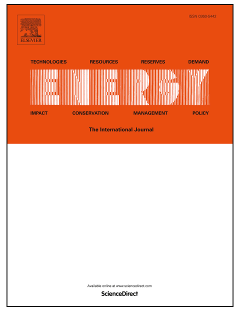

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Optimal Collaborative Demand-Response Planner for Smart Residential Buildings

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Abstract

This work presents a collaborative scheme for the end-users in a smart building with multiple housing units. This approach determines a day-ahead operational plan that provides demand-response services by taking into account the amount of energy consumed per household, the use of shared storage and solar panels, and the amount of shifted load. We use a biobjective optimization model to trade off total user satisfaction versus total cost of energy consumption. The optimization works in combination with a price structure based on time and level of use that encourages load shifting and benefits the participants. Computational experiments and an extensive sensitivity analysis validate the performance of the proposed approach and help to clarify its strengths, its limits, and the requirements for ensuring the desired outcome.

Keywords: Smart Buildings, Demand-Response, Residential Load, Biobjective Optimization, Compromise Programming.

1. Notation

Sets:

$i \in I$: Energy levels
$j \in J$: Users
$t \in T$: Time frames

Parameters:

D_{jt} : Energy demand of user j in time frame t (kWh)
K_{it} : Price per energy unit bought from the grid in level i in time frame t (¢/kWh)
C^L : Available capacity in the lower level (kW)
C^H_j : Available capacity in the higher level for user j (kW)
B : Cost of charging the battery per energy unit (¢/kWh)
S^{max} : Capacity of the battery (kWh)
Γ : Battery efficiency
Z : Number of cycles allowed in the battery
P_t : Incentive paid by the grid per energy unit in a demand-response call in time frame t (¢/kWh)
DR_t : Energy consumption reduction requested by the grid in time frame t (KWh)
G^{max}_t : Available energy from solar panels in time frame t (¢/kWh)
F : Cost per energy unit obtained from the solar panels (¢/kWh)
Y_j : Max accumulated shifted demand over the horizon accepted by user j (kWh)
$\hat{Y}_j$: Max unmet demand at the end of the horizon for user j (kWh)
Ψ^{max}_{sol} : Max percentage of total demand satisfied by solar panels
Ψ^{min}_{sol} : Min percentage of total demand satisfied by solar panels
Ψ^{max}_{bat} : Max percentage of total demand satisfied by the battery
Ψ^{min}_{bat} : Min percentage of total demand satisfied by the battery

Variables:

x_{ijt} : Energy bought from the grid in level i by user j in time frame t
y_{jt} : Accumulated unmet demand at the end of period t for user j
soc_{jt} : Individual state of charge for user j at the end of time frame t
s^+_{jt} : Energy charged in the battery in time frame t by user j
s^-_{jt} : Energy discharged from the battery in time frame t by user j
r_{jt} : Amount of demand-response service provided by user j in time frame t
g_{jt} : Consumed energy from solar panels for user j in time frame t

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