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Maximum Demand Management: An overlooked energy saving opportunity in industries

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Abstract. Maximum demand management is always overlooked as an energy saving opportunity in industry. Maximum demand charge is part of total electricity charges of an Industrial energy tariff and contributes around 20% of the total electrical energy bill. An energy audit conducted in an Industry revealed an opportunity of reducing the total plant maximum demand of average from 2736 kW to 2220 kW saving up to RM 17,000 on an average/month. The paper briefs the process re-engineering and technologies that could be used in the plant to reduce up to 20% Maximum demand charges from the total electricity bill. This can bring in a significant saving with minimal investment and is sustainable.

1. Introduction

All industrial sectors, the need for continuous enhancement in competitiveness necessitates enhancement of the quality to cost ratio of the products. This demand, besides all other aspects, very tight regulation of the production costs. It is an obvious observation that the factory managers often neglect the influence of energy costs in general, especially electricity costs. This could be either due to their minor impact on total costs or perhaps they are regarded as “non-manageable”. But a quick investigation will reveal that by taking benefit of incentives and favourable pricing policies offered by utilities, consumers could be encouraged to utilize power in such a way that the utility can manage load patterns. Taking advantage of these incentives in the best possible ways, significant savings in production costs could be realised and that too without compromising the product quality or productivity. Maximum demand (MD) control is a well-known technique by means of which electric power consumers could avoid the penalties due to MD charges, imposed by the energy supplier, and is in use under a great number of tariff schemes [1].

Maximum Demand is the highest load levied by the end-user to the utility supply system at any point in time. The utility supplier needs to accommodate to this peak load whenever necessitated by the consumer. Since there is no practice of storage, electricity generation, should be sufficient to meet the highest possible demand. Maximum Demand tariffs are designed to replicate the time of day of its usage. Under such circumstances, most tariffs for bigger end-users are structured to encourage customers to cut-down their power demand during daytime peaks. The end user can shift the daytime usage to the off-peak night hours and take advantage of the lower night rate for electricity. The Maximum Demand charge is being practised by most utilities throughout the world. Mohamed and Khan [2] concluded that

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load management initiated by customers on the demand side was based on the implementation of strategies that lead to a reduction of electrical energy consumption.

The objective of this work is to highlight the importance of Maximum demand measurement and control in an energy conservation viewpoint industries and also to create an awareness on energy and money that could be saved with little investment. Some case studies are discussed here to establish the hypothesis. The savings made and the techniques used all may vary according to the nature of the industry and their operation management.

2. Measurement of Maximum Demand

Maximum Demand, usually measured in kiloWatts (kW) in Malaysia, defined as the maximum level of electricity demand observed during a specific period, which will be typically for a month. Maximum Demand for particular month usually will be twofold of the largest kilowatt-hours (kWh) supplied during any successive half an hour(30 minutes) for that particular month. According to Kumari et al [3], the forecasting of MD will result in cutting down the extra bill charges. The MD could be evaluated either graphically or mathematically and will help in controlling the total demand, and reduce the effective cost.

Even though a lot of information is available on the theoretical and those based on practice for demand response, little study is seen to be done on the relationship between demand management and energy conservation/ efficiency [4]. Matenaer [5] in their findings mentions customers could reduce their peak demand/ Maximum demand by an average of 21% with simple energy management techniques. Masri and Halim [6] discussed in their work that the annual electrical power demand for Malaysia is predicted to escalate to 206 TW/h by 2035 and one of the measures to counter this crisis would be Demand Side Management (DSM) like increasing energy efficiency, control on maximum demand etc.

2.1. Calculation of Electricity Cost.

Table 1: Tenaga Nasional Berhad, Malaysia Commercial Tariffs

COMMERCIAL TARIFFS	COST
TARIFF B - LOW VOLTAGE COMMERCIAL TARIFF	
For the first 200 kWh (1 -200 kWh) per month	43.5 sen/kWh
For the next kWh (201 kWh onwards) per month	50.9 sen/kWh
TARIFF C1 - MEDIUM VOLTAGE GENERAL COMMERCIAL TARIFF	
For each kilowatt of maximum demand per month	30.3 RM/kW
For all kWh	36.5 sen/kWh
TARIFF C2 - MEDIUM VOLTAGE PEAK/OFF-PEAK COMMERCIAL TARIFF	
For each kilowatt of maximum demand per month during the peak period	45.1 RM/kW
For all kWh during the peak period	36.5 sen/kWh
For all kWh during the off-peak period	22.4 sen/kWh

Table 2: Tenaga Nasional Berhad, Malaysia, Industrial Tariffs.

INDUSTRIAL TARIFFS	COST
TARIFF B - LOW VOLTAGE INDUSTRIAL TARIFF	
For the first 200 kWh (1 -200 kWh) per month	38.00 sen/kWh
For the next kWh (201 kWh onwards) per month	44.10 sen/kWh

TARIFF C1 - MEDIUM VOLTAGE GENERAL INDUSTRIAL TARIFF	
For each kilowatt of maximum demand per month	29.60 RM/kW
For all kWh	33.70 sen/kWh
TARIFF E2 - MEDIUM VOLTAGE PEAK/OFF-PEAK INDUSTRIAL TARIFF	
For each kilowatt of maximum demand per month during the peak period	37.00 RM/kW
For all kWh during the peak period	35.50 sen/kWh
For all kWh during the off-peak period	21.90 sen/kWh
TARIFF E3 - HIGH VOLTAGE PEAK/OFF-PEAK INDUSTRIAL TARIFF	
For each kilowatt of maximum demand per month during the peak period	35.50 RM/kW
For all kWh during the peak period	33.70 sen/kWh
For all kWh during the off-peak period	20.20 sen/kWh

Source: Malaysian energy supplier, TNB's tariff structure. Source: tnb.com.my [7]

2.2. Calculation of Maximum Demand Charges

Maximum Demand (MD) is the maximum electrical power demand logged by a utility or supply company (TNB in this case) meter during a consecutive 30 minutes interval in a particular month under consideration. The energy cost imposed on the cunsumer is on the basis of this recorded Maximum Demand in kW at the respective Maximum Demand rate. As an illustration, the amount payable by a Tariff E2 Industrial customer registering 2000kW of Maximum Demand for a particular observation period is RM74,000 (2000kW x RM37.00/kW).

2.3. Procedures to reduce Maximum Demand Charges

Following activities could be carried out to reduce MD [7] charges:

- Practising demand side management techniques such as shifting their highest consumption to an off-peak period as the MD tariffs are not applicable during the off-peak period for a cunsumer with off-peak tariff
- Choosing to utilize any cost saving schemes offered by the utilities involving MD reduction like Tariff Rider Schemes etc.
- Using your motors and heavy equipment in stages or using them only in the off-peak hours.
- To implement energy efficiency projects to bring down base loads.

3. Case studies and discussions

An energy audit conducted in an Industry revealed an opportunity of reducing the total plant maximum demand of average from 2736 kW to 2220 kW. The following technologies and methods were used to bring down the Maximum demand.

3.1. Installation of EnMS with Maximum Demand Controller:

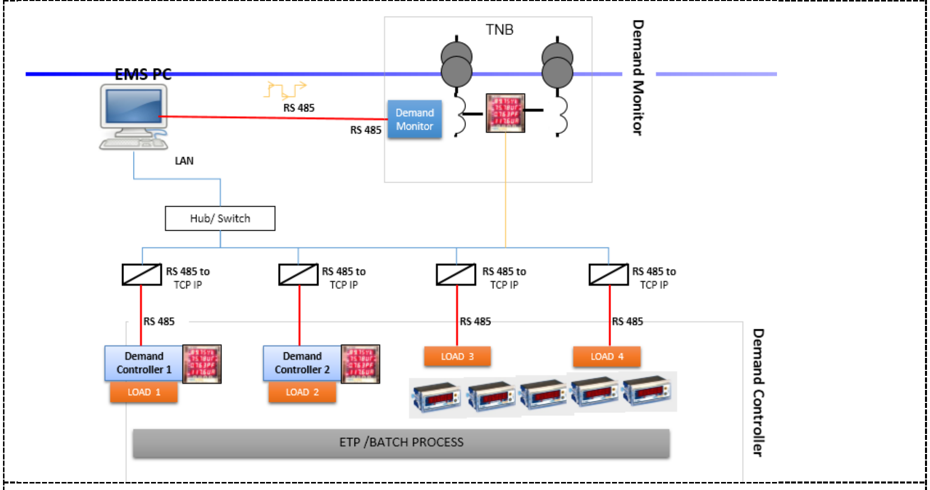

Figure 1. Typical schematic diagram of EnMS with MD controller

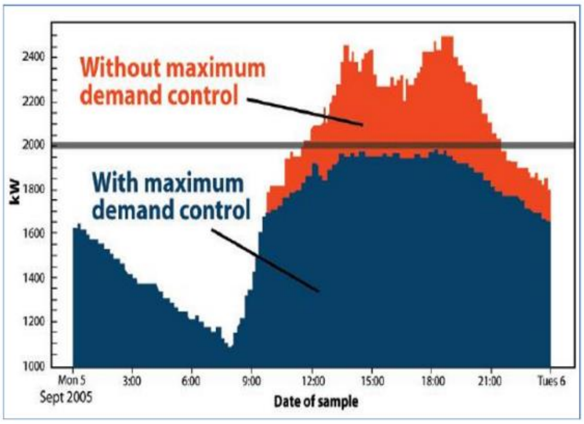

Figure 2. Typical kW chart with and without MD controller

3.1.1. The Demand Controller:

The control of loads is realised by help of equipment that would improve power reduction or cut off the system from grid when the load exceeds the pre-established limit on maximum load. The demand controller is usually triggered by a "peak load" from the utility. It can also start in response to the different peak/off-peak power rates, a load limit rate is pre-set for each in such a case for the period. The controller, when the load approaches the setpoint, consecutively switches offloads according to the priority set. Usually, interruptible loads are disconnected, will be automatically reconnected as programmed when the load is within the limits.

Load controllers, typically, will have the following major components as illustrated in the figure below:

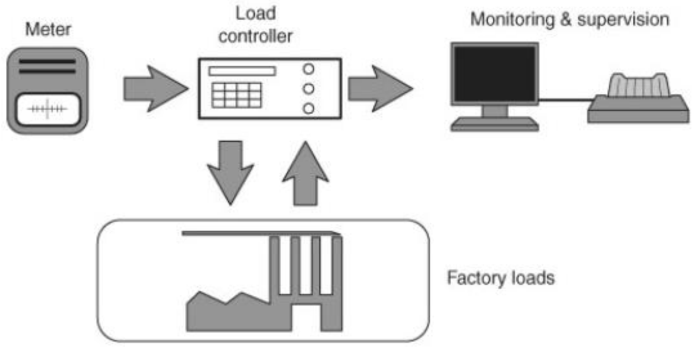

Figure 3. Components of EnMS with MD controller

1. a keyboard to program, load setpoints and priority levels for the power usage.
2. a screen to display the programmed aspects and self-diagnosis
3. a microprocessor controlled system that monitors the demand levels in comparison with the set points and adopts appropriate control actions.
4. Signals from the appropriate meter for kW/kVA and input on the peak signal from the utility or from the meter itself.
5. input/output channels to switch ON and OFF the loads or status detection of loads
6. Interfacing with computer and printing facility can also be adopted if the necessary.

The controlling is mainly achieved with the help of a forecasting algorithm; usually, the difference between the total available energy in a given time period and the energy consumed during the beginning of the period is evaluated. The ratio between this calculated difference and the remaining time to the end of the stipulated period represents the maximum power that can be consumed without exceeding the limits set by the utilities.

3.2. Variable Frequency Drives for Blower Pumps at Waste Water Treatment Plant(WWTP)

The plant has 200 kW air blower pump for the Waste Water Treatment Plant. The air supplied by the blowers to the aeration basin has several functions. The main function of an aeration control system is to satisfy the oxygen requirements to maintain the treatment process with a minimal cost incurred. DO (Dissolved Oxygen) Concentration is usually the measurement of a proper air flow to a treatment process.

Figure 4. Aeration Tank in a typical WWTP

The aeration control is connected with the Maximum demand controller in such a way that it will monitor the DO level, Maximum Demand and speed of the Blower pump. Once the MD controller triggers, the VFD starts to reduce the speed of the blower pump. In an average in reduced around 130 kW of base load.

3.3. Booster Pump for Air Compressor

The plant currently has two units of a centrifugal compressor with a capacity of 187kW/ unit and one unit of screw compressor with 75 kW/h. During the normal operation, the plant has to operate two units of centrifugal compressor to cater the required pressure at 8 bar and flow of 1769 cm. However, during the audit on air compressor system, it is found that the actually required flow is only 1157 cfm.

Figure 5. Booster pump installation along the compressed air line.

Figure 6. Recorded Total Flow Demand

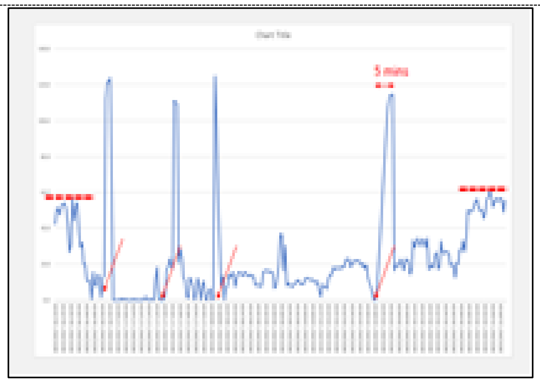

Figure 7. Recorded Air Peak Load

When a detailed analysis was done, it is found that one production unit required 8 bars pressure at the peak of 150 cfm. This machine will automatically shut down if the pressure drops below 7.5 bars. To cater this, the plant was operating 2 unit of the high capacity centrifugal compressor.

3.3.1. How does it work?

The main working principle is to boost the pressure from 6.5 bars to 8 bars and maintain the pressure in an air receiver to cater the demand without adding in any electrical power (kW) and use compressed air to cater the demand.

3.3.2. The System Arrangement:

The system compressed of 6 units of the booster with automatic change over 3 units at a time to cater the demand.

3.3.3. *Achievement:*

After the installation, the plant stopped one unit of a centrifugal compressor and only operate with one unit of a centrifugal compressor and one screw compressor with complete savings of 90,000kWh/year with the return of investment (ROI) within a year. This brings down the base load of approximately 100 kW

3.4. Retrofitting Fluorescent/High bay lights to LED lights

The plant has 86 no.s of High bay lights of capacity 250 watts each and 5000 no.s of 4 feet 36watts Fluorescent lights, which were working 24 hours. These two lighting loads are base loads and it contributed 220 kW to the Maximum Demand.

In a phased manner, the conventional High bay lights were changed to LED High bay lights with 100 watts and the 4 ft. Fluorescent tube lights were changed to 4 ft. 16 watts LED tube lights. After the total LED retrofit the base load came down to 88 kW from 220 kW. This is the reduction of 132 kW.

3.5. The switch of Battery Chargers

The plant has 12 units of battery chargers to charge the batteries of the Forklifts. At any one point of time, there will be 10 units of battery would be getting charged. Once the MD controllers triggers, the battery chargers will get disconnected from the system and will get resumed once the MD reaches back to the setpoint. Thus, a maximum of 150 kW of the load could be switched off during the peak load.

4. Conclusions

Once the medium and high voltage electrical energy consumers of Industrial sectors and Commercial buildings start to analyse their Maximum Demand occurrences, they will not only come to know their system flaws but will know the energy-saving opportunities. Eventually, it will bring down the total cost of production in Industries and energy cost per area in Commercial buildings. An average annual savings of RM 180000 could be achieved with the MD control. Most of the MD control techniques are inexpensive and will have a payback period of less than a year. To ROI and Payback period calculations are project dependent and are avoided in this work keep the brevity of the paper.

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