



## Load Factor, Load Profile and Power Factor

So what's the difference between Load Factor, Load Profile and Power Factor? People in our industry will say that a meter has a low, medium or high load factor.....but do you know how to calculate a load factor? If not, it's important to learn how to do this using historical energy usage data.

### Load Factor (LF)

This term refers to the energy load on a system as compared to its maximum or peak load for a given period. Load factor is most typically calculated on a monthly or annual basis. When a customer creates his maximum demand on the system, he will probably not continue to use electricity at that same level for the whole month, but will use it at different levels throughout the month. The extent of his use for the month as compared to his maximum use for that same month is called his "load factor". Load Factor is computed by dividing his kWh usage for the month by the product of the month's "peak" or maximum demand for him times the hours for the same period (730 for a month and 8,760 for a year). Here is the formula:  $\text{Load Factor} = \frac{\text{Month's kWh Usage}}{(\text{Peak Demand or KW} \times 730)}$

So what is the difference between load factor and load profile? Load profile is not the same as Load Factor.

### Load Profile

Load profile is a graph of the variation in the electrical over time. A load profile will vary according to customer type, (typical examples include residential, commercial and industrial), temperature and holiday seasons.

So.....what is power factor? Is it the same as Load Factor? The answer is no. See the definition of power factor, below, and make note of the difference between these two forms of measurement.

## Power Factor (PF)

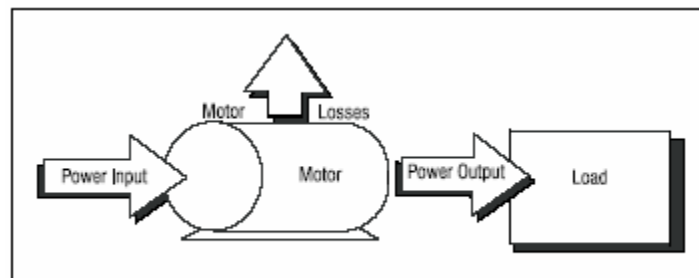


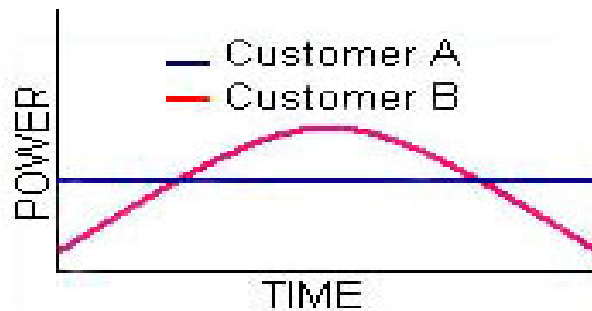
Figure 5 Depiction of Motor Losses

This term is used to express the relationship between "useless current" and "useful power". It can be very confusing to explain and understand. Certain types of electrical devices have a power factor of 100%, such as an electric stove, a light bulb, toaster, etc., which means when the appliance is on, all available power is being used to heat or illuminate and none is being wasted. Some other devices, especially induction motors as commonly used today, are not being used at capacity and result in a demand on the system greater than actually being used or put to good use. The actual work being done by the motor results in a certain kilowatt (kW) demand that is measured by the ordinary meters for measuring such demand. This motor, however, when "partially" loaded, makes an additional demand on the electric system which is not measured by the ordinary meter, but such additional demand requires capacity in the electric system in just the same way as the useful demand requires capacity. When there is no useless current in evidence, the power factor is said to be in "Unity". Power Factor is normally used in calculating kilowatts by the expression  $W = kVA \times PF$ . To compute power factor, the expression would be:  $PF = kW/kVA$  or  $(W/(E \times I))$ . If an electric motor requires 100 kilowatts of useful power and is operating at 50% power factor, the above formula would yield as follows:  $100 \text{ kW} = kVA \times .50 \text{ PF}$ . To solve for kVA,  $kVA = 100 / .5 = 200$ . In other words, this motor requires 200 kilovolt-amperes (kVA) of capacity in the electric system although it only uses 100 kW of useful power. The electric system is still having to provide 200 units of capacity in transformers, lines, etc. to serve that motor.

If power factor for that motor could be increased to "unity", the motor would do no more useful work, it would take no more energy to perform this work, but would make a demand of 100 kw on the electric system, and only 100 kw in capacity in the electric system would be required to serve the motor. If that same 100 kw motor is now working at 70% power factor, the kVA required would be 143, or  $100 / .7$ . An improvement over the 200 previously required. The higher the power factor of a load, the better it is to serve.

Generally, if a customer pays an electricity bill with units of energy measured as kVA, then the customer will benefit from savings by increasing power factor. If the customer pays an electricity bill with units of energy measured as kW, then the utility company will benefit from savings by increasing power factor. Frequently, however, utility

companies impose a power factor penalty charge on customers with poor PF, giving the customer an economic incentive to increase power factor, even if the customer is billed based on kW demand.



### What is Load monitoring?

Electric load monitoring generates important data that can help to unravel the mystery behind commercial facilities' energy usage characteristics. Let Eneserv Consultants show you how to uncover real potential for energy cost savings. Call (405) 824-3002 for a consultation, or read on for more information:

In a perfect world, every customer would use a constant amount of power at all times of the day, every day of the year. This would make it easy for the companies saddled with the responsibility of maintaining and operating the electricity generation and distribution systems to keep everything running smoothly, and at an economical price. Unfortunately for everybody, the world doesn't work that way. People use more power at peak hours during the day when they are operating power-hungry machines under bright fluorescent lights in air-conditioned offices, than they use at night when they are home in bed. This means that utility companies must make allowances for mid-day peaks in power consumption as they provide for the generation, transportation and distribution of power to customers in the city.

In a deregulated electricity supply market, there are theoretically numerous merchant power companies with generation assets standing by to provide consumers with the power they need to operate the homes and businesses at a fair price. Consumers are theoretically able to negotiate with the merchant power companies to agree to a price for power, which will be added to the charges imposed by the incumbent transmission and distribution grid owners to deliver power to the consumer. However, not all customers will be able to get the same good deal as every other customer, economies of scale aside.

## A Comparison of Energy Consumers

To better understand how customers with different power usage characteristics can get vastly different power bills and bids for power supply in deregulated markets, let's start with a comparison of two theoretical commercial consumers of power. Customer "A", (let's call her Alice), has a business that uses power on a steady basis, all day long, every day of the year. Customer "B", (let's call him Bob), has a business that uses, on average, an identical amount of power as Alice, but his usage characteristics differ from those of Alice. Bob turns off all of his power-hungry machines and electrical devices each evening, then turns them back on again in the morning. Bob's business competes with that of Alice, so to maintain the same level of production as Alice, Bob's machines have to make up for lost time, so he uses much more power than Alice during peak hours although he uses less power at night. Now, for argument's sake, let's assume both these customers want to negotiate with owners of generation assets for the electricity supply to their facilities.

Let's assume Alice's absolute peak demand for power is 1,000 kilowatts, (kW). Thanks to her flat demand for power, this means she requires 8.76 million kilowatt-hours (kWh) to service her business. (8,760 total hours per year X 1,000 kW). Bob also uses 8.76 million kWh annually, but his peak demand is 1,500 kW. This means Bob has a "load factor" of 66.7%, which is the relationship Bob's average demand for power, (1,000 kW), bears to his peak demand for power, (1,500 kW). From a generator's viewpoint, the lower a customer's load factor, the less desirable the customer will be.

To understand this, consider the viewpoint of one of the hypothetical companies bidding to supply power to Bob and Alice. Let's assume a given generator's maximum capacity is 1,500 kWh, which is equal to Bob's peak demand, but 50% greater than Alice's peak demand. The generator is owned by a merchant power company which has financing in place to cover the acquisition of the generation plant. The merchant power company also employs staff to operate and maintain the plant, and the company must purchase fuel, (natural gas, coal, oil, etc.), to produce power. The fuel cost is a variable which will fluctuate in direct proportion to the amount of power generated by the unit, while the financing costs and many of the operating and maintenance costs are fixed. When offering a proposal to supply electricity to Alice, the merchant power company knows that it will have 500kW left over to sell to other consumers. Alice will get a much better offer than Bob. If the merchant power company ends up doing a deal with Bob, it won't be able to sell power to other consumers. Realistically, the merchant power company will need to capture all of its operating expenses, financing costs and profit from Bob alone, while Alice would only need to bear the brunt of 2/3 of those fixed

costs. To put it simply, the less-pronounced the customer's peak, and the higher the customer's load factor, the better price the customer will achieve for power in any market, deregulated or not. It makes economic sense for all consumers of power to improve their load factors.

The same cost differential stemming from varying load factors applies to the cost of transmission and distribution of power. Think of transmission lines as conduits of a commodity. Similar to any conduit, electricity transmission and distribution grids have a maximum capacity, just as you can only pipe so much data over telecommunications lines or water through plumbing. As such, electrical transmission and distribution capacity has value, and there is a cost associated with the "rental" of space on the grid. Because Bob has a peak demand 50% higher than Alice, Bob has to pay rent for 50% more capacity on the transmission and distribution grid. Bob's cost for transmission could end up being far higher than Alice's in the event his peak demand for power contributes to congestion over a grid. Congestion is a condition that occurs when there is insufficient transmission capacity to supply all the demand on a grid. This condition could lead to grid failures such as blackouts, and because power could be drawn from adjacent grids at a premium, it would most certainly lead to increased costs for consumers on the affected grid. There is also a variable used in calculations of consumers' power costs known as "coincidence factor" which is linked to that degree by which a given consumer's peak demand coincides with the peaks of other consumers on a given system. The lower, (read: worse), a customer's load factor, the more the coincidence factor could contribute to exceptionally high costs for the delivery of power from the generator to the consumer, especially during peak seasons. Most of the customers we encounter can make changes to their operating methods or their facilities' systems to improve their load factors. Better load factors lead to better prices for power.

Armed with the understanding that improving his facility's load factor will save money and help his business compete with that of Alice, Bob might ask a consultant what he can do to make a difference in his monthly power bills. The first step to answering this question is to gather information regarding current conditions and practices at the customer's facility. I would ask Bob to send me at least twelve months of his past (recent) electricity bills so I could get a clear understanding of how he used power on a monthly and annual basis. Sometimes, in conjunction with a customer interview, this stage of information-gathering can reveal many things, and I might make some suggestions for possible energy saving techniques. The suggestions might have to do with no-brainer equipment retrofits including lighting system upgrades, but without a more detailed information-gathering effort, I would be unable to make concrete and supportable recommendations which would include energy upgrade payback schedules, etc.

Just as detailed inventory of energy-consuming equipment at Bob's facility would help to refine my suggestions and pin down supportable estimates of cost savings associated with the proposed changes, so too would a detailed analysis of electricity usage patterns at Bob's facility help to pin down really germane advice regarding how power usage characteristics could be modified, (without impacting Bob's operation in any negative manner), to improve his load factor. The vast majority of existing electricity meters installed in commercial facilities record how much power was used in a given period, (kWh), and what the peak demand was during that period, (kW). This information is reported on a bill, but it is not really detailed enough to serve our purposes. This is where load monitoring equipment makes its debut at Bob's facility. I would rig a device to monitor kW usage in fifteen-minute intervals, while recording ambient conditions such as temperature, major equipment duty cycles, and other factors which might affect power usage characteristics. The load monitoring equipment would be programmed to upload to our servers its recorded data via one of Bob's existing phone lines at a pre-set evening hour while Bob is asleep. Armed with this data, I might note by careful analysis in conjunction with personnel interviews that all four air conditioning chillers at Bob's facility were activated simultaneously each day when the temperature in the facility reached 80 degrees. Bob might not have known that the simultaneous activation of all four chillers actually contributed with the other systems in his facility to set his peak at 1,500 kW each day. All Bob and I have to do is train his staff or install an automatic control to stagger the starts of the chillers, starting them one-at-a-time, in 15 to 20 minute intervals, and Presto! Bob's peak demand might fall to 1,400 kW, and his load factor just improved from 66.7% to 71.4%. Bob's cost for this modification alone is close zero.

There may be other quick fixes which have a negligible cost to Bob, but there will most certainly be fixes such as a comprehensive lighting system retrofit, which will have a substantial cost of implementation. In general, lighting retrofits will pay back the investment in one to three years, (depending on kW rate and hours of lighting system operation), and most business people are hard-pressed to match that kind of return on capital, but as each subsequent modification of facility systems is evaluated, we will certainly note a diminishing return on capital and effort. For this reason, I always advise people like Bob to set out a roadmap of expectations. How far do they want to drive, for example, for a progressively better view, when the first couple of miles yield stunning vistas, but then it could be many, many rest stops before the ultimate view is achieved? Most people in Bob's shoes would save themselves a lot of time and frustration if they would set out clear goals at the outset of any effort to improve energy usage characteristics in a facility. For example, Bob might choose to draw the line at any investment which does

not yield a simple payback of four or five years. Once this line is drawn, it becomes a quick and easy matter to use the data collected by the load monitoring equipment over a period of several months to calculate exactly how various energy upgrades and operating method modifications will reduce Bob's total cost for power. The picture painted by the load monitoring equipment will allow us to document in supportable figures exactly what the savings will be, (assuming other variables are unchanged).

#### "Time of Use" Meter

Data produced by load monitoring equipment can help save customers money in other ways too. For example, in many regulated and deregulated electricity supply markets, consumers of power can request from their incumbent utility company a "time of use" meter. This new meter would be installed at the consumer's facility, replacing the older, "dumber" meter. The time of use meter would record the same 15 minute interval data that our load monitoring equipment would record, and, (now this is the key), the consumer would from that point on be billed based upon their actual time of use. There are usually different rates charged by utility companies for different times of day. It's not hard to imagine that power will cost less at night when nobody wants it, right? So, before the time of use meter was installed, the utility company was making an assumption regarding how much power the customer was using during "on-peak" hours, and how much power was being used during "off-peak" hours, and chances are, their assumption was off, to the customer's benefit or perhaps to their detriment as the case may be. Of course, certain customers such as theaters, late-night restaurants, and possibly even hotels are most certainly getting a bum deal by holding on to their "dumb" meters, but if a customer doesn't know for certain that it would make economic sense to make the switch, the customer had better not risk it. Once a customer switches, he may not be permitted to go back to the dumb meter. At best, the customer might be required to stick with the new meter for at least a year. The accumulation and careful analysis of real-time load monitoring data can help a consumer of power make the correct choice about switching to alternative meters or rate classes, which could conceivably save a great amount of money. These techniques apply to all sizes of electricity consumers, and the potential for savings could be on par for large and small on a percentage basis. However, if a sole homeowner could save 10% on her power costs, the savings would take years to pay off her costs associated with the retainer of the consultant, the installation of the load monitoring equipment and the completion of the analysis and final report. If, on the other hand, an owner of a large midtown office building could save 10% on his electricity costs, the cost of the consultant, analysis and equipment becomes negligible. For this

reason, we recommend load monitoring to medium and large-size businesses.

Take the first step towards realizing energy cost savings at your facility by contacting Eneserv Consultants today to schedule a consultation to review the benefits of load monitoring equipment installation. Call us at 405 824 3002