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Automatic Load Shifting Techniques for Reduction of Peak Generation using Matlab Simulation

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***Abstract*— The current state of distribution equipment has changed due to the conversion of energy systems and the implementation of demand-side management. Peak load control is important for utilities as energy costs rise. Energy suppliers include demand-side control in their technical plans without imposing limits corresponding to customer comfort or high energy quality levels. This study proposes an automatic crushing strategy for commercial users to move their luggage at specific times. A set of rules have been developed to shift controlled loads from peak hours to off-peak hours to reduce high load and flow. The shift in this approach depends on load concerns and time of day hundreds of times. Experimental evaluations are performed using strength controllers and optimization approaches, each taking into account specific branches with their own stress priorities.**

Keywords*— Smart Grid; Energy Management System; HEMS, Load Shifting, Demand Side Management (DSM) Time of Day Tariff.

I. INTRODUCTION

In this paper, we describe the various factors which are necessary for the load management of a system. Demand-side management is an important factor in energy management for smart grids. This usually refers to a program implemented by an energy supplier to limit energy consumption on the part of the customer. Installing load management activities is very useful for balancing supply and demand. Introduce Time of Day (TOD) tariffs as part of the demand facet management scheme to encourage users to use electricity smarter.

In the industry, consumers use certain types of loads with their own type of power consumption. This paper presents a satisfactory way for the industry to efficiently transport energy during peak hours and retain load with the additional power of PV parks. Recently, enterprise power management has become an important issue and many demand facet management strategies for planning manufacturing units have been proposed. We proposed an optimization method mainly based on linear programming. This white paper provides a way to move the load to a specific time during peak hours of spikes and stinks of the day. The set of rules used in this document is device-specific to minimize peak load or power generation. In this document, the algorithm calculates the cycle of turning on and off a group of manufacturing units. At some point during the management period, you can often manage each institution. Pre-diagnosed group size and algorithmic planning for each facility, taking into account that the body weight intake of the last tissue is constant and the results obtained are not optimal. This algorithm also reduces peak load and manufacturing costs. There are many technologies and rules developed for on-demand load control, the main purpose of which is to reduce the greatest needs in terms of machine and operational costs. DSM programs have been proposed primarily on the basis of load-shifting methods that can control large numbers of controllable devices using genetic algorithms. This set of rules manages controllable load transmission times to reduce power demand and application charges. These strategies can be an overview and are mathematically proven, but can be very difficult for the average user to follow. The longer the operation period, the longer the calculation time.[1]-[2]

This work provides a demand-side load management method based on load shift technology. It is less complex and requires less computation time. The load shift algorithm adjusts the controllable load from peak to off-peak to reduce peak demand and energy costs from a utility perspective. This method shifts the load based on priority and different power consumption at different times of the day. The purpose of this paper is to propose load fluctuations in the microgrid of industrial models using Matlab / Simulink.

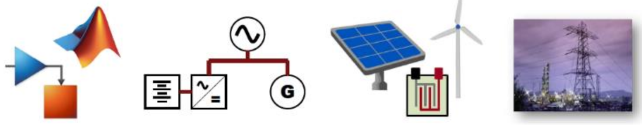

Fig. 1 Load shift and demand response using optimization in Matlab

II. LOAD SHIFTING TECHNIQUES

The most important program on the smart grid is management on the demand side. It represents a strategy for monitoring and regulating the effective use of electrical energy on the part of consumers. The demand-side management system changes the pattern of energy consumption in response to the desired changes in the load shape of the distribution system. The main purpose of DSM is to reduce peak demand, reduce power supply from the grid, or reduce operating costs. DSM also recommends that users use less power during peak hours and shift energy consumption during off-peak hours to flatten the target load curve. Six different load management approaches are commonly used to adjust the shape of the load. Load shift, peak clipping, valley filling, load growth strategy, conservation strategy, and flexible load geometry [4]-[10]

a. Peak Limit Reducing the peak load over a specific time period means that some of the load is limited to a specific time of the day.[1]

b. BC valley means increasing the load during the off-peak period, which means increasing energy consumption during this period. [2]

c. Load shift Reduction of peak demand load for shifting peak load to off-peak. [4]

d. Strategic energy savings to reduce overall load requirements through more efficient use of energy. [1]

Example: Load increase strategy to increase overall load demand and improve consumer productivity and quality of life.

The fundamental aim of the Peak c1ipping and valley filling technique is to lower the variance of call for for the duration of top and valley times, therefore decreasing the stress of excessive call for at the system. By shifting hundreds from top to off top hours, the burden moving approach combines the blessings of those strategies.

III. METHODOLOGY

A. Mathematical Model

The suggested load shifting algorithm shifts the system's controllable / shift-able load in such a way that the load consumption curve is as close to the desired load curve as possible. As a result, the suggested load shifting method is theoretically defined as:

$$Minimize \sum_{t=1}^{24} (PLoad(t) - ObjectiveLoad(t))$$

Where Objective Load (t) is the value of the target load curve at time t, and PLoad (t) is value of actual load after load shifting at time t. The Pload (t) is known by equation:

$$PLoad(t) = forecast(t) + connect(t) - disconnect(t)$$

Where, forecast (t) is the forecasted load at time t,

and connect (t) is the load which connected at time t, and disconnect (t) is the load which disconnected at time t for the duration of load shifting. Figure 3 shows the forecasted load, connected load, disconnected load and load after shifting i.e. PLoad (t).[9]

The purpose of the load shift algorithm can vary from utility to utility. The main goal of the utility is to reduce fluctuations in demand at different times of the day. As a result, utilities are relieved of the burden of building additional power plants to meet peak demand and reduce energy waste during the valley. As consumers seek to reduce energy prices, demand-responsive goals on the demand side can shift from one utility to the next. This study describes the adaptability of the proposed method used to generate a completely independent objective load curve.[9]

B. Proposed Load Shifting Algorithm

1) Load Shifting

Load shifting is a means to make load management easier and more efficient. Minimize peak demand by shifting the load to off-peak and partial load periods. This strategy does not affect overall energy consumption and is very easy to implement. Use this strategy to move or reschedule the load and not shut down the load. Since it is not possible to shift or reschedule all loads, this approach requires choosing a load that can be carried over to another time period.[4]

2) Peak Demand Shift

To balance the low peaks on the demand side, PV arrays were installed to maintain the balance of load demand through the energy management system.

Numerous batteries were used in a linked configuration, along with a photovoltaic system or PV park to store energy from photovoltaics.

During peak demand, storage tanks are used to power freely linked PV and energy management systems.[10]

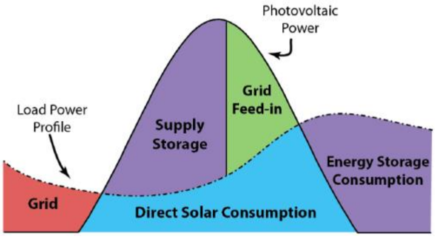

Fig. 2 Peak Demand shift using energy management

3) Energy Management System

The grid consists of distributed PV generation connected to the utility grid. Figure 3. Microgrid power management mode and various features.[8]

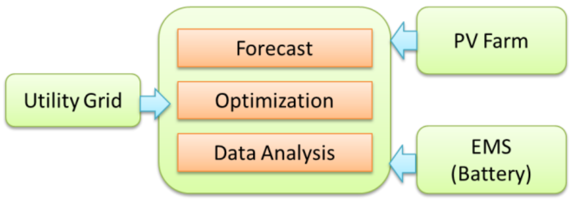

Fig 3. Micro-grid energy management System

Problem has been solved by using linear programming based algorithm which balance the utility grid at on and off peak load. Implementation of Energy management logic can be seen in the flow chart.

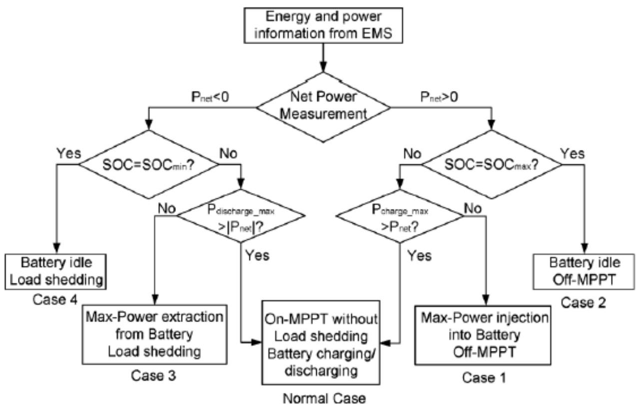

Fig.4 Flowchart for Energy Management Logic

4) *Industrial Load*

Industrial loads can be c1assified into two types:

a. Fixed load: - These types of loads have fixed power requirement and also need a continuous power supply. These types of loads are not shifted to any other time.[13]
b. Shiftable load: - These types of loads can be shifted or scheduled at any other time. Shift ability is c10sely related to consumer's needs or convenience. In this paper shiftable loads can be divided into three priority loads. Some loads have higher priority than other loads.[13]

IV. IMPLEMENTATION OF PROPOSED ALGORITHM

To test the effectiveness of the proposed algorithm, load the data from the housing sector. Consider the industries and the hourly forecast load data supplied by industries. Set the control period to 24 hours (that is, T = 24) and the time interval to 1 hour. [15]

Every industry has some significant loads. That is, there are fixed loads that do not shift in any period, and some shift able loads. Displaceable loads can be divided into three priority loads. Some loads have a higher priority than others.

A. *Linear Program-based Algorithm*

Standard form of for the linear program (LP) -lapdog

$$\min_x f^T x \text{ such that } \begin{bmatrix} A.x \le b \\ A_{eq}.x = b_{eq} \end{bmatrix}$$

Define states (x) necessary for linear optimization

$-P_{grid}(1:N)$

$-\, power\ from\ grid\ used\ from\ time\ step\ 1\ to\ N$

- $P_{batt}\ (1:N) - power\ from\ battery$

$E_{batt}\ (1:N) - Energystored\ in\ battery$

$$x = P_{grid}(1:N) \quad P_{batt}(1:N) \quad E_{batt}(1:N)T$$

Equivalent Constrains:

$$\begin{bmatrix} I_{N\times N} & I_{N\times N} & 0_{N\times N} \\ 0_{N\times N} & \gamma_{N\times N} & \Phi_{N\times N} \end{bmatrix} x = \begin{bmatrix} P_{load}(1:N) - P_{pv}(1:N) \\ E_{batt}(1) \\ 0_{N-1} \end{bmatrix}$$

$$\gamma_{N\times N} = \begin{bmatrix} 0 & 0 & 0 \\ \Delta T & 0 & 0 \\ 0 & 0 & \Delta T \end{bmatrix} \qquad \Phi_{N\times N} = \begin{bmatrix} 1 & 0 & 0 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$$

Inequality Constraints:

$$\begin{bmatrix} O_{N\times N} & I_{N\times N} & O_{N\times N} \\ O_{N\times N} & -I_{N\times N} & O_{N\times N} \\ O_{N\times N} & O_{N\times N} & I_{N\times N} \\ O_{N\times N} & O_{N\times N} & -I_{N\times N} \end{bmatrix} \mathrm{x} \ge \begin{bmatrix} P_{max} \\ -P_{min} \\ E_{max} \\ -E_{min} \end{bmatrix}$$

Forecasted load data for proposed TOD pricing scheme shown in Figure 6.

The industry's maximum load requirement is 2.88KW. Load collapse technology shifts the load during rush hours to off-peak hours to the level of the load consumption curve. [12]

In general, a normal day is morning during the off-peak hours, and evening during peak hours of the load consumption curve. If the load shift control period is 24 hours, the peak load cannot be transferred to valley time. Therefore, in this study, the load collapse control period begins at the 17th hour of the day, in which case the load collapse technique is simply performed.[5]-[6]

V. SIMULATION MODEL AND RESULTS

With variable load at different times of the day connected to renewable energy sources as PV parks to balance the demand load of the industry with optimized energy management system using optimization technology Designed an industry micro grid model. The Matlab simulation design reflects the results before and after the optimization, shifting the load to a specific time during successful execution. This model simulates a 24-hour execution cycle depending on industrial demand.[14]

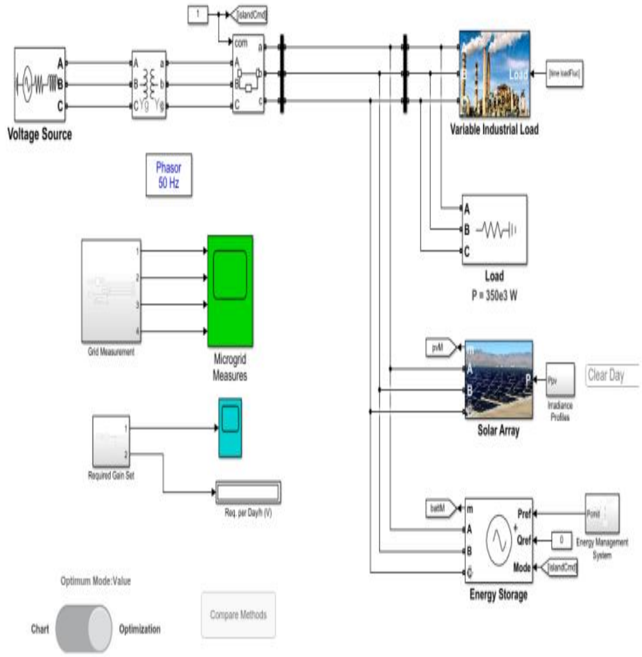

Fig.5 Matlab Simulation model of microgrid connected with PV and ESS for industries.

In this case, the simulation was simplified to a single 24-hour branch which is shown in figure 6 of TOD Pricing Scheme.

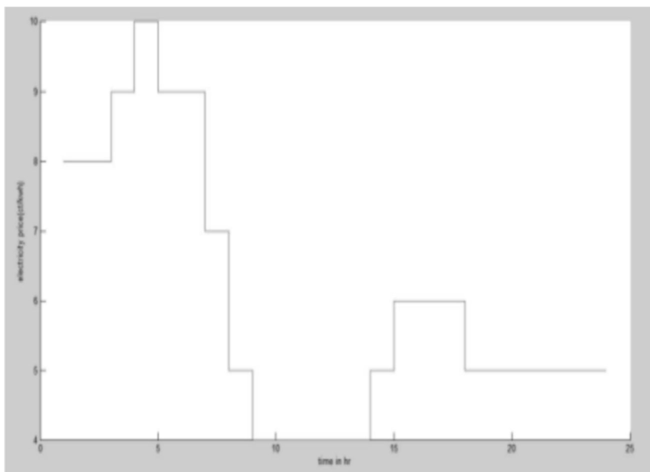

Fig.6: TOD Pricing Scheme

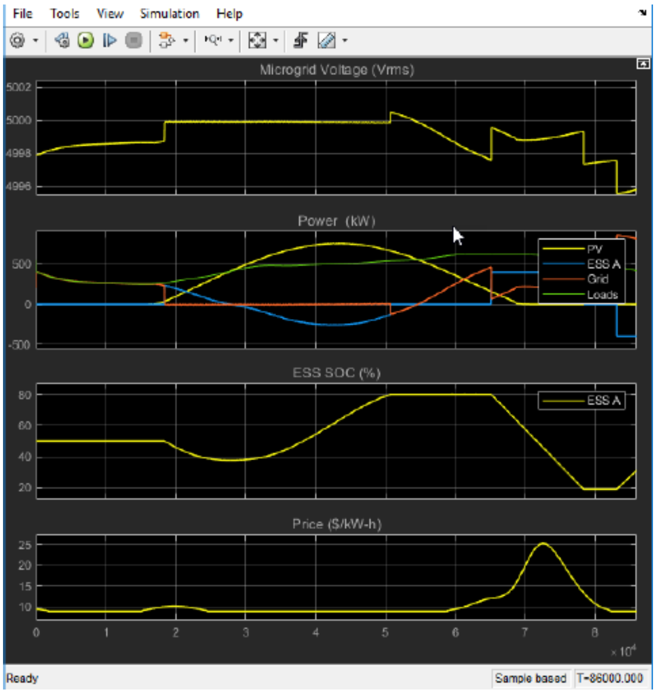

Fig. 7: Heuristic Micro-grid Results without optimization

The proposed algorithm reduces energy costs as well as peak demand. In this case, the results show peak demand and energy costs with and without industry load-shifting algorithms using optimization techniques in PV-connected grid energy management systems. [11]

The first plot shows the voltage and the second plot shows the voltage for different loads. PV balances demand and ESS balances declines at peaks at various times. The third plot is the ESS SOC of the ESS and the fourth plot is the cost of the layer.

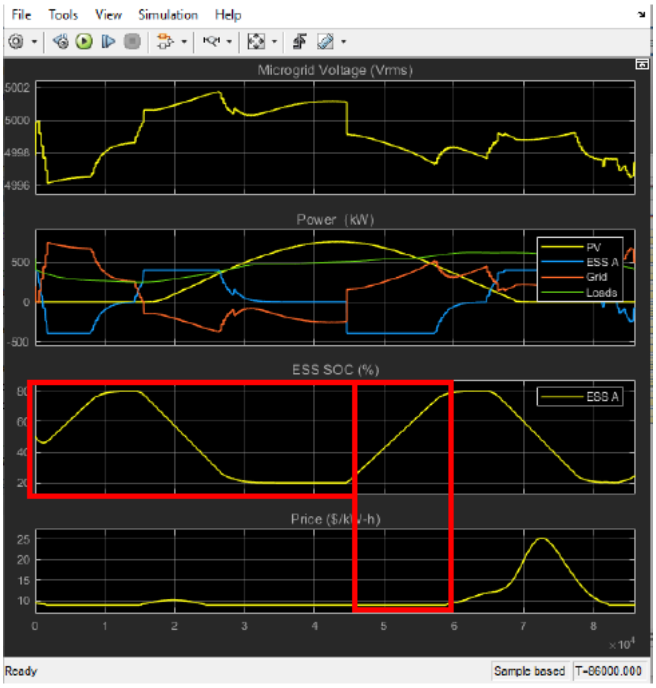

Fig. 8: DSM Optimized Result for Micro-grid.

VI. CONCLUSION

In this paper, we proposed a load collapse technology for load management on the demand side (consumer side). This load shift algorithm works well to balance and smooth load demand throughout the day without reducing overall energy consumption. The algorithms developed in this work are based on shift able consumer priorities. This depends on the consumer and the time of day. Unlike other papers, load-shift algorithms are developed using a traditional approach that takes less time to execute. It has been shown that the implemented strategy of shifting consumer load to the right time to reduce peak load and utilities is unloaded.

It also reduces electricity bills. The load shift algorithm can shift the controllable load to the appropriate time, that is, off-peak hours, to reduce peak demand. This proposed algorithm not only reduces consumer costs, but also power generation costs. The optimized model allows the consumer industry to balance industrial load and electricity and maintain the cost and efficiency of electricity throughout the day. It is possible to implement this algorithm in multiple industries.

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