Small-Scale Communities Are Sufficient for Cost- and Data-Efficient Peer-to-Peer Energy Sharing

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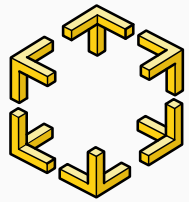
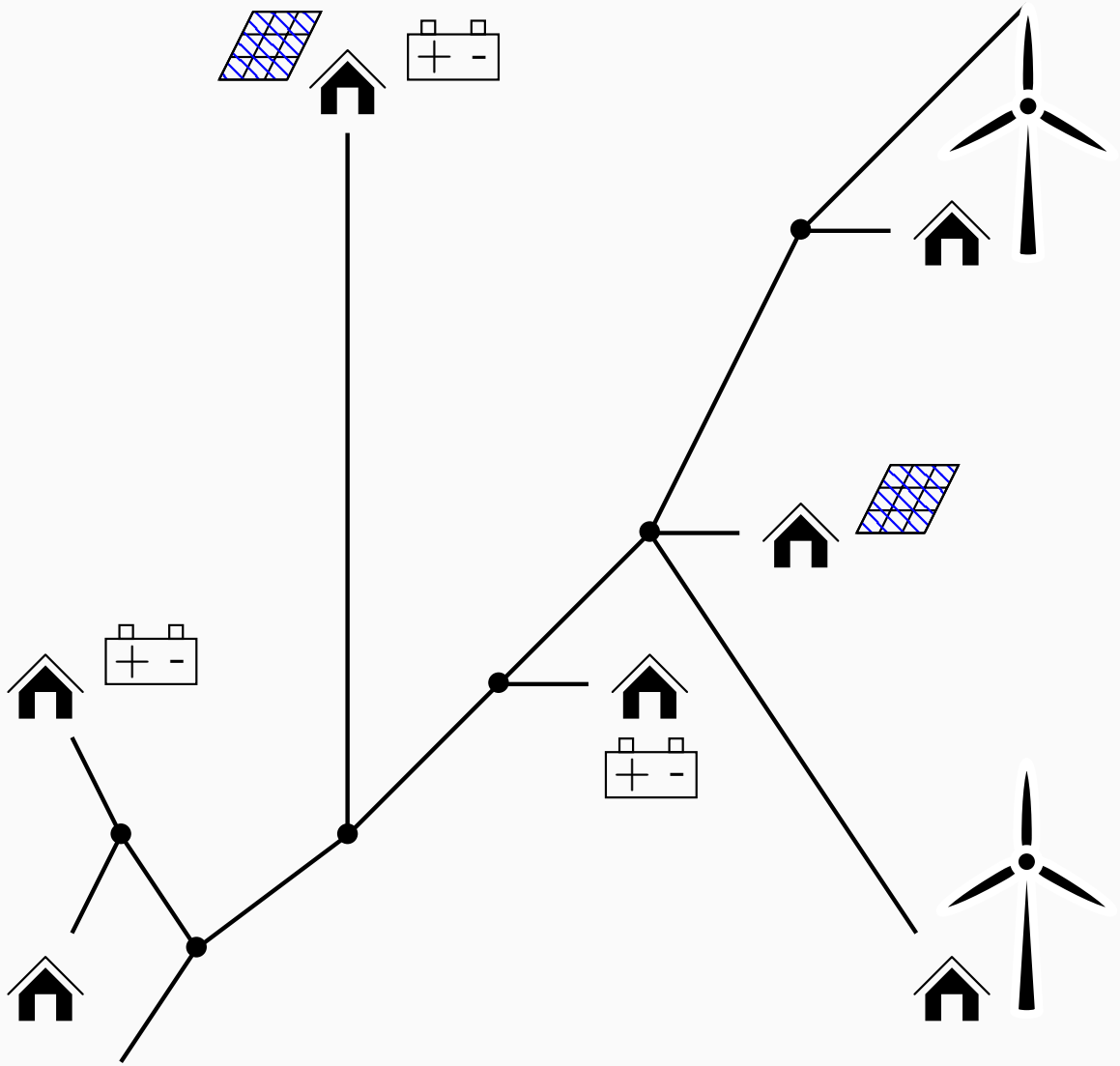


Introduction

Introduction: Context & Motivation



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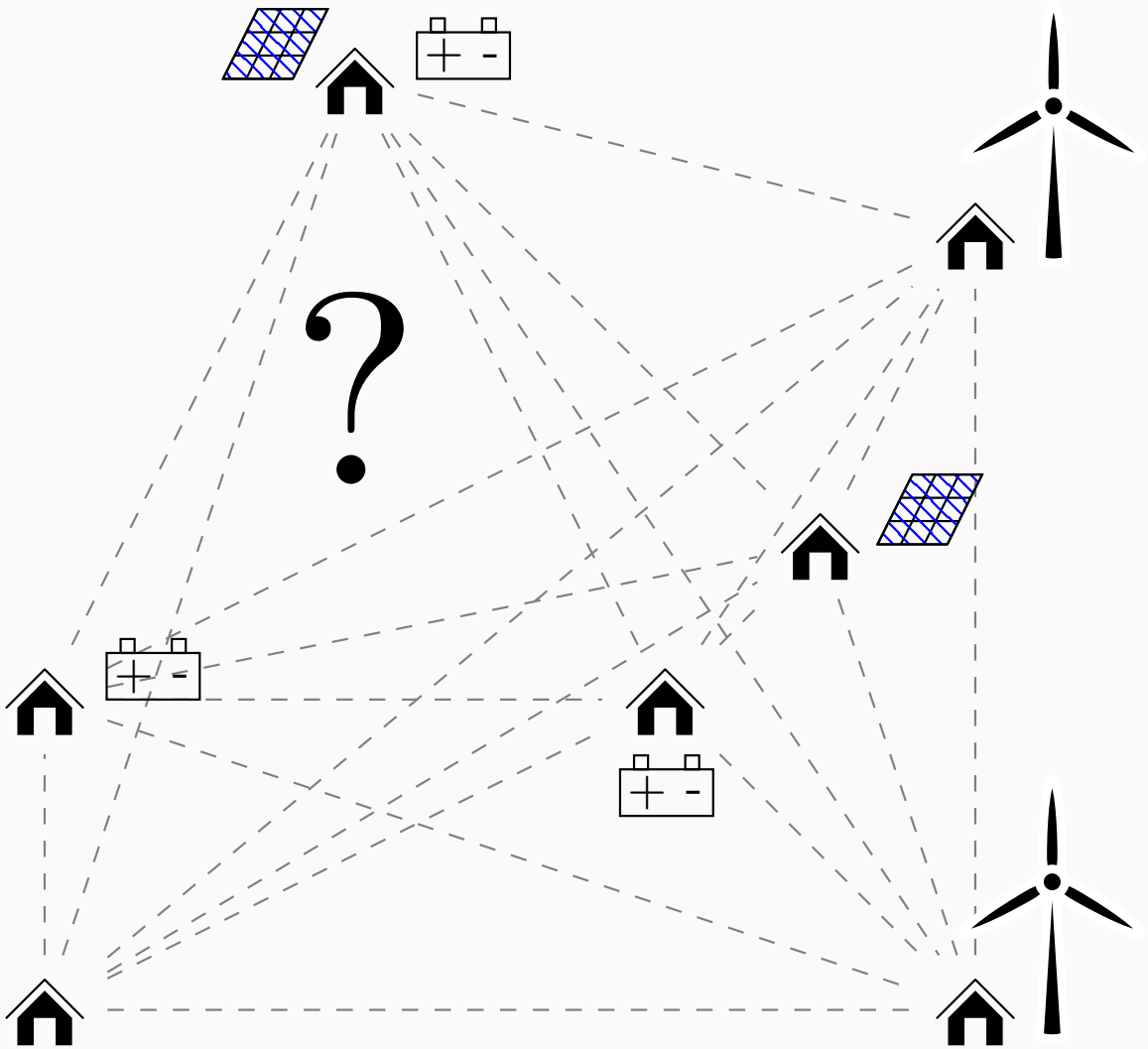

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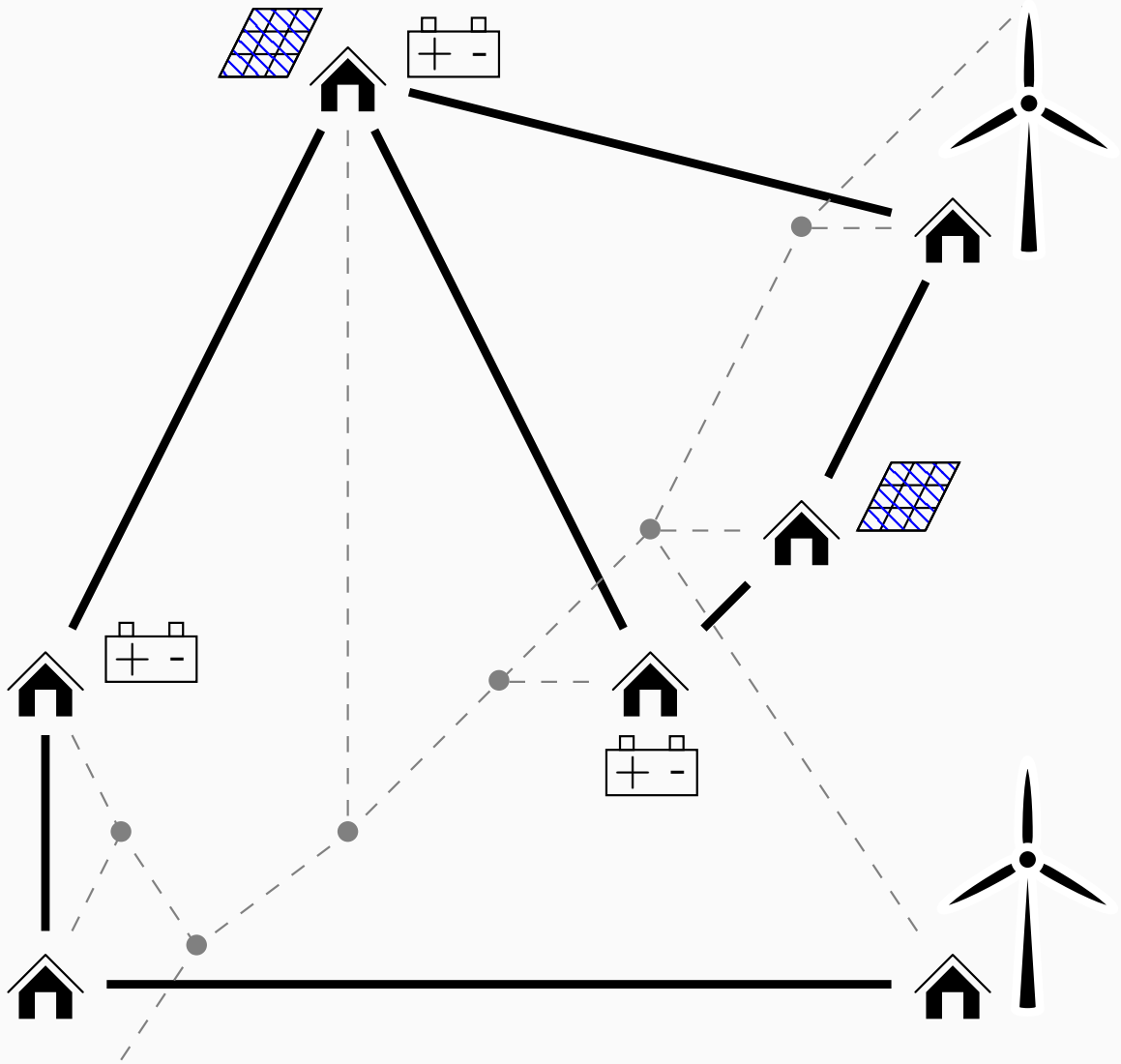


Introduction: Research Questions

Research Questions

1. **Cooperation:** to understand which configurations lead to noticeable cost savings.
2. **Capacity:** to identify ranges of sizes for energy production, where cooperation becomes interesting.
3. **Size:** to identify from which community sizes the gain starts to become important.

Introduction: Contributions

Contributions

- **Forecast Range**: replace *perfect foresight* by *limited prediction* (online decision-making problem).
- **Community Compositions:** use different local generation and storage capacities.
- **Gain-sharing Mechanisms:** show how to split the cooperative gain (average financial advantage of cooperating).

Model

Optimization Model

Individual

- **Objective:** minimize yearly electricity bill of each household h.
- **Parameters for h:**
  - PV and Battery capacities.
  - Hourly consumption.
- **Parameters for all:**
  - Solar profile.
  - Electricity prices.

Cooperative

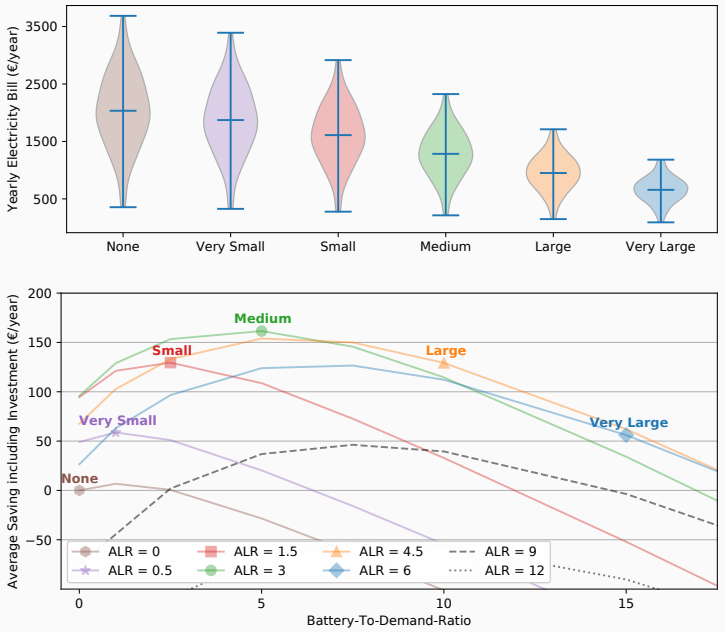
- Same as individual but with aggregated **consumptions**, **generation** and **storage** capacities.
- **Assumptions:** no battery degradation, transmission losses nor constraints on connection capacities or communication faults.

Our case study: 100 households

- **Dataset:** consumption for 100 swedish households with wide range of consumption (0.33-3.36 kWh average consumption).
- **Production levels:**
  - **ALR (Array to Load Ratio)**: controls PV panels size.
  - **BDR (Battery to Demand Ratio)**: controls Battery size.

5 Scenarios, avg. # PV (min-max):

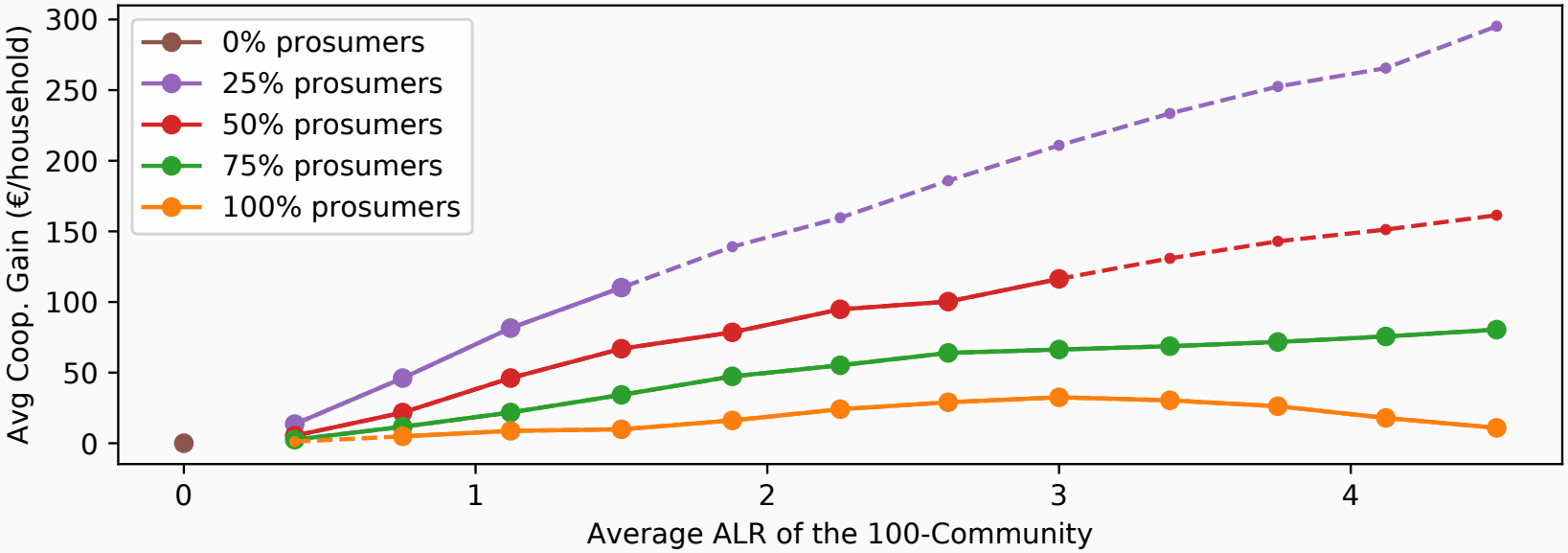
1. **Very Small** – 3 PVs (1-6)
2. **Small** – 9 PVs (2-17)
3. **Medium** – 18 PVs (3-33)
4. **Large** – 27 PVs (5-50)
5. **Very Large** – 36 PVs (7-67)

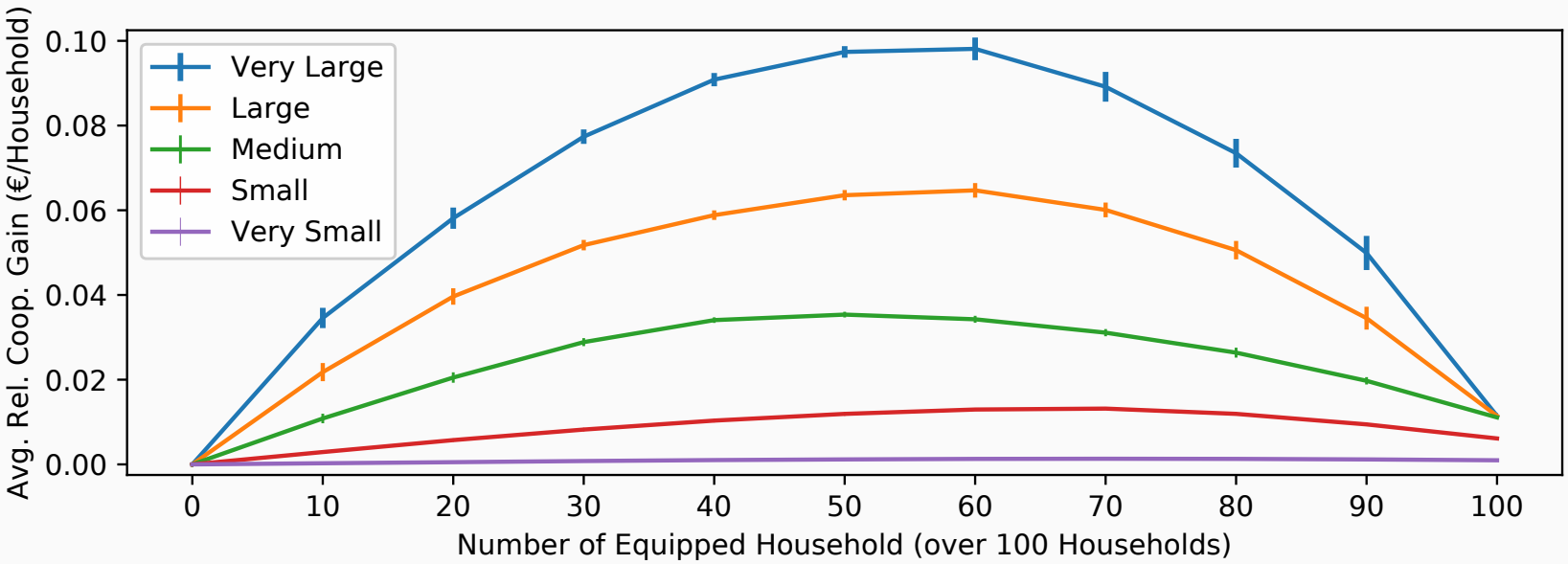


(ALR,BDR): *Very Small* (0.5,1), *Small* (1.5,2.5), *Medium* (3,5), *Large* (4.5,10), *Very Large* (6,15).

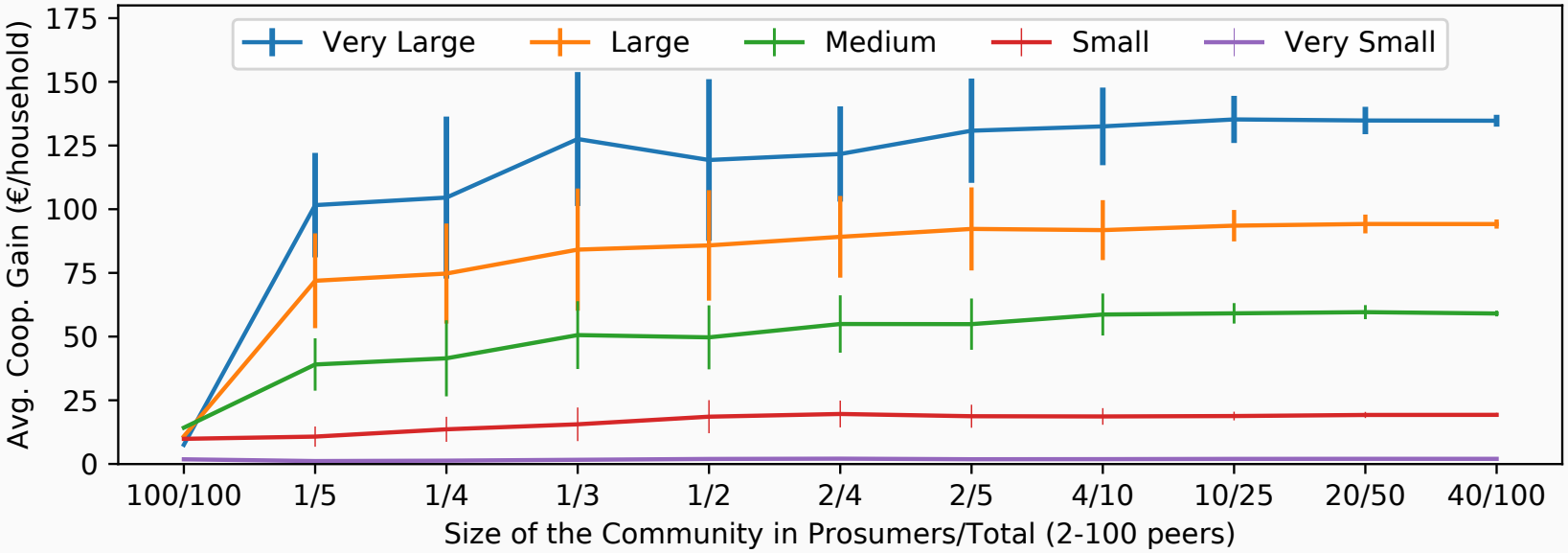
Results

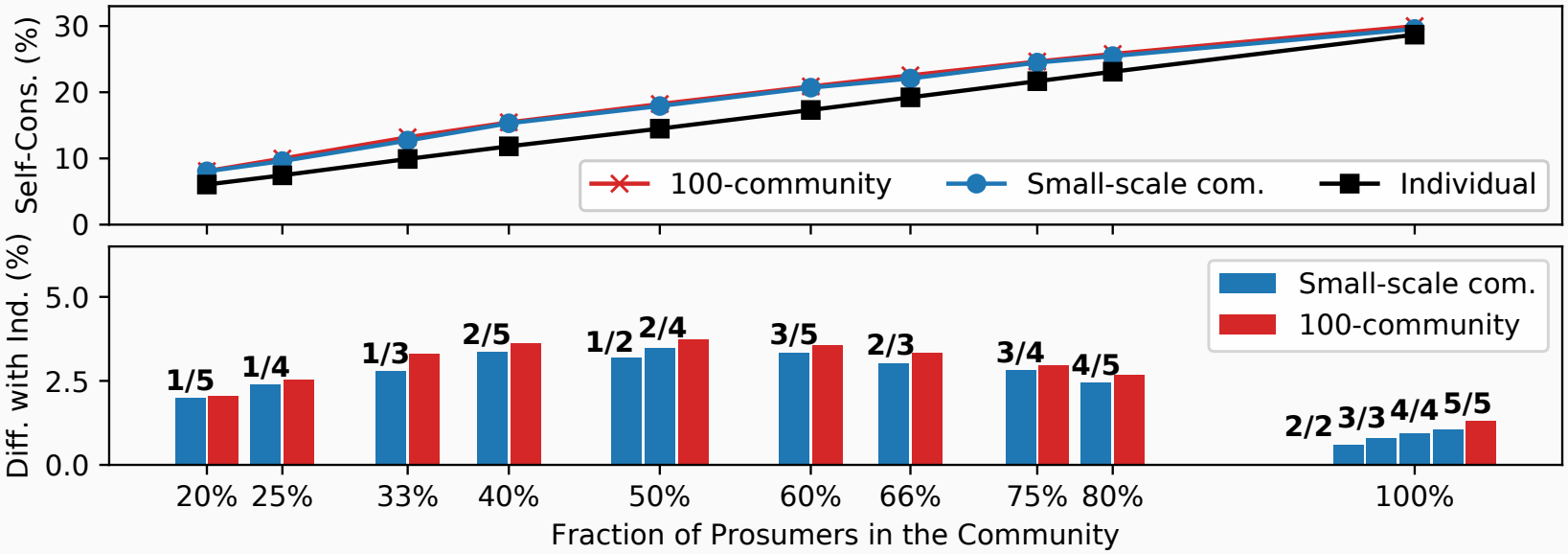
Result 1. We need pure-consumers as well!



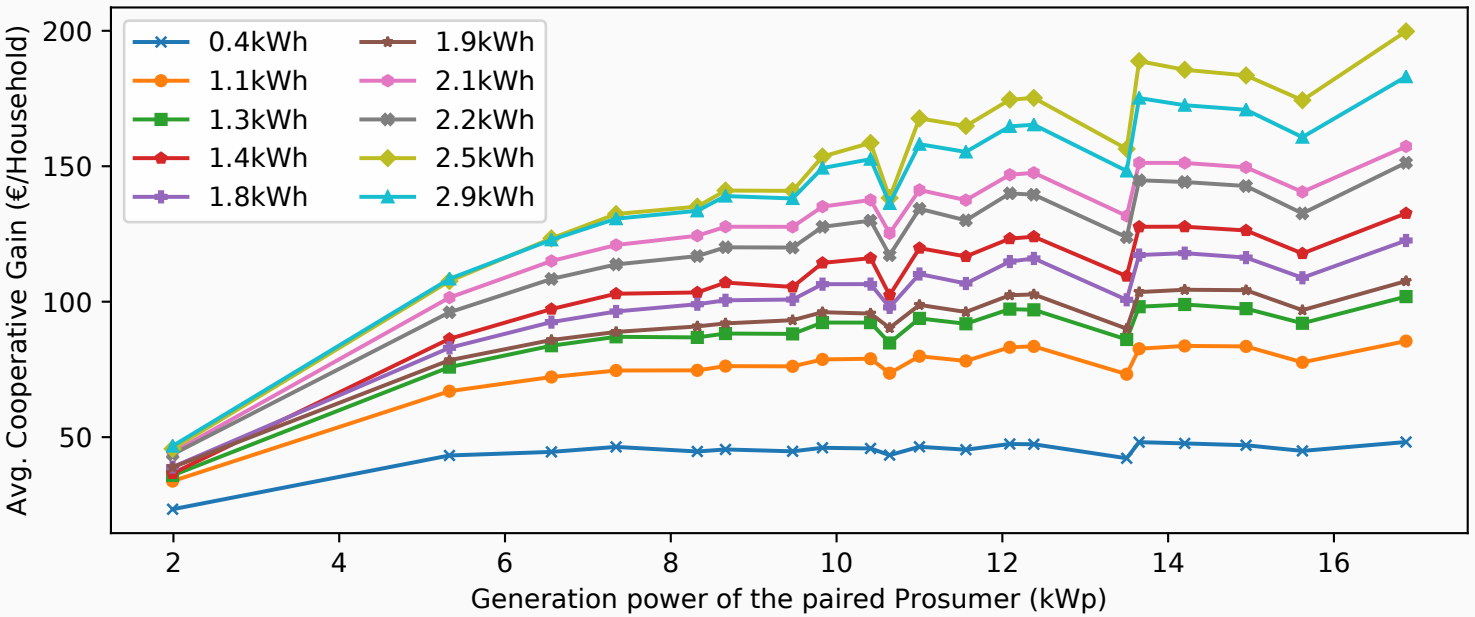


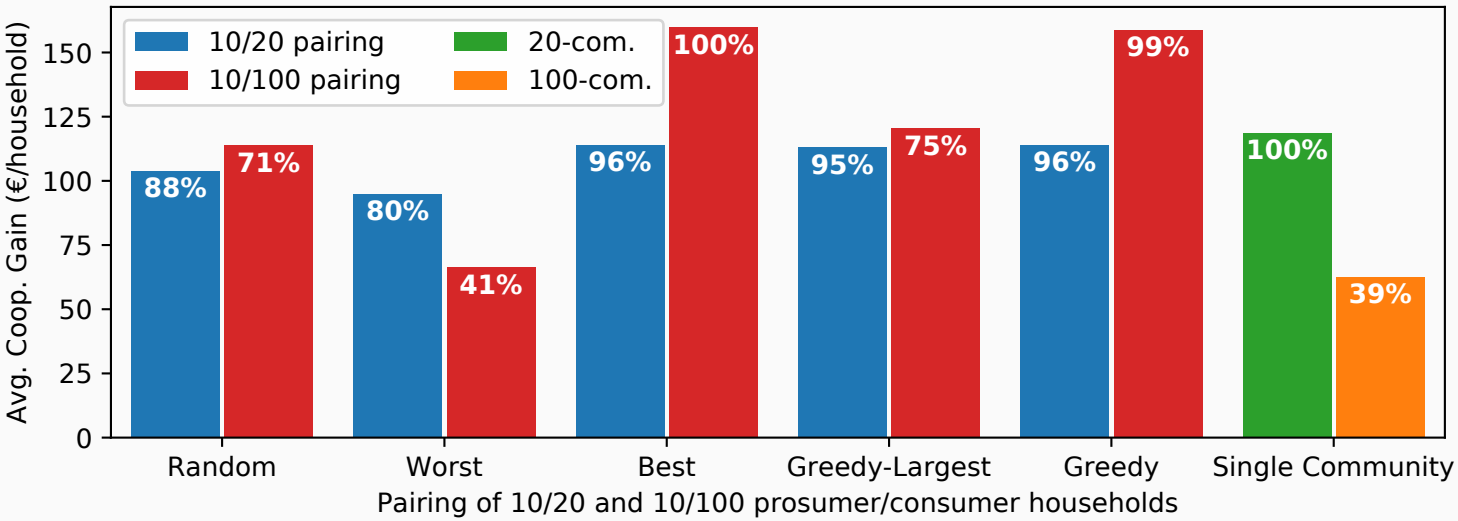
Result 2. Small-scale communities are enough!



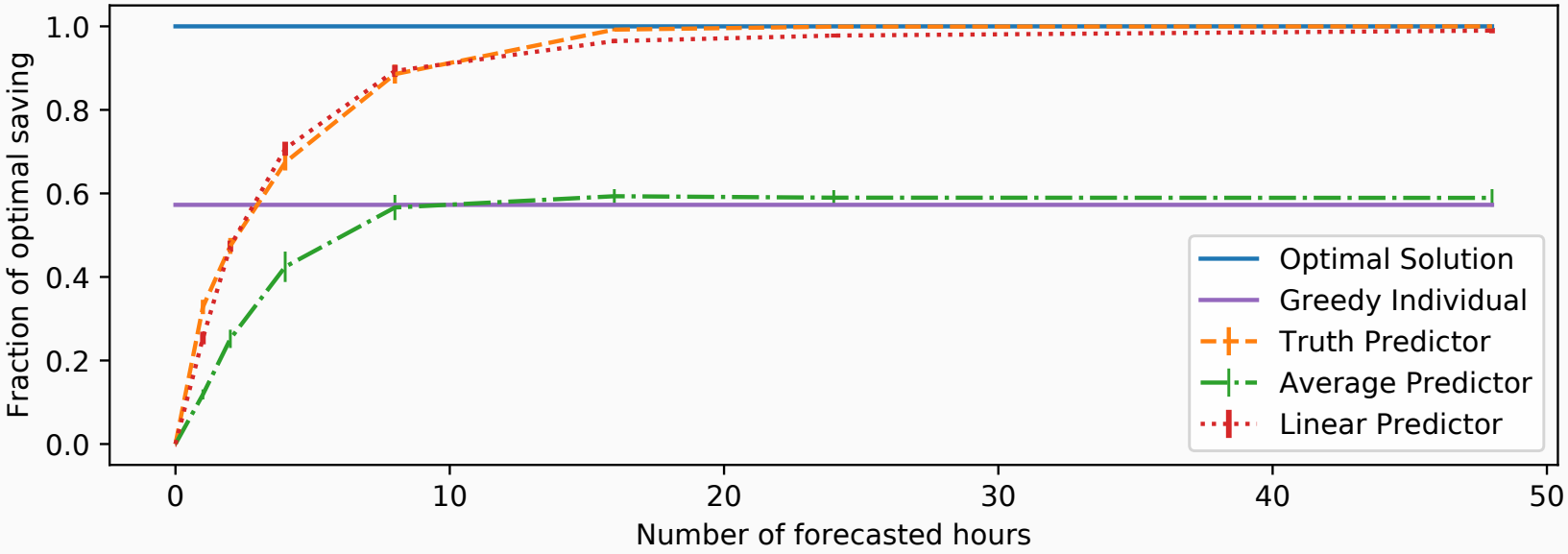


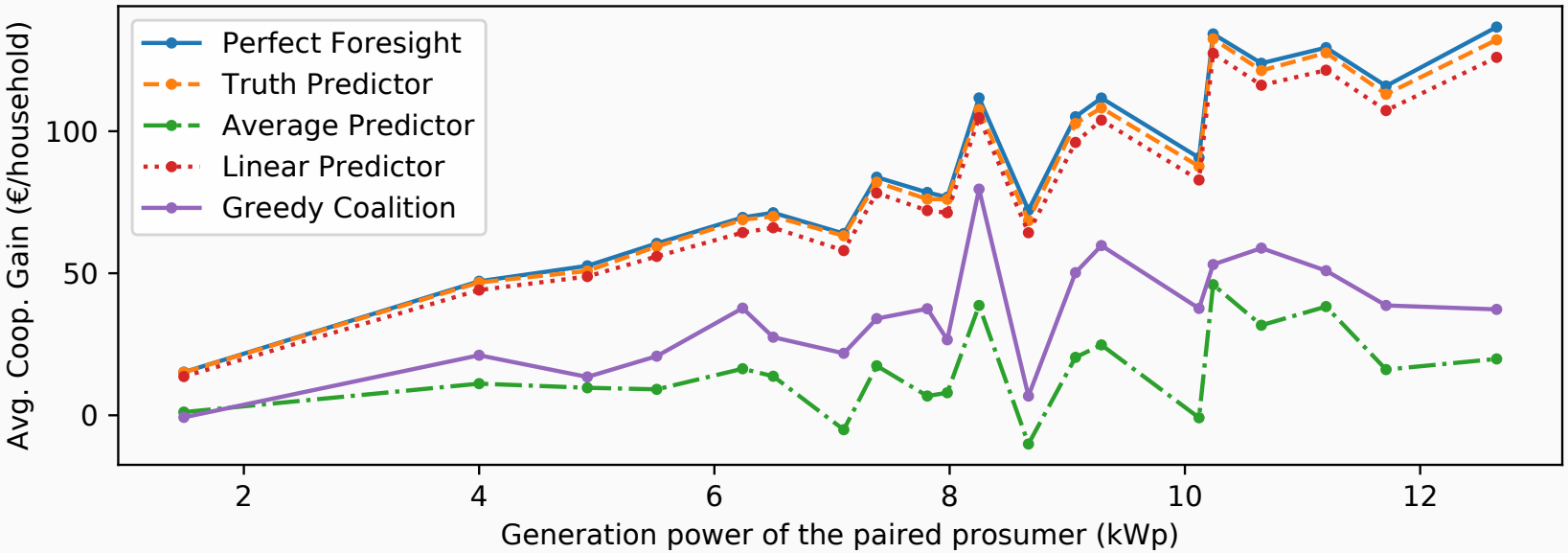
Result 3. Forming the right pairs is important!



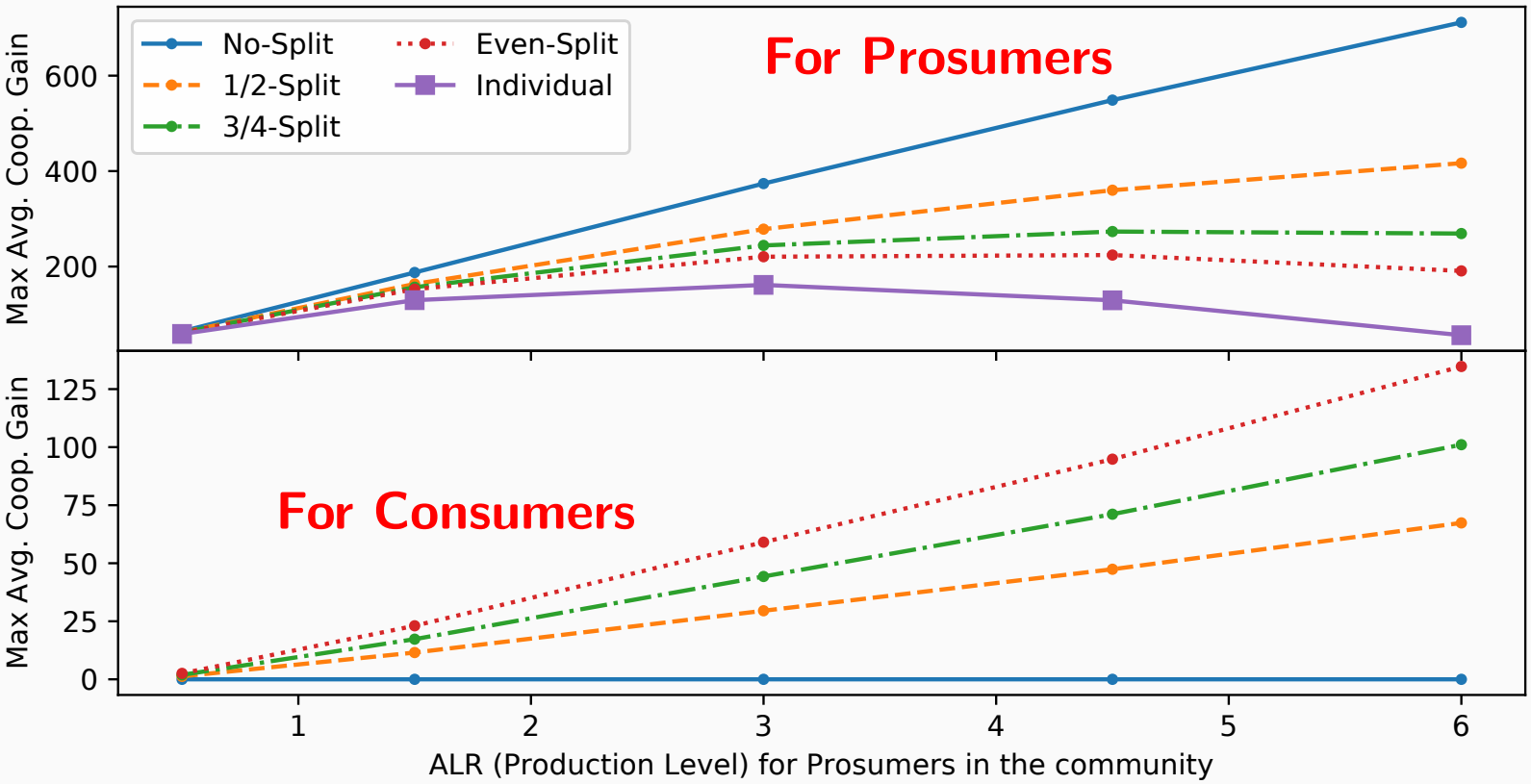


Result 4. We don't need much prediction power!





Result 5. Consumers should also get rewarded!



Conclusion

Take Home Messages

1. **Small-scale communities** obtain up to 88-97% of the same benefits of any larger community $\rightarrow$ large reduction in the amount of data to share over the network!
2. **Matching prosumers with pure-consumers** in the right way can lead to up to 59% improvement on the coop. benefit!
3. **No need for very accurate predictions:** you can achieve up to 90% of the optimal cooperative gain with inaccurate and limited foresight of only 8h, and 96% with 16h!
4. **How the gain is split** among the peers influence *motivations* both on investing in energy resources and participating in the sharing process!

- **Future Work:** Can we organize households (matching problem) into **a data- and cost-efficient P2P network** in a **distributed and continuous fashion**?

Thank you for your attention,

and take care!