Hierarchical Framework

The envisioned framework considers a home energy management system (HEMS), which manages DERs in each home; a community-level aggregator, which manages the HEMS in the community of homes; and a substation-level utility controller, which manages the aggregators of the communities on the distribution feeder.

Abstract

This paper develops a hierarchical control framework to aggregate and to manage behind-the-meter distributed energy resources (DERs), which will be ubiquitous in future distribution systems. The proposed framework has following major steps:

1) Each controller in the hierarchy determines the flexibility of the DERs such that the obtained flexibility is feasible with respect to its operational boundaries.

2) Based on the feasible flexibility, optimal setpoints for the DERs are then determined by the hierarchical controllers to help provide grid services such as voltage regulation to the distribution power network.

A Model-Predictive Hierarchical-Control Framework for Aggregating Residential DERs to Provide Grid Regulation Services

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Numerical Results

A. Optimization Modes

The aggregator has a higher preference toward HEMS nominal powers while regulating home node voltages.

B. Home Voltages

The aggregator has a higher preference toward utility requested powers while regulating home node voltages.

Conclusions

1) A hierarchical control framework is presented to determine the available power flexibility of the smart homes in a distribution system as well as of the distribution system itself, considering unbalanced power flow formulation and network voltage constraints.

2) The bidirectional flow of information and control ensures that the distribution-level DERs are also able to participate in the grid service markets, thereby helping the power network use the DER flexibility while earning cost savings for the DER owner.

3) The proposed framework is well suited to accommodate other DER types, such as electric vehicles, as well as cost benefit maximization of individual controllers in the hierarchy, which will be studied extensively in our future work.

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