Commercial Building Planning and Retrofitting Strategy for Grid Services

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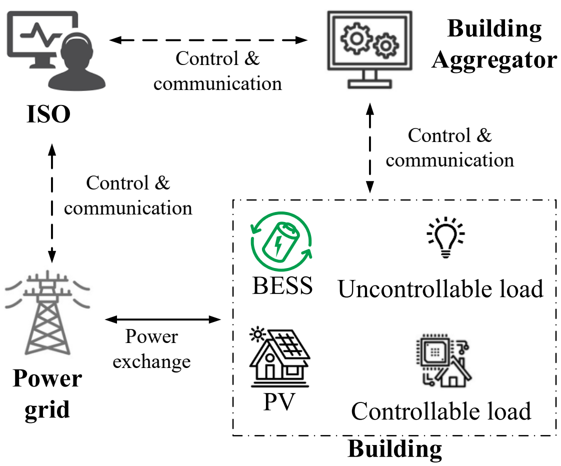
Abstract

The increasing integration of distributed energy resources (DERs) plays an important role in improving energy consumption efficiency. In September 2020, the Federal Energy Regulatory Com-mission (FERC) approved Order 2222 that opens wholesale electricity markets to small capacity DERs. The benefit from this new FERC Order 2222 is that DERs, such as rooftop solar panels and batteries, will be able to participate in regional electricity markets and provide grid services. Meanwhile, the planning and operation strategies of DERs are facing new challenges to account for the impact of the wholesale market with numerous uncertainty fac-tors. Therefore, in this paper, we propose a new planning and retrofitting model for long-term commercial building that considers both DER investment and market participation. Specifically, we explore the capability of implementing DERs for grid services. The effectiveness of the proposed model is validated using real-world data. Simulation results also validate that participating in grid services can significantly increase revenues through appropriate building energy management and shorten the payback period of DER investments.

Building Energy Management



Targeted Grid Services

- **Peak Load Management**: Limiting the peak load will help utility systems and building aggregators to defer grid upgrades and new investments.
- **Demand Response/shift**: Demand response is a well-defined service where the load will be curtailed at the requested period. Demand shift increases the power load to level off peak-valley variations.
- **Frequency Regulation**: Frequency regulation is a market product that will be open to aggregated DERs. Inverter-based DERs such as BESS can promptly respond to frequency regulation signals. BESS is assumed to be eligible, while PV and other building loads will not participate.

Planning Model Formulation

Objective	Min. Investment_cost + Operation_cost – Service_revenue
Subject to	Planning Option Set (PV and BESS investment, Controllable load retrofit)
	PV, BESS, Controllable Load constraints (Power, energy, etc.)
	Building peak load capacity limit
	Grid Service constraints (Service request, revenue, and penalty)

Simulation Results

- Case 1: No grid service
- Case 2: Demand response only
- Case 3: Both demand response and frequency regulation

Case 3 has the highest capital cost, while enjoying lowest energy bill thanks to the revenues from participating grid services.

Case No.	1	2	3
PV capacity (kW)	291.7	347.6	316.3
BESS capacity (kWh)	0.0	0.0	300.0
Controllable load (kW)	250.0	250.0	250.0
Demand response (kW)	0.0	64.6	127.9
Annuity cost ($/yr)	315458	314701	279942
Annual energy bill ($/yr)	236807	228912	184165

Peak load (kW)	500	400	250
Case 1			
PV capacity (kW)	0.0	84.95	500.0
BESS capacity (kWh)	0.0	0.0	201.9
Annuity cost ($/yr)	300907	301660	345690
Case 3			
PV capacity (kW)	55.4	209.8	436.9
BESS capacity (kWh)	300.0	300.0	300.0
Demand response capacity (kW)	438.3	361.6	74.8
Annuity cost ($/yr)	262436	266784	291774

- Peak load capacity of the building, which is of particular interest to the building aggregator and utility operator.
- Original peak load is 500 kW
- Case 1 needs to invest in PV and BESS to meet the peak load capacity of 400 kW and 250 kW.
- In Case 3, BESS investment will be made with a peak load capacity limit of 500 kW to gain more profit from grid services.
- Grid services help aggregators to meet lower peak load capacity at lower cost.

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