Comparison of greenhouse gas emission reduction potentials of energy communities in Europe

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Energy communities

Recap Radl:

- Profitable to investment in PV and (small) battery systems
- Application of BEVs and Heat-Pumps
- Sharing of energy in energy communities → less grid consumption
- In terms of costs, benefits are attainable, but what about **greenhouse gas emission reduction**?

Research questions:

- What is the effect of installing PV and Battery systems on the total greenhouse gas emissions of an urban community?
- Can energy sharing enhance greenhouse gas emissions mitigation potential?

Countries and Reference Cities

8 countries

PVP 4Grid

LCA and Greenhouse Gas emissions of Urban Communities

Greenhouse Gas Emissions are released (indirectly) due to:

- Electricity use from the grid
- Manufacturing of PV systems, batteries, BEVs, Heat-pumps
- “Negative emissions” by feeding in PV electricity to grid

Since the emission factor of grid electricity fluctuates every hour, timing of electricity use (or grid feed-in) is important

LCA+: using time-varying emission profiles

- **Emission Factor**: CO_2 intensity* of electricity generation (kg/MWh)

- Current standard: use of a constant Emission Factor, the **average** of a country over a whole year

With increasing share of **renewables** in the generation mix:

- Emission factor **fluctuates** over time, depending on e.g. renewable electricity generation and economic dispatch
- Timing of generating and consuming electricity becomes increasingly important

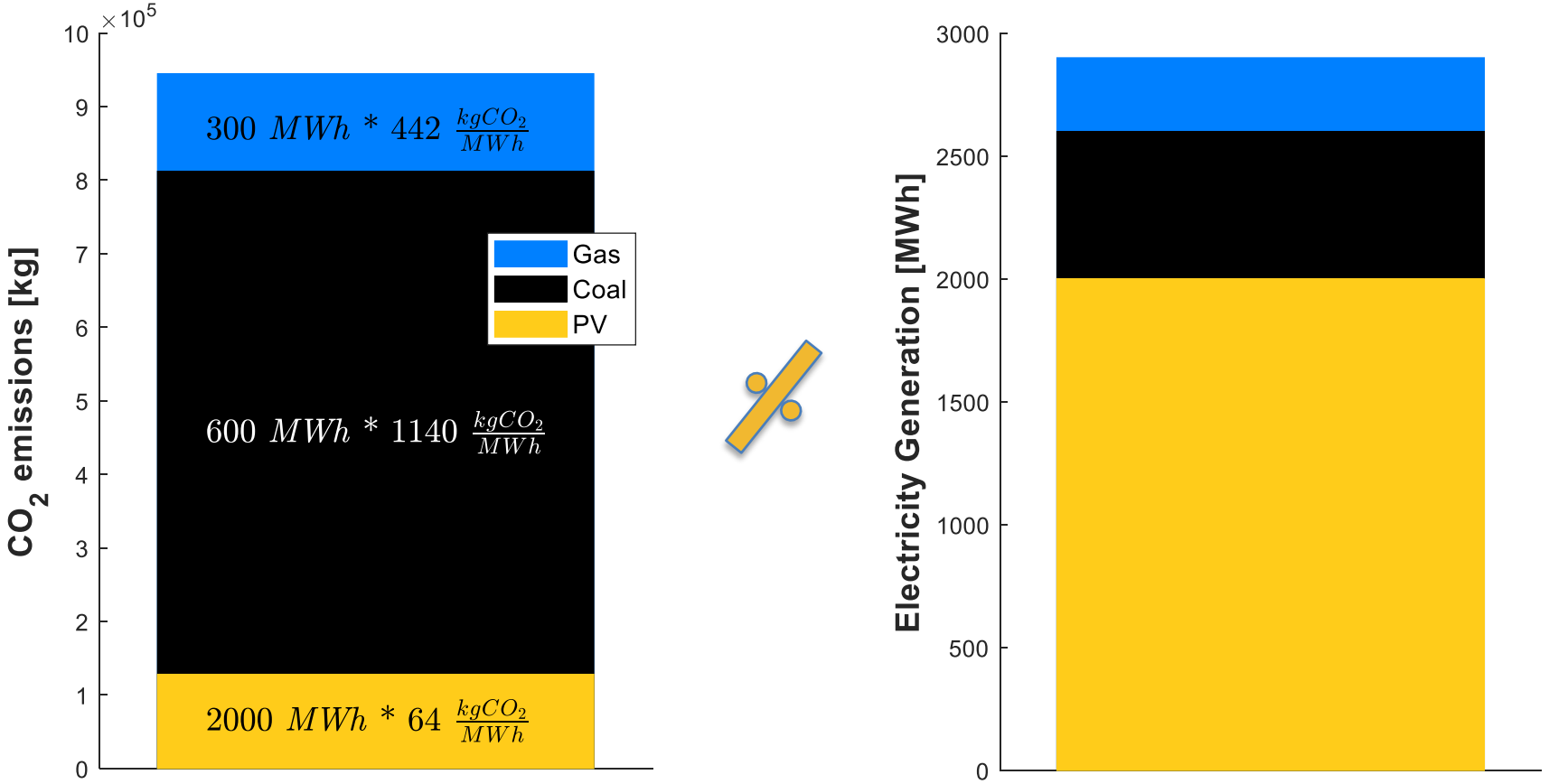
→ Solution: use of **Hourly Emission Factors**: the CO_2 intensity of electricity consumption **in a given hour.**

** All results are based on CO_2-eq*

Hourly Emission Factor (HEF)

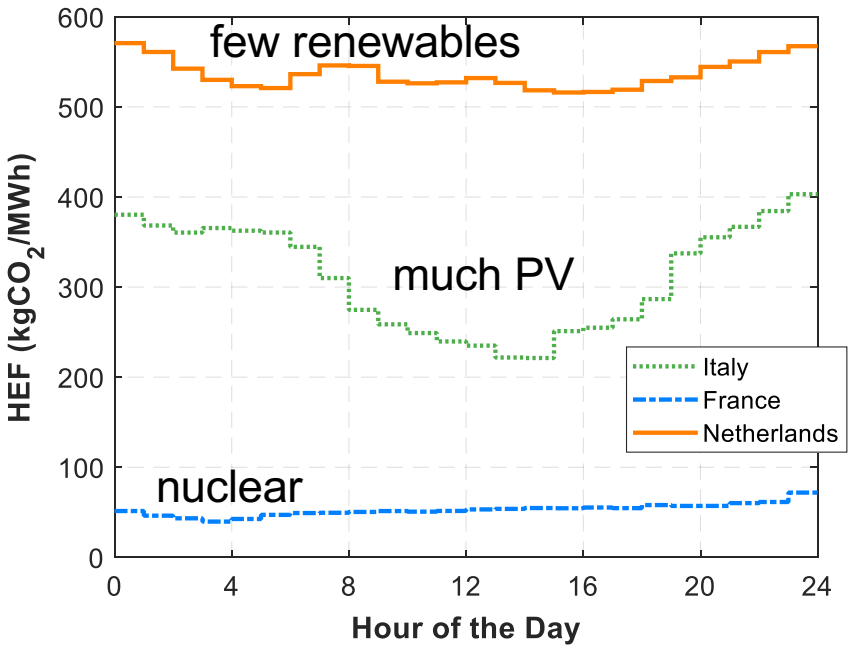
Example

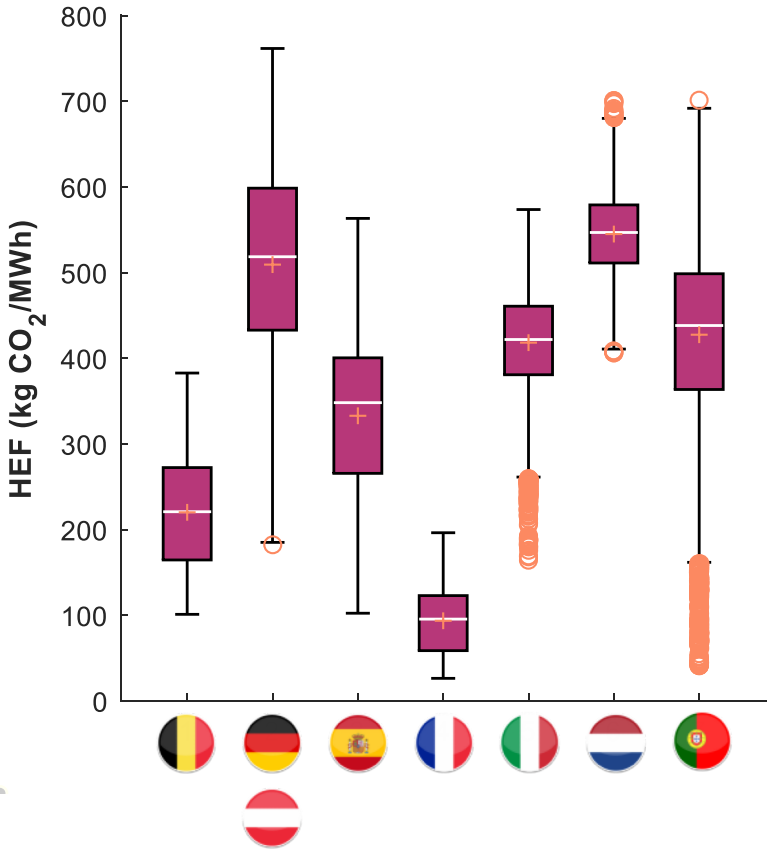
Hourly weighted average emission of dispatched generators $n \in \{1, 2, \ldots, N\}$



$$HEF = \frac{\sum_{n=1}(E_{\text{gen},n} * EF_n)}{\sum_{n=1} E_{\text{gen},n}} = \frac{9.45 * 10^5 \text{ kg CO}_2}{2900 \text{ MWh}} = 326 \text{ kg CO}_2/\text{MWh}$$

Hourly Emission Factor (HEF)





- If you feed-in PV electricity in hour *x*, you mitigate emissions **in that hour**
  → Shows where in Europe PV can have highest CO_2 mitigation potential

Lifecycle Assessment: Foreground Data and Modelling

We calculate Electricity Related Emissions with timeseries of

- Hourly Emissions Factors
- Electricity Consumption

Additionally, we take into account manufacturing of technologies:

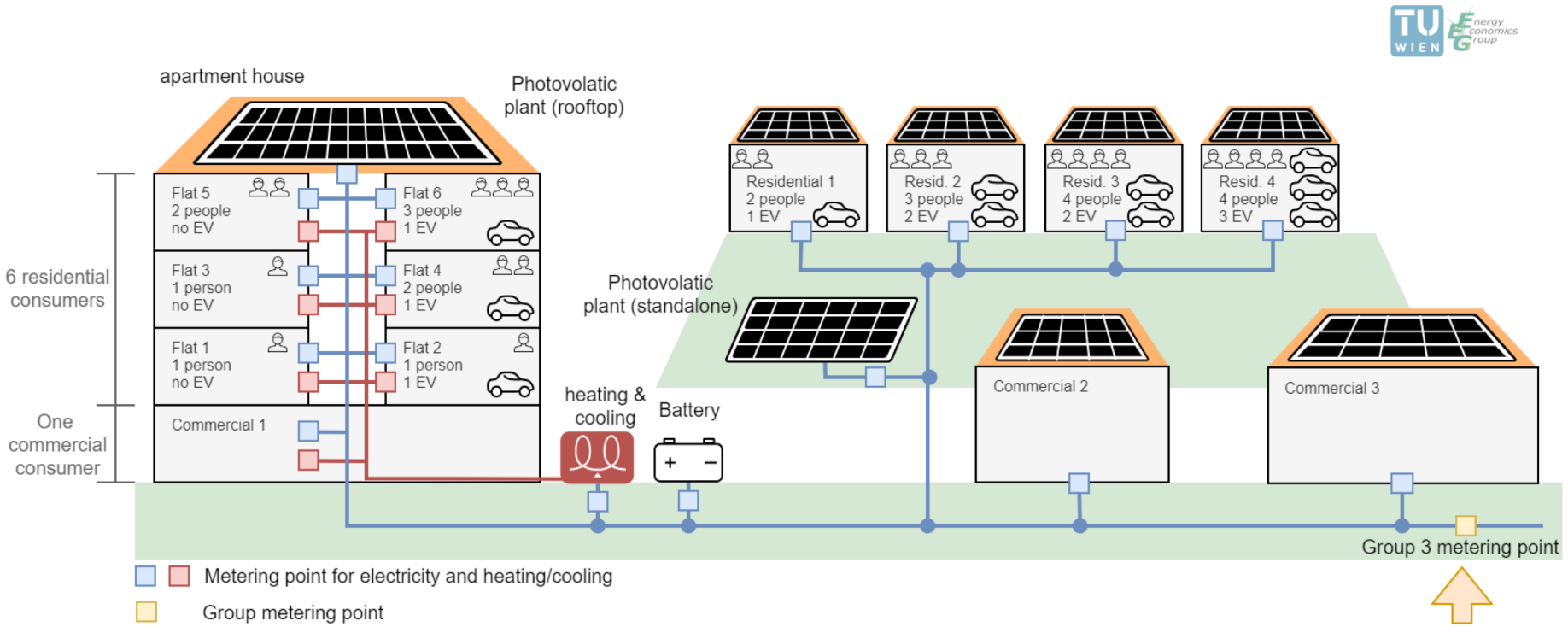
- BEVs
- Heat-pump
- PV system
- Battery storage system

We use the “European Village” and community scenarios

LCA data was taken from ecoinvent v3 database (for consistency)

Setup for the renewable energy community

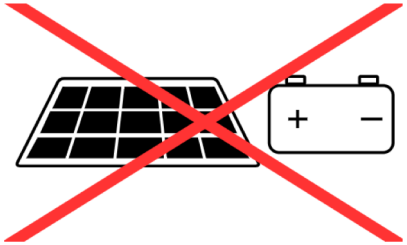
- "European Village" represents average housing situation in Europe



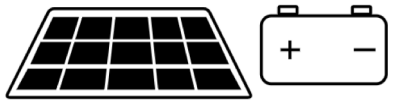
Community Scenarios

Technologies

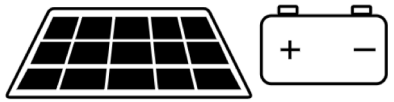
- ***Grid consumption***:
  - No PV and BESS
  - Demand is satisfied via the grid



- ***No community***:
  - PV and BESS are possible
  - Energy sharing not allowed



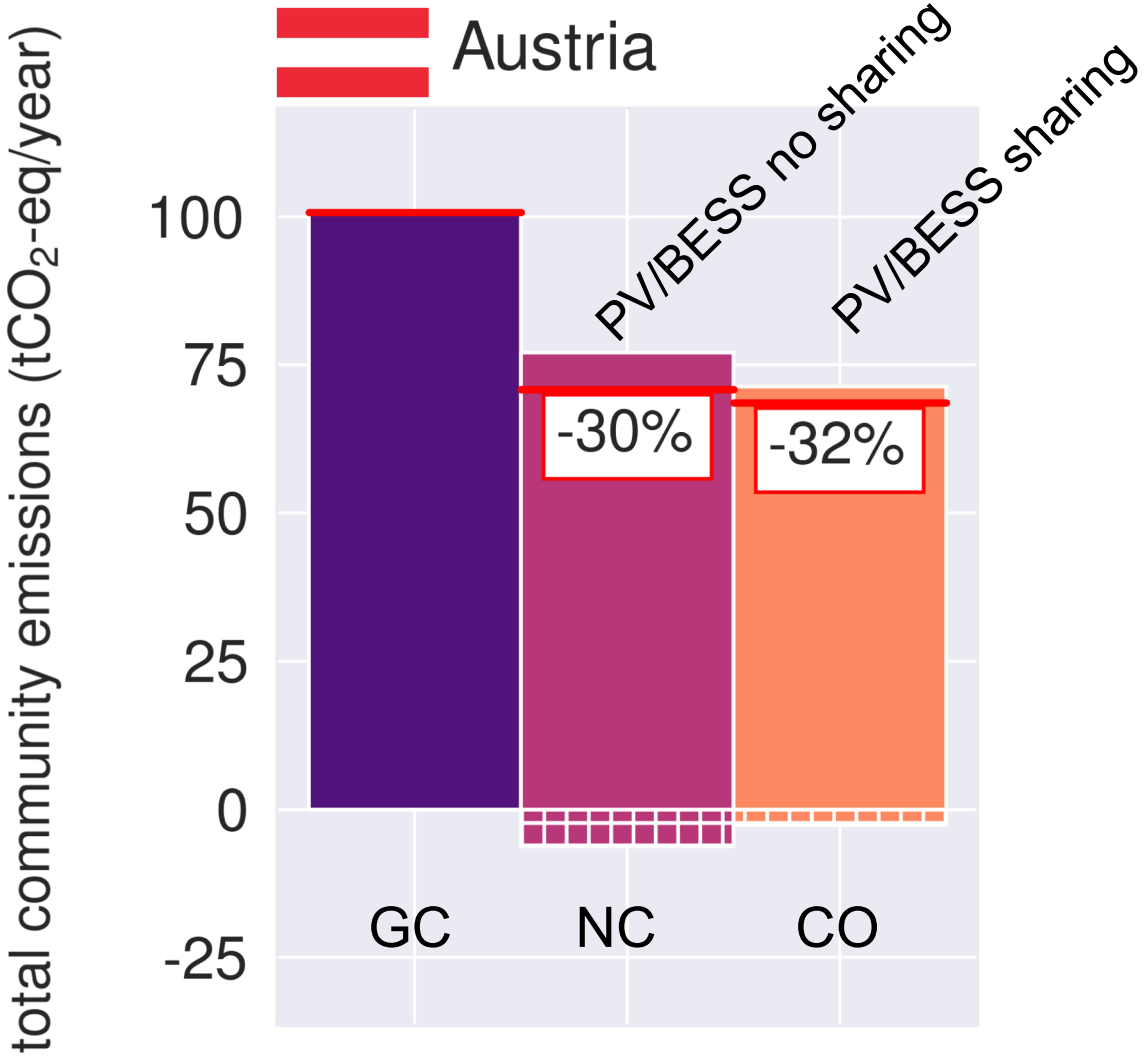
- ***Community***:
  - PV and BESS are possible
  - Energy sharing allowed



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

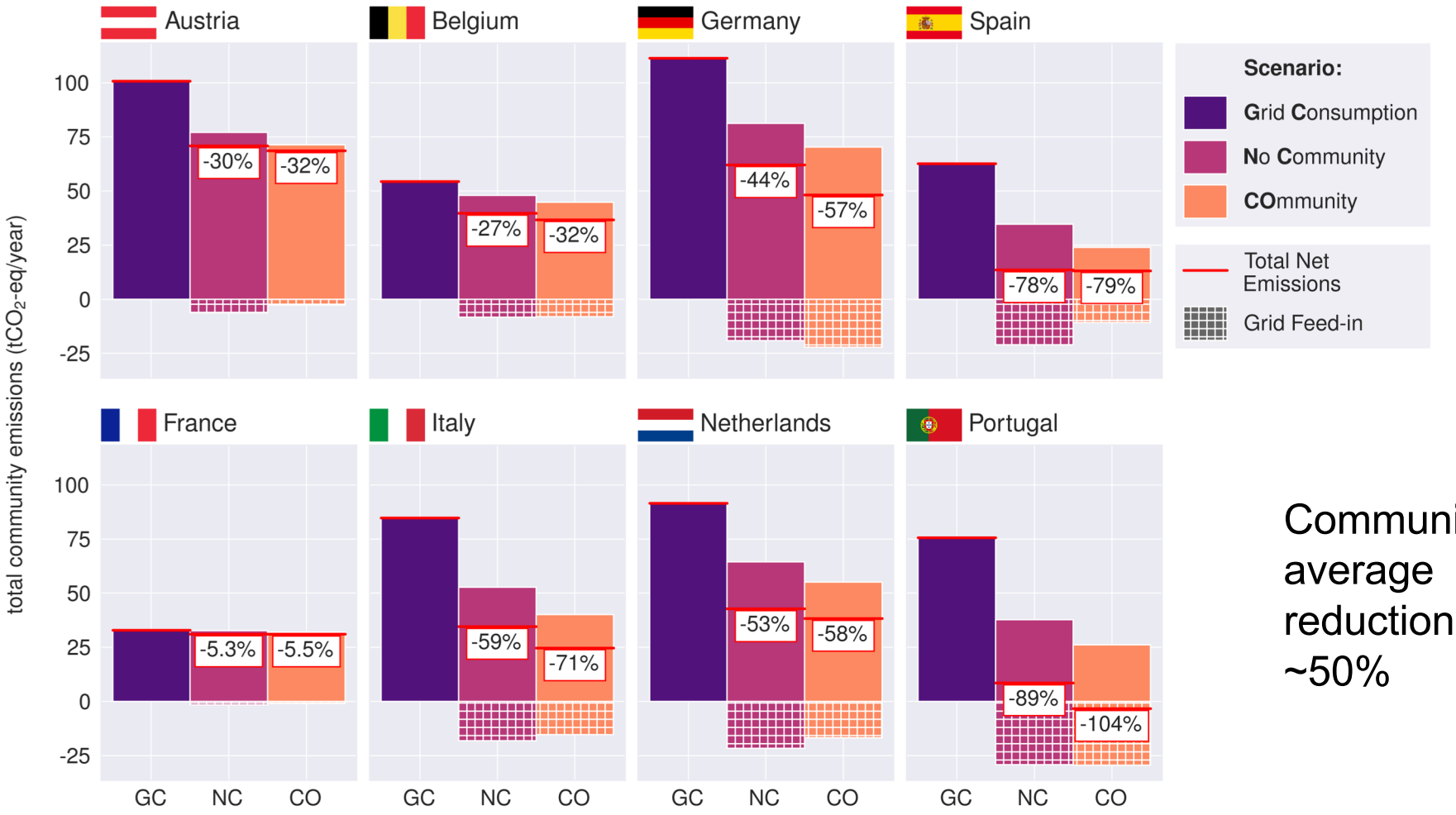
Results for “European Village“

GHG emissions for whole community, Austria



Results for “European Village“

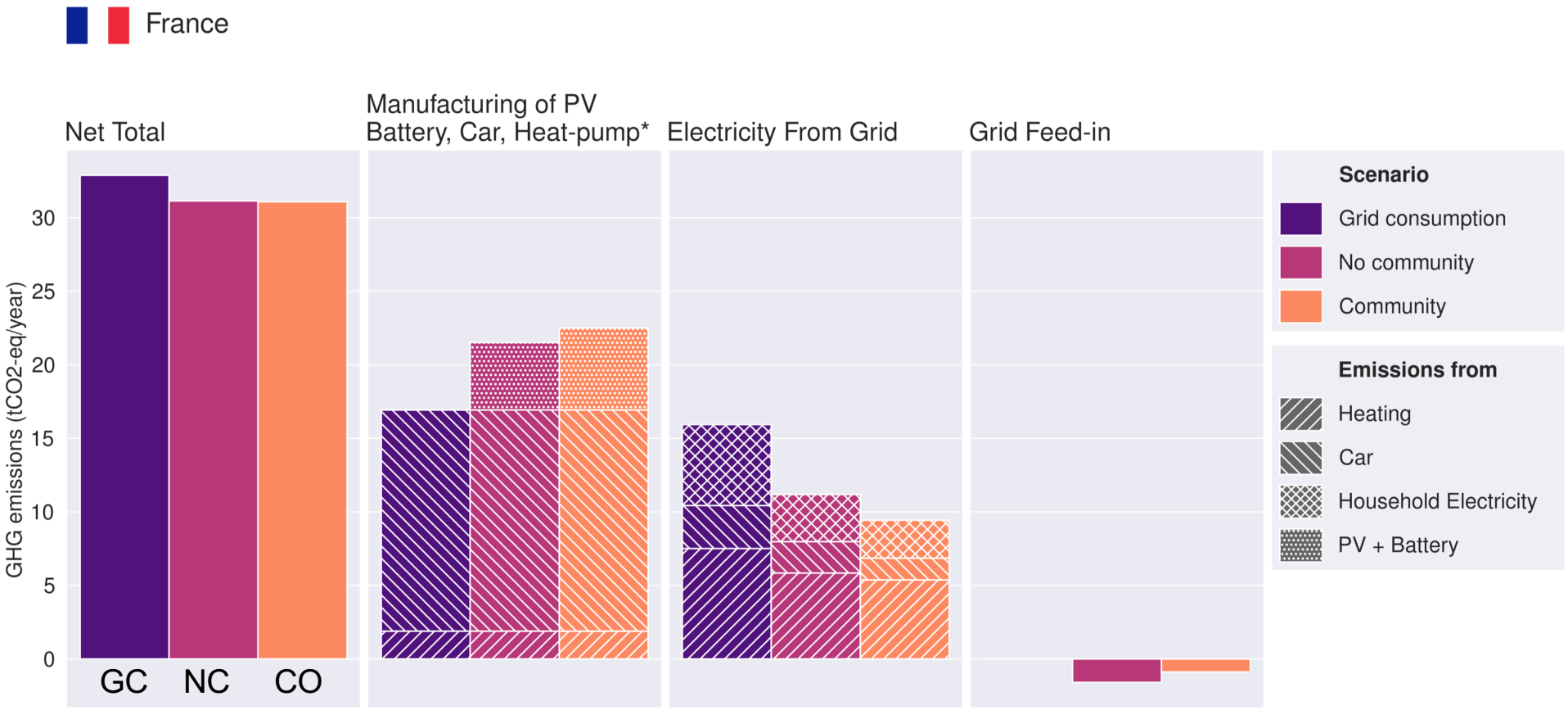
GHG emissions for whole community



Community: average reduction ~50%

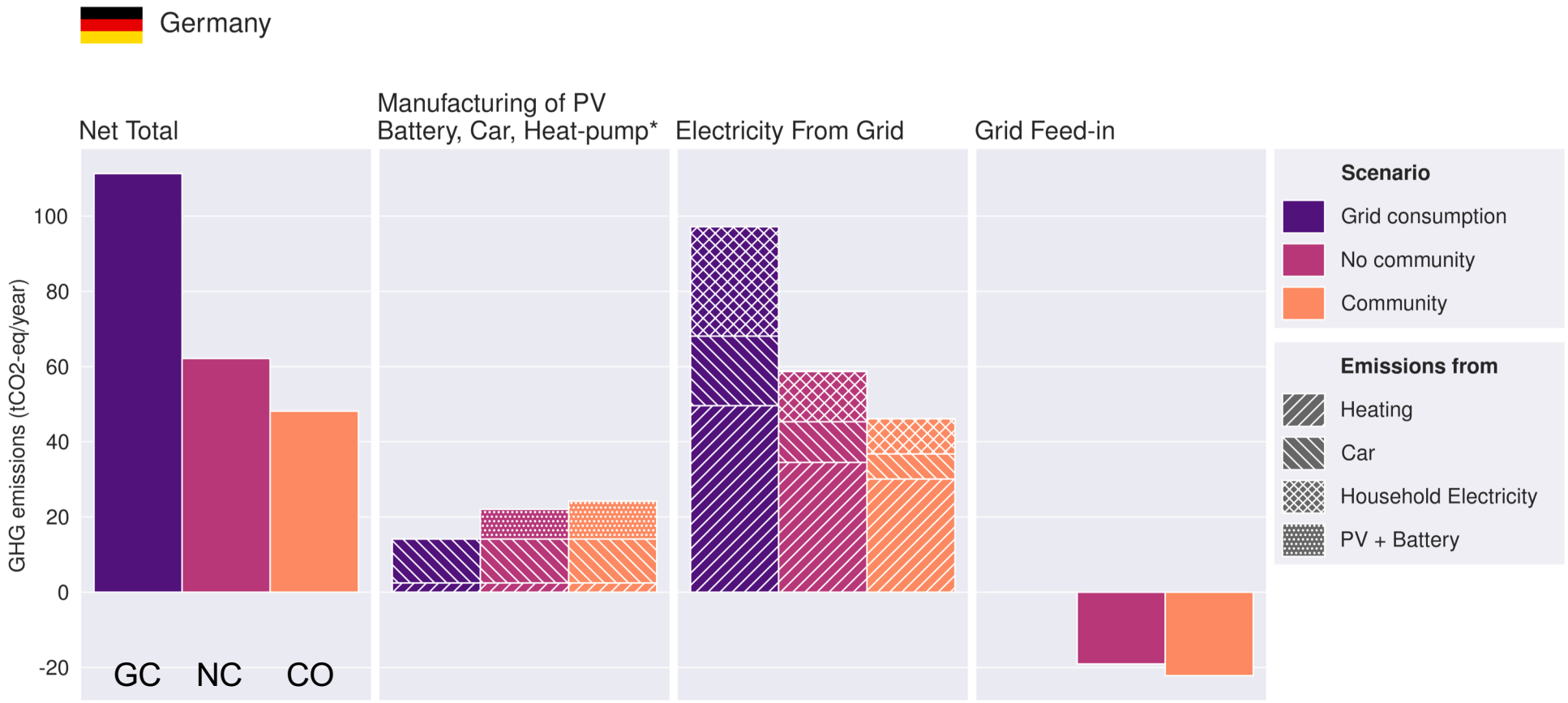
Results for “European Village“

GHG emissions for whole community, country examples



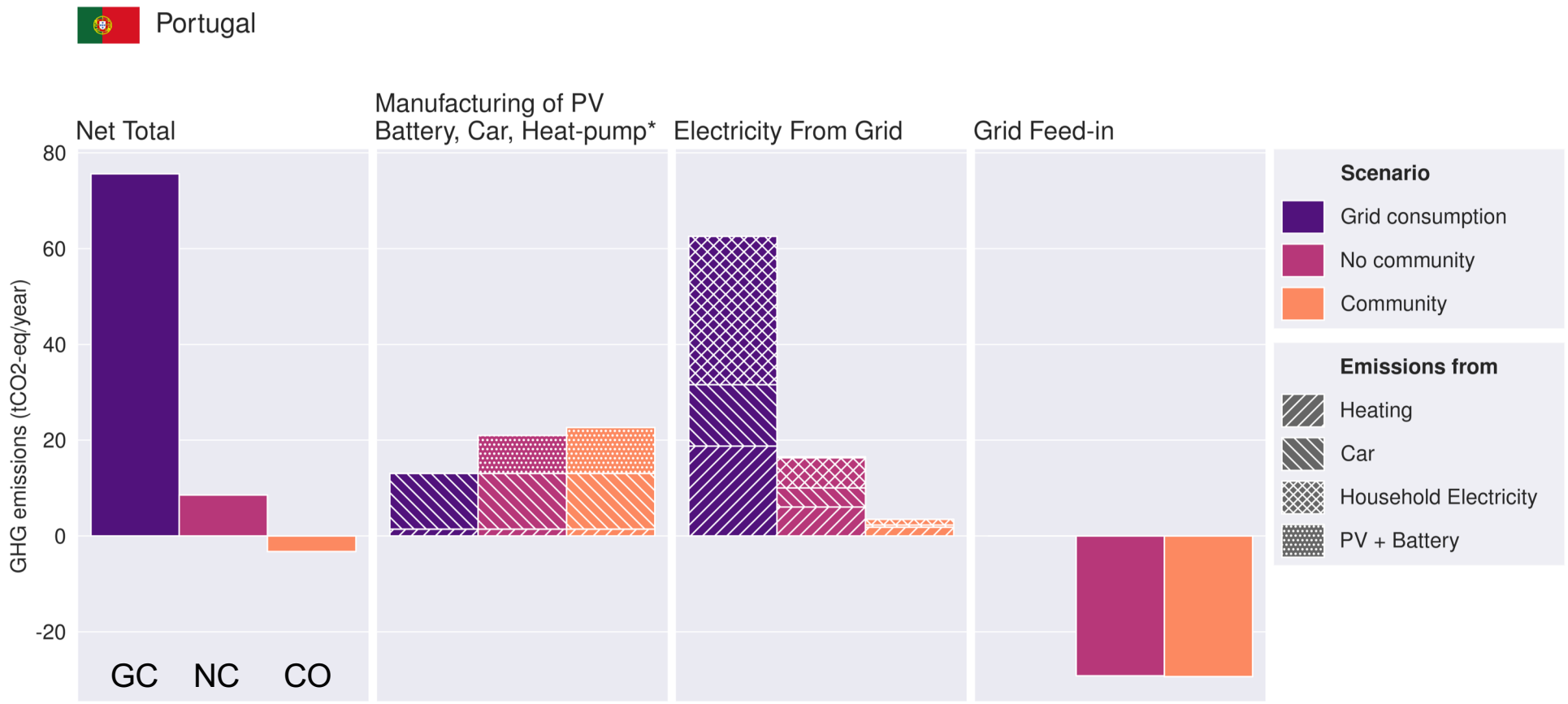
Results for “European Village“

GHG emissions for whole community, country examples



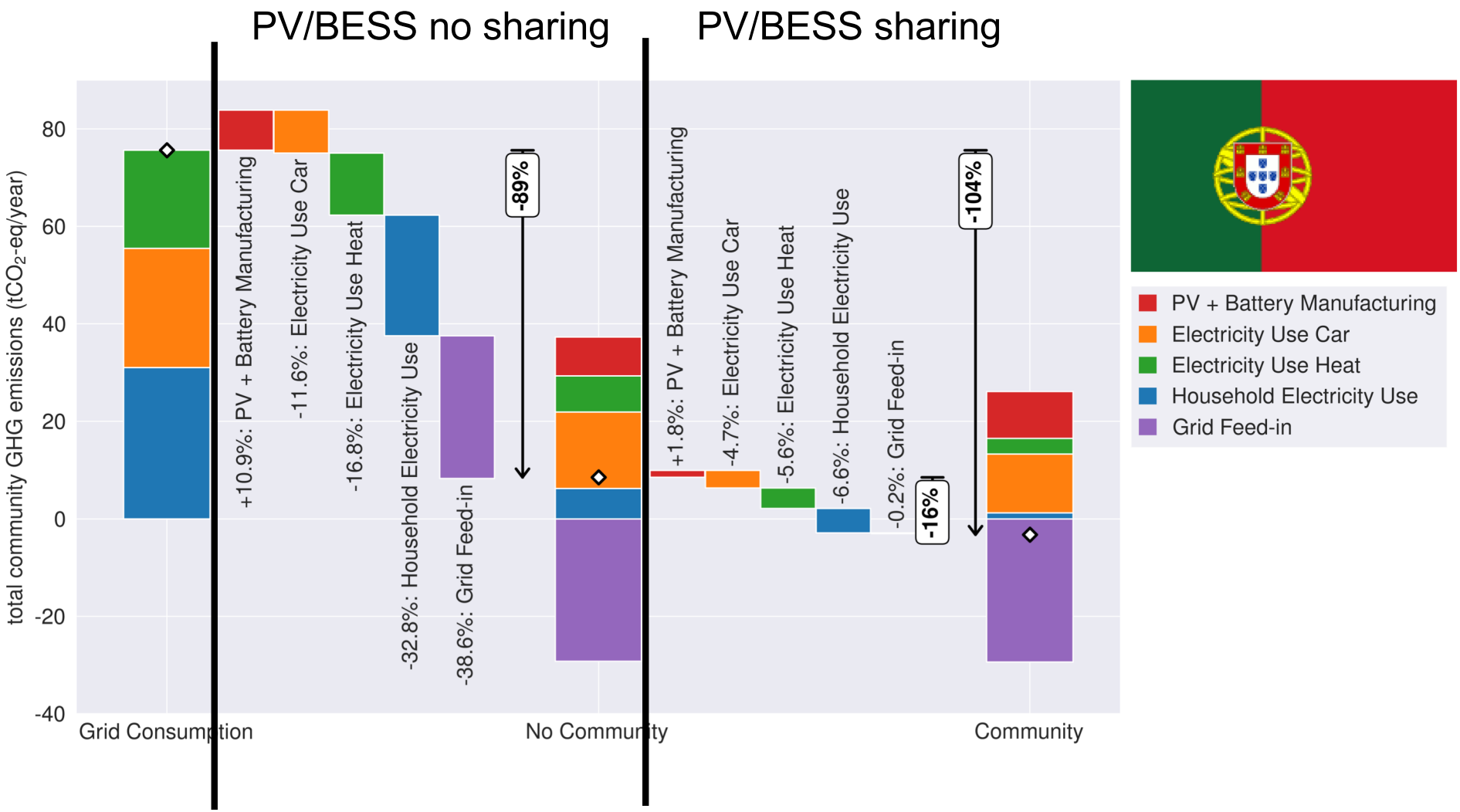
Results for “European Village“

GHG emissions for whole community, country examples



Results for “European Village“

GHG emissions for whole community, breakdown



Conclusions

- In countries with high grid emission factors, installation of PV reduces total emissions due to reduction in Grid Consumption and Grid Feed-in
- Energy sharing increases CO_2 mitigation impact
- Match between PV electricity generation and EV & Household electricity use is larger than between PV electricity generation and Heat demand
- Note: Hourly Emission Factors of 2017 are used – future generation mix will be different

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About the project „PV-Prosumers4Grid“

„The aim of the PV-Prosumers4Grid project is to develop and implement innovative self-consumption and aggregation concepts and business models for PV prosumers that will help integrating sustainable and competitive electricity from PV in the electricity system.“

- Target countries: Belgium, Germany, France, Italy, Netherlands, Austria, Portugal & Spain
- Start: 01.10.2017
- Duration: 30 Months (March 2020)
- 12 Partners
- Coordinator: BSW-Solar

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