Case Study 2: Behavior of Communities of Actors

Theresia Perger, Hans Auer, and Sebastian Zwickl-Bernhard

TU Wien

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Scope of the case study

- Communities of actors are energy communities:
  - Voluntary participation and consideration of individual willingness-to-pay
  - Low entry barriers: No closed systems; all members are connected to the distribution network
  - Trading and sharing of locally generated energy within a certain framework: E.g., with a local electricity/energy market, here as Peer-to-Peer Trading
  - Dynamic phase-in and phase-out of members

1 PEER-TO-PEER TRADING MODEL FRESH:COM

- Upscaling the potential of energy communities for different European countries based on building stock, PV potential, electricity consumption
- Reference countries:
  - Austria, Greece, Spain, Norway, England
- Quantitative upscaling of the local energy community potential is conducted for Europe as a whole

2 UPSCALING THE POTENTIAL OF ENERGY COMMUNITIES

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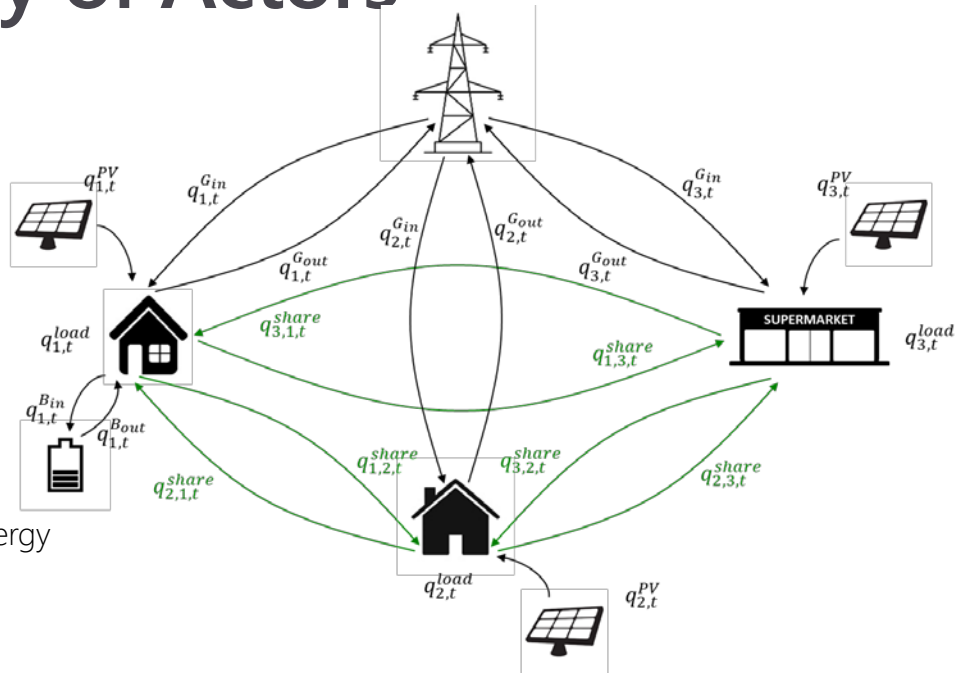
FRESH:COM

- "FaiR Energy SHaring in Local COMmunities"
- Local Energy Community (EC):
  - Members are consumers or *prosumers*
  - Private **households** or small or medium-sized enterprises (**SMEs**)
  - Participants have different reasons to join an EC (**economic or ecologic aspects**)
  - **Fully democratic participation:** voluntary participation, willingness-to-pay for renewable energy
  - Renewable energy technologies: **PV** and **battery** storage
  - Peer-to-peer trading via **public grid**



- Linear optimization model made **open-source** during this project (see GitHub: https://www.github.com/tperger/FRESH-COM)
- Objective function: Maximizing the **community's total welfare**
- Three scientific publications:
  - [1] T. Perger et al., PV sharing in local communities: Peer-to-peer trading under consideration of the prosumers' willingness-to-pay, Sustainable Cities and Society, Volume 66, 2021, https://doi.org/10.1016/j.scs.2020.102634.
  - [2] Perger T and Auer H. Dynamic participation in local energy communities with peer-to-peer trading [version 1; peer review: 1 approved]. Open Research Europe 2022, **2**:5 (https://doi.org/10.12688/openreseurope.14332.1)
  - [3] Perger, T., Zwickl-Bernhard, S., Golab, A., & Auer, H. (2022). A stochastic approach to dynamic participation in energy communities. Elektrotechnik Und Informationstechnik : E & i. https://doi.org/10.1007/s00502-022-01069-2

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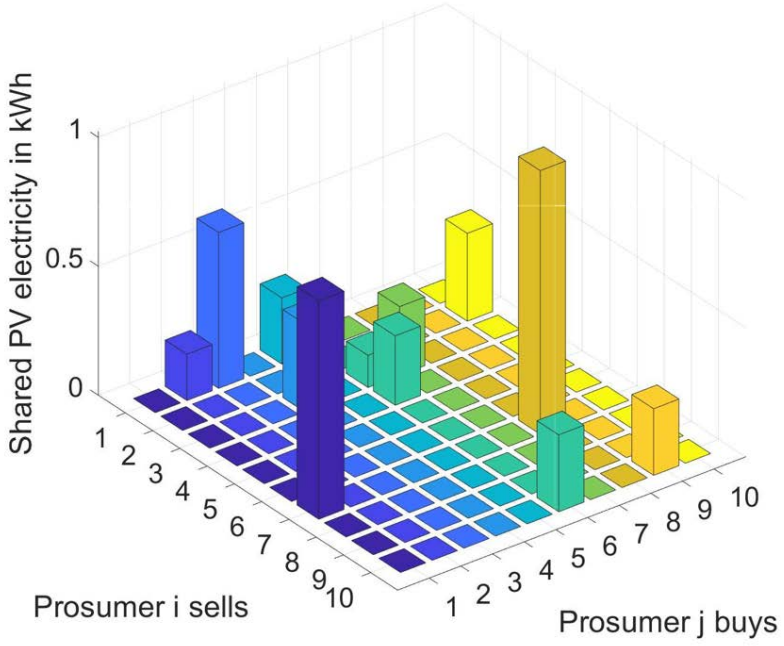
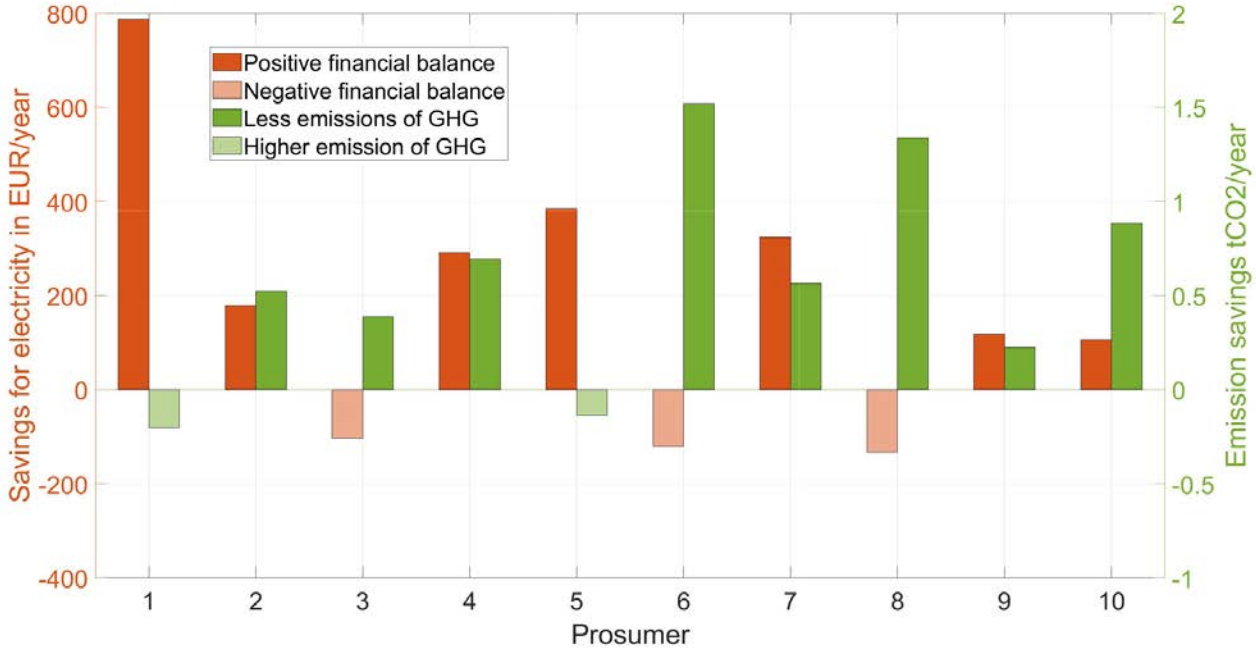
Results FRESH:COM

Results from [1] T. Perger et al., PV sharing in local communities: Peer-to-peer trading under consideration of the prosumers' willingness-to-pay, Sustainable Cities and Society, Volume 66, 2021, https://doi.org/10.1016/j.scs.2020.102634.



Peer-to-peer trading in a community of 10 members (specific hour)



Peer-to-peer trading in a community of 10 members (cost and emission savings over a year)

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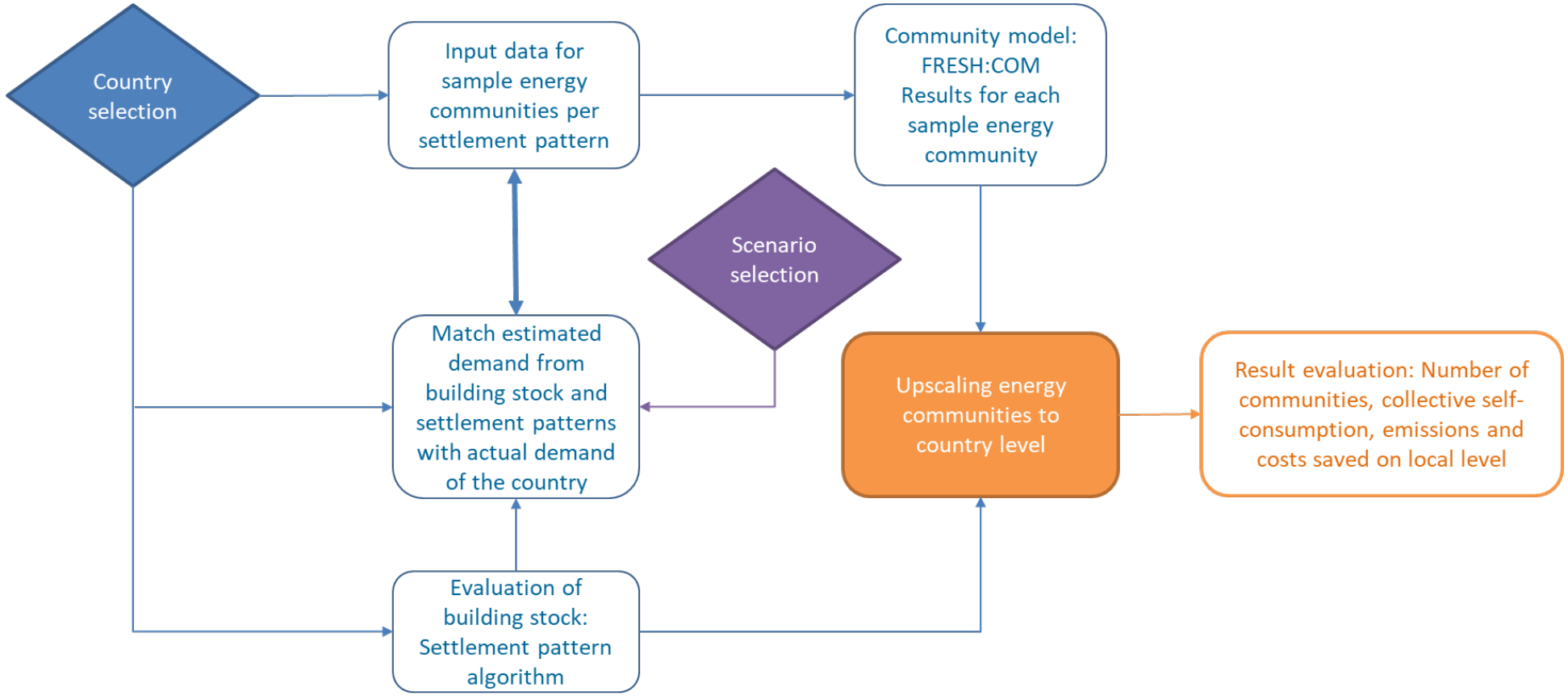
Upscaling the potential of energy communities to country level: reference countries



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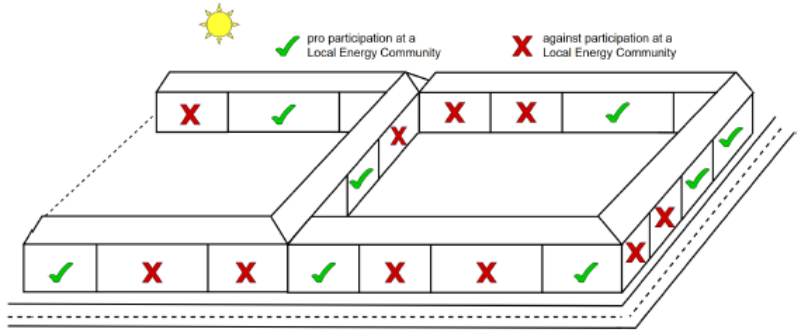
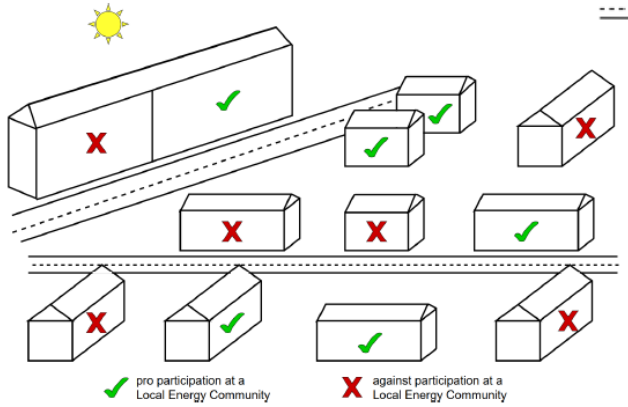
Upscaling the potential of energy communities to country level: reference countries

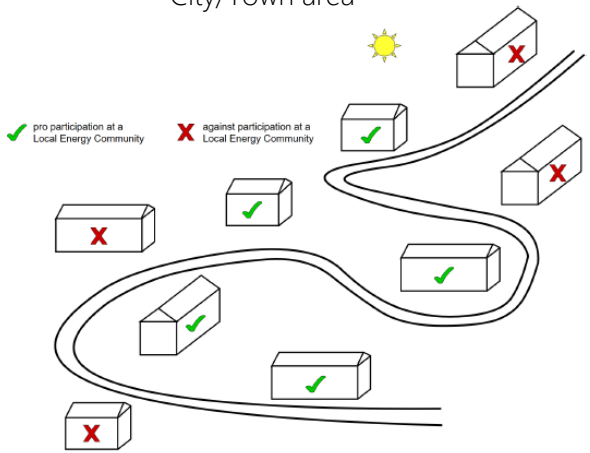
1. City areas (high population density)
    - Large apartment buildings
        - Aggregation of tenants' load profiles
        - Possibly with different types of businesses in the buildings (shops on the first floor, offices, …)
        - Limited rooftop area for PV systems
2. Town areas (medium density)
    - Mostly small apartment buildings
    - Limited rooftop area for PV systems
    - Some businesses included (e.g., shops, bakery, …)
3. Suburban areas (low-to-medium density)
    - Mix of apartment buildings and single-family houses
4. Rural areas (low population density)
    - Mostly single houses
    - Sufficient rooftop area available



City/Town area



Suburban area



Rural area

Source: [4] Fina et al. (2019) Profitability of PV sharing in energy communities: Use cases for different settlement patterns. *Energy* 189.

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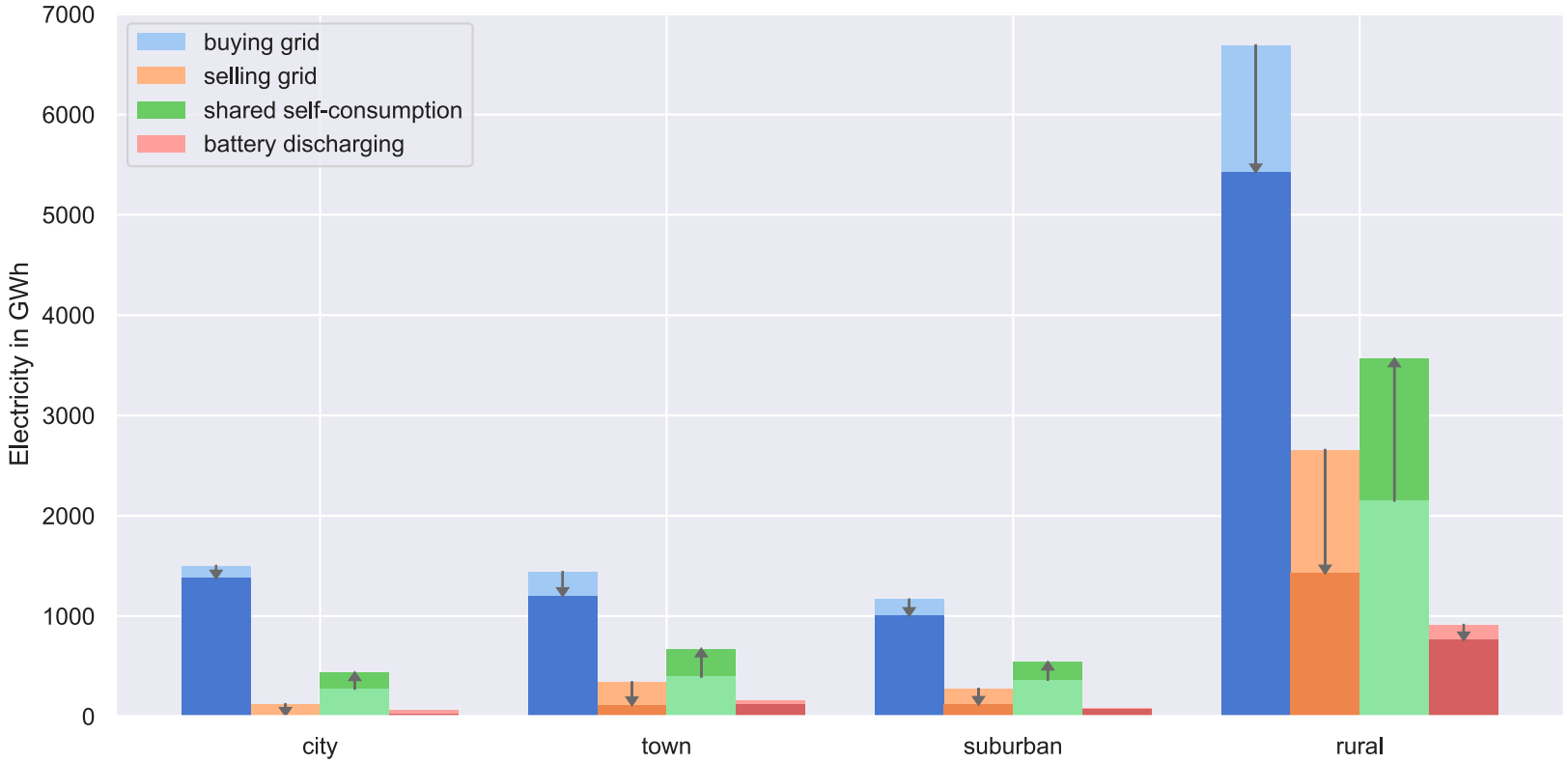
Results Upscaling the potential of energy communities to country level: reference countries

Impact of ECs on grid purchases, grid feed-in, shared self-consumption, and battery operation: Austria



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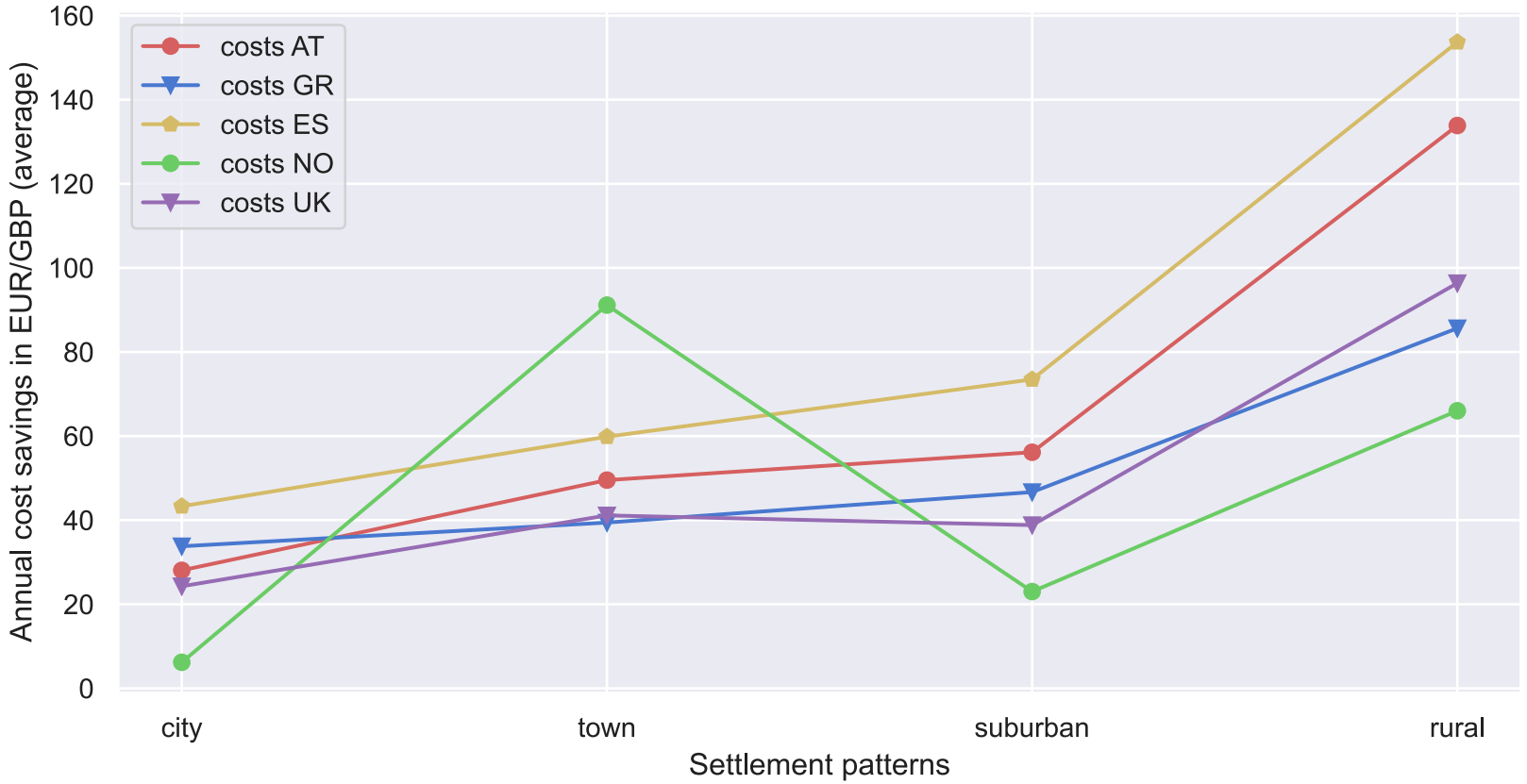
Results Upscaling the potential of energy communities to country level: reference countries

- Impact of ECs on individual costs
- Impact of ECs on individual emissions



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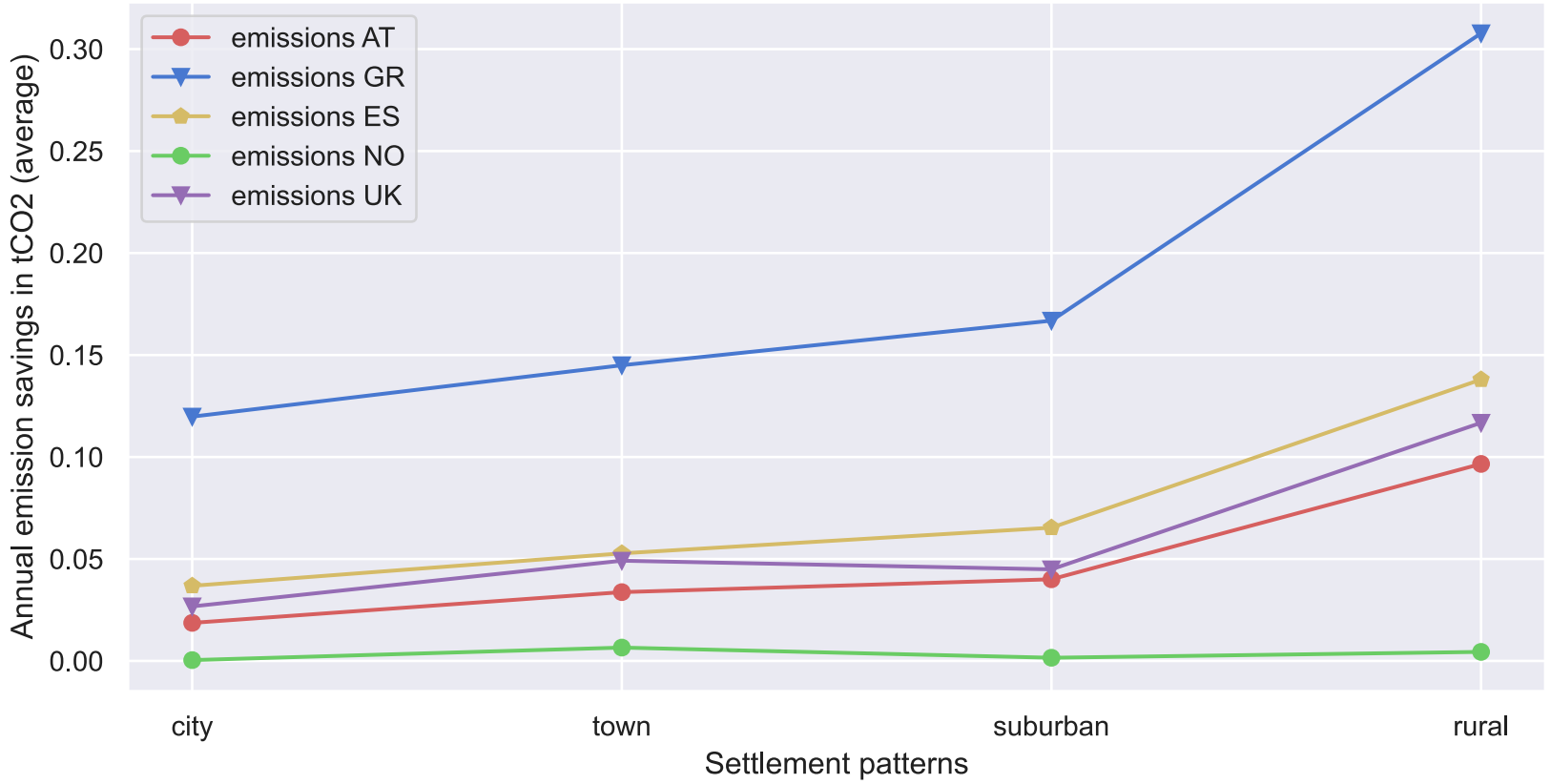

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Results Upscaling: Potential on European level

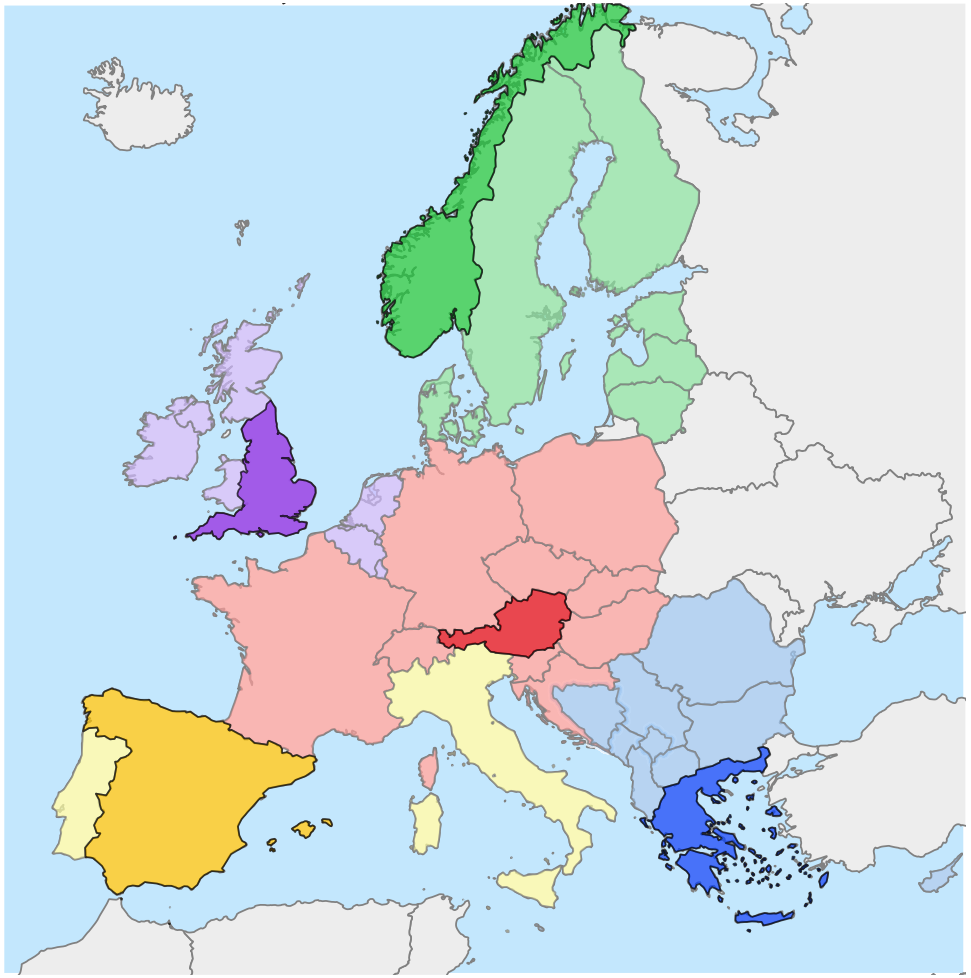
Estimation based on the reference countries:

- For each cluster of countries represented by one of the five reference countries, the number of energy communities is

$$EC_{cluster} = EC_{ref.country} \frac{population_{cluster}}{population_{ref.country}}.$$

Table 3: Total number of ECs per settlement pattern type and cluster of countries

	city	town	suburban	rural
Austria	115,641	428,320	285,157	3,934,573
Greece	21,393	139,857	57,609	802,394
Spain	69,458	132,814	220,718	1,191,911
Norway	9,751	104,834	78,358	747,398
England	5,024	192,906	13,539	3,123,995
Europe total	221,266	998,730	655,381	9,800,271



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Expert comments

From Ulfert Höhne (energy cooperative “ourpower”, see https://www.ourpower.coop/)