# BASIC DEMAND CONTROL

**Thomas D. ‘‘Dan” Mull, P.E., C.E.M., C.L.E.P., C.D.S.M.**
**Carolina Consulting Group, Inc.**

Dan has been actively involved in energy management for over twenty-five (25) years. He has served in various engineering and management capacities for Carolina Power & Light Company and has been an adjunct instructor with the North Carolina State University Industrial Extension Service since 1983. Dan formed the Carolina Consulting Group, Inc. (CCG) in 1989 to provide technical expertise and training. He has taught energy management and performed energy surveys on six continents, published several articles in professional journals, and been a speaker for the Association of Energy Engineers on numerous occasions.

One of the basic tasks that confront every energy manager is the development of a viable strategy to optimize energy efficiency while minimizing costs. In order to do this effectively, one must fully understand the *rules of the game*, i.e., how each energy source is metered/billed and the facility’s actual load/energy requirements to produce the final product(s), or provide the necessary services.

For every energy source there are units of measure, such as pounds of steam, therms of natural gas, gallons of oil or propane, etc. Consumption for each source is typically measured and tracked by the selling entity. The cost of that energy is then calculated based upon these measured units of consumption applied to a relatively simple rate schedule or tariff. The actual rate may take one of several forms including:

- *Fixed cost rate* – In this format all units consumed are charged at the same price, regardless of consumption level. For example, the last therm of natural gas costs exactly the same as the first.

- *Declining block rate* – With this rate design the cost per unit varies based upon consumption levels; the more you use the less expensive it is per unit. For example, the first 2,000 therms of a billing period may cost of 50¢/therm, the next 10,000 may be at a charge of 40¢/therm, and all over 12,000 at a cost of 35¢/therm.

With *electricity*, however, the billing phase can be quite complicated and perplexing to laymen and engineers alike. There can be a number of factors built into an electric rate, not directly based upon actual usage, that impact the final price to the consumer. It is generally understood that a customer is never charged for more energy (kilowatt-hours – kWh) than they actually consume in a given billing period. The same cannot be said for demand.

Demand is actually the rate at which electrical energy is consumed. For other systems an equivalent measure could be gallons per minute of flow or pounds of steam per hour. Demand is normally measured in kilowatts (kW) or kilovolt-amperes (kVa) by the supplying entity. We generally think of demand in terms of the power required to operate a piece of equipment, a system, or a facility.

Even though the demand for a facility can vary seasonally, daily, and hourly, the supplier must have equipment installed (generating capacity, transformers, and power lines) to provide the maximum or peak demand at any time; even if that peak demand occurs for only one 15 minute period per month. Therefore, in commercial and industrial rates there is a separate charge for demand. This allows the supplying utility to recover the cost of providing that equipment.

To further illustrate the difference between demand and energy, let's look at an example. If an electric unit heater rated at 20,000 watts (20kW) is operated for one (1) hour it would have a *demand of 20 kW* and consume 20kWh of electrical energy (20 kW x 1 hour = 20 kWh). If that same heater were operated for 200 hours it would still have a demand of 20 kW, but the energy consumed would increase to 4,000 kWh (20 kW x 200 hours = 4,000 kWh).

Not fully understanding how your facility is billed for its electrical usage can result in a failed energy strategy and a great deal of frustration for the energy manager. In fact, in a worst case scenario, actions initiated as part of a load management program could actually increase energy expenditures. Therefore, it is essential that the various mechanisms for billing electricity be fully understood.

With an understanding of how electrical demand (and energy) is metered/billed, the next step in the development of a successful demand control strategy is to understand the site processes and the actual load requirements of the facility. To aid in this load (and energy) profiles can be used to evaluate current levels of demand (and consumption). For example, knowing the shape and magnitude of the daily, hourly, and quarter-hourly load profiles can provide vital information, such as: Does an opportunity exist for demand control? If so, what is the potential magnitude (kW and dollars) and is it cost effective? With this information, controllable process or support loads can then be matched to determine which loads would be likely candidates for control and how long they might be controlled.

The optimum result of any successful demand control strategy would be to have a flat load profile, without significant peaks and valleys. This is an ideal situation not only for the consumer, but also for the supplier. With a flat load profile the suppler achieves better utilization of their generation and distribution facilities. In today's competitive market, the higher the utilization a utility achieves the more competitive they can become with their rates. Some utilities even offered incentives in the form of lower rates to customers with consistent power requirements, i.e., high *load factors*.

Load factor is the term given to the relationship between the actual energy (kWh) consumed during a given period and the maximum amount of energy that could have been used, based upon the recorded peak demand during the same period. Therefore, it can be viewed as a measure of *utilization efficiency*. To illustrate how power factor is calculated, if a customer used 300,000 kWh in a thirty-day period, with a peak demand of 1,000 kW, the load factor for that period would be:

Load Factor = 300,000 kWh/(1,000 kW x 30 days x 24 hr./day)
= 0.417 or 41.7% (normally quoted as a percentage)

For a typical single shift operation, a monthly (or annual) load factor in the range of 35% to 45% would be considered normal. For a two-shift operation the load factor should be in the 45% to 65% range. The typical load factor range for a three-shift operation (24 hours/day, seven days per week) should be 65% to 80%. The higher the load factor for a specific customer, the better the utilization of the purchased energy, i.e., *the higher the better*. Of course, for this statement to be applicable the energy must be providing useful work.

For most consumers achieving a high load factor is not possible. Seasonal variations in consumption due to heating and cooling requirements are usually sufficient to establish significant variations in the load profile. However, an effective demand control strategy can potentially minimize peaks, fill valleys, and result in a more consistent power requirement. Not only does this reduce electrical expenditures, but by establishing a reasonably flat load profile a consumer becomes a more attractive customer to the utility, thereby establishing a better position for possible negotiations with suppliers.

Therefore, the starting point for any effective demand control program is to understand *the rules of the game*. Only with the knowledge of how we are billed and consume power can we develop a meaningful and successful demand control strategy. So, with this as a basis let's take a closer look at each of these fundamentals.

**Fundamental No. 1 - Understanding Electrical Pricing:**

Unlike most commodities in the market today, electricity is not sold at a fixed price. Even so-called *fixed rates* can actually incorporate a number of factors that may dramatically impact the final cost to the consumer. Typically, rates are set by state or local regulatory authorities. The design of those rates can take many forms. However, *how and when* the consumer utilizes the electricity may have a significant impact on its final cost. The manner in which we use power can, under some rate designs, change its final cost by a factor of 50% or more.

Where else do we purchase a commodity on a daily basis where the final cost is dependent upon:

- the pricing schedule (rate) we select,
- how much we use; the total energy consumed,
- when we use it; the time of day or time of year,
- the maximum (power) requirement in a given interval,
- how efficiently we use the commodity,
- how we impact the supplier providing the service, and
- how we impact other customers of the supplier

While all of these can play a part in the cost of electricity, the three factors that are most often used in determining the final cost are: the maximum power requirement (kW or kVa), the total energy consumed (kWh), and the resulting power factor (pf). How much each of these influences the ultimate cost is determined by the basic rate philosophy of the selling utility. While all of these can be important factors, for the purposes of this discussion we will focus only on the demand (kW) component.

**How is Demand Billed?**

Demand is the rate at which electric energy is consumed. Also referred to as *power* or *load*, demand is typically measured over an integrated 15 or 30 minute rolling interval. Demand can be compared to the BTUs per hour of heat loss (or gain) for a structure, gallons of water pumped per minute, or pounds of steam used per hour. In many rate structures demand charges can account for 30% to 50% of the total billing. There are a number of different terms used throughout the industry to describe demand. They include contract demand, actual demand, coincident peak demand, non-coincident peak demand, billing demand, and minimum billing demand.

- *Contract demand* (kW or kVa) – This is the anticipated customer peak demand specified in a contractual arrangement and the demand value on which installed transformer capacity (kVa) for a facility is typically based. If a customer uses less than a specified percentage (normally about 75%) of the contracted amount, then they may be billed for that percentage, regardless of actual usage. For example, If a customer contracted for 4,000 kW of power and the actual usage for a billing period was only 2,500 kW, then the customer could be held liable for 3,000 kW (4,000 kW x 75% = 3,000 kW).

  *Note*: If a load reduction is permanent (i.e., resulting from a demand control program), then provisions can normally be made with the supplier to reduce the contracted amount.

- *Actual demand* (kW or kVa) - This is the maximum demand value recorded on the customer's meter during a billing period.

- *Coincident peak demand* (CP) - Coincident peak demand refers to the demand that a facility incurs at the same time the supplying utility sustains its peak demand during a billing period. Many larger customers have requested rates based upon CP billing, since their actual contribution to the *system peak* is less that their recorded maximum demand.

- *Non-coincident peak demand* (NCP) - The non-coincident peak demand refers to the maximum facility demand incurred during a billing period, regardless of the time.

- *Billing demand* – This is the demand on which monthly billing charges are calculated. This may be the *actual demand* incurred during the billing period, a percentage of the peak demand for the previous eleven months (*ratchet*), a percentage of the *contracted demand*, or based upon other contractual factors. Unless a ratchet is involved, the billing demand will typically be the actual demand.

- *Minimum billing demand* - This is the minimum demand value specified in the utility rate schedule. This value will vary depending upon the rate selected, but seldom is a factor in the billing.

**Other Factors Impacting Demand Charges:**

**Ratchets** - This is a pricing mechanism that allows a supplier to recover a portion of their fixed costs in equipment (power plant, transformers, etc.), if a customer does not maintain a specified level of usage. The pricing is usually in the form of a percentage of the peak demand that occurred within the previous eleven months. For example, if a facility consistently used 2,000 kW during the summer months and only 1,400 kW during the non-summer months, with a ratchet of 90% the customer would be held to minimum of 1,800 kW of billing demand (2,000 kW x 90% = 1,800 kW). The ratchet would only apply in months in which the demand was less than 1,800 kW. When a new peak demand was established, the ratchet value would then change. Ratchet percentages usually vary from 50% to 100% of the established peak kW.

Ratchets can be important factors in determining the payback periods associated with demand control. If ratchets are applicable, they can reduce the projected savings resulting from demand control for up to eleven months, depending upon when the control was initiated. In our example above, if a strategy were initiated in the fall (immediately following the setting of the summer peak demand), there would be no billing demand savings until a new summer peak were established the following year. Therefore, unless other savings were sufficient to warrant action, the implementation of the strategy could be delayed until prior to the following summer, especially if it involved a significant capital expenditure.

*Note*: Ratchets are seldom applied in Time-of-Use or other time-based rate designs.

**Time-of-Use Rates** - Also referred *Time-of-Day Rates*, this is a rate philosophy that separates the pricing of electricity (demand and energy) into different periods of the day and year, based upon the cost of production.

- **On-peak period –** This refers to periods when it is more costly for a utility to produce electricity, usually during times of high capacity requirements. Therefore, the rates associated with on-peak periods are higher. Typical on-peak periods might be from 10:00 am to 8:00 pm weekdays during the summer months. During the non-summer months, the on-peak hours might be from 6:00 am to 10 am and 4:00 pm to 9:00 pm.
- **Off-peak period –** Off-peak periods refer to times when it cost less for the utility to produce electricity, usually during times of low capacity requirements. Therefore, the rates are lower. Typical off-peak periods would be any hours not specified as on-peak.

In Time-of-Use pricing for demand, there is typically no (or minimal) cost associated with off-peak demand. Therefore, if load can be shifted off-peak (load leveling) the savings can be quite significant. The differential for energy charges is usually minimal.

**Real Time Pricing** - This is a rate philosophy that separates the pricing of electricity into hourly increments. Customers under this type of rate schedule are typically notified the day before with the pricing. The cost of electricity (usually on a ¢/kWh basis, inclusive of demand) is provided for each hour of the following day. The price can vary by a factor of 15 or more, depending upon the time of day and year. A typical rate differential might be from 2.0¢/kWh to 30.0¢/kWh. The customer can then decide if, or to what degree, he/she wants to purchase electricity. Real Time Pricing is under study in several states and limited pilot programs are available for commercial and industrial customers.

**Riders** - A rider is an add-on, or extension, to an existing rate that states specific conditions, terms of applicability, or charges. For example, a rider may permit seasonal operation under certain conditions. Therefore, billing provisions may only be applicable for selected times of the year. Another type of rider might actually *reduce charges* if the power factor or load factor of a facility is maintained above a specified value. Riders may also be used for fuel adjustments. In some cases the fuel adjustment provisions under a rider have been as much, or more, than the actual energy charge noted in the rate.

**Understanding Your Rate Structure:**

While the factors discussed can impact demand billing, in most rate structures only a few of them apply. Therefore, it is critical that you understand the rate under which you are currently being billed and exactly how each of these factors applies. It should be noted that there could be alternative rates available that might be more beneficial. Your supplier should be consulted to insure that the current rate is the most beneficial now, *and after your demand control strategy has been fully implemented*.

**<u>Fundamental No. 2 – Know Your Facility's Energy Requirements (Load Profiles)</u>:**

It should go without saying that understanding your facility's energy requirements is crucial to the development of an effective demand control strategy. Knowing what the true requirements are and what loads can reasonably be controlled, without having an adverse impact on system operations, is essential. However, how does one determine *if* an opportunity for demand control exists and the magnitude (kW and dollars) of that opportunity. The most direct approach begins with a review the facility's load profiles. Reviewing the load profiles can provide visual information with respect to peak demand values, frequency of occurrences, and patterns of usage. Graphically representing this data allows for quick recognition of elevated peak demands and unusual variations or anomalies in usage patters, all of which might represent opportunities for control.

At a minimum, *monthly* load profile information should be available from the supplying utility or billing records. For purposes of identifying demand control opportunities, this level of information is of minimal value. For larger customers (500 kW and greater), utilities will typically have electronic metering installed that can provide the data necessary to construct *half-hourly* or *quarter-hourly* load profiles (depending upon the billing period; i.e., 30 minutes or 15 minutes). In some cases these profiles can be supplied directly by the utility each billing period at a modest or no cost. As a general rule, the shorter the time frame the greater the detail and more meaningful the data, thereby providing the best information on which to base decisions.

If your supplier does not have the metering to provide this level of information, additional metering can be installed (immediately downstream of the billing meter). Either leased through the supplier or individually purchased and installed, metering can be provided for a modest fee. It should be noted that to insure accuracy with the billing meter, meter pulses will be required from the supplier. There may be an additional charge for these pulses.

Once this information has been obtained, one can evaluate the profiles to determine the potential for demand control. For example, short duration peaks (or spikes), elevated demands during low production periods, and unusual patterns of demand usage can all be indicative of potential opportunities *and dollar savings*. (See Charts I and II) Evaluating the magnitude of savings may be possible by comparing demand anomalies to consistent patterns of usage and then applying the appropriate demand charges.

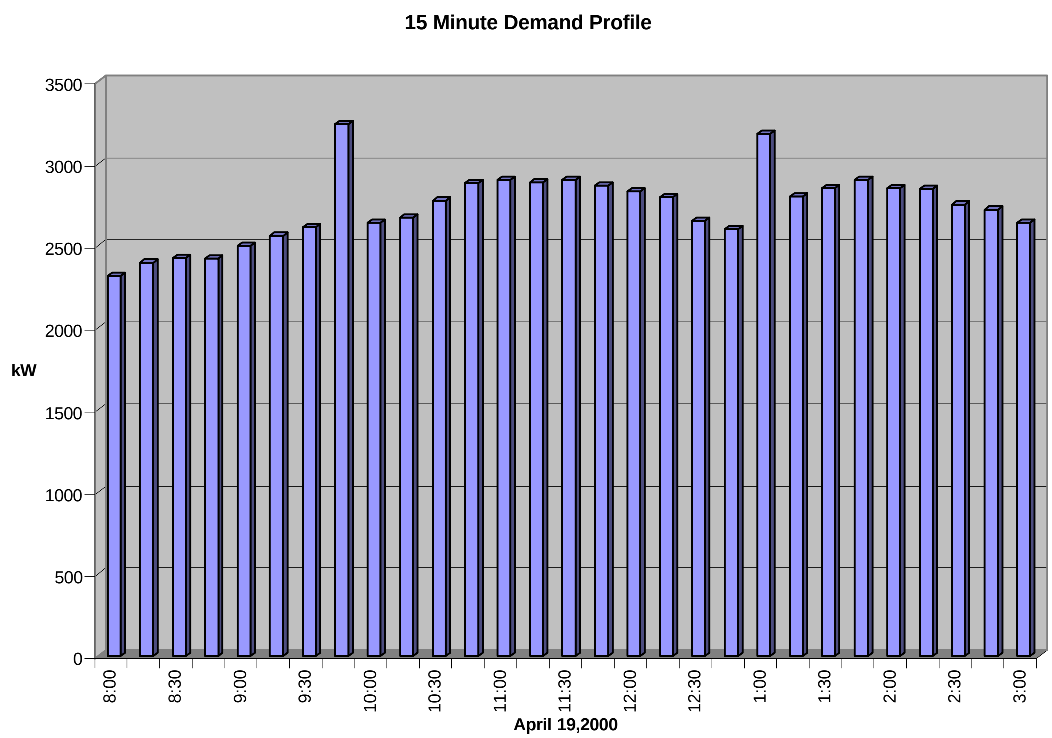


CHART I – GENERIC LOAD PROFILE

**Utilizing Demand Profiles** - In Chart I two distinct elevated peaks are depicted, one at approximately 9:30 am and the other at 1:00 pm. Note how these values are obviously uncharacteristic, as compared to the others. While this information could be picked up from reviewing the numerical data, the use of the load profile makes it obvious and allows for a quick rough approximation (in kW) of the potential for demand control. With a maximum peak demand of approximately 3,250 kW (9:30 am value) and a consistent requirement of about 2,850 kW, this usage pattern represents the potential to reduce peak demand by 400 kW. This value could then be applied for the appropriate billing period(s) and rate, thereby providing an approximate dollar saving.

A less obvious savings opportunity is depicted in Chart II. If this facility were a single shift operation, the elevated demand values reflected after a shift change (at 4:00 pm) would be indicative of a savings opportunity. Depending upon specific requirements after production hours, this usage pattern may represent a significant opportunity to reduce *actual* demand. However, since this demand reduction *would not reduce the peak (billing) demand*. The only savings that would be incurred would be energy savings, which could be quite large.

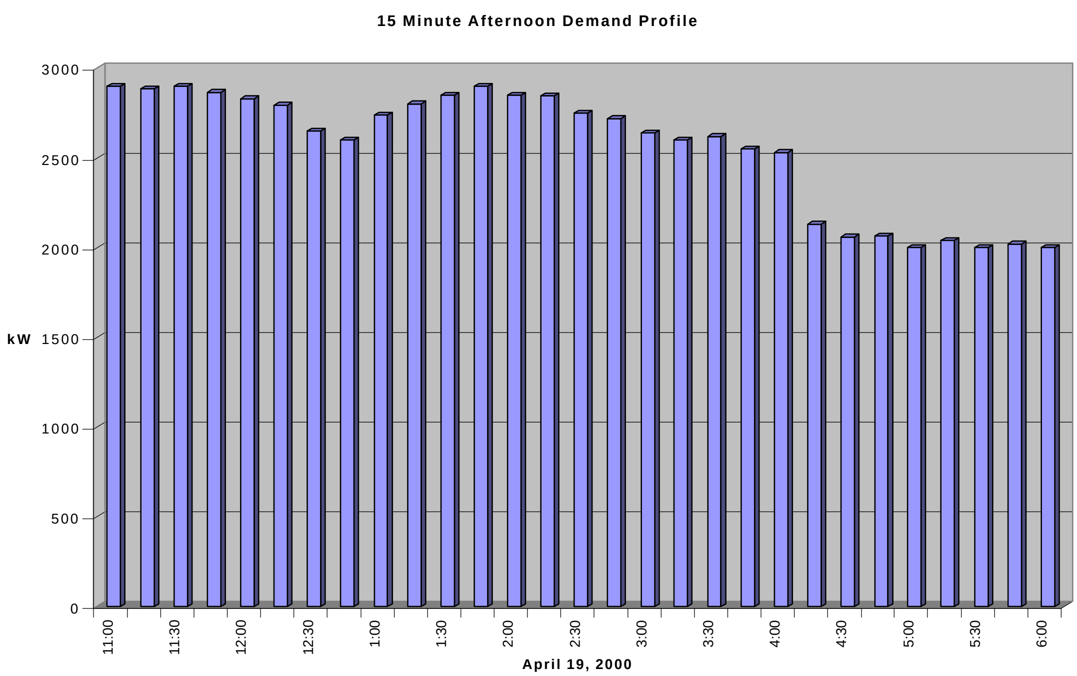


CHART II – GENERIC AFTERNOON LOAD PROFILE

It should be noted that the use of profiles only identifies the opportunities and provides a starting point for evaluating options. They typically do not provide meaningful data to indicate what loads are creating the elevated demands. The next step in the process would be to identify the loads creating the demand and determine what loads could be controlled to provide the desired kW reduction or shift.

**Summary:**

In order to develop an effective demand control strategy for any facility, it is essential that an energy manager have a comprehensive understanding of the two basic program building blocks, 1) how their electricity is metered and billed and 2) knowledge of the process requirements and load profiles for their facility. These are only two of a number of steps that are necessary for a successful program. However, they are the two most fundamental. Without fully understanding and developing the strategy around these, the best-intentioned program cannot succeed.