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A novel demand response management model to reduce smart grid costs

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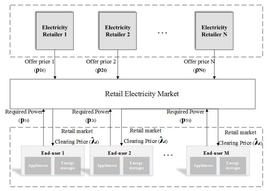
Introduction to demand response management (DRM)

DRM means leveling demand curve based on electricity prices. Indeed, using variable price rates, electricity consumers are encouraged to use electricity in periods with cheap electricity price ranges. Therefore, total system cost would decrease efficiently.



Motivations

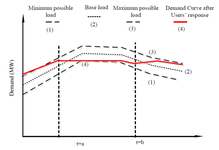
- To model dynamics between electricity end-users and utility companies.
- To present a model with simple implementation on smart households.
- To reduce electricity production costs and to maximize social welfare.

Methodology (Electricity consumers)

- Electricity consumers would tend to reduce their total cost. (They will receive hourly electricity price and adjust their consumption accordingly)
- Electricity consumers can shift their consumption to cheap periods.(DS)
- Electricity consumer can use energy storages (ESs).

Presented model for consumers:

$$Min\ Cost$$
$$s.t$$
$$DS \in \{TV, Dish\ washer, iron, conditionar\}$$
$$ES \in \{charge, discharge\}$$



Methodology (utility Companies or electricity retailers)

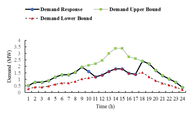
- Utility Companies (UCs) aim to maximize their profit.
- The main challenge for Ucs is that how they can attract more costumers?

Presented model for UCs:

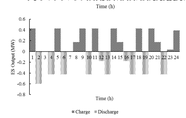
$$Max\ profit$$
$$s.t$$
$$Consumers\ satisfaction$$

Results (Electricity consumers)

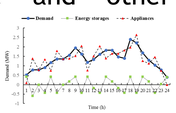
- Electricity consumption patterns;



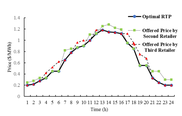
- Energy Storage output;



- Combination of Energy storage and other appliances;



- Electricity price



Results (Electricity consumers and UCs)

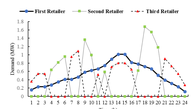
- Electricity consumption Costs;

Total cost ($)	Total amount of saved cost compared with flat pricing ($)	Total amount of saved cost using ESs ($)	Total cost of ES ($)
24.04	5.25	3.04	2.17

- Electricity price table;

t=1	t=2	t=3	t=4	t=5	t=6	t=7	t=8
0.2	0.22	0.28	0.33	0.45	0.45	0.65	0.78
t=9	t=10	t=11	t=12	t=13	t=14	t=15	t=16
0.87	0.9	1	1.12	1.18	1.15	1.14	1.12
t=17	t=18	t=19	t=20	t=21	t=22	t=23	t=24
0.95	0.85	0.55	0.55	0.33	0.25	0.2	0.2

- Utility Companies profit;



Conclusion

- A comprehensive model which considers interaction between electricity consumers and utility companies.
- A novel method to reduce electricity consumption costs.
- A precise algorithm to show demand elasticity to electricity prices.
- A simple implementation on any micro controller.

References :

1. K. Sakurama, M. Miura “Communication-Based Decentralized Demand Response for Smart Microgrid”, *IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS*, VOL. 64, NO. 6, pp 5192-5202, JUNE 2017
2. J. Ma, H. Chen, L. Song, Y. Li, “Residential Load Scheduling in Smart Grid: A Cost Efficiency Perspective”, *IEEE TRANSACTIONS ON SMART GRID*, VOL. 7, NO. 2, pp 771-784, MARCH 2016.
3. L. Zhao, Z. Yang, W. Lee, “The Impact of Time of Use (TOU) Rate Structure on Consumption Patterns of The Residential Customers”, *IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, Early access, 2017*.