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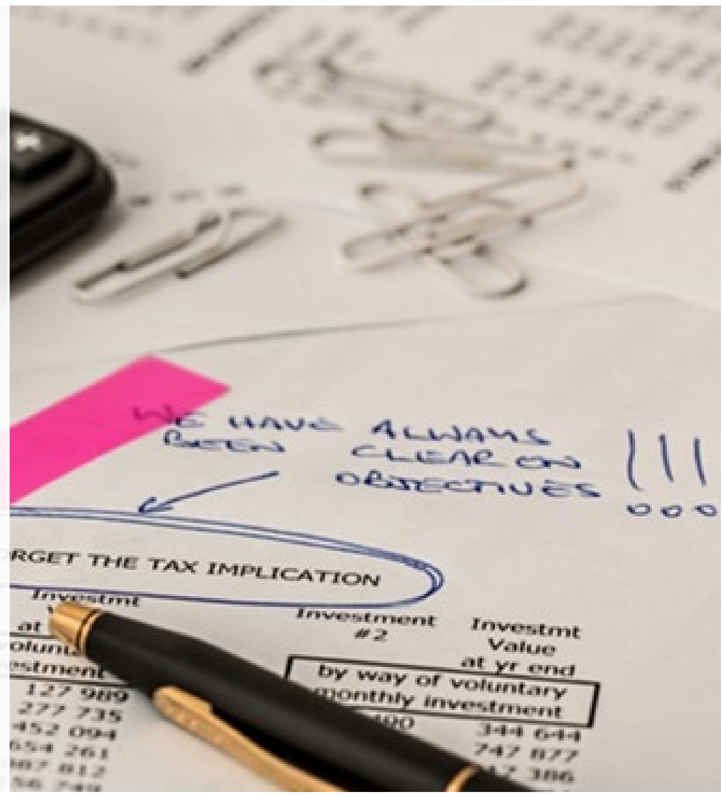
U.S. DEPARTMENT OF ENERGY



Understanding Your Utility Bills:

Electricity

2021

ORNL/SPR-2021/1839

Authors and Acknowledgments

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Preface

The U.S. Department of Energy's (DOE's) Better Buildings, Better Plants Program (Better Plants) is a voluntary energy efficiency leadership initiative for U.S. manufacturers and water/wastewater entities. The program encourages organizations to commit to reducing the energy intensity (EI) of their U.S. operations over a 10-year period, typically by 25%. Companies joining Better Plants are recognized by DOE for their leadership in implementing energy efficiency practices and for reducing their EI. Better Plants Partners (Partners) are assigned to a Technical Account Manager who can help companies establish EI baselines, develop energy management plans, and identify key resources and incentives from DOE, federal agencies, states, utilities, and other organizations that can enable them to reach their goals.

Partners are expected to report their progress to DOE once per year. This involves establishing an EI baseline upon joining the program and then tracking their progress over time. ***Understanding Your Utility Bills: Electricity*** is intended to help companies meet the program's reporting requirements by helping them to learn about and analyze their electric bills. Data collected from utility bills can be used with the DOE Energy Performance Indicator software tool to establish an energy baseline and track progress over time.

This guidance document is applicable to companies participating at either the program or the challenge level. Although the guide is intended primarily to assist companies participating in Better Plants, the methodologies and guidance within the document are applicable to any organization interested in understanding their electricity bills.

For more information on the Better Plants program, please visit:
betterbuildingssolutioncenter.energy.gov/better-plants

For more information on the Better Plants Challenge program, please visit:
https://betterbuildingssolutioncenter.energy.gov/better-plants/better-plants-challenge

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Definition of Terms

The following definitions apply to the Better Buildings, Better Plants Program. Certain terms may have different definitions in other methodologies or contexts.

Calendarization	The process of allocating energy usage and costs to standardized billing periods.
Coincident Peak (CP)	Measurement of a facility's electrical demand when the grid reaches its maximum load.
Consumption	The total amount of electricity that a facility consumes over a given period. Usually measured in kWh.
Critical Peak Pricing/Rebates	A utility pricing structure where the utility can call a "critical peak" day and adjust the cost of electricity to encourage customers to cut usage during high-grid demand.
Demand	The rate at which a facility consumes electricity. Usually measured in kW, kVA, or KVAR.
Actual Demand	The amount of electric demand that a facility requires during a given month. A facility's actual demand may or may not equal the billed demand.
Baseload Demand	The minimum continuous level of power used by a facility during all operating conditions.
Billed Demand	Billed demand is an adjustment to actual demand based on ratcheting clauses, power factor penalties, and so on. Billed demand determines the monthly demand charges.
Peak Demand	The maximum level of demand required by a facility. Peak demand is equal to actual demand listed in utility bills.
Demand Response (DR)	A set of incentive programs offered by utilities for facilities to cut demand during times when the electrical grid is critically stressed or when wholesale power prices are high.
Automated Demand Response (ADR)	A variation of DR that enables automated, preprogrammed, preauthorized load shedding in response to grid conditions.
Energy Intensity (EI)	EI is the ratio of energy consumption and a defined physical unit of output(s) for a facility or company. Lower EI indicates better energy efficiency.
The Grid	The interconnected network of power lines required to connect a manufacturing plant to generated electricity.
Load Profile	A plot showing a facility's electrical load over time. Load profiles can be used to avoid unnecessary electrical demand changes and for participation in DR programs.
Load Shedding	A temporary reduction in electrical load for a short period of time.
Load Shifting	The movement of shed load from on-peak to off-peak hours. Load shifting can be used to avoid high energy costs and reduce measured demand.
Electrical Load Factor	The ratio of energy consumption to the maximum possible energy consumption using total billing hours.
Predominant Use Study	A third-party analysis of energy consumption on an electric meter. If more than 50% of electricity is used toward production, some states offer exemptions on state sales tax.
Production Load Factor	The ratio of energy consumption to the maximum possible energy consumption using only production hours.
Apparent Power	The total amount of power a utility must provide to a manufacturing facility.

Reactive Power	The component of apparent power that does no work but energizes magnetic fields required to operate motors and other equipment.
Real Power	The component of apparent power that does work such as spinning motors or providing light.
Deregulated Power Market	A utility market where electricity generation and distribution have been separated. In a deregulated market, a facility can choose among several electricity providers.
Regulated Power Market	A market where electricity generation and distribution are managed by the same entity. In a regulated market, a facility can only purchase electricity from their utility.
Power Factor (PF)	The ratio of real power in kW to apparent power in kVA. A utility must provide more power to a facility with a lower PF to do a given amount of work.
On-Peak/Off-Peak Pricing	A utility pricing structure where the cost of electricity is higher when the grid normally experiences high demand.
Time-of-Use (TOU) Pricing	A general utility pricing structure where the cost of electricity depends on the time the electricity is used. TOU pricing structures include on-peak/off-peak pricing, real-time pricing, and critical peak pricing.
Ratchet Charge/Clause	A common feature of industrial electricity rate structures whereby a minimum billed demand is set based on a percentage of the previous 12 months' maximum demand.
Block Rate	A utility pricing structure where the cost of electricity varies based on the amount of electricity consumed.
Flat Rate	A utility pricing structure where the cost of electricity remains constant for all amounts of consumption.
Shoulder Rates	Intermediate rates leading into and out of on-peak prices.
Rate Schedule	A comprehensive list of electrical rate structures offered by a utility for all types of available service.
Rate Structure	A set of charges assessed by a utility for providing electricity service. Electricity bills can be reproduced using the rate structure and measured energy usage and demand.
Real-Time Pricing	A utility pricing structure where the price electricity can change in real time in response to changes in weather, grid load, wholesale costs, and other factors.
Retail Electric Providers (REPs)	Companies in deregulated energy markets that can provide power to facilities. Depending on the location, multiple REPs may compete for customers. In some locations, REPs are known as "Power Marketers."
Riders	Adjustments or changes to existing rate structures. Riders often finance regulatory requirements such as energy efficiency programs or environmental cleanup.
Significant Energy Users (SEUs)	Industrial equipment or processes that consume the most electricity in a manufacturing facility. SEU's can be used to double-check usage on utility bills and can be identified for ISO 50001-conforming energy management systems.

1 Using This Guide

Electricity bills can sometimes be very difficult to decipher. Depending on your utility company, your bills can be very long and detailed or quite short, with just a few totals listed. Different charges can appear each month with no apparent explanation of why or how they are calculated. Learning to read your utility bills and understand why your utility charges different fees is very important in maximizing your cost savings through energy efficiency.

Partners in the U.S. Department of Energy's (DOE's) Better Buildings, Better Plants (Better Plants) Program are required to submit an annual report to DOE. Reporting requires establishing an ***energy intensity (EI)*** baseline within one year of joining the program. The first step in creating a baseline is collecting and analyzing several years of utility data. Historical data from your electricity bills can identify trends and help to find the best baseline year for your company. Utility data will also be used to document your progress in the Better Plants Program, with the ultimate goal of achieving your EI improvement target and receiving recognition from DOE.

This document provides guidance on the basics of understanding electricity bills (Figure 1). Section 2 provides an overview of how electricity is generated and delivered to your facilities. Knowing how the electric grid is managed is key to understanding why utilities charge for consumption and demand, as well as why poor power factor (PF) and spikes in demand are penalized. Section 3 gives an overview of the different types of charges on your bills, including consumption, demand, and riders, while Section 4 discusses different rate structures your utilities might offer. Section 5 reviews simple energy and cost-saving opportunities that you can identify by analyzing your electric bills. Finally, Section 6 provides a detailed example of how the concepts discussed in this guidance can be applied to a set of electricity bills.

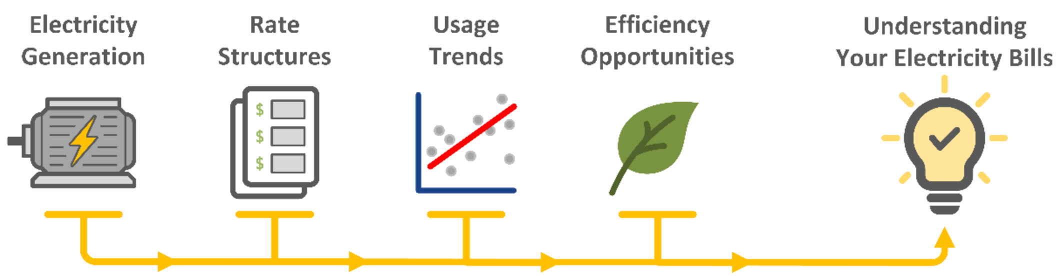


Figure 1: Key pieces needed to fully understand your electricity bills.

This guidance is meant to cover topics that appear on most industrial electricity bills. However, each utility is different and certain charges may be unique to your region. Utilities are also experimenting with new and innovative rate structures to encourage further energy efficiency investment. Please contact your Better Plants Technical Account Manager (TAM) with any questions you might have about your bills or charges that might not be discussed in this document.

2 How Electricity Is Generated

The electricity that is supplied to your facilities comes from many different sources[1]. The largest energy sources for electricity are fossil fuels (coal, natural gas, and petroleum), nuclear power, and renewables (e.g., wind, hydro, solar, biomass, geothermal). The relative amounts of each fuel source used have changed over the past few decades, with natural gas displacing coal-fired power plants and heavy investment in renewable energy, particularly wind and solar. Power plants generate alternating current (AC) power by converting energy sources into electricity. Most power plants use energy from fuels, moving air/water, or underground heat to create steam that powers electric generators. Photovoltaics create direct current (DC) electricity that is converted to AC through an inverter. All of this power is delivered first to the electrical grid and then ultimately to your manufacturing plants (Figure 2).

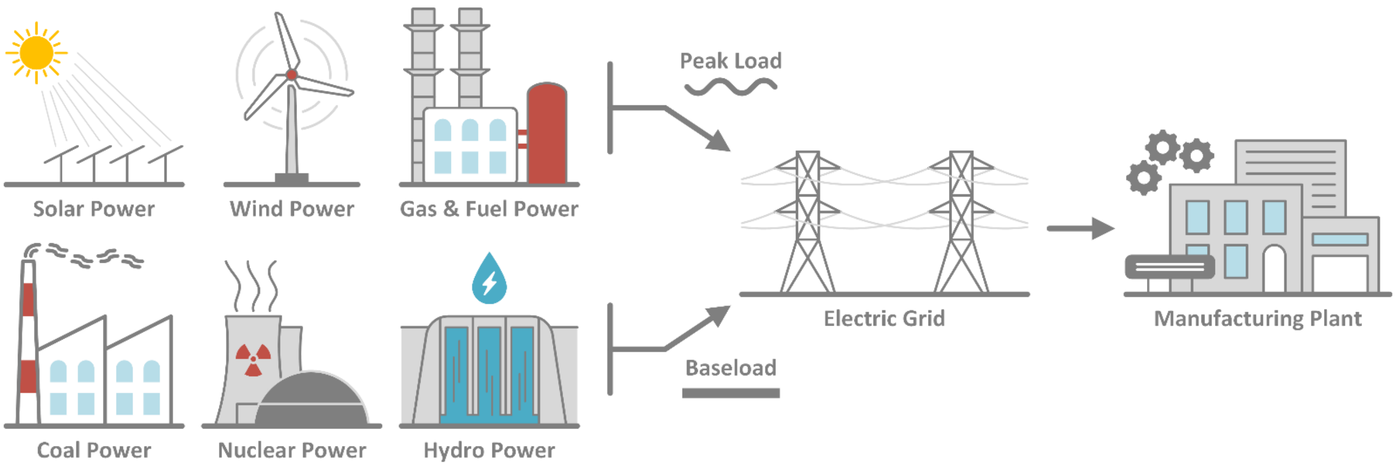


Figure 2: Baseload and peaking power plants supply electricity to the grid, which delivers electricity to your facilities.

The amount of electricity being consumed from the grid naturally varies throughout the day and year[2]. For example, more power is needed during summer evenings after the heat of the day when people get home from work and turn up their air conditioning. To supply electricity reliably and to maintain grid stability, two kinds of electrical power plants are operating: baseload plants and peaking plants. Baseload plants supply a stable amount of electricity that satisfies the minimum continuous requirements of the grid. Peaking plants can ramp their electricity production quickly and are used to fill in the gaps when baseload plants cannot meet grid demand.

The types of energy used to generate electricity vary based on generating costs, weather, and location. Baseload plants must be highly reliable and produce a steady amount of electricity, which is why they tend to be coal- or nuclear-power facilities. Peaking plants must be able to vary their output quickly, which is why they tend to be natural-gas- or petroleum-powered turbines that can be started rapidly or adjusted easily. Renewable energy sources split the boundary between peaking and baseload sources, depending on the availability of energy storage. Hydro and geothermal energy, for example, can be baseload sources because of their steady energy output. Solar and wind power, however, are used in conjunction with peaking plants, depending on their energy output and weather conditions. As battery storage capacity increases, the lines between peaking and baseload energy producing plants will blur, and fossil-fuel plants may become less common. These changes will accelerate as many coal-fired power plants reach the end of their expected lifetimes and are gradually retired from the generation mix.

[1] "Electricity Explained: Electricity in the United States," U.S. Energy Information Administration, March 20, 2020, https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php.

[2] "Electric Generator Dispatch Depends on System Demand and the Relative Cost of Operation," U.S. Energy Information Administration, August 17, 2012, https://www.eia.gov/todayinenergy/detail.php?id=7590.

No matter where electricity is generated, there must be infrastructure to transport it to your facility[3]. The connection between generators and your facility is called the grid. ***The grid*** consists of substations that step voltage up or down, transmission lines that carry power over long distances, and distribution lines that connect to individual customers. There are three main electric grids in the contiguous United States: Western Interconnect, Eastern Interconnect, and Texas. Balancing authorities in each grid ensure that supply for electricity is matched with demand by managing the peaking and baseload generation so that you reliably receive your electricity. Stability of the entire U.S. electric grid is managed by the North American Electric Reliability Corporation (NERC), which provides standards and oversight to ensure reliable power service within more regional zones.

2.1 Regulated and Deregulated Power Markets

Electricity markets have traditionally been ***regulated power markets*** where utility companies own and control all the equipment from generators through to your electric meter. Starting with the 1992 Energy Policy Act, however, some states have had the option to "deregulate" their power markets by separating electricity producers and distributors. In a ***deregulated power market***, companies known as ***retail electricity providers*** (REPs) generate power for the electric grid that utility companies then distribute to customers by building and maintaining the transmission and distribution system. The two main goals for deregulating a power market are: (1) to lower energy prices through competition and (2) to promote green energy production by lowering barriers for green power projects. As of 2020, more than 15 states plus Washington D.C. have allowed deregulation of their electricity markets in some form[4] (Figure 3). Local municipalities and cooperatives are often exempted from state deregulation laws.

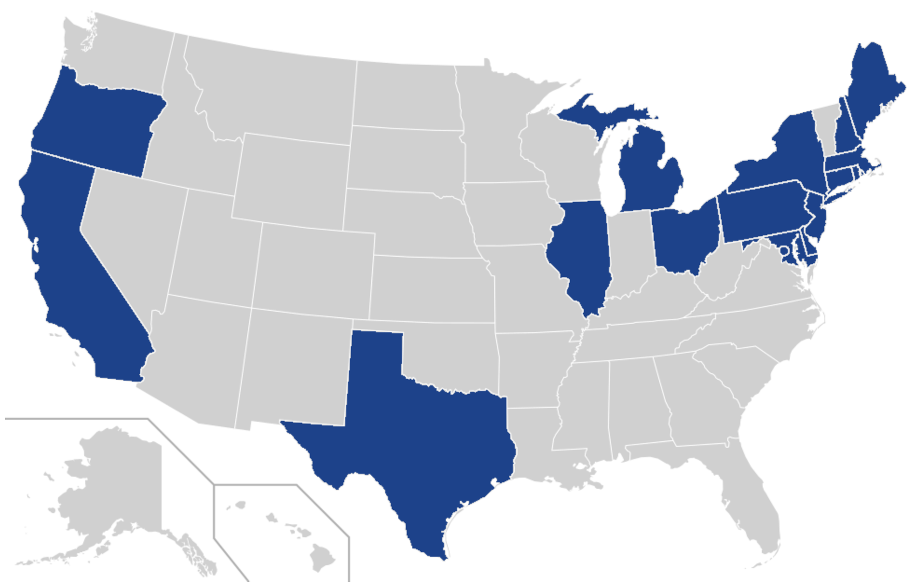


Figure 3: Deregulated or retail-choice electric markets (blue) in the United States.

Electricity rates in a regulated power market are governed by a state's public utility commission[5]. This leads to stable pricing, reliability, and long-term certainty for energy costs. Prices in a deregulated market, however, are allowed to

[3] "Electricity Explained: How Electricity Is Delivered to Consumers," U.S. Energy Information Administration, October 22, 2020, https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php.

[4] "Understanding Electricity Market Frameworks & Policies," Overviews and Factsheets, U.S. Environmental Protection Agency, September 29, 2016, https://www.epa.gov/repowertoolbox/understanding-electricity-market-frameworks-policies.

[5] Kathryne Cleary and Karen Palmer, "US Electricity Markets 101," *Explainer* (Resources for the Future, March 3, 2020), https://www.rff.org/publications/explainers/us-electricity-markets-101/.

fluctuate with the energy market. REPs in deregulated markets often offer long-term contracts with set pricing schedules that provide some certainty on energy costs but may lock consumers into higher prices when the market price drops. In general, if your company is in a deregulated power market, you may have several options for purchasing your electricity. Depending on your ability to research REPs and negotiate contracts, exploring your options can lead to electricity cost savings.

In a deregulated electricity market, you may receive separate invoices from your power producer and your electric utility. When estimating costs, make sure to include charges from both bills to get your "all in" cost of electricity. Energy readings from the producer bills will generally be larger than those on the utility bills due to grid losses during transmission and distribution to your facility. Therefore, when estimating energy consumption, make sure to use numbers from the utility invoice because these reflect only the power actually delivered to your plant. In cases where you receive a single bill, producer costs are often labeled as "pass-through" charges on the invoice.

2.2 Connecting Electricity Generation to Your Bills

With a general idea of how your electricity is generated and the type of energy market your facility is in, the process of understanding your bills and the charges on them becomes much easier. Fuel costs, generation costs, grid upkeep, distribution costs, and so on all help to explain why utilities include each charge. The following sections will work through these charges and other important parts of an electricity bill. Sections 3–5 discuss common charges on your utility bills, typical electricity rate structures, and opportunities for cost savings based on analyzing your bills. Section 6 shows how a simple analysis of your bills can lead to substantial energy and cost savings by identifying areas where your company can improve its efficiency or by avoiding unnecessary charges. This information can help your company make informed decisions on how it uses and purchases electricity.

3 Electricity Bills and How to Read Them

The first step in understanding your utility bills is to determine what kinds of energy you use at your plant (e.g., electricity, gas, solar). Accounting for each energy stream entering and being consumed in your facility is essential in reducing your usage.

This section focuses on your electricity bills and the key information that you can learn about your facility by collecting and analyzing them. Finding bills from the past several years is helpful to understand how energy was used in the past and how it is being used currently. Looking for trends or anomalies in your data is a great resource for finding cost savings and identifying possible efficiency projects. It may even save you money by spotting issues like a shutdown procedure override on your most expensive piece of equipment. You may need to work with your accounting department or local utility to track down old bills if you do not have them on hand.

Once you have a few electricity bills, you can start extracting data from them. Unfortunately, this can be a difficult process because some bills can be difficult to decipher and can vary for each invoice you have. Some common things to look out for on your bills are the meter number, consumption reading, demand reading, PF, charges based on consumption, charges based on demand, penalties, riders and fees, and fixed charges (Figure 4). The following sections will provide an overview of these key aspects of electricity bills. Understanding what these charges cover and why they are assessed is key in avoiding or reducing their impact on your electricity bills.

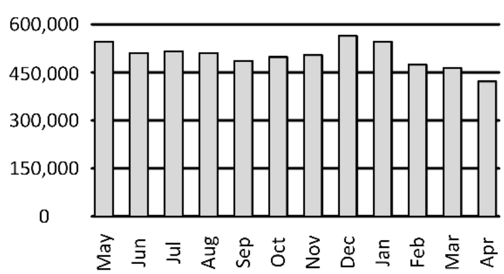
> Date Billed: 3/26/2020
> Account #: 1234-5678
> Invoice: 32620-12345

BETTER PLANTS ELECTRIC INC
Here to help you save.

Total Amount Due by 4/1/2020 $32.446.48

Service for:
Manufacturing Plant
987 Sixth Avenue
Oak Ridge, TN 37830

Meter #:	1	J942U4L71
Days on Bill:		30
Total kWh:		421,855
Billed Demand:	2	1,257 kW
Actual Demand:		1,151 kW
PF:	3	0.87



Customer Charge:	4				$45.00
Metering Charge					$175.00
Energy Charge 1:		250,000	x	0.0625	$15,625.00
Energy Charge 2:	5	171,855	x	0.0482	$8,283.41
Energy Efficiency Cost Recovery:		421,855	x	0.0004	$168.74
Transmission Charge 1:		1,257	x	2.2582	$2,838.56
Transmission Charge 2:		1,257	x	0.3247	$408.15
Transmission Cost Recovery:	6	1,257	x	2.4849	$3,123.52
Nuclear Decommissioning:		1,257	x	0.0079	$9.93
Distribution Cost Recovery:		1,257	x	0.4594	$577.47
PF Penalty:		106	x	5.5351	$586.72
Energy Subtotal:					**$31,841.49**
	7				
Local Sales Tax:				0.25%	$79.60
State Sales Tax:				1.65%	$525.38
Late Payment Fee:					$0.00
Taxes & Fees Subtotal:					**$604.99**

Figure 4: Example utility bill with key information highlighted—(1) meter number, (2) meter readings, (3) PF, (4) fixed charges, (5) consumption charges, (6) demand charges, (7) taxes, fees, and penalties.

3.1 Consumption Charges

Electricity ***consumption*** or ***usage*** is the total of all the electricity that your plant uses to manufacture parts, generate compressed air, light rooms, air condition spaces, and so on. Consumption is measured in kilowatt-hours (kWh), which is a composite unit equal to 1 kilowatt of power sustained for 1 hour. Consumption per unit of production is known as ***energy intensity (EI),*** which is a measure of how efficient your process is. Energy efficiency typically refers to reducing your energy consumption and, by extension, lowering your EI.

Consumption charges are items on your electricity bills based on your usage. Generally, most bills list consumption charges as some variation of energy charge, energy cost, delivered energy cost, and so on. Although the specific name for the energy charge varies, it will be assessed using a $/kWh rate. Depending on your rate structure, your rate may change based on the amount of energy that you use (block rates), the time of year (on-/off-peak rates), or even the time of day (real-time pricing). As discussed later in this section, some utilities assess a cost recovery factor per kWh that adjusts the energy rate depending on the types of fuels used to provide energy to the grid. Notably, many riders and fees (also discussed later) are also calculated using your electricity consumption.

Knowing how to read your electric meters can help you monitor your consumption between bills and spot any anomalies before they drastically affect your bottom line. Electric meters come in several varieties: analog dial, analog mechanical, and digital. Dial meters like the example in Figure 5a can be the trickiest to read. Starting from the left, take the lower number when the dial is between values. If the dial appears over a number (like 1 in the example to the left), look at the next dial to the right. If the dial is past zero, take the higher number; if the dial is below zero, take the lower number. To read an analog mechanical or digital meter, simply read the displayed numbers, ignoring any decimal places (usually highlighted in red).

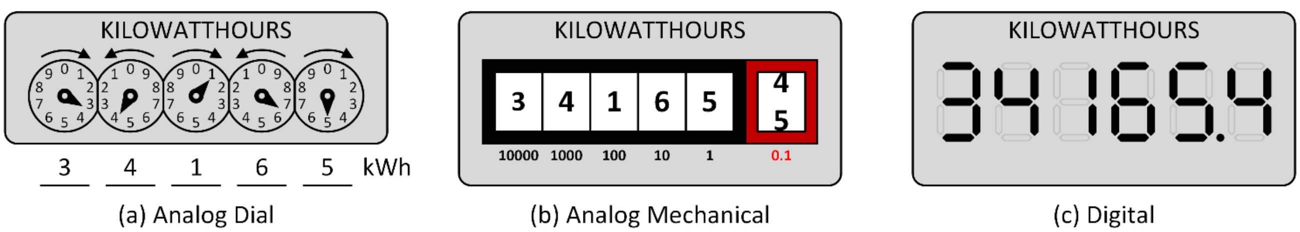


Figure 5: Common types of electricity consumption meters.

3.2 Demand Charges

In addition to consumption, commercial and industrial facilities are charged for their ***electrical demand***. Demand measures the rate of electricity consumption and is calculated by averaging consumption in discrete windows (often 15 minutes) continuously throughout the day. For example, a facility consuming 25 kWh of electricity in a 15-minute window has 100 kW of demand (Equation 1). Although demand comes in many types, utility companies use it to determine how much grid infrastructure is required to deliver power to their customers even during peak load. In general, most bills will list demand charges as some variation of demand charge, demand cost, transmission and delivery (T&D) charge, and so on.

$$\frac{25\ \text{kWh}}{15\ \text{minutes}} \times \frac{60\ \text{minutes}}{1\ \text{hour}} = 100\ \text{kW} \qquad (1)$$

Because of limited storage on the electric grid, energy generation must always balance consumption. As discussed, utilities and generators work to meet this balance through steady baseload and variable peak load power generation. Residential customers will usually consume electricity at predictable times and rates, allowing utilities to charge them based on consumption alone. Commercial and industrial facilities, however, use significantly more power and at vastly different rates during the day/month/year depending on factors like production and weather. Utilities, therefore, also charge industrial/commercial customers for their demand to offset costs related to grid management and infrastructure required to deliver power when needed.

Load Profiles, Peak Demand, and Baseload Demand

Figure 6 shows four days of electrical demand data from October 2020 at an example plant. These demand curves are known as a ***load profile*** and show how the plant uses its electricity throughout a day or month. From these profiles, ***peak demand*** is the maximum observed demand over the course of the billing cycle while ***baseload demand*** is the continuous demand used when there is no production.

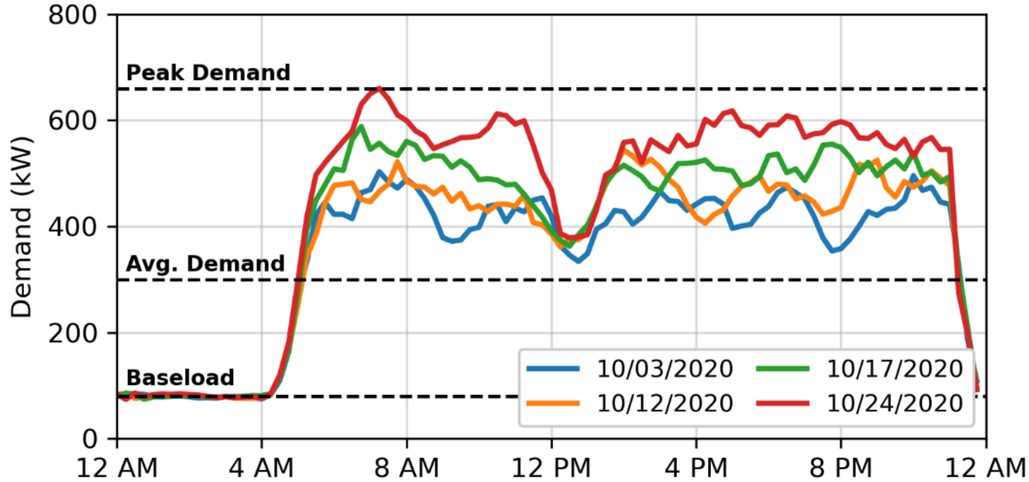


Figure 6: Daily load profiles for an example plant. Demand on utility bills corresponds to the monthly peak demand.

Utility companies bill for demand based on the monthly peak demand. This means that one spike in demand will set your demand charge for the entire month and, as discussed in the following sections, possibly affect your demand charges for an entire year. Understanding your load profiles, baseload usage, equipment, startup/shutdown procedures, etc. are all vitally important in avoiding unnecessary demand charges on your bills.

Demand charges can appear on your bills in several ways. Any charge that is billed per kW, kVA, or kVAR is a demand-based charge and is related to your demand peak. The unit of the charge can tell you a lot about how it works and what actions you might need to take to avoid additional charges. The following sections discuss common demand charges and how they affect your bills.

Actual vs. Billed Demand

On most electric bills, two types of demand values will be listed: ***actual demand*** and ***billed demand***. Actual demand is the peak demand observed by the utility over the billing cycle. Billed demand is an adjustment to actual demand based on several clauses in your electricity rate structure. Demand charges are calculated using the billed demand, which is generally higher than your actual demand. Ratchet charges, PF penalties, coincident peak clauses, etc. can all increase your billed demand, leading to additional spending on energy. Depending on your rate structure, multiple demand readings with different units may be listed on your bills.

Ratchet Charges

Although your facility may only use its peak power a couple of times each year, utility companies must build and maintain permanent infrastructure to deliver electricity when you need it. A ***ratchet charge*** is one way utilities can recoup costs for providing that service. A ratchet charge (or clause) states that a customer's minimum billed demand will be the larger of (1) the current month's demand or (2) some percentage, usually 70%–80%, of the peak demand from the past 11 months. Figure 7 illustrates how these clauses affect the billed demand on your monthly bills. Note how the facility is penalized for the demand spike in July 2020 for the next 9 months. One way to spot a ratchet clause is a billed demand reading that is the same on multiple bills after your highest demand month.

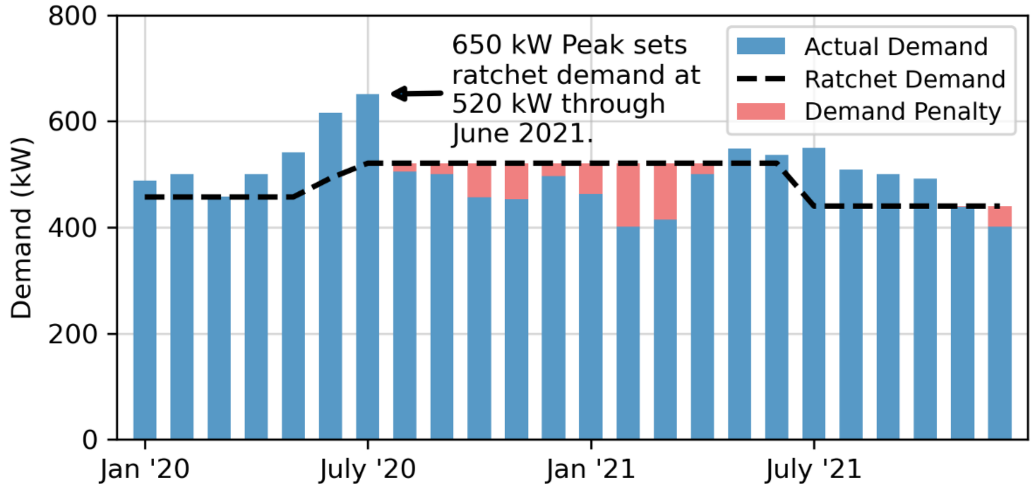


Figure 7: Ratchet clauses set the minimum billed demand for the next 11-month period.

Coincident Peak Charges

Some utility rate structures can have demand charges based on a ***coincident peak*** (CP) structure. These charges measure your demand when the electrical grid reaches its peak load, not necessarily when your facility reaches its peak demand. CP charges are therefore distributed among the customers that strain the grid the most during its peak load. These charges usually have compound units of kW and the letters "CP."

Four coincident peak (4CP) is another type of CP demand charge that might appear on your bills. It is calculated during the four highest months of electric grid demand (usually June, July, August, and September). Your facility's demand is measured each month when the grid reaches its peak load and these values are averaged to become your 4CP demand for the next calendar year. The exact times of the grid peak demand are not known ahead of time but are generally weekday afternoons between 1 p.m. and 5 p.m. Some utilities offer 4CP warning programs to help you avoid peaking at the wrong time and to protect the grid.

Example 1: Four Coincident Peak Demand Calculation

A manufacturing plant's utility measures its demand during the four monthly grid peaks listed below. Calculate this plant's 4CP demand for the next calendar year.

Known: Demand readings corresponding to the grid's peak demand in June, July, August, and September.

Calculate: 4CP demand.

Date	June 2020, 2:45 p.m.	July 2020, 3:30 p.m.	August 2020, 4:45 p.m.	September 2020, 4:15 p.m.
Demand (kW)	379	427	393	401

The 4CP demand value for calendar year 2021 is calculated by averaging the plant's demand during the 15-minute windows when the electric grid reached its peak in June, July, August, and September:

$$4CP\ Demand\ for\ 2021 = \frac{379 + 427 + 393 + 401}{4} kW = 400\ kW$$

Avoiding Unnecessary Demand Charges

With a general understanding of what demand charges are, avoiding them boils down to managing your facility's demand profiles. For example, consider a facility that has two large air compressors that alternate as backups. If these compressors are accidentally operated at the same time there will be a large, one-time spike in demand. If the facility has ratchet clauses in their rate schedule, the minimum billed demand is now set at 80% of the spike for the next 11 months. If the spike also occurred during the 4CP period (June–September) and when the grid was at its peak, the 4CP demand for the next year will also be affected.

Avoiding unnecessary demand charges therefore requires keeping your load profiles within a tight range. To do this, you must have or develop a comprehensive knowledge of your processes, equipment, and production schedules. Detailed startup/shutdown procedures can ensure that large machinery does not operate at the same time. Using variable frequency drives (VFDs) on large motors can reduce demand if they operate under partial load. Shifting high-energy processes to off-peak hours can also help to smooth out your load profile and minimize the chances of coincident demand peaks with the grid. See Section 5 for more information on demand savings opportunities.

Example 2: Effect of Motor Startup on Demand

A common myth is that installing soft starters or VFDs on large motors can significantly reduce your demand costs[6,7]. When started, motors draw a large inrush of current as the windings energize and the rotor begins to spin. This inrush can consume 5–10 times more power than the motor draws during normal operation. However, this increase in power consumption lasts at most few seconds and is often measured in milliseconds. Because demand windows are based on rolling averages that are usually 15 minutes long, the extra power consumed by the inrush current is averaged out and will barely affect your demand costs.

For example, consider a 50-kW motor that draws 10 times more power for 1 second (0.02 min) on startup. From the following calculation, inrush current adds only 0.6 kW of demand.

$$D_{start} = \frac{10 \times 50\ kW \times 0.02\ min + 50\ kW \times\ 14.98\ min}{15\ min} = 50.6\ kW$$

Motor soft/start controllers and VFDs are, however, excellent at extending the operational lifetime of a motor. The large additional inrush current at startup generates significant heat, which can cause the motor to exceed its maximum operating temperature. Slowing the inrush of current with a soft starter or VFD can reduce this heat and allow your motors to last much longer.

3.3 Power Factor Penalties

The way AC power interacts with equipment in your facility affects the amount of energy your utility must provide. This effect is captured by the ***power factor*** (***PF***), which can appear as a penalty charge on your utility bills. To understand how PF is inherent to AC circuits and why poor PF is penalized, some basic equations are presented here. While none of these equations need to be understood in great detail, they do highlight why utilities penalize for poor PF. For more technical information on PF derivations, please see Chapter 7 of *Fundamentals of Electrical Engineering* by Giorgio Rizzoni.

Consider an oscillating voltage $V(t)$ and current $I(t)$ delivered to a facility. At any time t both waves can be defined as sine waves alternating at a frequency of $\omega = 60\ Hz$ in the United States (Equation 2). Depending on the inductive

[6] Stephen Mraz, "5 Common Motor Myths," Machine Design, August 6, 2015, https://www.machinedesign.com/community/article/21832263/5-common-motor-myths.

[7] Lisa Green, "Digging Deeper into Motor Inrush Current," *Energy 350* (blog), September 28, 2017, https://www.energy350.com/609-2/.

and capacitive loads in the facility, current can be θ degrees out of phase from the voltage (Figure 8). Instantaneous power $p(t)$ delivered by the utility is simply the product of these sine waves (Equation 3). After some math and simplification, the delivered AC power has two components: ***real power*** and ***reactive power***.

$$\begin{gathered} V(t) = V \cdot \cos(\omega t) \\ I(t) = I \cdot \cos(\omega t - \theta) \end{gathered} \tag{2}$$

$$p(t) = V(t) \cdot I(t) = \underbrace{P_{avg} \cdot (1 + \cos(2\omega t))}_{\text{Real Power}} + \underbrace{Q \cdot \sin(2\omega t)}_{\text{Reactive Power}} \tag{3}$$

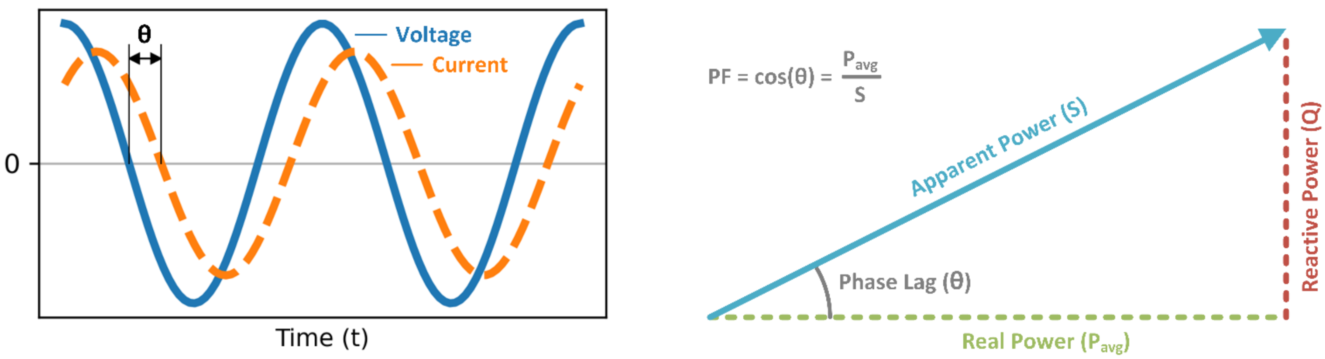


Figure 8: Inductive loads cause current to lag voltage (left). The PF triangle relates real and apparent power (right).

Both real and reactive power are required to operate your facility. Real power is related to the resistive loads in your facility that perform work (e.g., creating heat, turning on lights, spinning motors). Reactive power is the energy required to energize the magnetic fields of motors and equipment, allowing them to operate. The magnitudes of real power (P_{avg}) and reactive power (Q) are both related to the phase difference θ between current and voltage and the impedance of equipment in your facility.

The amount of power a utility must deliver for a given amount of real and reactive power is given by Equation 4. This ***apparent power*** (S) is greater than or equal to the amount of real power used by a facility and can be represented using a PF triangle (Figure 8). PF is the ratio of the real power, measured in kW, to apparent power, measured in kilovolt-ampere or kVA, and is related to the phase difference θ between voltage and current by the PF triangle (Equation 5). Therefore, PF reflects the extra amount of energy a utility must provide to energize equipment in your facility. This is why utilities penalize for low PFs (PF < 1): the lower the PF, the more apparent power utilities must deliver which also requires developing and maintaining more infrastructure.

$$S = \sqrt{P_{avg}^2 + Q^2} = V_{rms} \cdot I_{rms} \tag{4}$$

$$PF = \cos(\theta) = \frac{P_{avg}}{S} \tag{5}$$

How Are You Penalized?

Although PF is usually listed directly on your bills, PF penalties can be unclear. If your utility charges for demand based on real power (kW), your facility's real demand (RD) is adjusted relative to a minimum threshold PF (PF_{req}) using Equation 6. Multiplying the difference between the PF-adjusted demand and real demand by the demand charge C_D from your utility rate structure gives the penalty cost (Equation 7). If your PF is above the minimum threshold, no PF adjustment is made.

$$PF\ Adjusted\ Demand\ (AD) = RD \times \frac{PF_{req}}{PF} \tag{6}$$

$$PF\ Penalty = C_D \cdot (AD - RD) = C_D \cdot RD \cdot \left(\frac{PF_{req} - PF}{PF_{req}}\right) \tag{7}$$

If your utility charges for demand based on apparent power (kVA), you are inherently penalized for any PF less than 1.0, even if a PF is not listed on the bill. Apparent power and real power are equal when PF = 1. Therefore, the PF penalty is simply the difference between apparent demand in kVA and actual (real) demand in kW. If RD is not listed on the bill, the relationship $RD = AD \cdot PF$ can be used (Equation 8).

$$\begin{aligned} PF\ Penalty &= C_D \cdot (BD - RD) \\ &= C_D \cdot BD \cdot (1 - PF) \end{aligned} \tag{8}$$

PF penalties can be compounded by your rate structure. If your utility has ratchet clauses on demand, the PF penalty will artificially boost the minimum billed demand for the next 12 months. Demand charges based on CP loads will similarly be affected. Although usually not explicitly listed on your bills, PF penalties can be expensive and will affect your bills for a long time.

How Do You Fix a Low PF?

Nearly all manufacturing plants have low PF because of the large motors used in their production processes. Motor windings act as large inductors and cause current to lag voltage. Correcting low PF is, therefore, usually solved by installing capacitor banks near the utility hookup. Static capacitance is always present and takes care of the baseload phase difference. Dynamic capacitance adjusts based on your current PF to ensures that the required PF is achieved, even during changing loads. Correct sizing of these capacitor banks is important to lower payback time because dynamic capacitance is more expensive than static capacitance. However, installing too much static capacitance can cause the current to lead the voltage, lowering the PF and causing other issues with the grid. In general, PF is only corrected to the minimum required by the utility rate structure to avoid these issues and reduce cost.

Example 3: Power Factor Penalty Calculation

A manufacturing plant's utility bill lists a PF of 0.85 and billed demand of 846 kW. If the plant is charged $8/kW for demand and there is no ratchet clause, calculate RD and PF penalty for this plant.

Known: PF = 0.85, BD = 846 kW, C_D = $8 kW, no ratchet clause.

Calculate: RD, PF penalty.

From the plant's utility rate structure, the minimum PF is $PF_{rec} = 0.95$. Using Equation 6, the RD for this plant is:

$$RD = BD \times \frac{PF}{PF_{rec}} = 846\ kW \times \frac{0.85}{0.95} = 757\ kW$$

Equation 7 gives the PF penalty for the current month:

$$PF\ Penalty = C_d \cdot (BD - RD) = \$8/kW \cdot (846\ kW - 757\ kW) = \$712$$

3.4 Riders

In addition to consumption and demand charges, several other usage and demand charges will appear on your bills. Riders are modifications to your rate structure for specific purposes and usually have very descriptive names. Unlike consumption and demand charges, riders may not appear on your bills each month. When reading your bills, pay careful attention to which riders are assessed and how they are calculated. Consult with your utility company for specific documentation on your rate structure and the riders that you are charged for. Some example riders that you may encounter are:

- Transmission Cost Recovery Factor
- Renewable Energy Development Fund
- Nuclear Decommissioning Charge
- Energy Efficiency Cost Recovery Factor
- Fuel Cost Recovery Factor

3.5 Non-Energy Charges

Utility bills will also have many charges that are not based on your electricity consumption or demand. Fixed charges are items that vary based on the number of meters or accounts. Examples include customer fees, metering fees, meter reading fees, and so on. Although fixed charges are often built into your rate structure, ensuring that you have the right kind of electricity service can minimize these types of costs (see Section 4).

Fees and penalties are extra costs on your bills for certain services or violations of your utility contract. Examples include late payment fees, insufficient funds fees, and so on. Although these kinds of fees can be expensive, often a fixed amount or a percentage of the outstanding balance, they are generally avoidable by paying your bills on time. Having a good relationship and checking in with your accounting department often helps to reduce the chances of these penalties on your bills.

Lastly, sales taxes are one more non-energy charge that will appear on your bills. Like standard sales taxes, these charges are a percentage of the billed cost. Some manufacturing facilities may be able claim an exemption from state sales tax if they can prove that at least 50% of the energy on a meter is related to production. A predominant use study is required to verify your energy usage and claim the exception. Notably, some states allow up to two years of back taxes to be refunded after filing. Consult with your utility to see if your state allows a state sales tax exemption for manufacturers.

3.6 Estimating Your Cost of Electricity

There are a couple of ways to estimate how much you pay for electricity. ***Blended cost*** is a quick and easy way to approximate cost savings by dividing your electricity spending by your total kWh consumption. This inherently lumps together fixed, consumption, and demand-related charges into a single charge based on kWh. For blended cost to be somewhat accurate, you will need to combine several months of electricity data to capture different pieces of your electricity rate structure. Although easy to calculate, blended cost is not able to capture savings from projects that focus on reducing demand (PF correction, load shifting, and so on).

A better way of estimating your electricity costs is to find your ***marginal costs*** of electricity—the cost of purchasing or saving the next/last unit of electricity on your bills. To estimate marginal costs, list and group every charge billed by kWh, kW, kVA, and so on for each month in a 12-month period. If these charges remain the same year-round, then your marginal costs are simply the average of each group of charges. If your bills use a block style or time-of-use rate structure (see Section 4), then the calculation is a bit trickier. In these cases, your marginal costs will be a weighted average of the charges based on how much of your electricity is consumed at each price (see Example 4 for more information). With marginal costs, you can estimate savings from a 1 kWh reduction in consumption and/or a 1 kW reduction in demand. Marginal costs require a deeper understanding of your rate structure but give a much better estimation of your actual electricity costs.

Both blended and marginal costs can be used to estimate potential savings when exploring energy efficiency projects. This can help focus your attention on which projects have the best paybacks or the projects that have the greatest impact on your bottom line. Before pursuing projects further, make sure to consult with your electricity provider to obtain detailed rate structure information to verify your estimated potential savings.

Example 4: Marginal Costs of Electricity

From the bill in Figure 4 on page 5, estimate the blended and marginal costs of electricity. These costs can be used to estimate savings from energy efficiency projects.

Known: Charges listed on bill for April 2020. The company is on a two-block rate structure and has enough consumption to reach the "Energy Charge 2" block eight months per year.

Calculate: Blended and marginal costs of electricity.

Blended Cost of Electricity:

The one-month blended cost based on the April 2020 electricity bill is:

$$C_{blend} = \frac{Electricity\ Costs}{Energy\ Consumption} = \frac{\$32{,}466.48}{421{,}855\ kWh} = \frac{\$0.0770}{kWh}$$

Marginal Cost of Electricity Consumption:

The bill in Figure 4 uses a block rate structure (see Section 4.2 for more information). For April 2020, saving or consuming 1 kWh of consumption only affects consumption in the "Energy Charge 2" block and leaves the "Energy Charge 1" block unaffected. Marginal cost of consumption can be estimated in two ways: (1) using the rate structure to estimate consumption charges for 421,856 versus 421,855 kWh of electricity usage or (2) simply summing all consumption charges affected by the last kWh of electricity used.

$$C_{mrg,\ April} = \frac{\Delta Consumption\ Charges}{\Delta Consumption} = \frac{\$24{,}077.2016 - \$24{,}077.1530}{421{,}856\ kWh - 421{,}855\ kWh} = \frac{\$0.0486}{1\ kWh}$$
$$= Energy\ Charge\ 2\ + Energy\ Efficiency\ Cost\ Recovery\ Factor\ (EECRF) = \frac{\$0.0486}{kWh}$$

A more accurate way to estimate the marginal consumption cost is to use a weighted average of "Energy Charge 1" and "Energy Charge 2" based on the number of months (8) that consumption reached block 2.

$$C_{mrg,\ Year} = \frac{4}{12} \times Energy\ Charge\ 1 + \frac{8}{12} \times Energy\ Charge\ 2 + EECRF$$
$$= 0.33 \times \frac{\$0.0625}{kWh} + 0.67 \times \frac{\$0.0482}{kWh} + \frac{\$0.0004}{kWh} = \frac{\$0.0530}{kWh}$$

Marginal Cost of Electricity Demand:

The demand charges on the bill remain the same throughout the year. The marginal cost of demand can again be calculated by either (1) estimating charges for 1,258 versus 1,258 kW of demand or (2) by summing all demand charges as below:

$$D_{mrg} = Transmission\ Charge\ 1 + Transmission\ Charge\ 2 + Transmission\ Cost\ Recovery\ Factor$$
$$+ Nuclear\ Decomissioning\ Charge + Distribution\ Cost\ Recovery\ Factor$$
$$= \frac{\$2.2582}{kW} + \frac{\$0.3247}{kW} + \frac{\$2.4849}{kW} + \frac{\$0.0079}{kW} + \frac{\$0.4594}{kW} = \frac{\$5.5351}{kW}$$

These costs represent the amount of money you can save by reducing your consumption by 1 kWh or demand by 1 kW. This can be used to estimate the potential savings of efficiency projects at your facility.

3.7 Calendarization

As you examine each month's utility bills, take note of how many days are on each invoice. It may become frustratingly apparent that the number of days on each bill can be quite different. Depending on when your meters are read, some billing periods can have fewer than 25 days, while others can be close to 35. When comparing between years, months, or to other utilities like natural gas and water, having consistent billing periods is essential.

Adjusting electricity data to normalize for billing periods is known as ***calendarization***. While beyond the scope of this document, standard practice is to divide monthly consumption by the number of billing days and allocate to each month an appropriate number of days from each bill. More information on calendarization and baselining your electricity consumption can be found in the Better Plants **Energy Intensity Baselining and Tracking Guidance 2020**[8], which can be found on the Better Plants Solution Center website.

[8] Christopher Price, Sachin Nimbalkar, and Thomas Wenning, "Energy Intensity Baselining and Tracking Guidance" (United States: Oak Ridge National Lab, Oak Ridge, TN, August 22, 2020), https://www.osti.gov/biblio/1649123.

4 Common Rate Structures

Now that you have a basic understanding of the types of charges on your electricity bills, the next question is why they appear on your bills. ***Rate schedules*** are collections of pricing structures offered by your utility to provide electric service. Choosing the right ***rate structure*** from your rate schedule is extremely important in minimizing your electricity costs. Schedules are public information and often easily accessible with a simple internet search. The following section outlines some common rate structures that your bills might be under.

4.1 Types of Services

Knowing the kind of service that you are receiving is critical to finding your rate schedule. Most utilities will offer different rate structures in their schedules, depending on the expected energy demand of the meter. Manufacturing facilities typically fall under a general-service rate schedule. Depending on the expected load, your meter may be classified as a small/medium/large general-service or similar designation, such as A/B/C. Each rate schedule will have its own pricing structure and rules for the allowable usage. Other rate structures that may apply to your bills include outdoor lighting service for parking lot and exterior lighting or commercial service for office space. Some example rate structures are given in Table 1.

Table 1: Example Electricity Service Types

Rate Schedule	Requirements	Rates
Exterior Lighting	Outdoor areas not covered by street lighting.	Flat Rate by Lamp Type
Small General Service	Less than 10 kW of monthly demand.	Service Charge: $15.25/customer First 600 kWh: $0.03225/kWh All other kWh: $0.02076/kWh
Medium General Service	Greater than 10 kW of monthly demand.	Service Charge: $43.00/customer Demand Charge: $2.20/kW First 10,000 kWh: $0.03438/kWh All other kWh: $0.02927/kWh
Large General Service	Demand greater than 100 kVA but less than 3,000 kVA.	Service Charge: $156.00/customer Demand Charge: $6.72/kVA Energy Charge: $0.00787/kWh

Your rate schedule will also vary based on the line voltage that is delivered to your facility. General-service rate structures often have primary and secondary voltage variants that affect the rates you pay. With secondary service, the grid's transmission voltage is stepped down by transformers owned and maintained by the utility. With primary service, the transformer equipment would be operated by your facility. Primary service is generally cheaper than secondary service because the utility is no longer responsible for maintaining the transformers. However, the additional burden of installing and managing the high voltage equipment can be cost prohibitive for many facilities.

Verifying and maintaining that your facility is using the correct rate structures is vitally important. Large general-service contracts often have minimum-billed demand provisions, while small general-service contracts have higher consumption ($/kWh) rates. If your facility has new meters, new equipment, or has rearranged old equipment, checking that each meter is using the proper rate structure is essential. The following example illustrates how this mistake can be extremely costly if left unchecked.

Example 5: Choosing the Right Rate Structure

Consider a company that has just built a new production building. Large equipment will be moved to the new building, and most of the original production floor will be converted to office space. If the company fails to change the rate structure for the old production floor, how much extra will they pay for electricity in February 2021?

Charges and Fees	Large General Service	General Service
Customer Charge:	\$125.73/month	\$39.20/month
Demand Charge:	\$14.18/kW	\$7.40/kW
Energy Charge:	\$0.0052/kWh	\$0.02210/kWh
Minimum Demand:	**4,000 kW**	**500 kW**

Known: Old production floor should be converted from *Large General Service* to *General Service* after equipment relocation. Demand for February 2021 is 1,200 kW and consumption is 480,000 kWh.

Calculate: The additional energy costs stemming from not updating the rate schedule.

The energy costs for the old production building under the *Large General Service* contract would be:

$$Energy\ Cost_{old} = 4{,}000\ kW \cdot \frac{\$14.18}{kW} + 480{,}000\ kWh \cdot \frac{\$0.0052}{kWh} + \$125.73 = \$59{,}341.73$$

The energy costs for the old production building under a new *General Service* contract would be:

$$Energy\ Cost_{new} = 1{,}200\ kW \cdot \frac{\$7.40}{kW} + 480{,}000\ kWh \cdot \frac{\$0.0221}{kWh} + \$39.20 = \$19{,}527.20$$

By not switching rate structures, the minimum demand stipulation in the *Large General Service* contract will cost the company in February approximately:

$$Extra\ Cost = Energy\ Cost_{old} - Energy\ Cost_{new} = \$59{,}447.33 - \$19{,}527.20 = \$39{,}814.53$$

4.2 Block Rates

Electricity rates structures that remain constant with energy consumption are known as ***flat rates***. However, the rates you pay often change based on how much electricity you use. ***Block rates*** are a common variable rate structure often used to incentivize energy efficiency. With block rates, your unit cost for electricity will be divided into distinct tiers based on your usage. In a declining or decreasing block structure, the unit cost for consumption and/or demand decreases as you consume more electricity. In an inverted or increasing block structure, the unit cost of consumption and/or demand increases with electricity usage. Both declining and inverted structures reflect the relative cost for the utility to generate additional electricity. Most utilities with block rates will have at least two blocks that appear on your bills with labels like “Energy Charge 1,” “Energy Charge 2,” and so on. Table 2 contains a few examples of block rate structures from different utilities.

Although most block rates have predetermined cutoffs between block charges, some rate schedules can adjust the block limits based on your consumption. For example, consider the two-block variable cap rate structure in Table 2. For this facility, keeping their demand curve flat is especially important because it will allow them to reach the Block 1 consumption cap earlier in the month and pay the cheaper Block 2 rate for all remaining usage.

Table 2: Example Block Rate Structures

Block Rate Type	Blocks	Cost
Declining/Decreasing	First 500 kWh All Additional kWh	\$17.07/kWh \$15.61/kWh
Inverted/Increasing	First 2,000 kWh Next 2,000 kWh All Additional kWh	\$0.09/kWh \$0.10/kWh \$0.12/kWh
Variable Cap	First X kWh, where $X = 1{,}600 + 200 \times$ Billed Demand All Additional kWh	\$0.085/kWh \$0.07/kWh

4.3 Time-of-Use Pricing

Demand on the electric grid, although highly variable, is usually very predictable. The grid is generally under greater strain in the afternoon and during hot summer months. ***Time-of-use (TOU) pricing*** is one way utilities incentivize customers to shift their energy demand and reduce stress on the grid. With TOU pricing, the time that energy is used determines the price of that energy[9]. This section discusses two common TOU rate structures that may be on your electric bills.

On-Peak/Off-Peak Pricing

One of the simplest TOU pricing structures is ***on-peak/off-peak*** pricing. With this rate structure, utilities designate time periods when the cost of electricity will be higher (on-peak) because of greater strain on the grid. On-peak times may apply only during peak summer months or year-round. Some utilities may even have ***Shoulder rates*** around on-peak times when electricity costs are slightly higher to encourage shifting demand ahead of the on-peak period. With on-peak pricing, you can realize significant costs savings by shifting as much of your electricity demand as possible to off-peak hours when your electricity rates are cheaper. Figure 9 provides two examples of on-/off-peak hours seen in electricity rate structures.

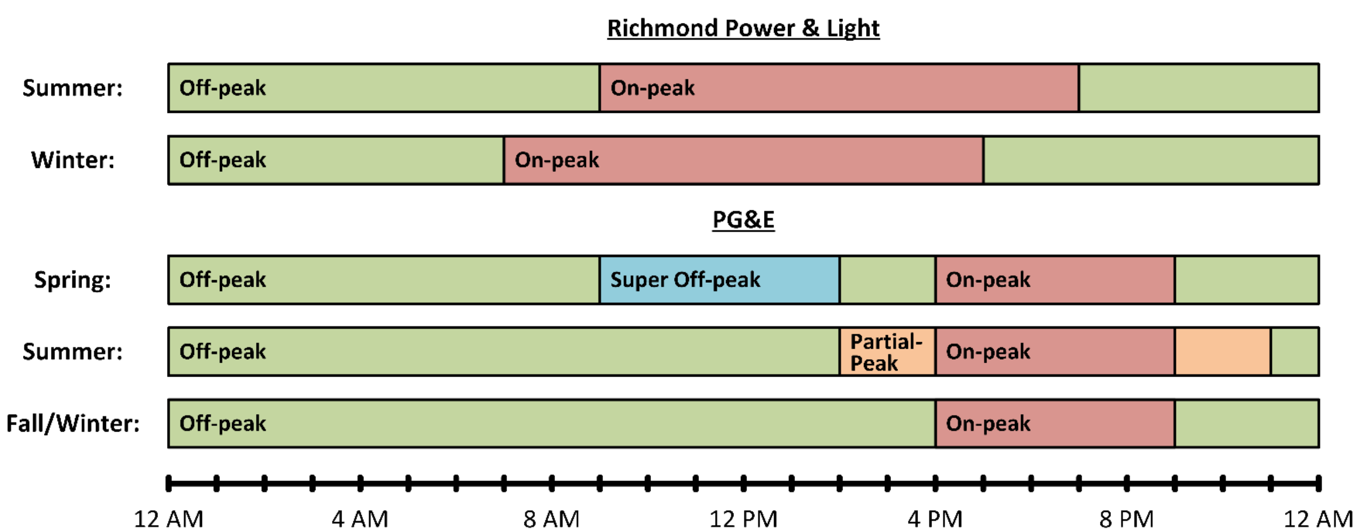


Figure 9: Example on-peak hour scheduling from two electric utilities.

[9] Yong Wang and Lin Li, "Time-of-Use Electricity Pricing for Industrial Customers: A Survey of U.S. Utilities," *Applied Energy* 149 (July 1, 2015), https://doi.org/10.1016/j.apenergy.2015.03.118.

Critical Peak Pricing/Rebates

Another way to implement TOU pricing is to use historical, real-time, fuel cost, and weather data to predict when the grid is likely to experience a "critical peak event." When an event is forecasted, utilities can adjust the cost of electricity for a specified period around the event to encourage customers to cut their demand and reduce strain on the grid. The two main ways to implement this pricing structure are:

- ***Critical peak pricing*** (CPP): Electricity rates increase significantly during a predicted peak event in exchange for a reduced rate during non-peak hours. Customers reduce their electricity usage during peak times to avoid the extra cost.
- ***Critical peak rebates*** (CPR): Electricity rates remain the same during predicted peak events, but customers receive a rebate in proportion to the amount of electricity they cut during the event. Customers reduce their electricity usage to receive more rebate payments.

Utilities will provide at least a day-ahead warning of peak events, allowing customers to plan their electricity usage. The number and frequency of events is usually limited, normally 10–20 times per year. The time of day and duration of an event can be fixed (e.g., always from 3 p.m. to 6 p.m.) or float depending on forecasted grid conditions.

Real-Time Pricing

The advent of smart electric meters has brought about the adoption of ***real-time pricing*** (RTP) structures for many energy consumers. With RTP, the price of electricity changes constantly in response to changes in weather, grid load, and other factors (Figure 10). Similar to on-peak pricing, the goal of RTP is to discourage energy consumption during high-grid-demand conditions. RTP also allows consumers to maximize cost savings by shifting production to times with the best electric rates.

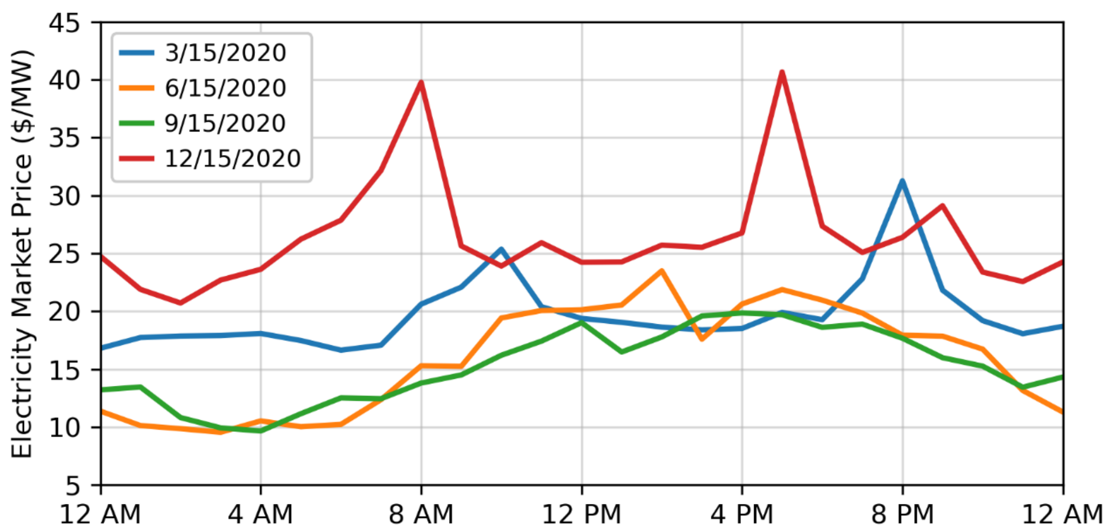


Figure 10: Example real-time pricing data from 2020 for the PJM Interconnection Dayton zone.

Implementation of RTP requires that electricity pricing information is easily available to consumers. Utilities will typically send rate forecasts via email or text message ahead of the expected grid demand. Consumers can then decide on adjusting their electricity usage, balancing production against the cost of energy. Decisions can be made based on historical trends or automated into equipment control systems that adjust production rates in real time. During times of significant price volatility, manufacturing facilities can negotiate blocks of on-peak/off-peak pricing to hedge against high electricity costs. Whether RTP is right for your facility depends on the ability to control your electrical demand, production schedules/deadlines, and the capital/personnel you have available. If your bills use RTP pricing, your manufacturing facility likely has a dedicated energy purchasing officer that manages your usage and costs. Working with that officer can help you save on your electricity costs.

4.4 Curtailment and Interruptible Rates

Many electric utilities offer special rates to large industrial customers to reduce or cut their power consumption during peak grid demand. Under a ***curtailment rate***, customers work with the utility to identify the base level of demand required to operate their facility and the loads/equipment that can be switched off or turned down. During peak events, facilities are required to reduce usage from their identified systems over the specified period in exchange for a reduced electricity rate. Likewise, ***interruptible rates*** reduce grid demand by simply disconnecting service to the identified loads during a peak event. For both rates, the utility will issue a warning 15 minutes to several hours before an event occurs. Depending on your facility's size, some cost-saving opportunities may be available on your electric bills if you are able to participate in one of these rate structures.

4.5 Net Metering Rates

If your facility has on-site electricity generation (solar panels, wind turbines, cogeneration, and so on), there may be times when you produce more electricity than you need. ***Net metering*** is a billing mechanism by which excess electricity can be sold back to the grid for a credit on your bills. The credit amount is usually some fraction of your electricity rate or equal to the current wholesale market price. Regulations on net metering vary state by state, including the eligible technologies[10].

Several types of net metering pricing structures exist. ***Feed-in*** structures pay more for power sold back to the grid than for power purchased from the grid and are usually used to incentivize customers to invest in renewable technologies like solar panels. ***Net-purchase and sale*** structures charge more for grid power then they pay for electricity sold back to the grid. Although this structure diminishes the benefit to the consumer, it still reduces the total amount paid for electricity. ***Aggregate net metering*** allows customers to combine multiple meters, while ***virtual net metering*** allows multiple customers to invest and benefit from a single net-metering project. Consult your local utility to understand if there are any net-metering pricing structures available in your area.

4.6 Other Rate Structures

Your electric utility may have other types of rate structure options available. As this section suggests, knowing your options for electricity purchasing can be key in saving money. Staying alert for any updates to your utility's rate schedule can help you to take advantage of innovative rate structures and save on future electricity costs.

[10] "Net Metering Policies," Database of State Incentives for Renewables & Efficiency (DSIRE) (NC Clean Energy Technology Center), accessed January 12, 2021, https://www.dsireusa.org/resources/detailed-summary-maps/net-metering-policies-2/.

5 Savings Opportunities from Your Electricity Bills

The previous two sections focus on the charges that appear on your bills and the reasons for those charges. This section focuses on some basic actions that you can take to reduce your electricity costs just by reviewing your bills. Some strategies have already been discussed, such as monitoring demand to avoid ratchet clauses (Section 3.2), PF correction (Section 3.3), or choosing the correct rate structure (Section 4). The following strategies do not compose a complete list—analyzing your bills and electricity consumption is an ongoing project.

5.1 Tax Exemptions

When reviewing your utility bills, pay attention to any listed taxes. Many states allow manufacturing facilities to claim a state sales tax exemption on their utility bills under certain conditions[11]. For example, Texas manufacturers can claim an exemption if they can prove that at least 50% of the energy on a given meter is used for production purposes including manufacturing, processing, refining, and so on. Activities such as purchasing, maintenance, testing, storage, and so on are not usually eligible towards tax exemption. A ***predominant use study*** from an independent third-party is typically required to claim the exemption. Some states will even refund up to 24 months of back taxes after claiming the exemption. Consult with your local utility to see if your state offers any tax exemptions for manufacturers.

5.2 Avoiding Late Fees

Almost every company (including utilities) charges a late fee when a payment is overdue. The exact size of the fee varies, but some utilities can charge as much as 10% of the outstanding balance. When bills are not paid, your facility is effectively borrowing money at an extremely high annual percentage rate (APR). For example, a late fee of just 5% has an effective APR of 80%. Working with your billing department and your utility can help you avoid these fees. Simple things such as understanding if a payment must be postmarked or received by the due date can save a lot of money over time.

5.3 Recreating Your Bills

Once you know your rate structure, you can now double-check charges on your bills. Every consumption and demand charge can be verified by using the line items in your rate structure and the meter readings from the bill. The goal is to balance the charges on the bills with your understanding of your rate structure. There are generally three possible outcomes.

1. **Your Calculation Matches the Bills:** This is the ideal case; you have identified the correct rate structure and the bills had no calculation errors.
2. **Incorrect Rate Structure:** Your estimated bill does not match your actual bill because you used the wrong rate structure. Understanding which rate structure you are under is key to avoiding unnecessary spending.
3. **Calculation Error:** Your estimated bill does not match your actual bill because of an error on your bill. Failed meters, data-entry issues, and clerical errors are a few issues that can occur. Catching these mistakes early can save time and money.

[11] "State Sales Tax Exemptions for Manufacturers," SM Engineering Co., June 20, 2014, https://www.smeng.com/manufacturing-sales-tax-exemptions/.

5.4 Load Shifting, Load Shedding, and Demand Response

As discussed in Section 3.2, one major strategy in avoiding demand charges is managing your demand profile. This is accomplished by using two main strategies: ***load shedding*** is a temporary reduction in demand, and ***load shifting*** is the transfer of load from on-peak to off-peak hours (Figure 11). Both strategies can be used to avoid demand charges by reducing large spikes in demand and avoiding coincident peaks with the grid. Strategies for managing load include switching off equipment during peak hours, moving production from one shift to another, slowing down motors using VFD technology, reducing air conditioning, and so on.

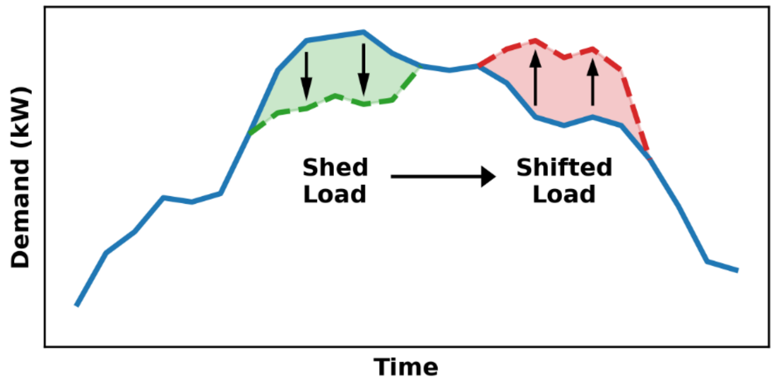


Figure 11: Load shedding reduces demand during certain times, load shifting moves load to another time.

Some utilities offer incentives called ***demand response*** (DR) programs for large industrial customers to shift or shed their load. Under a DR contract, manufacturing facilities agree to reduce their electric demand by a given amount in exchange for reduced energy costs or direct financial payments. Utilities will call a facility ahead of an expected grid peak and the facility must reduce its demand before a given deadline. DR incentives scale with the size and speed at which the load is shed. DR contracts typically have a maximum number of load-shedding events that are allowed during the contract period. Smart meters and internet technologies enable ***automated demand response*** (Auto DR), allowing facilities to program their load shedding. When an Auto DR signal is received, predetermined steps are taken that reduce the facility's demand. In short, managing your demand and analyzing your bills can yield large electricity cost savings by avoiding spending during peak periods and through incentives offered by your utility.

5.5 Consolidating Meters

Depending on your plant's layout and power needs, there may be opportunities to combine multiple meters into a single meter. In some cases, this might allow you to qualify for different rate structures that have higher minimum usage requirements but provide cost savings for larger consumers. There are also savings associated with reducing the number of fixed fees that are on each meter invoice; instead of paying three metering fees, you only pay one. You should think about the number of meters in your plant every time you purchase new production space, expand existing infrastructure, or re-arrange equipment in your facility. Contact your local utility to determine if meter consolidation is a feasible option for your plant.

5.6 Load and Production Factor Analysis

Electrical load factor (ELF) analysis is one way you can estimate how well your facility uses its electricity[12]. ELF is the ratio of your monthly kWh consumption divided by your maximum possible consumption (Equation 9). Actual demand (not billed demand) multiplied by the total number of hours in the billing period gives a rough estimate of

[12] "Customer Care: Understanding Load Factor," Explainer (Austin Energy, April 29, 2009), https://austinenergy.com/wcm/connect/8fe76160-0f73-4c44-a735-529e5c7bee61/understandingLoadFactor.pdf?MOD=AJPERES&CVID=kC1aR-I.

how much energy in kWh your facility would use if it operated full tilt for the entire month. An ELF near 1.0 indicates that your facility uses electricity consistently throughout the month while lower values may indicate that large spikes in demand have occurred. Table 3 gives nominal values for ELFs based on shift operating hours and Figure 12 shows how ELF is calculated from the monthly energy consumption and demand.

$$ELF = \frac{Consumption}{Demand \times Hours\ in\ Billing\ Period} \tag{9}$$

Table 3: Typical Ranges for Load Factor Analysis by Shift Type

Shift Type	Typical ELF Range
Single-Shift Operation	0.20–0.25
Two-Shift Operation	0.45–0.60
Three-Shift Operation	0.75–0.85

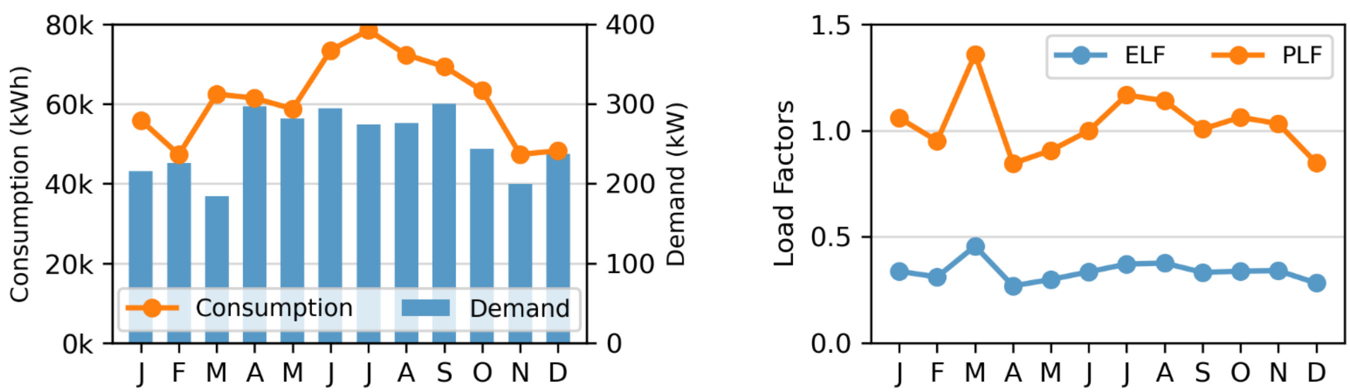


Figure 12: Example electrical and production load factors (right) calculated from consumption and demand data (left).

Another simple metric for analyzing your energy usage is the ***production load factor*** *(PLF)*[13]. Instead of total billing hours, the PLF multiplies your monthly demand by production hours (Equation 10). Although a PLF of 1.0 is ideal (your facility uses its peak demand for all production hours), values of around 0.85 are considered good for most facilities. A PLF well over 1.0 indicates that electricity is being used outside of production hours, possibly by equipment running outside of those times. PLFs well below 1.0 indicate large spikes in demand similar to the ELF. Notably, if your facility runs 24/7, the ELF and PLF will be the same. Figure 12 also shows PLFs calculated from data at an example facility.

$$PLF = \frac{Consumption}{Demand \times Production\ Hours} \tag{10}$$

5.7 Tracking Your Electricity

As you are reviewing your electricity bills, saving and tracking your electricity data can be very helpful. Some companies have internal dashboards for their energy data, which makes the information easily shareable within the facility and with upper management. A lower-tech solution is a humble spreadsheet that records your electricity

[13] Tapajyoti Sen, "Electrical and Production Load Factors" (Master's Thesis, College Station, TX, Texas A&M University, 2010), https://oaktrust.library.tamu.edu/handle/1969.1/ETD-TAMU-2009-12-7475.

usage and demand over time and perhaps includes a few key charts and statistics. Tracking your energy usage can help you identify anomalies and prevent unnecessary electricity usage or spending.

DOE has developed free software tools that can help you keep track of your electricity data. First, the Energy Footprint Tool (EFT) is an Excel-based tool for collecting and tracking energy data. The EFT can track up to 20 types of energy consumption (electricity, natural gas, etc.) as well as other variables that affect your energy usage including weather, production, and operating hours. The EFT is also an excellent way to create a list of your ***significant energy users*** and balance their energy consumption with the meter readings on your bills.

DOE's Energy Performance Indicator (EnPI) Tool is an Excel-based tool for analyzing and comparing energy usage between years. EnPI is the main tool that the Better Plants Program uses to track improvements in energy intensity. The tool uses a regression-based approach to normalize for differences in energy consumption by accounting for variables such as production, weather, humidity, and so on. The tool can also aggregate savings from multiple facilities into a corporate-level energy improvement metric. For more information on this type of analysis, please see the ***Energy Intensity Baselining and Tracking Guidance 2020***. Screenshots of both the EFT and EnPI tools are shown in Figure 13.

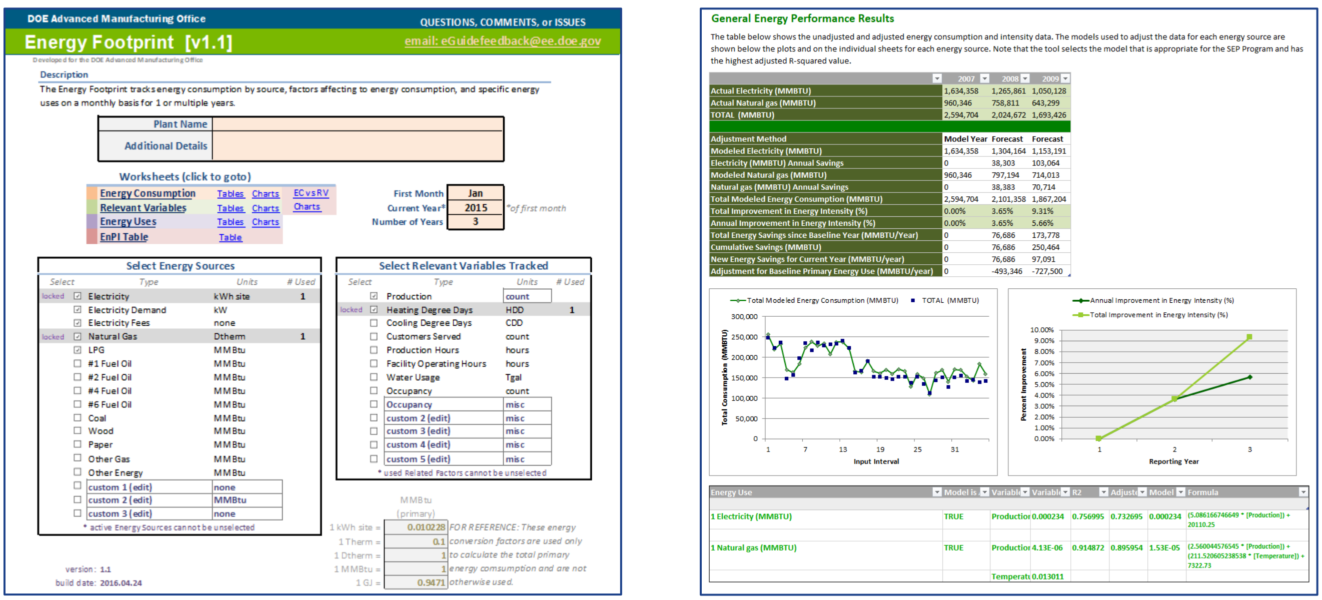


Figure 13: DOE's Energy Footprint Tool is a great resource for storing and analyzing your energy usage (Left). The EnPI tool can perform detailed energy analysis, including regression-based modeling (Right).

6 Performing a Utility Bill Analysis: An Example

This section provides a detailed analysis of 12 months of sample electricity bill data. The example highlights several key concepts discussed in this document. The numbers presented, although based on actual bills, have been randomized. The appearance of specific electric suppliers is not an endorsement but is used to discuss actual rate structures for electricity. Your Better Plants TAM is available for any assistance you may need to understand the analysis and can help you perform a similar analysis on your electricity bills.

6.1 Rate Structure

Fine Factories Incorporated (FFI) has a manufacturing facility located outside of Dallas, Texas. Because Texas is a deregulated power market, FFI has opted to use local ***Retail Electric Provider*** (REP) Reliant Energy for their power generation and Oncor Electric Delivery (ONCOR) as their ***transmission and distribution service provider*** (TDSP). FFI's bills will reflect charges from both the REP and TDSP. The facility has an average monthly electrical demand between 400 and 600 kW and annual energy consumption around 125,000 kWh. FFI has a 24-month fixed-price contract with the REP for their energy usage and has contracted with the TDSP for transmission and delivery services under the "secondary service greater than 10 kW" rate structure. Rate schedules for both providers can be found online. The following charges and the riders in Table 4 apply for FFI's electrical service as of 2020:

- (REP) An energy charge of $EC = \$0.063$ per kWh,
- (TDSP) A monthly customer charge of $9.25,
- (TDSP) A monthly metering fee of $30.82,
- (TDSP) An 80% ratchet clause for all demand charges based on the previous 11 months,
- (TDSP) A minimum 0.95 PF requirement,
- (TDSP) The following contract riders:

Table 4: Riders for Fine Factories Incorporated transmission and distribution service.

Rider	Rate	Unit	Charge Type
Competitive Meter Credit (CMC):	$1.72	/month	Fixed
Energy Efficiency Cost Recovery Factor (EECRF):	$0.000348	/kWh	Consumption
Capital Structure Refund (CSR):	$0.103036	/kW	Demand
Distribution Cost Recovery Factor (DCRF):	$0.266647	/kW	Demand
Distribution System Charge (DSC):	$4.497330	/kW	Demand
Nuclear Decommissioning Charge (NDC):	$0.053	/kW	Demand
Rate Case Expense Surcharge (RCE):	$0.011057	/kW	Demand
Tax Refund Factor (TRF):	$1.692637	/kW	Demand
Transmission Cost Recovery Factor (TCRF):	$3.859794	/kW	Demand

From the REP and TDSP rate schedules, the marginal costs for electricity at the FFI facility are therefore:

$$D_{mrg} = -CSR + DCRF + DSC + NDC + RCE - TRF + TCRF = \$6.89/kW$$

$$C_{mrg} = EC + EECRF = \ \$0.063348/kWh$$

6.2 Electricity Bill

FFI's REP bundles their energy charges and the TDSP service charges into a single bill (Figure 14) that is received every month. The bill lists the current and previous electric meter readings, the current month's kWh consumption and kW demand, the account balance, and a list of current charges. The bills do not explicitly list any charges for electricity demand, PF, ratchet clauses, or any of the individual TDSP riders from the rate schedule shown in Table 4. All TDSP charges are lumped together as the single line "TDSP Pass-through Charges" with only a total amount given. To understand this electricity bill, the rate schedules for both the REP and TDSP and some independent calculations are required.

REP Services
Your local choice.

Billing Summary

Billing Date:	04/01/2020	Amount Due:	$10,629.19
Due Date:	04/15/2020	After Due Date:	$11,160.65

Account Information

Invoice Number:	12 345 678 – 9
Customer Name:	Fine Factories Inc.
Service Address:	123 Four Street Dallas, TX 75005
Current Meter Reading:	293,581
Previous Meter Reading:	288,599
Meter Multiplier:	20
kWh Consumption:	99,633
kW Demand:	451
Power Factor	0.88

Questions or comments? We're available 24/7 at:
betterbuildingssolutioncenter.energy.gov/better-plants/program-information

Account Summary

Account Number:		98 765 432 – 1
Previous Amount:		$10,805.08
Payment 03/12/2020:		-$10,805.08
Balance Forward:		$0.00
Days on Bill:	03/01/2020 – 04/01/2020	31
Energy Charge:	99,633 @ $0.063/kWh	$6,276.88
TDSP Pass-through Charges:		$3,656.94
Base Charge:		$0.00
Sales Tax 7.00%:		$695.37
Current Charges:		$10,629.19
Amount Due:		$10,629.19

Figure 14: Example electricity bill for Fine Factories Incorporated from their Retail Electric Provider (REP).

Using historical utility bill data and the meter readings on the bill in Figure 14, the following analysis will recreate each listed energy charge.

kWh Consumption

The current month's kWh consumption is calculated by taking the difference between the current and previous meter readings and multiplying by the meter multiplier:

$$kWh\ Consumption = (Current\ Reading - Previous\ Reading) \times Meter\ Multiplier$$
$$= (293{,}581 - 288{,}599) \times 20 = 99{,}633\ kWh \quad ✓$$

Energy Charge

The REP service contract has a single fixed-price charge for kWh energy consumption. Therefore, the energy charge is simply the current kWh consumption multiplied by the kWh rate:

$$Energy\ Charge = Energy\ Consumption \times kWh\ Rate$$
$$= 99{,}633 \times \$0.063/kWh = \$6{,}276.88 \quad ✓$$

TDSP Pass-Through Charges

Reviewing the TDSP rate schedule, there are three fixed monthly charges—a customer fee, a metering fee, and the competitive metering credit (CMC) rider. The total fixed charge for the TDSP pass-through is therefore the sum of the two fees minus the metering credit:

$$\begin{aligned} TDSP\ Fixed &= Customer\ Fee + Metering\ Fee - CMC \\ &= \$9.25 + \$30.82 - \$1.72 = \$38.35 \end{aligned}$$

The only TDSP charge that is billed on kWh consumption is the EECRF rider. The total consumption-based pass-through charge is therefore the kWh consumption multiplied by the EECRF rate:

$$\begin{aligned} TDSP\ Consumption &= kWh\ consumption \times EECRF\ Rate \\ &= 99{,}633\ kWh \times \$0.000348/kWh = \$34.67 \end{aligned}$$

To calculate the TDSP demand-based charges, several additional pieces of information are required. As mentioned, the TDSP will adjust actual demand based on a 0.95 minimum PF requirement. The adjusted demand is calculated using Equation 6 (page 11):

$$\begin{aligned} PF\ Adjusted\ Demand &= Real\ Demand \times \frac{PF_{req}}{PF} \\ &= 451\ kW \times \frac{0.95}{0.84} = 510\ kW \end{aligned}$$

From the TDSP rate structure, an 80% ratchet clause is also charged based on the previous 11 months' PF-adjusted demand data. FFI has been tracking their electricity bills and was able to determine that their highest adjusted demand over the previous 11 months was 650 kW after adjusting for a PF of 0.84. FFI's billed demand is therefore:

$$\begin{aligned} Ratchet\ Demand &= 80\% \times Max\ PF\ Adjusted\ Demand \\ &= 0.8 \times 650\ kW = 520\ kW. \end{aligned}$$

$$\begin{aligned} Billed\ Demand &= \max(PF\ Adjusted\ Demand, Ratchet\ Demand) \\ &= \max(510\ kW, 520\ kW) = 520\ kW \end{aligned}$$

The total demand-based pass-through charges are equal to the billed demand multiplied by sum of the demand-based riders. Note how refund and credit riders are subtracted instead of added:

$$\begin{aligned} TDSP\ Demand &= Billed\ Demand \times (-CSR + DCRF + DSC + NDC + RCE - TRF + TCRF) \\ &= 520\ kW \times \$6.89/kW = \$3{,}583.92 \end{aligned}$$

The total TDSP pass-through charge is now simply the sum of the fixed, consumption, and demand-based charges:

$$\begin{aligned} TDSP\ Total &= TDSP\ Fixed + TDSP\ Consumption + TDSP\ Demand \\ &= \$38.35 + \$34.67 + \$3{,}583.92 = \$3{,}656.94 \end{aligned}$$

✓

This analysis highlights how understanding a rate structure is key to understanding an electricity bill. Penalties for FFI's low PF and the 80% ratchet clause are not listed on the bill directly but obviously affect how much they pay for their electricity. Likewise, specific demand-related charges are also not directly listed. Understanding FFI's bills requires knowledge of the rate structure and further analysis of the TDSP pass-through charges. Twelve months of utility data for FFI's production facility are summarized in Table 5 and Table 6.

Table 5: Fine Factories Incorporated Electricity Bill Data

Month	Jan. 20	Feb. 20	Mar. 20	Apr. 20	May 20	Jun. 20	Jul. 20	Aug. 20	Sep. 20	Oct. 20	Nov. 20	Dec. 20
Days on Bill	31	29	31	30	31	30	31	31	30	31	30	31
Prev. Meter Reading	278,914	283,488	288,599	293,581	298,416	303,558	309,528	316,123	323,357	330,537	336,926	342,743
New Meter Reading	283,488	288,599	293,581	298,416	303,558	309,528	316,123	323,357	330,537	336,926	342,743	347,739
Meter Difference	4,574	5,111	4,982	4,835	5,142	5,969	6,595	7,234	7,180	6,389	5,817	4,996
Consumption	91,480	102,228	99,633	96,708	102,835	119,389	131,902	144,679	143,598	127,786	116,346	99,922
Demand	474	432	451	454	503	522	549	556	563	559	530	495
Power Factor	0.89	0.83	0.84	0.88	0.83	0.85	0.89	0.86	0.86	0.88	0.86	0.85
Energy Charge	$5,763.24	$6,440.36	$6,276.88	$6,092.60	$6,478.61	$7,521.51	$8,309.83	$9,114.78	$9,046.67	$8,050.52	$7,329.80	$6,295.09
TDSP Pass-Through Charges	$3,654.11	$3,657.85	$3,656.94	$3,655.92	$4,042.11	$4,100.86	$4,123.13	$4,321.76	$4,374.68	$4,242.00	$4,113.95	$3,886.11
Sales Tax	$659.21	$706.87	$695.37	$682.40	$736.45	$813.57	$870.31	$940.56	$939.49	$860.48	$801.06	$712.68
Total	**$10,076.56**	**$10,805.08**	**$10,629.19**	**$10,430.93**	**$11,257.16**	**$12,435.93**	**$13,303.27**	**$14,377.10**	**$14,360.85**	**$13,152.99**	**$12,244.82**	**$10,893.88**

Table 6: Fine Factories Estimated TDSP Rate Charges

Month	Jan. 20	Feb. 20	Mar. 20	Apr. 20	May. 20	Jun. 20	Jul. 20	Aug. 20	Sep. 20	Oct. 20	Nov. 20	Dec. 20
TDSP Ratchet Demand	520	520	520	520	520	520	520	520	520	498	498	498
TDSP PF-Adjusted Demand	506	494	510	490	576	583	586	614	622	603	585	553
TDSP Billed Demand	520	520	520	520	576	583	586	614	622	603	585	553
TDSP Fixed	$38.35	$38.35	$38.35	$38.35	$38.35	$38.35	$38.35	$38.35	$38.35	$38.35	$38.35	$38.35
TDSP Demand	$3,583.92	$3,583.92	$3,583.92	$3,583.92	$3,967.97	$4,020.96	$4,038.88	$4,233.07	$4,286.36	$4,159.18	$4,035.12	$3,812.98
TDSP Consumption	$31.84	$35.58	$34.67	$33.65	$35.79	$41.55	$45.90	$50.35	$49.97	$44.47	$40.49	$34.77
TDSP Total	**$3,654.11**	**$3,657.85**	**$3,656.94**	**$3,655.92**	**$4,042.11**	**$4,100.86**	**$4,123.13**	**$4,321.76**	**$4,374.68**	**$4,242.00**	**$4,113.95**	**$3,886.11**

6.3 Opportunities for Savings

The same analysis from the previous section was carried out on all 2020 utility data for FFI. Consumption and demand charges are given in Table 5 as they appear on the REP bills. The reconstruction of the TDSP pass-through charges are given in Table 6. The following analysis uses this historical data to estimate some initial savings opportunities for FFI based off tracking and understanding their utility bills.

Energy Tracking

The data from Table 5 were used to make the charts in Figure 15. From the consumption and demand data, there was a clear increase in electricity usage starting from May through September of 2020. This could correspond to an increase in production at the facility or be related to higher cooling loads from the extremely hot summer weather in Texas. The production floor at FFI is air conditioned and could explain the increase in energy usage. FFI should investigate if their building insulation is adequate or if the increase in energy is solely due to production. Identifying trends like this can help FFI spot anomalies to save energy and plan their energy usage to save costs.

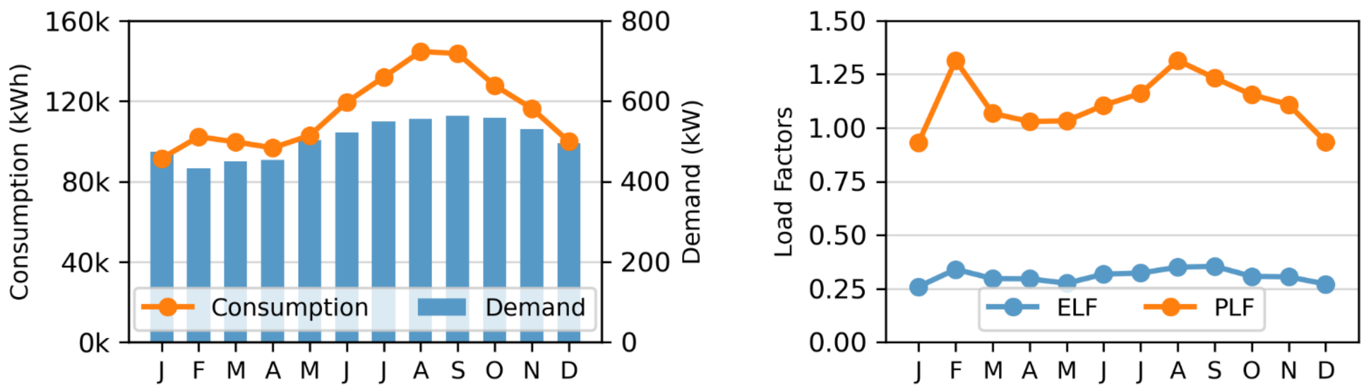


Figure 15: Fine Factories Incorporated 2020 electricity usage trends (left) and load factor analysis (right).

Figure 15 also shows an ELF and PLF analysis of the energy data (see Section 5.6 for more information). The plant normally operates as a single-shift facility with production Monday through Friday, nine hours per day. FFI operates an occasional shift on Saturdays to meet production requirements. The ELF analysis gives values between 0.25 and 0.40, which is consistent with a single shift operation with additional hours. The PLF analysis shows a few months with values substantially above 1.00. The data from February and approximately July through October should be investigated to determine if equipment is being left on after hours during these months. As with the consumption and demand chart, plotting ELF and PLF data can be used to save energy and costs through identifying opportunities and implementing energy/cost-saving projects.

Sales Tax Exemption

The bill in Figure 14 lists a 7.00% sales tax for each of the months analyzed. Texas allows manufacturers to claim a state sales tax exemption on utilities if more than 50% of the energy used on a meter is manufacturing related. FFI applies for and receives a predominant use study that verifies that their facility meets this requirement. FFI claims the sales tax exemption and is able to receive up to 24 months of sales tax refunds. For 2020, this saves FFI:

$$\begin{aligned} Sales\ Tax\ Savings\ (2020) &= Sales\ Tax_{Jan} + \cdots + Sales\ Tax_{Dec} \\ &= \$9{,}418.45 \end{aligned}$$

Altogether, FFI stands to save around \$10,000 annually on their utility bills by claiming a tax exemption and recover more than \$18,000 from the last two years of electricity spending!

Power Factor Correction

From the data in Table 5, FFI's PF has consistently been below the minimum 0.95 required by the TDSP rate structure. Correcting the facility's PF will result in direct cost savings but not generate any energy savings. The following calculations estimate the potential savings based on the 12 months of bills shown. For a simplified and conservative estimate, the analysis ignores the 80% ratchet clause in the TDSP rate structure. Excluding the ratchet will undercount the PF penalty for all months when the real demand is below the ratchet demand. A more accurate calculation would use data starting from February 2019 to determine how the ratchet demand is affected by the PF correction for the bills from January 2020 through August 2020.

Table 7 shows the results of applying Equations 6 and 7 from page 11 to FFI's 2020 utility bill data. As shown, each month's billed TDSP demand is 30 to 80 kW higher than FFI's actual demand. Given the TDSP demand charge of $6.89/kW, the PF penalties add up to more than $4,000 per year! Simple payback times for PF correction projects are usually between one and two years.

Table 7: Estimated Power Factor Correction Savings for FFI's Production Facility.

Month	Real Demand (kW)	PF-Adjusted Demand (kW)	PF Penalty
Jan. 20	474	506	$220.24
Feb. 20	432	494	$430.47
Mar. 20	451	510	$407.05
Apr. 20	454	490	$248.90
May 20	503	576	$501.22
Jun. 20	522	583	$423.26
Jul. 20	549	586	$255.09
Aug. 20	556	614	$401.03
Sep. 20	563	622	$406.08
Oct. 20	559	603	$306.47
Nov. 20	530	585	$382.27
Dec. 20	495	553	$401.37
Total	**6,088**	**6,724**	**$4,383.43**

Demand Management

From the TDSP rate structure, FFI is subject to an 80% ratchet clause each month based on the previous 11 months of demand data. The billed demand in Table 6 suggests a large peak in demand occurred in September 2019 that then set the ratchet demand for the TDSP pass-through charges through July 2020. The 520-kW ratchet demand corresponds to 575 kW of actual demand with a PF of 0.84. The ratchet affected the FFI's billed demand from January through April of 2020.

Managing the facility's demand would help to reduce the impact of the ratchet clause on the facility's electricity spending. The following calculation and Table 8 illustrate how shaving approximately 5% off the September 2019 demand spike would have affected FFI's electricity spending throughout 2020. This could be done by shifting some operations to off-peak times, installing VFD's on lightly loaded motors, and so on.

$$New\ Ratchet\ Demand = (575\ kW \times 95\%) \times \frac{0.95}{0.84} \times 0.8 = \ 494kW$$

Table 8: Effects of Demand Management on FFI's Ratchet Clause Penalty.

Month	Old Billed Demand (kW)	New Billed Demand (kW)	PF Penalty
Jan. 20	520	506	$96.80
Feb. 20	520	494	$176.04
Mar. 20	520	510	$68.51
Apr. 20	520	494	$179.20
Total	**6,724**	**6,803**	**$520.55**

6.4 Summary

Altogether, the preliminary analysis of FFI's utility bill data in this section has identified more than $23,000 in utility savings. Although most of these projects are purely cost-savings opportunities, the potential to identify energy savings also exists. Hopefully this example has illustrated how understanding and tracking your electricity bills can help your company save energy and money. Please contact your TAM or the Better Plants program if you have additional questions or would like help analyzing your electricity bills.

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