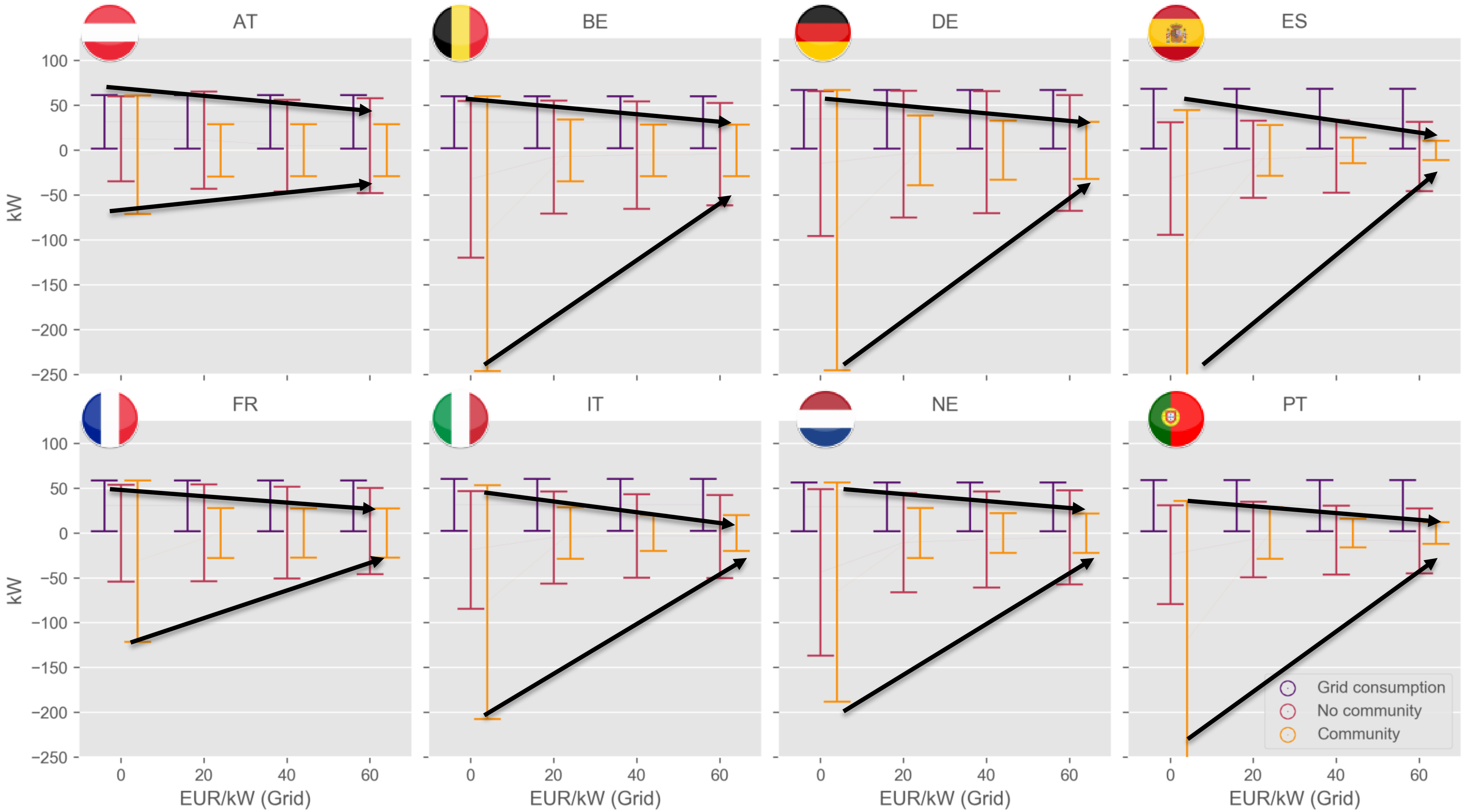


Sensitivity Analysis
Tariff design: 0 – 60€/kW



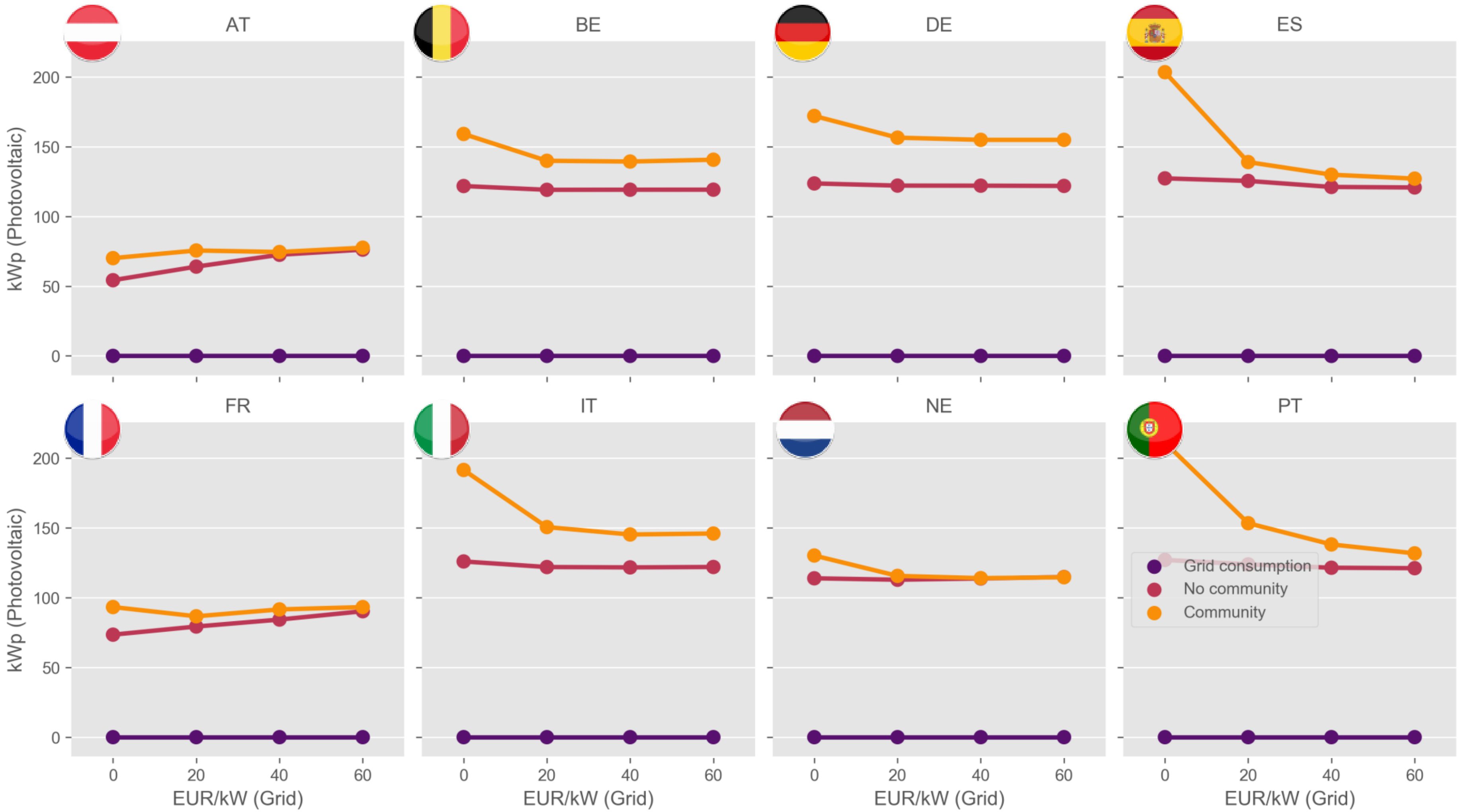
Results Group 3

Residual load in kW



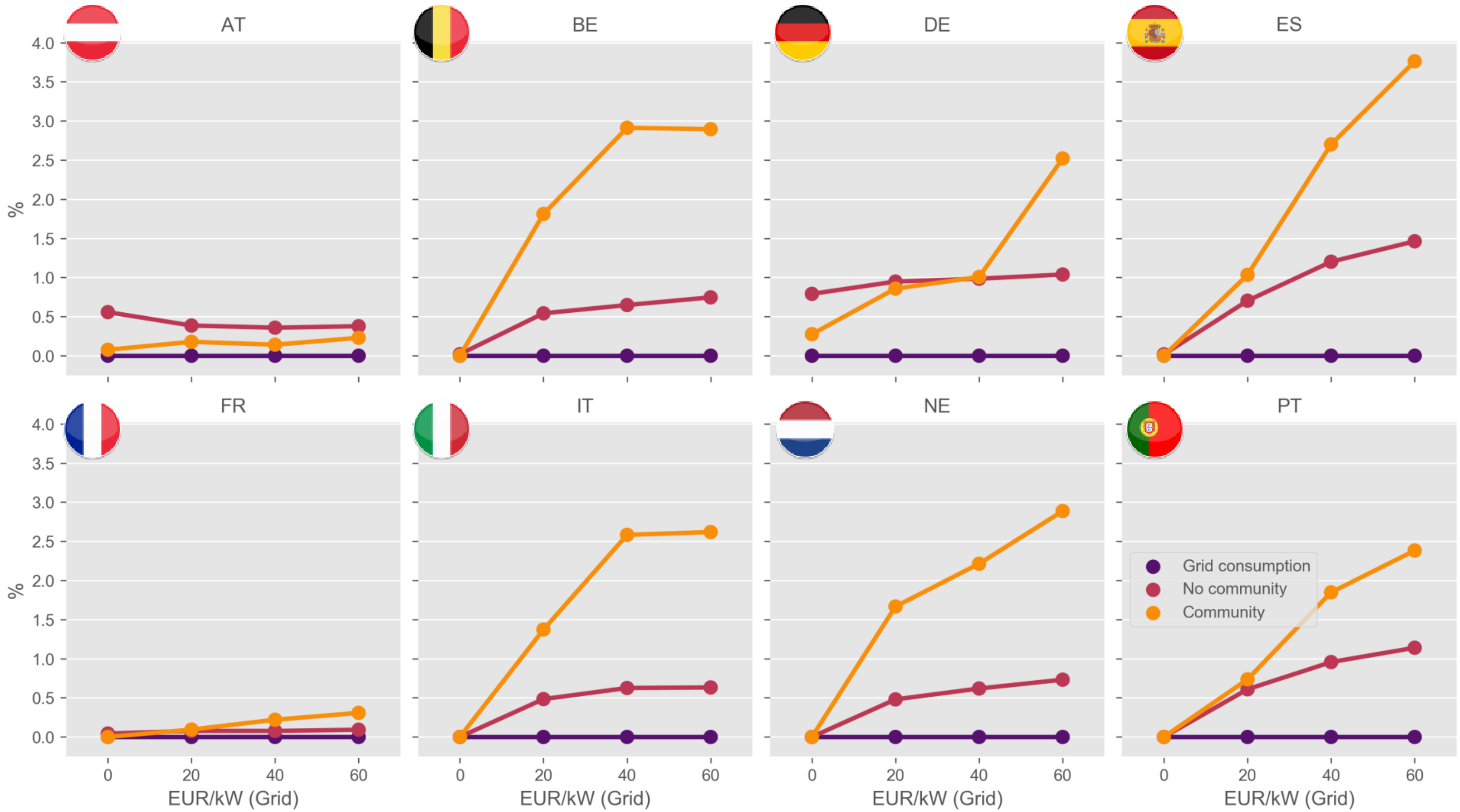
Results Group 3

Installed PV capacity in kWp



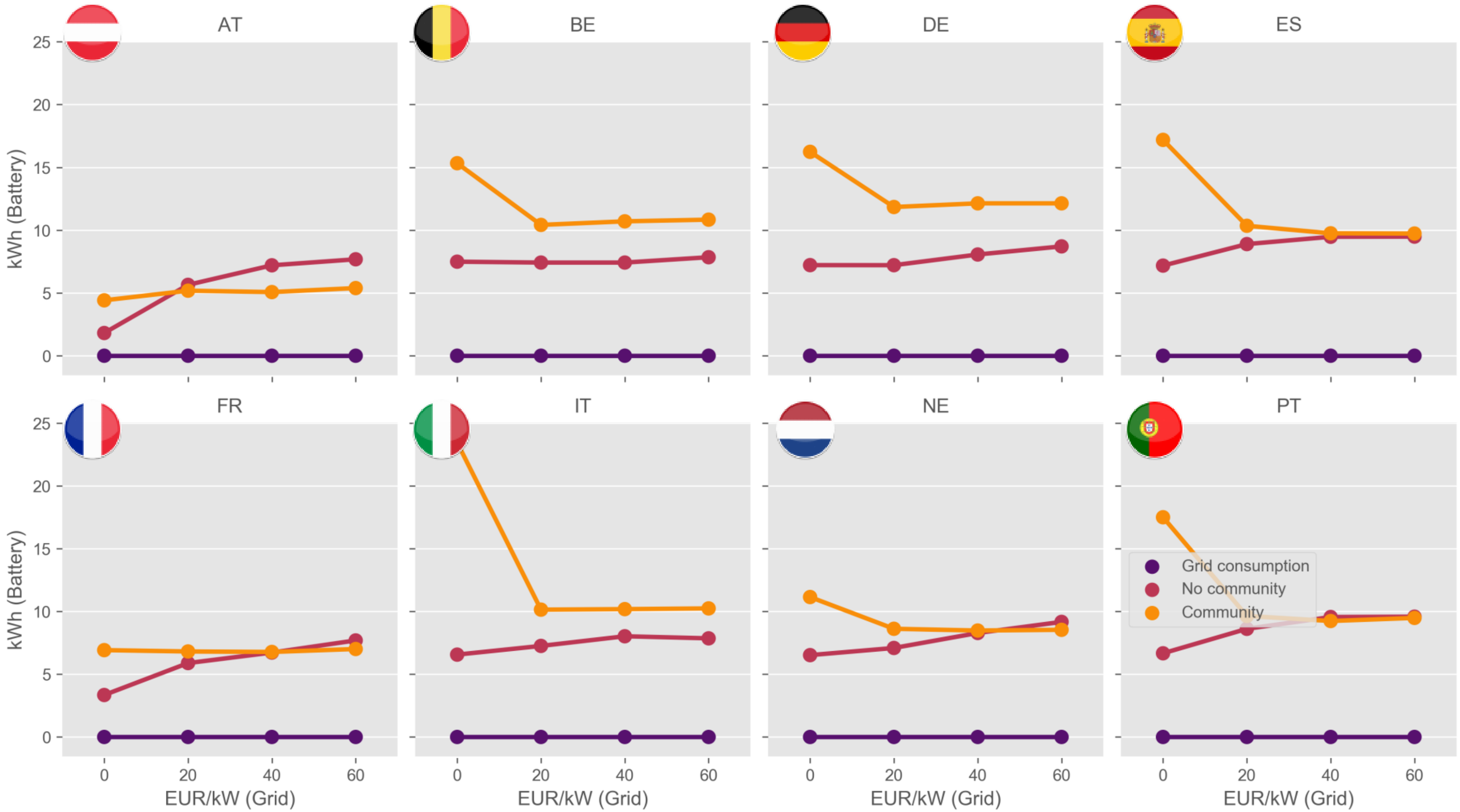
Results Group 3

Curtailment of PV generation



Results Group 3

Installed battery capacity in kWh



Conclusions

- The energy community makes photovoltaics more profitable, reducing the need of subsidies.
- Households with no access to photovoltaics (roof limitation or building restrictions) have the opportunity to be part of a community and benefit from renewable technologies.
- “Grid friendly” behavior must be incentivized by the tariff design.
- Appropriate tariff design (power component) may reduce peak feed-in of photovoltaics.
- While the electricity cost for communities decreases due to reduced procurement from the grid, the income for distribution system operators decreases as well → discussion of grid tariff design

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PVP4Grid Calculator: www.pvp4grid.eu/cmt
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