Power Management Techniques
(White Paper)

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Table of Contents:

Summary

"Power management" is a matter of taking certain actions to level off or make steady the rate of energy transfer for a given facility. It has the effect of reducing the peak demand being measured by the demand meter, which will eventually lead to lower electrical utility bills.

Before any given demand management method can be applied, the company must undergo a site energy audit to determine which if any of the standard techniques would provide the greatest return. In some cases, the high utility bills can be attributed to some piece of plant equipment that is not working as specified. When any such defects are corrected, it may be that there is no longer a demand problem of any significance. Examples of such faults are mechanical or electrical defects causing bad power factors, excessive harmonic distortion, and phase imbalances. Not only do these things cause increased utility bills, they also increase the wear on major plant equipment by overheating the electric motors.

Implementing good power management techniques can enable a company to increase the amount of energy that it can get from the utility without having to upgrade the existing electrical service. This, in combination with improvements in plant efficiency, can allow a plant to increase its productivity, with a relatively small increase in the plant utility bill.

Background

Numerous companies in North America are looking for competitive advantages while struggling with the effects of electrical utility deregulation. Some firms find they are paying a great deal on their electrical utility bills for non-value-added items such as demand and administrative charges. A good way to improve their competitive edge is to decrease the portion of their utility bill that is not related to electrical energy, without increasing their total monthly bill. This strategy allows the electrical energy user to purchase more electrical energy in two ways: it frees up cash for the energy purchase, and it reduces the risk of tripping their main circuit breaker.

The *energy* costs on the utility bill can be reduced by:

- negotiating a better rate per energy unit (KWH or Gigajoule)
- replacing old plant equipment with more energy-efficient equipment
- changing inefficient operating methods and user behaviour
- upgrading plant electrical motors to newer high efficiency designs; This has the effect of saving on energy costs while potentially increasing demand surcharges, unless other measures are applied to control demand. It should also be noted that over 75% of all the energy and power on the North American grids are due to electrical motors.

Demand charges are more difficult to control. The power company owns the power meters. There is generally only one meter per load circuit, which means there is no way to reconcile any readings that may be inaccurate. Some users pay to have their own government certified meters installed just so that they can be sure that the utility is billing them honestly. This is a very expensive proposition, especially if they don't find the "smoking gun" they were hoping for.

Demand Power

Industrial and commercial electrical energy users pay for energy, and they pay for a thing called "demand". In the days before deregulation, that was pretty much it, but it was enough.

Since deregulation the energy rates have become a bargaining chip, just as the protagonists of deregulation claimed it would. However, the utilities added a few new items to the utility invoice: administrative, maintenance, and depreciation charges to name a few. The exact number and name vary. The effect is the same. If the user could cut their usage to zero for a whole month, those sundry charges are the portion of the utility bill that will not drop to zero.

This leaves users with two variables that they can try to control: their energy usage, and their demand charge that relates to their highest rate of energy usage.

For example, suppose a company used 72,000 KWH of energy in March. Being that there are on average 720 hours per month, this equates to an average demand of 100KW.

It is impossible to have perfectly flat energy usage across all hours of the month. Businesses open up and close every day. Equipment gets turned off and on with each usage. For that reason this hypothetical company is very likely to see a demand charge on their March bill between 200KW and 300KW. At the rate of $6.80 per kilowatt, the average extra monthly charge is given as (250 - 100) x $6.80 = $1,020 per month.

Remember, this is the extra charge over and above the average monthly demand of 100 KW. Also, the firm is not actually receiving anything value-added for this money. It is energy that turns the wheels of industry, so to speak, not the demand power.

Once a commercial user demonstrates that they may demand a certain amount of power, the utility locks them in at this rate until sufficient time has passed during which they have proved to not need that level of power. After one year, or a specially negotiated time frame, the electrical utility that delivers the energy resets their locked-in rate and waits until the demand meter provides them with a new peak demand power reading.

How Demand Power Is Calculated

Energy is equal to *power* x *time*. The power meter measures the instantaneous power and multiplies it by segments of time (seconds). The result is an accumulation of joules x 1,000,000 or kilowatt-hours since the last reading, depending on the region and the utility company. This value is multiplied by the negotiated energy rate (dollars per gigajoule or KWH) for the time period in question (regular hours or peak hours).

As mentioned, peak demand is the highest power measured by the utility's demand meter. The power meter repeatedly measures the *energy* usage for a moving 15-minute window. This energy sum is then multiplied by four to calculate the *power* (rate of energy transfer per hour). In most parts of Canada the law requires this power value to be reduced to 90% of the measured value.

If the newest calculated peak demand is higher than the stored peak, the old value is replaced by the new and the clock that locks in the rate is restarted. This is the end demand value that the user is supposed to be billed for. If no new peaks are stored before the clock times out, the peak value is cleared and the next peak that is measured is stored until a higher peak replaces it, and so on and so forth.

Three Business Cases

Let us look at three fictional business cases:

1. Bob's Frozen Fries
   Bob's firm makes oven-ready French fried potatoes for restaurants and hotels. The process consists of a giant automated machine that is turned on all at once at the start of each day. The only other major load in the plant is the overhead lighting, and that accounts for less than 5% of the total electrical utility costs. Their average power is 200 KW, and they hit a peak of 500 KW each time they start their automated process. The conveyor motors, exhaust fans, and elements all must start up at precise times.
2. ACME Flour Mills:
   ACME supplies six kinds of flour to various wholesale bakeries. They run their grain blending process in batches, and they grind their blended grains in batches. They have three mixers and two grinders that can all be started and stopped independently of each other. The mixers run at approximately 75 KW each. The inlet augers add another 25 KW each, and they run intermittently while the mix is being optimised. The grinders have blowers to get rid of heat buildup from the grinding process. The blowers use 25 KW and the grinders use 75 KW. The blowers are controlled by automatic thermostats. ACME's average power is 200 KW, and they pay a demand surcharge based on a 650 KW peak that happens rarely.
3. Cow Patty Pipeline:
   This is a crude oil pipeline that moves oil from the well head north west of Edmonton to a refinery near Saskatoon. It uses ten 100 KW electric motor driven fluid pumps to keep the oil moving. The motors run non-stop. The pipeline's average power is 1,050 KW, and their peak demand is based on 1,100 KW. This is because they use stored air pressure to start their motors up before applying electrical power.

Managing Demand (Power)

What can be done for each of these firms to cut back on demand surcharges? Let us start with case #3, Cow Patty Pipelines. Their peak demand charges are based upon measured peaks that are essentially equal to their average power. In short, they have the situation under control.

What about Bob's Frozen Fries? He has a package system that is automated. The elements turn on when the frying fat needs to get hotter. The fans turn on when the smoke gets too thick. The conveyors turn on when it is time to move the product along. From looking at the power bill it is apparent that sometimes these individual loads are turned on at the same time. This coincidental start-up loading is what is driving the high demand power charges. The only thing that can be done for Bob is have the company that designed the automation refine their programs so that coincidental start-ups don't have to happen. The only up-side is that Bob can install a second process and have it interlocked with the first one so that only one can start up during any given 20-minute time frame. Bob would have to pay for the extra electrical energy, but the demand would be nearly the same as it was with just one process machine.

ACME Flour Mills is the best candidate for reducing demand surcharges. There are a number of ways for ACME Flour Mills to control their demand:

1. For very large inductive loads (motors) a soft-start controller can be installed. This provides a way to spread out the energy used to get the motor moving from a stand-still to the normal RPM. Soft-start controllers are very expensive, and they increase the maintenance budget for the firm. Furthermore, they do not reduce the actual energy usage of the load. The required start-up energy is determined by the mass of the moving parts and the normal RPM. Starting the motor up more slowly does not change this fact.
2. Add interlock timers to each load so that no two loads can be started within a certain time frame. Interlock timers can help, but they are no guarantee that the peak demand will always be reduced. Also, the loads will only come on when the timers expire, even if the critical power level has long since passed.
3. Add a central demand controller that performs load-shedding when demand starts to get beyond a set limit. Load shedding controllers are available from various vendors. These systems monitor the total instantaneous power at the billing meter. Loads that can afford to be "dumped" are turned off so that more critical loads can be turned on during periods of power peaks, or at times of the day when the billing rate is more expensive.
4. Suppose the grain drier motors are sometimes being restarted before they have had ample rest time. This usage pattern can actually use more energy than the motor is rated for because of too many restarts per hour. This in turn can harm the motor as well as drive up energy costs. Reducing the number of restarts will reduce the chances of setting a high demand through multiple coincidental start-ups. This can be achieved by installing delayed shutoff relays, or by installing devices that monitor the motor duty cycle and intervene when the duty cycle is causing a cost overrun. Delayed shutoff relays and electronic duty cycle monitors are available from a variety of commercial sources. The duty cycle monitor provides more features and better overall savings. In some cases, these devices can be networked together to provide an even higher level of savings (see #5 next).
5. Monitor the instantaneous power at the main panel and billing meters, and monitor start-up commands to each load. If a given load is commanded to turn on at a time when the power level is already quite high, delay the action a few seconds until the power level drops a bit. This type of demand control has more regard for the

"business as usual" needs of the plant, compared with other solutions such as load shedding and interlock systems.

Monitoring the off-on command and instantaneous power for each load in a plant requires an installed load monitoring device at each load that senses the "on" command and load current. Also, it requires that there be a central monitoring unit that constantly measures the power at the billing meter.

Such power monitoring systems are expensive to install. They require a certain level of knowledge and training to properly understand and interpret the technical reports that they can generate. As such, it would not be cost-feasible for most small companies that can only hope to shave a few hundred dollars off their monthly electrical utility bill. However, such a system would be ideal for ACME Flour Mills.

ACME Flour Mill's large demand charge is due to rare coincidental start-ups of several loads. A sophisticated load monitoring system would be able to delay two or three loads for just a few seconds and avoid setting large demands. Such short delays would not bother the milling process in any way. The type of equipment used for such a system would be able to provide other benefits as well, such as predicting load failures and analysing trends in plant energy usage.

Suppose the 650 KW peak demand can be cut to 50% by installing a power monitoring system. This means the power monitoring system would be tuned to limit the demand to 325 KW. At a demand rate of $6.83 per KW, the old invoices would show a demand surcharge of $4,439 per month. This would be reduced to $2,220 - a saving of $2,219 per month. Assuming the power monitoring system could be leased for $1,000 per month, this would yield a net saving of $1,219 per month (before taxes). Expressed yearly, this is $14,628 in net savings.

Now suppose ACME wanted to add a new mixer so that they could increase their productivity. If their main panel was limited to 800 KW, they could not run the new equipment. By installing the power monitoring system they would be able to double their plant capacity without doing an electrical service upgrade (as long as they have the space for the extra equipment).

It is difficult to quantify the savings in such a scenario. One way would be to look at the electrical panel upgrade expense that has been avoided. Looking at the electrical costs plus plant down-time, that could easily exceed $100,000 of up-front expenditure, which equates to over a hundred lease payments.

Whether it is done by interlock timers, load shedding systems, or load monitoring and controlling networks, the power demand for a company like the fictitious ACME Flour Mills can reduce the demand charges on their monthly electrical utility bills. When this happens, they take a great deal of stress off their electrical panel. This, in turn, enables the company to get more energy delivered to their plant equipment without having to upgrade their electrical panel. For companies that are trying to increase their output, this is ideal.

About the Author

Eric Olson is a DeVry graduate (Electronics Technology) and an honours graduate of the Canadian Institute of Management (CIM). From 1976 until 1992 Eric has worked extensively in the fields of data processing and business data communications as a field service engineer. From there he began a career in automation, starting with electrical power generation and transmission (G&T) control systems, oil and gas pipeline control, and eventually process safety engineering. It was during his work with electrical power G&T control that he initially became interested in how electric power consumers use electrical energy.

Eric Olson is now the president of Olson Power Trend Management, a company that specialises in site electrical power analysis and demand management services.

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