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# Smart Diaspora 2023

**10 - 13 Aprilie 2023, Timișoara**

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Eveniment aflat sub înaltul patronaj al Președintelui României

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Smart
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2023

# Energy communities in smart cities (Comunități energetice în orașe inteligente)

George Cristian LĂZĂROIU
Universitatea POLITEHNICA din București

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# Energy communities

- **What are, why we discuss about, why is important?**

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# Energy communities

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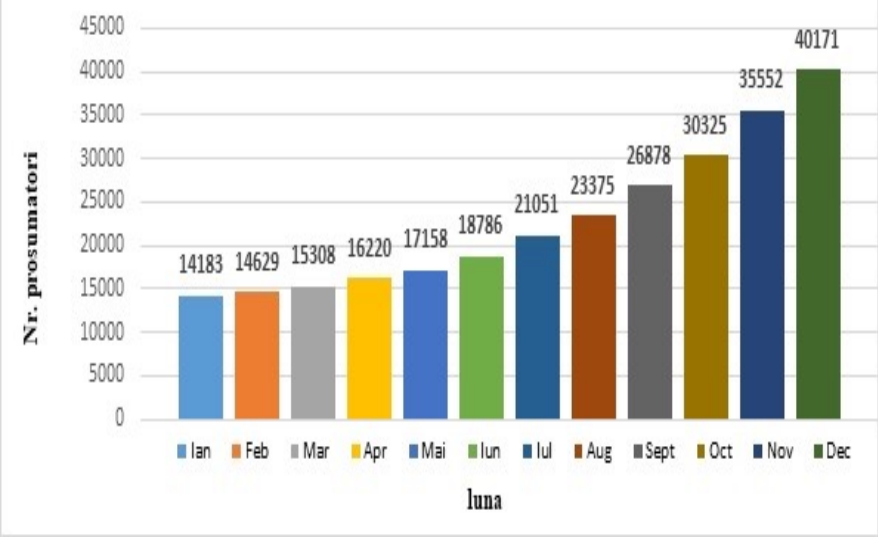

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# Energy communities

- What are, why we discuss about, why is important?

- **The energy transition, the objectives for the future development are relatively new challenges.**

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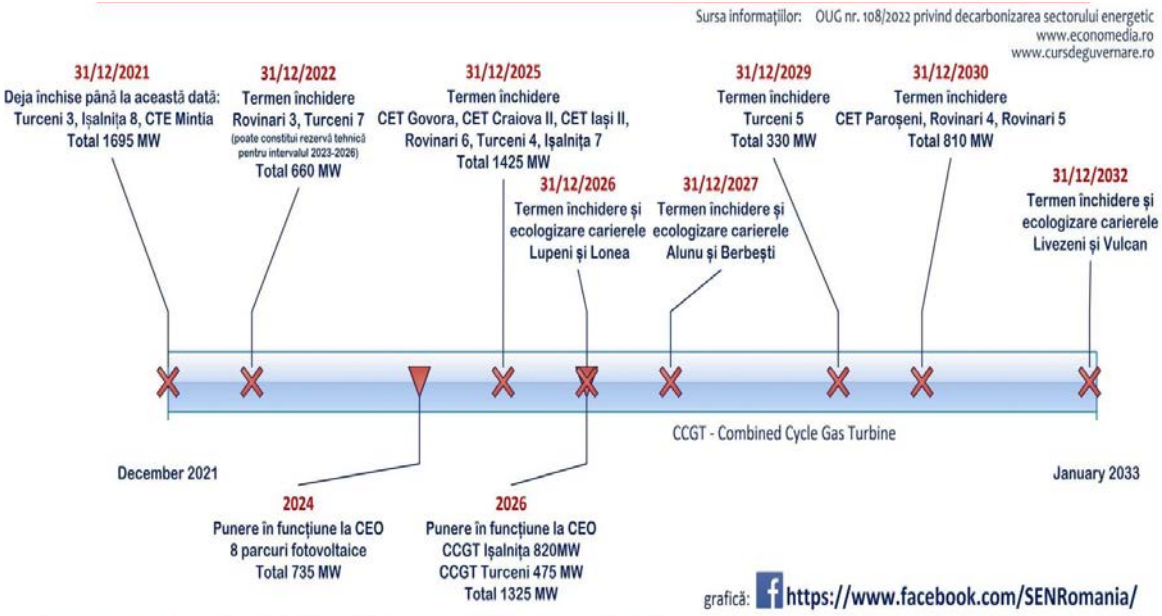
- What are, why we discuss about them, why seem important?

- The energy transition, the objectives for the future development are relatively new challenges.



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# Energy communities

- What are, why we discuss about, why is important?

- The energy transition, the objectives for the future development are relatively new challenges.

- **The change of our habits and of our energy systems historically never occurred in such a steep slope**
  - For the last 3 years, Romania became a net importer of electrical energy, considering also the reduction of industry activities and high electricity prices.  4% of consumption is imported.

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# Energy communities

- What are, why we discuss about, why is important?
- The energy transition, the objectives for the future development are relatively new challenges.
- The change of our habits and of our energy systems historically never occurred in such a steep slope
- Thus, the energy community can be an opportunity for inclusiveness, key component of smart cities, of the final customer
- The interests of the end-users will become more incisive in the near future

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# Energy communities

- The energy communities (ECs) that are present today are different in structure and governance;
- There are regulatory barriers affecting the opportunities for development ECs
- There are cultural differences and socio-demographic characteristics in different areas affecting the development;
- The willingness to invest in ECs depends on renewable energy integration.

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# Energy communities

- The current energy crisis and the need for a sustainable energy development reveal the necessity to invest and advance the technological innovation towards decarbonization of energy system through higher penetrations of renewable energy sources (RES) and augmented acknowledgement of energy savings benefits

- Energy communities determined the development of new energy services in line with consumer needs towards their transformation from passive to active subjects

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# Energy communities

- The EU presented for the EU Clean Energy Packages new provisions on the energy market design, governance and frameworks for new energy initiatives;
- The Renewable Energy Directive (REDII) and The Electricity Market Directive (EMDII) contain important definitions and requirements of two different types of ECs, citizen energy communities (CEC) and renewable energy communities (REC).
- New possibilities for governing the energy market have emerged;
- Energy initiatives that introduce new actors in the market and determine an increased decentralized renewable energy production and consumption are occurring.

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# Energy communities

- The Electricity Market Directive (EMDII, 2019) defines the **citizen energy community** (CEC)
- The Renewable Energy Directive (REDII, 2018) promotes the use of energy from renewable sources and defines the **renewable energy community** (REC)
- REC can be viewed as subset of CEC and the main differences is the geographical scope and governance/ownership

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# Energy communities

**Similarities**

- Require a legal entity
- Must be voluntary and open
- Should be primarily value driven rather than focusing on financial profits
- Require a specific governance

**Differences**

| CEC | REC |
| --- | --- |
| • Don’t have geographic limitation (also open to cross-border participation) | • There must be a proximity to the source and an effective control under a defined in national law |
| • No limitation on the membership | • Limitations on the membership: large companies are not allowed as shareholders or members |
| • Must be focused only on electricity but not necessarily focused on renewable energy | • Are open only to renewable energies but of any kind (e.g., also heat) |
| • Purpose is to create a new market actor | • Purpose to promote a way to expand the share of RESs at national level. |

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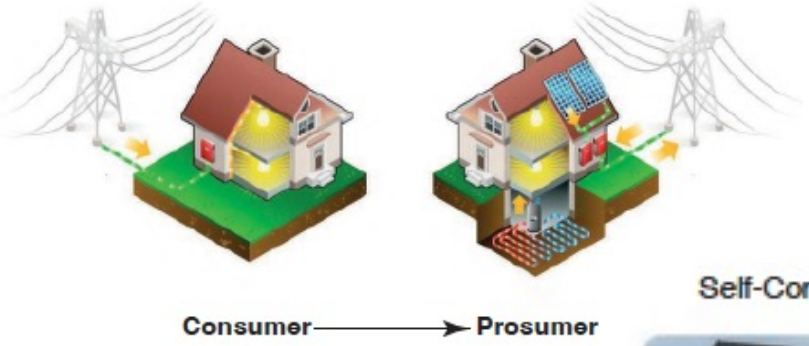
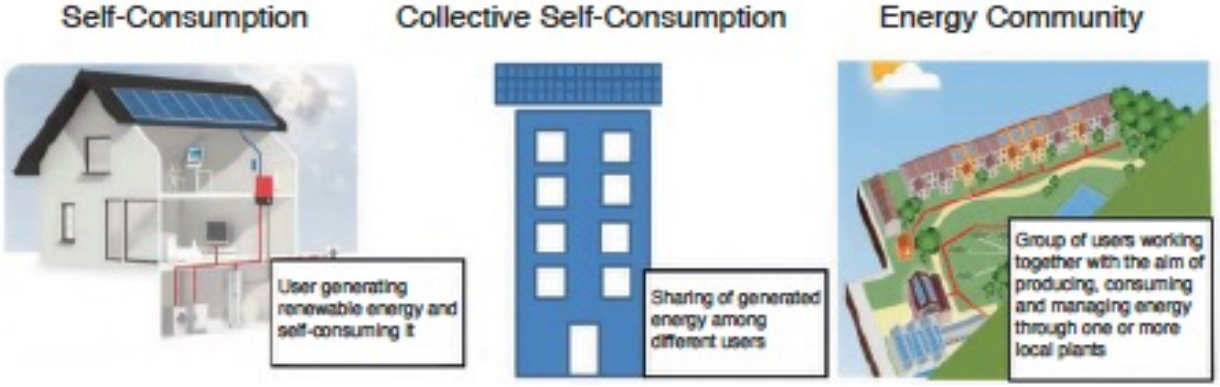
# Energy communities



Consumer → Prosumer



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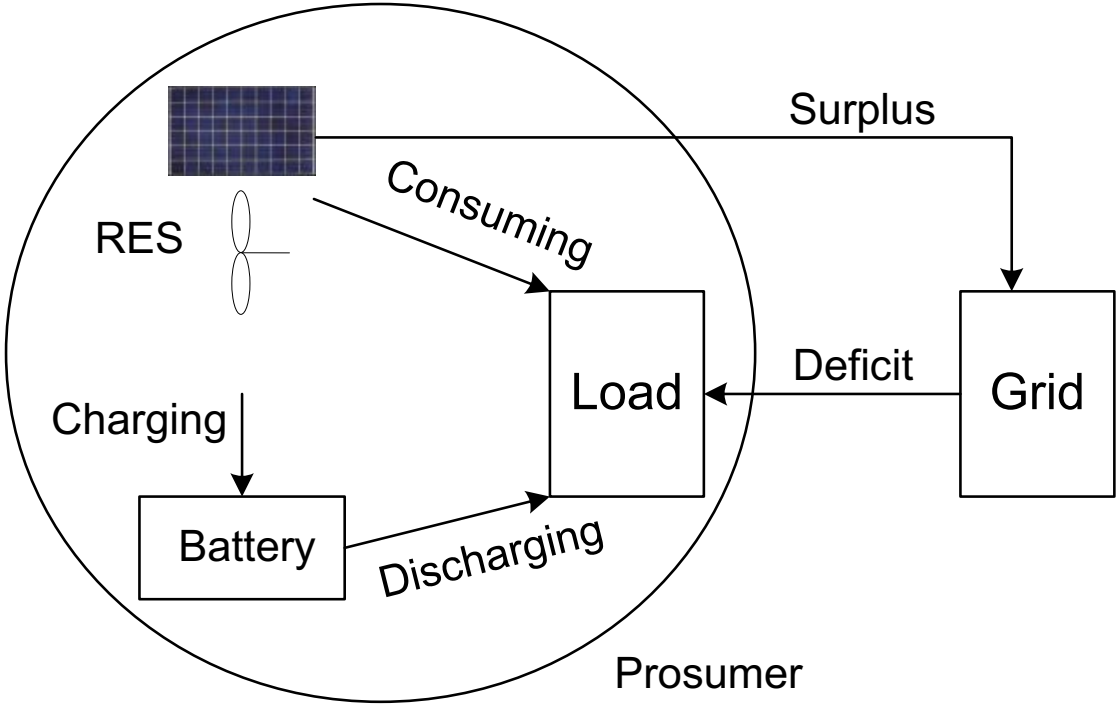
# Example of Renewable Energy Community

# Energy communities



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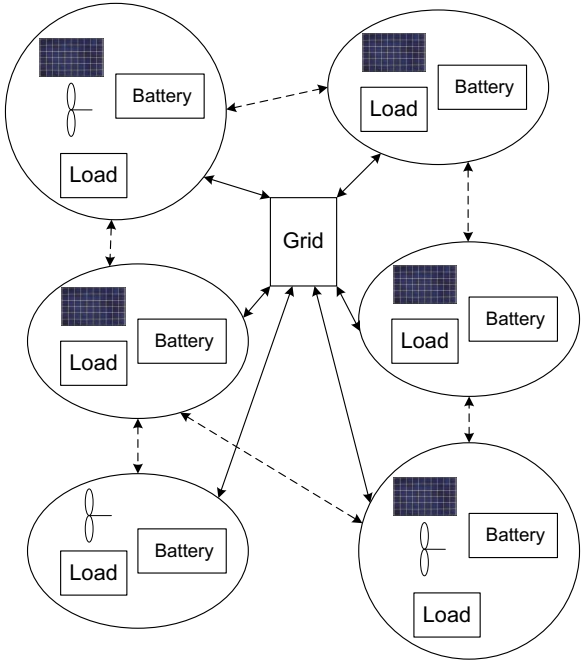
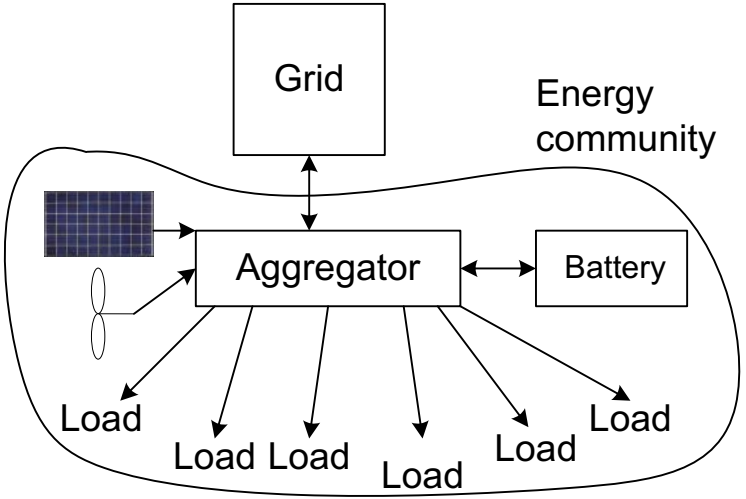



Prosumers with own installations




Energy community with shared installations

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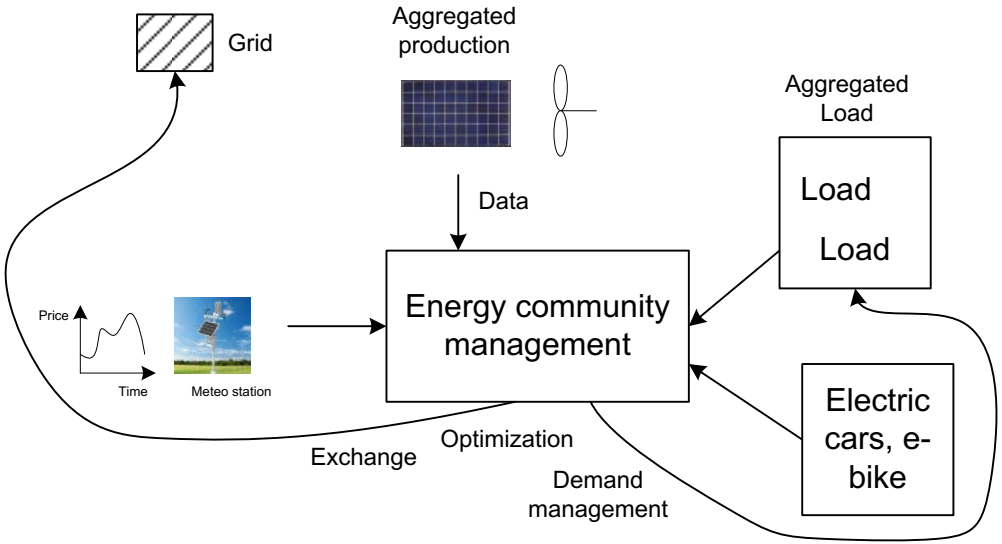
# Energy communities in smart cities



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# Energy communities

- Optimization models are widely adopted for controlling energy communities based on classical methods with various constraints (capacity, demand balancing, battery depreciation);

- Heuristic-based models to minimize the overall costs and to maximize battery usage.

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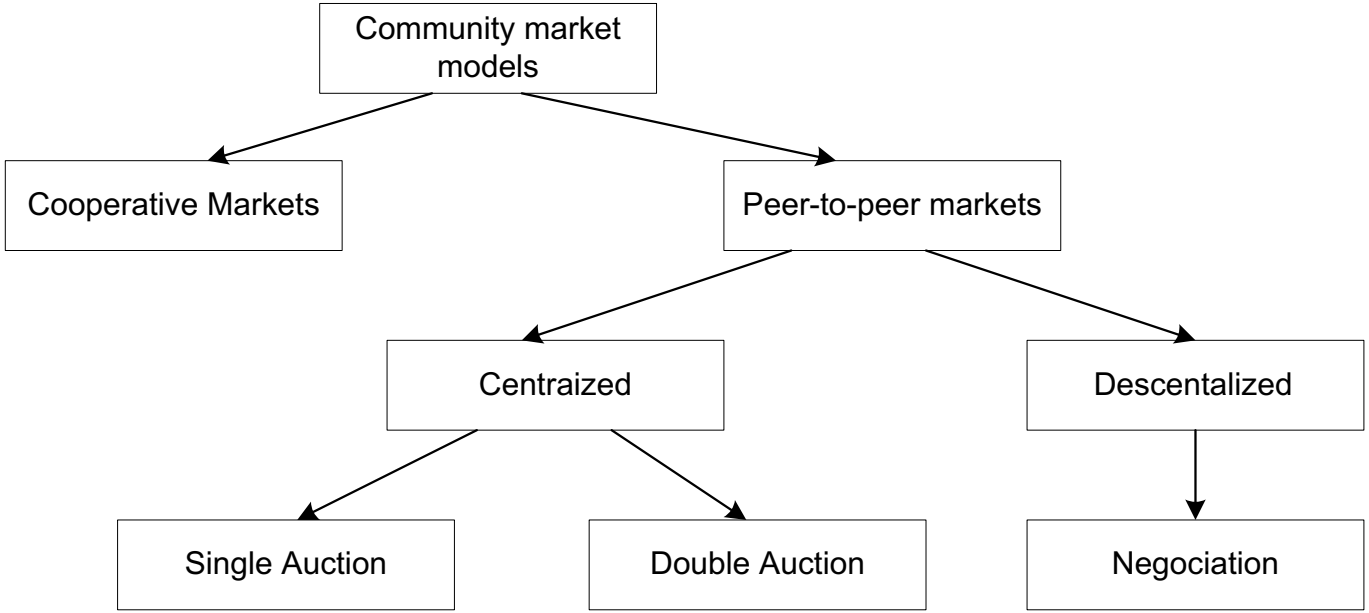
# Energy communities in smart cities



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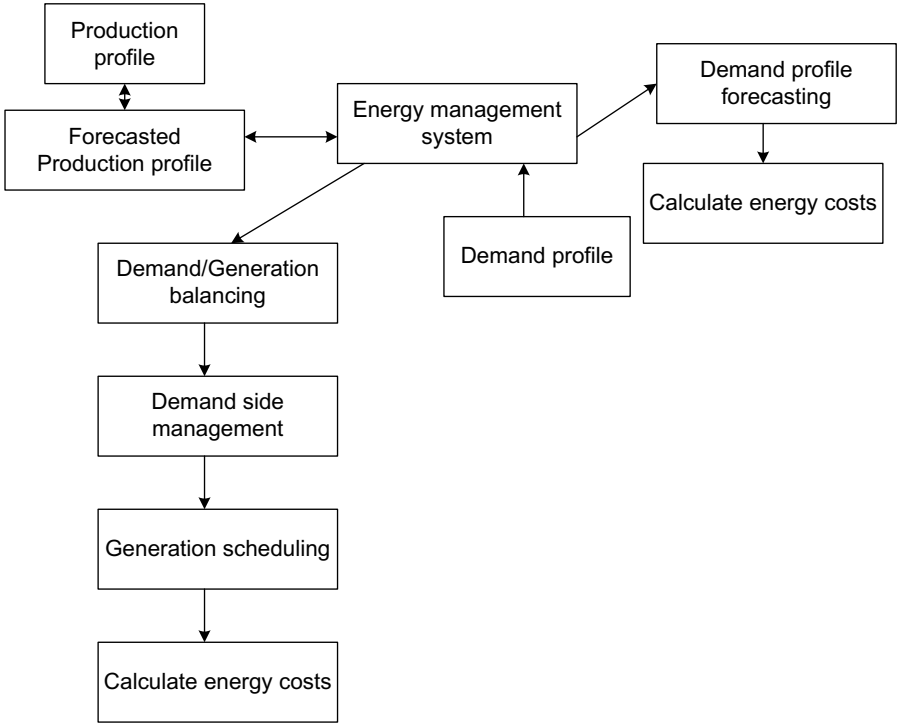

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# Energy communities

- The interactions among prosumers in the energy community can be divided into:
  - community self-consumption (cooperative community) maximization where given the aggregated demand and generation, the benefits are maximized (minimizing the imported energy from the upstream grid and exporting the surplus) considering the physical constraints. The prosumers are modeled together;

  - Peer-to-peer trading among prosumers leading to transparency and preserving privacy, but the complexity is higher as involves negotiation. Smart contracts can be a solution.

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# Energy communities

- The blockchain management implements logics of power/energy sharing among the end-users and logics of demand flexibility in a double way:
    - interior flexibility among the participants to apply a set of internal rules;
    - external flexibility to the grid, between the EC and the distribution operator to play in the energy market by demand side management.

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# Energy communities

- The demand of prosumers can be satisfied by combining them as sum of demand at each time, as the prosumers share their installations, and their demand can be satisfied by anyone generation;

- Thus, the demand profile is anticipated and the generation profile for the energy community can be determined.

- The minimization of costs or maximization of benefits can be achieved.

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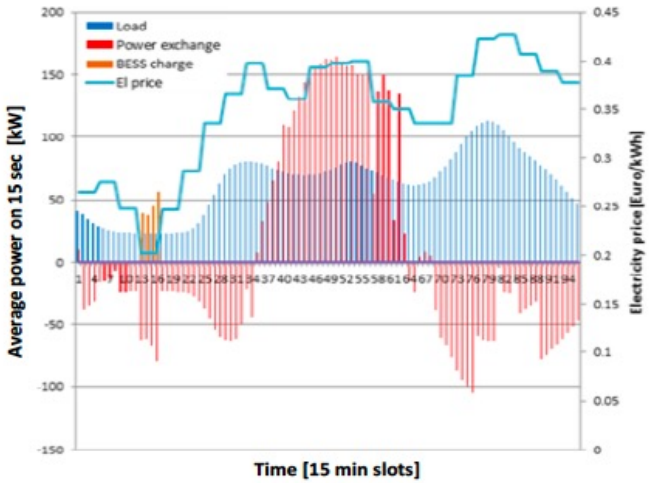
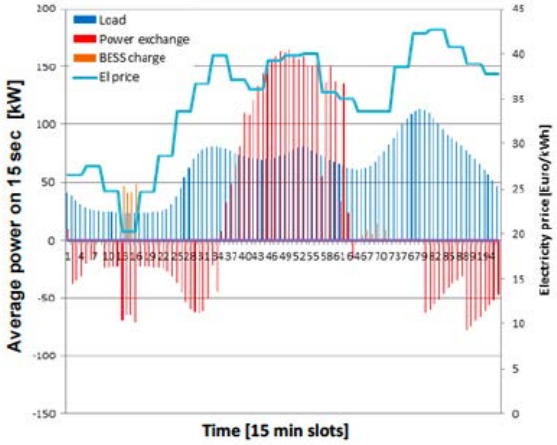
# Energy communities

- Deterministic optimization models can be formulated considering also the upstream electricity price




On-grid

Off-grid



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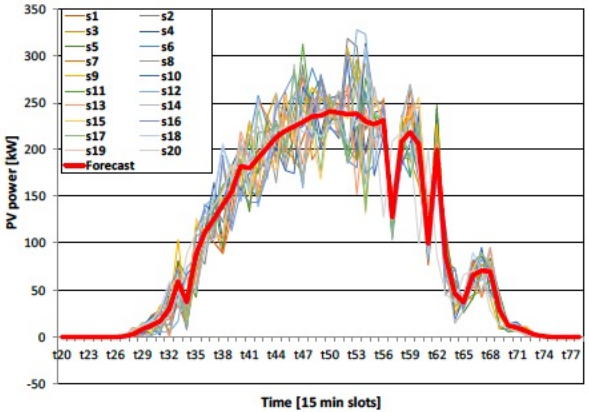
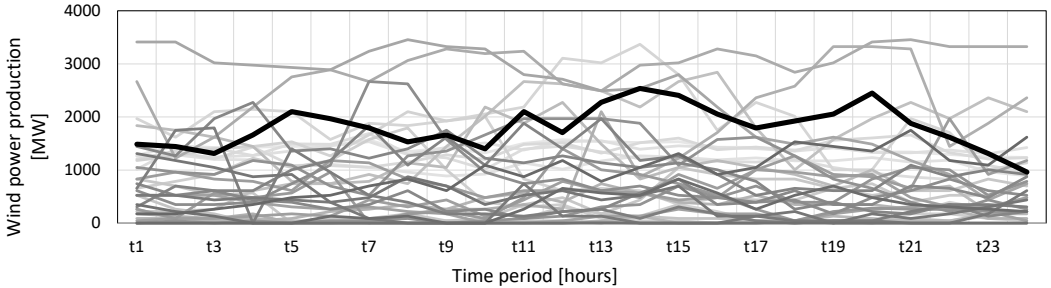
# Energy communities

- Stochastic optimization models can be formulated considering also the upstream electricity price



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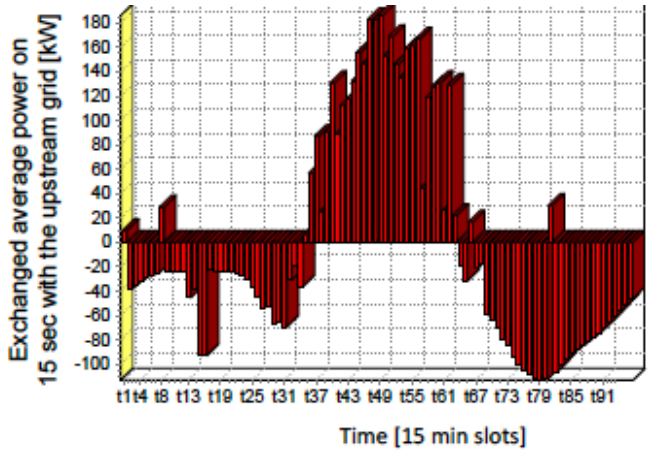


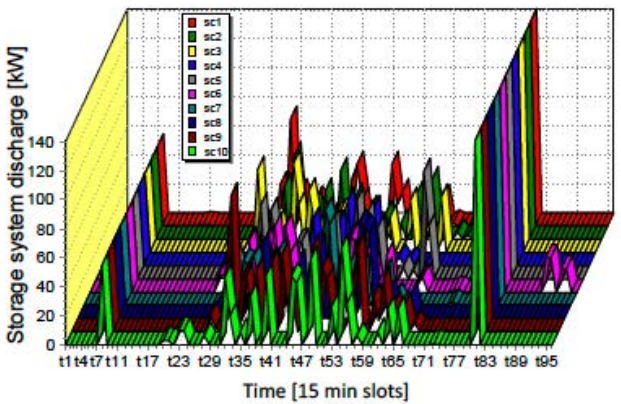

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# Energy communities

- Dynamic pricing through Blockchain Technology Business model

- Possibility of contributing to the balancing of the network, with the batteries of electric vehicles, instead of contributing to the imbalance, there would be a compensation for the Prosumer, with the RESCoins managed by the Blockchain in an individual wallet for each driver

- RESCoin, digital currency linked to RES production.

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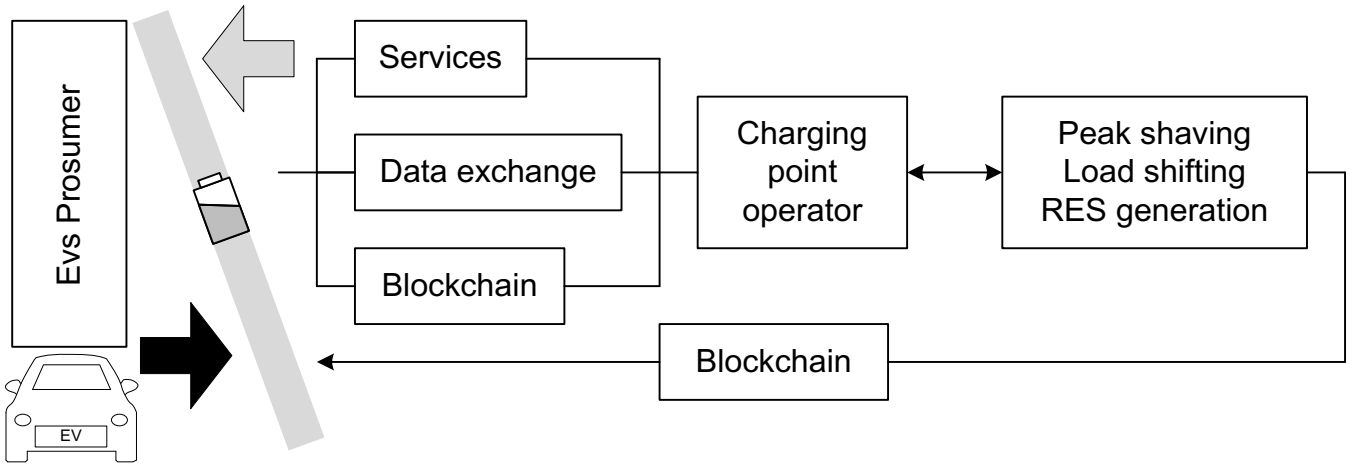

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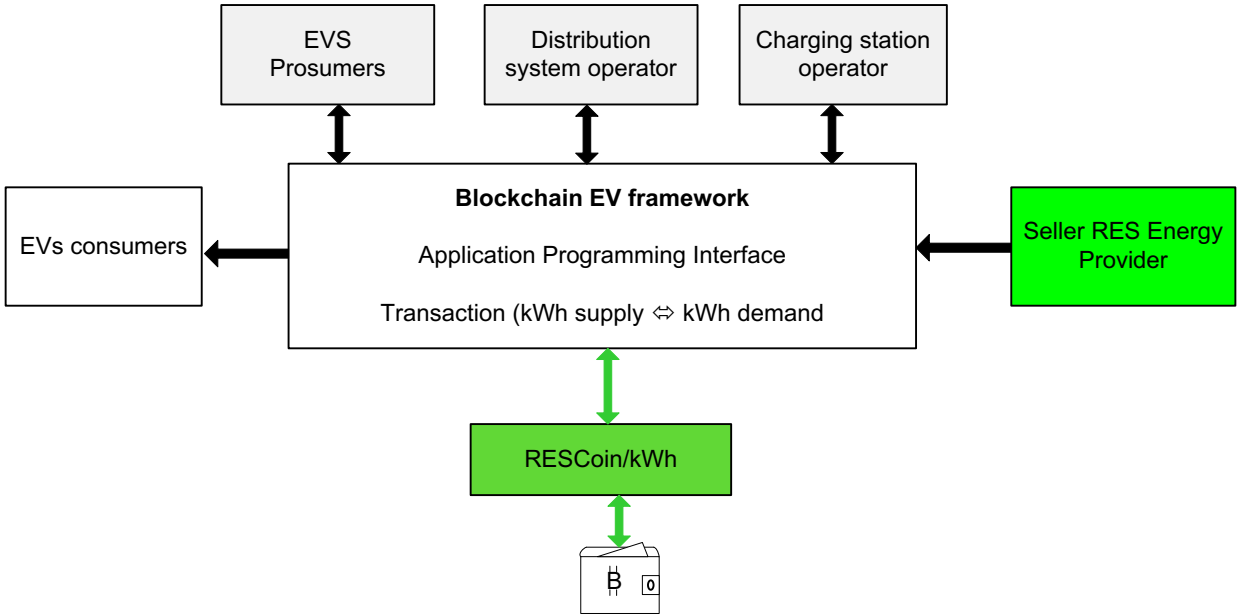

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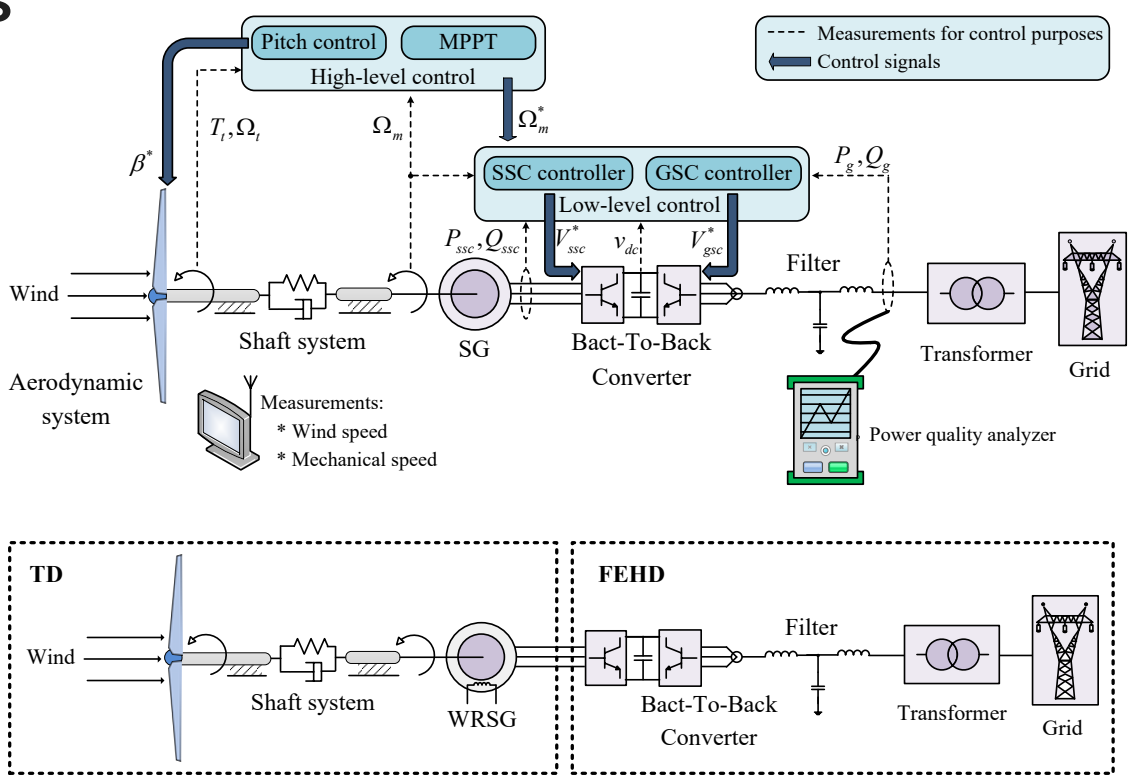
- Modeling challenges for network studies in energy communities



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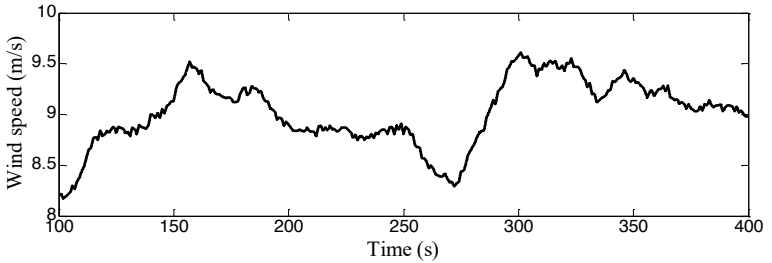


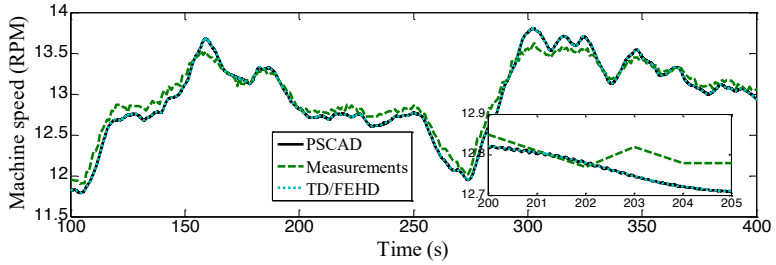


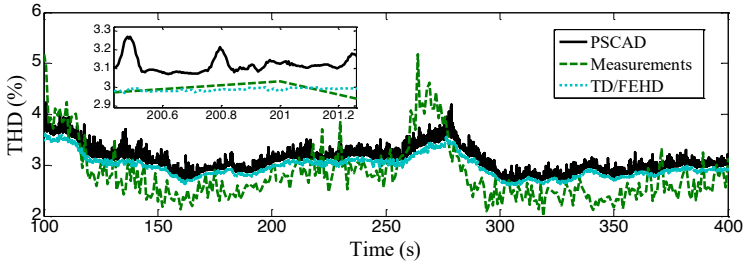

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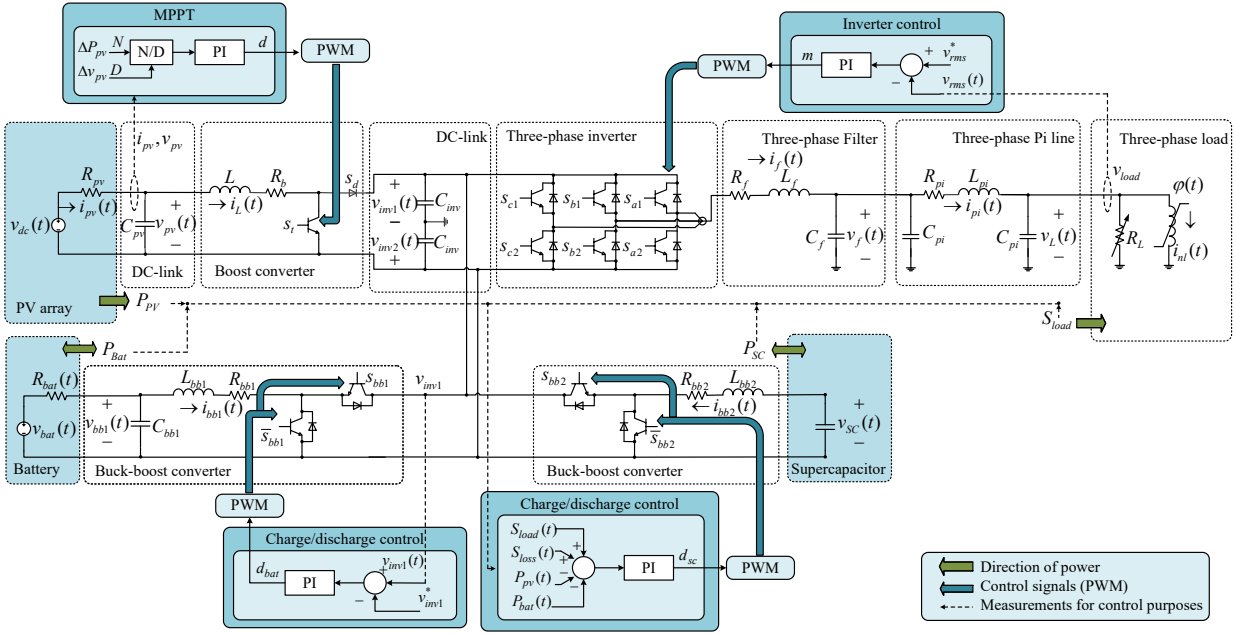

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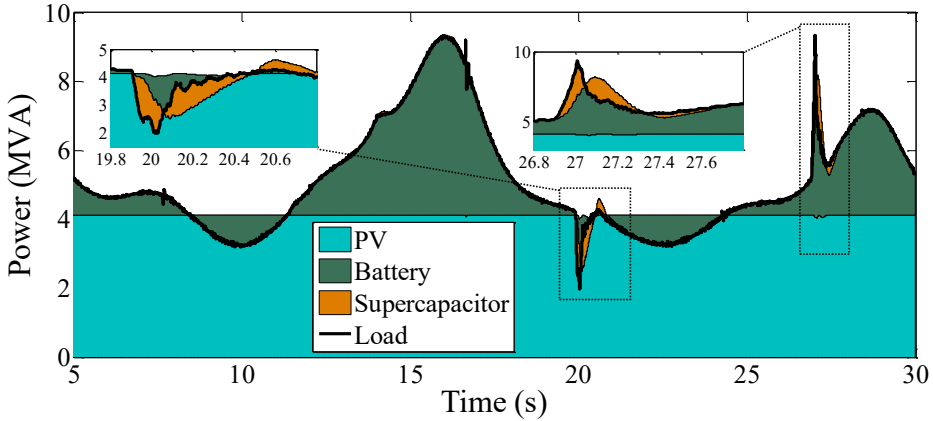
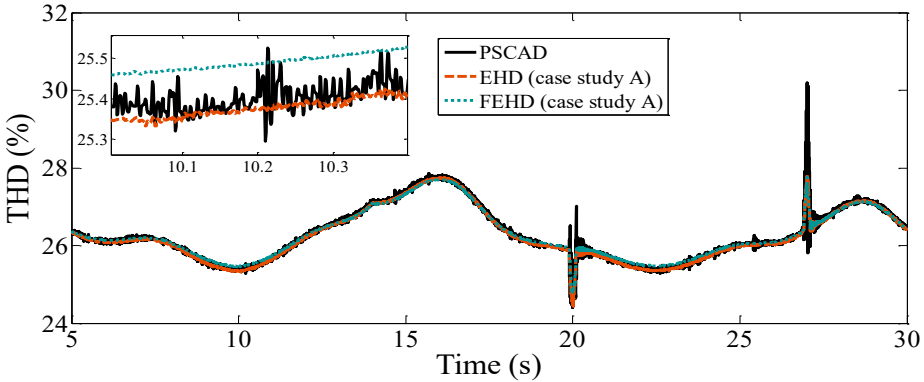
- Modeling challenges for network studies in energy communities
- Power contribution by the stand-alone PV-battery-supercapacitor hybrid system



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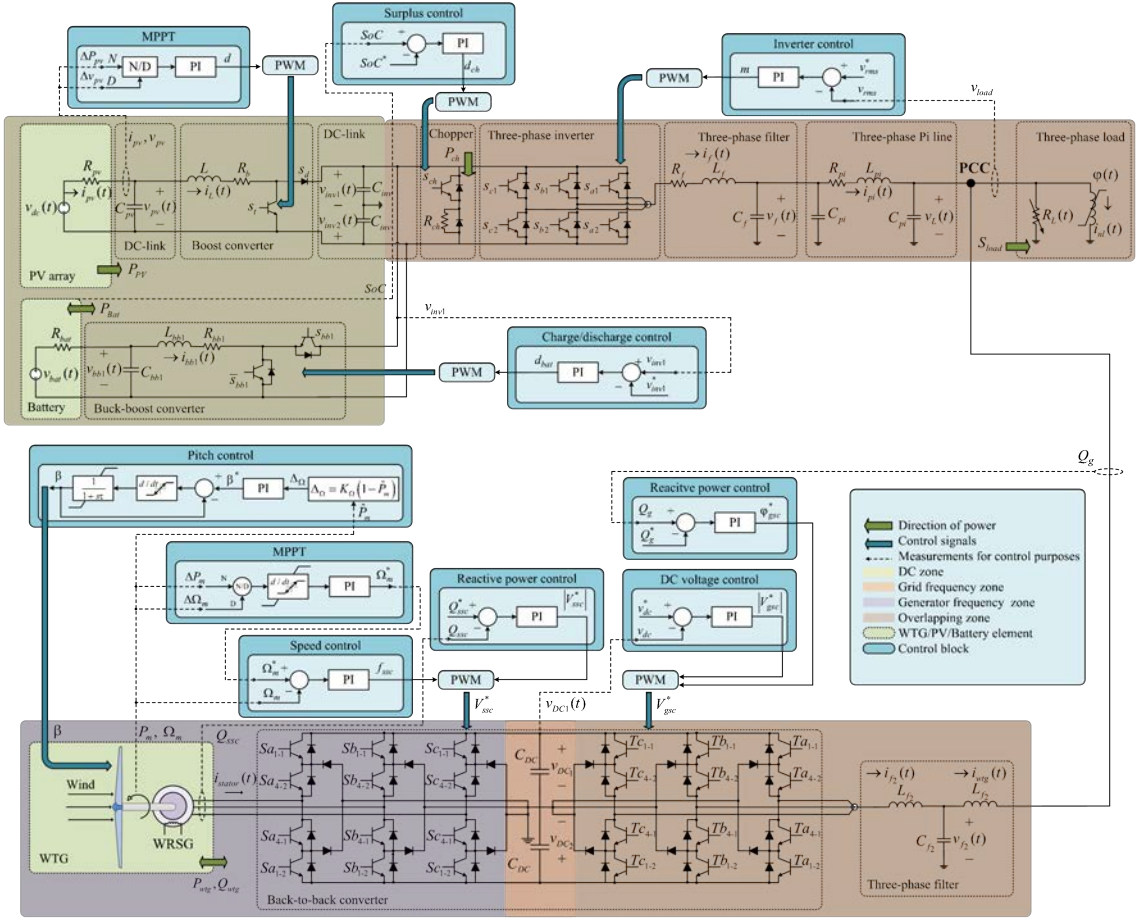

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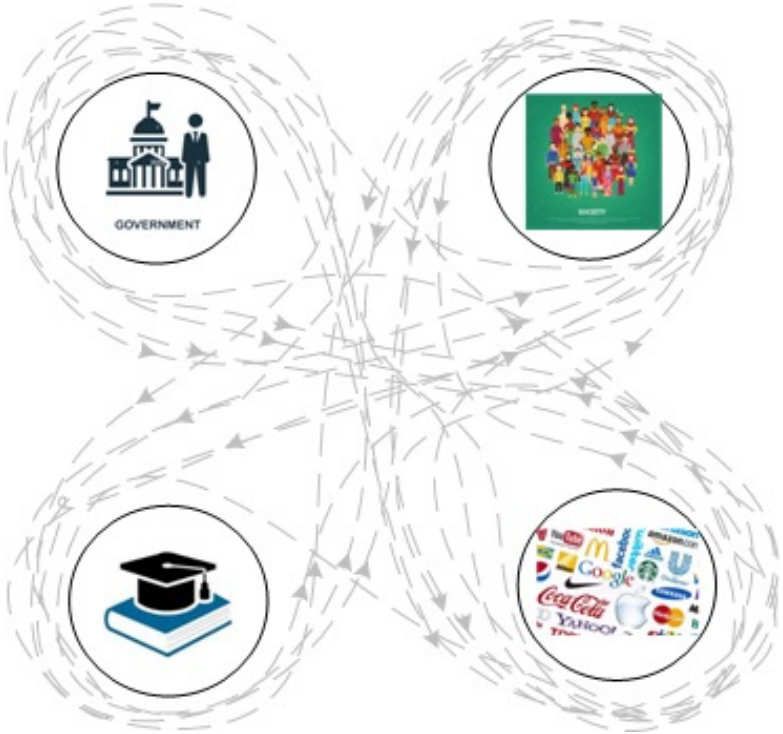


*Quadruple Helix* model for smart city development and the bidirectional interactions between industry, academia, public authority, and citizen

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# Energy communities

- The customers will not remain just “users” of this new structure (energy communities), but will become main figures of the energy transition revolution

- This will be a difficult task as different users have different needs and characteristics, as well as different interests

- The participation of various actors in the future energy transformation need to be based on regulations, tools, dissemination initiatives to solve engineering challenges and to increase social and cultural awareness

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# Energy communities

- The energy communities within smart cities answers the existing challenges of RES local diffusion and demand flexibility through cross energy vector insertion

- The coordinated inter-exchanges of cross-vectors among independent and aggregated energy communities, are maximizing the technological and economic benefits

- Optimized energy use of individual/aggregated energy communities and intersection with the upward smart cities

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