Demand Response Optimization using Genetic Algorithm and Particle Swarm Optimization

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Abstract – *Due to increase in population growth demand is also increasing and it is the main issue for utility company to balance consumption and production. In the past problem with insufficient capacity in the grid often affected the supply side only and it was solved by capacity additions, but due to increasing power generating units its affected both environment and economy. And the nightmares will come when peak period will come the demand side response come into play. So, when peak period will come the demand side response comes into play. In demand side response consumer will take part and reduces the load at peak period of time. Smart meter is adopted on demand side so that it gives information to the consumer will take part and reduces the load at peak period of time. Smart meter is adopted in demand side response comes into play. In demand side response consumer will take part and educes the load at peak period of time. Smart meter is adopted on demand side response comes into play. In demand side response consumer will take part and reduces the load at peak period of time. Smart meter is adopted on demand side so that it gives information to the consumer of their electricity used and accordingly they reduce their load. In its total load is divided into two part-elastic and inelastic, and by controlling elastic load total load will be controlled and reduce peak demand and also reduce total fuel cost and electricity bills of consumer. In it one day electricity used by customer is assumed to conduct simulations. As seen from the result, it is found that through elastic load the use of time interval changes, minimum tariff objective can be reached. And by comparing the result for both GA and PSO it is seen that GA gives better results as compared to PSO.*

Keywords: Demand Side Management, Optimization, Genetic Algorithm, Particle Swarm Optimization

1. INTRODUCTION

Peak load demand situations in grid-based energy supply systems, such as electricity, natural gas and district heating, present particular challenges for the generation and transmission of the energy demanded. Each system has to be designed to give uninterrupted service to consumers, within the terms of the particular agreements and tariffs chosen.

In this thesis, electricity use and supply is the major interest. The key components of a liberalized electricity system can be clarified in a following way:

1. Electricity is generated by Producers.

2. The Network Companies (also called 'network owners') are transmitting the electrical energy from the production plants to the Consumers (also here called 'Customers') via the national grid, the regional networks and the local networks. The regional networks transmit power from the grid to the local networks and sometimes to large consumers, e.g. industries. The local networks distribute power to the consumers.

3. The financial transactions are undertaken by Suppliers (also called 'Supply Companies'); these competing companies buy energy from Producers and sell to Consumers. Each of the Supplier and Network Company may be also called a Utility.

4. National grid operator, is responsible for the national grid and has the role of system operator. This means ensuring that production/imports correspond to consumption/exports and that the power system works in a reliable way.

Load demand is an especially sensitive factor in the electricity supply system. Demand (consumption) and supply (production) should be constantly balanced in order to avoid supply interruptions with all their negative technical, economic and social consequences.

If electricity storage is connected in the system (e.g. as pumped hydroelectricity, compressed air storage), then this is a load when being charged, and a supply when being discharged.

Problems with insufficient capacity in the grid in the past often were addressed at the supply side (energy generators and suppliers) and solved by capacity additions. According to Bellarmine (2000), "In generating power the concept has been straightforward. If the society demanded more power, the power companies would simply find a way to supply users even by building more generation facilities. This concept of doing business has been labelled as supply-side management." This was a wide-spread opinion within the energy industry. However, such continuous expansion nowadays would hardly be compatible with a target of sustainable energy systems.

The liberalization of electricity markets brought up new concerns about generation and transmission capacities in many countries. Growing competition among power producers forced them to optimize production and decrease their internal costs. After the liberalization of electricity markets, the focus for solving peak load problems has moved more from the supplier/utility side towards the demand side/consumer.

When discussing load reduction activities, we can note that different actors in the electricity market have different interests in peak load demand reduction, seen from technical, economic, environmental and social perspectives.

2. LITERATURE REVIEW

This literature survey intended to provide information to understand the context of this research. Proposed architectural model, control strategies and different methods discussed briefly.

Yamille Del Valle [2008]: In this paper presents a detailed overview of the basics concepts of PSO and its variants .Also, it provides a comprehensive survey on the power system applications that have benefited from the powerful nature of PSO as an optimization technique .For each application, technical details that are required for applying PSO, such as its type, particle formulation ,and the most efficient fitness function are also discussed.

Jian Jiao [2010]: In this paper present a overview of the basics concepts of PSO according to continuous PSO and discrete PSO. The difference between single objective PSO and multi objective PSO is presented. At the same time an implementation of PSO in multi objective optimization is discussed. To overcome the limitations of PSO, hybrid optimization algorithms are proposed.

Zhiyu You [2010]: In this paper presents an adaptive weight Particle Swarm Optimization algorithm with constriction factor is proposed combined with an analysis of convergence of Particle Swarm Optimization algorithm .The value of the inertia weight is set according to dynamic information about the changes in the objective function value, as to effectively balance the advantages of global optimization against the shortage of local optimization .

M. Marwan [2006]: In this paper presents a demand side response scheme, which assists electricity consumers to proactively control own demands in such a way to deliberately avert congestion periods on the electrical network. The scheme allows shifting loads from peak to low demand periods in an attempt to flattening the national electricity requirement. The scheme can be concurrently used to accommodate the utilization of renewable energy sources, that might be available at user's premises. In addition, the scheme allows a full capacity utilization of the available electricity infrastructure by organizing a wide –use of electricity vehicles.

Marwan Marwan [2008]: This research aimed to develop consumer demand side response model to assist electricity consumers to mitigate peak demand on the electrical network. The model developed demand side response model to allow consumers to manage and control air conditioning for every period, it is called intelligent control. The result indicates the potential of the scheme to achieve energy savings, reducing electricity bills to the consumer and targeting best economic performance for electrical generation distribution and transmission.

Duy Long Ha [2008]: This paper focuses on Demand side load management applied to residential sector. A multi-scale optimization mechanism for demand side load management is proposed. It compose the Agent Management of Energy, it carries out the distribution of the energy of the housing by proposing a dynamically threshold of total energy consumption will be applied to each household .The home automation system integrated in each household plays the role of controlling all the energy consumption in the housing by using service flexibilities, which have the possibilities to be modified and controlled.

Chao-Rong Chen [2013]: This paper proposes a method of minimizing tariff for customers through changing elastic load use time intervals where customers electricity use time is divided into inelastic and elastic intervals by electricity use characteristics. By use of genetic algorithm it is found that through elastic load use time interval changes, minimum tariff objective can be reached, and feasibility of the proposed method is verified.

Abaravicius J. [2006]: This study aims to discuss the possibilities and the benefits of using interval (hourly) metering data from residential consumers. Through the analysis of strengths and weaknesses of different load analysis tools, this paper defines the knowledge they could give, how applicable they are and what value they could have both for the utility and for the residential customer. The study is exemplified with ten cases of households with electric space heating in Southern Sweden.

Abaravicius J. [2007]: This paper reports about a study conducted with the objective of developing a detailed load demand analysis for commercial buildings. This study was performed in collaboration with IKEA and E. ON and contributes to an ongoing IKEA energy efficiency programme. Two sample department stores in Sweden were selected and analysed within this project. The demand data analysis covers almost three years period, 2004-2006.

Abaravicius J [2005]: The objective of this study was to experimentally test and analyse the conditions and potential of direct load management from customer and utility viewpoint. Techno economic and environmental aspects as well as customer experiences were investigated. Space heating and hot water systems in ten electric-heated houses were controlled by the utility using an existing remote reading system.

Pyrko J. [2003]: The objective of this study is to investigate the extent to which a Load Demand Component, included in electricity pricing, can influence energy use and load demand in residential buildings. This paper investigates the impact of the new tariff on the utility and different types of typical residential customers, making comparisons with the previous tariff.

Abaravicius, J. [2006]: The key objective of this study is to discuss the possible environmental benefits of load management and evaluate their significance, primarily focusing on CO2 emissions reduction. The analysis is carried out on two levels: national – the Swedish electricity market, and local – one electric utility in southern Sweden.

Shockman Ch. [2006]: This study examines the limits and possibilities of environmental decision making by local managers of multinational operations such as IKEA managers. Some definitions were provided to general store employees to determine their reaction to a program called "demand response". The power and authority of local managers to respond quickly to potential social problems is examined. The formal decision-making process is explicated and projections about future avenues of approach for environmentally desirable projects are included. This study provides insight for other socially desirable environmental projects that face adoption difficulties in large, complex organizations.

3. ECONOMIC LOAD DISPATCH

Economic load dispatch is one of the basic optimization problems in power system analysis. The main focus of ELD is to get out the optimal arrangement of power generations is equivalent to total power demand at least possible cost while maintain the power generators and system constraints. The cost of generation, especially in thermal power plants, is more, hence suitable arrangement of unit outputs can give to outstanding saving in operating cost.

The optimization of economic load dispatch problem involves the answers of two different problems. The first one is the unit commitment or pre dispatch problem wherein it is required to choose the more desirable way out of the accessible generating sources to run to assemble the expected load and give a define margin of operating reserve over a define period time. Another one feature of economic dispatch is the on line economic dispatch whereas it is need to scatter load among the generating units indeed paralleled with the system in such way as to reduce the total cost of supplying the moment to moment requirements of the system.

4. RESULTS AND DISCUSSION

For optimize our laod we used two optimization technique GA and PSO and compare the result by using these two technique.

We discuss case study on three customer schedule 24 hour power use. In this section we draw four graph for each customer .1) Load curve before optimization . 2) cost curve before optimization. 3) Load curve after optimization. 4) cost curve after optimization . When we analysis all these graph it is clearly shown how how load and cost is reduces after optimization and it directly reduces our tarrif also.

Some assumption in Load curve:
Maximum load :1.6MW

Red line : Inelastic load

Green line : Elastic load

Blue line : Total load (Elastic+Inelastic laod)

Case 1: Electricty Scheduling of Customer by using Genetic Algorithm

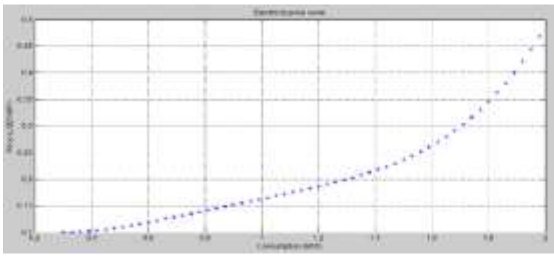

Figure 4. 1 Electricity Price Curve

Electricity Scheduling of Customer 1

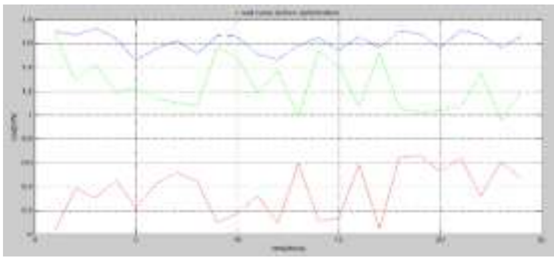

Figure 4. 2 Load Curve Before Optimization

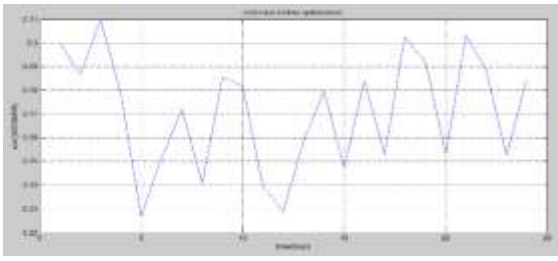

Figure 4. 3 Cost Curve Before Optimization

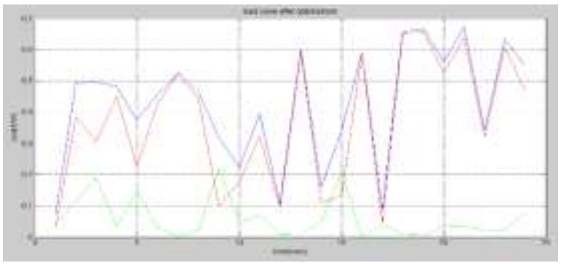

Figure 4. 4 Load Curve After Optimization

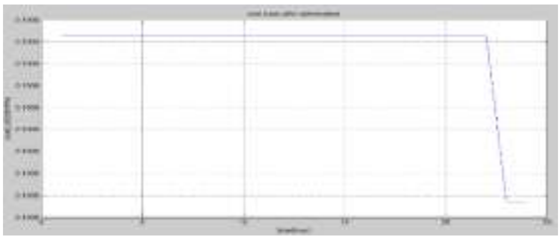

Figure 4. 5 Cost Curve After Optimization

Electricity Scheduling of Customer 2

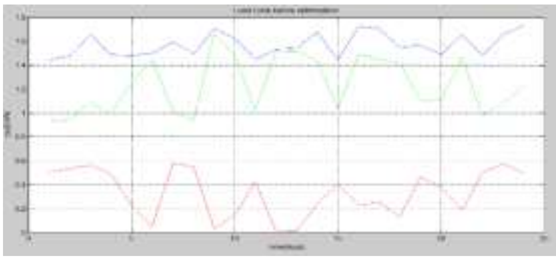

Figure 4. 6 Load Curve Before Optimization

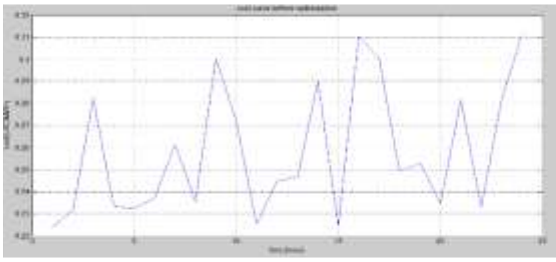

Figure 4. 7 Cost Curve Before Optimization

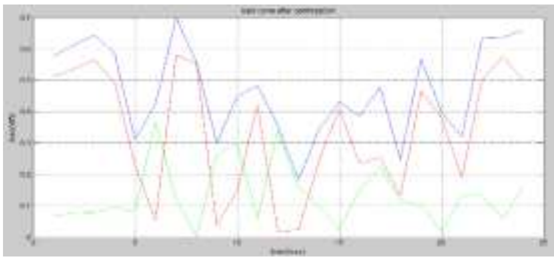

Figure 4. 8 Load Curve After Optimization

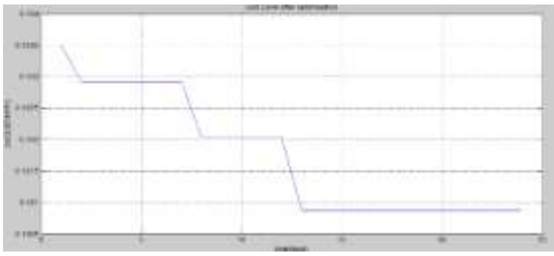

Figure 4. 9 Cost Curve After Optimization

Electricity Scheduling of Customer 3

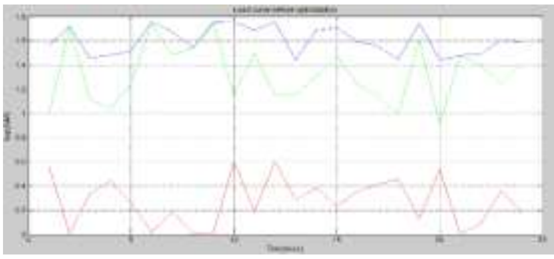

Figure 4. 10 Load Curve Before Optimization

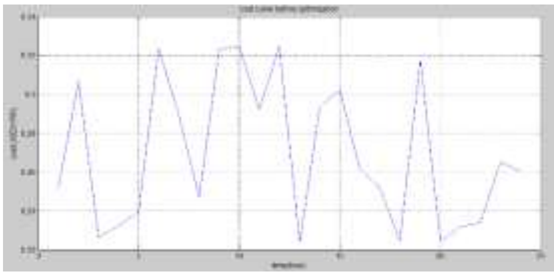

Figure 4. 11 Cost Curve Before Optimization

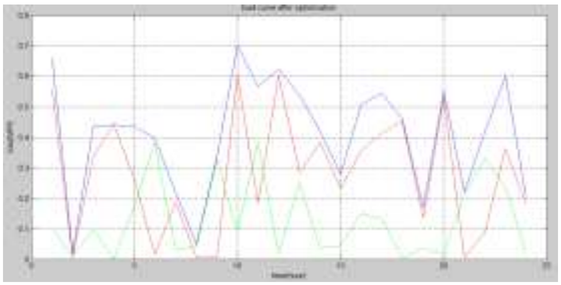

Figure 4. 12 Load Curve After Optimization

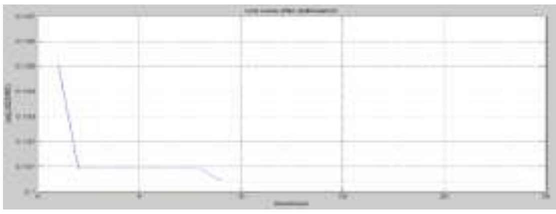

Figure 4. 13 Cost Curve After Optimization

Electricty Schedule of Customer by using Genetic Algorithm

Customer	Maximum Elastic Load Before Optimize	Maximum Elastic Load After Optimize	Total Maximum Load Before Optimize	Total Maximum Load After Optimize	Maximum Cost Before Optimize	Maximum Cost After Optimize
1	1.68	0.24	1.70	0.68	0.31	0.1009
2	1.62	0.38	1.75	0.70	0.31	0.1035
3	1.70	0.39	1.78	0.70	0.325	0.1050

Table 4. 1 Electricity Schedule Before and After Optimization

Case 2: Electricty Scheduling of Customer by using PSO

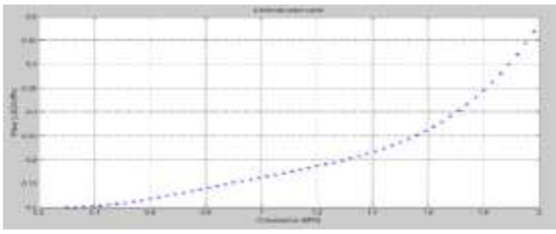

Figure 4. 14 Electricity Price Curve

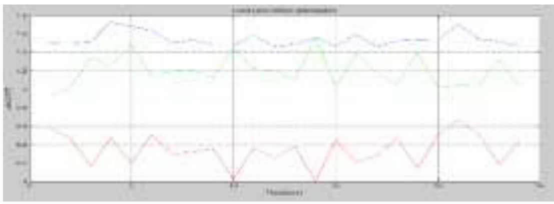

Figure 4. 15 Load Curve Before Optimization

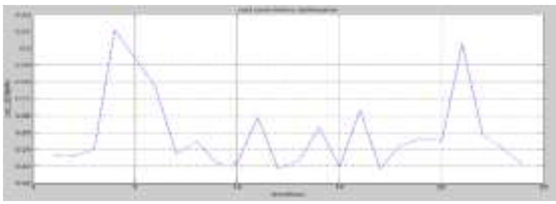

Figure 4. 16 Cost Curve Before Optimization

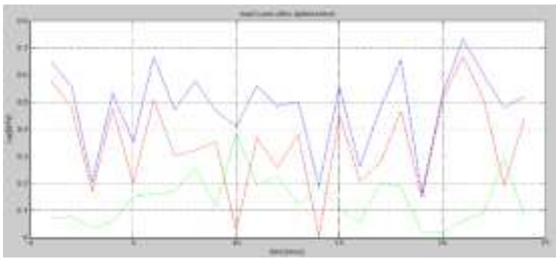

Figure 4. 17 Load Curve After Optimization

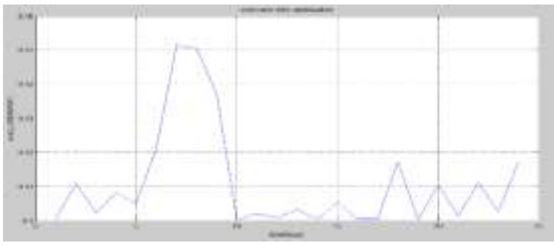

Figure 4. 18 Cost Curve After Optimization

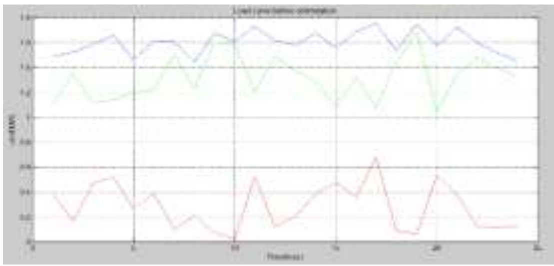

Figure 4. 19 Load Curve Before Optimization

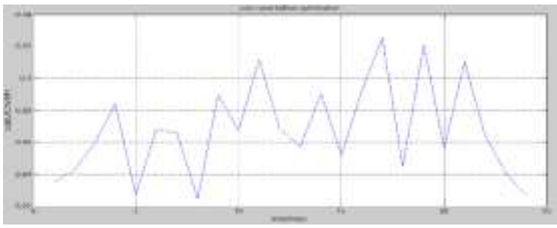

Figure 4. 20 Cost Curve Before Optimization

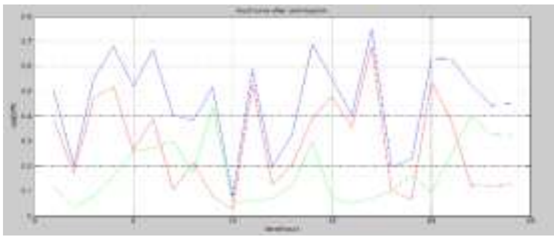

Figure 4. 21 Load Curve After Optimization

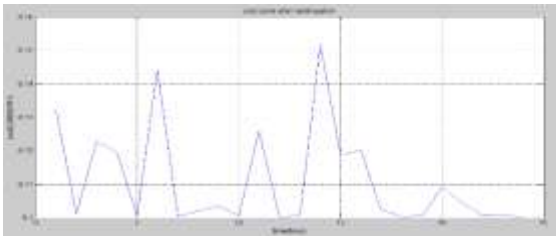

Figure 4. 22 Cost Curve After Optimization

Electricity Scheduling of Customer 3

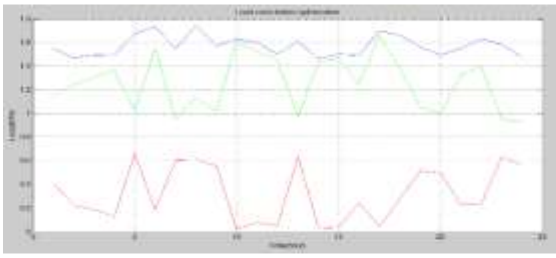

Figure 4. 23 Load Curve Before Optimization

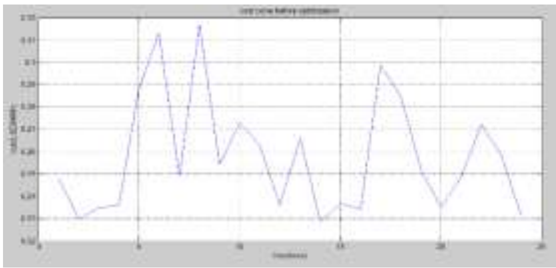

Figure 4. 24 Cost Curve Before Optimization

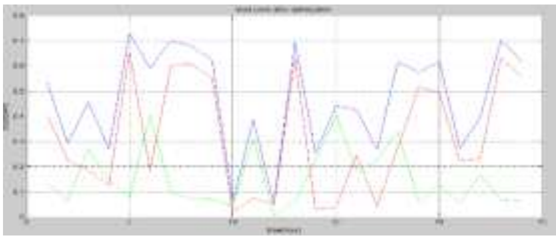

Figure 4. 25 Load Curve After Optimization

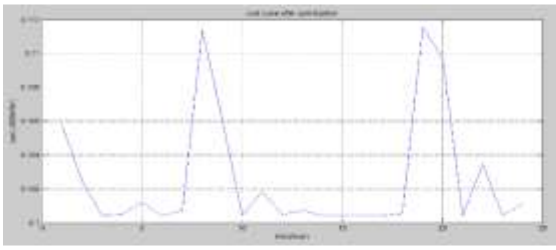

Figure 4. 26 Cost Curve After Optimization

Electricty Schedule of Customer by using PSO

Customer	Maximum Elastic Load Before Optimize	Maximum Elastic Load After Optimize	Total Maximum Load Before Optimize	Total Maximum Load After Optimize	Maximum Cost Before Optimize	Maximum Cost After Optimize
1	1.58	0.38	1.75	0.72	0.312	0.152
2	1.69	0.48	1.78	0.75	0.324	0.152
3	1.66	0.40	1.76	0.72	0.318	0.1118

Table 4. 2 Electricity Schedule Before and After Optimization

COMPARISION BETWEEN GA AND PSO:

So, by comparison of table 1, table 2 and table 3 we can say that both methods optimize in better way. But GA gives better result as compare to PSO, in all cases and for all elastic load, total load and cost. So we prefer GA method for optimization.

Customer 1: table 1 shows the maximum elastic load before and after optimize, total maximum load before and after optimize and maximum cost before and after optimize between Genetic Algorithm method and Particle Swarm Optimization method.

	Maximum Elastic Load Before Optimize	Maximum Elastic Load After Optimize	Total Maximum Load Before Optimize	Total Maximum Load After Optimize	Maximum Cost Before Optimize	Maximum Cost Before Optimize
GA	1.68	0.24	1.70	0.68	0.31	0.1009
PSO	1.58	0.38	1.75	0.72	0.312	0.1520

Table 4. 3 Comparison Table for Customer 1

Customer 2: table 2 shows the maximum elastic load before and after optimize, total maximum load before and after optimize and maximum cost before and after optimize between Genetic Algorithm method and Particle Swarm Optimization method.

	Maximum Elastic Load Before Optimize	Maximum Elastic Load After Optimize	Total Maximum Load Before Optimize	Total Maximum Load After Optimize	Maximum Cost Before Optimize	Maximum Cost Before Optimize
GA	1.62	0.38	1.75	0.70	0.31	0.1035
PSO	1.69	0.48	1.78	0.75	0.324	0.152

Customer 3: table 3 shows the maximum elastic load before and after optimize, total maximum load before and after optimize and maximum cost before and after optimize between Genetic Algorithm method and Particle Swarm Optimization method.

	Maximum Elastic Load Before Optimize	Maximum Elastic Load After Optimize	Total Maximum Load Before Optimize	Total Maximum Load After Optimize	Maximum Cost Before Optimize	Maximum Cost Before Optimize
GA	1.70	0.39	1.78	0.70	0.325	0.105
PSO	1.66	0.40	1.76	0.72	0.318	0.1118

5. CONCLUSION

In this thesis we made a model for the economic dispatch problem integrated with stochastic demand side management. Our model proposes a solution for the economic dispatch problem and reduces the load by providing the chance to the user to engage and supervise their load according to their requirement by combine the demand side management.

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