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Peer-to-Peer Power Trading with Voltage and Congestion Management for Distribution Grids

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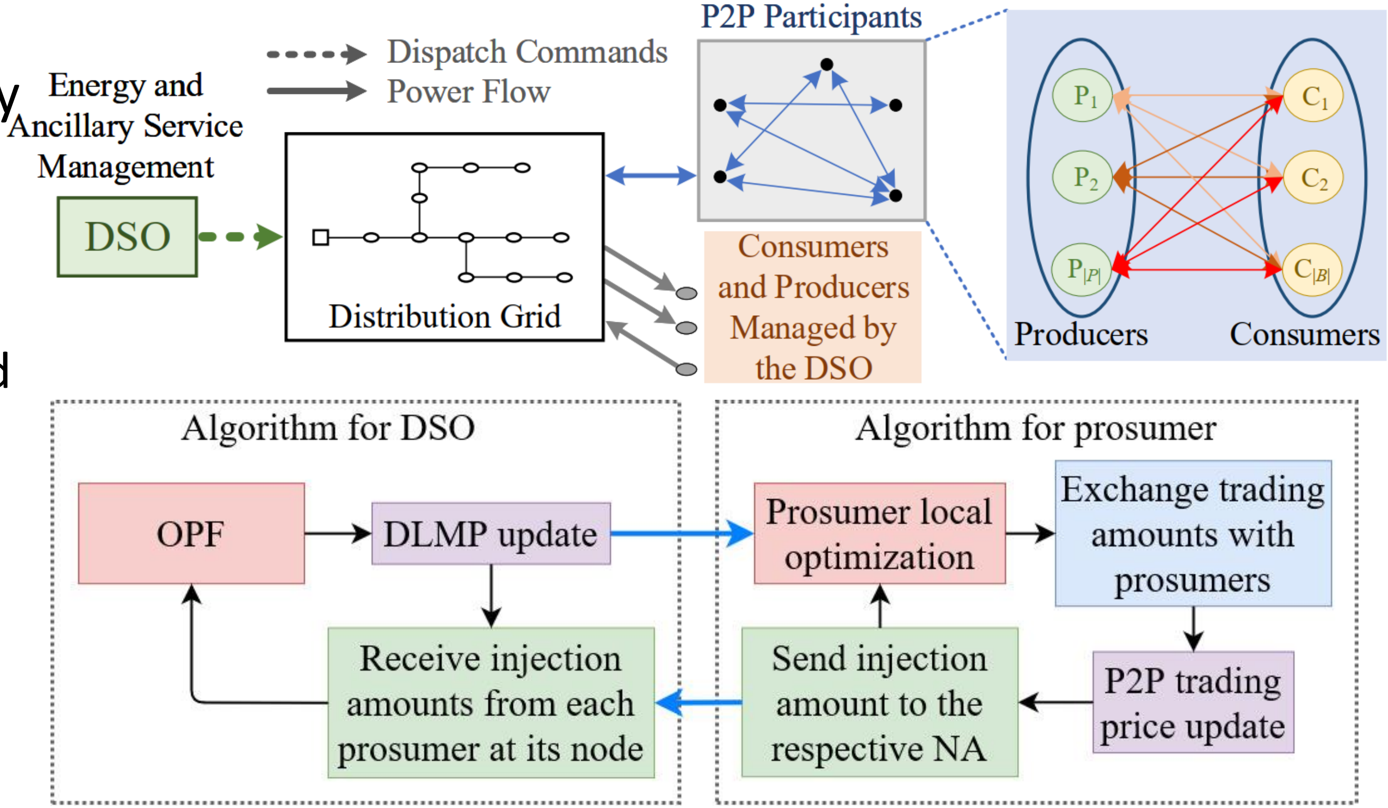
Peer-to-Peer (P2P) Energy Markets

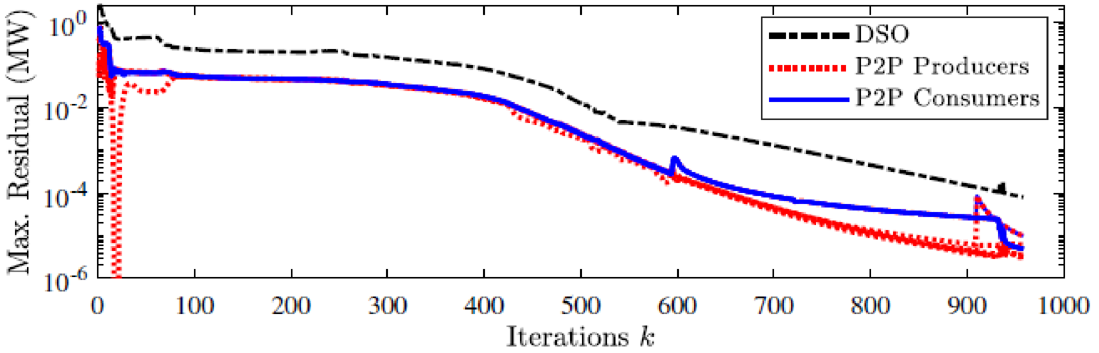
- Function alongside the existing retail energy market arrangements in a distribution grid.
- Allow prosumers to establish bilateral **energy trading contracts** between them.
  - include the **amount of power exchange** and the **price per unit of energy**.
- Power transactions between prosumers result in additional **ancillary service requirements**
  - Voltage and congestion management.
- Follow a **decentralized market mechanism** as prosumers are not willing to share their internal information.
  - A two-stage decentralized **P2P energy market framework**.



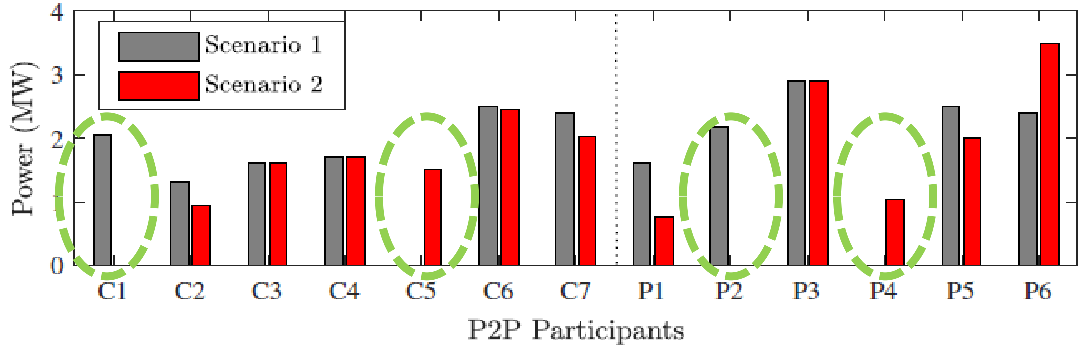
- **DSO-to-prosumer** and **prosumer-to-prosumer** coordination and optimization.
  - Alternating direction method of multipliers (ADMM)

Case Study and Results

- IEEE 33-bus system is used to illustrate the effectiveness of the proposed ADMM-based coordination-optimization algorithm for a single market interval.
  - Six producers and seven consumers.
  - Five additional sources of provisioning ancillary service are also considered in addition to the point-of-common-coupling.
- Figure (above) shows the **convergence trajectories** of the infinity norms of the residuals of each consumer, producer, and the DSO.



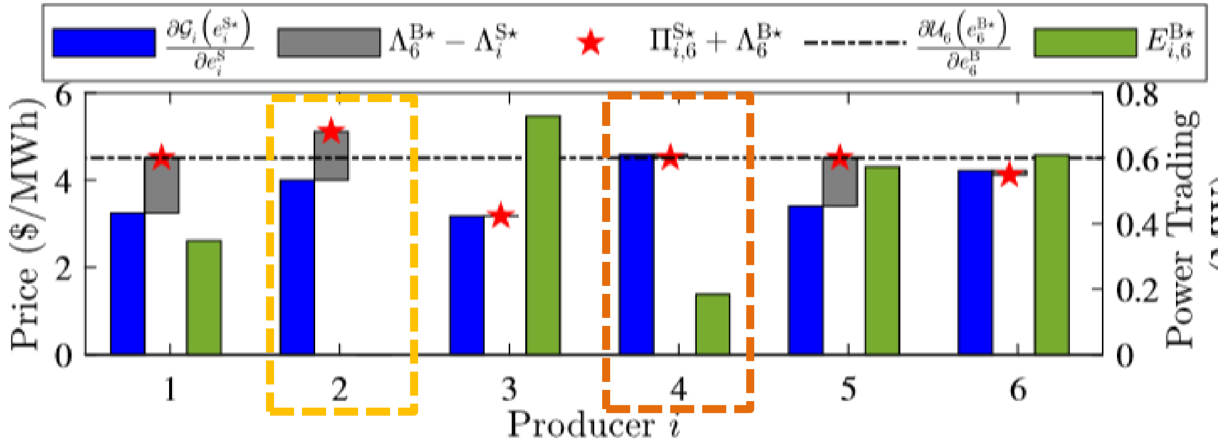
- Figure (below) shows that the **power consumption/production of the prosumers** are significantly different for
  - Scenario 1: without considering the grid constraints (and ancillary service costs), and
  - Scenario 2: considering ancillary service costs-**proposed approach**.



Case Study and Results

- **Ancillary services costs** associated with **producer-consumer pairs** are reported in Table.
  - difference between DLMPs of buyer buses and seller buses.
- Figure shows the **trading price decomposition** between **consumer 6** and the set of producers.
- Marginal generation cost of producer 2 is lower than that of producer 4.
- The **negative ancillary services costs** between consumer 6 and producer 4, enforces consumer 6 to purchase power from producer 4 and abandon producer 2.

($/h)	C1	C2	C3	C4	C5	C6	C7
P1	1.254	1.380	1.585	0.770	0.149	1.265	1.346
P2	1.101	1.227	1.432	0.617	−0.005	1.111	1.192
P3	−0.009	0.117	0.321	−0.493	−1.115	0.001	0.082
P4	−0.082	0.044	0.249	−0.566	−1.187	−0.071	0.010
P5	1.099	1.225	1.430	0.615	−0.006	1.109	1.191
P6	−0.112	0.013	0.218	−0.597	−1.218	−0.102	−0.021



- Consumers only prefer to trade when the **marginal aggregated costs** of the offers are less than their marginal welfare.

Conclusions/Recommendations

- Novel **ADMM-based coordinating algorithm** is proposed to enable distributed P2P energy trading in distribution grid level.
- Each prosumer in the P2P energy market and the DSO **solve** individual **optimization problems** while respecting the **privacy concerns** of each other.
- The case studies were conducted on the **IEEE 33-bus system**.
- The proposed market clearing algorithm **converges to the optimal solution** with **sufficient accuracy** in an **acceptable computation time**.
- P2P energy trading **without** considering the **grid constraints** resulted in **infeasible power transactions**.
- Prosumers evaluate the **cost of ancillary services** required to **facilitate each P2P power transaction** within the **distributed market mechanism,** which determines the **equilibrium**.