How to efficiently decentralize energy communities management ?

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1 Introduction

In [2] we have developed heuristics for load scheduling in energy communities. That work assumed that there is a centralized decision maker that assigns optimal decision to the community members. That model is hardly implementable in practice, where individuals may not wish to follow the decisions decided by that authority. We have, therefore, started as in [1] to study how to efficiently decentralize this decision process. Instead of dictating schedules, the centralized authority (Community Coordinator, CC) would merely provide prices and information to the community members. In this presentation, I will present our first results along that line.

1.1 Description

We consider a collective self-consumption community composed of N members with different asset possession characteristics as presented in Figure 1. Producers can store and exchange their energy surplus with other members or the primary grid (green links). No additional links exist between members apart from the green energy exchange ones; CC is the intermediary between members disseminating information (orange). The members remain connected to the main grid and collect energy when needed (gray). We aim to provide a decentralized model that initiatives the consumption of the local generation in the community as much as possible.

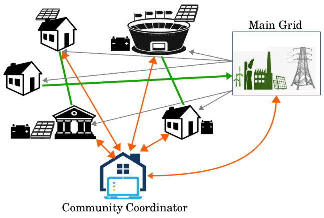

Figure 1: Community's presentation.

2 Allocation keys

No direct links between the members apart from green energy transfers. Instead, each member determines their own local schedules and sends information about energy needs and availability to the CC. The latter determines the allocation keys (the maximum periodic amount of energy each member can draw from the community) and sends them to members, who adjust their decisions according to this information. We calculate the allocation keys in three ways:

- **The business method**, **AE**: It is a calculation method based on the total periodic energy consumption and availability. This iterative method allows fair energy allocation among members.
- **Per application method**, **PA**: consists of determining the candidates for the energy reception and then sharing (uniformly) the power between these members. A candidate is a member who does not inject energy.

- **Combination**, **Com**: is a combination of the previous methods.

3 Experimental Results

We conduct experiments on a realistic instance. We use the column generation-based heuristic in [2] to solve the scheduling problem per member with `maxIter` $= 10$ and `time_limit` $= 20s$ as the pricing problem's time limit. Table 1 presents the solutions where column *obj* is the total amount of power collected from the main grid. Column q_{av} is the total amount of energy that can be shared in the planning horizon, and p_{sh} is the percentage of q_{av} consumed in the community. We use total gain and energy withdrawn from the main grid as objective functions and compare the two cases.

Decentralize solutions: Withdraw				Decentralize solutions: Gain		
Key	*obj* kWh	q_{av} kWh	p_{sh} %	*obj* kWh	q_{av} KWh	p_{sh}%
AE	119.07	42.72	84.00	119.33	46.00	71.32
PA	111.01	42.05	100.00	113.77	46.05	100.00
Com	118.27	42.72	67.88	118.74	46.00	54.92

Table 1: Decentralized management solutions for the illustrative instance.

Table 1 shows that decentralized management with keys **PA** returns the best solutions; it ensures greater local consumption of green energy than the other keys. Figure 2 shows the different key calculation methods' consumption shifts. **PA** ensures the Demand Response in opposition to **EA** and **Com**. Indeed, these methods allocate energy according to needs. As a result, the keys follow the consumption trend, and a lot of energy that could have been consumed locally is injected into the main grid. In contrast, **PA** depends on energy availability. Since prosumers inject after optimally determining their schedules, and energy is shared uniformly, non-producers will are incentivized to shift their consumption to periods where they can draw energy from the community.

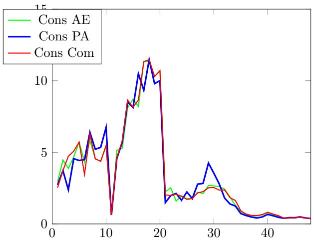

Figure 2: Energy consumption for the keys: Demand Response illustration.

4 Conclusion

We have proposed an efficient management process where members build their schedules according to incentives sent by the centralized authority. That management process is easily implementable; it will be even easier in a community where everything is smart.

References

[1] Cheng Lyu, Youwei Jia, and Zhao Xu. Fully decentralized peer-to-peer energy sharing framework for smart buildings with local battery system and aggregated electric vehicles. *Applied Energy*, 299:117243, 2021.

[2] Mariam Sangaré, Michael Poss, Eric Bourreau, and Amaury Pachurka. Loads scheduling for Demand Response on Smart Grids. In *ROADEF 2022 - 23ème congrès annuel de la ROADEF*, Villeurbanne, France, February 2022. INSA Lyon.