Politecnico di Torino
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PhD in Computer and Control Engineering
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Modelling, Simulation and Analysis of Residential Demand-Side Management Strategies

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1. Context

The traditional power system is evolving towards the so-called Smart Grid, an upgraded electricity network with a reorganised architecture and new actors. These participants include the consumer itself, whose role is turning from passive to active. Besides pilot projects, a complementary way to analyse the consequences of this shift is represented by simulation tools.

2. Goal

This thesis aims at developing a hierarchical and modular agent-oriented framework to support the energy transition. It should ease the test and the comparison of new residential strategies by adding models that tackle different aspects of the agent or changing simulators via a plug-and-play mode (Fig. 1A).

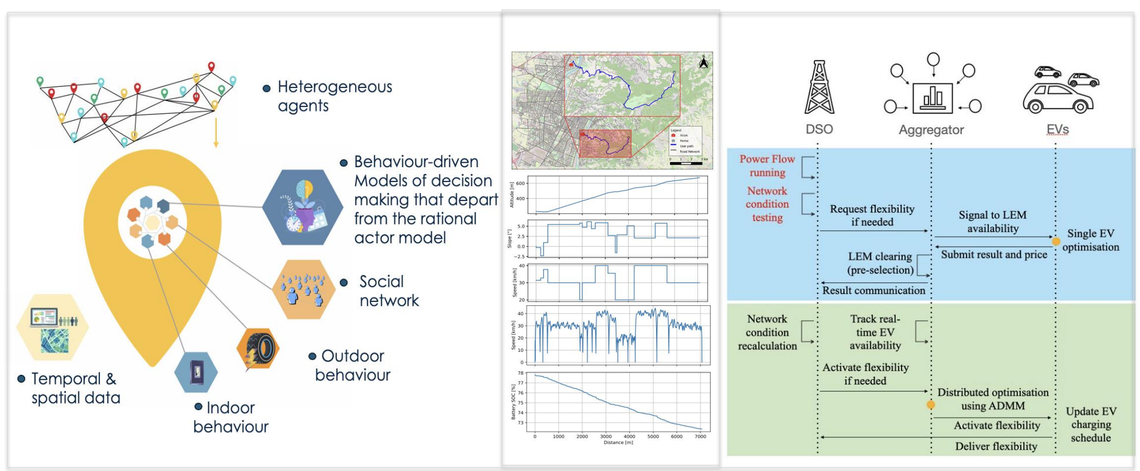

Fig. 1A – Framework overview

Fig. 1B – EV simulator

Fig. 1C – AS procurement using EV flexibility

3. Novel Contributions

The proposed models allow the study of:

Electric Vehicles (EV). A framework (Fig. 1B) capable of simulating i) user activities, ii) car trips, iii) the driving behaviour, iv) the motion of the EV and its discharge considering spatial data and v) the charge considering users' preference was proposed. The achieved level of realism enables simulating future mobility and testing new strategies, e.g. ancillary service (AS) procurement using EV flexibility (Fig. 1C).

Energy Communities(EC). A flexible formulation to analyse many EC typologies was developed [1]. Several pricing mechanisms led to similar results from the aggregate point of view, but differences were found at the individual level. As an example, the daily load profile of a Non-Shared Resources EC is shown in Fig. 2A.

Residential users. A framework [2] that considers a realistic model of the user, social and psychological factors in consumer energy choices was proposed to study the diffusion of Demand-Side Management programs (Fig.2B). Results demonstrate that a high initial financial gain for the utility does not translate into higher economic benefits in time if the users are not understood, kept motivated and engaged.

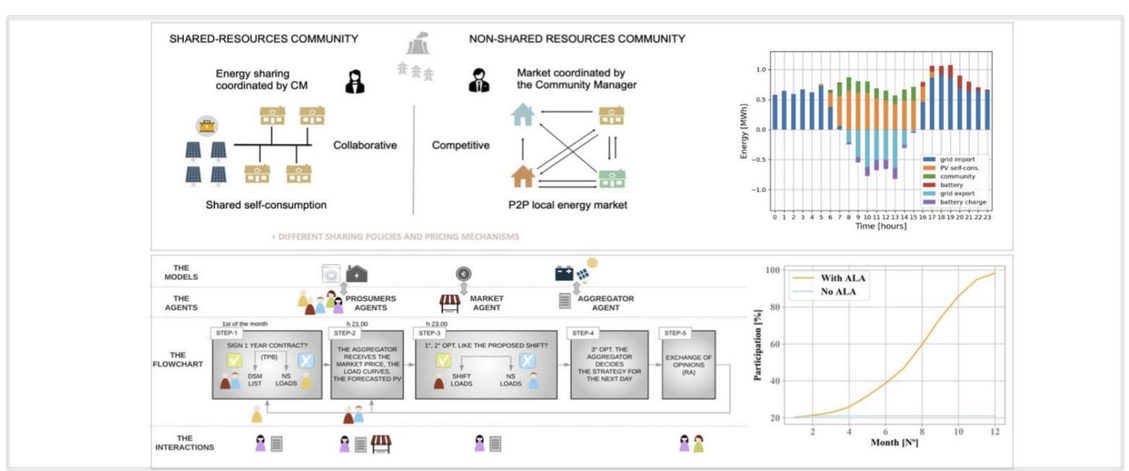

Fig. 2A (above) - EC comparison
Fig. 2B (below) - Diffusion of DSM programs

4. Conclusion

The framework helps to understand the consequences of what-if scenarios based on behavioural changes and technological diffusion observed or predicted.

5. References

1. Schiera D.S., De Vizia et al. Modelling and techno-economic analysis of Peer-to-Peer electricity trading systems in the context of Energy Communities. In: 2022 EEEIC/I&CPS Europe
2. De Vizia et al. (2022) A User- Centric View of a Demand Side Management Program: From Surveys to Simulation and Analysis. In: IEEE SYSTEMS JOURNAL, vol. 16, pp. 1885-1896.