An algorithm for load curtailment in aggregated demand response program

An Algorithm for Load Curtailment in Aggregated Demand Response Program

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Organization

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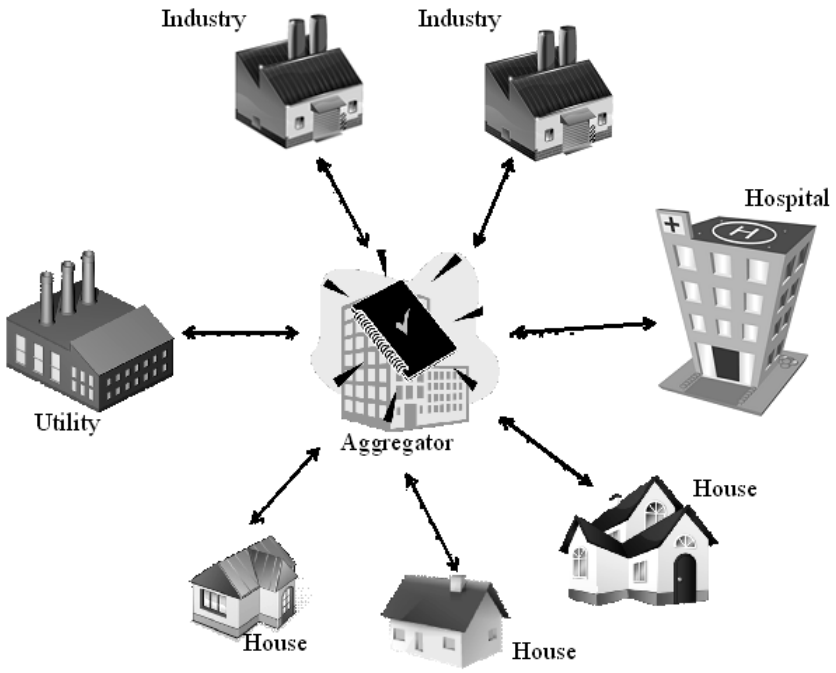
Introduction

- The increase in rate at world energy resources are being consumed have highlighted the importance of energy saving across the globe.
- It has been recognized that investments in Peak Power Demand Management such as load curtailment programs could be significantly more cost effective than building new power plants to supply the peak demand load.
- In the emerging electric power market structures, there are opportunities for third-party aggregators to provide demand side services to multiple consumers
- an algorithm for load curtailment in aggregated demand response program.



Problem Formulation

$$\min_{(P_1,P_2,\ldots,P_n)} \sum_{i=1}^{n} f_i(P)$$

$s.t.$

$$P_1 + P_2 + \ldots + P_n = P_D$$

where;

$$\begin{aligned} 0 < P_1 < P_1^{max} \\ 0 < P_2 < P_2^{max} \\ \ldots\ldots\ldots \\ 0 < P_i < P_i^{max} \\ \ldots\ldots\ldots \\ 0 < P_n < P_n^{max} \end{aligned}$$

Scheduling Algorithm

- Stage 1

$$F_1\left(P_{T_1}\right) = \min_{\left\{(P_1,P_2)|P_1+P_2=P_{T_1}\right\}} \left[f_1\left(P_1\right) + f_2\left(P_2\right)\right]^1$$

- Stage 2

$$F_{n-1}\left(P_{T_{n-1}}\right) = \min\left[F_{n-2}\left(P_{T_{n-2}}\right) + f_n\left(P_n\right)\right]$$

- Stage k

$$F_2\left(P_{T_2}\right) = \min_{\left\{(P_{T_1},P_3)|P_{T_1}+P_3=P_{T_2}\right\}} \left[F_1\left(P_{T_1}\right) + f_3\left(P_3\right)\right]$$

- Final Stage

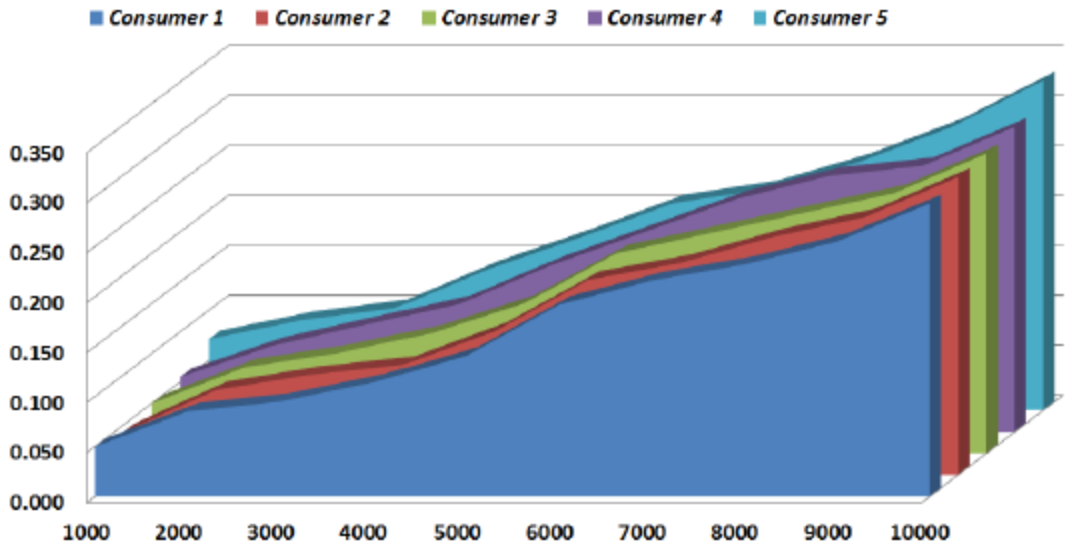
$$F_K\left(P_{T_K}\right) = \min\left[F_{K-1}\left(P_{T_{K-1}}\right) + f_{K+1}\left(P_{K+1}\right)\right]$$

Case Study

TABLE I
DEMAND REDUCTION BIDS PROPOSED BY THE CONSUMERS OVER CORRESPONDING LOAD REDUCTION.

Load Reduction	Consumer 1	Consumer 2	Consumer 3	Consumer 4	Consumer 5
kW	SAR/hr	SAR/hr	SAR/hr	SAR/hr	SAR/hr
1000	0.05	0.043	0.05	0.055	0.071
2000	0.085	0.085	0.086	0.086	0.09
3000	0.095	0.1	0.1	0.107	0.102
4000	0.114	0.11	0.12	0.128	0.141
5000	0.141	0.144	0.15	0.167	0.173
6000	0.192	0.195	0.2	0.2	0.207
7000	0.216	0.212	0.22	0.233	0.221
8000	0.232	0.238	0.24	0.256	0.248
9000	0.255	0.258	0.26	0.266	0.283
10000	0.293	0.298	0.3	0.305	0.33

Case Study


Consumer 1
Consumer 2
Consumer 3
Consumer 4
Consumer 5
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

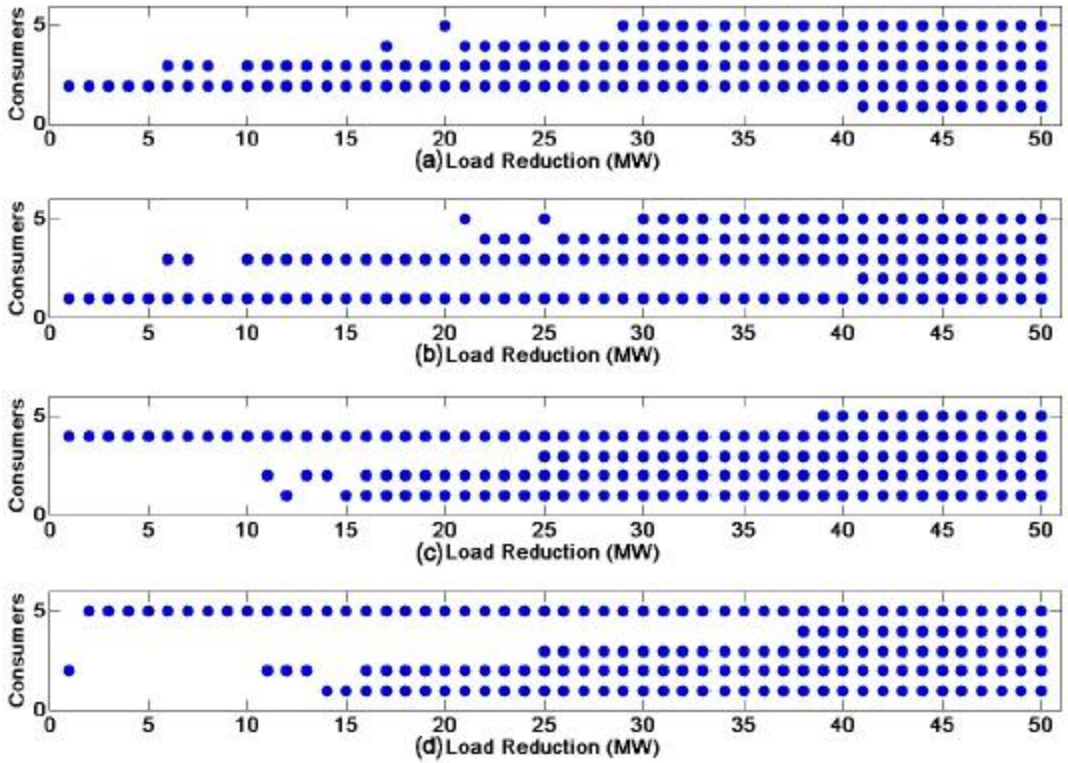
Simulation Results

TABLE II

OPTIMAL SOLUTION GENERATED BY AGGREGATOR TO CORRESPONDING UTILITY LOAD REDUCTION REQUIREMENT.

Utility Load Reduction require-ment	Load Reduction by Consumer 1	Load Reduction by Consumer 2	Load Reduction by Consumer 3	Load Reduction by Consumer 4	Load Reduction by Consumer 5
kW	*kW*	*kW*	*kW*	*kW*	*kW*
2,000	0	2000	0	0	0
6,000	3000	3000	0	0	0
17,000	4000	9000	4000	0	0
26,000	8000	9000	9000	0	0
35,000	8000	9000	9000	9000	0
44,000	8000	9000	9000	9000	9000

Simulation Results



Conclusion

- Algorithm for load curtailment based on dynamic programming in an aggregated demand response program.
- Algorithm provides an optimal solution by using the proposed mathematical framework for aggregated load control.
- The algorithm takes into account the bilateral contract between the aggregator and end-user for curtailment of load over their proposed bidding.
- Results indicate that algorithm provides different solutions as the bidding values change.