Peak demand charges typically account for half the electric bill in an industrial plant. Most plants have the potential to reduce their maximum peak demand charges without significantly affecting production. Working toward greater electrical efficiency will not only reduce your plant's power costs but will also help your electric utility provide more efficient service at lower rates. This Technology Update helps you identify whether your plant has the potential for reducing maximum demand and describes various demand control methods.

Industrial plants normally have electrical loads that vary both daily and seasonally. For plants with a connected load of more than 35 kW, a demand meter is used to establish the 15- to 30-minute maximum demand within a billing period. The demand charge reflects the peak rate at which electrical energy is consumed and is higher when there is more electrical equipment running.

Electric utilities must have sufficient capacity to serve the instantaneous demand of all customers at any time; therefore, electricity charges are based on maximum plus the total electrical energy consumed.

Controlling Maximum Demand
You can gain two major benefits when your maximum demand is limited to a predetermined level: released electrical system capacity and reduced operating costs.

Released Electrical System Capacity
In many industrial plants, a time comes when the process requires more horsepower but the transformer, incoming lines, and main switch are already running at capacity. Limiting the maximum demand becomes one possible low-cost alternative to upgrading the electrical system.

For example: A foundry wants to add a 150-hp sand reclaimer; however, the 1,500-kVA transformers are running fully loaded. The solution is to allow the reclaimer to run only when the induction furnaces are not operating.
Reduced Operating Costs
Many electric utilities charge for the maximum demand used in a 30-minute period within the billing period, so limiting this peak will reduce total power charges.

Typical Electrical Rates
A portion of a hypothetical general service rate is shown below. Complete rate schedules are available from your local electric utility. The rates are structured so that as more electrical energy is used, the kWh cost is lowered; however, the greater the demand, the higher the kW cost. Therefore, adding load without increasing demand can reduce the average cost of electricity.

Demand charges (kW):
- First 35 kW of billing demand/month—$0.00/kW
- Next 115 kW of billing demand/month—$3.27/kW
- All additional kW of billing demand per month—$6.28/kW

Energy charges (kWh):
- First 275 kWh/month—$0.0781/kWh
- Next 6,725 kWh/month—$0.0577/kWh
- Next 23,000 kWh/month—$0.0426/kWh
- All additional kWh/month—$0.0276/kWh

Typical Demand Calculations
Assume a sawmill with a demand of 2,880 kW. The demand charges each billing period would be:
- First 35 kW—$0.00
- Next 115 kW—115 x $3.27 = $376.05
- Remaining—(2,880 - 150) x $6.28 = $17,144.40
  Total—$17,520.45

A survey of the plant operation determined that 300 kW of electric slab heating is operating during peak load time. If this slab heating is deferred to an off-peak time, a saving of $1,884 is achievable. This load shifting moves peak loads to off-peak time periods without changing overall consumption.

Table 1 compares demand charges for the load profile in Figure 1, based on the rates previously outlined.

Controllable Loads
Some electrical devices can be turned off from a few minutes up to a few hours without causing loss of production, inconvenience, or harm. The following are some of the more common controllable electrical loads that can be deferred to reduce demand charges:
- Storage water heating
- Slab heating
- Storage room heating
- Ventilation air heating
- Space heating
- Air conditioners
- Industrial vehicle battery chargers

Here are some other loads that have the potential for demand control; however, they might affect production if they are shut down for prolonged periods:
- Air compressors
- Process grinders
- Dehumidification kilns
- Refrigeration motors
- Electric process furnaces
- Pumps

In all cases, the decision to control any load must be carefully studied to identify the effects of any deferment. Normally there will also be limits, such as time and temperature, in any load that has been shed so that a damaging or dangerous situation does not arise.

For example: Will shutting down an electric furnace affect the production schedule or the product quality? A thorough analysis of the application and costs should be made for each load.

Determining the Potential for Demand Control
Demand charges can be lowered only if:
- The energy consumption rate has fluctuations or
power peaks during the billing period.

- Some significant loads can be temporarily shed at peak demand times.
- The time to shed and restore loads is known.

Is there a potential for demand management at your plant? Following the steps below should give clear direction whether there is a potential and just how much can be saved. If you determine that your plant has the potential for demand control but implementation is outside your staff’s area of expertise, then consider hiring an electrical consultant to do a thorough study, complete with recommendations on implementation and guaranteed savings.

**Step 1 - Understand Your Electric Utility Bill**

This task is essential so that you know how the billing system works and where your changes are going to have an effect. Most companies monitor long distance telephone calls and investigate if their bills are quite different each month, and yet many businesses do not examine their electric bills that closely.

In order to understand your electric bill, it is important to also understand how your electric utility’s demand meter works. The demand meter records the maximum demand required over a 30-minute period.

At the end of a billing period the meter reader resets the demand meter to zero, and then the meter is ready to register the next billing period’s peak demand. The time response of the meter is very close to a true exponential curve (see Figure 2), with approximately 50 percent of the maximum demand registered in 5 minutes, 90 percent in 15 minutes, and 99 percent in 30 minutes. Therefore, manual switching is not effective except in the simplest situations, because the decision to turn a load off, and thus negate demand charges, must be made quickly.

Remember, the peak has only to occur once in a billing period for full demand to be registered. An extreme case is the plant that is shut down and then starts production on the last day of the billing period. The demand meter would show the same demand as if the plant had operated for the entire billing period.

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**Figure 1. Typical load profile for a sawmill**

**Table 1. Electrical Demand Cost Comparison**

<table>
<thead>
<tr>
<th>Demand Charge</th>
<th>Demand Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>for 2,880 kW</td>
<td>for 2,580 kW</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>1st 35 kW</td>
<td>$0.00</td>
</tr>
<tr>
<td>Next 115 kW</td>
<td>$376.05</td>
</tr>
<tr>
<td>Additional</td>
<td>$17,144.40</td>
</tr>
<tr>
<td>Total</td>
<td>$17,520.45</td>
</tr>
<tr>
<td>$ Savings</td>
<td>—</td>
</tr>
<tr>
<td>% Savings (demand)</td>
<td>—</td>
</tr>
</tbody>
</table>
If your bill is still difficult to understand, call your local electric utility office. Some information from your bill is required to complete Step 2.

**Step 2 - Calculate Your Load Factor**
Load factor is a number that indicates how efficiently you are using your demand. Theoretically, your load factor should approach 100 percent. Calculate your monthly load factor for 6 to 12 months so that a maximum, minimum, and average can be determined. If you do not have billing records for this length of time, contact your local electric utility office.

If your load factor varies significantly from billing period to billing period without an explanation, your operation should be carefully reviewed. Also, if your load factor is less than 80 percent, there may be potential to reduce your maximum demand.

If either of these cases is true, then you can go on to Steps 3 and 4. However, if your plant has a constant load factor and it is above 80 percent, then, in all probability, there is little potential for demand control in your plant.

**Step 3 - Evaluate Your Load Profile**
Although this step will probably be the most time consuming, it will give you a great deal of insight into your energy use. The information about load variation by time of day or month will show any anomalies that might exist.

A load profile of your entire operation is required to evaluate your plant’s energy use patterns. If the machinery in your plant does not run at constant load throughout the day or year, then profiles of some individual equipment or systems will also be necessary.

Because data collection procedures can alter the apparent load profile, you must consider the sampling rate and the sampling method.

Sampling rate is the time between recordings of data. For example, a load curve could be sampled every hour, every 15 minutes, every second, or whatever is deemed necessary. A good rule of thumb is that the sampling rate should be faster than the proposed control time.

Sampling methods are normally either instantaneous or period integration. The instantaneous method involves taking one reading at the sample time (for instance, one reading every 15 minutes) and is thus quite crude. Period integration involves taking a number of readings throughout the sample period and then averaging these readings. This method is more accurate and therefore recommended. However, if equipment constraints require using the instantaneous method, a fast sampling rate can be used and then manual integration performed on the collected data.

For best results, the same sampling method and rate should be used throughout a load.

**Step 4 - Understand Your Operation**
Your plant operation must be examined from this new perspective of peak demand control. Plant personnel must know how and why jobs are performed at specific times and thus determine if any jobs can be done at a different time with little or no effect on production.

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**Formula:**

\[ LF = \frac{E}{(D \times 24 \text{ hr/day} \times N)} \times 100\% \]

Where:
- \( LF \) = load factor (%)  
- \( E \) = energy use (kWh)  
- \( D \) = maximum demand (kW)  
- \( N \) = number of days in billing period

**Example:**

**Billing Information —**

<table>
<thead>
<tr>
<th>Energy Use</th>
<th>Demand</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,132,000 kWh</td>
<td>2,880 kW</td>
<td>30 days</td>
</tr>
</tbody>
</table>

**Load Factor Calculation —**

\[ LF = \left[ \frac{1,132,000}{(2,880 \times 24 \times 30)} \right] \times 100\% = 54.6\% \]
Because demand control strategies are based on comparing the actual demand to a target or ideal value, the load profiles and plant operation will have to be examined with a view to setting a demand limit and thus preventing unwanted peaks. The economic factors that set this limit are desired power reductions, acceptable frequency of shutdowns, and duration of shutdowns for the shed load.

Next comes setting load priorities:

- Which loads can be shed?
- Which loads are off first?
- How long can each load be off?
- Which loads can be operated at reduced power/speed?
- Which loads cannot be shed no matter what the demand?

Priorities will establish whether loads will be last off-first on (production type equipment) or first off-last on (heaters).

If everything is clearly defined at this point, the most acceptable method of control should be straightforward.

**Demand Control Methods**

Demand control methods perform three basic functions that are essential to ensure that the target demand is not exceeded:

- Measurement
- Monitoring/decision-making
- Control

The following methods for maximum demand control are listed in ascending order of measurement and decision-making complexity. Note that Methods 1 and 2 do not have interactive measurement and monitoring; these functions are manually performed during load profiling and targeting.

### 1. Scheduling

If the electrical operation of your plant is consistent day by day such that the peak demands occur regularly each day, or if a known operation is bound to exceed the predetermined demand limit, then scheduling equipment to run at different times could work.

For example: A shipyard dry-dock has a demand of 2,000 kW and operates for 112 hours twice a month. If the drydock was operated during the regular workday, it will pay $12,000 in demand charges and only $26 in energy charges. If the drydock was operated before or after the normal workday, there is the potential to save up to $12,000 per month depending on the base load.

![Meter response curve](image)

The time response curve of the element follows very closely to a true exponential curve.
2. Time Clocks and Duty Cyclers

Time clocks provide an automatic method of scheduling. Therefore, the same constraints mentioned for Method 1 will apply: Your operation must either be consistent each day or be able to be operated consistently every day.

There is a large selection of timing devices available. The choice ranges from electromechanical to digital and from single to multicircuit units. Suppliers will help you to determine the best equipment for specific needs.

Duty cyclers can be used to operate two or more pieces of equipment such that only a set number are on at one time. For example: Because of the large demand caused by a sawmill’s slab heating, a duty cycler was installed that will allow only 50 percent of the cable to be on at any one time.

Scheduling, time clocks, and duty cyclers are inflexible to changes that might occur on a daily basis and therefore should be very carefully considered.

3. Manual Control

Manual control means assigning somebody to turn certain equipment off when the load reaches the target level or when other equipment is on. However, as discussed in the section “Understand Your Electric Utility Bill,” this is not the most desirable form of control because of the tight time constraints. However, it may be worthwhile to try this type of control before investing in automatic controls.

Also, if manual control is going to be used on a permanent basis, it would be wise to install some type of alarm system to advise the people responsible for limiting the demand that the maximum is being reached. However, human error is likely to occur occasionally, and the maximum demand charges will then apply.

4. Meter Alarm and Load Shedders

Thermal demand meter manufacturers can provide a meter that will automatically initiate an alarm or remove a load when demand reaches a predetermined peak. This meter can be used as a stand-alone demand controller or in conjunction with a manually controlled programmable logic controller, dedicated demand controller, energy management system, and emergency generator.

5. Interlocks

Interlocks, such as normally closed (NC) contacts on a motor starter, provide the simplest form of input/output control.

Decisions are made during installation so that the NC contact will not allow two large pieces of equipment to operate at the same time. For example: In a fruit processing plant the freezer compressors should be interlocked with the electric frost heave protection so that the slab heaters are not on when all the compressors are running.

6. Programmable Controllers

Because programmable logic controllers (PLCs) are common in a large number of industrial plants, they are a very good choice for control. PLCs have a wide range of features and capabilities, from simple relay replacers to complex analog and digital input/output devices.

Therefore, PLCs can be used as software interlocking units or true measurement, monitoring, and decision-making devices.

7. Dedicated Demand Controllers and Energy Management Systems

Dedicated demand controllers and energy management systems are typically more expensive and complex than other demand control methods; therefore, a good deal of expertise is required to successfully implement this method of control.

Normally this type of equipment is used in large, multibuilding, multipurpose plants.

If you believe that your plant has the potential for demand savings and you require complex decision-making from your automatic control system, then contact either an electrical consultant or the major suppliers of this type of equipment. These people can do a detailed analysis of your plant and then provide figures on guaranteed savings and paybacks.
8. Adjustable Speed Drives

Adjustable Speed Drives (ASDs) may or may not have some form of interactive measuring and monitoring. The primary applications of ASDs are for pumps and fans where the flow can be reduced up to 50 percent, with a corresponding reduction in power of up to 78 percent.

For example: For the shipyard mentioned in Method 1, if, instead of scheduling, two 1,000-kW ASDs were used to reduce the power by 78 percent and the drydock was raised in 1 hour rather than 1/2 hour, the results would be a saving of $9,400 per month with a payback of approximately 1.9 years. This system could be installed and set at a 50-percent flow rate or varied depending on the base load and a monitoring and measuring system.

9. Diesel and Natural Gas Generators

In some cases it may be practical to use an emergency generator to provide peak load shedding. Generators cannot be financially justified for demand control only; however, if your plant already has or requires an emergency generator, then it may be economical to add the necessary controls to use the generator to provide power to a large load.

This will have the same effect on your power bill as turning equipment off, but will have no effect on production.
The Electric Ideas Clearinghouse is a comprehensive information source for commercial and industrial energy users. It is operated by the Washington State Energy Office and is part of the Electric Ideas technology transfer program sponsored by participating utilities and the Bonneville Power Administration.

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