Better Plants®
U.S. DEPARTMENT OF ENERGY

Understanding Your Utility Bills:

Electricity

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U.S. DEPARTMENT OF ENERGY

Meeting Recording Announcement

This Zoom call is being recorded and may be posted on DOE's website or used internally. If you do not wish to have your voice recorded, please do not speak during the call or disconnect now. If you do not wish to have your image recorded, please turn off your camera or participate only by phone. If you speak during the call or use a video connection, you are presumed to consent to recording and to the use of your voice or image.

Energy Awareness Month

Yesevents.com/EnergyAwareness

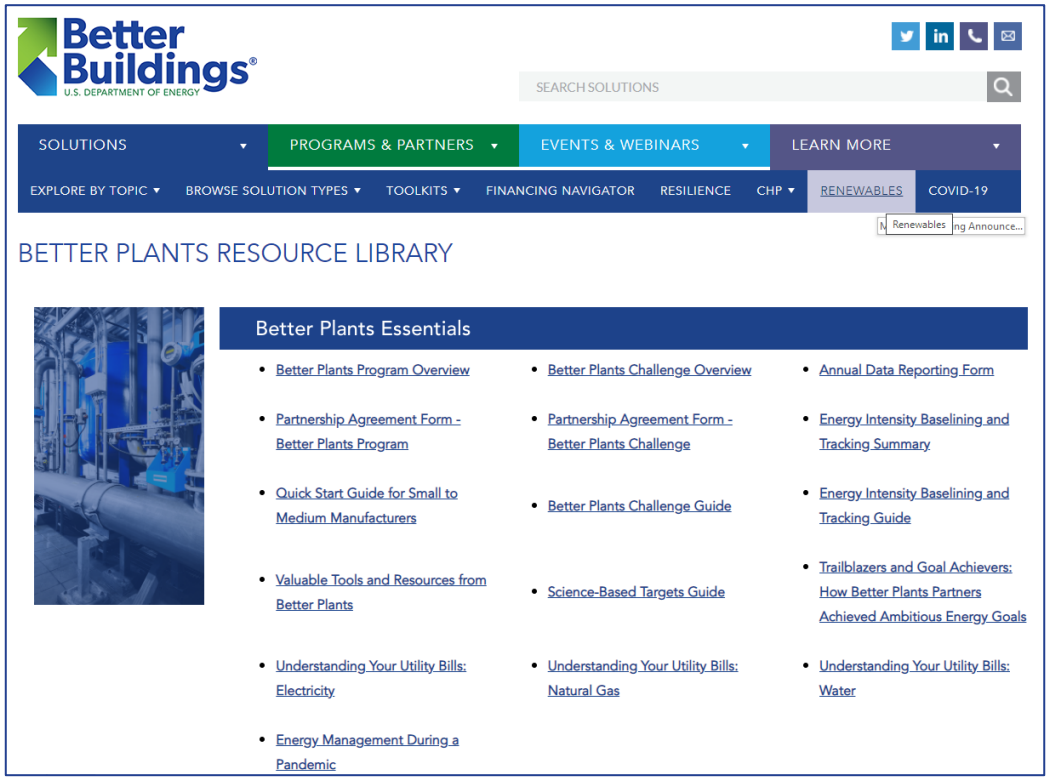
Energy Awareness Month Webinar Schedule

Date	Title
Thursday, Oct 7, 1pm – 2pm ET:	Quick Start Guide to Saving Energy for Small to Medium Manufacturers
Tuesday, Oct 12, 11am – 12pm ET	The Updated Energy Intensity Baselining and Tracking Guide
Thursday, Oct 14, 1pm – 2pm ET	Understanding Your Electricity Bills
Tuesday, Oct 19, 11am – 12pm ET	Understanding Your Natural Gas Bills
Tuesday, Oct 26, 11am – 12pm ET	Understanding Your Water Bills
Thursday, Oct 28, 1pm – 2pm ET	Lessons Learned From Goal Achievers

Yesevents.com/EnergyAwareness

Engaging with DOE

- Have questions? Please use the Zoom chat!
- Want to learn more? energy.gov/BBSC



Today's Presenter

Dr. Christopher Price
Oak Ridge National Laboratory

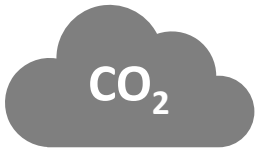
About Better Buildings, Better Plants

Helping manufacturers and other industrial partners save money and improve their resource efficiency.

Increased Energy Productivity

Greater Water Savings

Improved Waste Reduction



Lower Carbon Emissions

Better Plants Resources

NO-COST SOFTWARE & TOOLS

Access to no-cost software and tools to identify and implement energy saving opportunities and manage energy use.

- **60+ Calculators**
- **20+ No-Cost Tools for Loan**
- **Financing Navigator**
- **No-Cost Resources & Guides**

TRAINING & EDUCATION

In-Plant Trainings Conducted to Date

Multi-day trainings for staff to identify, implement, and replicate energy savings projects.

No-Cost Webinars & Growing

RECOGNITION

49 Better Project & Better Practice Winners

For innovative and industry-leading accomplishments in implementing and promoting company-wide practices, principles, and procedures of energy management, as well as improvement projects at individual facilities.

Goal Achievers

National Recognition in Media and Online

Solutions on Solution Center

INNOVATION & LABS

National Labs Across the Country

Partnerships with the National Labs spurs innovation.

Lab Technology Days

Sneed peek at early-stage R&D Technologies

Field Validation

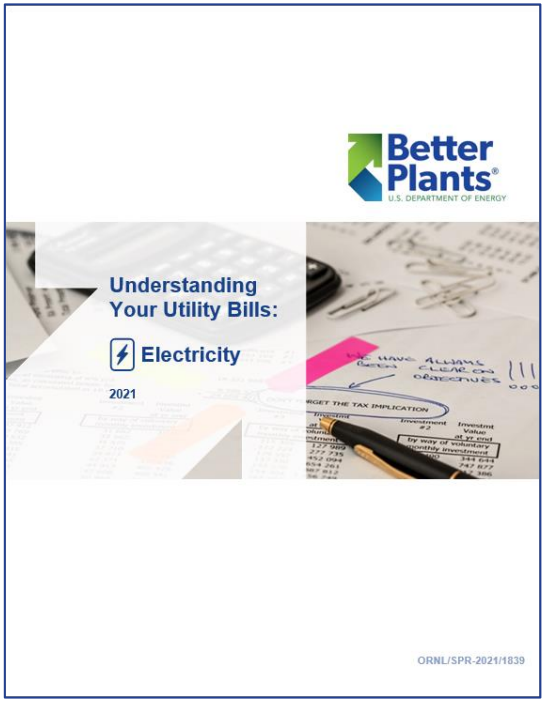
A new pilot for partners to accelerate the voluntary adoption of cost-effective, high-impact technologies while reducing adoption risks.

What Leadership Looks Like

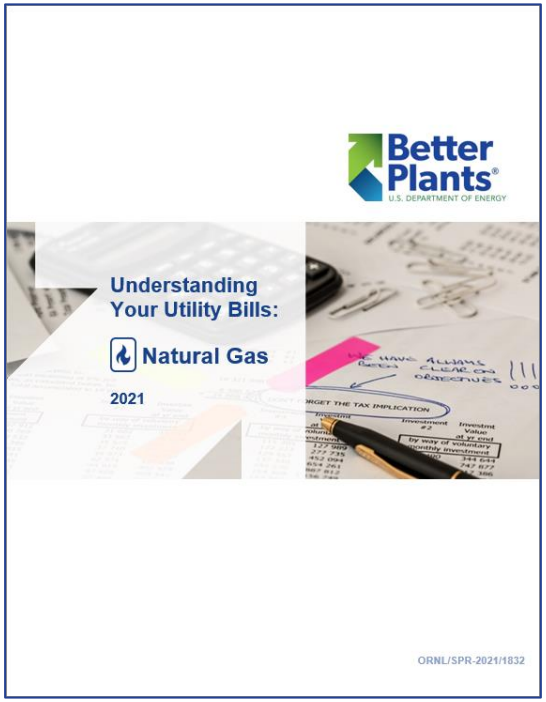
250+ partners across the United States and territories

Understanding your Utility Bills

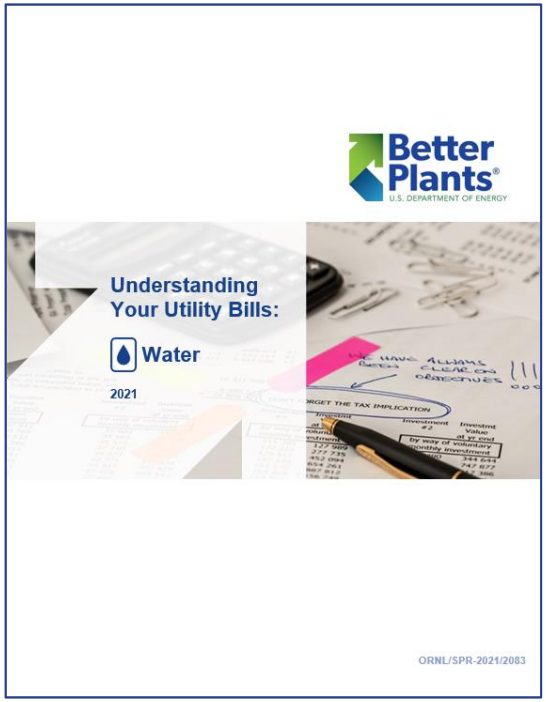
Just one in a series of guidance documents:



Electricity Bills



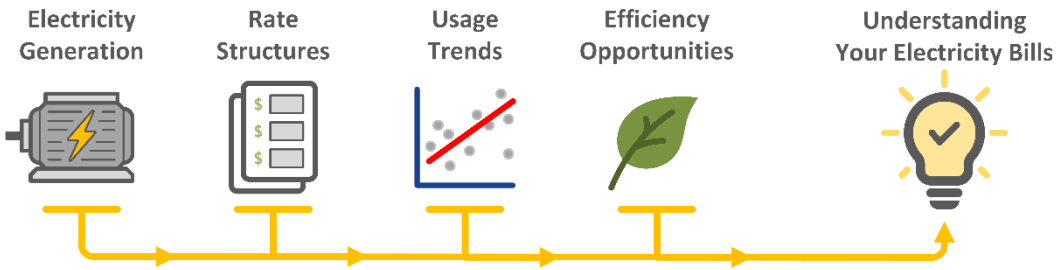
Natural Gas Bills



Water Bills

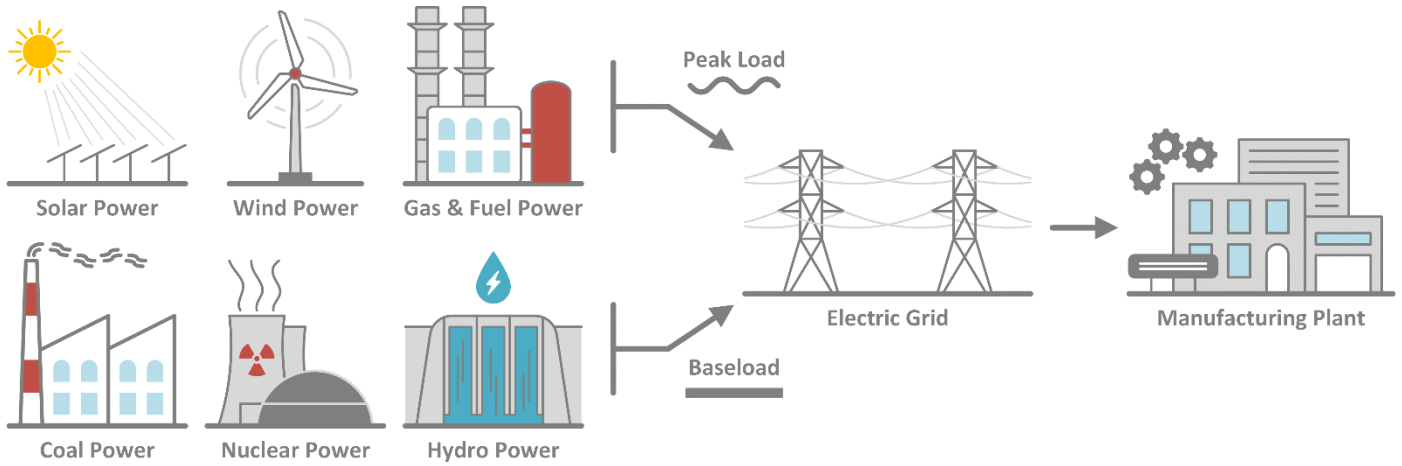
Using the Guide

- Electricity bills can be hard to decipher
- Some bills can be very detailed, some are very short
- Some charges appear each month, some do not
- Understanding your bills and why your utility charges different fees is important to save energy and cost
- The guide covers the basics of electricity bills:



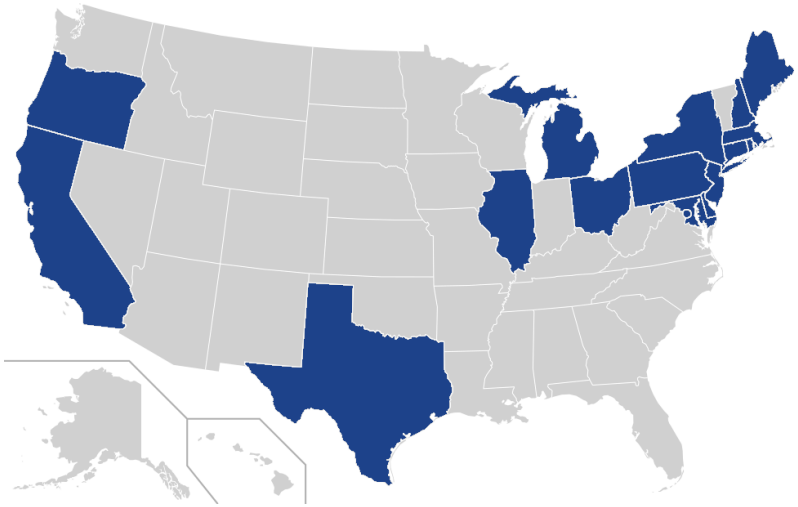
How is Electricity Generated?

- Electricity comes from many different sources
- The mix of electricity sources is changing
- Power is delivered to your facility through the ***Grid***
- Generating costs are different for each source

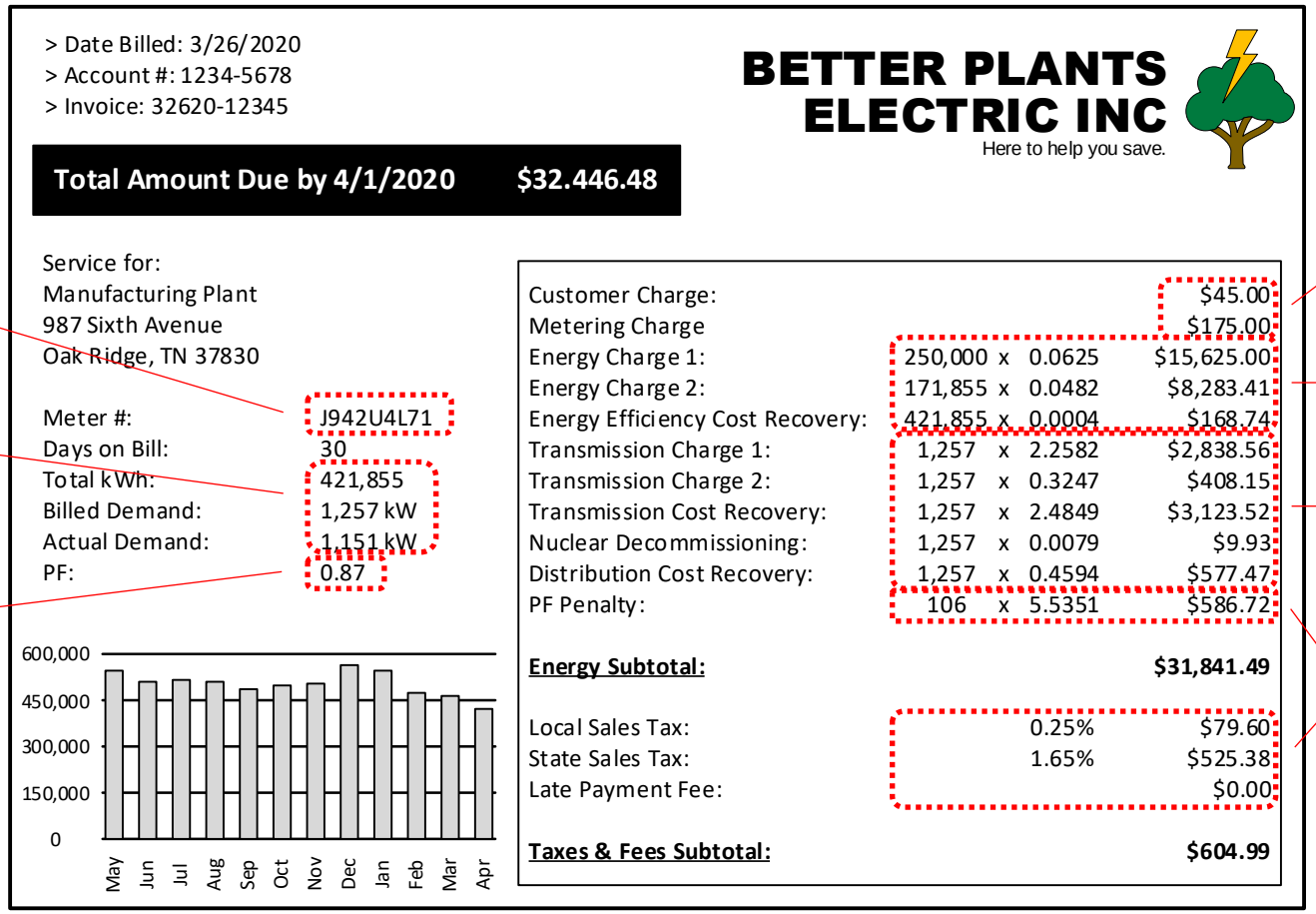


What are Deregulated Power Markets?

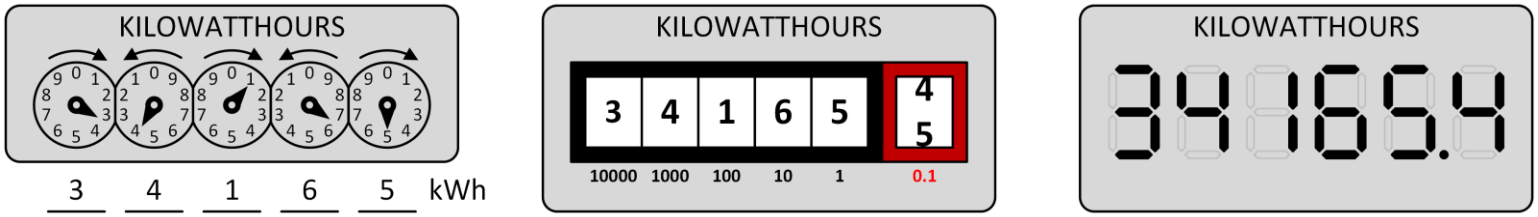
- ***Regulated Power Markets***: Utilities own and maintain all the equipment from generator to your meter
- ***Deregulated Power Market***: Generators and distributors are separate entities
- Deregulation is meant to:
  (1) Lower energy costs through competition
  (2) Promote green energy
- May get multiple bills
- Currently 15 States + DC



Key Components to Your Electricity Bills



Consumption Charges



- Electricity ***Consumption*** or ***usage*** is the total amount of electricity your facility uses to make products
- Measured in kilowatt-hours (kWh) which is equal to 1 kilowatt of power sustained for 1 hour
- Can appear on your bills as energy charge, energy cost, delivered energy cost, etc.
- Billed at a rate ($/kWh) determined by your contract

Demand Charges

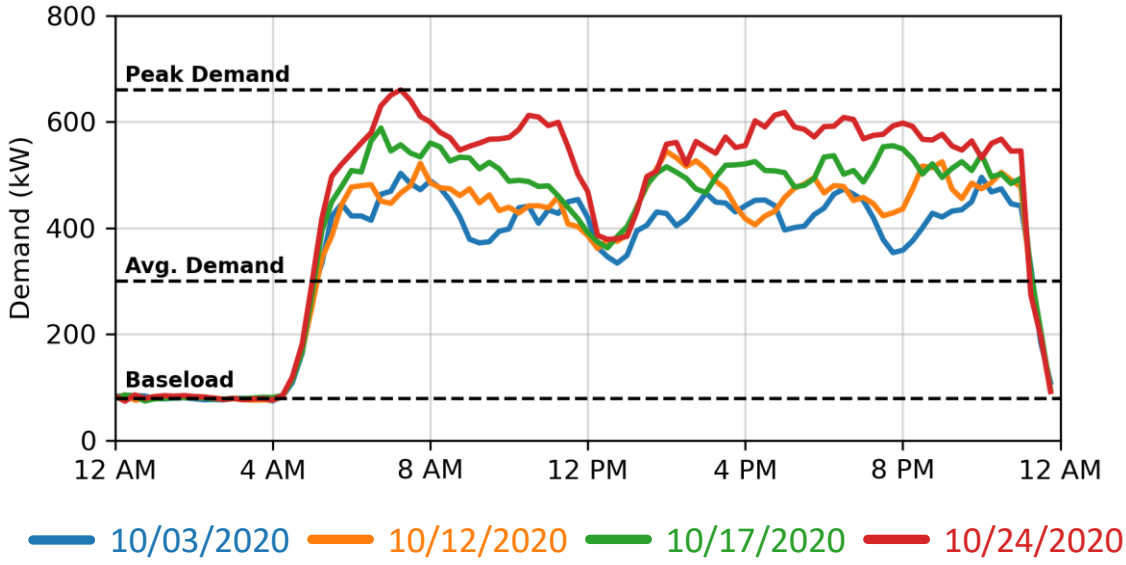
- Industrial facilities also charged for ***Electrical Demand***
- Demand measures the rate of electricity consumption
- Calculated by averaging consumption over a window:

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

- More demand means more grid infrastructure your utility must build and maintain to deliver power
- Can appear on your bills as demand charge, demand cost, transmissions and delivery (T&D) charge, etc.

Types of Demand Charges

- Your facility's demand will vary over a typical day
- You are billed based on the monthly ***Peak Demand***
- One demand spike can set your charges for months!

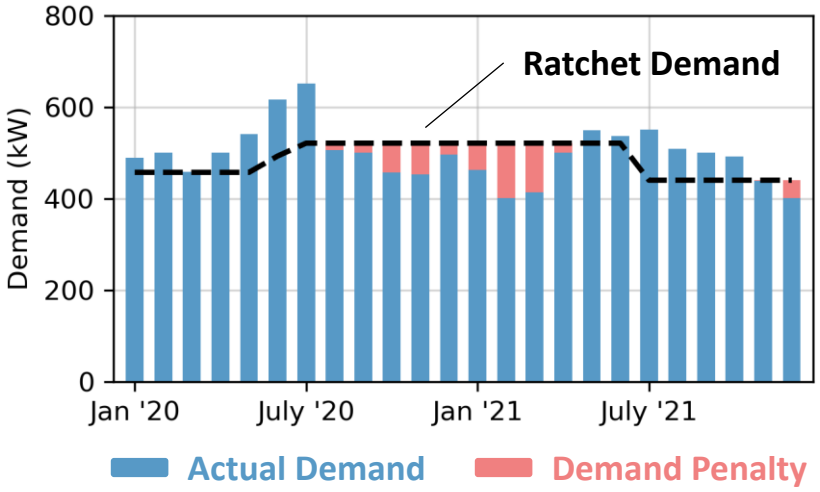


Types of Demand Charges

- ***Actual Demand*** is observed peak from the last month
- ***Billed Demand*** is an adjustment to your real demand established by clauses in your electricity rate schedule

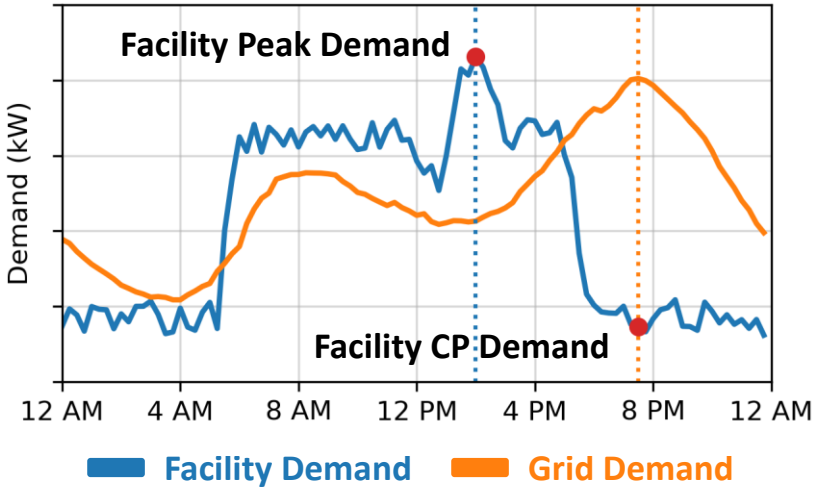
Ratchet Clauses

"80% of max demand from last 12 months"



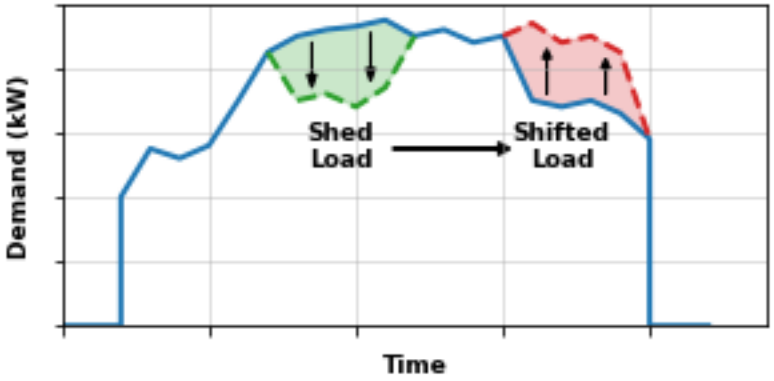
Coincident Peak (CP) Clauses

"Facility demand when grid hits its peak"



Managing Your Demand

- Lowering your demand costs means managing your facility's load profile
- Two main strategies:
  1) ***Load Shedding***: A temporary reduction in demand
  2) ***Load Shifting***: A transfer of load to off-peak hours



- Some utilities offer ***Demand Response*** incentives to shed or shift load during high grid stress events

Power Factor Penalties

- The way AC power interacts with your equipment affects how much power your utility must deliver
- This effect is captured by your ***Power Factor (PF)***
- Most utilities will penalize you for having a low PF
- PF is inherent to AC circuits, but it can be managed!

Voltage

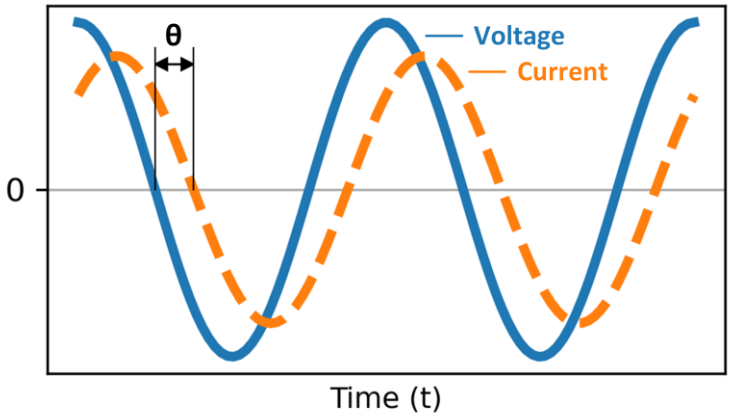
$$V(t) = V \cdot \cos(\omega t)$$

Frequency (60 Hz)

Current

$$I(t) = I \cdot \cos(\omega t - \theta)$$

Phase Difference

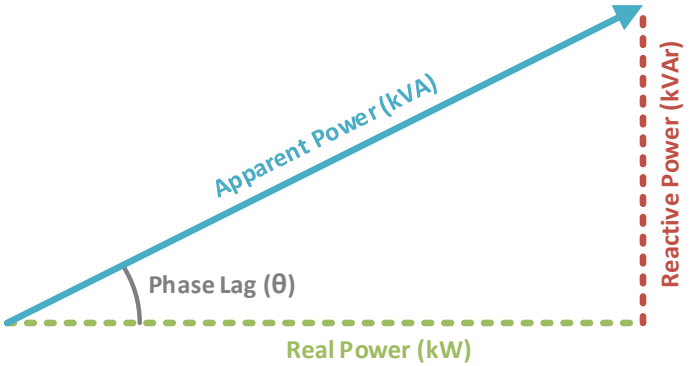


Power Factor Penalties

Power: $P(t) = V(t) \cdot I(t) = \ldots \text{Math!} \ldots =$

$$P(t) = \underbrace{P_{avg} \cdot (1 + \cos(2\omega t))}_{\text{Real Power (kW)}} + \underbrace{Q \cdot \sin(2\omega t)}_{\text{Reactive Power (kVAr)}}$$

- Both real and reactive power are required to run your facility
- Utility must deliver **Apparent Power** (S) which is related to PF



$$S = \sqrt{P_{avg}^2 + Q^2} \qquad \boldsymbol{S \geq P_{avg}}$$

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

The lower your PF, the more apparent power your utility must deliver!

Power Factor Penalties

- PF is usually listed on your bills
- PF penalties are rarely clearly listed on your bills
- Penalties depend on how you are billed for demand:

Billed for Real Power (kW)

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

PF Penalty $= C_d \times (AD - RD)$

Penalized only if PF ≤ PF_{req}

Billed on Apparent Power (kVA)

PF Penalty $= C_d \times (BD - RD)$

PF Penalty $= C_d \times BD \times (1 - PF)$

Penalized for any PF < 1

How Do You Fix Low PF?

- Nearly all facilities have low PF because of large motors used in their production process
- Windings act as large inductors causing current lag
- Install capacitor banks to offset inductive loads
- Two types of capacitors:
  1) Static ($)
  2) Dynamic ($$)
- Fix baseload phase difference with static capacitors
- Fix remaining difference with dynamic capacitors

Wikimedia Commons

How Much Does Low PF Cost?

- Consider a facility with an average $PF_{avg} = 0.85$
- Demand cost is $8/kW with not ratchet clause
- Utility requires a minimum $PF_{req} = 0.95$
- Average billed demand is $BD_{avg} = 850\ kW$

$$\text{Real Demand } (RD_{avg}) = BD_{avg} \times \frac{PF_{avg}}{PF_{req}} = 761\ kW$$

$$\text{PF Penalty} = C_d \times \left(BD_{avg} - RD_{avg}\right) \times 12 = \mathbf{\$8,544/yr}$$

Riders

- Several other charges can be listed on your bills
- ***Riders*** are modifications to your rate structure
- Some riders apply only certain months
- Usually very descriptive and for specific purposes


Transmission Cost Recovery Factor

Renewable Energy Development Fund 


Nuclear Decommissioning Charge

Energy Efficiency Cost Recovery Factor 


Fuel Cost Recovery Factor

Non-Energy Charges

- Some charges on your bills may not be related to consumption or demand
- Fixed charges are built into your rate structure but ensuring you have the right schedule can save costs
- Some charges can be avoided with a little planning

Customer Fees
Metering Fees
Etc.

Late Payment Fees
Insufficient Funds Fees
Etc.

Local Taxes
State Sales Tax
Etc.

→ Some states allow sales tax exemptions for manufacturers under certain conditions!

Rate Structures

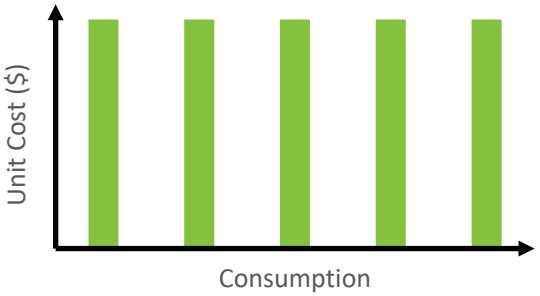
- ***Rate Schedules*** are collections of pricing structures offered by your utility
- Choosing the right rate structure is critical for minimizing energy costs

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

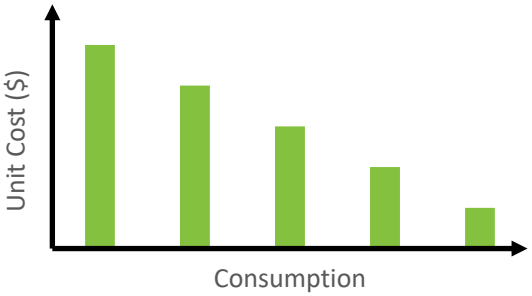
Rate Structures

There are several common pricing options:

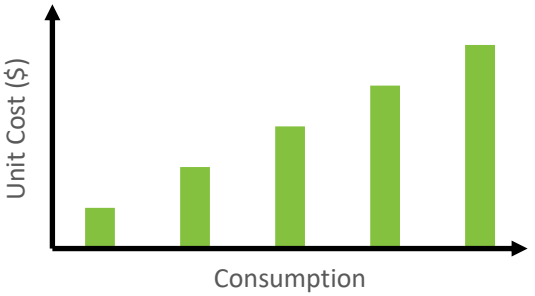
Uniform



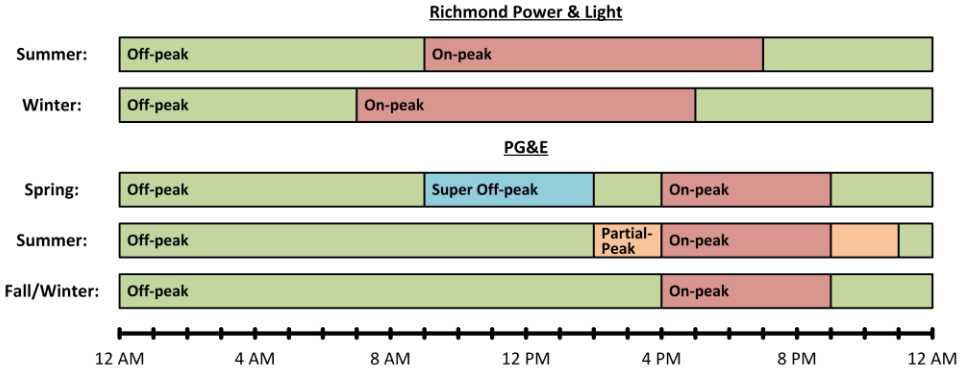
Decreasing Block Rate



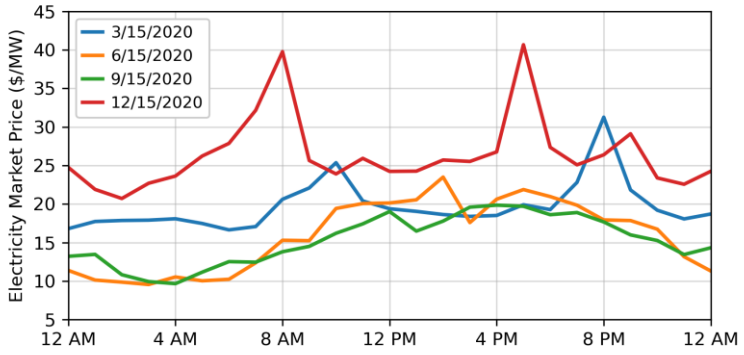
Increasing Block Rate



On-peak/Off-peak



Real-time Pricing



Your Cost of Electricity

Blended Cost:

- Quick and easy way to estimate costs
- Only estimates consumption savings

$$C_{blend} = \frac{Total\ Electricity\ Costs}{Total\ Energy\ Consumption}$$

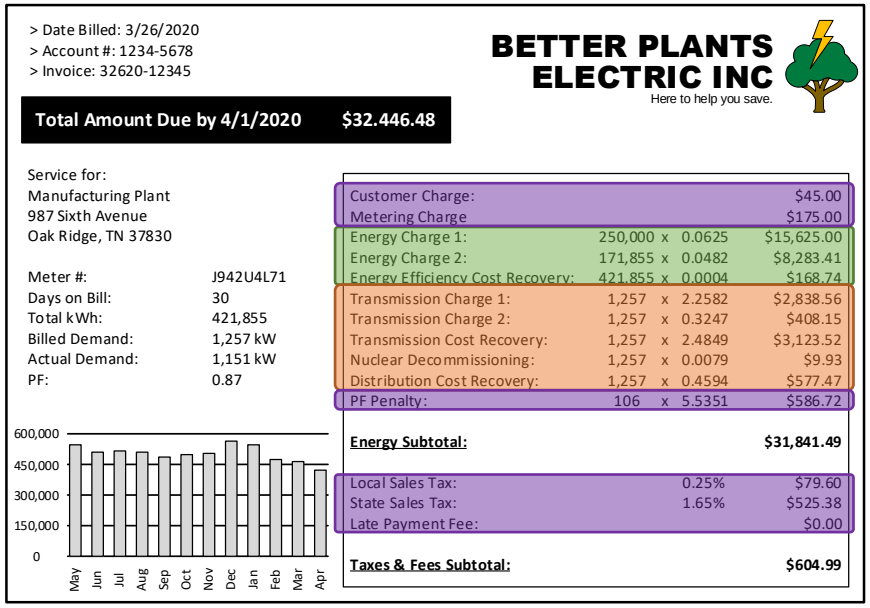
Marginal Cost:

- More detailed estimate of costs (consumption + demand)
- Requires knowing your rate structure

$$C_{mrg} = Energy\ Charge\ 1 + Energy\ Charge\ 2 + \cdots$$
$$D_{mrg} = Demand\ Charge\ 1 + Demand\ Charge\ 2 + \cdots$$

Your Cost of Electricity

Identify all the charges and how they are assessed...



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

Customer Charge:				$45.00
Metering Charge				$175.00
Energy Charge 1:	250,000	x	0.0625	$15,625.00
Energy Charge 2:	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:	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**
Local Sales Tax:			0.25%	$79.60
State Sales Tax:			1.65%	$525.38
Late Payment Fee:				$0.00
Taxes & Fees Subtotal:				**$604.99**

Consumption Charges (per kWh)

- Energy Charge 1: $0.0625
- Energy Charge 2: $0.0482
- EE Cost Recovery: $0.0004

Demand Charges (per kW)

- Transmission Charge 1: $2.2582
- Transmission Charge 2: $0.3247
- TRNS Cost Recovery: $2.4849
- Nuclear DECOM: $0.0079
- DISTRO Cost Recovery: $0.4594

Other Charges:

- PF Penalty
- Customer & Metering Fees
- State and Local Sales Taxes

Your Cost of Electricity

Blended Cost:

$$C_{blend} = \frac{Electricity\ Costs}{Energy\ Consumption} = \frac{\$32{,}466.48}{421{,}855\ kWh} = \frac{\$0.077}{kWh}$$

Marginal Costs:

- For 4 months, consumption never reaches the block 2 rate…

$$C_{mrg,yr} = \frac{4}{12} \times EC1 + \frac{8}{12} \times EC2 + EECRF$$

$$= 0.33 \times \frac{\$0.0625}{kWh} + 0.67 \times \frac{\$0.0482}{kWh} + \frac{\$0.0004}{kWh} = \frac{\$0.0530}{kWh}$$

$$D_{mrg} = TC1 + TC2 + TCRF + NDC + DCRF$$

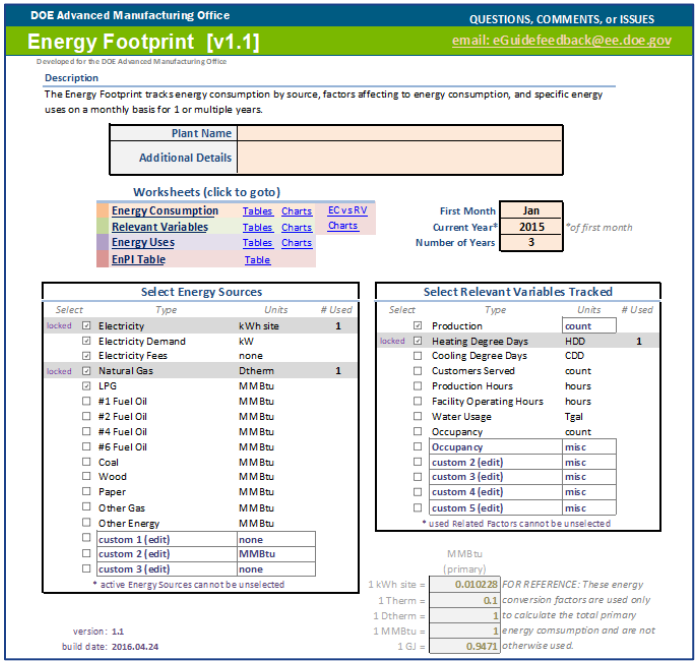
$$= \frac{\$2.2582}{kW} + \frac{\$0.3247}{kW} + \frac{\$2.4849}{kW} + \frac{\$0.0079}{kW} + \frac{\$0.4594}{kW} = \frac{\$5.5351}{kW}$$

Opportunities for Cost and Energy Savings

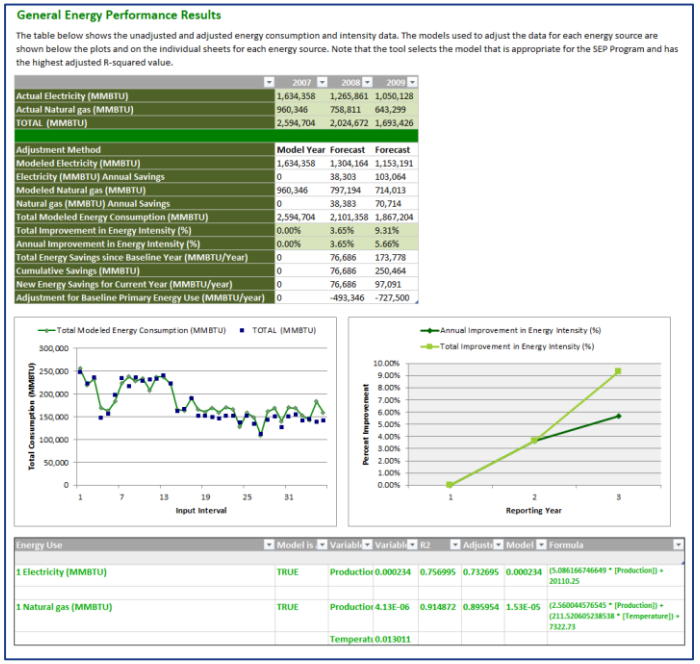
- Demand Management
- Power Factor Correction
- Recreating Your Bills
- State Sales Tax Exemptions
- Avoiding Late Fees
- Tracking Energy Consumption
- Production/Load Factor Analysis

Tracking Your Electricity Usage

- DOE offers software tools to track energy usage
- Identify trends, anomalies, and opportunities



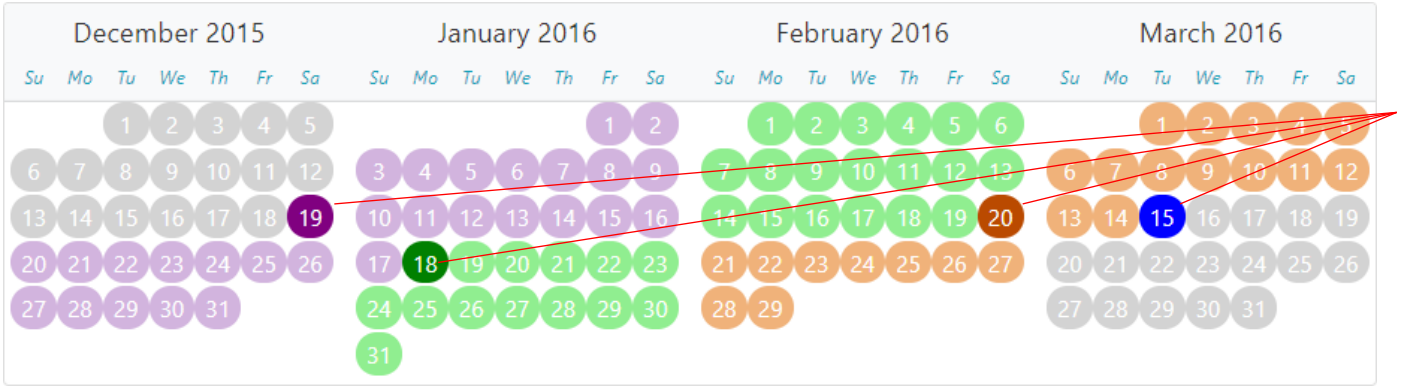
Energy Footprint Tool



Energy Performance Indicator Tool

Calendarization

- Billing periods depend on when the utility reads your electricity meters
- Normalizing electricity data for billing periods is known as ***Calendarization***
- Divide consumption by days on bill and allocate energy to calendar month



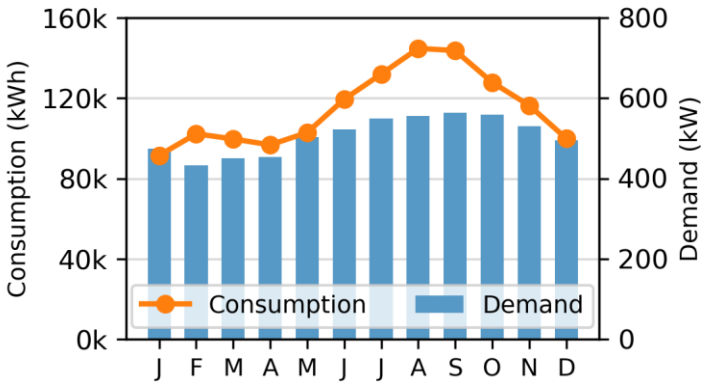
Load Factor Analysis

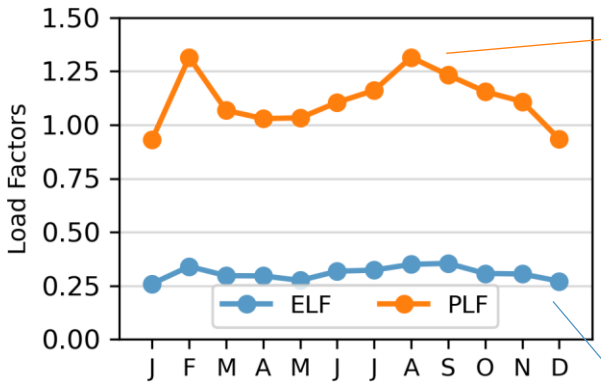
- ***Electrical Load Factor (ELF)***: Ratio of monthly kWh consumption and maximum possible consumption

$$ELF = \frac{Consumption}{Demand \times Billing\ Hours}$$

- ***Production Load Factor (PLF)***: Ratio of monthly kWh consumption and maximum production consumption

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





$PLF \gg 1$
Equipment is being left on

$ELF \approx 0.2$
One-Shift

Questions?

Future Webinars

Additional Questions:

- Pete.Langlois@ee.doe.gov
- Pricecr@ornl.gov
- Eli.Levine@ee.doe.gov

Reminder:

- Next webinar is Thursday, Oct. 14th from 1-2pm ET
- Understanding Your Electricity Bills
- Register at Yesevents.com/EnergyAwareness