Colorado Springs Utilities
It's how we're all connected

LOW LOAD FACTOR, REDUCING DEMAND & YOUR BILL WHITE PAPER #7

Load factor is like a utilization factor for the electrical system. For a given amount of energy use, larger peak demand creates a lower load factor.

A useful analogy is seeing the peak demand value and demand charges as the size of generator rented for the month.

This paper applies to large customers that have demand charges as separate line items on their bills. 'Demand charges' are like renting a generator by the month: the cost is the same whether used once for 15 minutes or steadily for the month.

What is Load Factor and Why Care?
The term 'Load Factor' is the ratio of average demand to maximum demand. But what does that mean?

The proportion of average power / maximum power and represents how consistently the system is utilized. Business view of expensive equipment that is purchased and just sits around most of the time is…not good….the thing used capital or was bought on credit and should be earning its keep to be a good investment. To the electric utility, setting aside a piece of the generation capacity and having it used only briefly is the same thing, under-utilized, and the un-cost-effectiveness is reflected in the bill when that happens.

Load factor (asset utilization factor) is low when the customer's load includes a large load for a short amount of time, i.e. when max demand is much higher than average demand. When this happens, the customer will see demand charges as a high proportion to the total bill, and the overall effect of higher cost per unit of energy used for the month.

In this paper is a brief explanation of how utility costs are recovered, and the role load factor plays. Then, we will illustrate the load factor concept with example usage patterns. Finally, we will show how load factor is useful as an electricity cost management metric, and how it can point you toward savings opportunities.

Utility Electric System Cost Recovery

Utility companies recover their costs in two main chunks: fixed costs and variable costs. For electricity, fixed costs include things like generators, wires, etc. – things that have a 'mortgage' payment each month regardless of usage; variable costs are operating costs that go up and down with usage, like fuel and maintenance. Generally, fixed costs are recovered through demand charges and variable costs are recovered through energy charges. Think of demand charges as the portion of the electric system you used for the months.

Clearer yet is the analogy of renting a generator. Supposing the generator rental is 'by the month', you'll rent the one you need for the biggest load, trying not to over-size it since bigger units cost more to rent. Once it is rented, you can use it as much as you want, adding fuel as needed. Like a generator rental, if you rent it and hardly use it, the fuel cost would be low, but the rental fee would be the same. Generator sizes are based on how fast they can deliver energy. Delivering a day's supply of electricity in one hour requires a bigger generator than if it were spread out. Electric meters identify the highest rate of energy usage (power, units if kW or thousands of watts) each month to determine the demand charge; double the demand, twice the generator size, twice the demand charge. Demand charges are your generator rental fee. This explanation shows why when a large demand is measured, even for a few minutes, it determines the portion of the infrastructure set aside for that customer for the month – the generator size you rented – your portion of utility fixed charges that month…. and so the *demand charges are the same whether used briefly or continually.*

- Aside: There are differences in utility fixed and variable costs for 'on peak' and 'off peak' times, mostly because on-peak usage is served by equipment that only runs in high demand periods – for the rest of the time, these items are under-utilized, while their 'mortgage' cost is the same regardless of usage. This is why 'on peak' charges cost more.
- Aside: Everyone shares in the infrastructure costs. For simplicity, demand charges are built-into some rates where usage is very patterned. For commercial and industrial customers, business needs vary a lot and so do their utility needs; here, separating demand charges makes sense to allocate costs more fairly.

How Load Factor Affects Electric Cost

Remember: load factor is *average demand* divided by *maximum demand* and demand charge is based on the highest load taxing the electrical system. When there is considerable base usage associated with a given demand, the capacity rented for the month is being utilized more and load factor will be higher. Load factor affects the bill by changing the proportions of demand and energy charges.

- The classic and unhappy case is when there is a large short-term demand that is much higher than the rest of the month. Say there is one hour when electric demand is double the rest of the month…this causes 'renting a bigger generator' for the month, in this case doubling the demand charge. The jump in demand charge makes it a larger portion of the total bill, causing the overall cost of the electricity for that month to go up. We'll show ways to spot this expense and hopefully to prevent it.

- Aside: sometimes, explaining load factor and its relationship to electric cost prompts a question:
    - Question: So, if I have to set a high demand for one short period, will it be cheaper on the bill to just run everything all the time then?
    - Answer: No, that would increase cost further unless the extra run time provided some benefit to your business like higher sales. Best economy comes from using only the energy you need to, plus avoiding short term high usage rates if you can.
- Aside: often, explaining load factor prompts another question:
    - Question: To reduce my demand, I should avoid starting motors at the same time, yes?
    - Answer: Good question, but no. Actually, it would be yes if the generator served just your business. Motors *do* have high inrush current and power draw, but only for a couple seconds. However, the electric grid serves thousands of customers and can ride through a few seconds of inrush current with no problem. But it can't ride through longer periods. The billed demand is based on the highest average 15-minute demand for the month. So, while power use from multiple motors starting together does increase kW demand, the few-second event is diluted over the 15-minute period (900 seconds long) and has only a tiny impact on the billable demand. Even doubling the entire facility demand from 100 kW to 200 kW for 5 seconds would only increase the billed demand to 100.6 kW. But if the doubling lasted for 15 minutes or more, then the billed demand would be 200 kW.

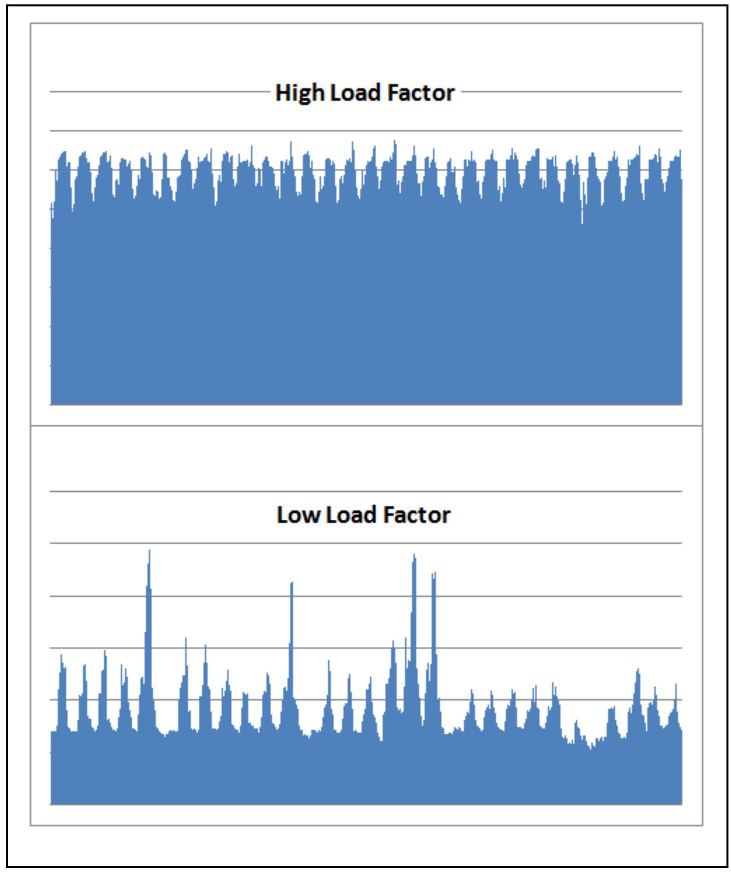


Figure 1. High vs. Low Load Factor Pattern

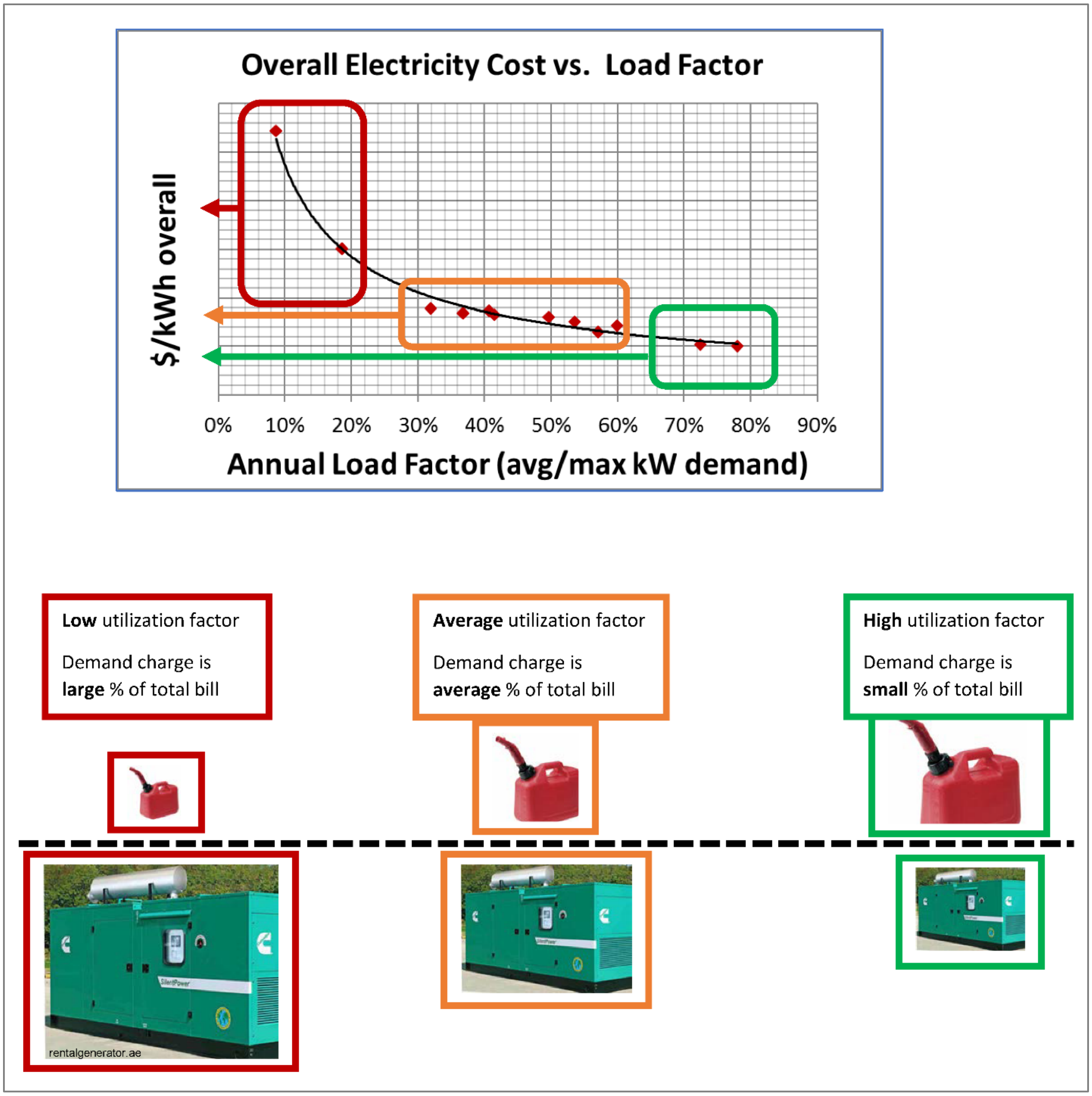


Figure 2. Load Factor Relationship to Overall Cost of Electricity

$ per kWh chart is generalized, to show increasing and decreasing overall electric cost as load factor changes from low to high respectively

Fuel can / generator pictorial representation is to show the connection between 'load factor' and equipment utilization concepts

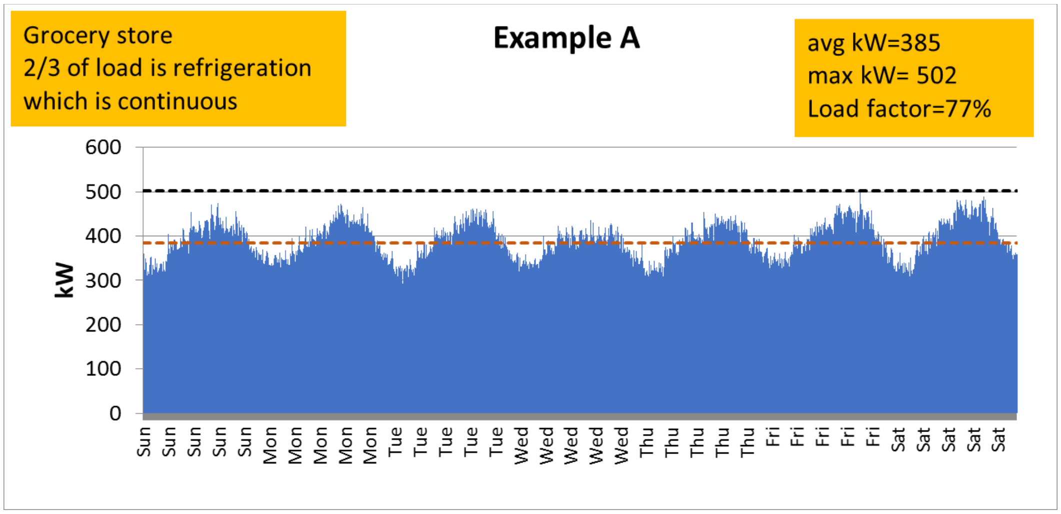
Load Factor Examples from Usage Patterns

Businesses use electricity differently depending on their needs. A business that operates continually 24x7x365 will naturally have a very low load factor and demand charges could be less than half of the total bill. A business that operates one day per week will naturally have low load factor – with short hours per month, energy use would be low, and the demand charge would be almost all of the bill. Those are extremes: most businesses have operating hours and inherent load factors in the middle.

The utility designs rates to recover costs as equitably as possible. As a 'we are all connected' message, it is interesting to know that rates are designed around average load factors of customers that are using the electricity in a given group. Refer to the chart in **Fig. 2**.

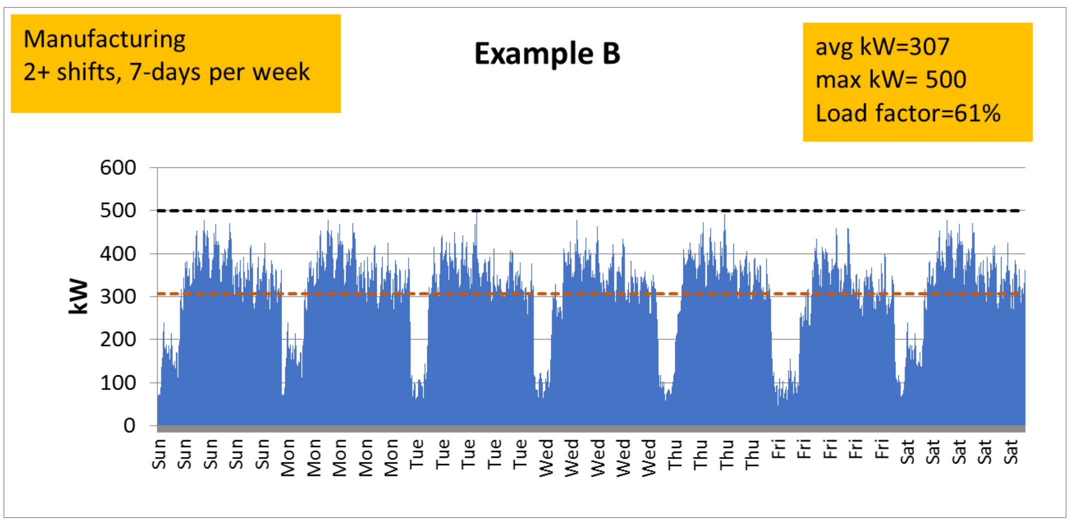
- Customers with load factors near the group average will see 'average' overall cost of electricity.
- If a customer's load factor is higher than the group average, the demand charge is a smaller % of total cost and overall cost of electric energy goes down.
- If a customer's load factor is lower than group average, the demand charge is a larger % of total cost and overall cost of electric energy goes up.
- If customer load factor is extremely low, like the 1-day per week business example, or if the customer creates a very large short term demand, demand charge can be almost the entire bill and overall cost of electric energy will be very high.

Examples of business load profiles will help reinforce the concept of 'load factor' as the ratio of average kW / maximum kW. In each chart, the dashed black line is the maximum kW and the dashed red line is the average kW. The closer the two lines are, the higher the load factor.

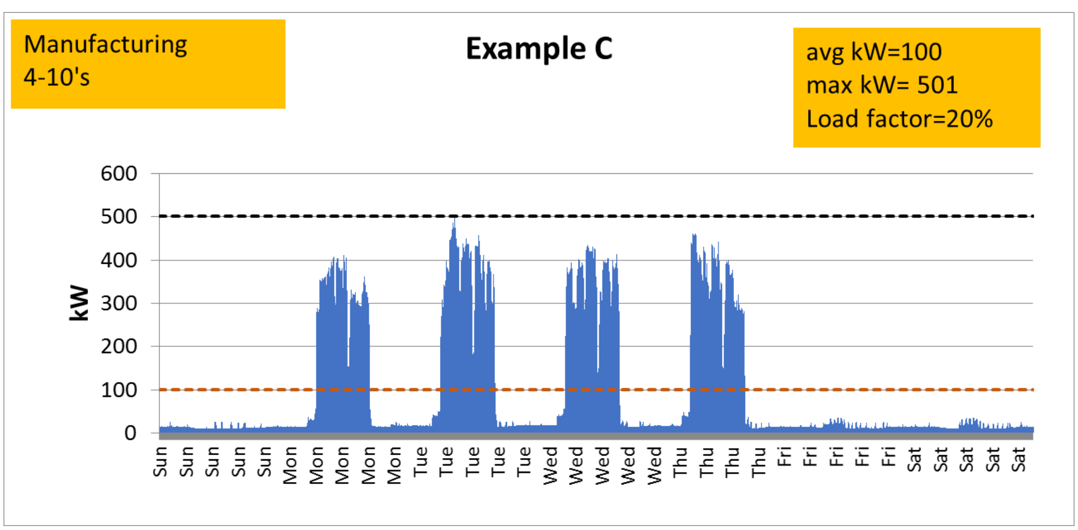


Average and max kW are very close. This is very steady use.

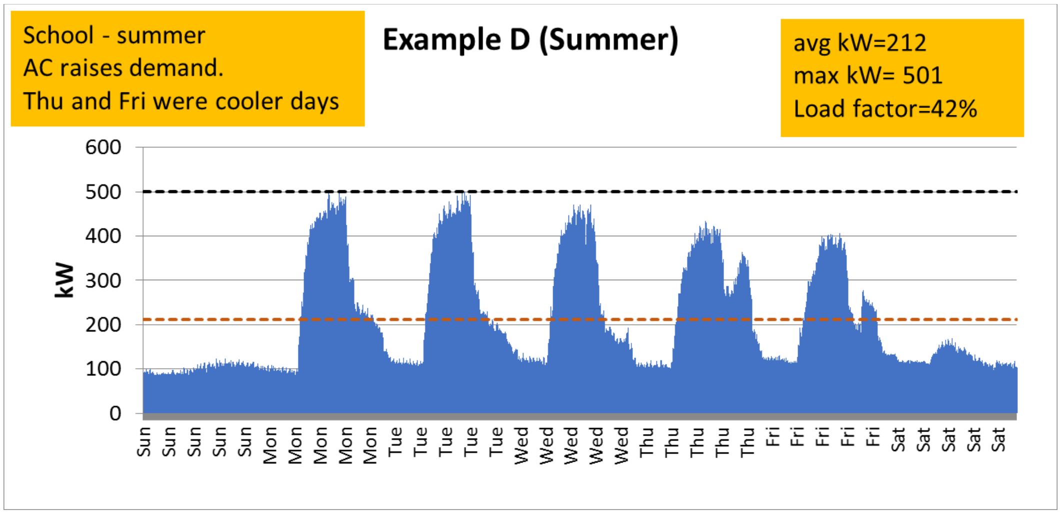
Normal pattern for this business.

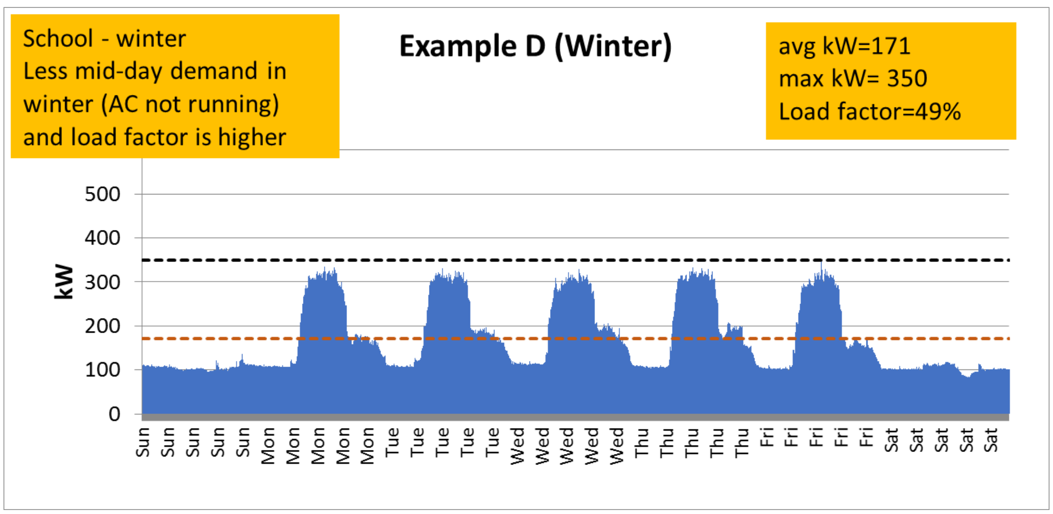


'2-shift' description is more like 2.5 shifts, with the down time less than 1/3, but this is normal



Very low load factor, but normal for this business that operates only four days per week.

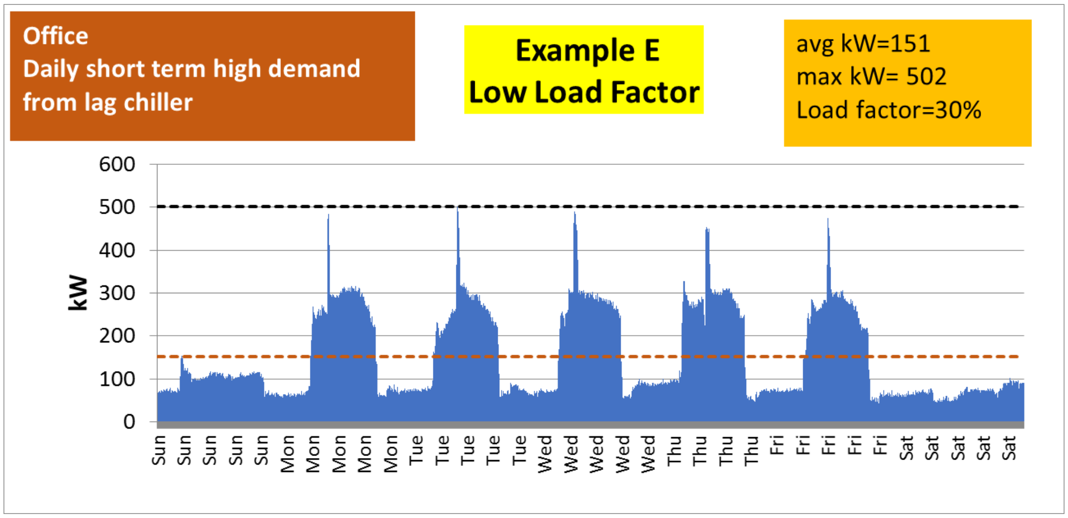




Upper and lower charts are the same building.

There is a considerable base load which is a question, but the load shape and load factor is normal.

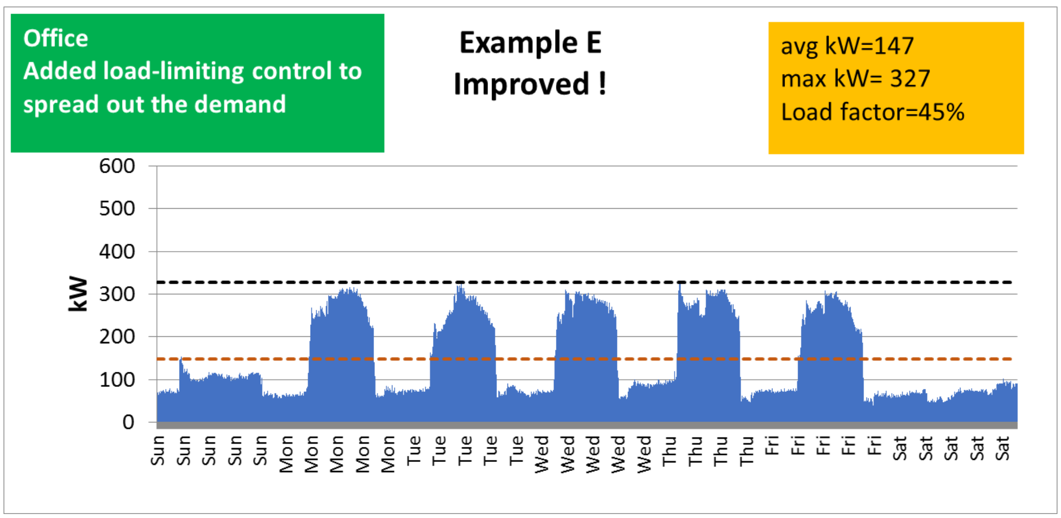
Note the peaks are higher in summer from air conditioning and how it causes the load factor to be lower in summer.



Upper and lower charts are the same building.

This is a case where review of interval data (customer portal) led to savings.

Note the large short-term demands occurring each day. This lowers the load factor and makes demand charges higher than necessary



Same building, with load-limiting applied. Cooling work of the ‘lag’ chiller is spread out over several hours, so it never sees full load, removing the short-term spikey load.

What is Your Load Factor?

Load Factor, calculating by month using bill data

For customers tracking usage and demand by month, the calculation is:

LF=avg kw / max kW **(eq. 1)**

where:

Avg kW = total kWh per period / hours in the period

Example calculation:

From August bill:30 days bill period, 235,000 kWh, 790 kW max demand

30 days x 24 hrs = 720 hours in the period

Average kW = kWh/hours; avg kW=235,000 / 790 = 326 kW

Load factor = avg/max kW; LF=326 / 790 = 41%

Load Factor, weekly or more, using interval data

To look for patterns, especially short term large demands that aggravate the demand charges, you will need 'interval data' of kW at readings 15 minutes apart or less. You can find this data in the customer portal at www.csu.org under your account. Charting in blocks of a week can be enough. Looking at several weeks is a good idea and including the week where the bill demand was set is better yet. You can take advantage of pre-made charts on the portal, or you can download raw data and chart your own – charting your own will allow charting not only the usage profile, but additional flat lines which are 'average kW' and 'max kw' if you find that helpful.

Making the first chart is an investment of time for you. But after that, it can be copied to a new tab each month and then all it takes is inserting new interval data and changing the title, so it reflects the new month. Easy, after the first one.

- Aside: Interval data is right up there with sliced bread. While studying the usage pattern and looking for short term large demands that may be correctible, you may also discover other savings opportunities that interval charts make visible:
  - Usage on a weekend or day when you know the building is closed
  - Something starting in the middle of the night (usually followed by 'what is that??')
  - Usage at night that is higher than you can account for

Savings Examples Related to Load Factor

Low load factor is an indicator, but electric billing amount is based on demand, energy, power factor, and other charges. When low load factor is connected to high bills, *it almost always comes to looking for ways to reduce demand charges.*

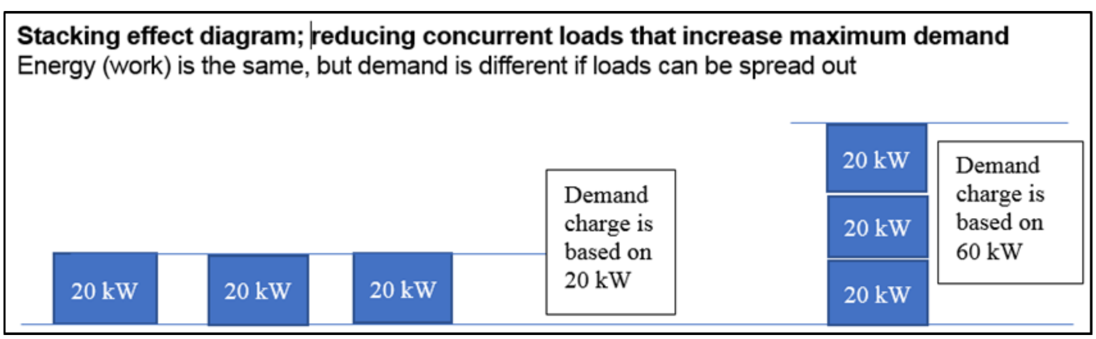
Some of the measures noted are conservation measures that save energy and usually also save demand, some involve new equipment, and some are controls-based to temporarily make adjustments during expensive peak time.

Notes for all demand measures

- For demand reduction to save money, it must occur at the time when the monthly peak would have otherwise occurred.
- For demand reduction to save money, it must occur consistently. It only takes 15 minutes on any one day in the bill period to set the demand. For this reason, demand savings have the most success when automated.
- Demand reduction measures that impact the process usually fail. Common fails:
    - Causes reduced production (ex. delays, slower tools, labor cost increase)
    - Causes discomfort (ex. spaces too warm or too cold, stuffy)
    - Impacts customer experience (ex. distraction, dim lights, tepid shower water)
    - Impacts product quality (storage temperature, any change in process recipe)

Un-stack electric loads

- Where large electric loads exist, making provisions to operate them mutually exclusively eliminates the 'stacking' effect where the loads run at the same time on some days, setting a peak for the month.
- Coordination. For loads that are random, have no other dependencies, and can be done 'sometime today', adjusting procedure may be enough (signage) or a timer. Ex. Trash compactor.
- Product storage between steps will allow sequential production steps to be done in non-sequential times. Ex. To get one of the production steps off-peak.
- Interlocking. This physically prevents machine B from starting until machine A is off. Only makes sense when avoided electric demand charges exceed the labor cost of the person standing around waiting.



Schedule loads in off-peak time

- Charging batteries off-peak can be done with a simple timer. This measure relies on the battery capacity being able to last through the peak period.
  - Forklifts
  - Golf carts
  - Electric cars
- If a manufacturing operation can run unattended, or where night shift labor cost is not at a premium, moving an operation such as plating or long-cycle baking to off peak will put this energy and demand into the lower cost period. Noting that 'off peak' times are different seasonally can be a barrier to this for shift 2 but shift 3 is at night and off peak year-round.
- Thermal storage. This is an engineered and capital intense system for cooling loads, moving the cooling load to off-peak. The cooling energy is stored as cool water or ice and used during peak time with compressors off or greatly load-limited.
- 'Almost' Just-In-Time manufacturing
  - If manufacturing customers can tolerate a small delay in shipment, the peaks set as a result of Just-In-Time manufacturing can be avoided.
  - In this scenario, warehousing and inventory costs are reduced (good) but another result is immediately jumping to produce an order, turning on multiple equipment items to make the part, then turning the equipment off (setting a peak)

More efficient cooling equipment

- For the same 'tons' of cooling load, high efficiency equipment that requires less 'kW per ton' will lower kW during summer.
- Water-cooled rather than air-cooled electric cooling will lower kW during summer. Note that this approach adds water/sewer cost which will negate some/all of the electric savings depending on the cost of the water in relation to the electricity savings.
- Evaporative cooling rather than electric cooling.

More efficient 'other' equipment

- High efficiency lighting.
  - Same light with less power.
  - (note: if replacing lighting, inquire about demand limiting capability option for LED lighting fixtures).
- High efficiency fan wheels.
  - For the same air flow, high efficiency fans that require less kW per unit of air flow will lower kW.
  - For variable air flow HVAC systems, the benefit will be during summer only.

  - For constant air flow HVAC, the kW benefit will occur all seasons.
- UPS in data center.
  - Efficiency improvements from downsizing (if grossly oversized)
  - Where multiple UPS units are operated in an array for reliability, they collectively end up at a very low load, such as 25%, with low efficiency. Some UPS manufacturers offer supervisory software that operates collections of UPS units as hot spares in idle mode (coming to life in a split second if needed), allowing active units to see a respectable load (such as 70%) and more favorable operating point.

Gas heat instead of electric heat

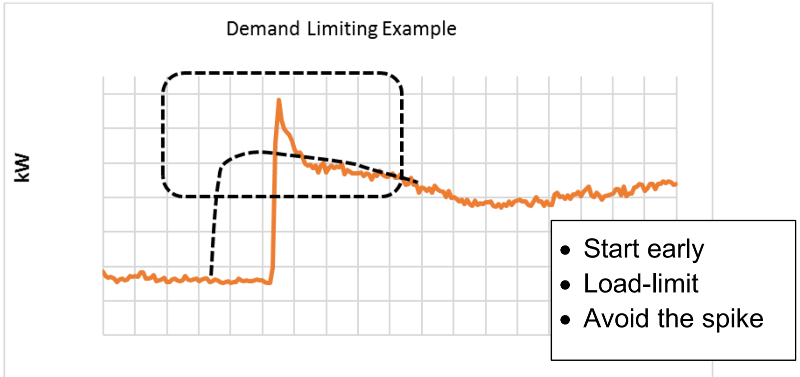
- Space heating, water heating, process ovens, heated tanks

Private generation or renewable energy with storage

- On-site generation, including PV or wind, will make the building load look smaller.
- On-site generation adds O/M cost and that probably negates the savings unless there are additional incentives.
- PV and wind power will need batteries for the Murphy's Law cloudy day / no-wind day that will occur at least one time in the month, eliminating most/all of the planned demand savings. For example, in full cloud cover and no battery, the kW output of a PV panel can drop to 15-20% of full output. If the cloud lasts only a minute, the effect will be diluted just like motor starting current, but if the cloud lasts 15 minutes during the peak period, then most of the demand benefit you hoped for will evaporate.

Active demand control

- Control response to shed load automatically can be set up to lower demands during peak hours, or whenever peak load exceeds a threshold. Most often used in conjunction with control feedback of electric demand meter but could also be programmed to shave loads during the utility on-peak period.
- Some possible things to shed using an automatic control system:
  - Load-limit step changes such as coming out of unoccupied or when a cooling load calls for a 'lag' compressor to start. This is discussed in greater detail in the **article Demand Control Strategies During Load Step Change'**



- If space heating is electric resistance, and natural gas ‘morning warmup’ bulk heater is available, preheat with natural gas for warm-up period but also exceed ‘occupied’ setting to ‘soak’ the building mass and furniture before switching to electric heat; this will allow a more graceful handoff, coasting down to the occupied setting, and helping avoid all the electric heaters coming on right after the handoff.
- If electric water heater: raise domestic water temperature before on-peak time, and then turn off the water heater or load-limit (requires blending valve).
- If electric cooling, close blinds and raise cooling set points.
- Reduce fan speeds by 10% below present value.
- Dim lighting 10%.
- Lock out electric VAV box reheat coils in summer (they shouldn’t be running in summer anyway, but you might be surprised).