Forseeing New Control Challenges in Electricity Prosumer Communities

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Introduction

• Electricity Prosumer Community
  • Distributed generation
  • Storage
  • Information technologies

• Objectives
  • Propose a rigorous mathematical framework for studying energy prosumer communities
  • Present a new class of interesting control problems and challenges, to increase the hosting capacity of LV networks.
Outline

- The Electricity Prosumer Community
- Formalisation
- Control challenges
- Centralized vs distributed schemes
The electricity prosumer community

• Definition

Electricity distribution system containing loads and distributed energy resources (such as distributed generators, storage devices, or controllable loads), that can be operated in a controlled, coordinated way.
The electricity prosumer community

• Similar to microgrids
• Cannot operate in island mode
• Comprises consumers cooperating for the satisfaction of their energy needs using local production sources
The electricity prosumer community

- Drivers
  - With a shared infrastructure between the members
  - Without a shared infrastructure
    - Network operation
    - Energy market

Communities extend the perimeter of self-consumption from one prosumer to several to pool production and flexibility means.
Formalisation - The prosumer

- **Production**: Active and reactive power production
- **Storage**: Active power stored, Level of charge
- **Load**: Active and reactive power consumption
- **Network**: Active and reactive power injected into the distribution network
Formalisation – The community

- Power exchanges between prosumers
- Losses equal to the difference between the houses and the root of the community
Formalisation

• Cost and revenues for each prosumer
  • Price between each member of the community
  • Price for electricity from the distribution network

• Community behaviour
  • Discrete time setting
  • For each time step, the variables change as a function of the previous states and exogenous variables, with some uncertainty
Control challenges

- Decision making problems
- Maximising the distributed production
  - And increase the network’s hosting capacity
  - And limit losses
- Optimising overall costs and revenues
  - Minimise the total electricity bill of the community
Centralised vs distributed

Requirements

- Inverters that are controllable in active and reactive power
  - Controllable loads can be considered
    - Voltage et power measurements
- Model of the network
- Extensive communication
  - Centralised computer/controller
- No model
- No or little communication
Distributed schemes

• Generating a data set using multiperiod OPF
  • Different load patterns, PV production profiles, prices
• Learning regressors using Extremely Randomized Trees
• Constraining the prediction
• Simulating the behaviour of the agents

<table>
<thead>
<tr>
<th>Community electricity bill compared to a distributed rule of thumb</th>
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<tr>
<td>Centralised (FBS-OPF)</td>
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<tr>
<td>Distributed (Rule of thumb)</td>
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<td>Distributed (Extra trees)</td>
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Conclusion

• In the paper:
  • Mathematical framework for modelling Electricity Prosumer Communities and energy exchanges between prosumers
  • Introduction of a distributed approach using machine learning

• Future work:
  • Using reinforcement learning for agent self-improvement