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HEURISTIC OPTIMIZATION FOR DEMAND SIDE MANAGEMENT IN SMART GRID

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ABSTRACT:

Demand side management (DSM) is major aspects in a smart grid which allows customers to take decision based on information for their consumed energy, which also helps in reduction of peak load demand for the energy producers which enables the reshaping of the load profile. Advantage of doing this will increase the sustainability of the smart grid and benefits in reduction of operational cost and lower production of green house gases. The various strategies available for demand side management uses an traditional energy management system which possesses and certain disadvantages related to algorithms. Moreover the existing strategies can handle only a limited number of controllable loads with limited types. In this paper presentation related to demand side management is implemented and explained for future grid, termed as smart grid. Load shifting technique before 24 hour was implemented and explained in this paper. Heuristic evolutionary algorithm(EA) is used for solving the minimization problem.

KEYWORDS: Demand side management, heuristic evolutionary algorithm, smart grids, a day ahead forecasting.

INTRODUCTION:

Smart grids are future of electrical grid, integrating advanced sensing technologies,, communication technologies and communication technologies will be employed for give more power to the smart and make capable of storing historical database, so that control operator will be adequate with knowledge to take decisions. Based on the US data the main characteristic of smart grid will be consumer friendliness, self healing property, resistance for attach and it can accommodate all types of loads, storage units, and generation, much better power quality. Smart pricing [1][2]is one of the important characteristic of smart grid, this tasks is accomplished by using the smart metering devices in the automatic metering infrastructure. If this system is employed it may lead to cost reflective based on the entire transmission network of electricity at a certain location, quantity and period. If we use smart pricing then demand side management is under control of the customers and any beyond energy usage will be influenced by real time penalty.

There are various demand side management techniques are available and many techniques had been listed in the literature [4][5][6]. Most of them are system specific strategies, and worst part is some of which may not be applicable to practical systems that includes wide variety of independent devices.

DEMAND SIDE MANAGEMENT TECHNIQUES:

The advantage of using demand side management changes the electricity consumption patterns for reproducing the desired result in terms of load profiles. Many times it is observed that actual consumption profile will largely dependent on the planning objectives of the distribution companies. Demand side management is based on the utilization of power saving technologies [8], savings based on utilization vector, monetary incentives and various other government policies for mitigating the peak loads. If mitigation of peak load is made possible then huge saving in terms of generating plant set up cost can be avoided also transmission and distribution cost is saved. For demand side management various load patterns should be considered as shown in fig. no.1.

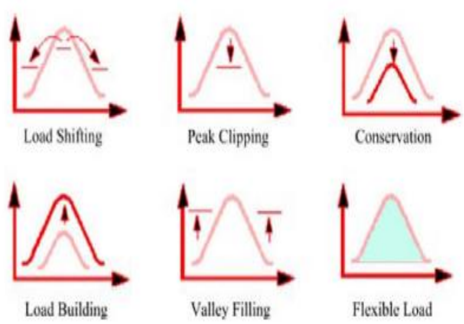

Fig.No.1. Demand side management techniques.

When demand side management techniques are used voltage mitigation techniques should be avoided as it can change the voltage profile. Whenever we implement the demand side management techniques utmost care must be taken to handle communication infrastructure amongst the central controller and certain controllable loads. The very important thing is deciding the optimal load consumption as it can vary widely and it could based on the environment and seasonal changes.

IMPLEMENTED DEMAND SIDE MANAGEMENT STRATEGY:

In this paper generalized day ahead DSM (demand side management strategy for the future of smart grid is implemented. While implementing this load shifting technique had been utilized primary, this task can be accomplished by sing central controller of the smart grid. The main purpose of DSM could be maximizing the used PV cells, Wind power and other renewable source. So that power imported from the distribution grid, or reducing the peak demand, maximizing profit can be achieved.

In fig. no. 2 implemented architecture based on the day ahead DSM in shown in detail. Based on the implemented architecture DSM received the objective load curve as input and then computerized algorithm calculates the required load control for fulfilling the load demand.

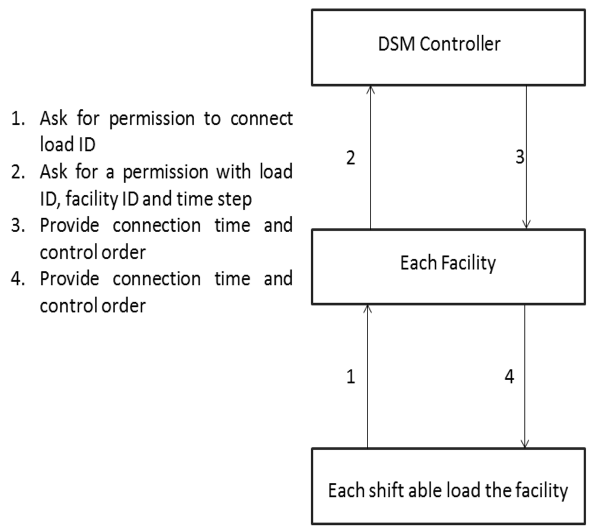

Fig.No. 2. Implemented architecture for DSM

The demand side management is carried out in the beginning of a certain control period which is considered as a day in this implementation. After that control actions are executed in real time. In fig no.2.complete architecture for information exchange demand side management controller

PROBLEM FORMULATION:

The implemented DSM technique uses an connection moments of each shift able device in the system in particular way which will bring the load consumption curve as same as the load consumption cure. Mathematical formulation of the implemented system is presented as follows.

Minimize

$$\sum_{t=1}^{N} (PLoad\,(t) - Objective\,(t))^2$$

The Pload(t) is given by following equation

$$PLoad\,(t) = Forecast(t) + Connect(t) - Disconnect(t)$$

The connect(t) is given by following equation

$$Connect(t) = \sum_{i=1}^{t-1} \sum_{k=1}^{D} X_{kit} \cdot P_{1k} + \sum_{l=1}^{j-1} \sum_{i=1}^{t-1} \sum_{k=1}^{D} X_{ki(t-1)} \cdot P_{(1+l)k}$$

Where Xkit is the number of devices of type K that are shifted from time i to t. D is the number of device types.

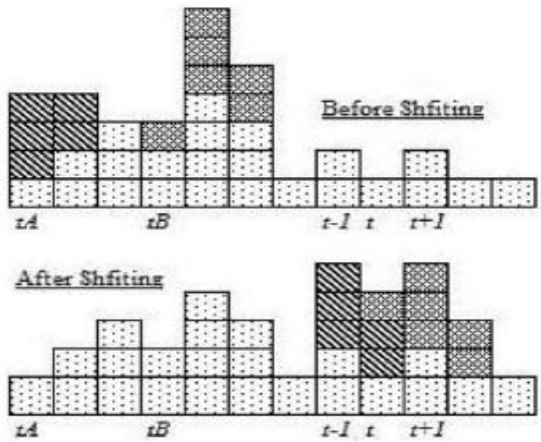

Fig. No.3. connect (t)

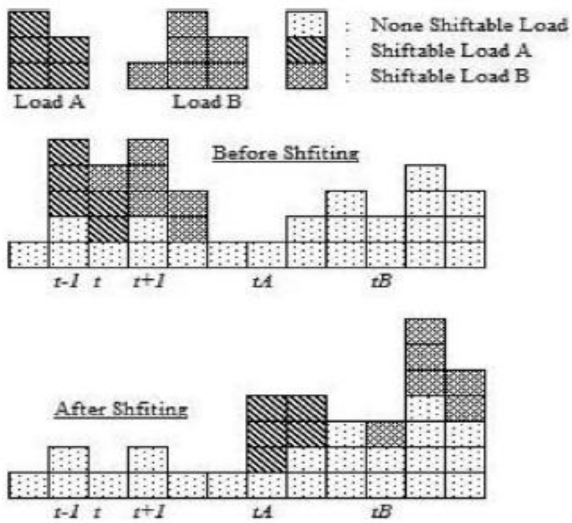

Fig.No. 4.Disconnect(t)

The disconnect equation can be expressed by following equation as follows.

$$Disconnect(t) = \sum_{q=t+1}^{t+m} \sum_{k=1}^{D} X_{ktq} \cdot P_{1k} + \sum_{l=1}^{j-1} \sum_{q=t+1}^{t+m} \sum_{k=1}^{D} X_{k(t-1)q} \cdot I$$

DETAILS OF THE TEST SMART GRID

The proposed DSM technique uses an three different approaches for validation. Customer data base consider are also different and that is based on residential customer, commercial customer and industrial customer.

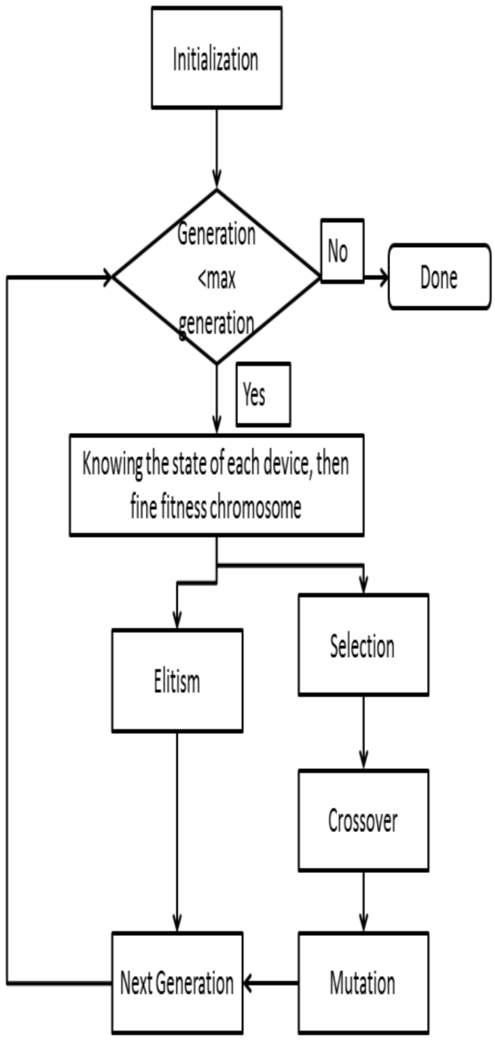

Fig. No.5. Implemented Evolutionary Algorithm

Table No. 1: Forecasted load Demands with wholesale energy prices

TABLE I
FORECASTED LOAD DEMANDS AND WHOLESALE ENERGY PRICES

Time	Wholesale Price (ct/kWh)	Hourly Forecasted Load (kWh)		
		Residential Microgrid	Commercial Microgrid	Industrial Microgrid
8hrs-9hrs	12.00	729.4	923.5	2045.5
9hrs-10hrs	9.19	713.5	1154.4	2435.1
10hrs-11hrs	12.27	713.5	1443.0	2629.9
11hrs-12hrs	20.69	808.7	1558.4	2727.3
12hrs-13hrs	26.82	824.5	1673.9	2435.1
13hrs-14hrs	27.35	761.1	1673.9	2678.6
14hrs-15hrs	13.81	745.2	1673.9	2678.6
15hrs-16hrs	17.31	681.8	1587.3	2629.9
16hrs-17hrs	16.42	666.0	1558.4	2532.5
17hrs-18hrs	9.83	951.4	1673.9	2094.2
18hrs-19hrs	8.63	1220.9	1818.2	1704.5
19hrs-20hrs	8.87	1331.9	1500.7	1509.7
20hrs-21hrs	8.35	1363.6	1298.7	1363.6
21hrs-22hrs	16.44	1252.6	1096.7	1314.9
22hrs-23hrs	16.19	1046.5	923.5	1120.1
23hrs-24hrs	8.87	761.1	577.2	1022.7
24hrs-1hrs	8.65	475.7	404.0	974.0
1hrs-2hrs	8.11	412.3	375.2	876.6
2hrs-3hrs	8.25	364.7	375.2	827.9
3hrs-4hrs	8.10	348.8	404.0	730.5
4hrs-5hrs	8.14	269.6	432.9	730.5
5hrs-6hrs	8.13	269.6	432.9	779.2
6hrs-7hrs	8.34	412.3	432.9	1120.1
7hrs-8hrs	9.35	539.1	663.8	1509.7

Table No.2.Data of controllable devices in residential area

Device Type	Hourly Consumption of Device (kW)			Number of Devices
	1st Hr	2nd Hr	3rd Hr	
Dryer	1.2	-	-	189
Dish Washer	0.7	-	-	288
Washing Machine	0.5	0.4	-	268
Oven	1.3	-	-	279
Iron	1.0	-	-	340
Vacuum Cleaner	0.4	-	-	158
Fan	0.20	0.20	0.20	288
Kettle	2.0	-	-	406
Toaster	0.9	-	-	48
Rice-Cooker	0.85	-	-	59
Hair Dryer	1.5	-	-	58
Blender	0.3	-	-	66
Frying Pan	1.1	-	-	101
Coffee Maker	0.8	-	-	56
Total	-	-	-	2604

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Table No. 3. Data of controllable devices in controllable area

Device Type	Hourly Consumption of Device (kW)			Number Devices
	1st Hr	2nd Hr	3rd Hr	
Water Dispenser	2.5	-	-	156
Dryer	3.5	-	-	117
Kettle	3.0	2.5	-	123
Oven	5.0	-	-	77
Coffee Maker	2.0	2.0	-	99
Fan/AC	3.5	3.0	-	93
Air Conditioner	4.0	3.5	3.0	56
Lights	2.0	1.75	1.5	87
Total	-	-	-	808

Table No.4. Data of controllable devices in industrial area

Area	Cost without DSM ($)	Cost with DSM ($)	Percentage Reduction (%)
Residential	2302.90	2188.30	5.0
Commercial	3636.60	3424.30	5.8
Industrial	5712.00	5141.60	10.0

SIMULATION RESUTS AND DISCUSSION:

From simulation results it has been seen that proposed demand side management strategy has emerge as an cost saving algorithm and objective to bring it near the final condition its been managed to bring the final consumption close predefined load curve. The implemented algorithm has efficiently found useful in reducing the operational cost and peak demand as well as presented in table no. 5 and table no.6.

Table No. 5. Operational cost reduction

Type of Area	Peak Load Without DSM (kW)	Peak Load With DSM (kW)	Peak Reduction (kW)	Percentage Reduction (%)
Residential	1363.6	1114.4	249.2	18.3
Commercial	1818.2	1485.2	333.0	18.3
Industrial	2727.3	2343.6	383.7	14.2

Table No.6. Peak demand reduction

Type of Area	Additional Saving by DSM ($)	Unsatisfied load (kWh)	
		Without DSM	With DSM
Residential	120.34	0	0
Commercial	393.81	0	0
Industrial	443.36	346.34	0
Whole Smart grid	157.4	0	0

Table No.7. Additional saving by generation scheduling

CONCLUSION:

Demand side management is having great potential and by using it one can avail many benefits for the utility as well as smart grid, most importantly at distribution network level. In this paper demand side management strategy with load shifting technique is ben used, mathematical formulation of the same is also been presented in this paper. A heuristic algorithm was been developed for solving the problem. All required simulations were carried out with a developed program and costing in done on dollar basis. And it has been found that if proposed algorithm is calculated then operational cost and peak demand various other benefits can be achieved.

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