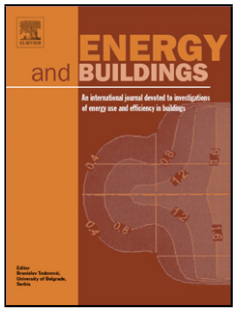

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PII: S0378-7788(17)30127-5
DOI: http://dx.doi.org/doi:10.1016/j.enbuild.2017.05.076
Reference: ENB 7657

To appear in: *ENB*

Received date: 11-1-2017
Revised date: 13-4-2017
Accepted date: 29-5-2017

Please cite this article as: Xiaodong Yang, Youbing Zhang, Bo Zhao, Feiteng Huang, Yu Chen, Shuaijie Ren, Optimal energy flow control strategy for a residential energy local network combined with demand-side management and real-time pricing, Energy and Buildingshttp://dx.doi.org/10.1016/j.enbuild.2017.05.076

Optimal energy flow control strategy for a residential energy local network combined with demand-side management and real-time pricing

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ABSTRACT:
Due to the increasing importance of demand-side resources in the energy internet, this paper proposes an optimal energy flow control strategy for a residential energy local network (RELN), which consists of a small number of households, based on the idea of demand-side management. In particular, a type of optimal and dynamic RELN energy consumption scheduling framework is formulated to minimize the daily total operation cost, while fully considering the output forecast error of renewable energy sources (RESs), the consumption preference of users and the status of the energy storage system. In this framework, we provide a unified appliance model to group various types of appliances, which are connected to the network, into a physical model with the same attributes, and a comprehensive real-time pricing mechanism between the RELN and power distribution company (PDC) is developed based on the generalized total load to guide the electricity consumption behavior of the end-users and to also balance the total residential load. On this basis, a mixed integer programming (MIP) model for dynamic energy management optimization of the RELN is optimized at each decision period and integrated into a model predictive control method to reduce the negative impacts of forecast errors of RESs, thereby realizing an optimal and automatic energy flow control for the RELN. Finally, the effectiveness of the proposed RELN energy flow management framework is verified using several case studies.

Keywords:
Residential energy local network, Energy flow control, Plug-in electric vehicle, Demand-side management, Comprehensive real time pricing

Nomenclature

Abbreviations

DSM	demand-side management
ESS	energy storage system
EI	energy internet
EMC	energy management center
IBR	inclining block rate
MPC	model predictive control
PEV	plug-in electric vehicle
PV	photovoltaic
PDC	power distribution company
PAR	peak-to-average ratio
RELN	residential energy local network
RES	renewable energy source
RTP	real-time pricing
SOC	state of charge
TOU	time-of-use
V2G	vehicle to grid
WT	wind turbine

Indices

$i \in \mathbb{R}$	index of households in the RELN
$j \le \mathbb{N}_i$	index of electric appliance in *i*-th household
$k \in \{1, 2, \ldots, K\}$	index of periods
$l \in \boldsymbol{L}$	index of PEVs

Parameters

K	total number of periods of a day
Δt	time interval
$P_{\mathrm{PV}}^{k} / P_{\mathrm{WT}}^{k}$	power output of PV/ WT at period k
$t_l^{\mathrm{in}} / t_l^{\mathrm{out}}$	plug-in time and the planned departure time of the *l*-th PEV
$S_l^{0} / S_l^{\mathrm{E}}$	initial SOC/ the expected SOC of the *l*-th PEV
Q_l^{s}	battery capacity of the *l*-th PEV

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