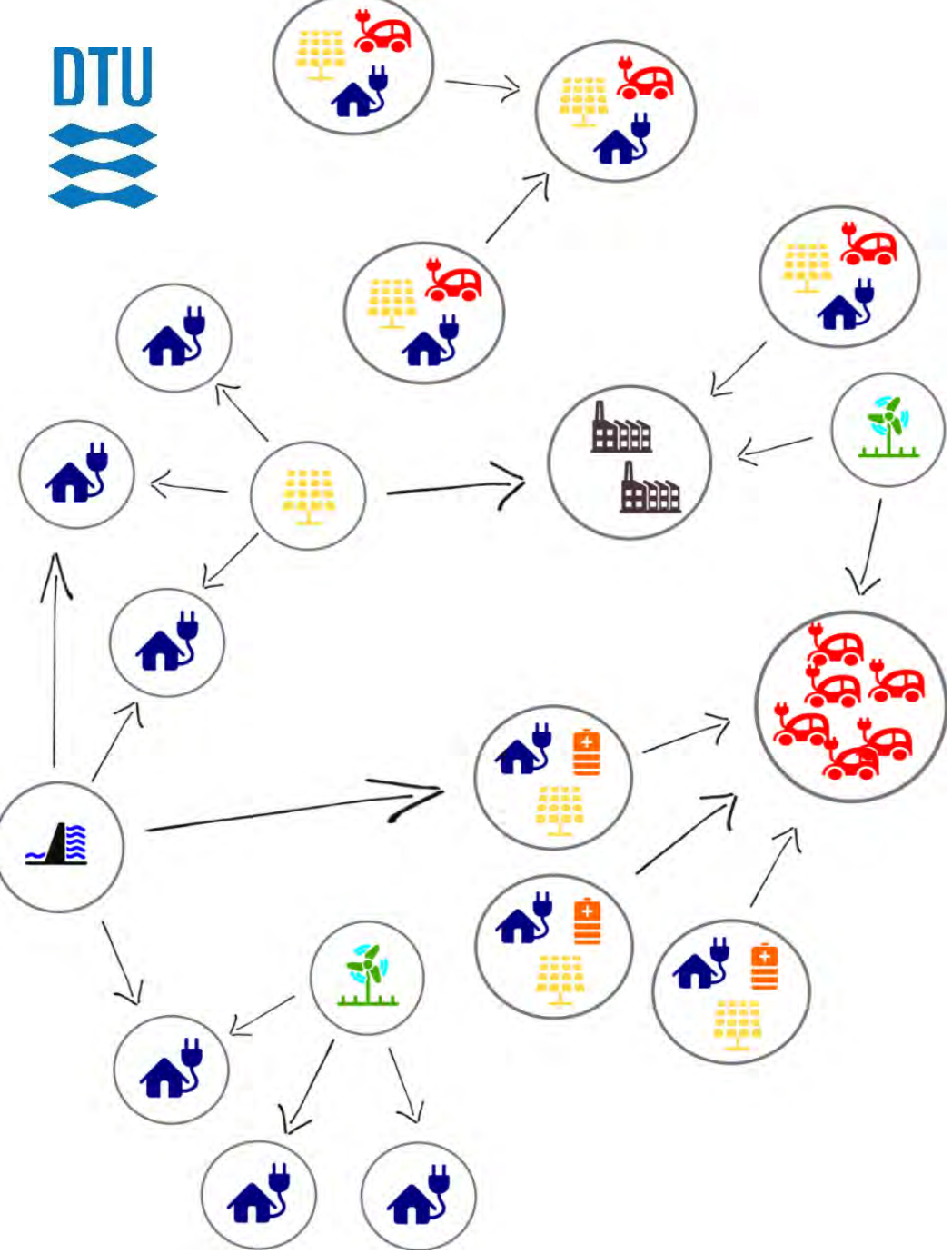


Center for Electric Power and Energy
Department of Electrical Engineering

Energy Collective project

Peer-to-Peer and community tools for consumer-centric energy markets

Tiago Sousa (tsousa@elektro.dtu.dk)

Postdoc Researcher

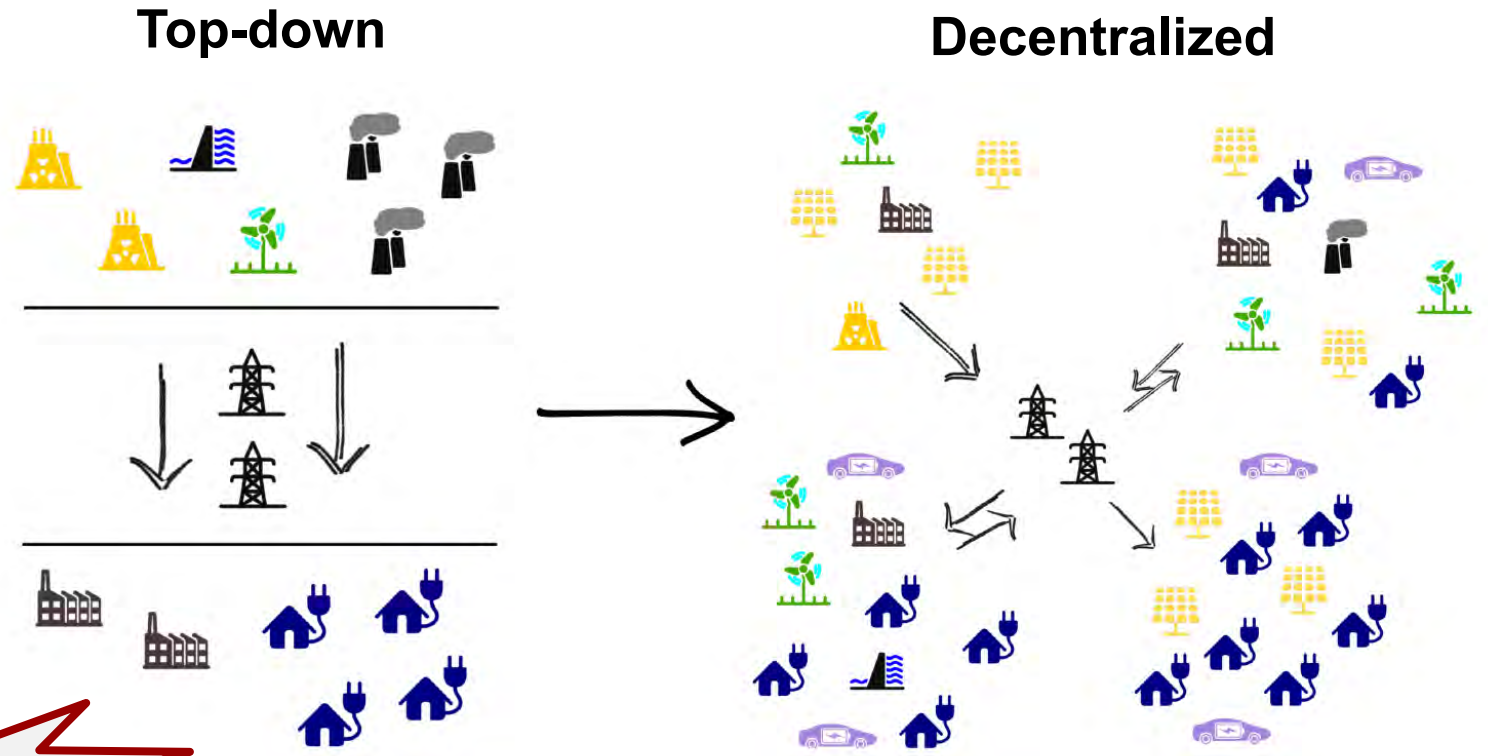
Contribution from: Pierre Pinson, Fabio Moret, Thomas Baroche, Pierre-Elouan Réthoré, Oliver Gerhke, Alexander Prostejovsky, and others!

Agenda

- Energy Collective project
- Market design
- Grid operation
- Setup
- Outlook

Towards a more decentralized model

- Transition of energy sector from **supplier-centric model** (top-down hierarchic) towards a more **decentralized** model



Challenge

How to **adapt electricity markets** to this new decentralized model

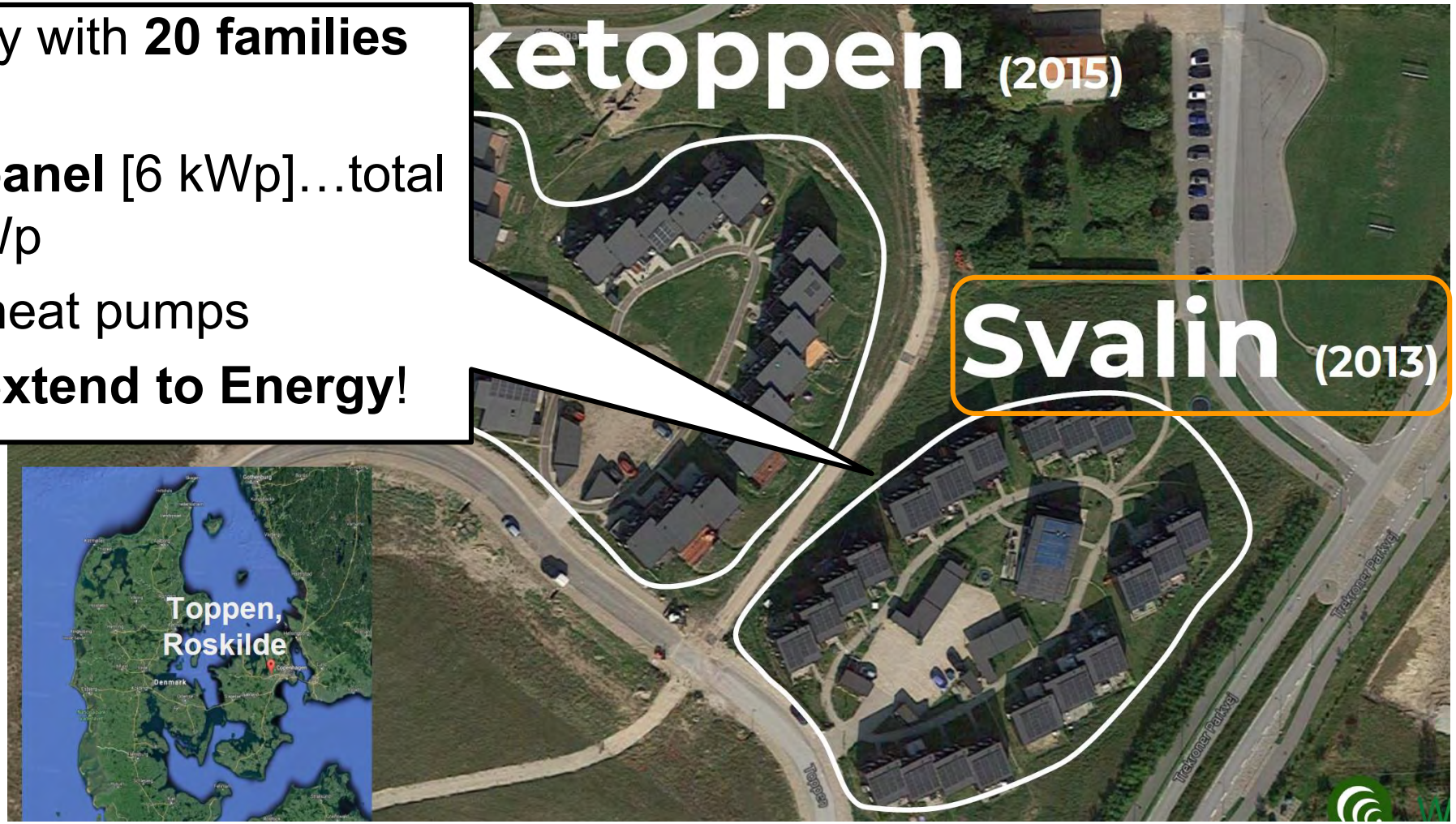
The Energy Collective

Funded by

http://the-energy-collective-project.com/

The Energy Collective

- Co-housing community with **20 families** living there
- Each house with **PV panel** [6 kWp]…total PV capacity of 150 kWp
- Electric vehicles and heat pumps
- Collective decision…**extend to Energy**!



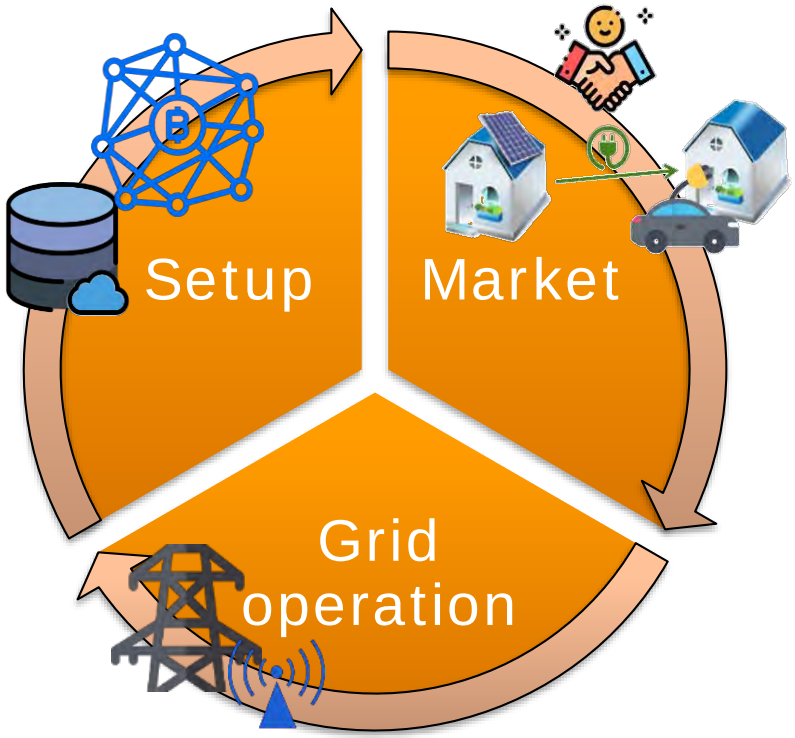
Funded by

http://the-energy-collective-project.com/

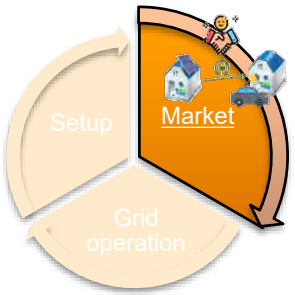
Energy Collective project

- **Energy Collective** project aims to reshape current market towards **consumer-centric electricity markets** through P2P energy trading

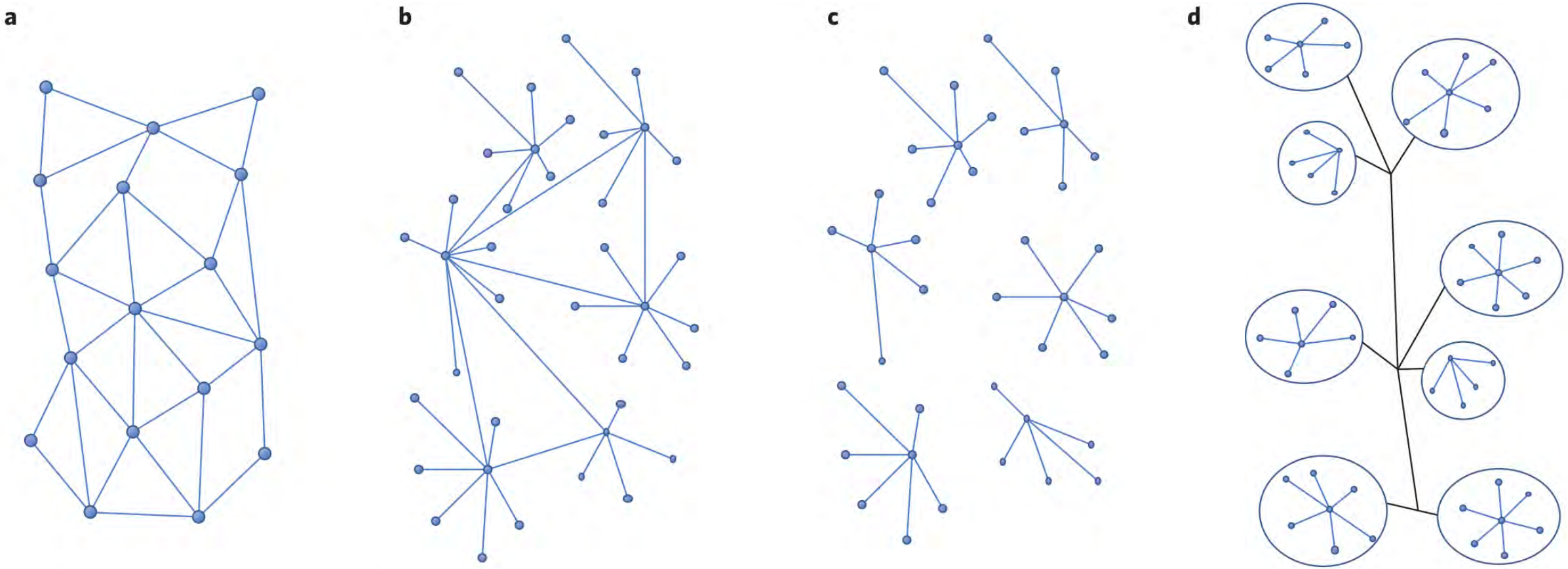
- To realize this goal, we work on **3 angles**:
  - Market design
  - Grid operation
  - Setup



Consumer-centric markets – Organizations

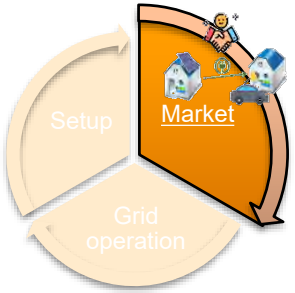


- Organizations: a) full P2P; b and c) microgrids; d) community



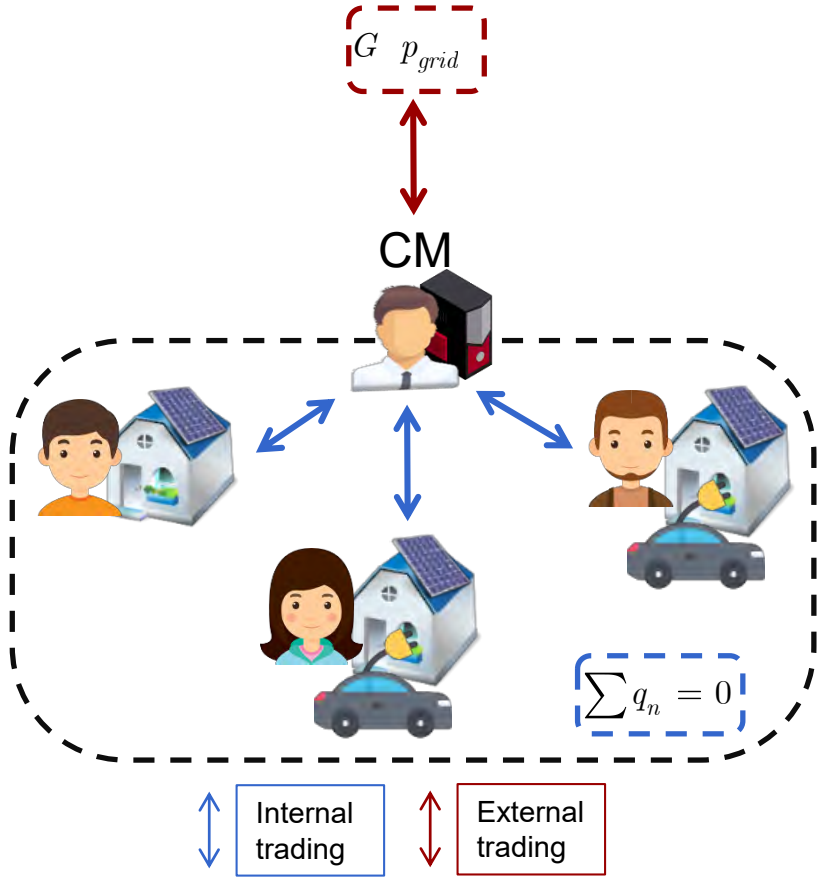
Reference (Reproduced with authorization from):
Y. Parag, B. K. Sovacool (2016), Electricity market design for the prosumer era, *Nature energy*.

Community-based market



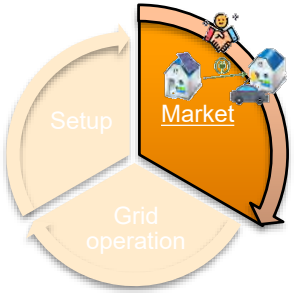
- **Energy collective approach:** Group of agents with common goal

- **Community manager**
  - Non-profit coordination node
  - Manage common assets $\sum q_n = 0$
  - Interface with market and system operator $G \;\; p_{grid}$



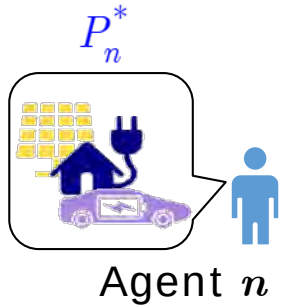
Reference:
F. Moret, P. Pinson (2018), Energy collectives: A community and fairness based approach to future electricity markets, *IEEE Transactions on Power Systems*.

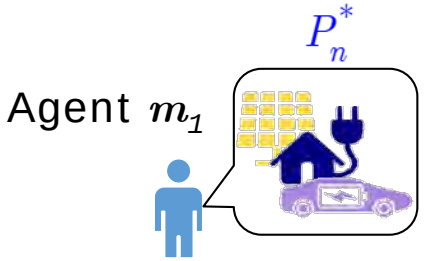
Agents negotiation – Market mechanism

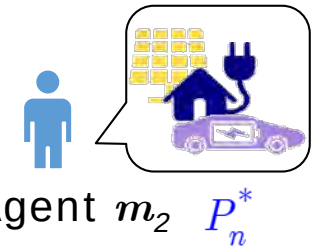


- We assume a distributed negotiation peer-to-peer:

1. **Assets optimization**: each agent optimizes its **independent assets** – Optimal set-point P_n^*







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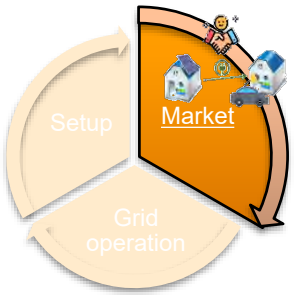

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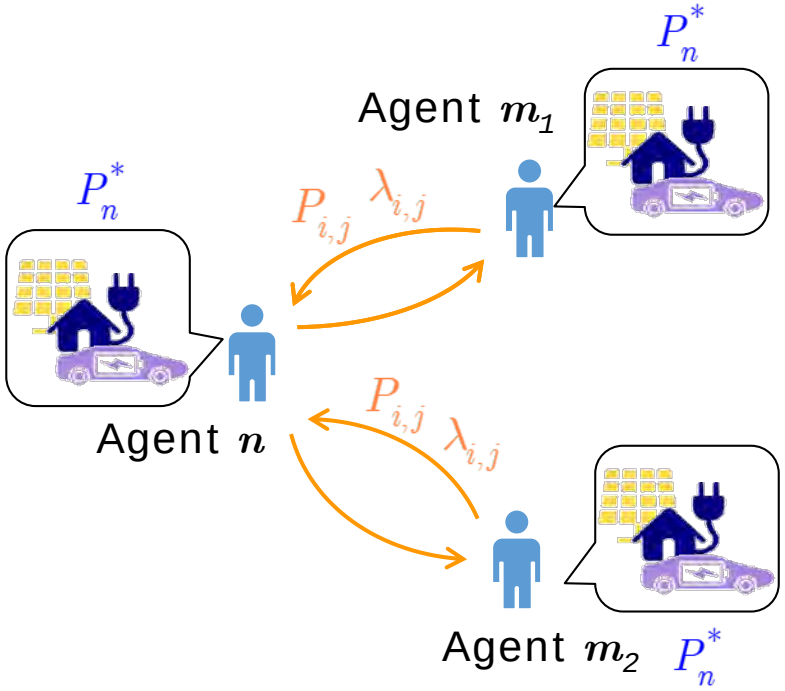

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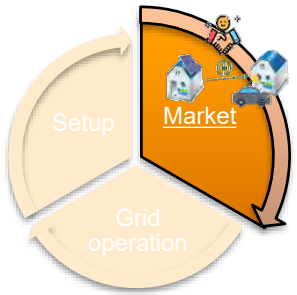

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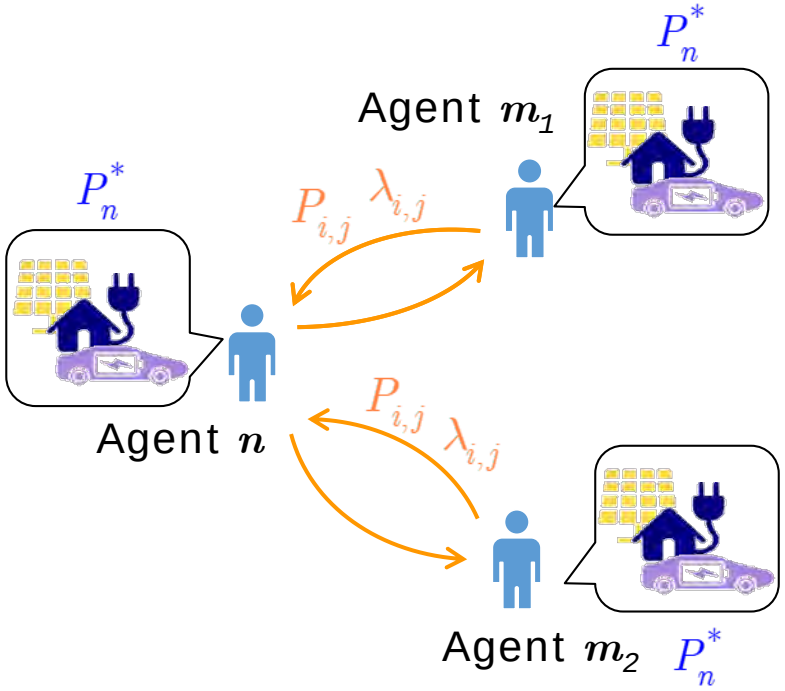
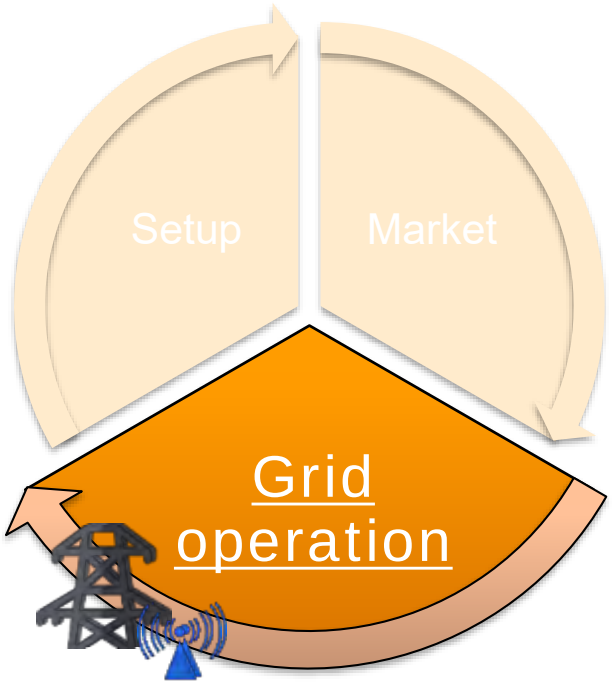
3. **Iterative process**: Continue until every agents reach a **consensus** towards energy and price $P_{i,j}$ $\lambda_{i,j}$

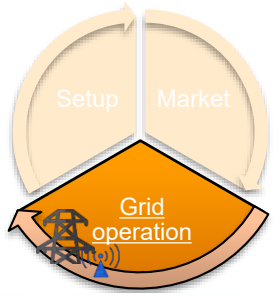


- Negotiation is **hard** to reach consensus when we **scale-up** to many-to-many agents

Grid operation



Grid operation – New grid tariffs



- Redesigning cost allocation with grid operation
  - **Socialized fee (uniform)**

$$\gamma_{nm} = \frac{u^{fixed}}{2}$$

  - **Zonal fee**

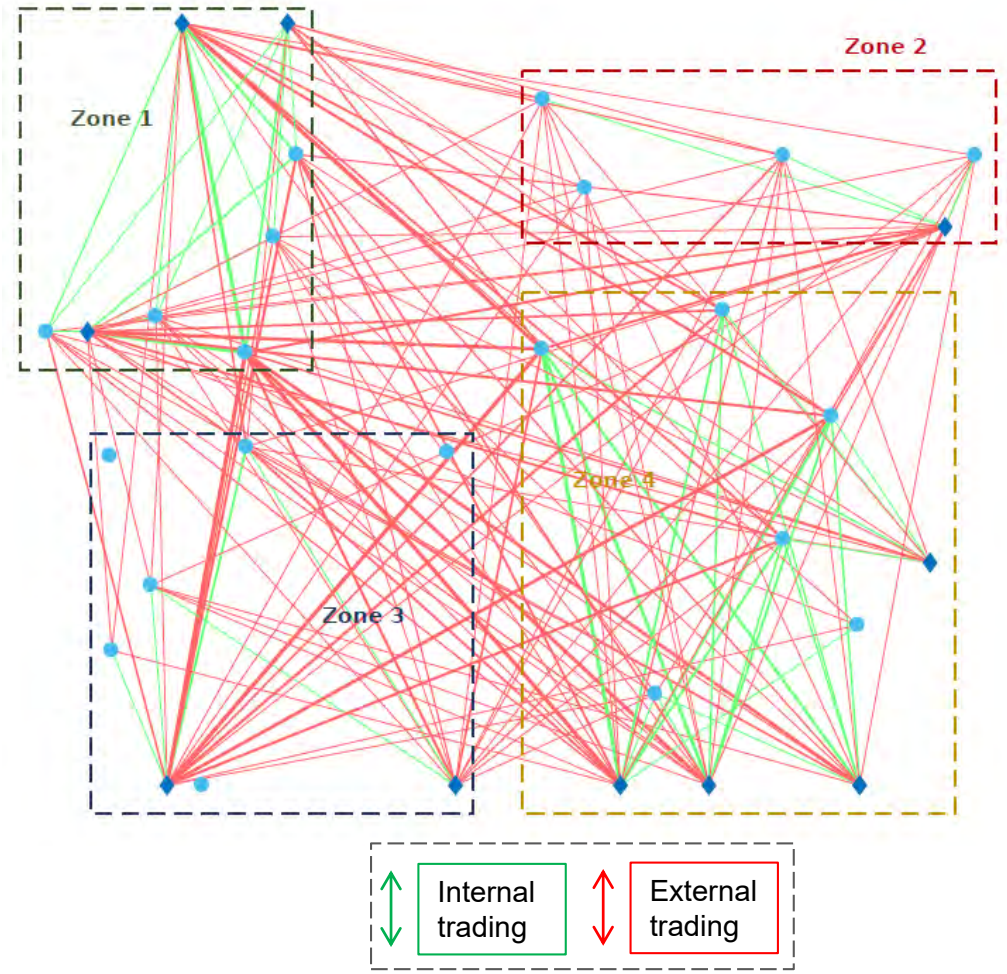
$$\gamma_{nm} = \frac{u^{Zonal} N_{nm}}{2}$$

where, N_{nm} is minimum **number** of **zones** to cross

  - **Electrical distance fee**

$$\gamma_{nm} = \frac{u^{dist} d_{nm}}{2}$$

where, d_{nm} is **Thevenin PTDF** electric distance



Reference:
T. Baroche, P. Pinson, *et al.* (2019), Exogenous approach to grid cost allocation in peer-to-peer electricity markets, *IEEE Transactions on Power Systems*.

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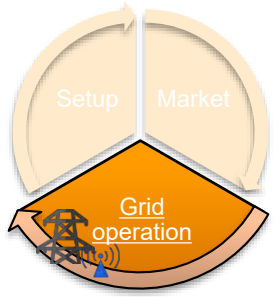

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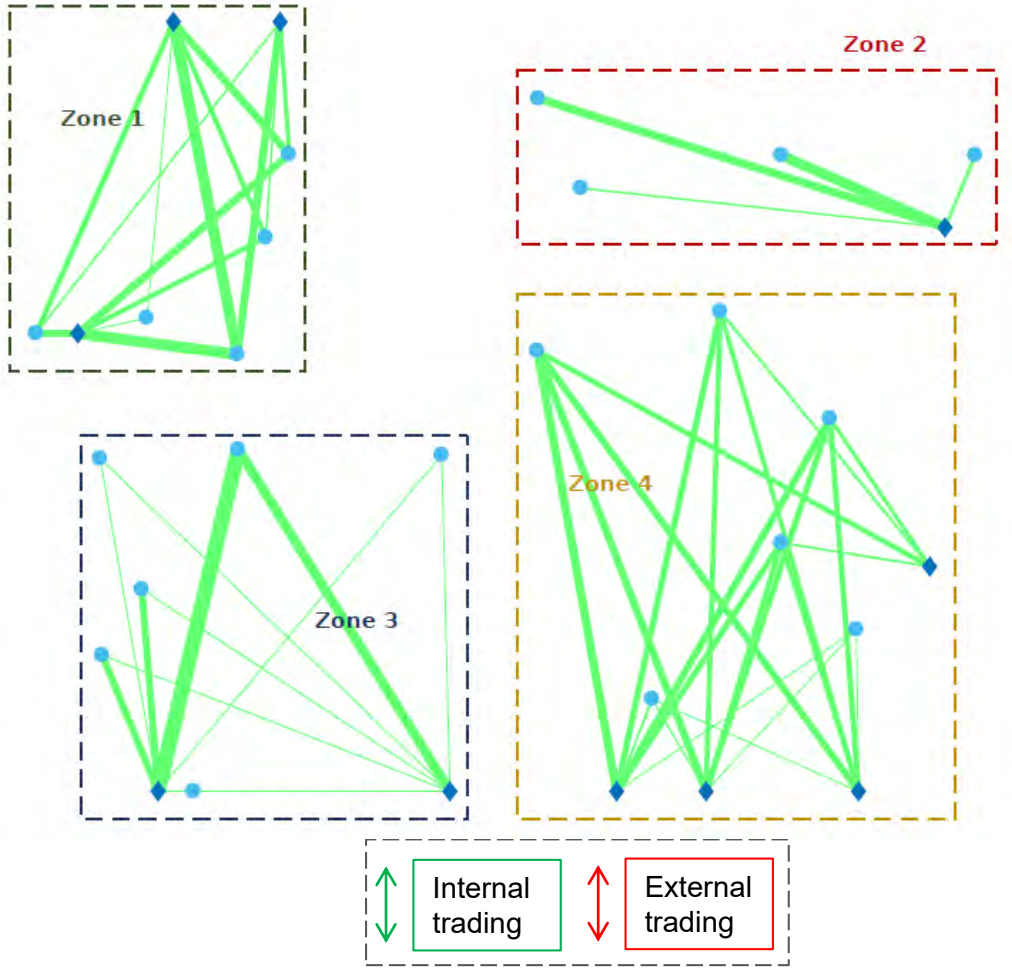

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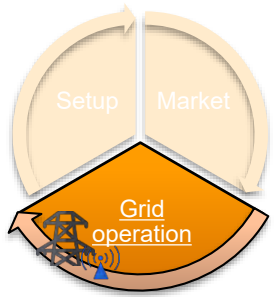

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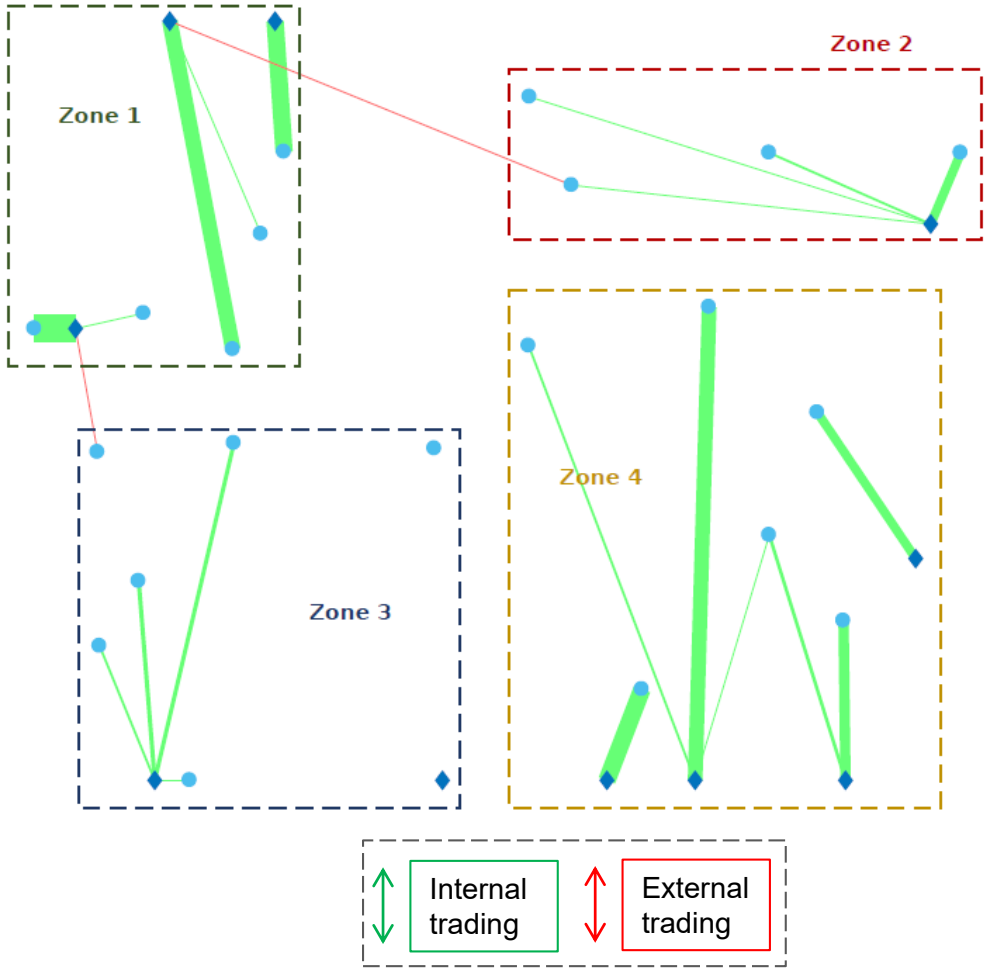

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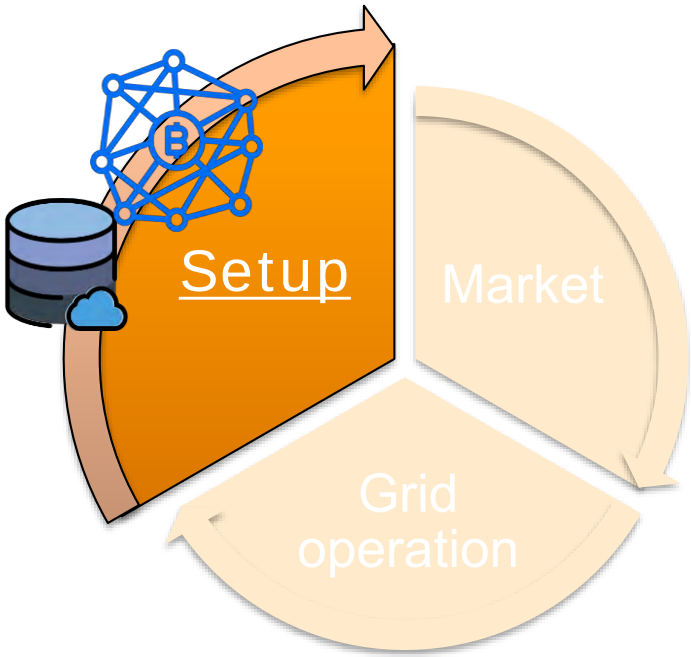
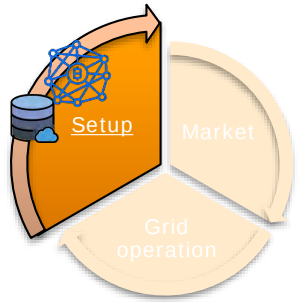
T. Baroche, P. Pinson, *et al.* (2019), Exogenous approach to grid cost allocation in peer-to-peer electricity markets, *IEEE Transactions on Power Systems*.

Setup used in the Energy Collective project



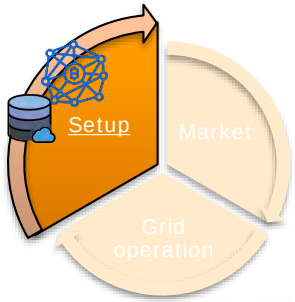
Setup – Infrastructure in Svalin



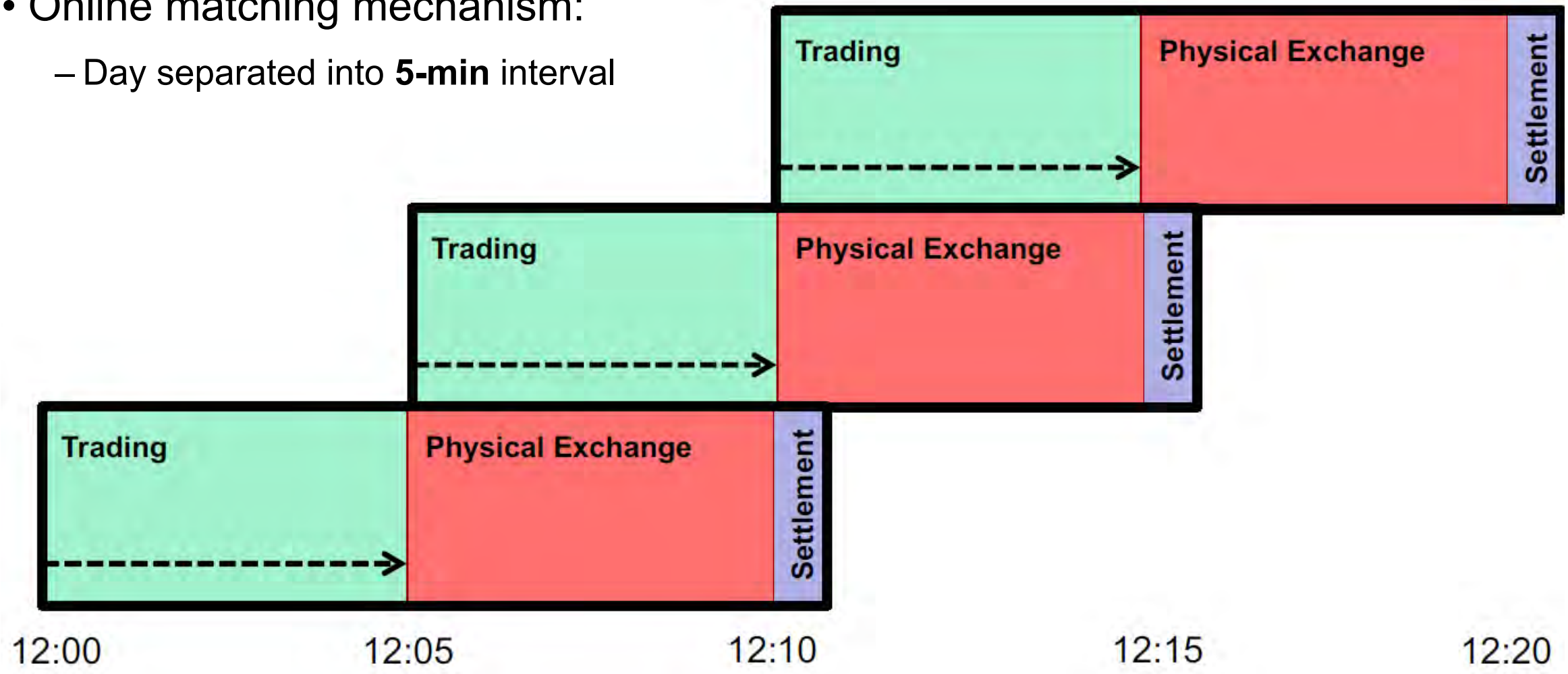
- Smart meters with ***smart-me*** interface:

- Data stored in ***smart-me cloud*** and we have local access through NAS device (API request)

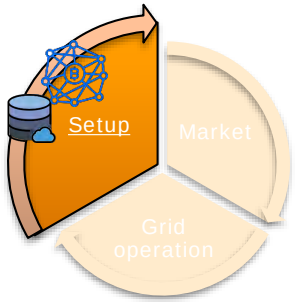
Setup – Market mechanism



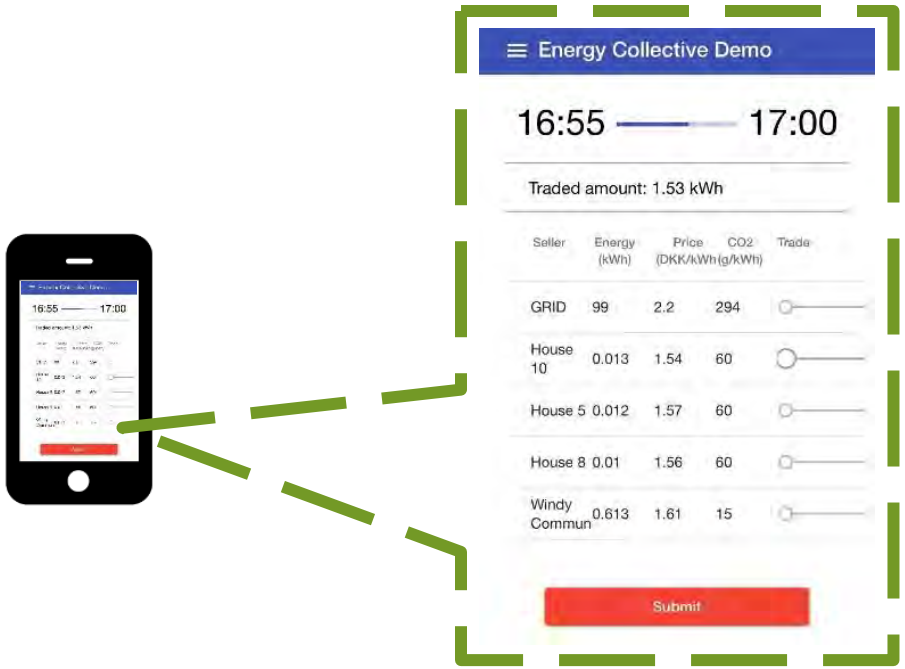
- Online matching mechanism:
  - Day separated into **5-min** interval



Setup – Live demo

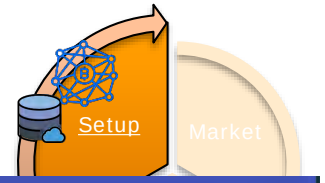


- Interface to **select** trading **partners**:



- Trading for **every 5-min** interval

Setup – Live demo



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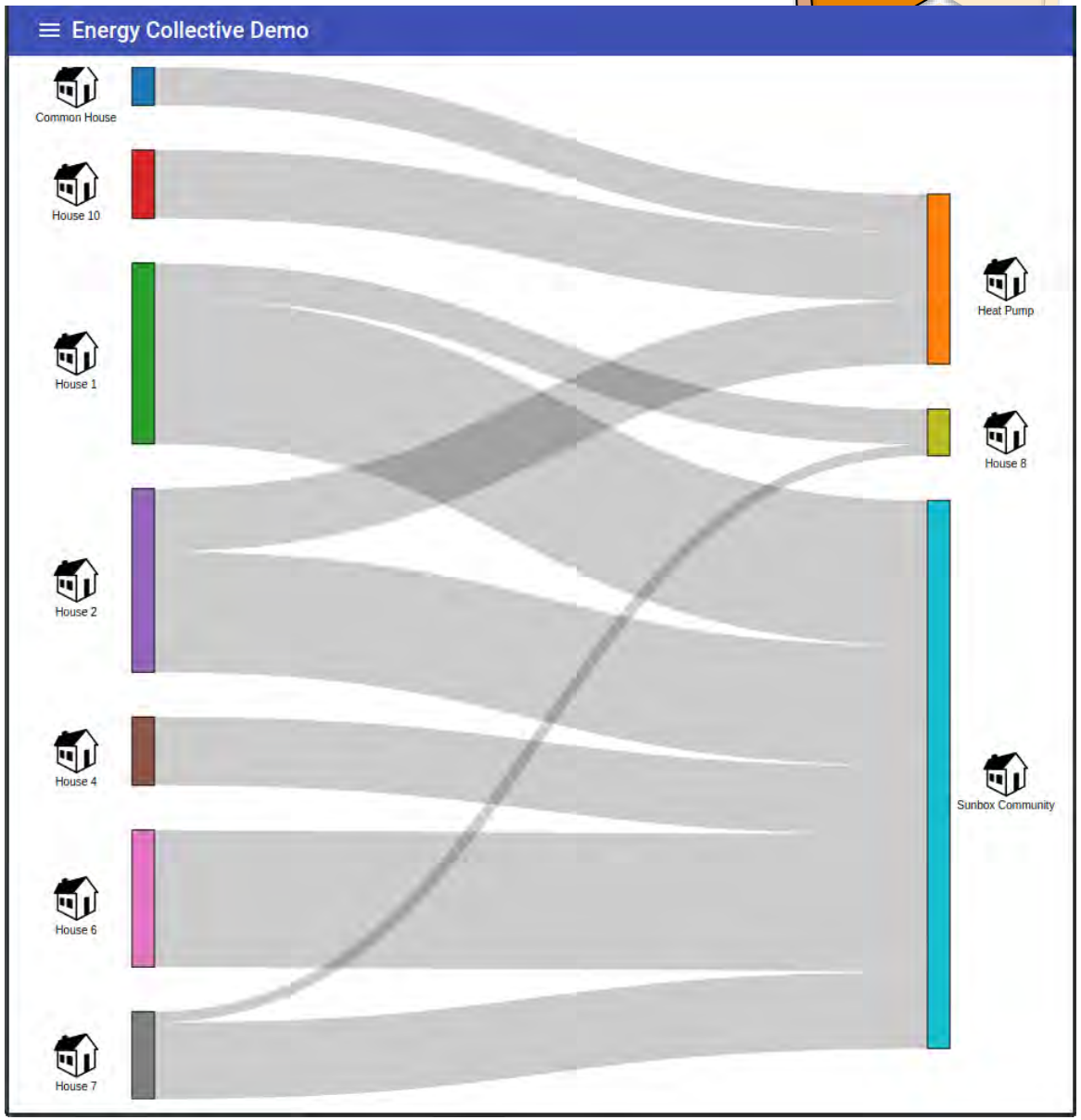
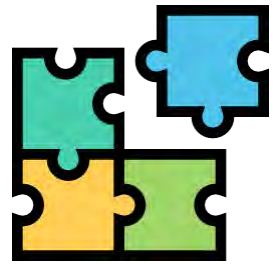


- Trading for **every 5-min** interval

Outlook

- Existing drivers offer the opportunity for a consumer-centric market
  - New paradigm allowing for social construction towards sharing energy
  - Increased awareness and commitment of residential customers

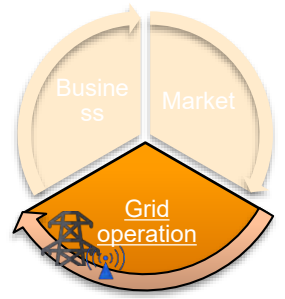
- P2P designs give new taste to electricity markets
  - **Boost retailer** market since lacks competition
  - Internalize externalities ← electricity as **heterogeneous commodity**



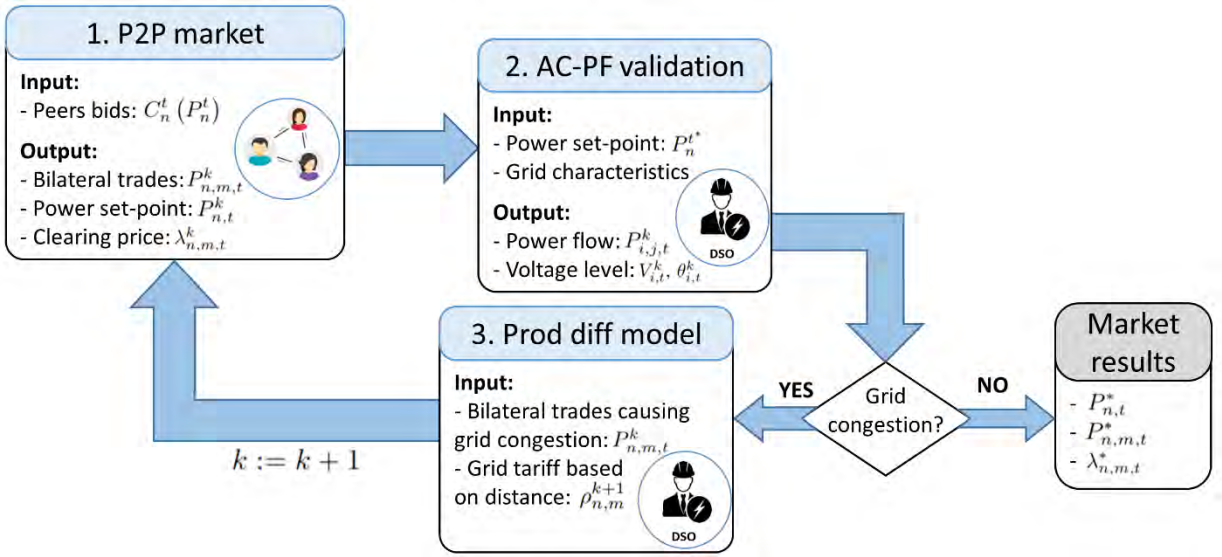
Thanks for your attention!

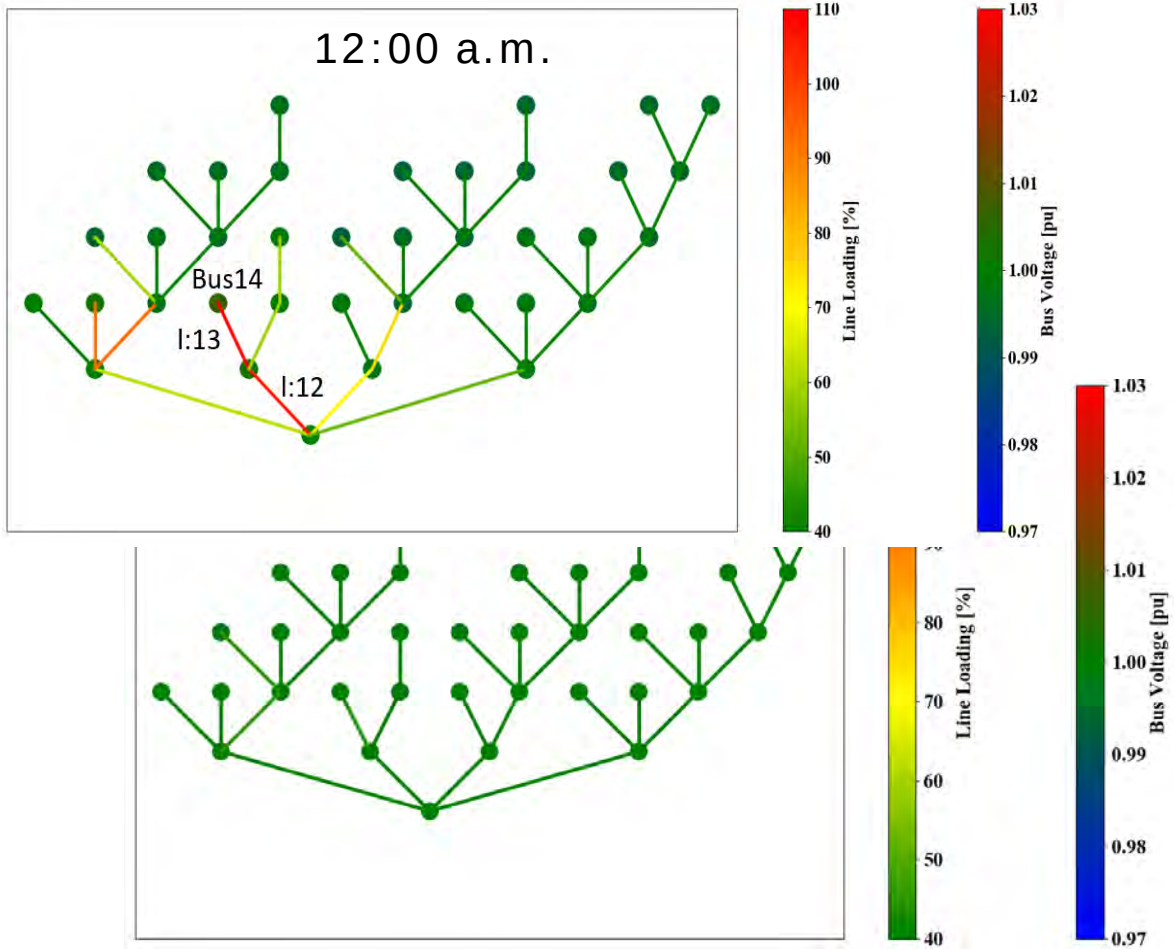
[Credits for the icons used in this presentation to Freepik, taken from https://www.flaticon.com/]

Grid operation – Mutual coordination



- **Coordination** between prosumers and system operator (iterative process)
  1. P2P market – agents negotiation
  2. System operator validation
  3. Extra fee penalizing trades causing problems (Prod diff model)

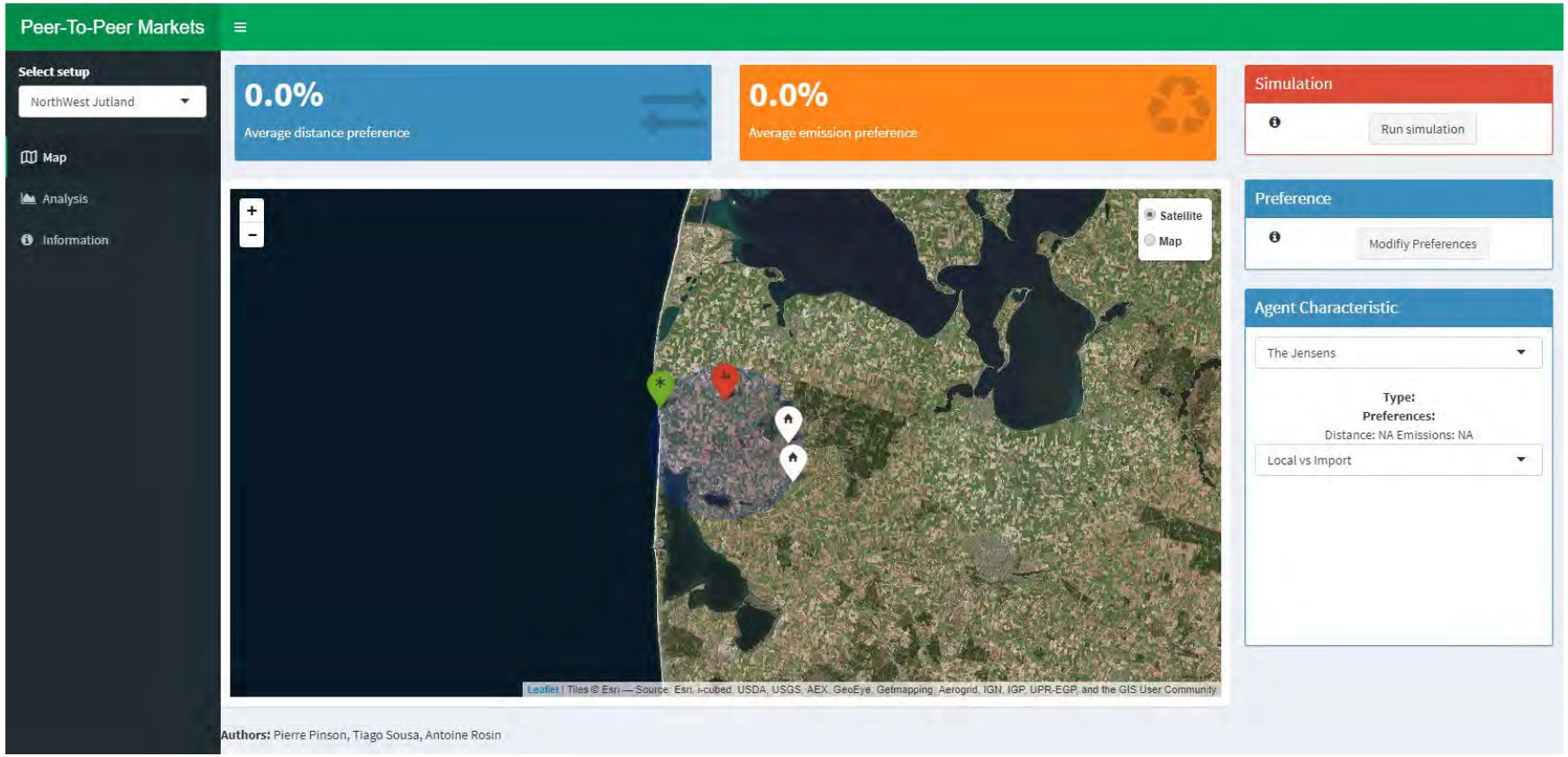




Reference:
T. Orlandini, *et al.* (2019), Coordinating consumer-centric market and grid operation on distribution grid, *EEM conference*, Ljubljana, Slovenia.

P2P app to visualize

- where our **experiments** and **real cases** are online!



Play yourself in our P2P app at https://p2psystems.shinyapps.io/ShinyApp_Project/.

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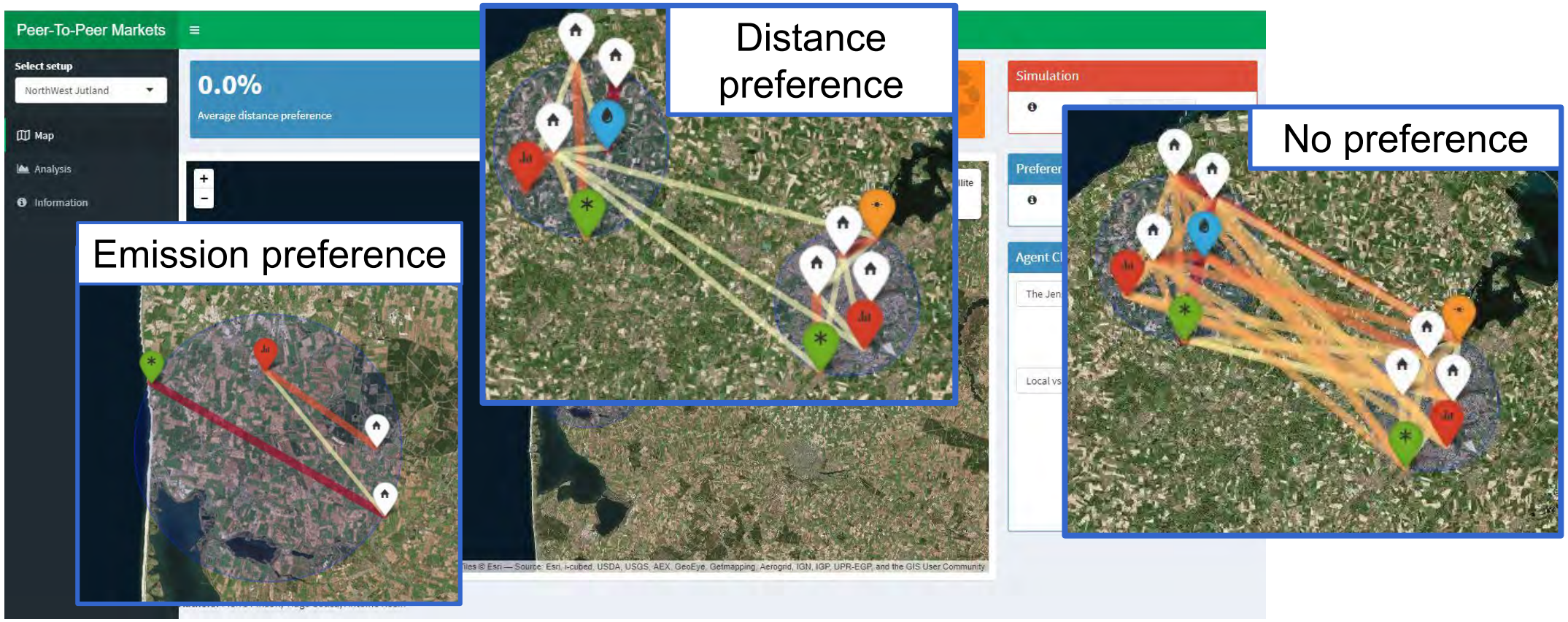

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