Demand Response for Multi-prosumer Microgrids in Energy and Ancillary Services Markets

Yan Yao[a,b], Nikos D. Hatziargyriou[a], Hongbin Wu[b]

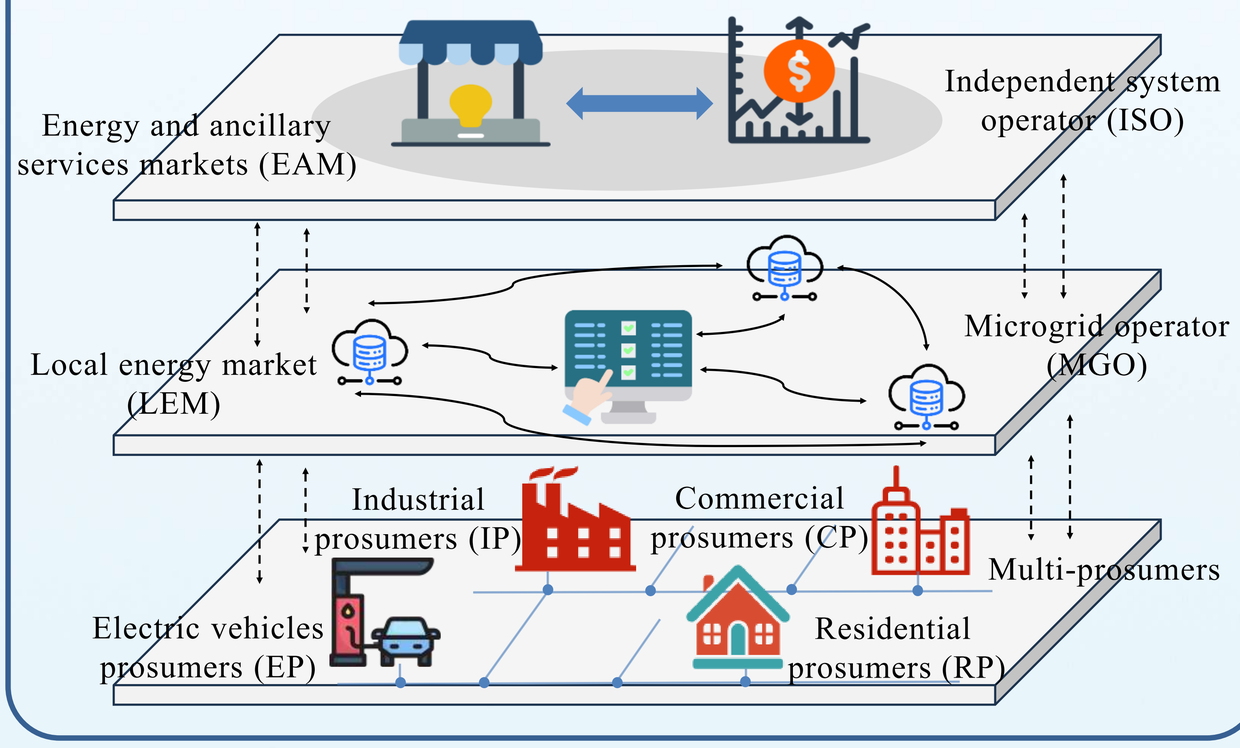
a. National Technical University of Athens, Athens, Greece

b. Hefei University of Technology, Hefei, China

yaoyanqqq@163.com

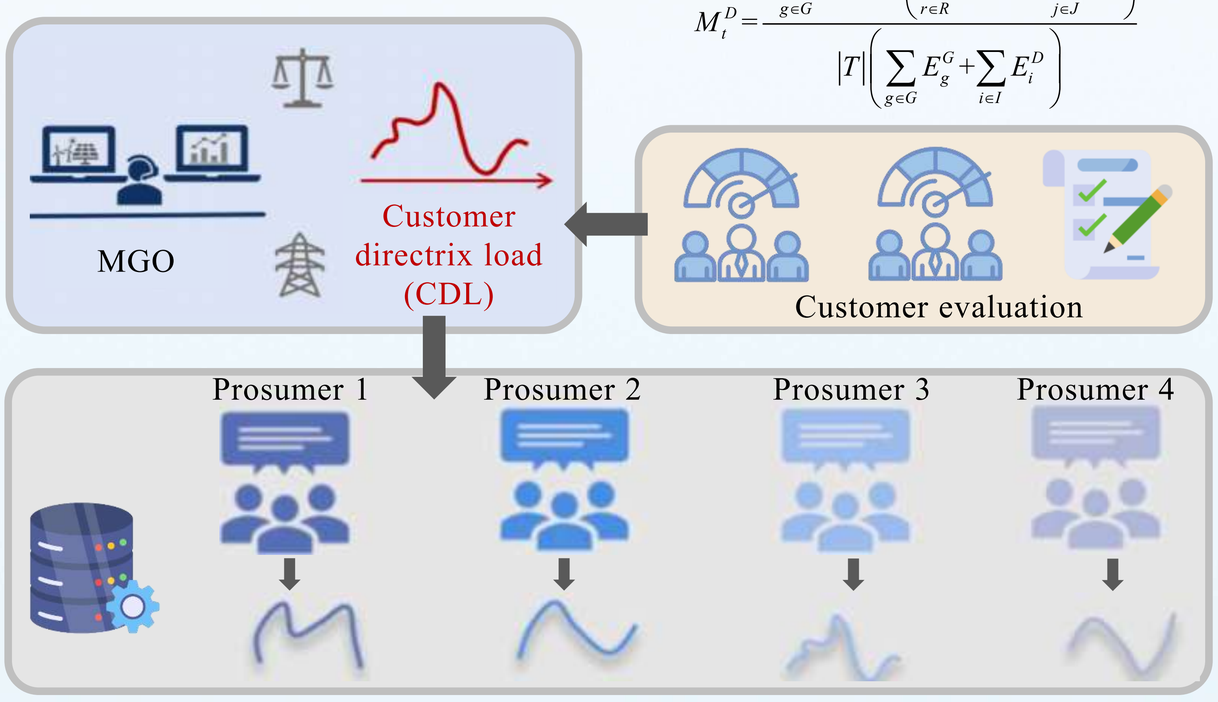
Introduction

Due to entry barriers in the external energy and ancillary services markets (EAM), prosumers that aggregate demand-side production and consumption resources are usually represented by a microgrid operator (MGO) to manage their energy demand and flexible regulation potential.



CDL-based Response

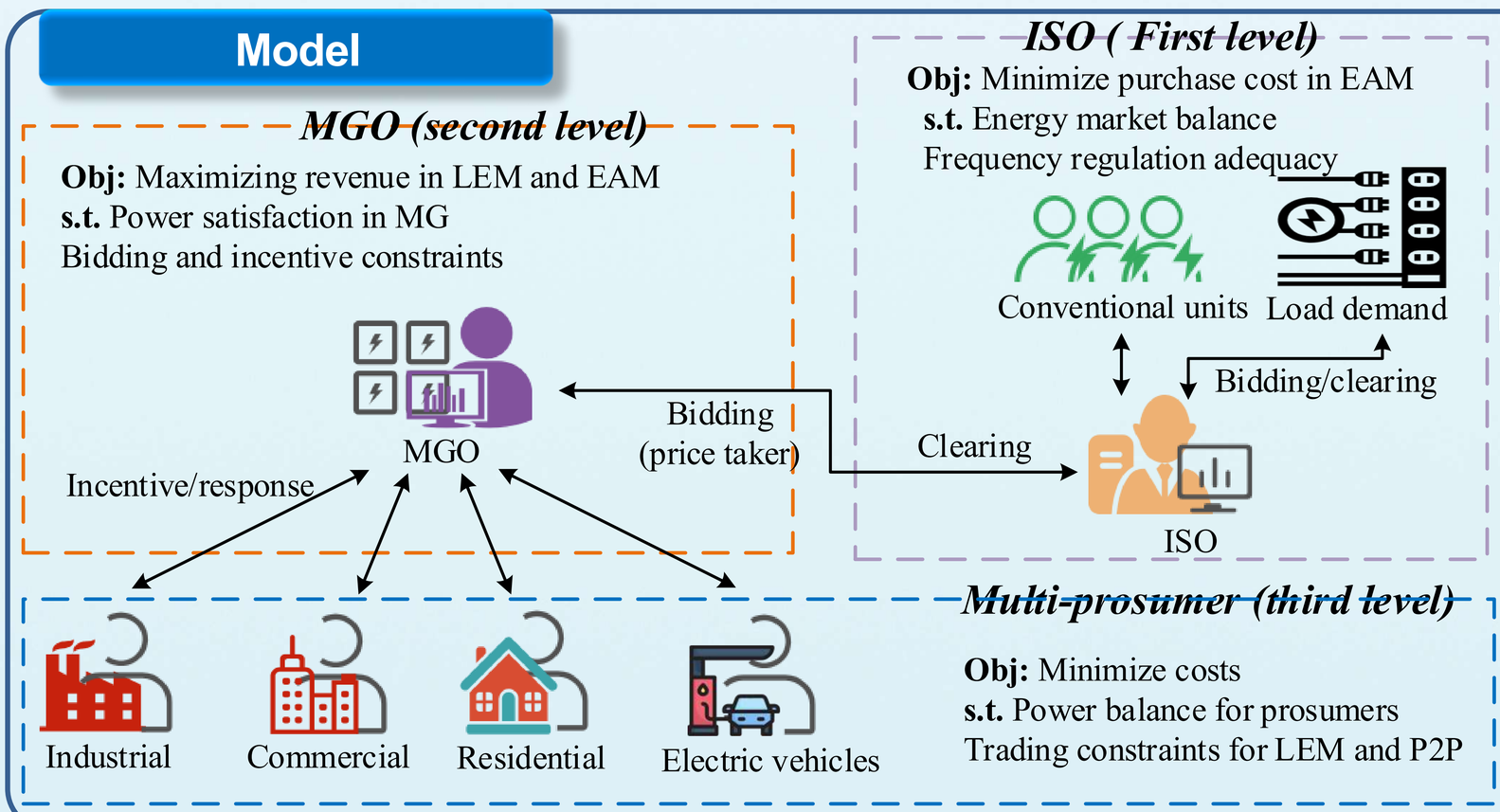
$$M_t^D = \frac{2\sum_{g\in G} E_g^G + |T|\left(\sum_{r\in R} E_{r,t}^{R,\max} - \sum_{j\in J} P_{j,t}^C\right)}{|T|\left(\sum_{g\in G} E_g^G + \sum_{i\in I} E_i^D\right)}$$

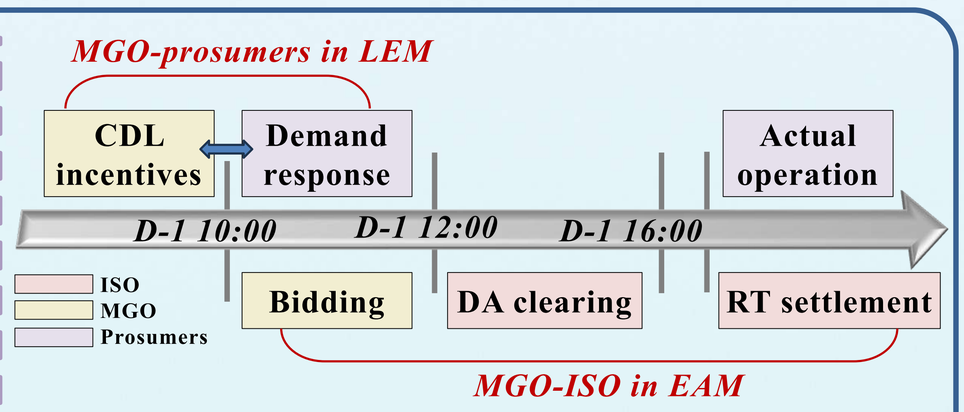


The CDL defines the guiding target for prosumers in the LEM:

- ✓ CDL-driven incentives for diverse prosumers (IP/CP/RP/EP)
- ✓ Central CDL incentives combined with P2P sharing in the LEM
- ✓ Market-based tool for further EAM bidding (Ancillary services)

Model

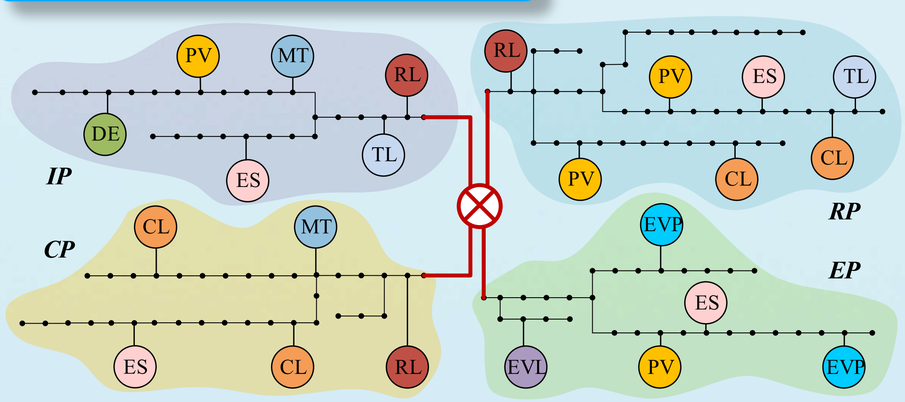




Model solution:

- ➢ ISO model embedded in MGO model via KKT
- ➢ MGO–prosumers: leader–multi-follower game
- ➢ Followers: joint utility maximization (product→ logarithmic → piecewise linearization)
- ➢ GA–LP hybrid algorithm for solving generalized Stackelberg–Nash equilibrium

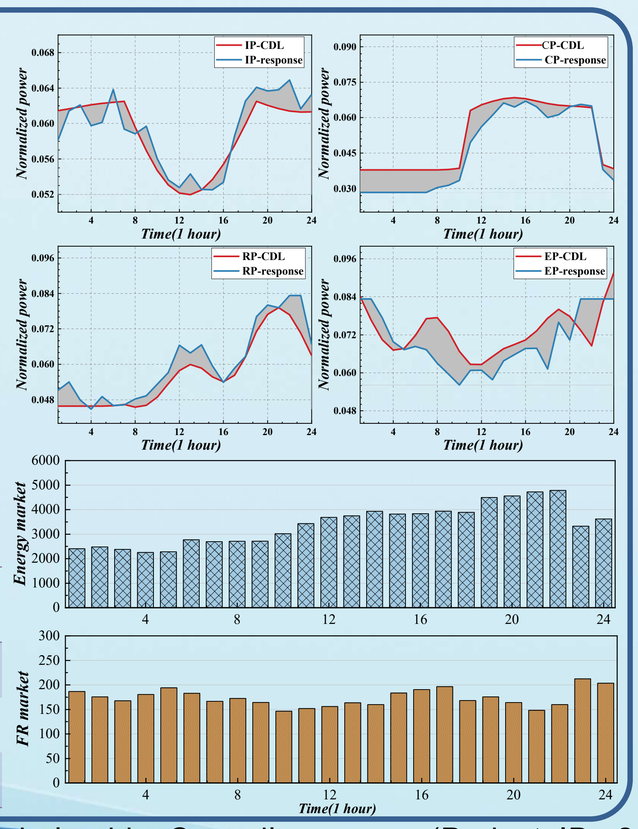
Verification



Prosumers in the case study

Comprehensive costs for prosumers (CNY)

Prosumers	Industrial	Commercial	Residential	Electric vehicles
LEM	16146.23	17182.76	13452.07	12095.06
Operation	1728.36	1059.01	429.27	683.04
P2P	-126.35	173.58	128.92	-176.15



Conclusion

A demand response and bidding strategy is proposed for multi-prosumer microgrids in the EAM. A microgrid with diverse prosumers (IP/CP/RP/EP) is modeled for verification. Results indicate that:

- ◆ CDL-based strategy improves prosumers' responsiveness and relieves trading pressure.
- ◆ MGO bridges LEM and EAM, enabling demand-side participation in external markets.
- ◆ ISO aggregates demand-side flexibility, reducing operation costs and enhancing scheduling efficiency.

Acknowledgments: This work was supported by the China Scholarship Council program (Project ID: 202406690007). Research was partially conducted at the EES Laboratory of the National Technical University of Athens.

References:

[1] L Li, et al. Energy management strategy for community prosumers aggregated VPP participation in the ancillary services market based on P2P trading.

[2] Y Zhang, et al. Multi-time scale customer directrix load-based demand response under renewable energy and customer uncertainties.

[3] D Wang, et al. Research on floating real-time pricing strategy for microgrid operator in local energy market considering shared energy storage leasing.