TradeRES

New Markets Design & Models for
100% Renewable Power Systems

Integrating prosumers into a fully decarbonized European wholesale electricity market

18th IAEE European Conference 26.7.2023

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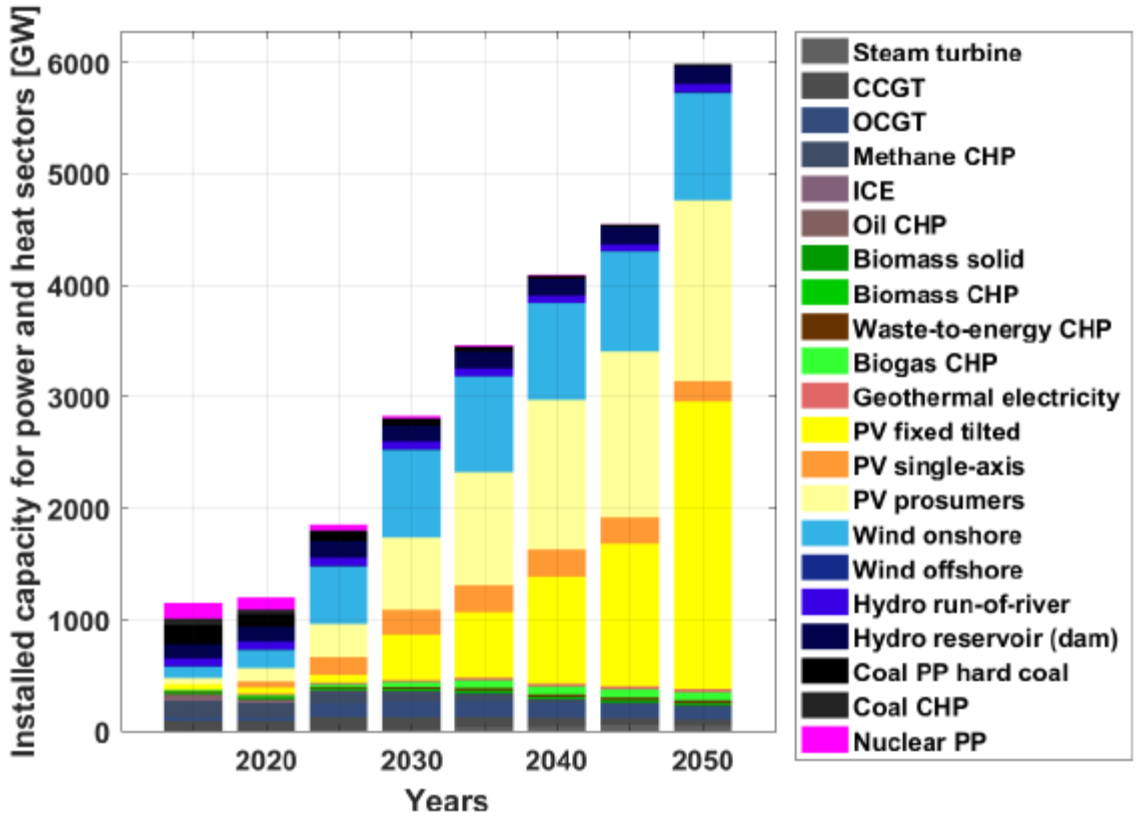
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864276

Agenda

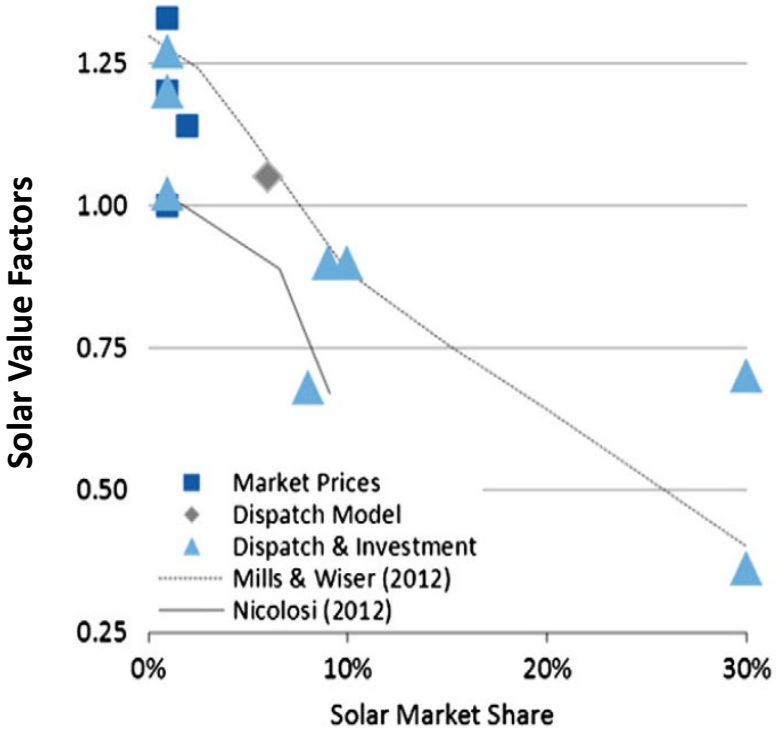
1. Motivation
2. Method
3. Results
4. Conclusion & Outlook

1. Motivation
Decarbonizing the EU requires massive expansion of solar PV capacities



Source: Ram et al. (2018)

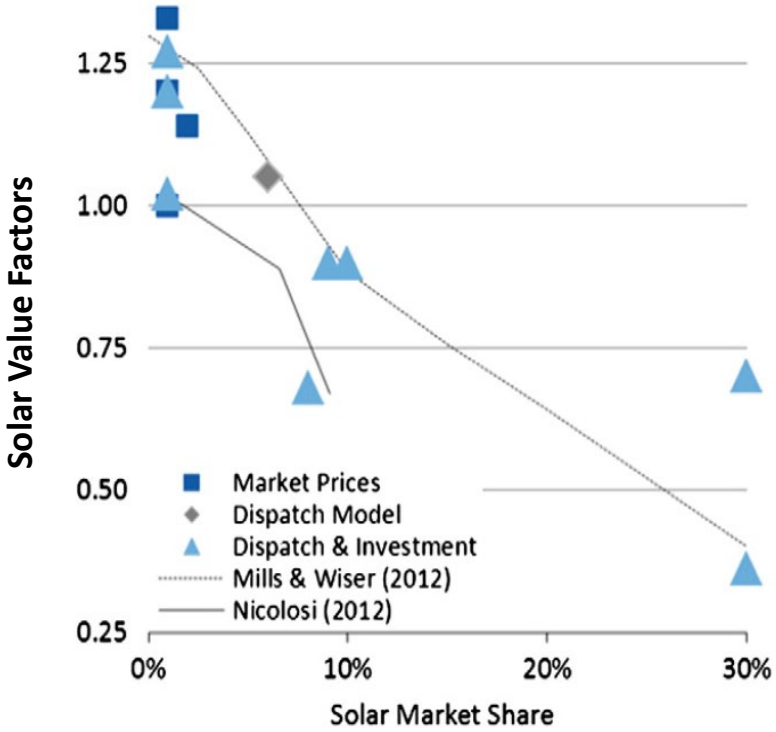
1. Motivation
Feasibility depends on PV market values that are highly affected by cannibalization



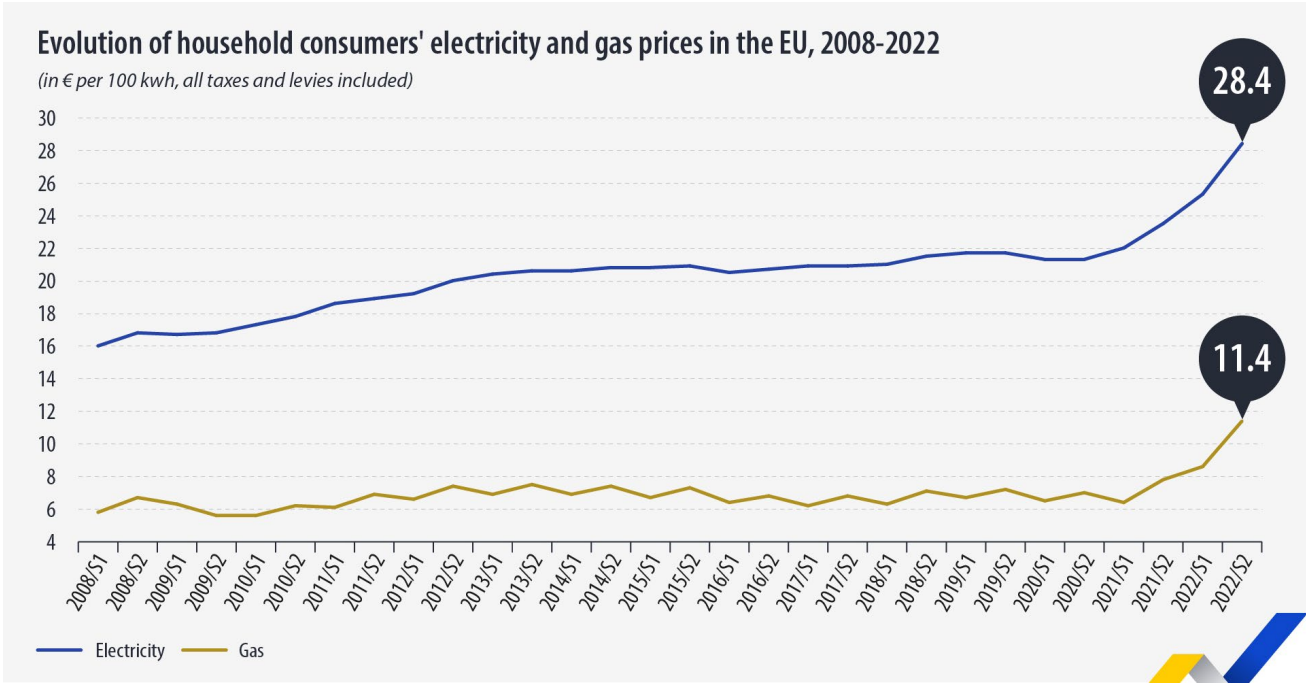
Source: Hirth (2013)

Literature: Prola et al. (2020), Sensfuß et al. (2008), Gelabert et al. (2011) and Burgos-Payán et al. (2013), Johanndeiter (2022)

1. Motivation
Real-life motives for prosumption typically not captured in optimization models



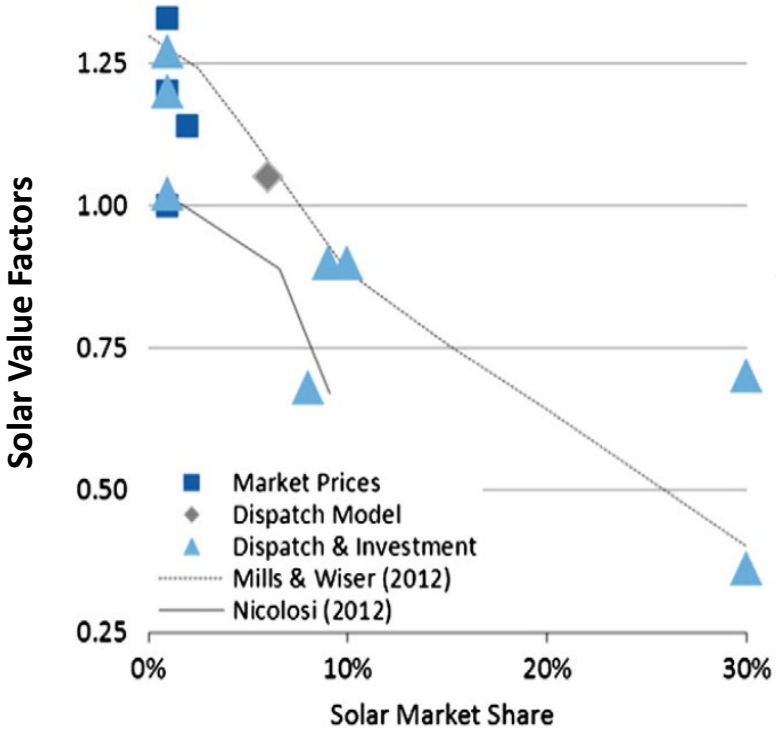
Source: Hirth (2013)



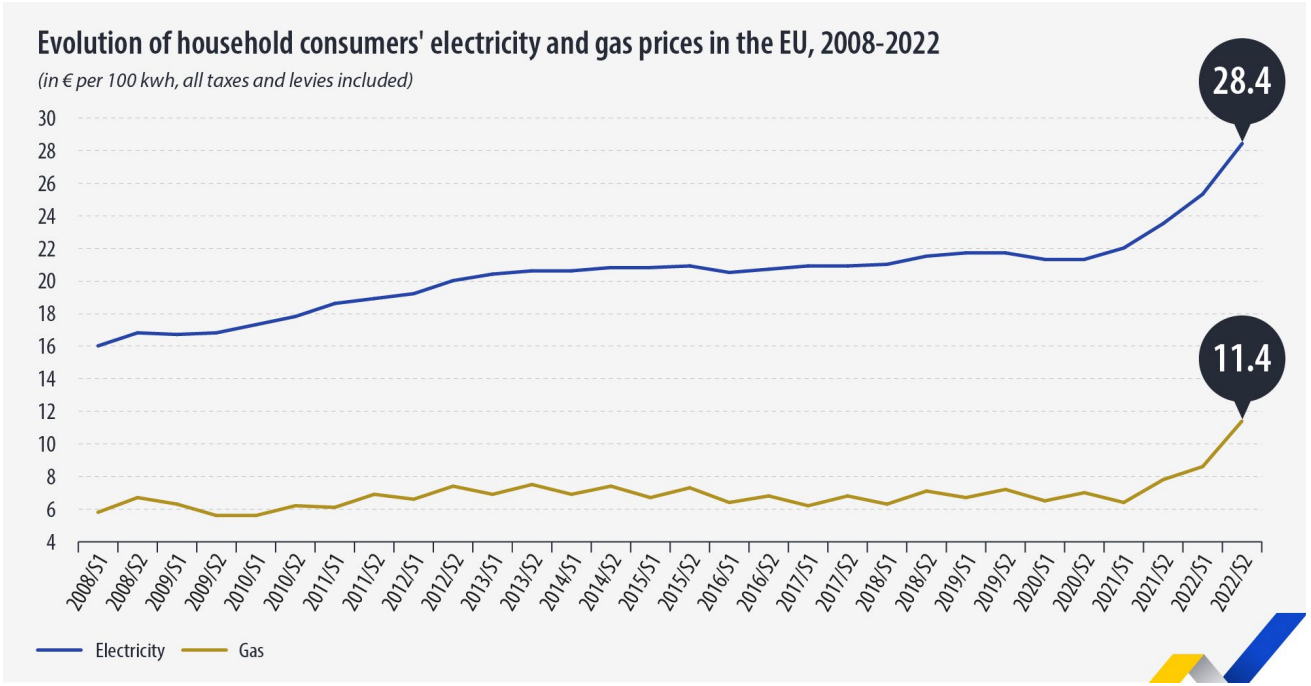
Source: eurostat

Literature: Prola et al. (2020), Sensfuß et al. (2008), Gelabert et al. (2011) and Burgos-Payán et al. (2013)), Johanndeiter (2022)

1. Motivation
How do prosumers affect utility-scale PV market values?



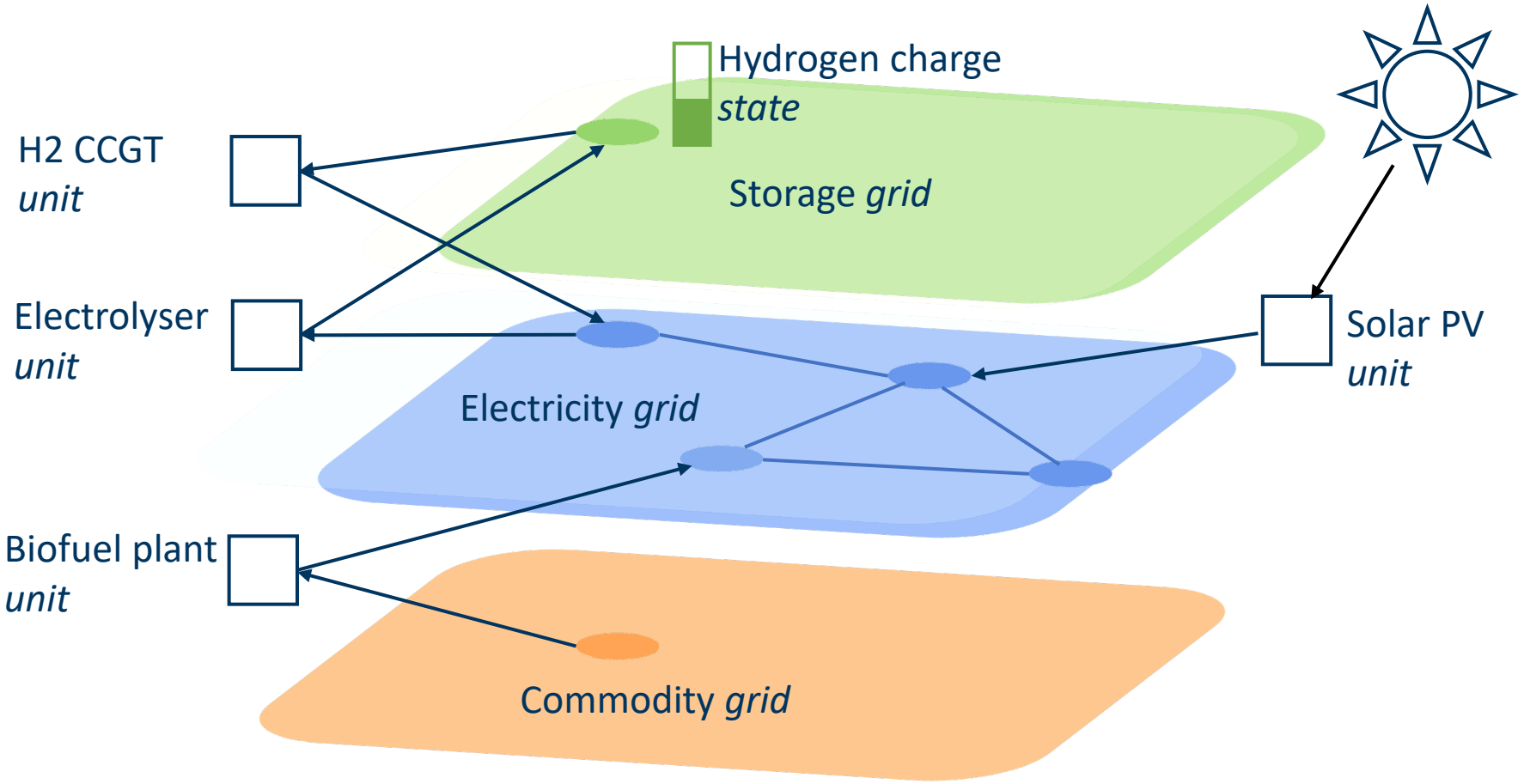
Source: Hirth (2013)



Source: eurostat

Literature: Prola et al. (2020), Sensfuß et al. (2008), Gelabert et al. (2011) and Burgos-Payán et al. (2013)), Johanndeiter (2022)

2. Method
Energy network optimization tool Backbone



Source: Helistö et al. (2019)

2. Method
Simulation of fully decarbonized EU energy system

Initial generation and transmission capacities for 2030[1]
Aggregated electricity and industrial H2 demand for 2050[2]
Fuel prices and costs for 2050[3]
Time series of selected weeks (weather year 2019)[4]

Investment optimization under the assumption of full decarbonization

New generation capacities

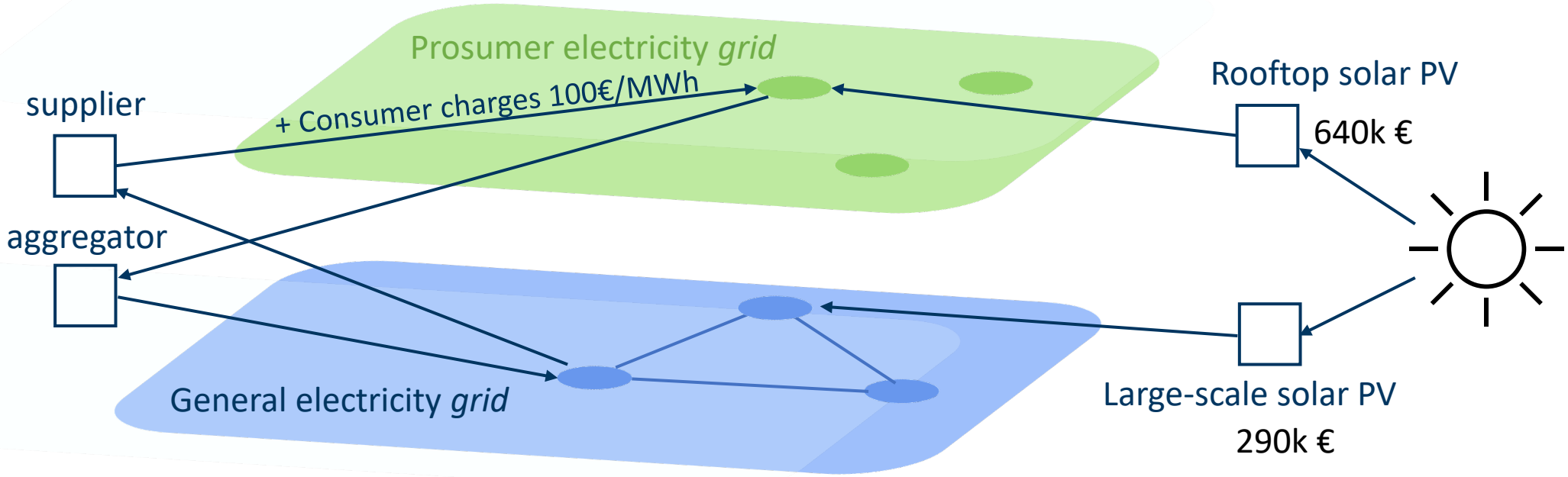
Full year time seres

Operational optimization

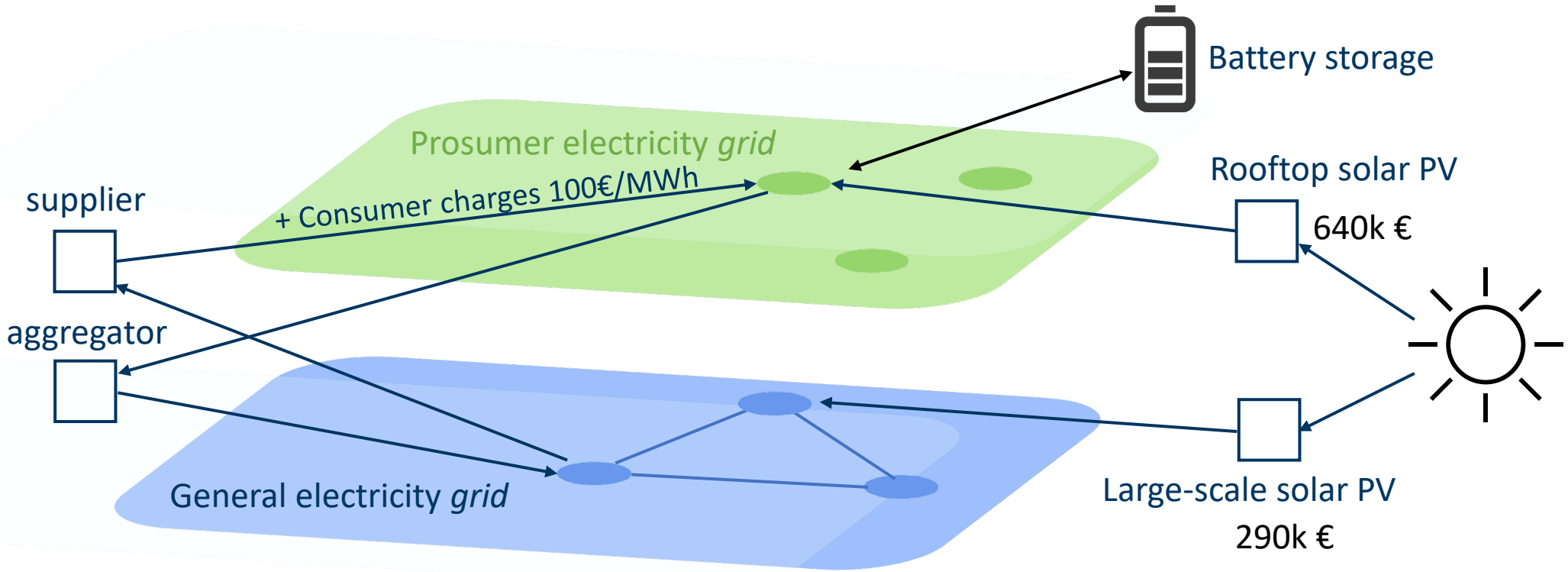
Production and consumption
Transfers
Wholesale electricity prices
Total system costs

1: Entso-E ERAA 2022 National Estimates, Enspresso, Entso-E TYNDP 2022, Entso-G TYNDP 2019
2: Entso-E TYNDP 2022 Global Ambition scenario; 3: Entso-E TYNDP 2022 fuel prices for 2050, Denish Energy Agency technology costs for 2050;
4: Renewables Ninja, sample selection using tsam

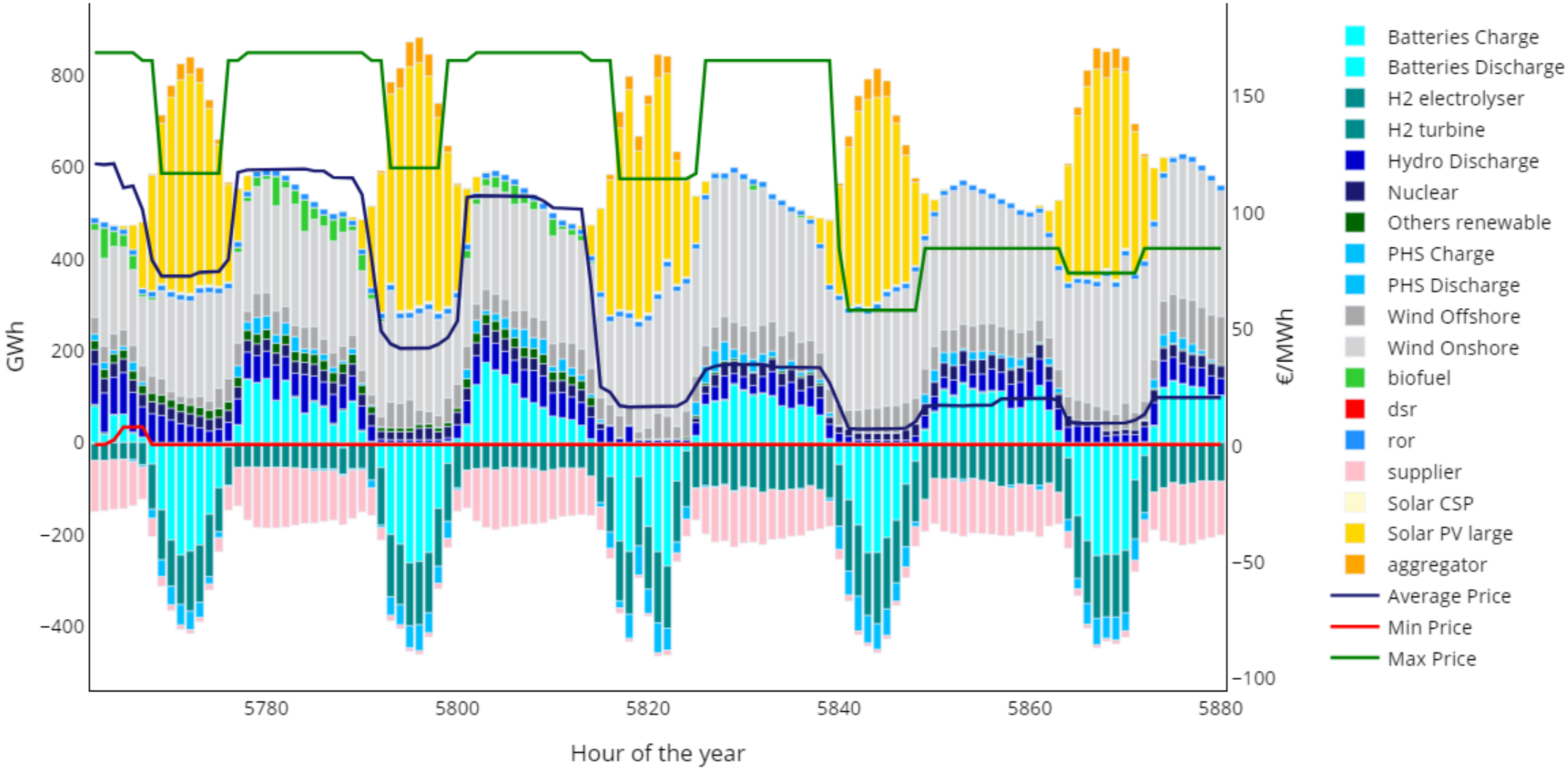
2. Method
Modelling prosumers with dynamic tariff



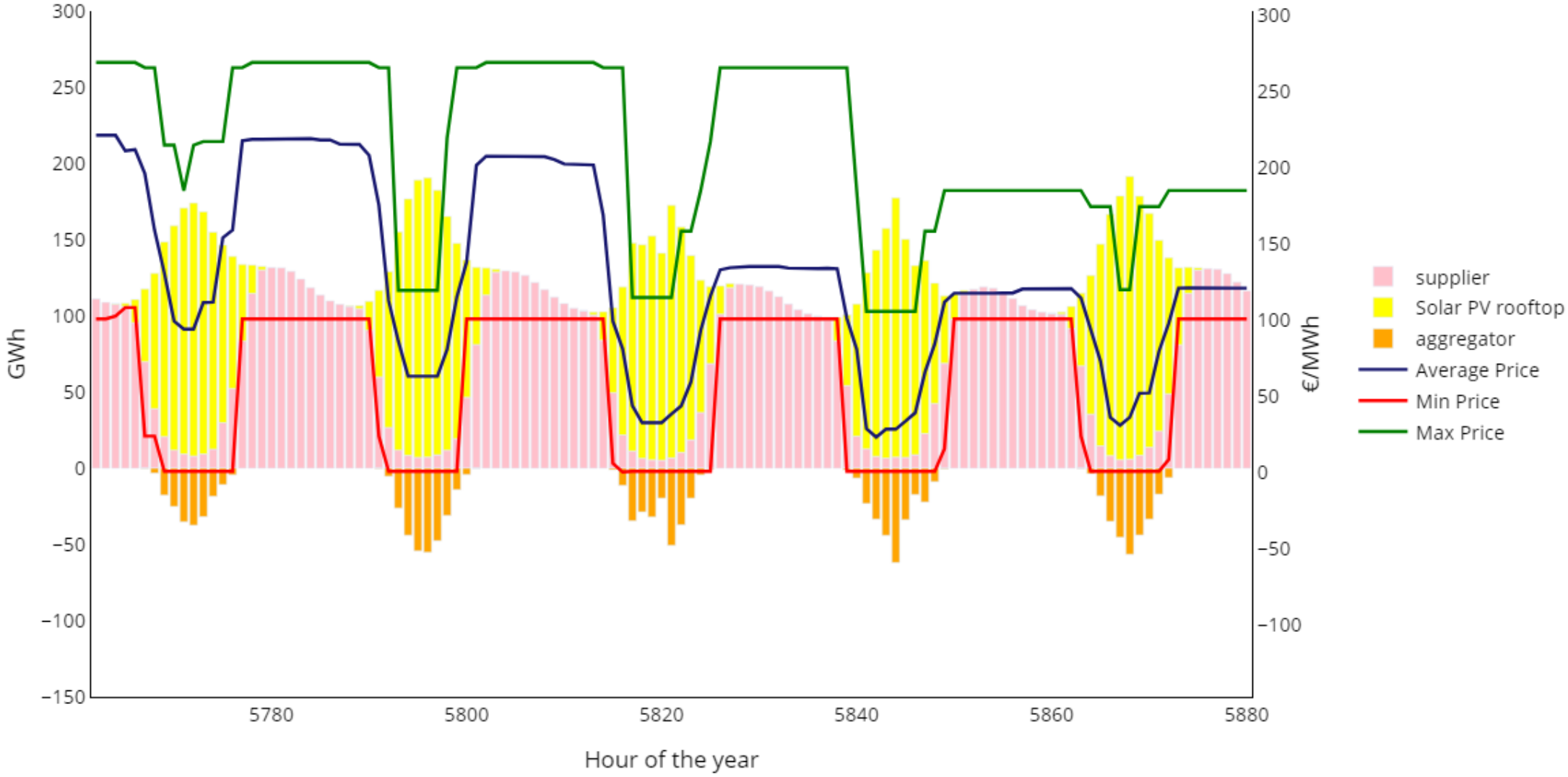
2. Method
Modelling prosumers with dynamic tariff + battery



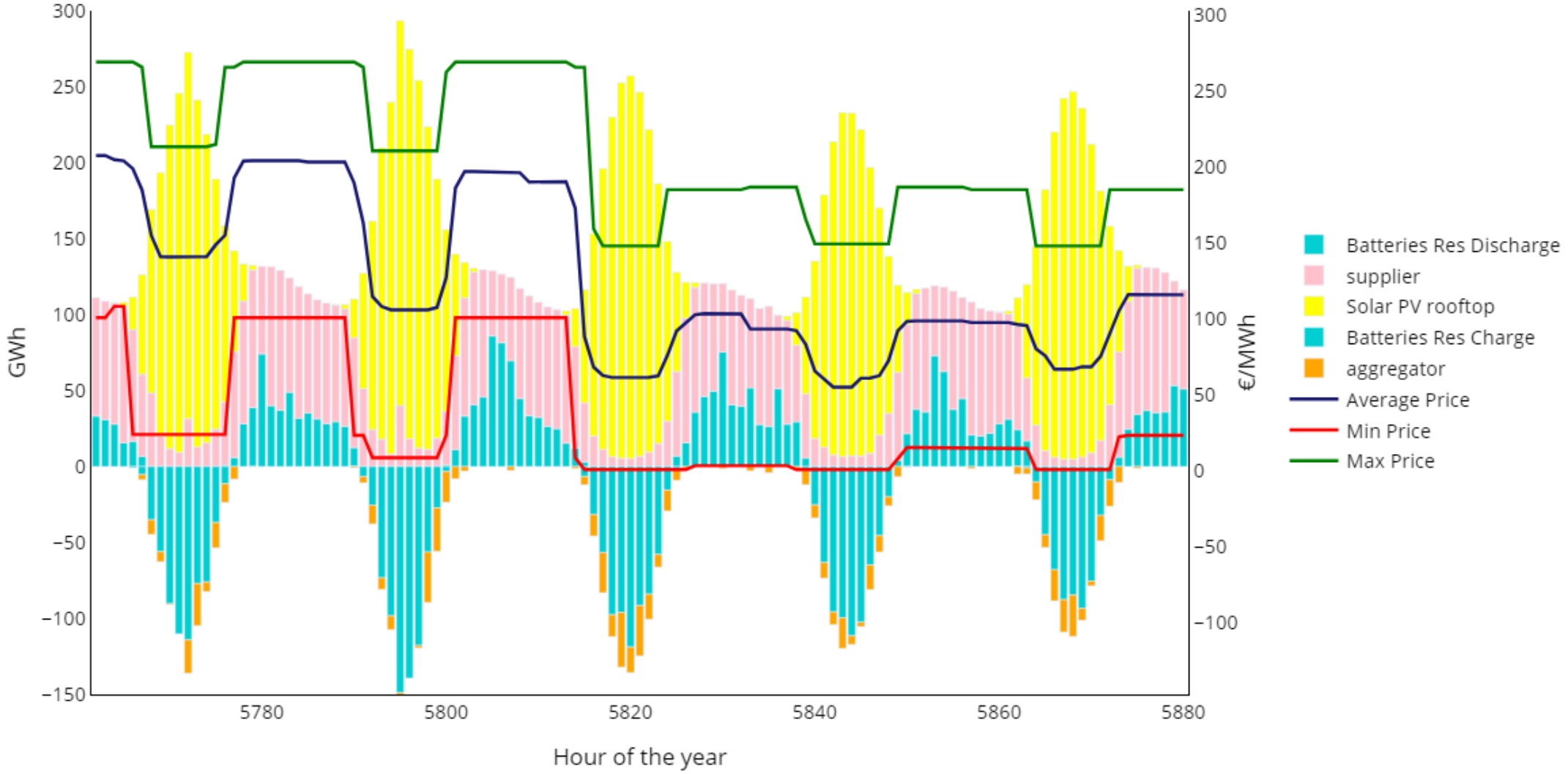
3. Results: Dynamic Tariff
A typical summer week in the general grid



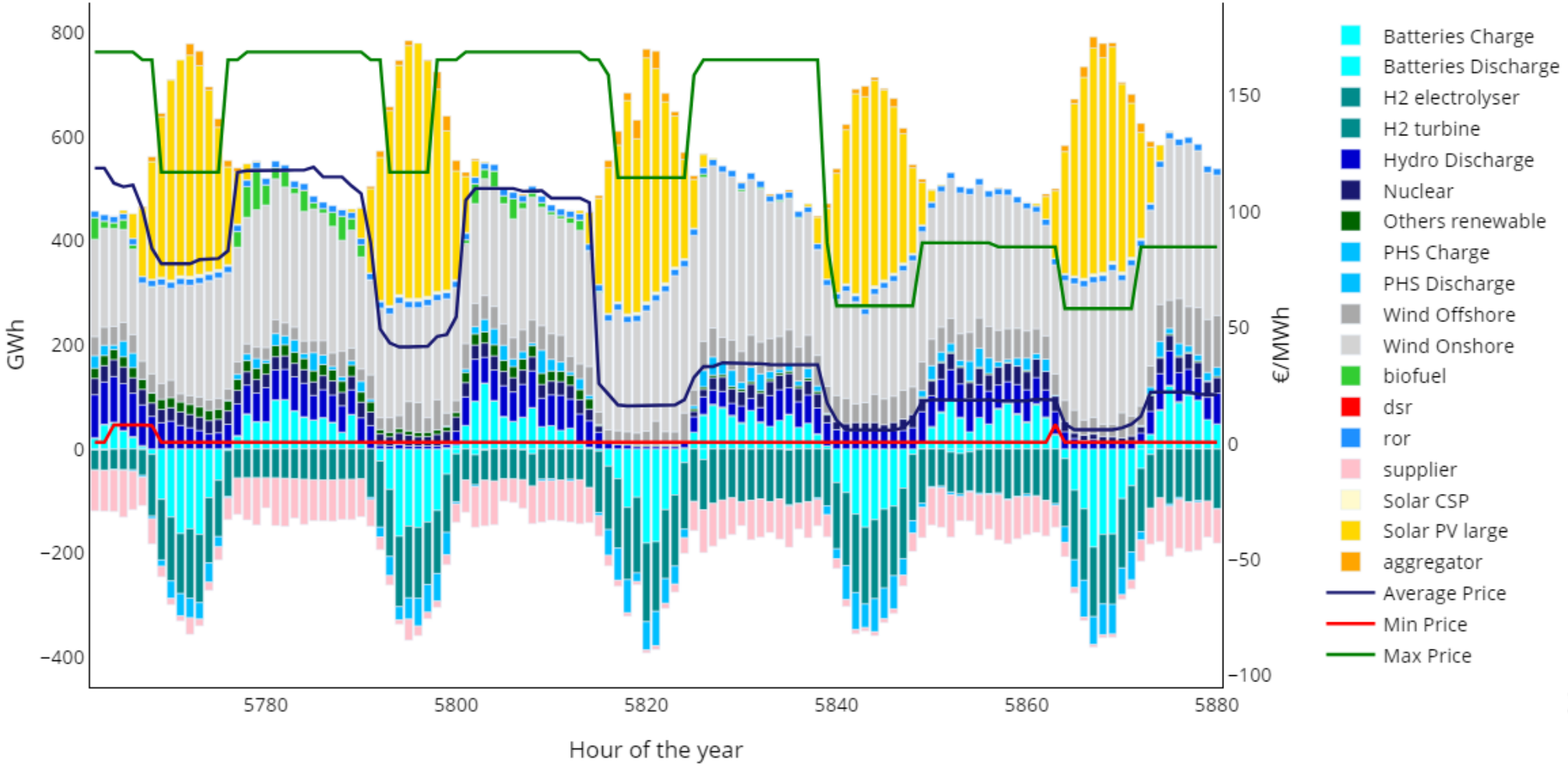
3. Results: Dynamic Tariff
A typical summer week in the prosumer grid



3. Results: Dynamic Tariff with Battery
A typical summer week in the prosumer grid

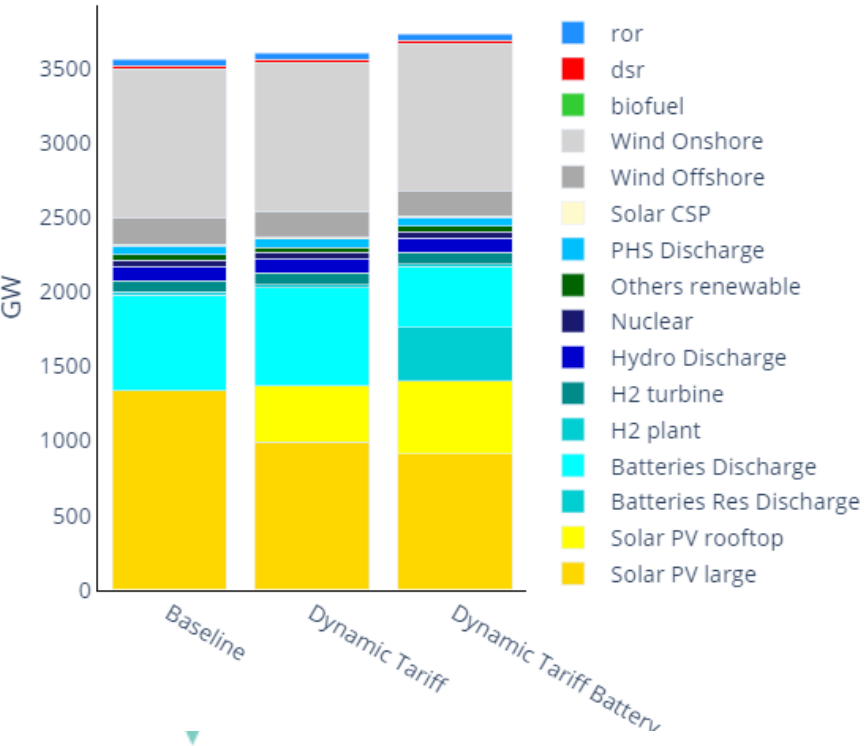


3. Results: Dynamic Tariff with Battery
A typical summer week in the general grid

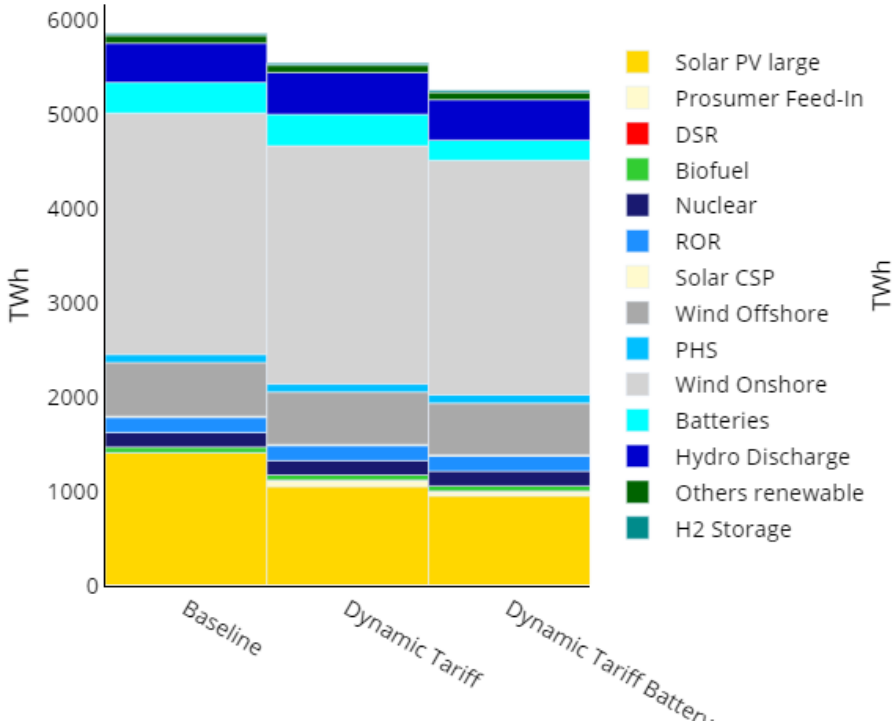


3. Results
Aggregated capacities and generation EU-27+GB

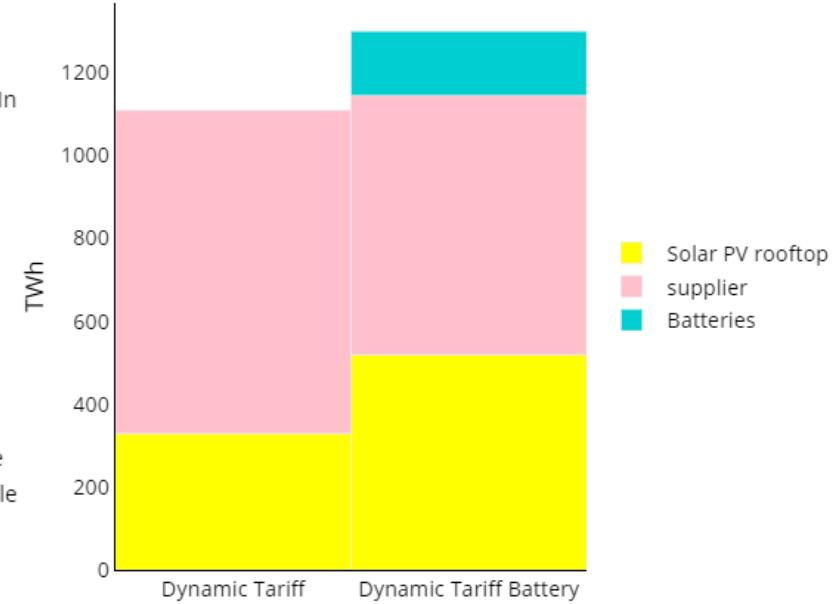
Total installed capacities



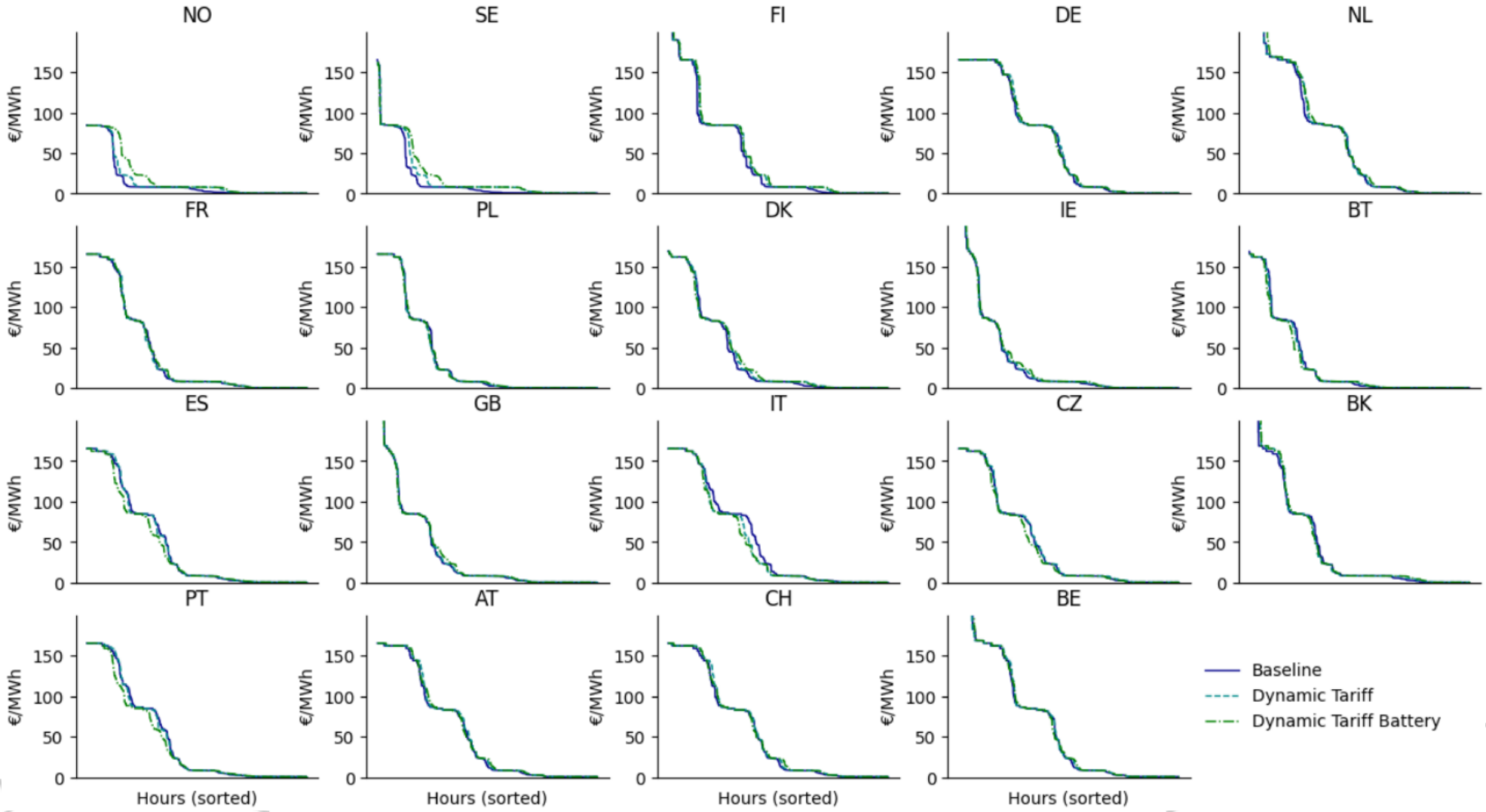
Generation mix public grid



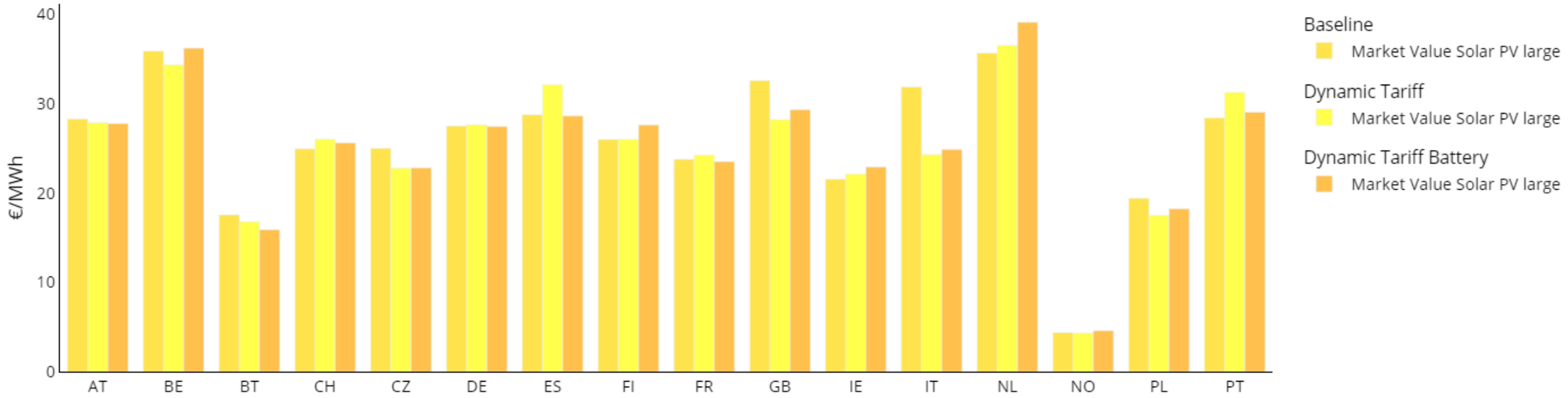
Generation mix prosumer grid



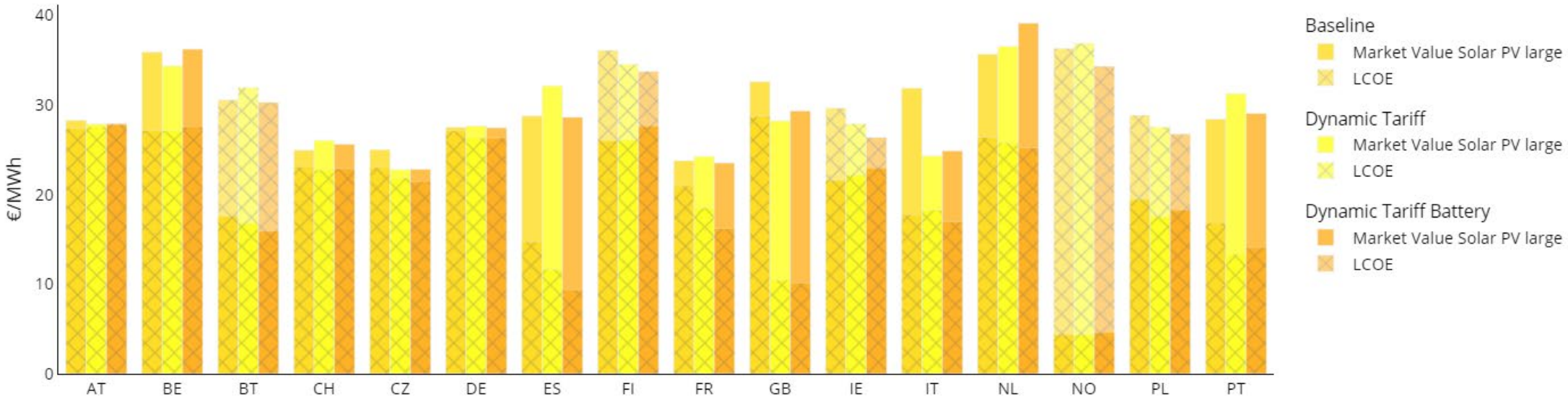
3. Results
Market prices



3. Results
Market values of utility-scale PV



3. Results
Market values and LCOE of utility-scale PV



4. Conclusion and Outlook

- Effect of prosumers on wholesale market prices and utility-scale PV market values is low, but matters and should therefore not be neglected in scenarios of fully decarbonized energy markets

- Effect differs across Europe depending on amount of investments and differences in dispatch
  - Outlook: isolation of dispatch effect

- Successful test of framework to integrate prosumers into optimization model of European energy system
  - Outlook: differentiated tariffs, introduction of static tariffs, many more possibilities…

EnBW

RUB Chair of Energy Systems & Energy Economics

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Thanks ☺

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864276

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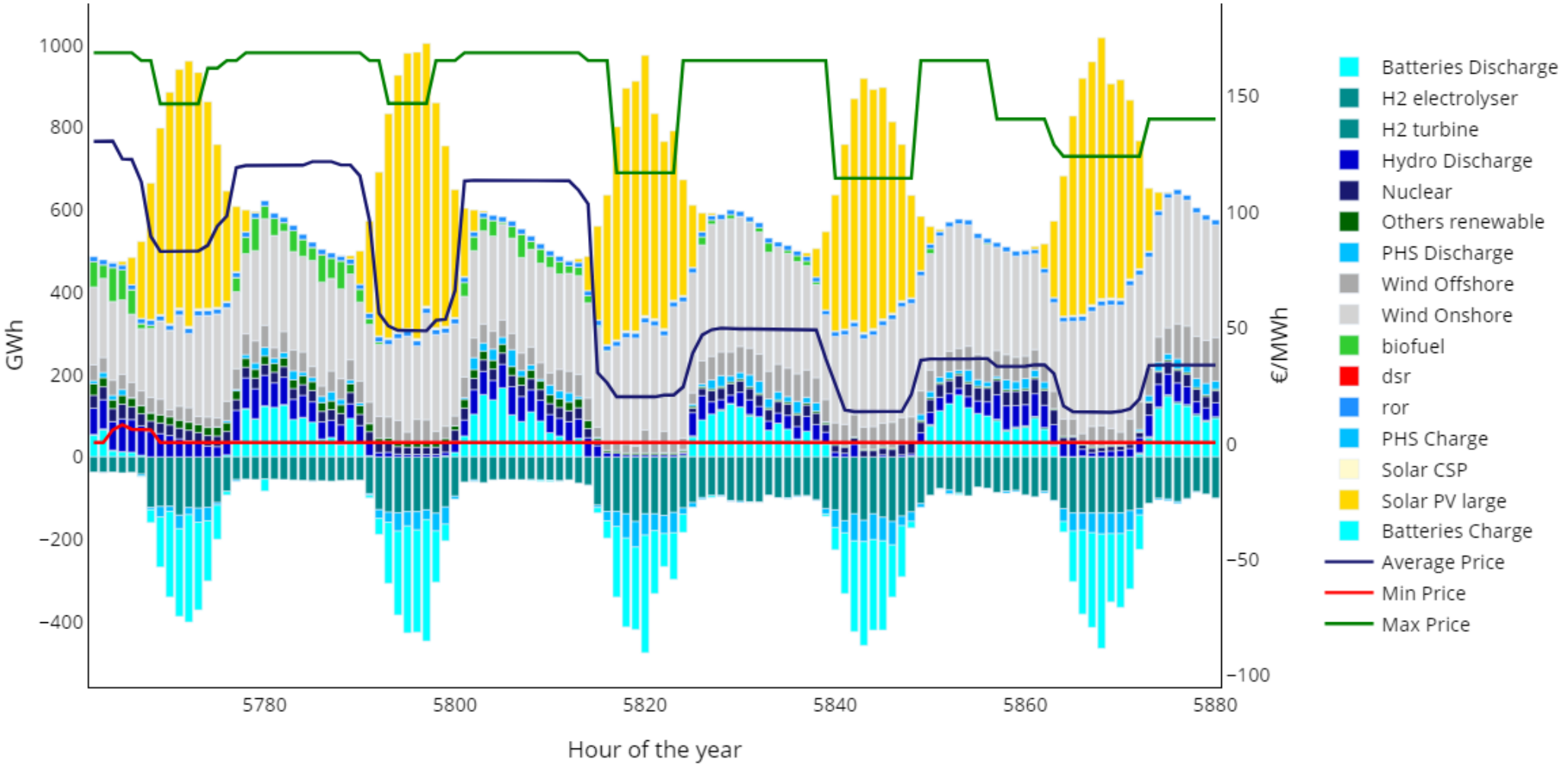
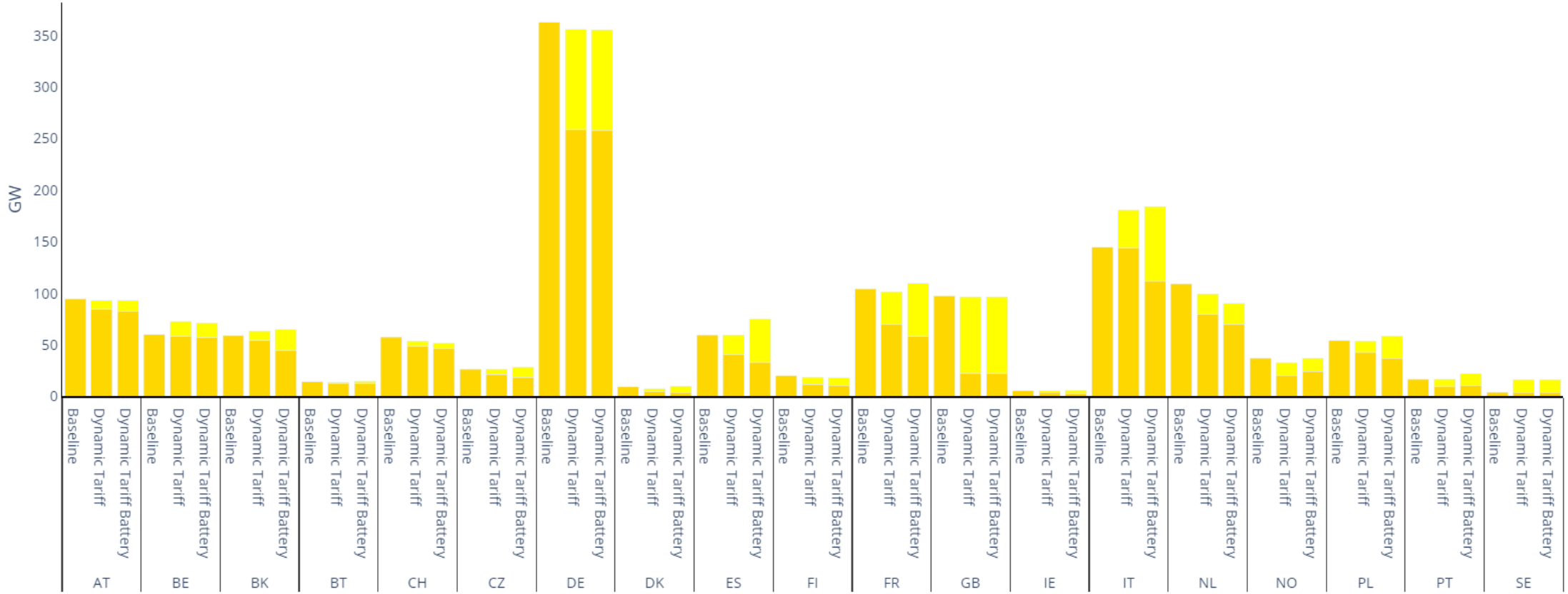
Backup

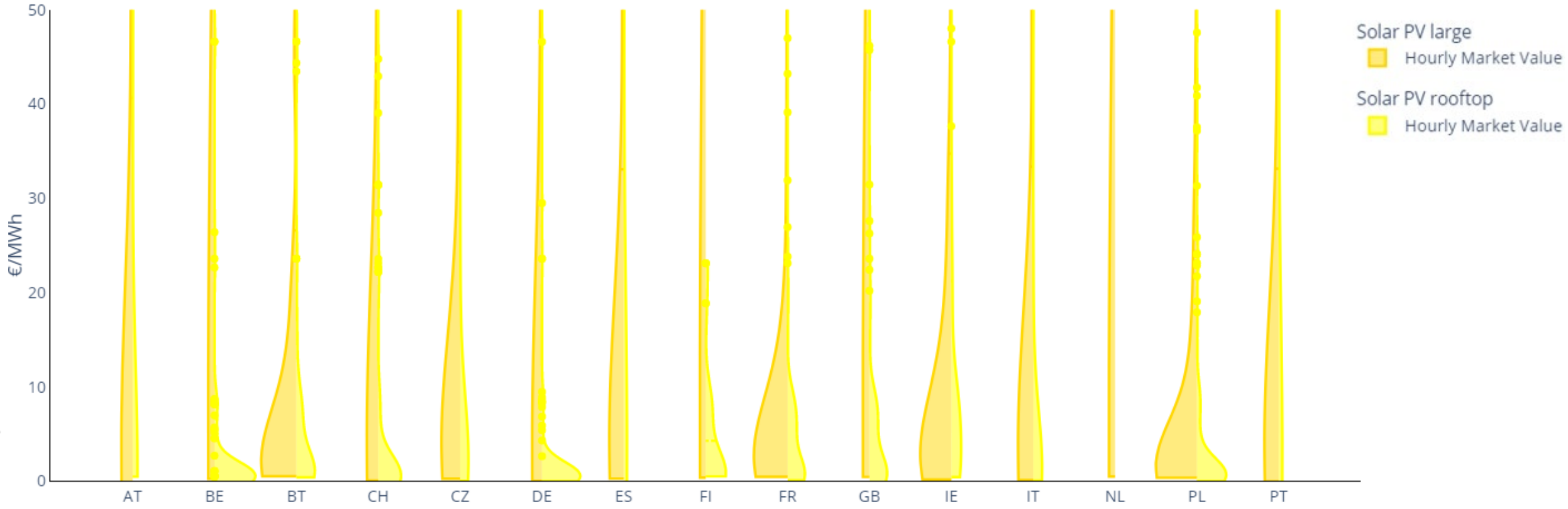
Baseline
A typical summer week



Installed solar PV capacities across Europe



Dynamic Tariff
Violin Plots of hourly market values



Dynamic Tariff with Battery
Violin Plots of hourly market values