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
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.
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
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

Wholesale market

LSO

DSO/TSO operation optimization

Grid services

LM optimization

Community services

Roles:
- Aggregator
- Intermediary
- Local energy retailer
- Energy storage manager
- EV operator
- Local service provider

LM end-users:
- Consumers
- Producers
- Prosumers
- Neighbourhood managers
- Storage owners

Flexibility contracts

Energy contracts (P2P, retail)

Community storage services

Smart mobility services

LM platform for complementary services

Information provider

Congestion management

Peak shaving

Frequency control

Power quality control

Loss management

Off-grid services

Information provider
Local E-Regio electricity market concept
Case study
Community-based Local Energy Market

Centralized Problem

\[
\begin{align*}
\text{minimize} & \quad \sum_{s \in S} p_s \sum_{i \in N} \sum_{t \in T} \left( \chi_{i,t}^{\text{ret, buy}} \cdot [\tilde{P}_{i,t,s}^\text{ret}]^+ - \chi_{i,t}^{\text{ret, sell}} \cdot [\tilde{P}_{i,t,s}^\text{ret}]^- \right) \\
\text{subject to} & \\
\sum_{i \in N} \hat{P}_{i,t,s}^{\text{lem}} = 0 & : y \\
\end{align*}
\]

De-centralized Problem

\[
\begin{align*}
X_i^{k+1}, Z_i^{k+1} := \\
\text{argmin}_{X_i, Z_i} f_i(X_i, Z_i) + y^T(k) Z_i + (\rho/2) \| Z_i - (Z_i^k - Z_i^k) \|^2_2 \\
\text{subject to} & \\
X_i, Z_i & \in S_i \\
\sum_{i \in N} \hat{P}_{i,t,s}^{\text{lem}} = 0 & : y^{k+1} = y^k + \rho Z^{k+1} \\
\end{align*}
\]
The Pilots

ÖBÖ, 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
  - 800kWh

Note the exchange of energy across two substations
The Skagerak model
Simulations: Utilization of the local flexibility resources will have a positive effect on operations

Local trade caters for:
- Reduced energy import
- Mitigation of local congestions
- Increased energy efficiency
- Decreased CO2 emissions

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

<table>
<thead>
<tr>
<th>Case</th>
<th>Profits (£)</th>
<th>Maximum (kWh/h) per month from the network</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Without PV and ESS (i)</td>
<td>-135,306,0</td>
<td>11,133,3</td>
</tr>
<tr>
<td>2. With PV and ESS with an RTE 80 % (ii)</td>
<td>-113,044,2</td>
<td>8,431,3</td>
</tr>
<tr>
<td>3. Δ (L - 2)</td>
<td>-22,261,8</td>
<td>2,702,0</td>
</tr>
<tr>
<td>4. Δ (L - 2) %</td>
<td>16.5</td>
<td>24.3</td>
</tr>
</tbody>
</table>

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

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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.
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