Local Energy Markets as a Solution for Increased Energy Efficiency and Flexibility

Iliana Ilieva & Bernt Bremdal, Smart Innovation Norway
Agustin A.S. la Nieta Lopez & Jose Luis Crespo, Utrecht University
Stig H. Simonsen, Skagerak Energi

ERA-NET SMART GRIDS PLUS | FROM LOCAL TRIALS TOWARDS A EUROPEAN KNOWLEDGE COMMUNITY

This project has received funding in the framework of the joint programming initiative ERA-Net Smart Grids Plus, with support from the European Union's Horizon 2020 research and innovation programme.

What are local markets?

Local markets can be considered markets that facilitate trade within a smaller town or a neighborhood

Typically established within an **energy community**

This project has received funding in the framework of the joint programming initiative ERA-Net Smart Grids Plus, with support from the European Union's Horizon 2020 research and innovation programme.

Smart Grids Plus ERA-Net

Why local markets?

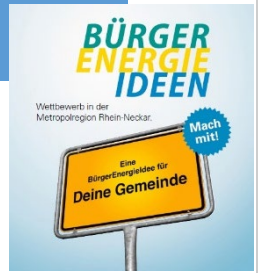
- Need to increase self-consumption of renewables
- Need to solve load management and congestion issues
- Local “self-balancing” makes sense
- Trade does not necessarily resolve local balancing problems directly, but creates price incentives that lead to this
- Flexibility or priority trade can be made part of market activity, can resolve capacity problems
- New technologies and new policies see peer-to-peer trade as an essential part of energy communities

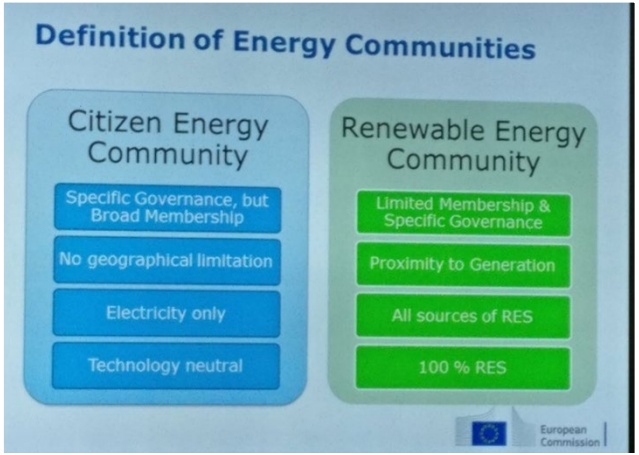
Local Energy Community

- an association, a cooperative, a partnership, a non-profit organisation or other legal entity
- effectively controlled by local shareholders or members
- generally value rather than profit-driven
- involved in distributed generation and in performing activities of a distribution system operator, supplier or aggregator at local level, including across borders
- Renewable Energy Community
- Citizen Energy Community

EU: Local Energy Communities

- ***Member States must assess potential, and existing barriers***
- ***Member States must develop enabling framework to 'ensure', inter alia:***
  - Reduction of unjustified regulatory and administrative barriers
  - Non-discriminatory treatment
  - Fair, proportionate, an transparent licensing and registration procedures & charges
  - Access to finance and information

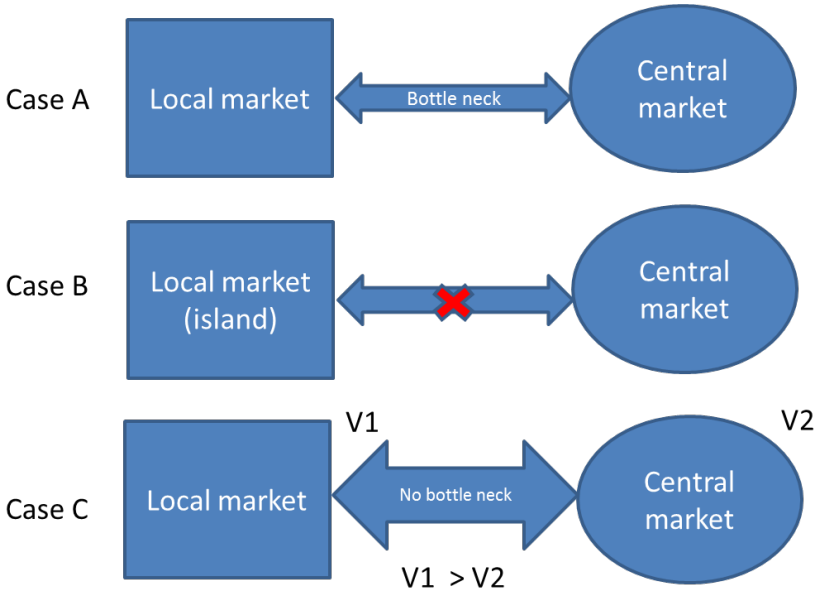




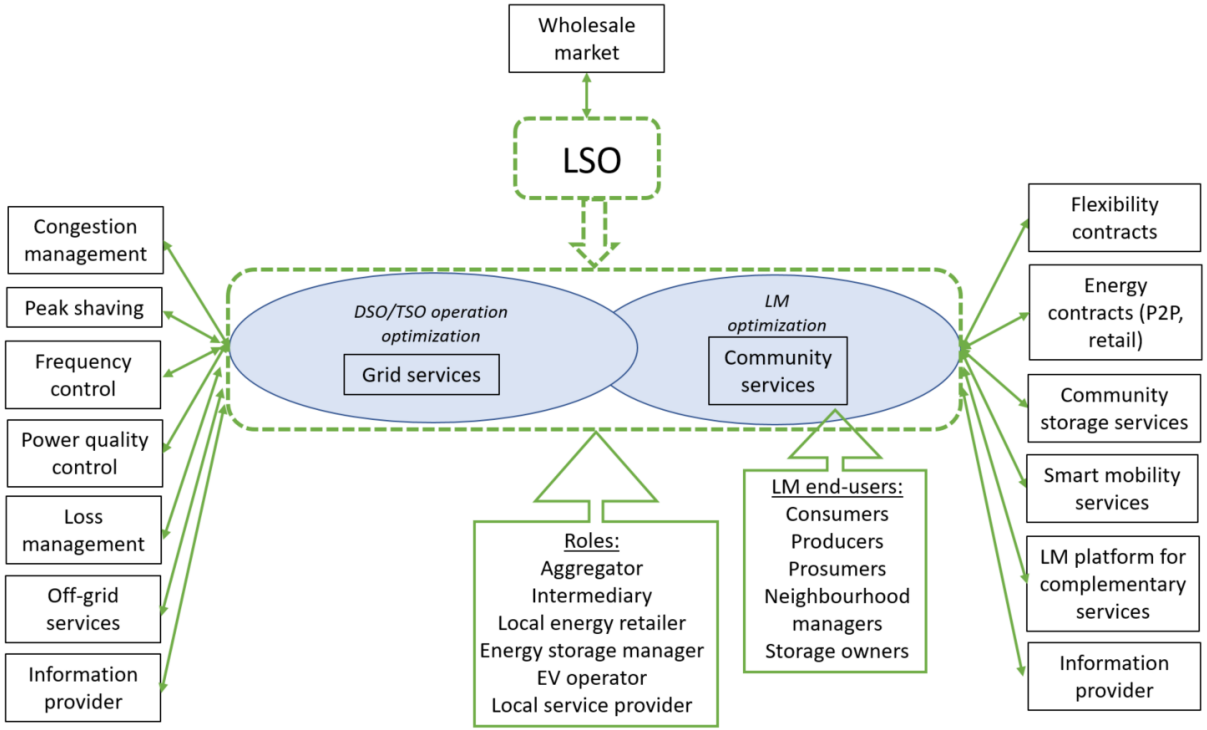
Article 2(16) Renewables Directive – 'Renewable Energy Community'	Article 2(11) Electricity Directive – 'Citizen Energy Community'
A legal entity: (a) which, in accordance with the applicable national law, is based on **open and voluntary participation**, is **autonomous**, and is **effectively controlled by shareholders or members that are located in the proximity** of the renewable energy projects that are owned and developed by that legal entity; (b) the shareholders or members of which are **natural persons, SMEs or local authorities**, including municipalities; (c) the **primary purpose** of which **is to provide environmental, economic or social community benefits** for its shareholders or members or for the local areas where it operates, **rather than financial profits**.	A legal entity that: (a) is based on **voluntary and open participation** and is **effectively controlled by** members or shareholders that are **natural persons, local authorities, including municipalities, or small enterprises**; (b) has for its **primary purpose to provide environmental, economic or social community benefits** to its members or shareholders or to the local areas where it operates **rather than to generate financial profits**; and (c) **may engage in** generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders;
*While not part of the definition, RECS are entitled to **produce, consume, store and sell** renewable energy, including through renewables power purchase agreements, to share renewable energy within the community, and to access all suitable markets*	

Why local markets? (2)

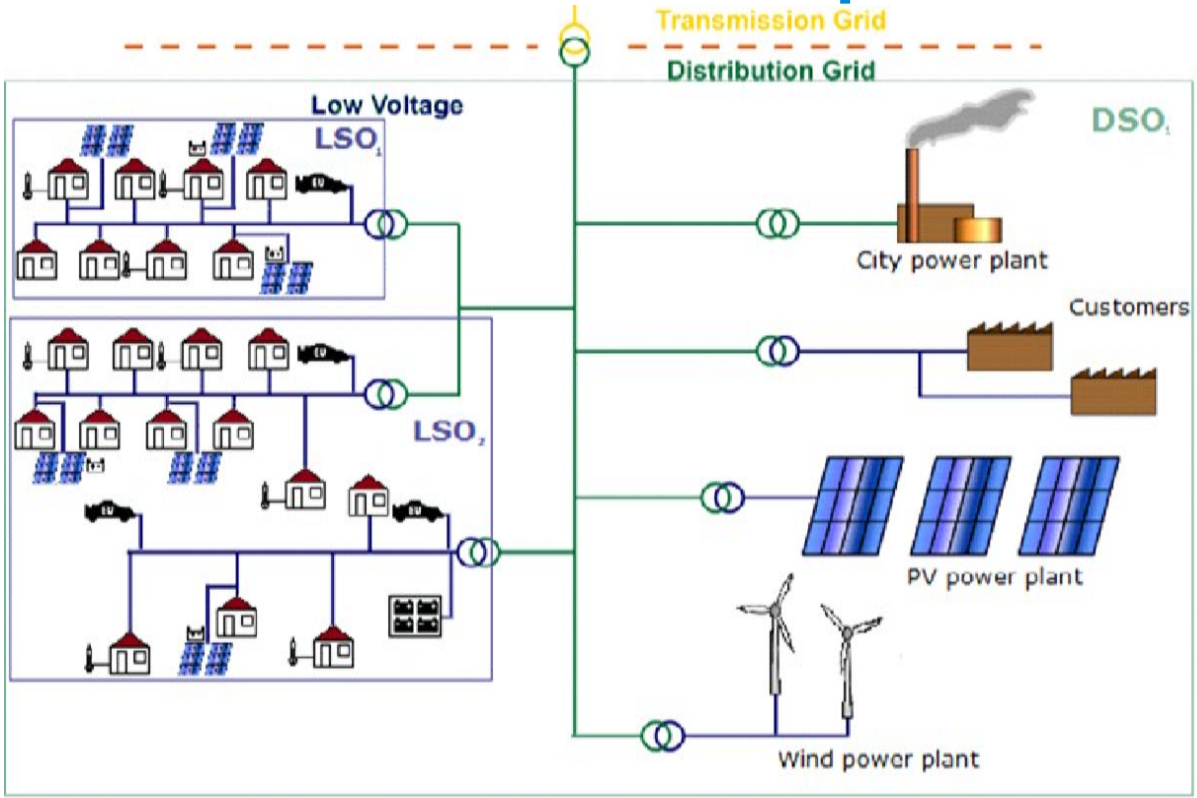
- Microgrids in permanent or temporary island mode
- To manage capacity constraints
  - Management of excess energy surplus locally
  - Management of serious energy deficits locally
- To create a local arena that delivers more value (economic, environmental, social, emotional) to each participant



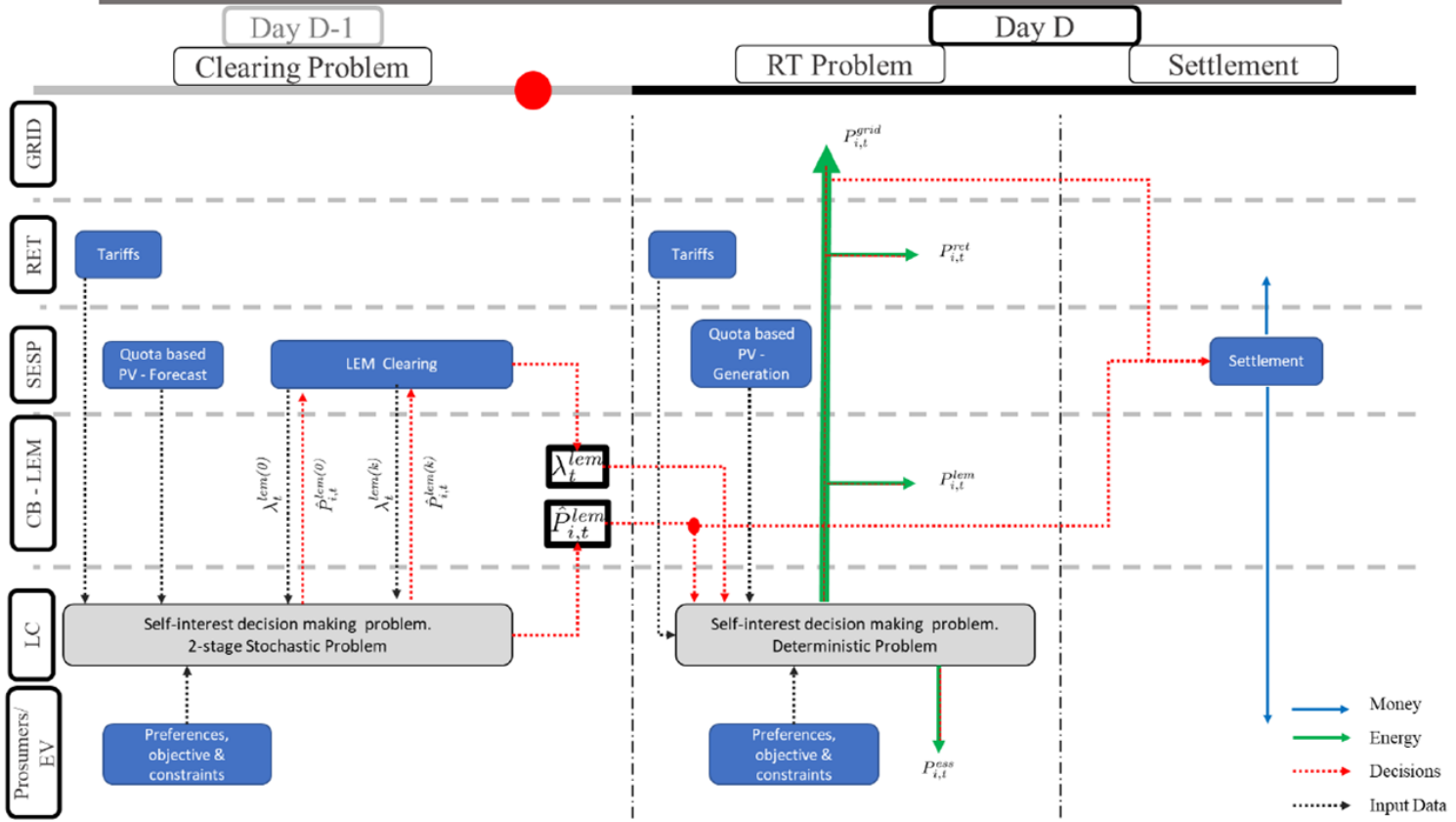
Market design overview



Local E-Regio electricity market concept



Community Based Local Energy Market



Centralized Problem

$$\text{minimize} \quad \sum_{s\in\mathcal{S}} \rho_s \sum_{i\in\mathcal{N}} \sum_{t\in\mathcal{T}} \left(\lambda_{i,t}^{ret,buy} \cdot [\hat{P}_{i,t,s}^{ret}]^- - \lambda_{i,t}^{ret,sell} \cdot [\hat{P}_{i,t,s}^{ret}]^+\right)$$

subject to

$$pv_{i,t,s} \le pv_{i,t,s}^{forec} \qquad |\hat{P}_{i,t}^{lem} + \hat{P}_{i,t,s}^{ret}| \le \overline{P}_i^{grid}$$

$$pv_{i,t,s} + E_{i,t,s}^{ess,out} - E_{i,t,s}^{ess,in} - d_{i,t} = \hat{P}_{i,t}^{lem} + \hat{P}_{i,t,s}^{ret}$$

$$\overline{SOC}_i \le SOC_{i,t,s} \qquad SOC_{i,t,s} = E_{i,t,s}^{ess}/\overline{E}_i^{ess}$$

$$E_{i,t,s}^{ess} \le \overline{E}_i^{ess} \qquad P_{i,t,s}^{ess,in} \le \overline{P}_i^{ess}$$

$$P_{i,t,s}^{ess,out} \le \overline{P}_i^{ess} \qquad E_{i,T,s}^{ess} = E_{i,0,s}^{ess}$$

$$E_{i,t,s}^{ess,\ in} = P_{i,t,s}^{ess,in} \qquad E_{i,t,s}^{ess,\ out} = P_{i,t,s}^{ess,out}$$

$$E_{i,t,s}^{ess} = E_{i,0,s}^{ess} + \sum_{\tau=1}^{t} \eta_{in} \cdot P_{i,\tau,s}^{ess,in} - \sum_{\tau=1}^{t} \frac{1}{\eta_{out}} \cdot P_{i,\tau,s}^{ess,out}$$

$$\sum_{i\in\mathcal{N}} \hat{P}_{i,t}^{lem} = 0 \qquad : y$$

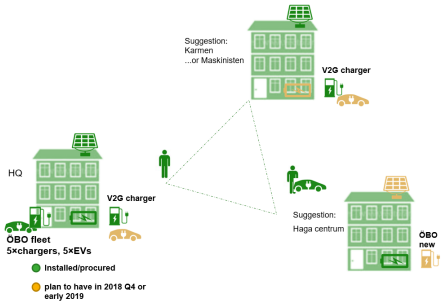
De-centralized Problem

$$X_i^{k+1}, Z_i^{k+1} :=$$

$$\text{argmin}_{X_i,Z_i} \quad f_i(X_i,Z_i) + y^{T(k)} Z_i + (\rho/2)\|Z_i - (Z_i^k - \overline{Z}^k)\|_2^2$$

$$\text{subject to} \quad X_i, Z_i \in \mathcal{S}_i$$

$$y^{k+1} := y^k + \rho \overline{Z}^{k+1}$$

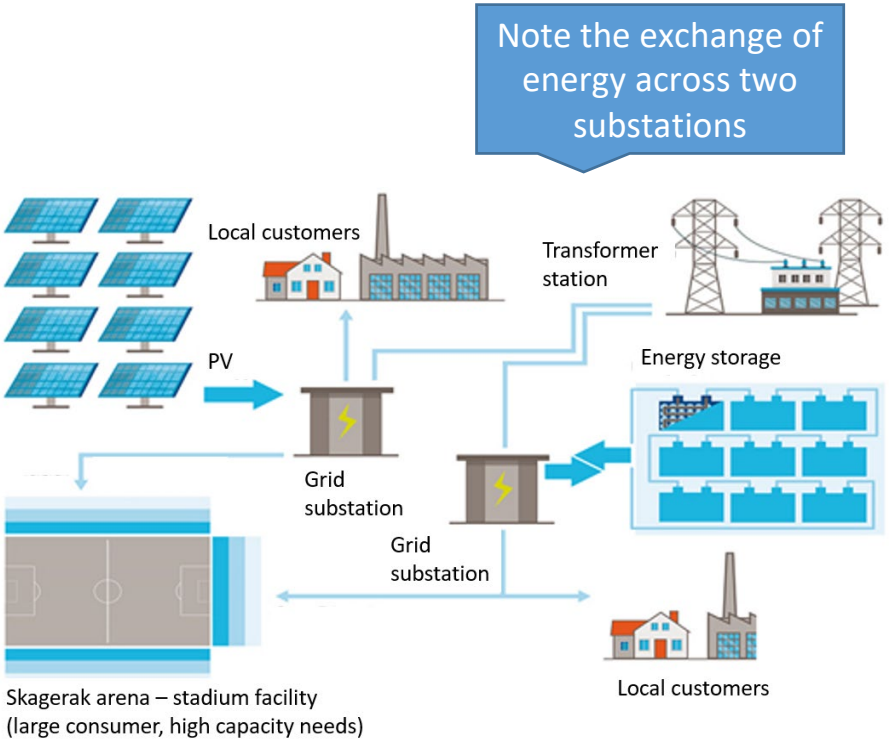


The Pilots

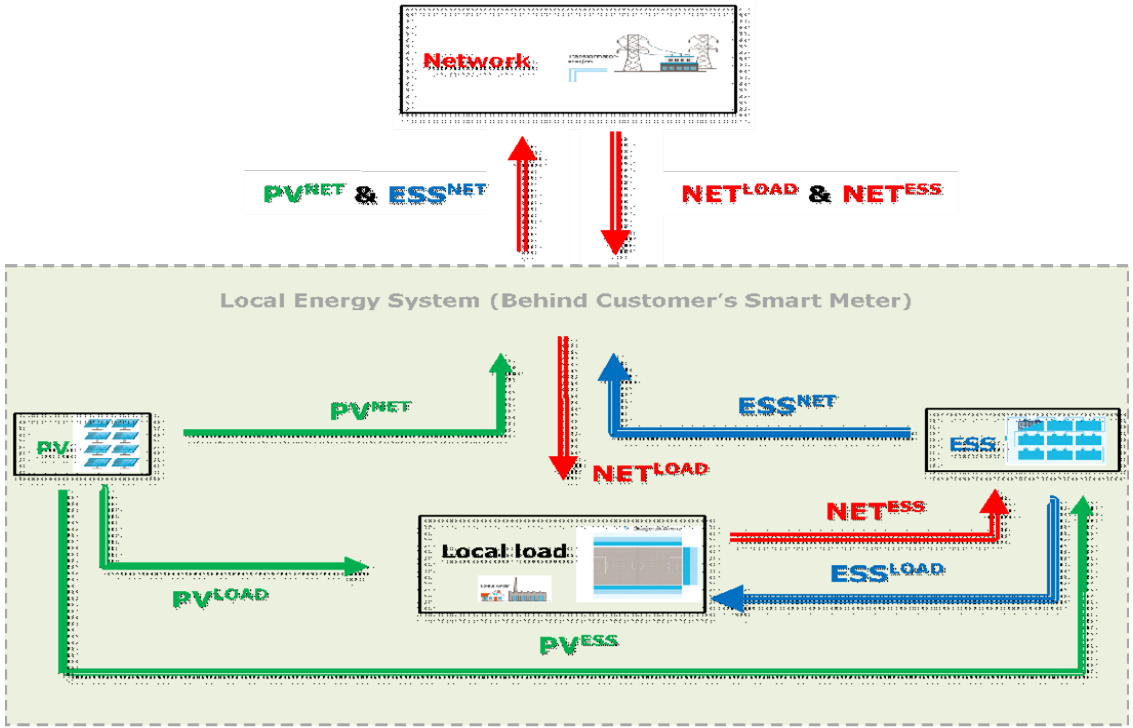
ÖBÖ, Sweden
Skagerak, Norway

The Skagerak pilot

- Skagerak EnergiLab
- Skagerak group includes:
  - Skagerak Nett (grid owner)
  - Skagerak Kraft (power generation)
  - Skagerak Varme (district heating)
  - Retailing
  - ----------
  - Odd Football club/Skagerak Arena
  - 3 x PV installations
    - 5000m2
    - 800 kWp
  - Battery capacity
    - 1000kWh
    - 800kW

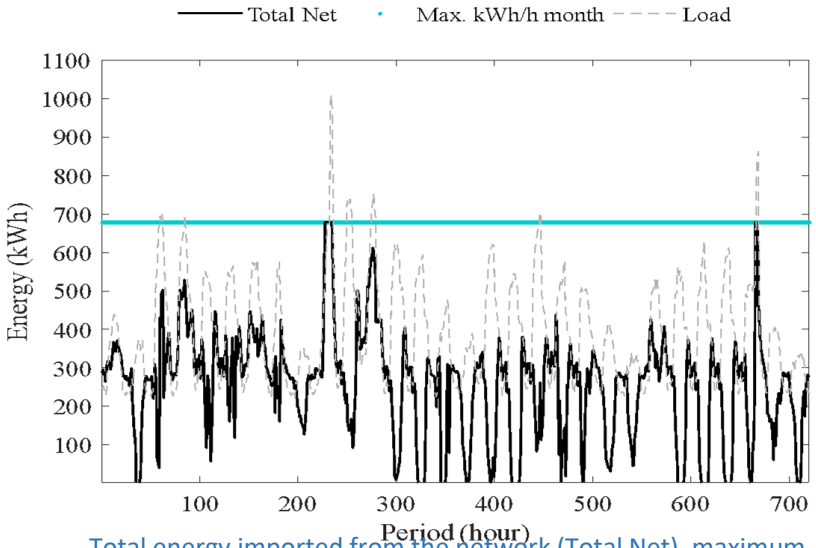


The Skagerak model



Smart Grids Plus
ERA-Net

Simulations:
Utilization of the local flexibility resources will have a positive effect on operations



Total energy imported from the network (Total Net), maximum kWh/h per month and the load.

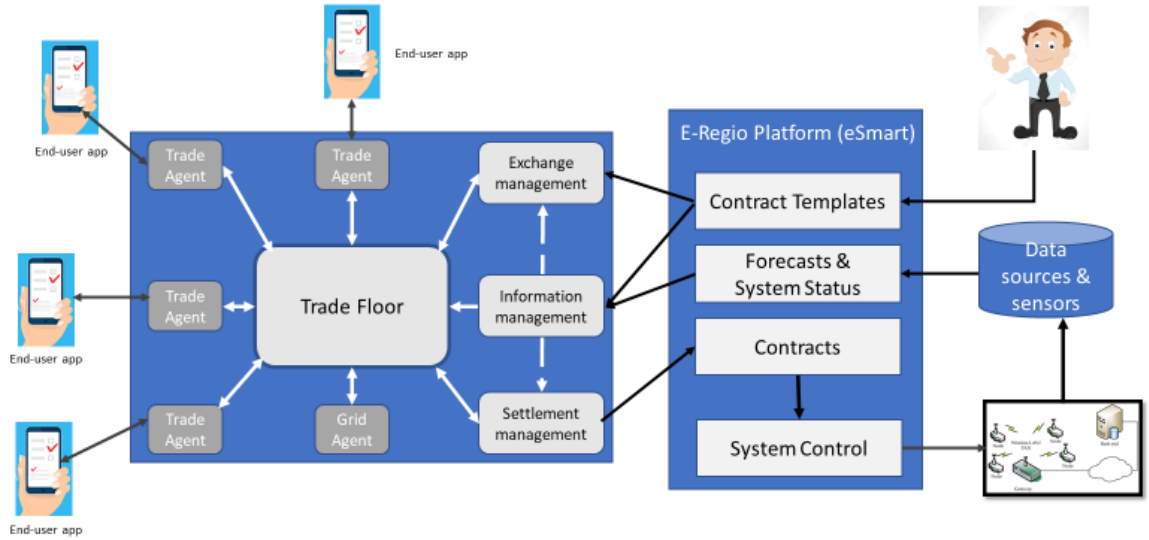
Local trade caters for:

- Reduced energy import
- Mitigation of local congestions
- Increased energy efficiency
- Decreased CO2 emissions

Case	Profits (€)	Maximum (kWh/h) per month from the network
1. Without PV and ESS (i)	-135.306,0	11.133,3
2. With PV and ESS with an RTE 80 % (ii)	-113.044,2	8.431,3
3. Δ (1. - 2.)	-22.261,8	2.702,0
4. Δ (1. - 2.) %	16,5	24,3

Annual profits, maximum kWh/h from the network and differences between cases

Implementing the distributed trade concept: A bazaar like market based on multi-agent P2P exchanges



Conclusions

- Simulations in E-Regio shows that business cases for “short travelled energy” exists
- Both energy trade and flexibility trade (and combos of these) are possible
  - P2P -> Skagerak
  - Pool based -> Öbo
- Price incentives through trade caters for economic optimization of operations within a lower and upper capacity limit of a local system i.e. physical or virtual microgrid (microgrid as a service).
- ESS emerges has a trade hub and ca serve multiple purposes
  - The more services that can be exchanged – the better the investment
- Bottom-up design caters for a distributed trade system
- Existing regulations ruin several business cases that ironically can support the grid owner and save the society money
- The recent “Clean Energy for All European Citizens” package suggests an imminent revision of national policies and regulations that will leverage the role of end-users and energy communities
- RECs and CECs will boost the practical impact of the R&D work in E-Regio and similar project

Disclaimer

The content and views expressed in this material are those of the authors and do not necessarily reflect the views or opinion of the ERA-Net SG+ initiative. Any reference given does not necessarily imply the endorsement by ERA-Net SG+.

About ERA-Net Smart Grids Plus | www.eranet-smartgridsplus.eu

ERA-Net Smart Grids Plus is an initiative of 21 European countries and regions. The vision for Smart Grids in Europe is to create an electric power system that integrates renewable energies and enables flexible consumer and production technologies. This can help to shape an electricity grid with a high security of supply, coupled with low greenhouse gas emissions, at an affordable price. Our aim is to support the development of the technologies, market designs and customer adoptions that are necessary to reach this goal. The initiative is providing a hub for the collaboration of European member-states. It supports the coordination of funding partners, enabling joint funding of RDD projects. Beyond that ERA-Net SG+ builds up a knowledge community, involving key demo projects and experts from all over Europe, to organise the learning between projects and programs from the local level up to the European level.

ERA-NET SMART GRIDS PLUS | FROM LOCAL TRIALS TOWARDS A EUROPEAN KNOWLEDGE COMMUNITY

This project has received funding in the framework of the joint programming initiative ERA-Net Smart Grids Plus, with support from the European Union's Horizon 2020 research and innovation programme.

Smart Grids Plus
ERA-Net