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The Role of Local Energy Communities in Providing Residential Flexibility

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Agenda

- (Local) Energy Communities: what and why?
- Our framework for residential flexibility provision by Local Energy Communities
- Conclusions

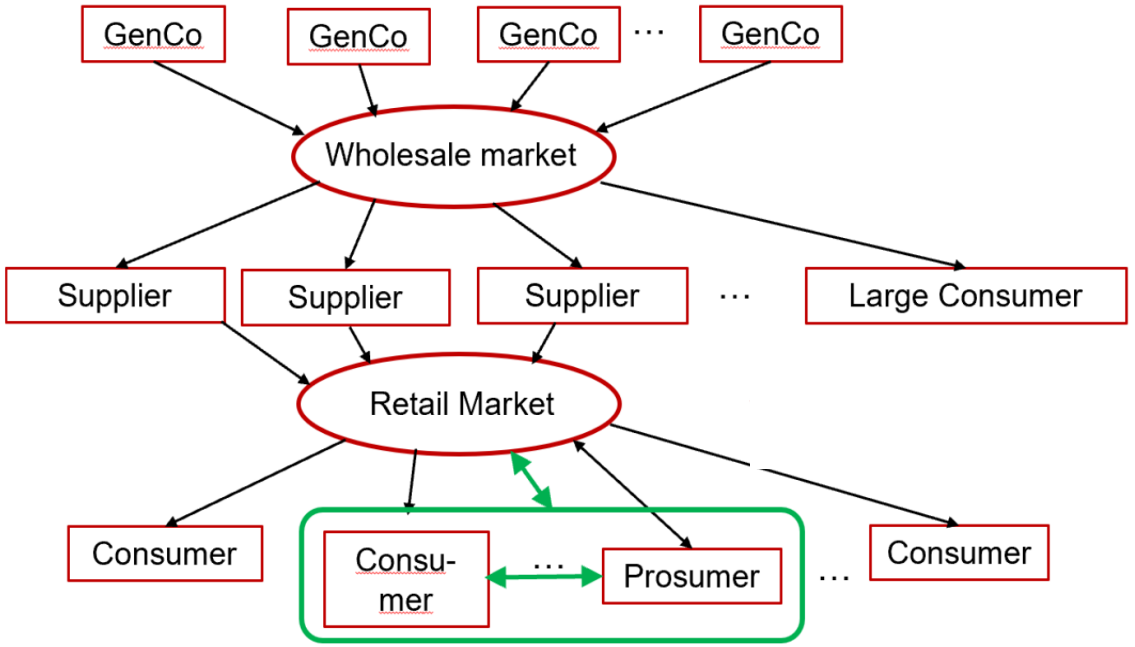
What is a Local Energy Community?

- An **organized entity of consumers and prosumers (= members)** of electricity established on the **public electricity distribution** network,
- in which **local exchanges of (renewable) electricity** can occur, using **private or community-owned assets**,

  But how is 'local' defined? See e.g. here
- **without resorting to the classical wholesale/retail markets**

  (but members may purchase the electricity not produced locally, or grey electricity, on traditional markets)
- which may involve **other energy vectors and networks** (heat, cold, etc.)

We do not consider private microgrids, which may operate in islanded mode



Simplified vision of the EU liberalized electricity market structure (for energy)

Why Local Energy Communities?

- **Allow the citizen to play an active and central role in the electricity supply chain**: by **collectively owning the energy assets (renewable generation**, storage), by expressing her/his heterogeneous preferences (economic, environmental, social preferences) for sourcing electricity, etc.

- **Creating a local economic framework, less subject to wholesale price spikes,** which stimulates investment in local renewable generation and storage assets

Electricity bill = Commodity Costs
+ Grid costs
+ Taxes - flexibility revenues

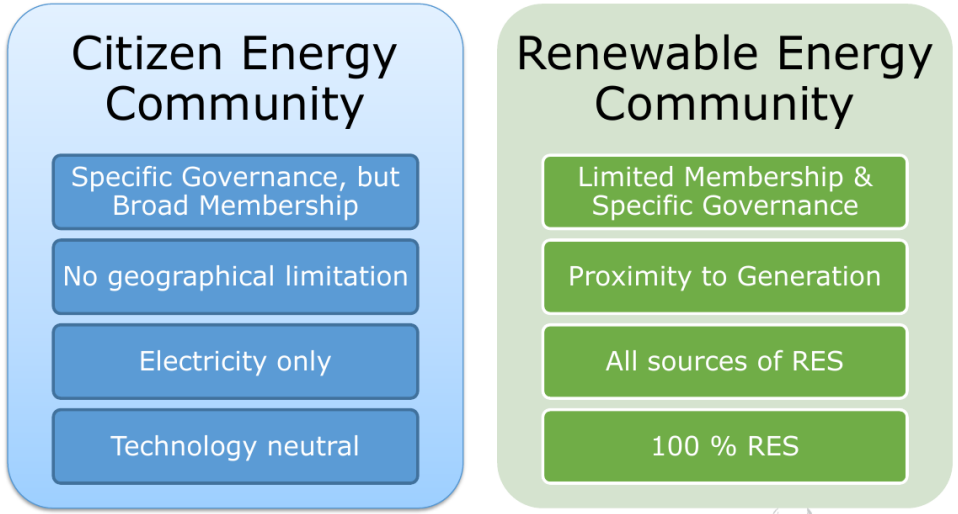
Operating as a Local Energy Community may impact these components

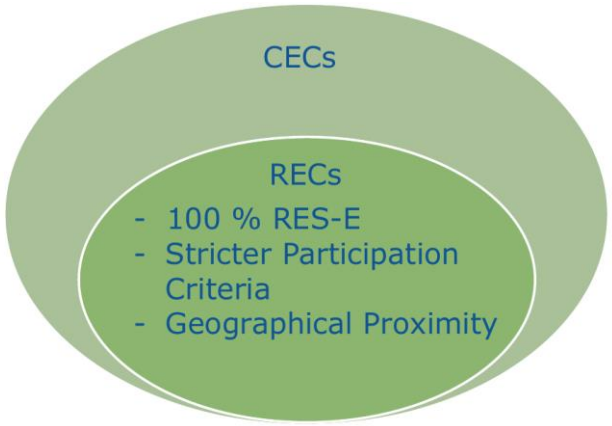
- **Unlock Low Voltage/Medium Voltage flexibility provision (e.g. by implementing demand-side management schemes coordinated at the community level),** in order to help the other system actors to ensure the balance and the safe operation of the electricity system (Balance Responsible Parties or BRPs, Flexibility/Balancing Service Providers or FSPs/BSPs, Distribution System Operators or DSOs, Transmission System Operators or TSOs, etc.)

And according to the EU?

- Concepts of 'Renewable Energy Community (REC)' and 'Citizen Energy Community (CEC)' introduced in the **Renewable Energy Directive for the promotion of energy from renewable sources, Directive (EU) 2018/2001 (RED II)**, and recent revisions

We assume here that Local Energy Communities fall within the scope of Renewable Energy Communities

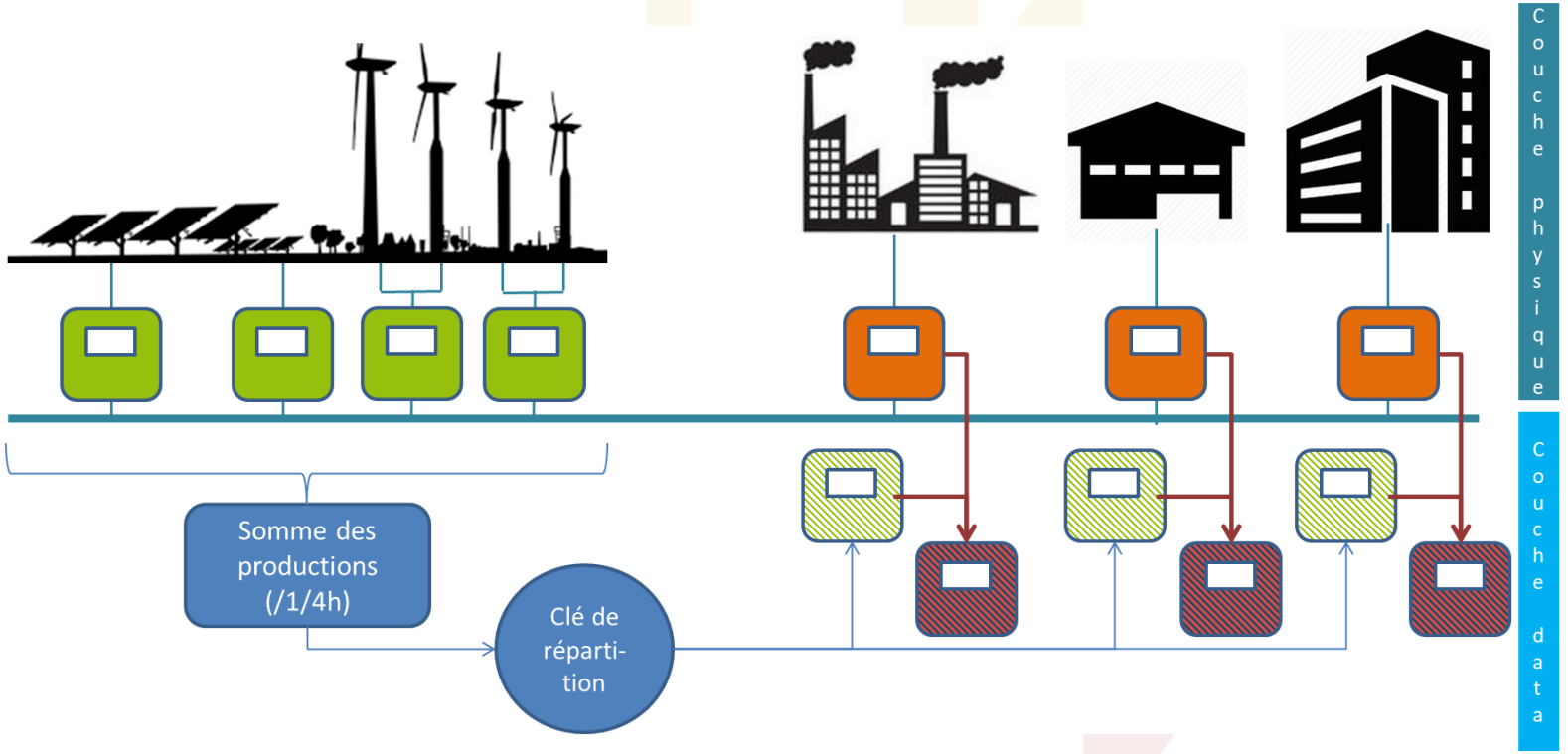




[M. Jasiak and J. Steinkohl, 'Energy Communities in the Clean Energy Package', Eurelectric Seminar,18th February 2019, link]

An example of REC

- Build on the Walloon case (see e.g. E-CLOUD pilot project, Tournai, 2017)
- **Virtual energy allocation:** quarter hourly allocation of local (total or excess) generation to members according to specific distribution keys (based on static or dynamic consumption, investment share, etc.). 'E-CLOUD like' mechanism.



Other market designs do exist in the literature/in practice:

- 'Minimum Cost' allocation
- (Local) auction mechanisms
- Intra-community Peer2peer exchanges
- etc.

Agenda

- (Local) Energy Communities: what and why?
- **Our framework for residential flexibility provision by Local Energy Communities**
  - ✓ Target flexibility products: *what products do we aim to model?*
  - ✓ Source of LV flexibility: *where does the flexibility come from?*
  - ✓ Technologies: *what LV technologies are suited to provide flexibility?*
  - ✓ Mode of activation of flexibility resources: *how is flexibility activated and remunerated?*
- Conclusions

Flexibility Provision by LV communities

- Target flexibility products
  - Balancing products
    - Reserve products (FCR, aFRR, mFRR)
    - Imbalance settlement
  - Ancillary Services for Distribution Grid Operators
    - Congestion management, Voltage Control

Opportunities: implementing an **Energy(Power) Management System coordinated at the community-level (CEMS)**, operated e.g. by a Community Manager, so as to **stack revenues** from different flexibility platforms

Challenges: market products follow **different time dynamics**, which is challenging to model in a single CEMS

- Source of LV flexibility: where does the LV flexibility come from?

A residential community established on the LV grid

VS

A collection of individuals (in the portfolio of a BSP/FSP)

Extra opportunities for stacking revenues streams:

Flexibility revenues (see above) + Local energy arbitrage (depends on internal market design and grid tariffs)

Flexibility Provision by LV communities

- Source of LV flexibility: where does the LV flexibility come from?

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Extra opportunities to invest in flexibility assets:

- given the variety of possible **financial arrangements**. Joint investment in larger assets? Individual investment while sharing (part of) the asset at the community level?
- **Access to hosting facilities** for energy equipment, which might not be accessible in an individual context (e.g. roof space, etc.)
- **Willingness to invest collectively** might be more important

We aim to study whether operating as a community enables the existence of new business models which will drive/accelerate the adoption in assets able to provide flexibility

Flexibility Provision by LV communities

- Source of LV flexibility: where does the LV flexibility come from?

A residential community established on the LV grid

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A collection of individuals (in the portfolio of a BSP/FSP)

Challenges:

- **Revenue stacking strategies** are complex to model (similarly to above, with local energy arbitrage in addition)
- How should we **internally share these revenues within the community** to ensure adhesion (and a stable community composition?)
- **Many investment strategies** to test…
- How can we **quantify the supplementary (if any) willingness to invest collectively** in energy assets in a community context, using e.g. field experiment?

Flexibility Provision by LV communities

- Technologies for LV flexibility: what LV technologies are suited to provide flexibility?
  - In line with the expected electrification of space heating and domestic mobility
  - Home Batteries, Heat Pumps, Electric Vehicles, Electric Water Boilers
  - (White goods: not for flexibility per se, but useful for local energy arbitrage)
  - (Multi-sector communities: model explicitly the strong coupling between electricity and other energy carriers such as heat/cold, mobility. Not a 'public' objective of ALEXANDER)

- Mode of activation of flexibility resources: how is flexibility activated and remunerated?
  - We assume first a control of flexibility assets by the community manager (although it is questionable), given that certain comfort constraints specified by the user are fulfilled

  Opportunities : provides an upper bound for estimating the LV community flexibilities potential

  Challenges:

  - Data privacy issues… (Not a 'public' objective of ALEXANDER)
  - What if scheduling recommendations instead of control of flexibility assets (towards a lower bound)?

Flexibility Provision by LV communities

— Mode of activation of flexibility resources: how is flexibility activated and remunerated?

Explicit (i.e. market-based) demand response for flexibility provision

(Reserve, Ancillary Services)

+

Implicit (i.e. price-driven) demand response for flexibility provision

(Ancillary Services, Imbalance Settlement)

↳ Community = FSP/BSP (= a BRP)

For Large, city-scale communities?

DSO/Community: e.g. through the grid component of the electricity bill (peak management, emergency signals, etc.)

↳ Community ⊂ portfolio of an FSP/BSP (including also other individual agents)

For smaller, district-level communities?

FSP-BSP/Community: an FSP/BSP participates to flexibility markets explicitly, and trigger flex internally through price-driven signals

Opportunity: assess the role of the Community Perimeter in the choice of the correct business model!

Challenges: hierarchical structure of the models

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Conclusions

- **Communities established on the public LV grids will have a role to play in fostering LV flexibility**
  - Opportunities for revenues stacking (flex + local energy arbitrage), for innovative investment strategies in flexibility assets (joint/individual, hosting facilities), for a possible increased willingness to invest in flexible assets (to be quantified)
  - LV Flexibility technologies: Home Batteries, Heat Pumps, Electric Vehicles, Electric Water Boilers. White goods kept for local energy arbitrage (and possibly implicit demand response) *a priori*.
  - A combination between explicit and implicit demand response for flexibility provision
- **Additional research questions: how should we regulate the roll-out of communities to provide system-wide benefits?**
  - **Avoid a transfer of costs to end-users not in communities**! If a LEC benefits from grid fee discounts, it must be linked to quantifiable benefits for the grid operator (and consequently for society). Studying appropriate tariff structures is crucial.
  - **How will standard commercial actors (e.g. suppliers/BRPs) react to a massive roll-out of communities?** Premium fees applied to electricity contracts of end-users participating to communities, (Virtual) PPA contracts offered to MV companies, etc.

Thank you!

Alexander

Perimeters of RECs (example of Brussels)

- Based on the notion of **'proximity'**, according to the definition of the Brussels regulator (BRUGEL, here)
- **Type A: Community in a building (or Collective Self-Consumption depending on regions/member states)**. No grid fees (transport and distribution) for community self-consumed electricity
- **Type B: LV Community supplied by the same MV/LV substation**. No grid fees for transport components, discount (50%) on distribution grid fees, for community self-consumed electricity. Typically domestic communities, possibly including small shops, SMEs, etc.
- **Type C: MV and LV Community supplied by the same HV/MV substation**. No grid fees for transport components for community self-consumed electricity, full distribution grid fees. Communities with mainly SMEs.
- **Type D: MV and LV Community supplied by different HV/MV substations**. Full grid fees. Communities with mainly SMEs, a city.

Communities in the EU member states

- The Directive has been/is being transposed in regional/national decrees, legal frameworks, etc., according to member states specificities:

  - Germany: energy cooperatives (*Energiegenossenschaften*) and citizen energy cooperatives (*Bürgerenergiegesellschaften*) in the 2017 Renewable Energy Act
  - France: law on Collective Self-Consumption in 2017 (*Auto-Consommation Collective*)
  - Italy: Law 08/2020 in February 2020 and later evolutions (Law 199/2021)
  - Netherlands: legal definition of RECs
  - Spain: local energy communities in 2019 Royal Decree 244/2019
  - Belgium (Wallonia): decree first published in 2019, reviewed in 2022, government edict in March 2023
  - Greece: law on energy communities published in 2018
  - etc. (see here for many examples of community projects across EU)
  - And in the US: e.g. community-solar projects (here). See here (chap 2) for a wider perspective