EnInnov2022

17. Symposium Energieinnovation | 16.02.–18.02.2022

Institut für Elektrizitätswirtschaft und Energieinnovation

NEWSLETTER

FUTURE OF ENERGY

Innovationen für eine klimaneutrale Zukunft

Aufgrund aktueller Entwicklungen findet das 17. Symposium Energieinnovation als digitale Veranstaltung statt.

Nachhaltige Entwicklung ist die bedeutsamste Herausforderung der Menschheit und entsprechende globale Zielsetzungen und Maßnahmen werden in den „Sustainable Development Goals" der UN festgeschrieben. Weltweit sind immer mehr Menschen von den stattfindenden klimatischen Veränderungen und insbesondere deren Wirkungen (z.B. Extremwetterereignisse, Waldbrände, Überschwemmungen, Gletscherschwund, Meeresspiegelanstieg) immer unmittelbarer betroffen. Aus wissenschaftlicher Sicht wird dies auch eindrucksvoll vom aktuellen IPCC-Bericht bestätigt. Die Welt steuert auf potenziell irreversible Veränderungen (Kipppunkte) zu, welche das Leben auf der Erde für den Menschen fundamental verändern. Diesen Erkenntnissen folgend wird bei der kommenden Weltklimakonferenz COP26 Ende Oktober 2021 basierend auf dem Paris Agreement über schärfere (energiewirtschaftliche) Maßnahmen zur globalen Bekämpfung des Klimawandels beraten.

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TECHNISCHE UNIVERSITÄT WIEN

UPSCALING THE POTENTIAL OF ENERGY COMMUNITIES TO COUNTRY-LEVEL

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EnInnov Graz, 16.02.-18.02.2022
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Motivation and Scope

Case study 2 “Behavior of communities of actors“ in Horizon 2020 project openENTRANCE

- Communities of actors are energy communities:
  - Voluntary participation and consideration of individual willingness-to-pay
  - Low entry barriers: No closed systems, but part of 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
- Previous work on CS 2:
  - Energy community model FRESH:COM [1]
  - Dynamic participation in energy communities [2]

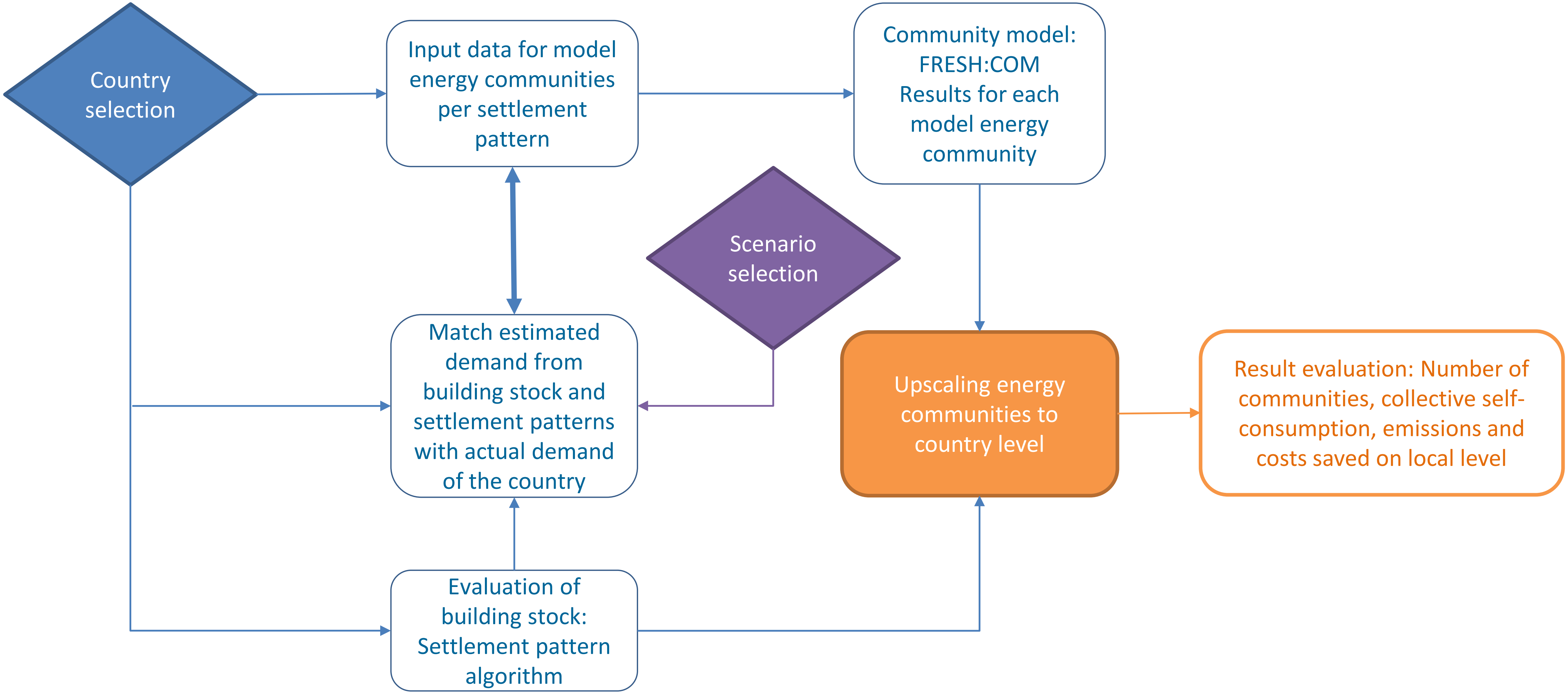
[1] T. Perger et al., PV sharing in local communities: Peer-to-peer trading under consideration of the prosumers’ willingness-to-pay, Sustainable Cities and Society, Volume 66, 2021, https://doi.org/10.1016/j.scs.2020.102634.
[2] Perger T and Auer H. Dynamic participation in local energy communities 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)

Motivation and Scope

Case study 2 “Behavior of communities of actors“ in Horizon 2020 project openENTRANCE

- Upscaling the potential of energy communities for different European countries based on building stock, PV potential, electricity consumption
- Reference countries:
  - Austria
  - Greece
  - Spain
  - Others (not shown here)
- Quantitative upscaling of the local energy community potential is conducted for Europe as a whole

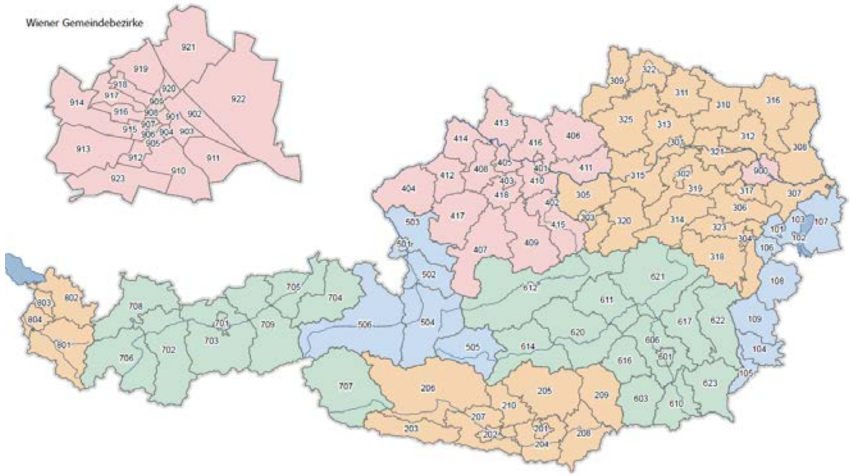
Methodology overview



Austria

About the Austrian building and household data (census 2011):

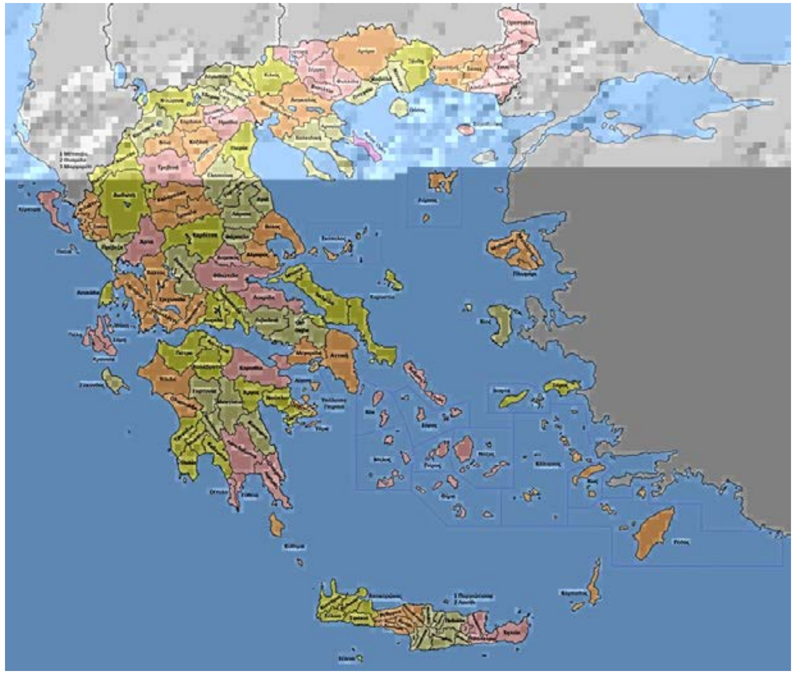
- Almost 9 Mio. inhabitants
- Household electricity demand in total 15222 GWh in Austria
- Average electricity demand (2016) of a
  - Single house: 5175 kWh/a
  - Apartment: 2000 kWh/a
- 121 political districts



Greece

About the Greek building and household data (census 2011):

- 11.1 Mio. inhabitants
- Over 3 Mio. buildings for residential use, about 6.4 Mio. dwellings
- Average electricity demand per household is 4152 kWh/a (2019)
- Percentage of occupied dwellings average over the whole country: 64%
  - Varying from 14-84% depending on municipality
  - Secondary and vacation homes are excluded
- 326 municipalities (spatial level: LAU)



Spain

About the Spanish building and household data (census 2011):

- 47 Mio. inhabitants
- Over 3 Mio. buildings for residential use, about 18 Mio. dwellings
- Household electricity demand in total 60 TWh
- Average electricity demand per household is 3318 kWh/a
- Percentage of occupied dwellings average over the whole country: 72%
  - Secondary and vacation homes are excluded
- 52 regions (spatial level: NUTS 3)

Settlement patterns

Characteristics of the different settlement patterns [3]:

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

[4] Bernadette Fina, Hans Auer, Werner Friedl, Cost-optimal economic potential of shared rooftop PV in energy communities: Evidence from Austria, Renewable Energy, Volume 152, 2020, DOI: https://doi.org/10.1016/j.renene.2020.01.031

Settlement patterns

From building stock to energy communities:

- Definition of energy communities per settlement pattern
  - City: 10 large apartment buildings (10 or more dwellings)
  - Town: 10 small apartment buildings (3-9 dwellings)
  - Suburban: 10 single houses (1-2 dwellings) + 2 large apartment buildings
  - Rural: 10 single houses
- Per district/region, the buildings are assigned to settlement patterns

  → number of energy communities per type and per region

[4] Bernadette Fina, Hans Auer, Werner Friedl, Cost-optimal economic potential of shared rooftop PV in energy communities: Evidence from Austria, Renewable Energy, Volume 152, 2020, DOI: https://doi.org/10.1016/j.renene.2020.01.031

Energy community model FRESH:COM

About the (open-source) model:

- Linear optimization model FRESH:COM [4] maximizing the community welfare of a **local energy community by peer-to-peer trading**
  - Community welfare:

$$CW = \underbrace{\sum_{t\in\mathcal{T},i\in\mathcal{I}} p_t^{G_{out}} q_{i,t}^{G_{out}} - \sum_{t\in\mathcal{T},i\in\mathcal{I}} p_t^{G_{in}} q_{i,t}^{G_{in}}}_{\text{I}} + \underbrace{\sum_{t\in\mathcal{T},i,j\in\mathcal{I}} wtp_{i,j,t} q_{i,j,t}^{share}}_{\text{II}}.$$

- Allocation mechanism: Peer-to-peer trading under the consideration of each prosumer's *individual willingness-to-pay*:

$$wtp_{i,j,t} = p_t^{G_{in}} + w_j(1 - d_{i,j}) \cdot e_t.$$

- Members: Private households and SMEs
  - Photovoltaic (PV) and Battery Energy Storage Systems(BESS)

[4] T. Perger, FRESH:COM, https://github.com/tperger/FRESH-COM

Data and assumptions

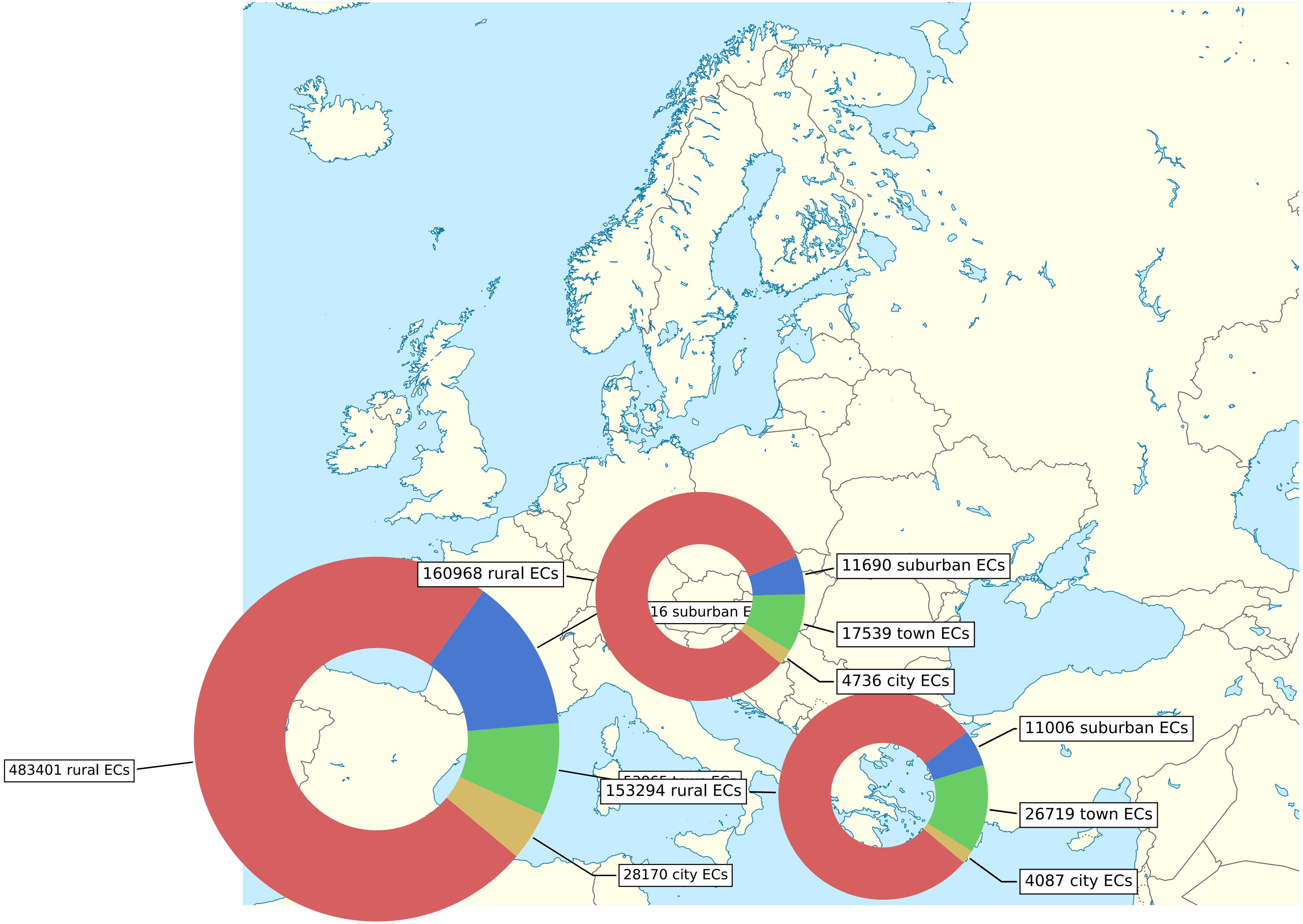
How to define each settlement pattern's energy community:

- Input data (normalized electricity demand and PV generation) from open-source tools
- Assignment of annual electricity demand per building:

	Austria	Greece	Spain
avg. Demand per household (kWh/a)	3486	4125	3318
avg. Demand per single house (kWh/a)	5175	5678	5401
avg. Demand per flat (kWh/a)	2000	2271	2160
Avg. Number of dwelling per single house	1.165	1.266	1.078
Avg. Number of dwelling per small apartment building	5.464	4.095	6.596
Avg. Number of dwelling per large apartment building	18.700	14	18

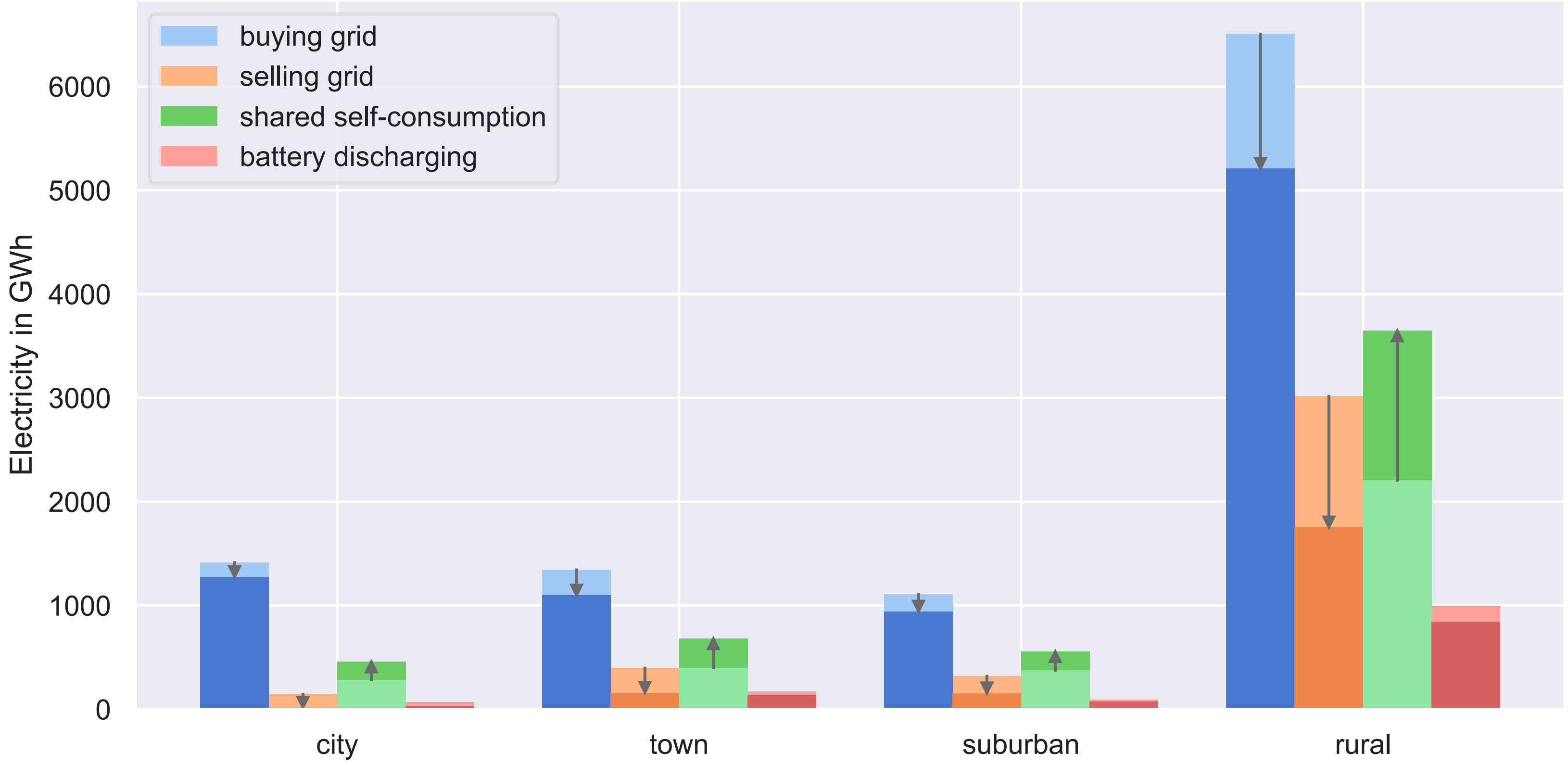
- Each prosumer is assigned a different annual electricity demand using normal distribution
- PV systems:
  - Peak capacities installed: 3-15 kWpeak
- Battery storage systems:
  - Storage capacities: 3-8 kWh
- Some members are consumers only

Results Austria, Greece, Spain



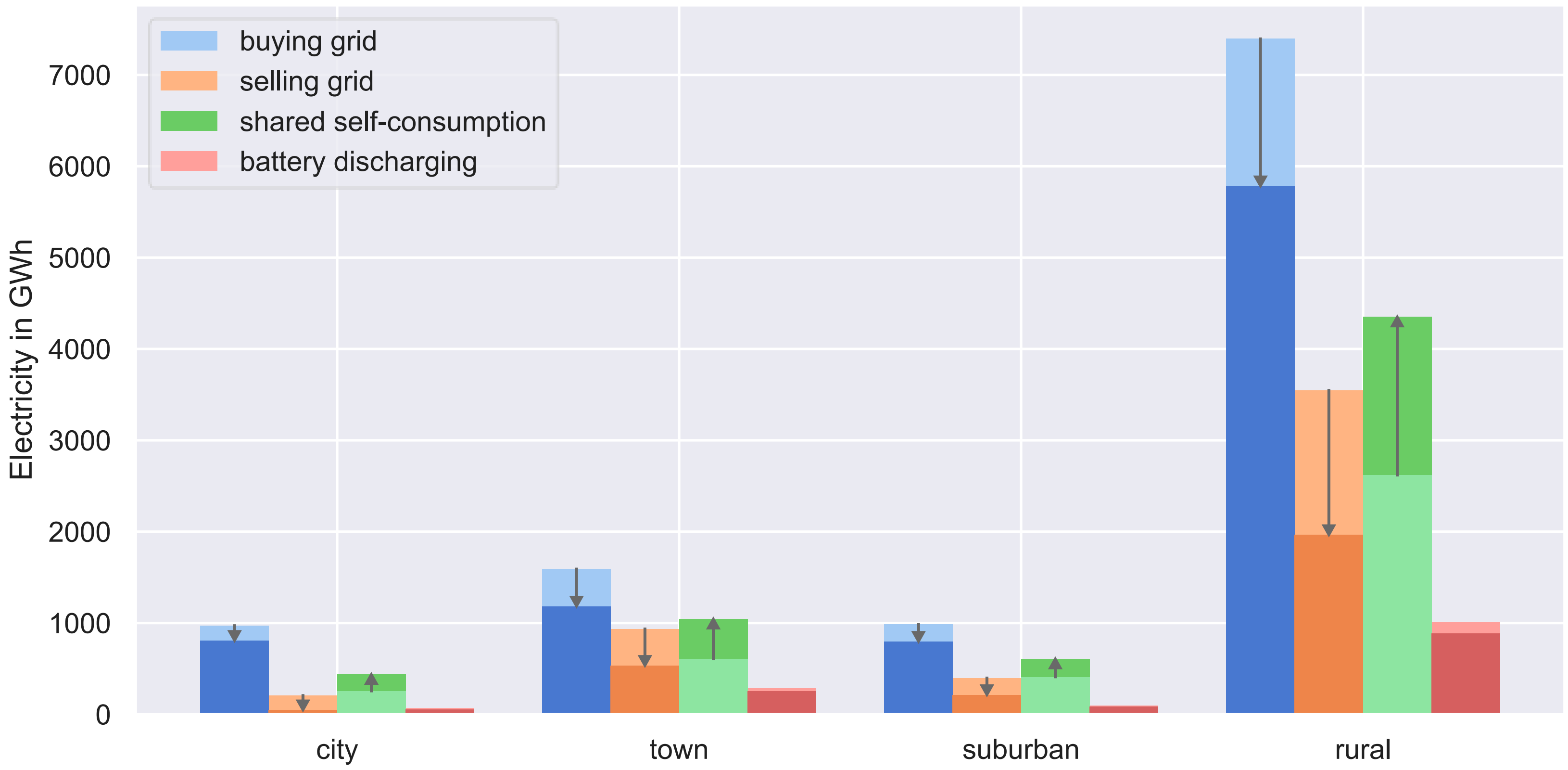
Results Austria

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



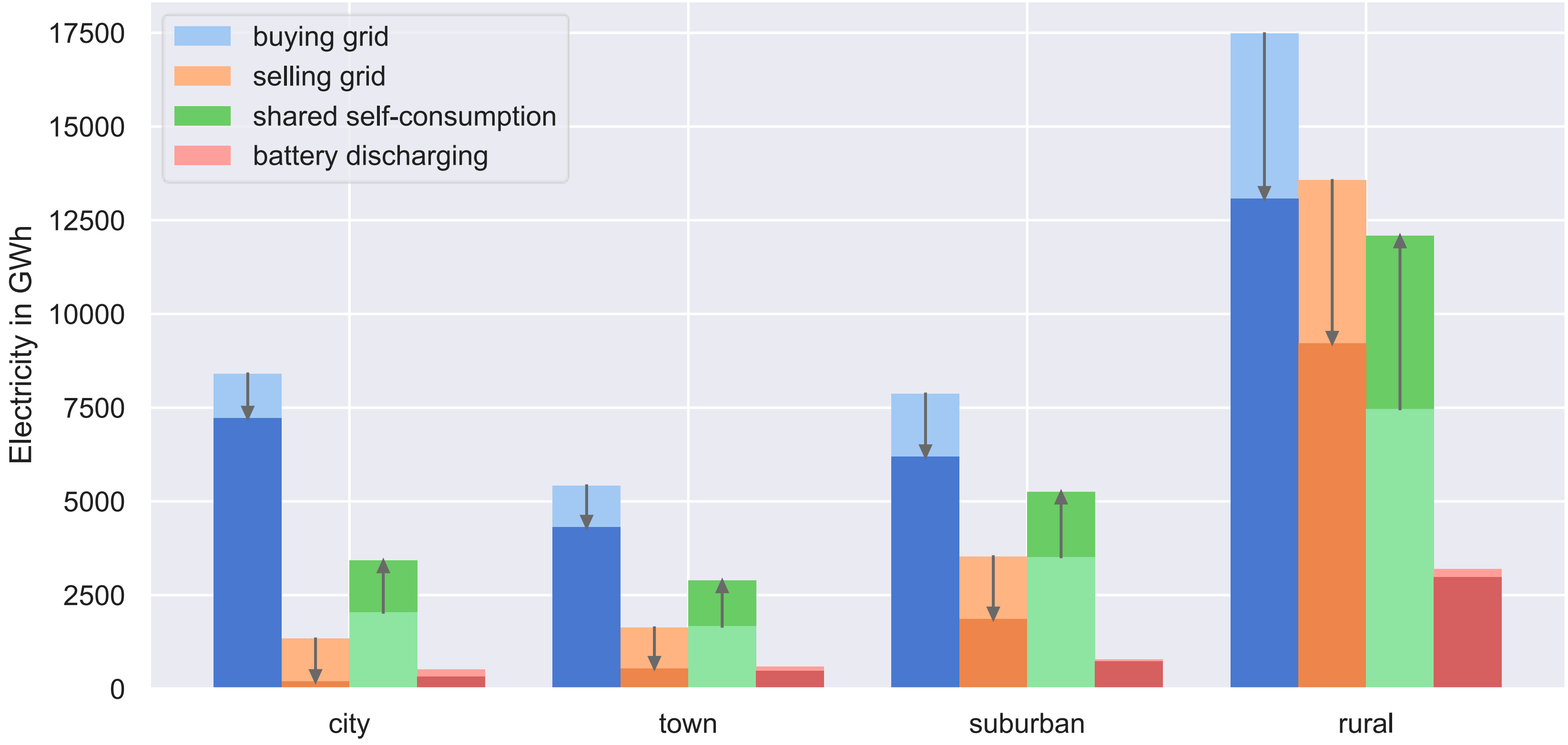
Results Greece

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



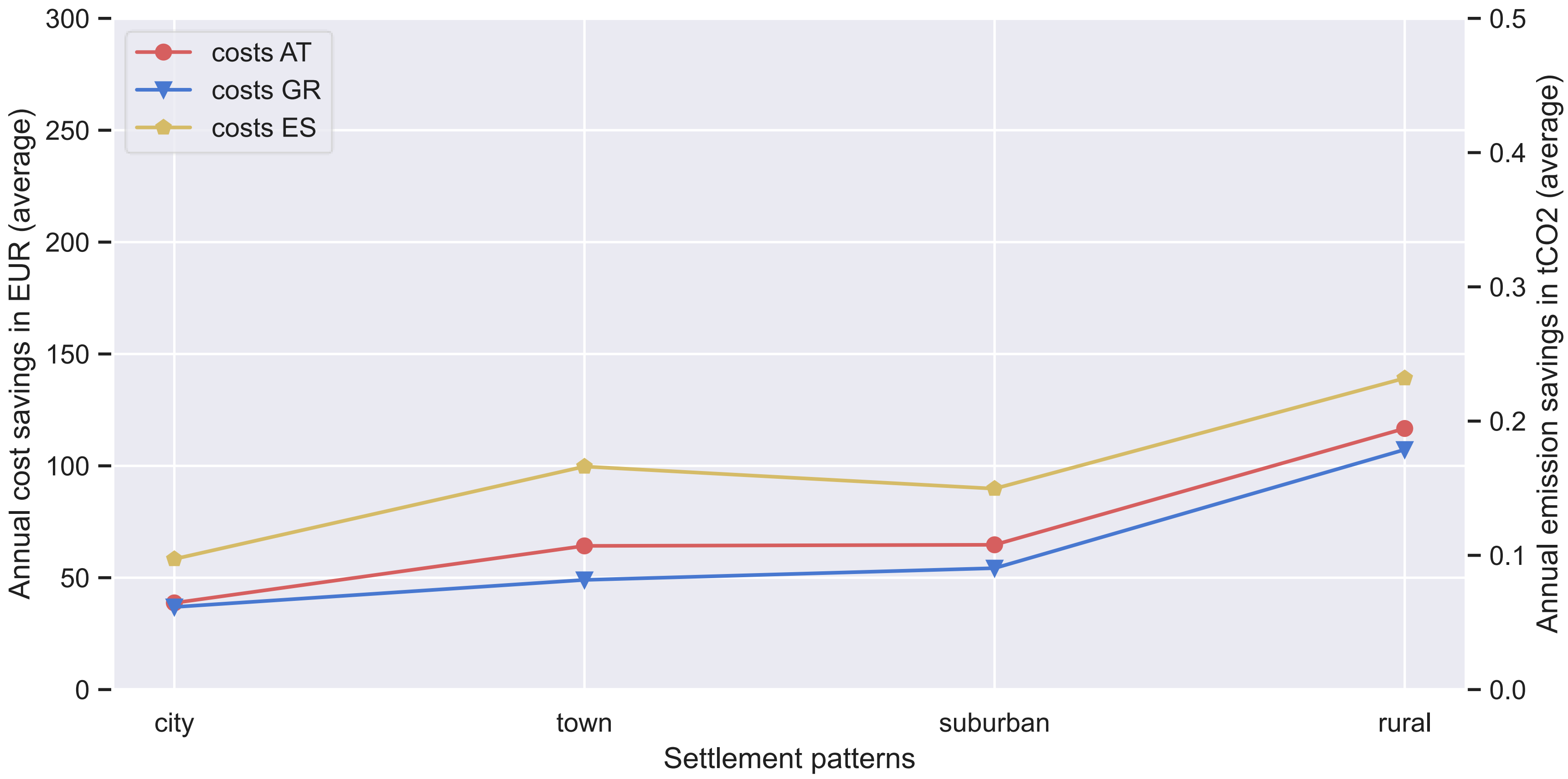
Results Spain

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



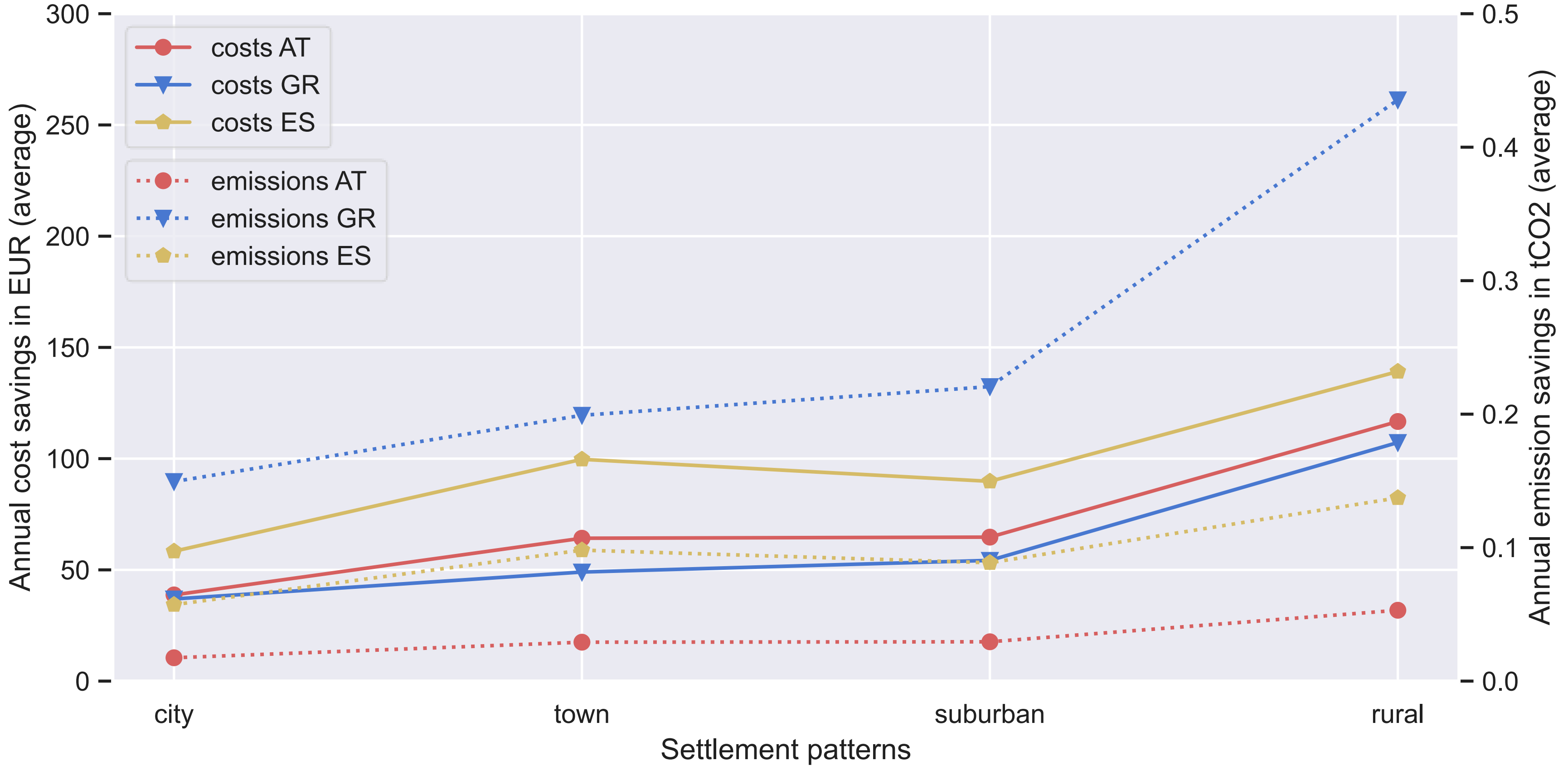
Results on prosumer level

Impact of ECs on individual costs and emissions:



Results on prosumer level

Impact of ECs on individual costs and emissions:



Conclusions

Findings and limitations of this work:

- Evaluation of building stock crucial
- High special resolution is desirable
- Ideal case with 100% participation (in contrast to voluntary participation …)
- Downscaling is possible, e.g. under consideration of settlement patterns and regions

Future outlook:

- Analysis of remaining reference countries
- Evaluation with the openENTRANCE scenarios for 2030/2050
- Further upscaling to European level
- See future development on GitHub + upcoming publications
  - https://github.com/tperger/ASCENDEMUS

Thank you for your attention!

https://github.com/tperger/ASCENDEMUS

https://github.com/tperger/FRESH-COM

open ENergy TRansition ANalyses for a low-Carbon Economy

https://openentrance.eu/

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