Baldor Motor Basics: Factors that Determine Industrial Electric Bills

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Former Baldor motors expert Edward Cowern PE, is a name known and respected by many in the electric motor industry. During his tenure at Baldor, Cowern — now enjoying his retirement — was tasked with producing a number of motor- and basics-related tutorials. The tutorials were primarily in response to a steady flow of customer questions regarding motors and applications. Today's customers continue asking questions and seeking answers to address their various motor-related concerns. We hope you find these articles useful and would appreciate any comments or thoughts you might have for future improvements, corrections or topics.

Introduction

A good deal of confusion exists regarding the factors that determine an industrial electric bill. The following information is presented to help sort out the various items on which billing is based, and to offer suggestions on measures to help control and reduce electric utility bills.

Three basic factors and an optional item (see 4) determine an industrial power bill. They are:

1. Kilowatt hour consumption
2. Fuel charge adjustments
3. Kilowatt demand
4. Power factor penalty (if any)

Kilowatt hours. The first of these is the easiest to understand since it is one that we are familiar with based on our experience at home. Kilowatt hour consumption is the measure of the electrical energy that has been used during the billing period without any regard to when or how it is used. In most cases it is determined on a monthly basis by taking the accumulated kilowatt hour readings from the dial of a conventional kilowatt hour meter.

Fuel charge adjustment. Fuel charge adjustment is an adjustment factor determined monthly. It is based on the cost of the fuel used to produce power during a given month. For example, in areas where water power is plentiful in the spring, the contribution of water power might be great and, it is cost low. Thus, in the spring of the year, a downward adjustment might be made in fuel cost. In other instances, and at other times of the year, a utility may find it necessary to burn large quantities of high-priced imported oil to meet their requirements. When this occurs there would be an upward adjustment of the fuel cost charge. Fuel charge adjustments are usually based on a unit charge per kilowatt hour.

Kilowatt demand. Perhaps the least understood factor involved in calculating an industrial electric bill is the matter of demand; demand is based on how much power is consumed during a given period of time. It is measured in kilowatts and it determines how much equipment the utility has to supply in terms of transformers, wire and generation capability, etc., to meet a customer's maximum requirements. Demand can in some ways be compared to the horsepower of an automobile engine. The normal requirement may be relatively low but the size of the engine is determined by how much power is needed to accelerate the car. Similarly, demand reflects a peak requirement. However, the term "peak" in relation to electric demand is frequently misunderstood. In virtually all cases demand for an industrial plant is based on a 15- or 30-minute average. Thus, brief high peaks, such as those that are present during the starting of large motors, are averaged because the starting is of very short duration with respect to the demand-averaging interval.

A description of how demand is measured may help to clarify this point. In each demand meter there is a resetting timer; this timer establishes the demand interval. And that interval, as mentioned previously, may be either 15 or 30 minutes. In effect, during the demand interval the total number of revolutions made by the kilowatt hour meter disc is recorded. Thus, a high number of turns during the demand interval would indicate high demand, and a small total number of turns during the demand interval would indicate low demand.

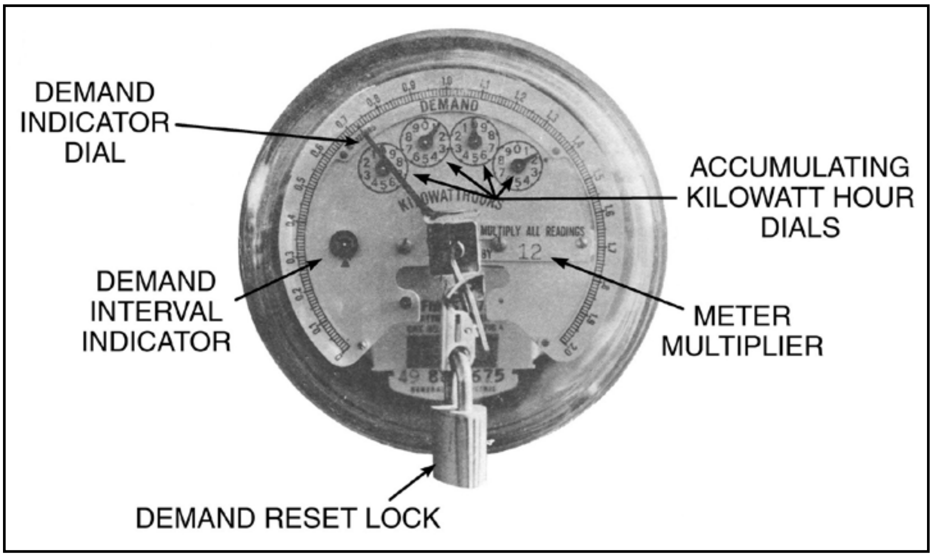

Figure 1 Example of typical demand meter used on a small commercial installation.

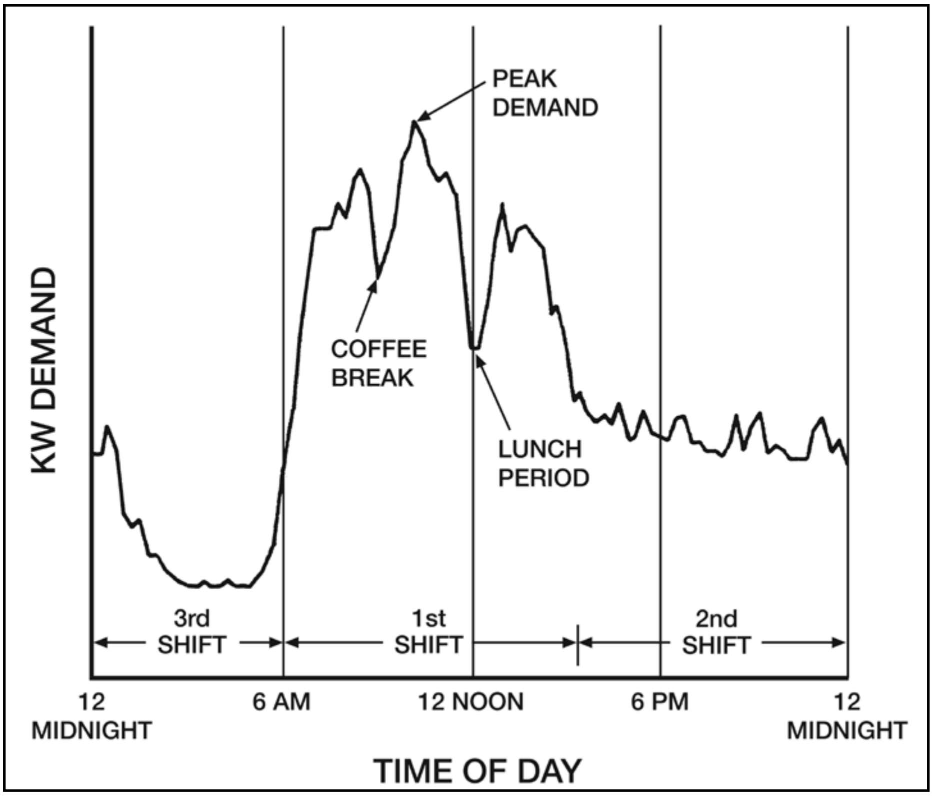

Figure 2 Example of typical manufacturing plant's recorded demand over the course of 24 hours.

For example, when a large motor is started it would cause the disc in the meter to surge forward for a short period of time. However, as the initial surge passes, the meter would settle down to a normal rotation rate. Thus, the extra disc revolutions recorded as a result of the motor in-rush would not have much impact on the total number of revolutions that accumulate during a 15- or 30-minute interval. At the end of each demand-averaging interval the meter automatically resets and starts recording for the next 15-minute period; this process goes on continuously. A special dial (Fig. 1) records only the highest demand since the last time the meter was read. When the monthly reading is taken the meter reader resets the demand to zero. Once again the meter starts searching for the highest 15-minute interval, and it does so continuously until the next time it is read. It is the highest demand for a month that is normally used to compute the bill. More about this later.

The meter shown in Figure 1 is a typical demand meter used on a small commercial installation. The demand is determined by reading the position of the top needle and multiplying that reading by the meter constant. In this case, the reading is .725 multiplied by 12 for a demand reading of 8.7 KW. After the monthly reading is taken, the lock is unlocked, the needle reset to zero, and the meter is relocked. Accumulated kilowatt hours are recorded in the conventional manner on the dials.

Figure 2 shows an example of typical manufacturing plant's recorded demand over the course of twenty four hours. This plant had a full first shift and partial second shift. By examining the graph it is easy to pick out some of the factors influencing the demand. The initial run-up of demand occurs as the first shift starts. The growth of demand continues until the preparation for a coffee break begins. Coffee breaks result in a major dip, followed by another run-up, until the peak demand is reached shortly after 10 a.m. Demand then stays reasonably steady until preparations for lunch and the lunch period begins.

It is interesting to note that after the lunch hour, things never quite get back to equal the peak that occurred before the lunch period. Another lower peak occurs at 1:00 p.m., followed by lower peaks and a final drop-off as clean-up and end-of-shift occurs. The second shift has peaks and valleys similar to the first shift, but shows the lower level of activity in the plant. Finally, on the third shift, demand drops sharply to a level reflecting only the very basic loads of security, lighting, and other continuous loads.

Controlling demand. Reducing demand peaks will result in lower demand charges and lower bills. High demand can result from a number of factors. Some of the most likely would be the heating up of large furnaces or ovens during the normal work day. This can happen since the heat-up requirement may be five to six times the sustaining requirement for this equipment. Installing time switches that will allow the unit to pre-heat to normal operating temperature before the plant shift starts is one easy way to reduce demand peaks. This approach keeps the large demand required by heat-up from being imposed on top of the normal plant demand. Large central air conditioning chillers can pose similar problems if they are allowed to start during the normal shift rather than pre-cooling the building during a non-working period.

Other factors that can contribute to high demands would be items such as air compressors if start-up is delayed until after the normal work shift starts. In this case the compressor may run at full load for an extended period, until the accumulator and distribution system has been filled. The solution with air compressors is the same as that with industrial ovens; a timer can be used to start the compressors and fill the system prior to the normal shift start. This approach allows the pressure to build up and the compressor to fall into a normal loading and unloading pattern prior to the time that the balance of the plant load is applied.

With some thought you will be able to discover some items within a facility that may fall into the category that can increase peak demand. The installation of seven-day timers that will start essential compressors, ovens and other similar loads ahead of the first shift can help reduce demand in most plants.

Demand charges are normally figured on a dollars-per-kilowatt basis. For example one Connecticut utility has an industrial power rate that charges $401.00 for the first 100 kilowatts of demand, and $2.20 for each additional kilowatt.

Demand ratchets. To encourage industrial plants to control their demand to reasonable levels, many utilities impose a twelve-month ratchet on demand. What this means is that a very high demand, established in a particular month, will continue to be billed at a percentage of that high demand for eleven months unless actual demand exceeds the established percentage of the previous peak. This type of arrangement can be expensive to the power customers who are not careful in controlling their demand— and to industries having high, seasonal variations.

In many situations it is not possible to exercise any great degree of control over plant demand without encumbering operations unnecessarily and adding extra labor costs, etc. Even if a plant happens to be in one of these situations, it is important to understand the basic factors involved in demand and to understand what equipment within a facility is contributing to the total demand picture.

Demand monitoring and control. Demand monitoring and control equipment is available to help plant operators control their demand and energy costs. This equipment is based on monitoring demand build-up over the normal demand-averaging interval and taking action to curtail certain loads or operations to level peaks and prevent new peaks from being established. For demand control to be effective a plant must have electrical loads that can be deferred. Typical examples of deferrable loads would be water heating for storage, heat treating, and possibly the controlled shutdown of certain portions of ventilation systems where short-term interruptions would not create a problem.

Demand control is not for everyone but it can save substantial amounts of money when the right conditions exist.

Power factor. Another misunderstood item in computing industrial electrical bills is power factor penalty. Power factor, in itself, is quite complicated to attempt to deal with in a broad manner. However, a capsule summary might be in order.

Utilities have to size their transformers and distribution equipment based on the amount of amperes that are going to be drawn by the customer. Some of these amperes are borrowed to magnetize inductive loads within the plant. This borrowed power is later returned to the utility company without having been bought. This borrowing and returning goes on at the rate of 60 times a second (the frequency of a 60-cycle power system). The borrowed power, as mentioned previously, is used to magnetize such things as electric motors, transformers, fluorescent light ballasts, and many other kinds of magnetic loads within a plant. In addition to the borrowed power there is the so-called "real power." This is the power that is used to produce heat from heating elements, light from incandescent bulbs, and to drive the shaft on motors. Power factor is a measure of the relative amounts of borrowed versus real power that is being used within the plant.

Obviously, utilities would like to have the situation where the customer borrows nothing and utilizes everything. In commercial and industrial situations, this ideal almost never exists. Plants with large quantities of lightly loaded motors or large quantities of electric welding equipment may run at poor power factors of 65 to 70%. On the other hand, plants with substantial amounts of electric heating equipment — as found in injection molding machines and fully loaded motors — could run with power factors of 85 to 90%.

Plants with poor power factors can improve their situation by adding power factor correction capacitors to their systems. Power companies like to have plants provide power factor correction capacitors since they lessen the number of amperes that need to be supplied. Within an individual plant, higher power factors also mean that incoming circuit-breakers and distribution panels are not being taxed as much. So, within the plant, good power factor has some rewards as well.

Power factor penalties. Some utilities impose power factor penalties. What this means is that when your power factor falls below a pre-established level, a penalty charge may be added to the basic bill for kilowatt hours, fuel charge, and demand. The amount of the penalty is dependent on how far below the pre-established level the power factor falls. There is no uniformity among utilities on how they determine the power factor penalties or at what level they start. The variations in the way they are imposed are almost as large as the number of different utilities in the country. The penalties can range from none at all — the case with a great many power companies — to very substantial penalties imposed by others. Frequently, when penalties are imposed there is also a reward arrangement. The reward is structured to reward high power factor customers by giving them a credit on the monthly bill for having high power factor.

If you are concerned with power factor and any possible penalty you may be paying, the best approach is to contact the local power company. They will provide you with any information you might require on the existing power factor and any penalties that are being paid. They can also help you compute the amount of power factor correction that you may need to eliminate any penalty charges.

Table 1 Simplified analysis of how various conservation and load control actions affect the four components that make up a normal industrial electric bill.

EQUIPMENT OR ACTION	ENERGY (KW HRS)	FUEL COST ADJ.	DEMAND KW	POWER FACTOR
REDUCED LIGHT LEVELS	REDUCED	REDUCED	REDUCED	NEGLIGIBLE
MORE EFFICIENT LIGHT SOURCE	REDUCED	REDUCED	REDUCED	NEGLIGIBLE
ENERGY EFFICIENT MOTORS	REDUCED	REDUCED	REDUCED	MODEST IMPROVEMENT
PROPER SIZING OF MOTORS	MODEST REDUCTION	MODEST REDUCTION	MODEST REDUCTION	REASONABLE IMPROVEMENT
DEMAND CONTROL	SLIGHT REDUCTION	SLIGHT REDUCTION	SUBSTANTIAL REDUCTION	NEGLIGIBLE

Summary

Understanding the four factors that go into determining industrial electric bills can help map approaches to saving money. Generally speaking, conservation efforts such as reduced lighting levels, buying more efficient motors, and replacing existing inefficient equipment with equipment having better designs, will reduce both kilowatt hour consumption and kilowatt demand. Reducing kilowatt hour consumption will also reduce fuel charge assessment. Shifting demand of certain types of equipment into more optimum time periods when plant demand is low, can reduce kilowatt demand and the charges associated with it. Finally, an improving power factor, if there are penalties being imposed, will help reduce power factor penalty charges.

A basic understanding of these four factors can help the conservation-minded to reduce overall electric energy costs. Table I shows a simplified analysis of how various conservation and load control actions affect the four components that make up the normal industrial electric bill. It can be used as a guide in directing conservation and electric bill reduction. **PTE**

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