Better Plants® U.S. DEPARTMENT OF ENERGY | Energy Bootcamp

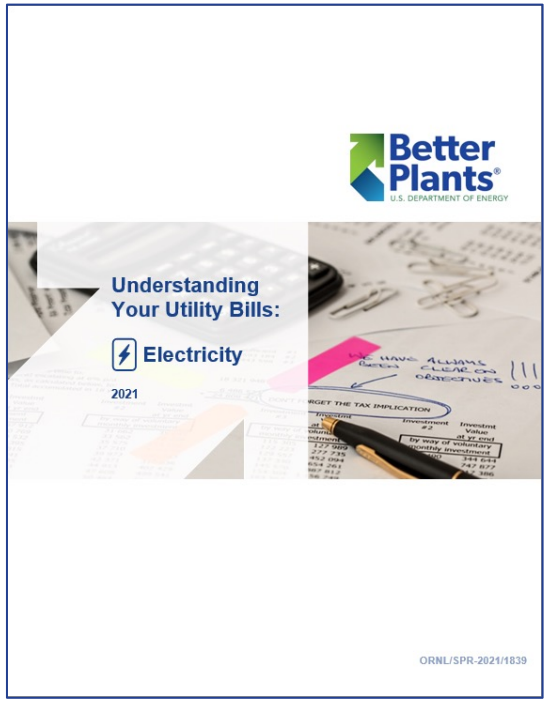
Energy/Carbon Basics and Understanding Your Utility Bills

Thomas Wenning, PE

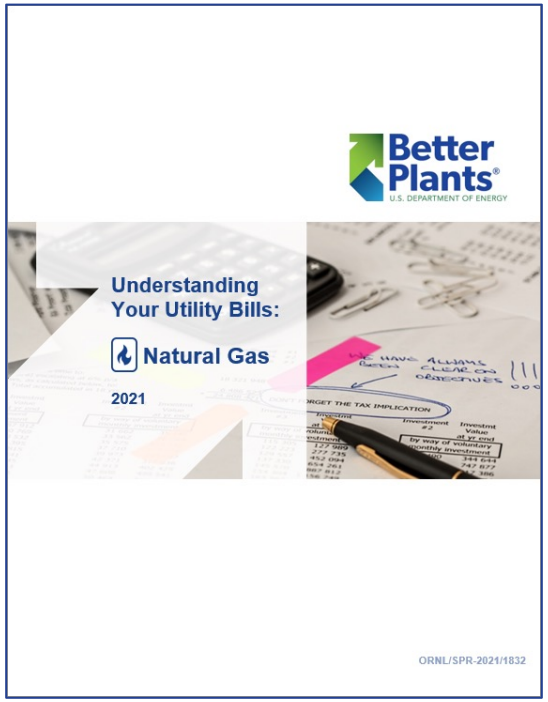
U.S. DEPARTMENT OF ENERGY

Understanding your Utility Bills

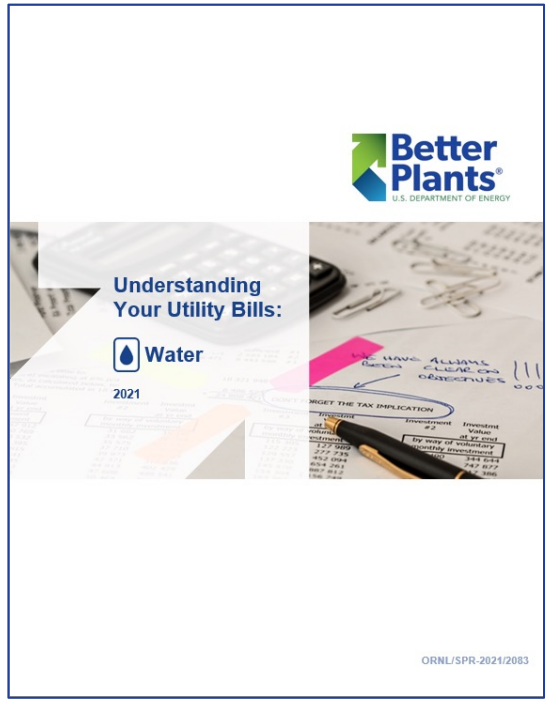
A series of guidance documents…



Electricity Bills



Natural Gas Bills



Water Bills

Electricity Billing

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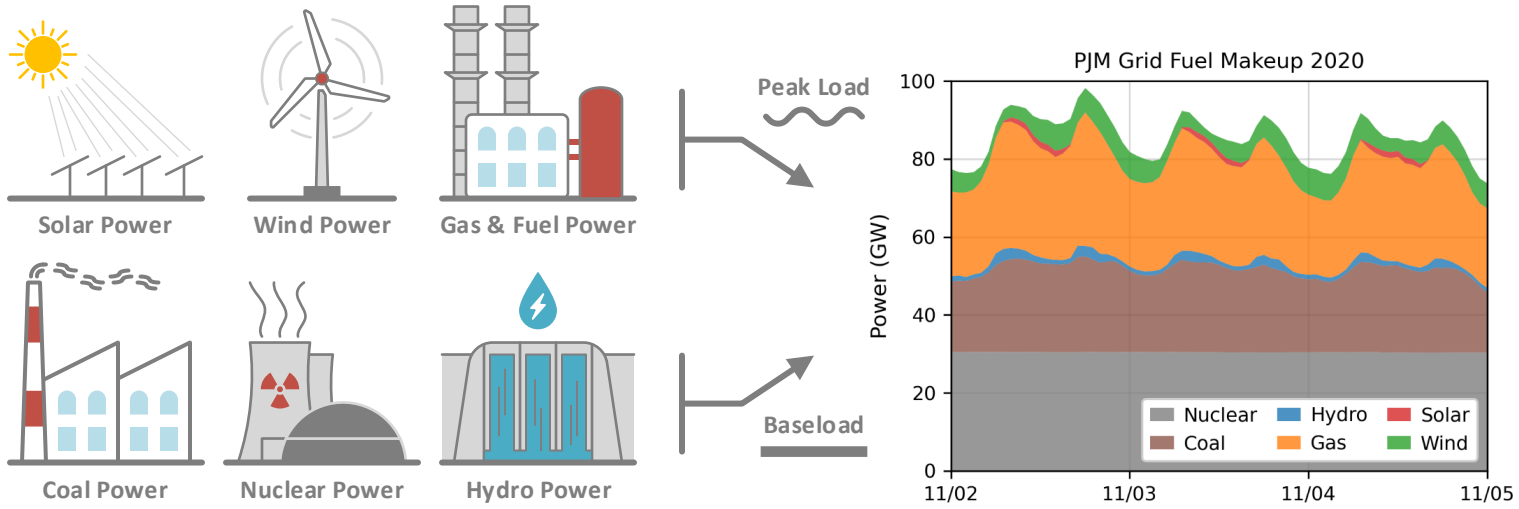
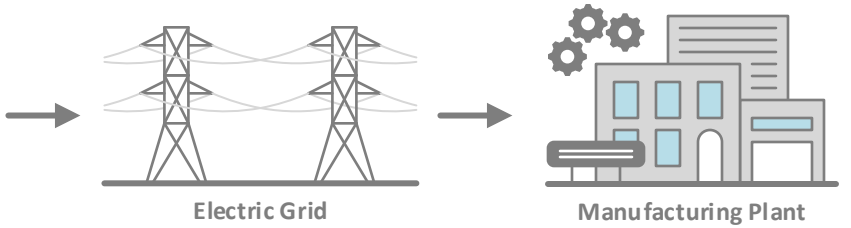
How is Electricity Generated?

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



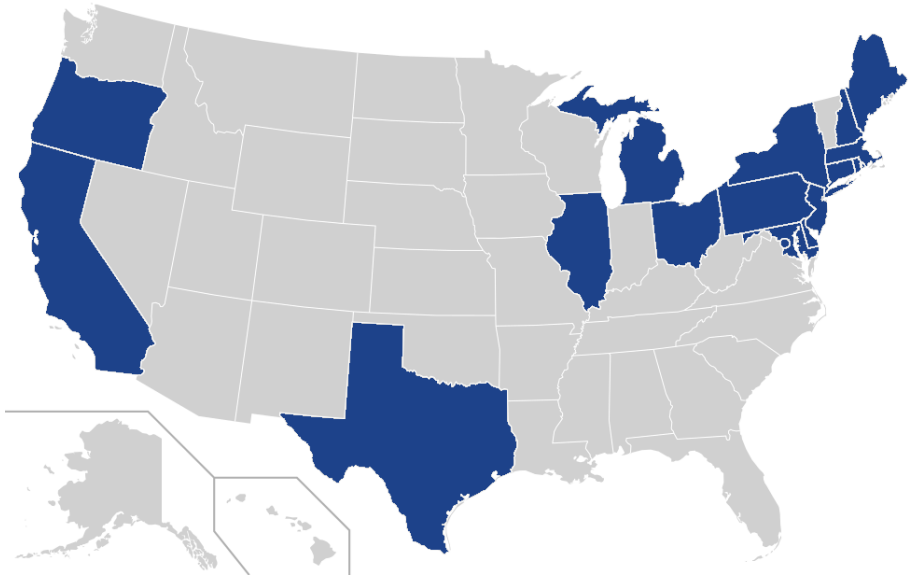
Generation



Distribution **Consumption**

How is Power Distributed?

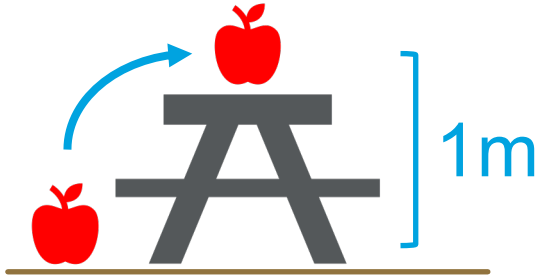
- ***Regulated Power Markets***: Utilities own and maintain all the equipment from generator to your meter
- ***Deregulated Power Market***: Generators and distributors are separate entities
- Deregulation is meant to:
  - Lower energy costs through competition
  - Promote green energy
- Currently 15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



Energy vs. Power

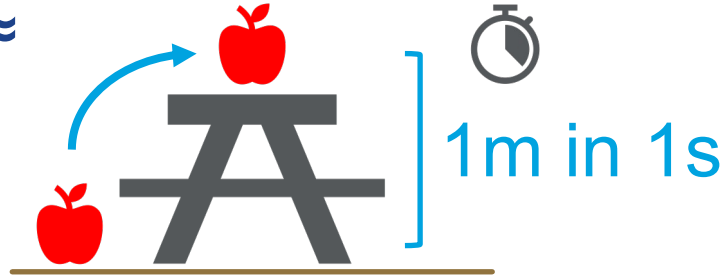
Energy (Consumption)

- Measures the amount of work done on an object
- Often defined as the product of force and distance
- Measured in joules (J)
- 1 MJ = 0.278 kWh
- 1 J ≈



Power (Demand)

- Amount of work done on an object per unit of time
- Defined as the time derivative of work (energy)
- Measured in watts (W)
- 1 kW = 1 kJ/s
- 1 W ≈



Key Components to Your Electricity Bills

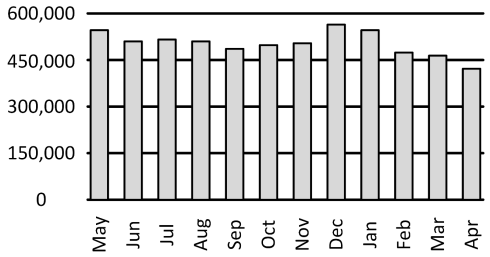
> Date Billed: 3/26/2020
> Account #: 1234-5678
> Invoice: 32620-12345

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 #:	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
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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**

1 Meter Number

2 Meter Readings

3 Power Factor

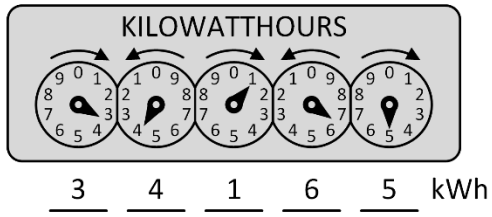
4 Fixed Charges

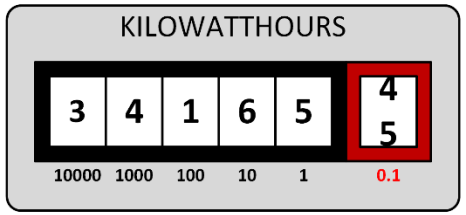
5 Consumption Charges

6 Demand Charges

7 Taxes, Fees, & Penalties

Consumption Charges



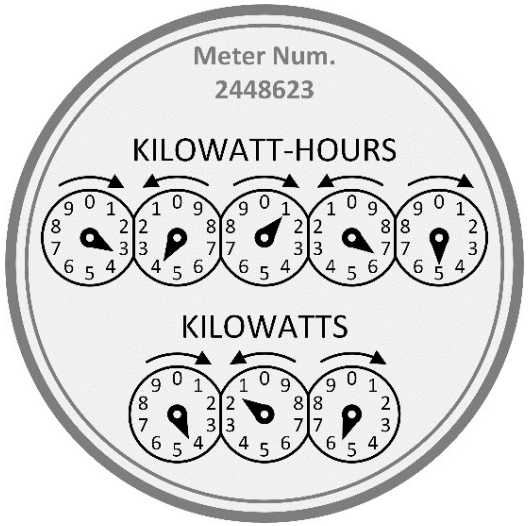


- Electricity Consumption or usage is the total amount of electricity (energy) your facility uses to make products
- Measured in kilowatt-hours (kWh) which is equal to 1 kilowatt of power sustained for 1 hour
- Billed at a rate ($/kWh) determined by your contract
- Can appear on your bills as energy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

Demand Charges

- Most industrial facilities are also charged for their ***Electrical Demand***
- Demand measures the rate of electricity consumption over a specified time window:

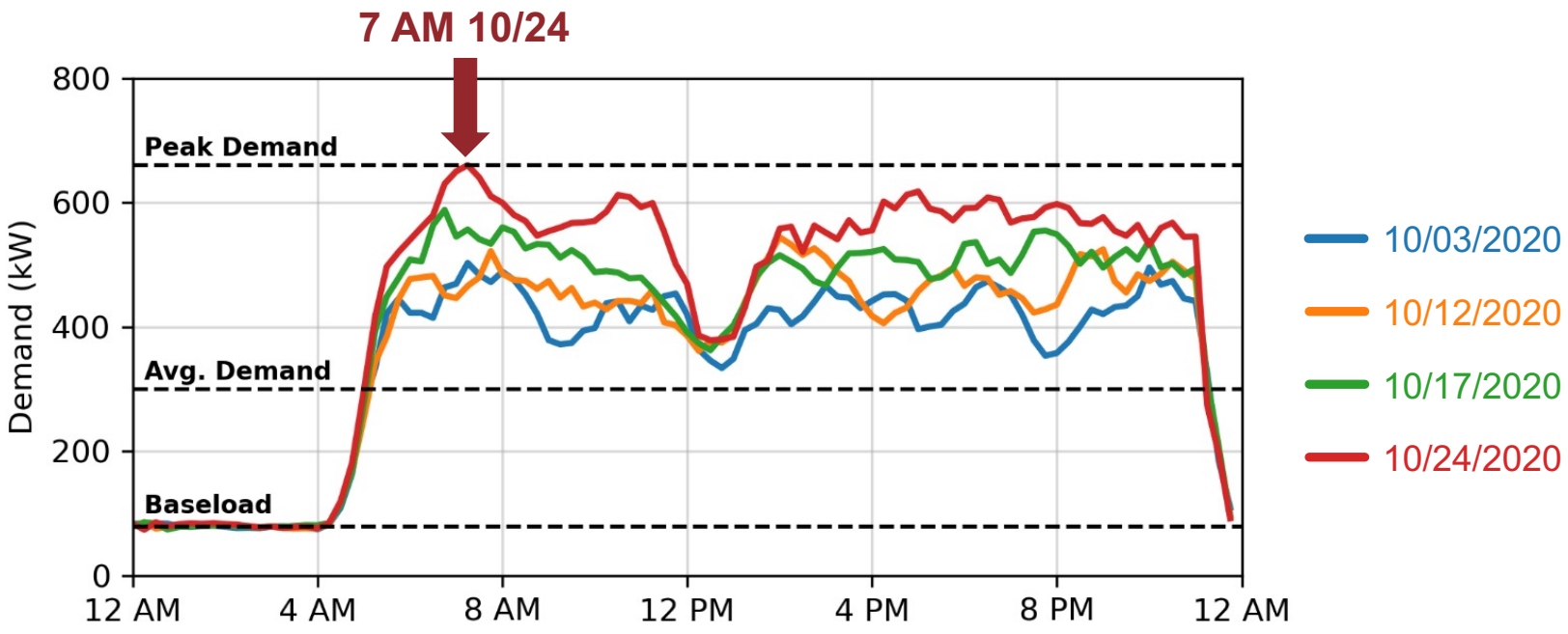
$$\frac{25\ \text{kWh}}{15\ \text{minutes}} \times \frac{60\ \text{minutes}}{1\ \text{hour}} = 100\ \text{kW}$$



- Higher demand means more grid infrastructure your utility must build and maintain to deliver energy when you need it
- Can appear on your bills as demand charge, demand cost, transmissions and delivery (T&D) charge, etc.

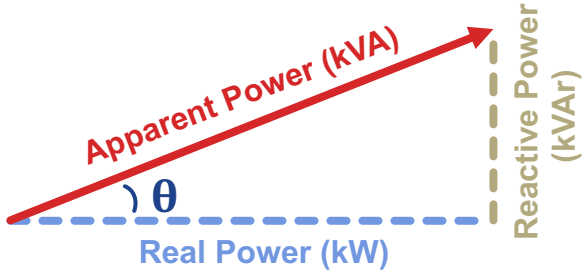
Types of Demand

- Instantaneous demand will vary over time
- You are billed based on the monthly ***Peak Demand***
- One demand spike can set your charges for ***months (Rachet)!***



Power Factor Penalties

- **Power Factor (PF)** is inherent to systems supplied with AC power
- **PF** is a number between 0.0 and 1.0
- Instantaneous power has two parts:
  - **Real Power (kW) – Does work!**
  - **Reactive Power (kVAr) – Does no work!**
- Utilities penalize facilities with low **PF**
  - Must deliver extra **Apparent Power (S)**



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

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

Example: 100 kW of Real Power

➢ Watch Apparent Power as PF decreases…

PF = 1.00

Riders & Non-Energy Charges

- Several other charges can be listed on your bills
- ***Riders*** are modifications to your rate structure for specific purposes and usually have descriptive names
- **Fixed charges** are built-in into the rate structures

Example Riders

Transmission Cost Recovery Factor

Renewable Energy Development Fund

Nuclear Decommissioning Charge

Energy Efficiency Cost Recovery Factor

Fuel Cost Recovery Factor

Fixed Charges

Late Payment Fees
Insufficient Funds Fees
Etc.

Customer Fees
Metering Fees
Etc.

Local Taxes
State Sales Tax
Etc.

Some states allow sales tax exemptions for manufacturers!

Rate Structures

- ***Rate Schedules*** are a collection of pricing structures that your utility offers
- A ***Rate Structure*** is a specific pricing system that your bills are based on
- Choosing the right rate structure is critical for minimizing energy costs

Example:

- Building converted from production to office space
- Demand = 1,200 kW
- Consumption = 480,000 kWh

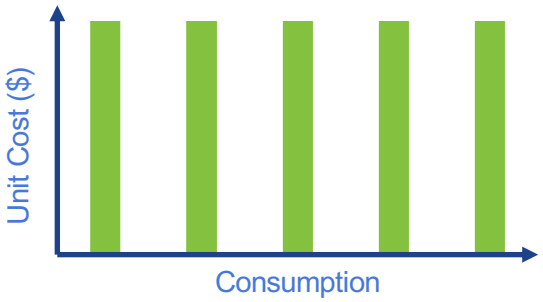
Monthly Charges	Large General (LGS)	General (GS)
Customer	$125.73	$39.20
Demand (per kW)	$14.18	$7.40
Energy (per kWh)	$0.0052	$0.02210
Minimum Demand	**4,000 kW**	**500 kW**
Total	**$59,342**	**$19,527**

~$40,000 in extra cost!

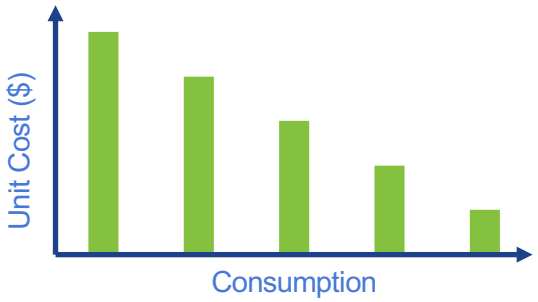
Block Rate Structures

- Cost of energy changes based on how much energy you use
- Common block structures:

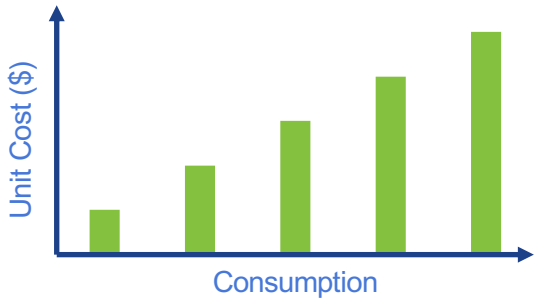
Uniform Rate



Decreasing Block Rate



Increasing Block Rate



- Example:

First 2,000 kWh	$0.15/kWh
Next 8,000 kWh	$0.12/kWh
Next 90,000 kWh	$0.10/kWh
All Additional kWh	$0.075/kWh

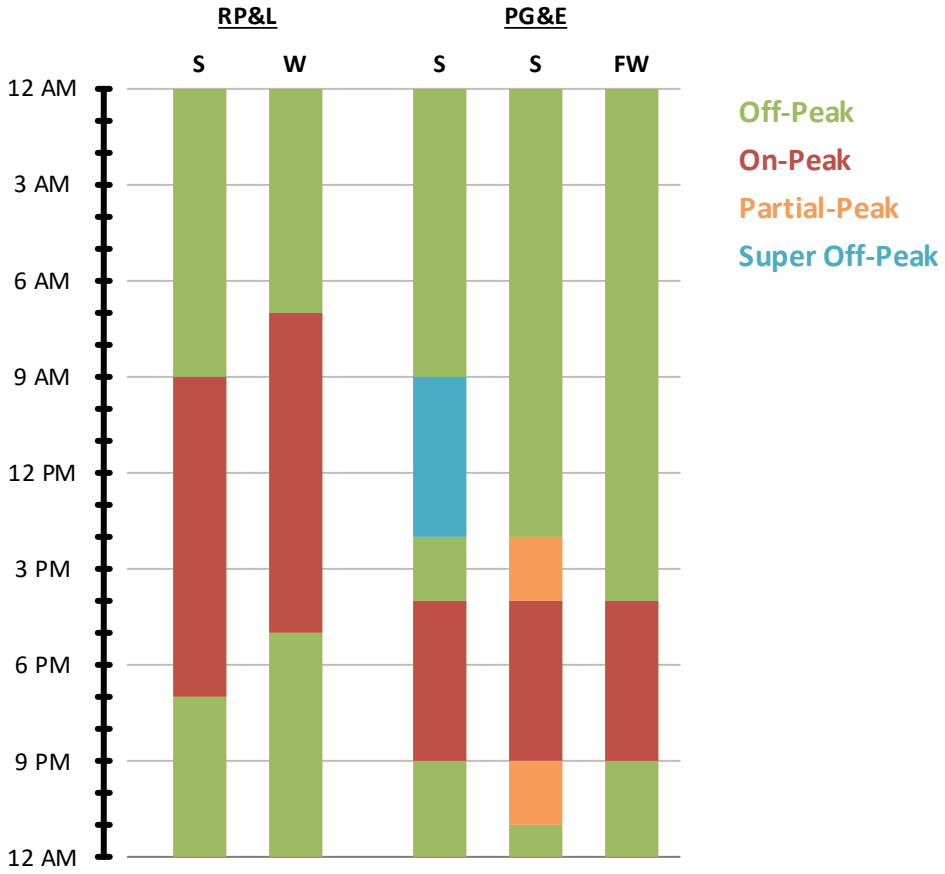
230,440 kWh of consumption is:

2,000 kWh x $0.15/kWh = $300
8,000 kWh x $0.12/kWh = $960
90,000 kWh x $0.10/kWh = $9,000
130,440 kWh x $0.075/kWh = $9,783

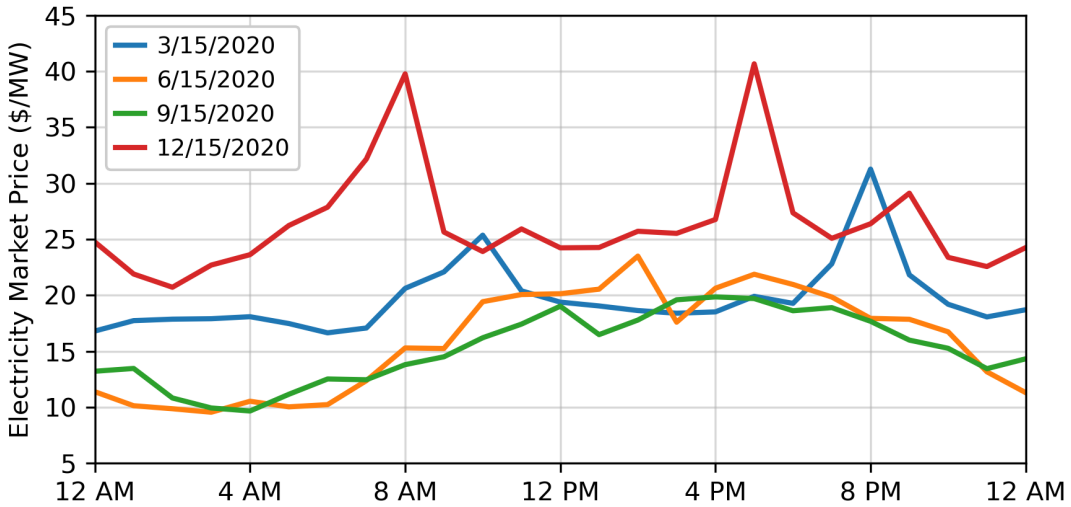
$20,043

Variable Rate Structures

- On-Peak/Off-Peak



- Real-time Pricing



Managing your energy is key to saving on costs!

Calculating 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

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

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

Calculating Your Cost of Electricity

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

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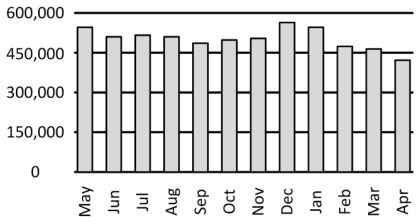

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Local Sales Tax:			0.25%	$79.60
State Sales Tax:			1.65%	$525.38
Late Payment Fee:				$0.00
Taxes & Fees Subtotal:				**$604.99**

Blended Cost:

$$C_{blend} = \frac{\$32,466.48}{421,855\ kWh} = \frac{\$0.077}{kWh}$$

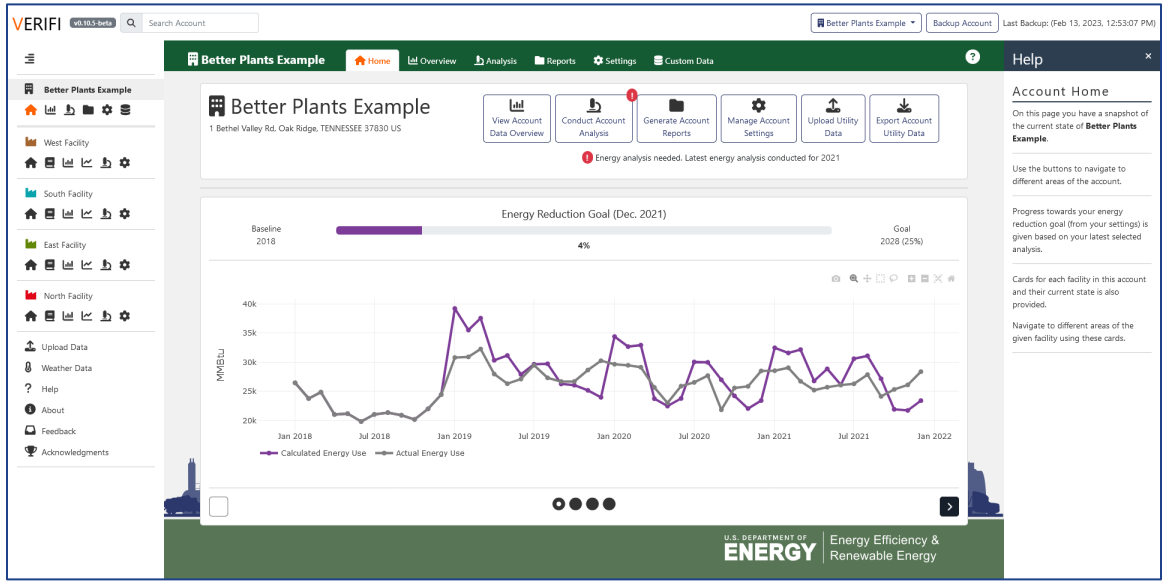
Marginal Costs:

$$C_{mrg} = EC2 + EECRF = \frac{\$0.0486}{kWh}$$

$$D_{mrg} = TC1 + TC2 + TCRF + NDC + DCR = \frac{\$5.5351}{kW}$$

Opportunities for Electric 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



New VERIFI Tool can help track your utility usage!
Beta Testing Version now available to try!
https://verifi.ornl.gov

Natural Gas Billing

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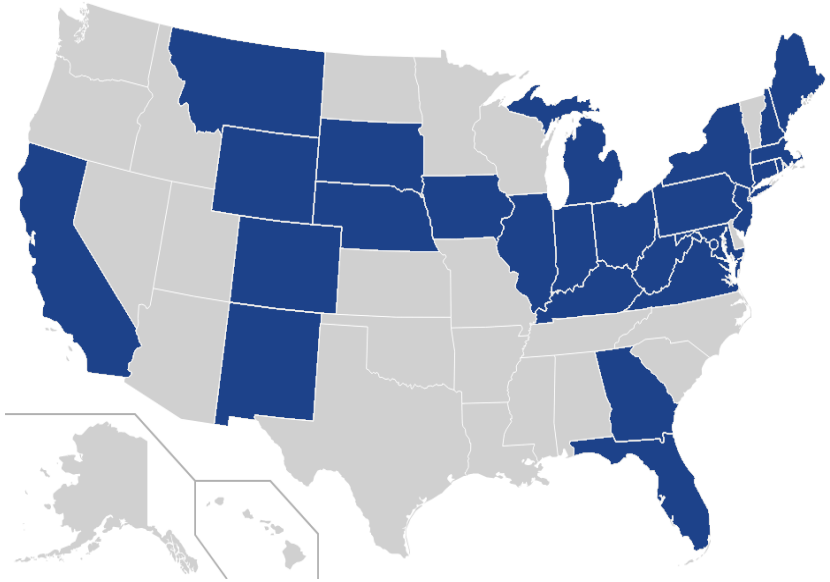
Natural Gas Deregulated Market

- ***Regulated Gas Markets***: Utilities charge you for all the steps from purchasing to distributing the gas
- ***Deregulated Gas Market***: Prices are no longer regulated which separates gas-purchasing transactions from the gas-delivery transaction
- Deregulation is meant to:
  - Equalize supply and demand
  - Lower energy costs through competition
- 1978 NG Policy Act and 1992 Federal Energy Regulatory Commission led to the deregulation of NG markets



Source: electricchoice.com

Key Components to your NG Bills

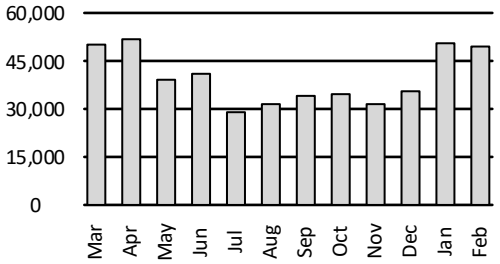
Account #: X123LG456-789
Invoice #: 98-75-54321
Invoice Date: 03/06/2021
Service Dates: 02/06/2021 to 03/04/2021

BETTER PLANTS NATURAL GAS INC
Here to help you save.

Total Amount Due by 03/20/2021	**$181,088.28**
Amount Due after 03/20/2021:	**$183,806.60**

Service for:
Oak Ridge National Laboratory
1 Bethyl Valley Road
Oak Ridge, TN 37830

Meter #:	800181754
Days on Bill:	26
Estimated Usage:	49,532 MCF
Max Daily Demand:	750 MCF
Energy Factor:	1.113
Rate Schedule:	LGS-I



Previous Balance:				$177,294.35
Payment (02/19/2020):				$177,294.35
Balance Forward:				$0.00
LGS Meter Charge:				$750.00
LGS Transport:	49,532	x	0.2312	$11,451.80
Maximum Daily Demand (MDQ):	750	x	8.683	$6,512.25
Block 1:	5,000	x	3.351	$16,755.00
Block 2:	15,000	x	3.195	$47,925.00
Block 3:	29,532	x	2.897	$85,554.20
Environmental Cost Recovery:	49,532	x	0.0710	$3,516.77
Usage Subtotal:				$172,465.02
Taxes:			5.00%	$8,623.25
Late Payment Fee:				$0.00
Taxes & Fees Subtotal:				$8,623.25

1 Meter Number

2 Meter Readings

3 Rate Structure

4 Customer Charge

5 Transport Charge

6 MDQ

7 Usage Charges

8 Taxes, Fees, Etc.

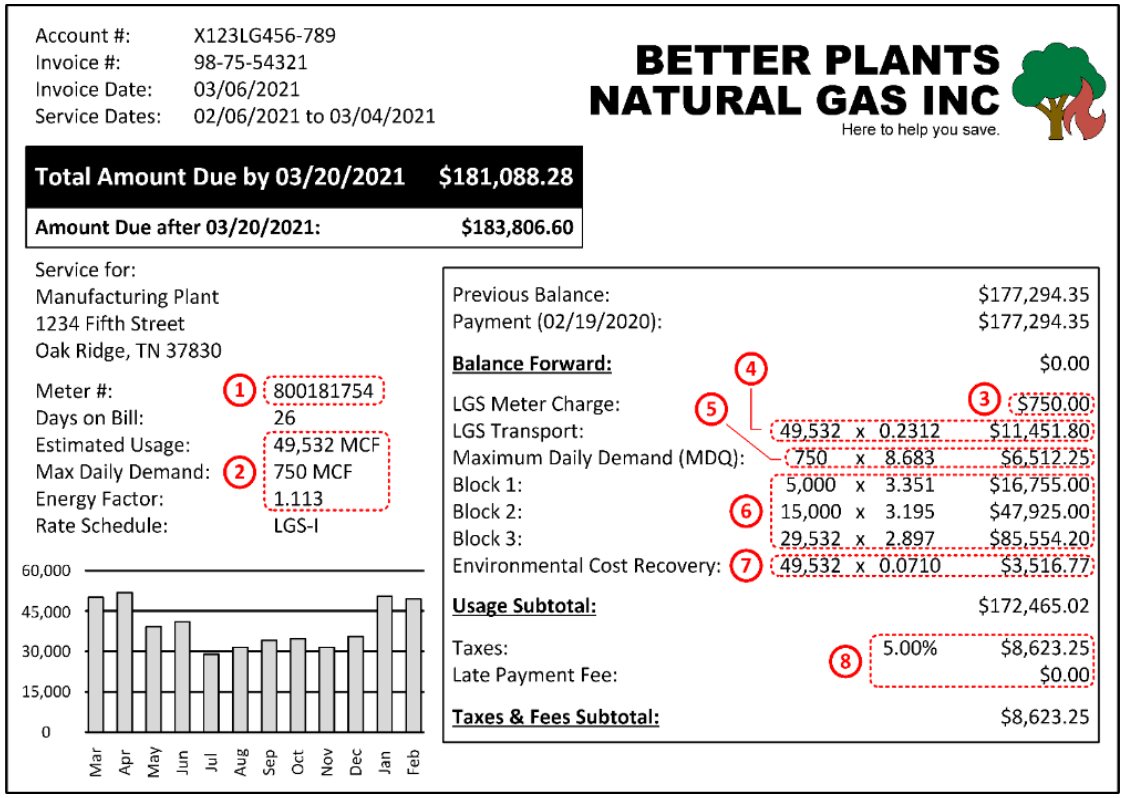
Natural Gas Charges

Customer/Meter Charge ① ③

- Fixed charge - Fees charged for customer service, accounting and meter

Consumption Charge ② ⑥

- Amount of gas you use in your facility for production or comfort cooling
- Billed at a rate ($/Mcf) determined by your contract (fixed or real-time market prices)



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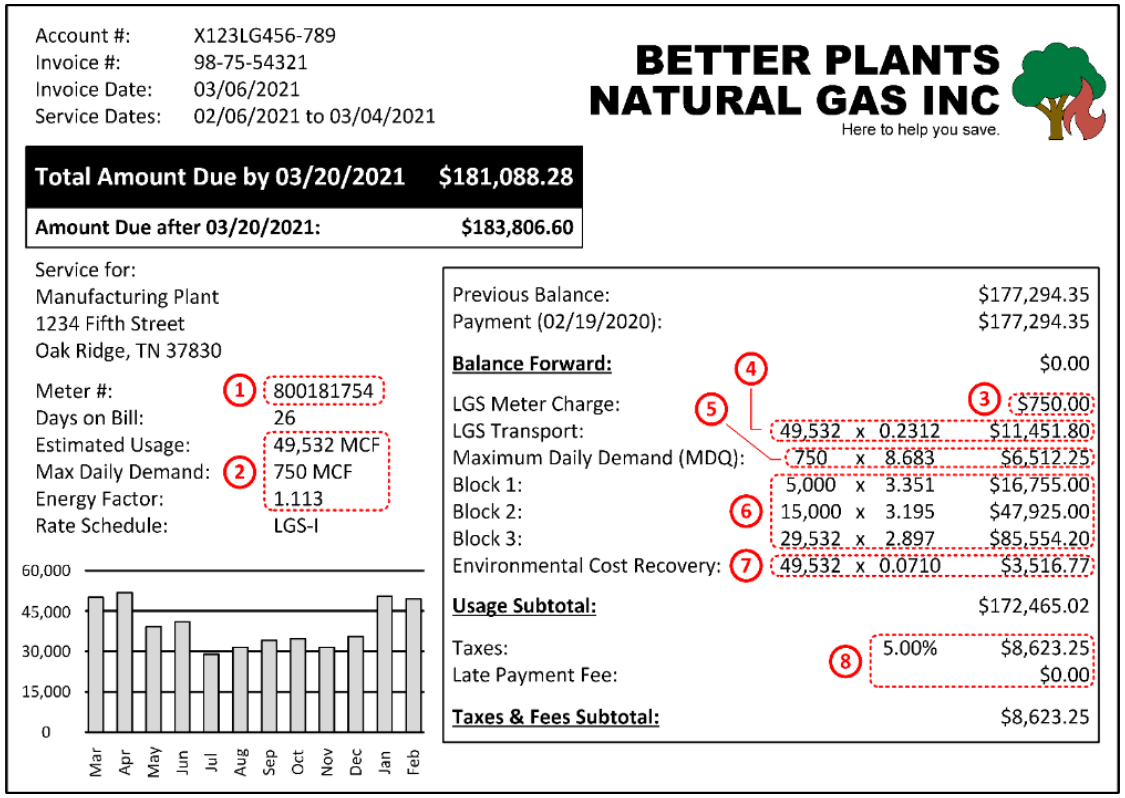
Natural Gas Charges

Maximum Daily Quantity (MDQ) 2 5

- Maximum quantity that a buyer has the right to take during a given day
- More demand means more grid infrastructure your utility needs to invest on

Transportation & Distribution Charges 4

- Volume of gas delivered to your facility by pipeline companies or utilities
- Gas purchased from marketers have the cost included in their bill



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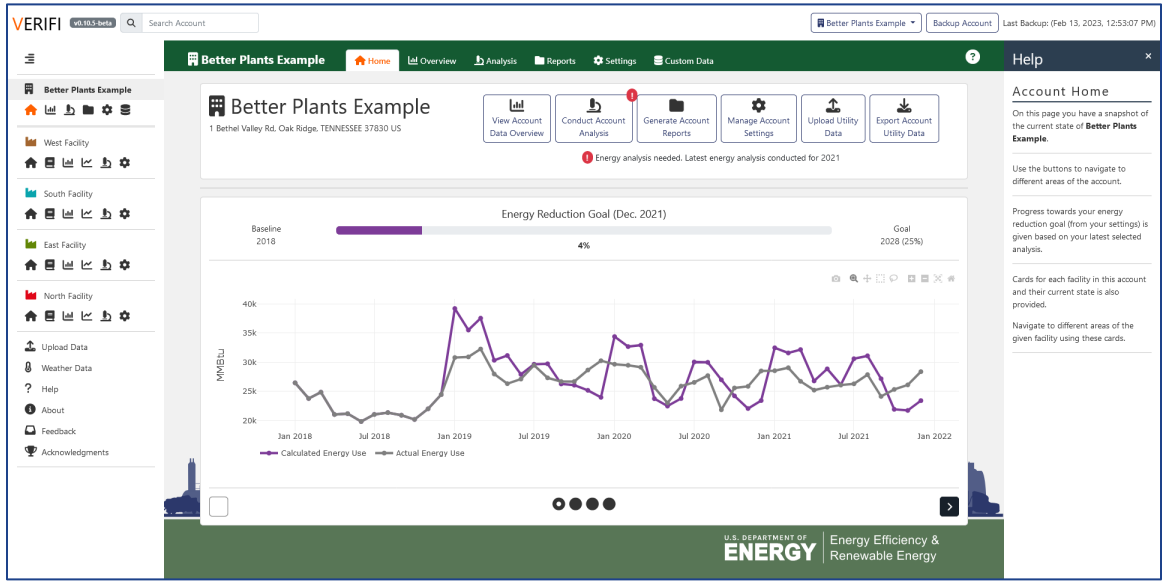
Opportunities for Natural Gas Cost Savings

- Purchasing contract negotiation
- Optimum rate structure selection
- Billing and accounting errors
- Tax Exemptions
- Avoiding Late Fees
- Tracking Energy Consumption
- Consolidating meters where feasible
- Credit assurance refunds
- Demand response program enrollment



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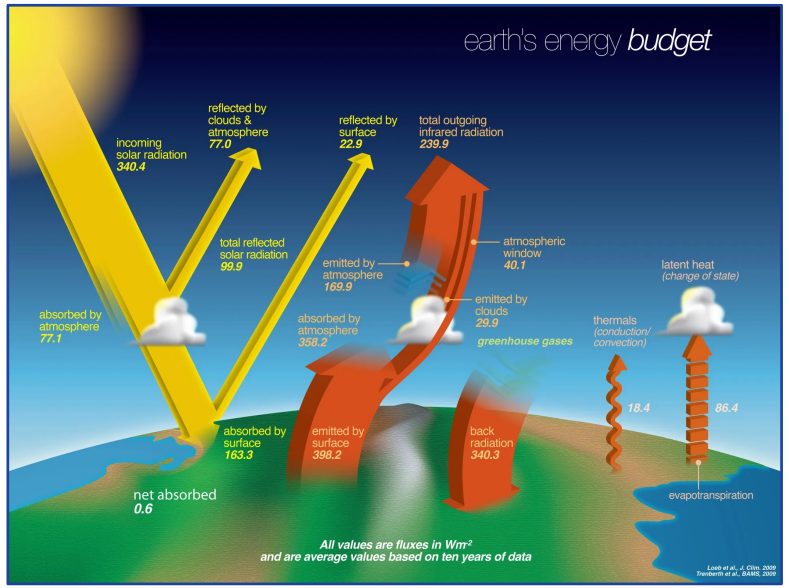
Decarbonization

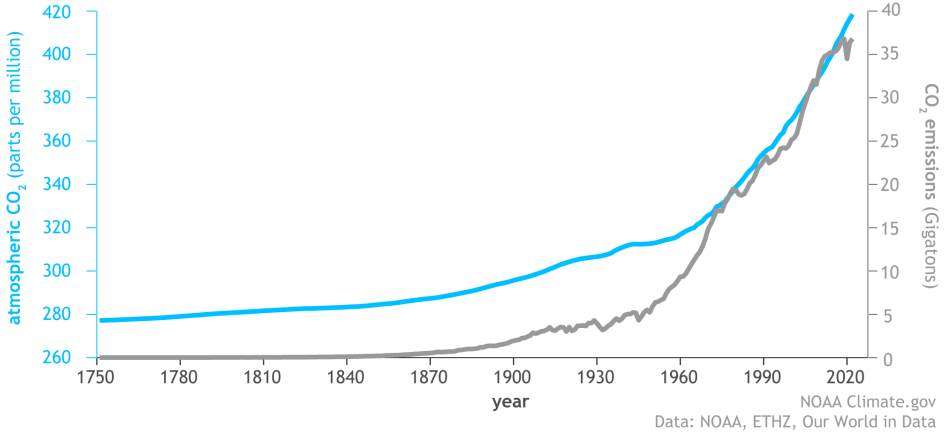
U.S. DEPARTMENT OF ENERGY

What are Green House Gases?

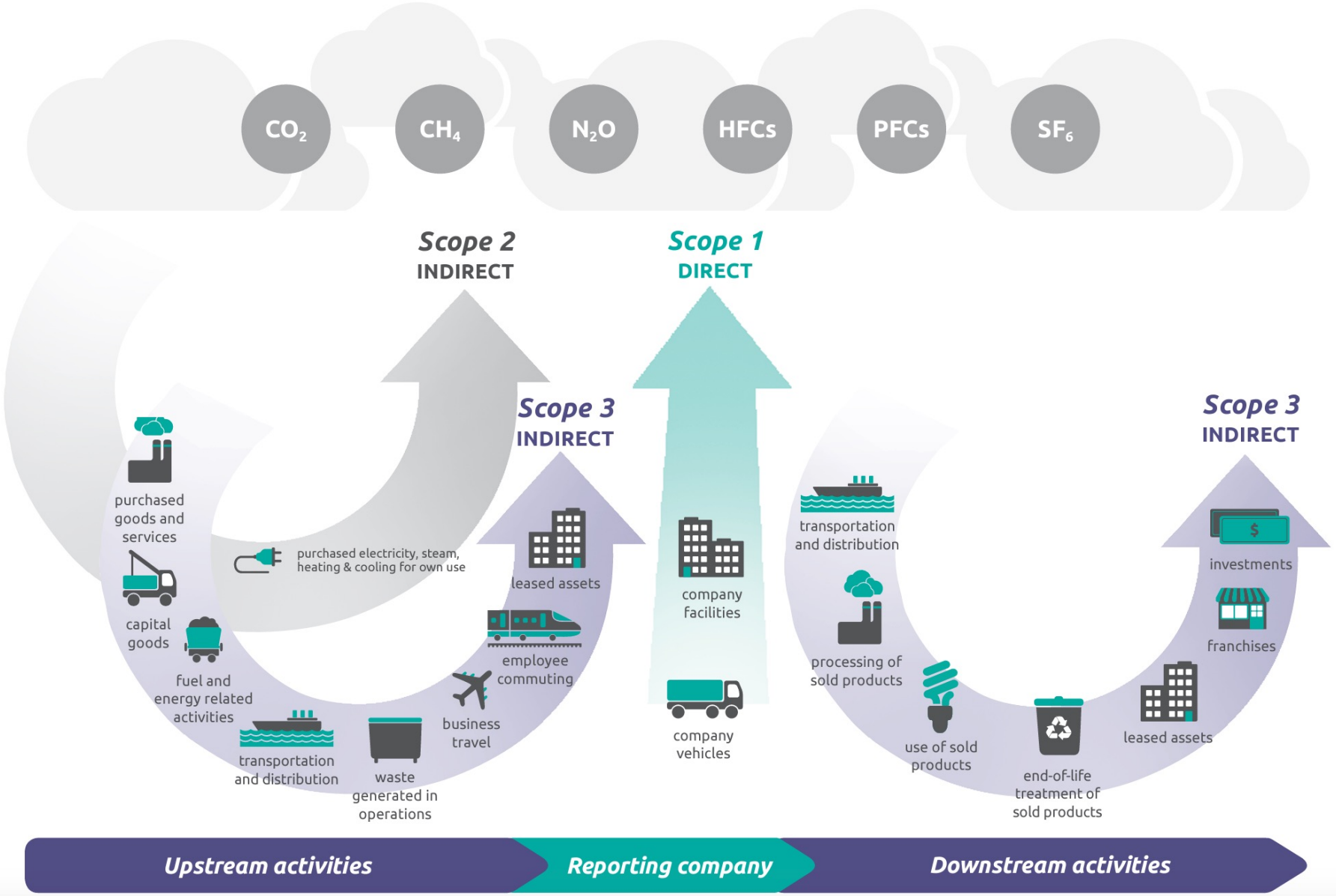
- Greenhouse gases (GHGs) trap heat from the Sun through the greenhouse effect
- Helps keep Earth's temperature suitable for human life
- Without the greenhouse effect, Earth would be on average 30°C (54°F) colder
- Concentrations of GHGs have risen dramatically over the past century due to human activity
- Has led to global climate change



Global atmospheric carbon dioxide compared to annual emissions (1751-2022)

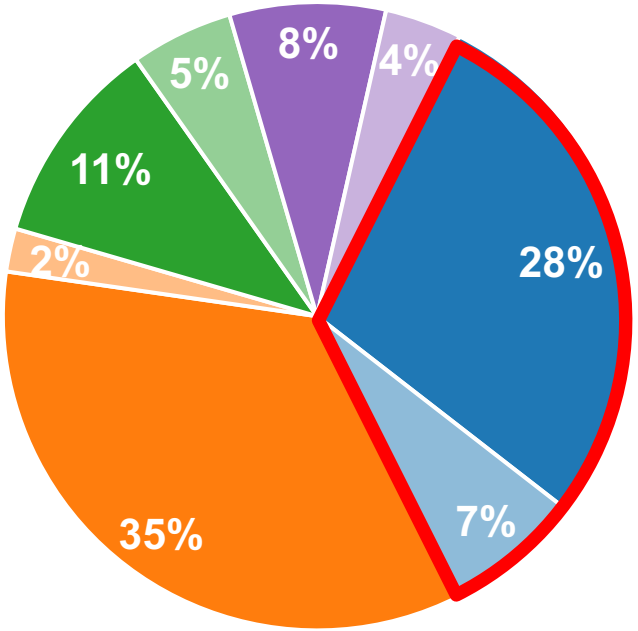


Scope of Emissions



Large U.S. Energy Demand and GHG Emissions

Primary Energy Consumption



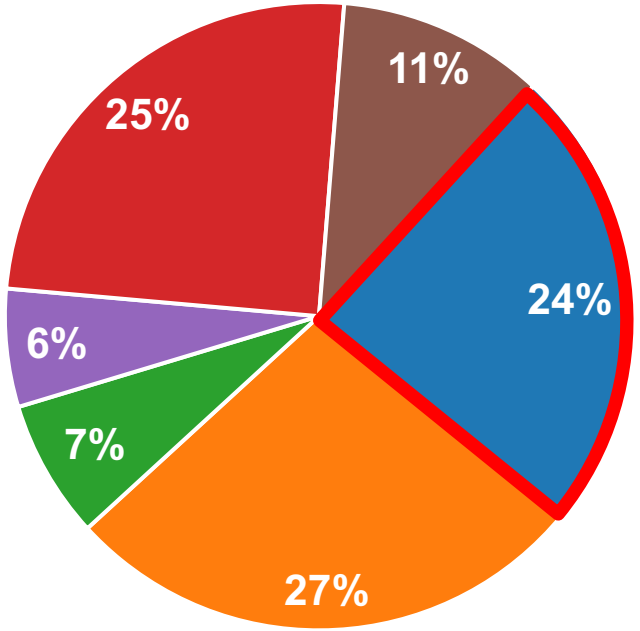
Sector

- Industrial
- Transportation
- Commercial
- Residential
- Electric Power
- Agriculture

Energy Source

- Fossil Fuels
- Other

CO2e Emissions

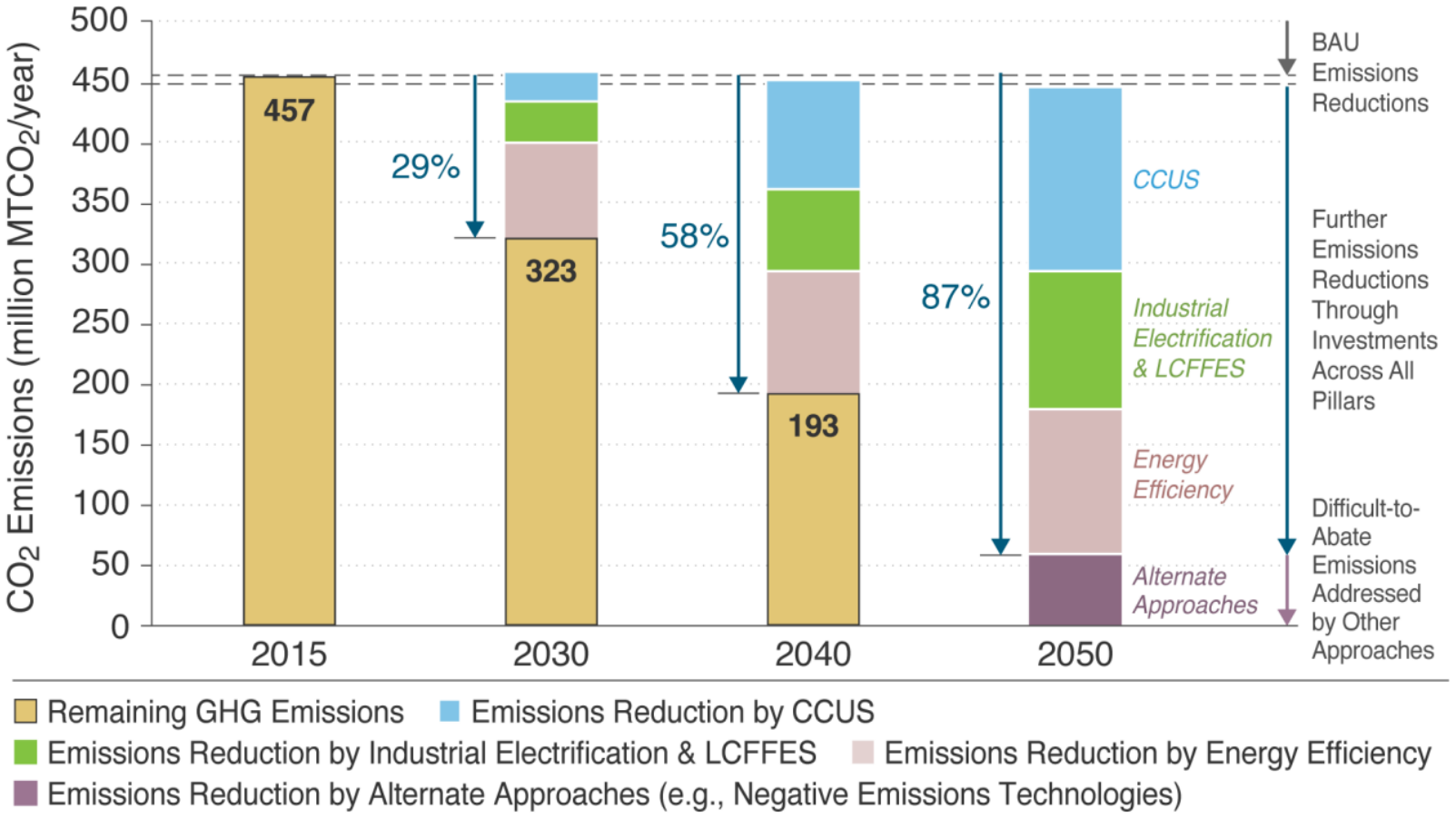


- The industrial sector makes up more than 35% of U.S. primary energy demand
- More than 80% of industrial energy consumption is derived from fossil fuels

- The industrial sector makes up more than 24% of U.S. CO2 equivalent emissions
- Emissions from direct combustion, industrial processes, electricity usage, etc.

Data from "Monthly Energy Review – U.S. Energy Consumption by Source and Sector", U.S. Energy Information Agency, 2022.

Projections for CO_2 Emissions Reductions

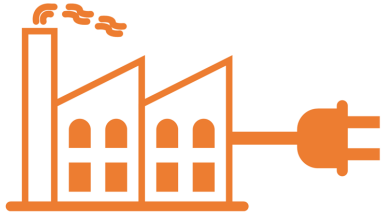


U.S. DOE Industrial Decarb Roadmap highlights **energy efficiency as a foundational strategy** for both near term and long term carbon reduction

The Industrial Decarbonization Pillars

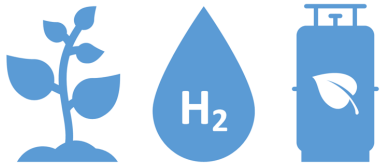
Energy Efficiency (near-term)

- Energy Management
- Adoption of Smart Manufacturing
- Improved Material and Process Efficiency
- Utilization of Combined Heat and Power



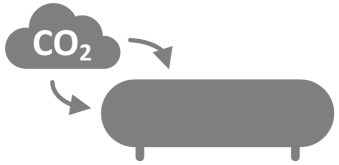
Industrial Electrification (mid- to long-term)

- Electrification of Process Heating
- Electrification of Space Heating
- Electrification of Hydrogen Production
- Development of Electrified Processes



Low-Carbon Fuels, Feedstocks, and Energy (mid- to long-term)

- Development of Carbon-Free Alternative Fuels
- Adoption of Low-Carbon Alternative Fuels
- Utilization of Low-Carbon Feedstock Materials
- Development of Biofuel Infrastructure



Carbon Capture, Utilization, and Storage (long-term)

- Direct Air Carbon Capture
- Carbon Capture, Utilization, and Storage
- CO_2 Distribution Infrastructure
- Chemical Utilization

Source: Industrial Decarbonization Roadmap; DOE/EE-2635; United States Department of Energy: Washington, DC, USA, 2022.

Steps to develop a GHG Inventory

Evaluate Corporate Boundary

- Setting Corporate Boundary to include all Scope of Emissions
- List facility/buildings that are owned or leased

Identify Scope of Emissions

- Identify fuel and process source of emissions
- Categorize the source of emissions by Scope

Collect Data & Quantify Emissions

- Collect purchased fuel or utility quantity data
- Collect leak
- Collect emissions rate
- Quantify emissions

Roll to corporate Level

- Roll emissions data to corporate level

Develop Inventory Management Plan

- Develop data quality check
- Keep track of change in corporate boundary
- Keep track of fuel or energy purchase contracts

Perform Energy Assessment

- Develop a **scope** for the assessment
  - Assessment goals and boundaries
- Determine who will be performing the assessment
  - Internal staff, Industrial Assessment Centers (IACs)
- Necessary data collectors (Diagnostic Equipment)
- **Outcomes** of the assessment
  - List of potential **energy savings opportunities**
  - **Baselining** and **Benchmarking**
  - Identifying **Significant Energy Users** (SEUs)
- Implement identified opportunities

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Industrial Assessment Center
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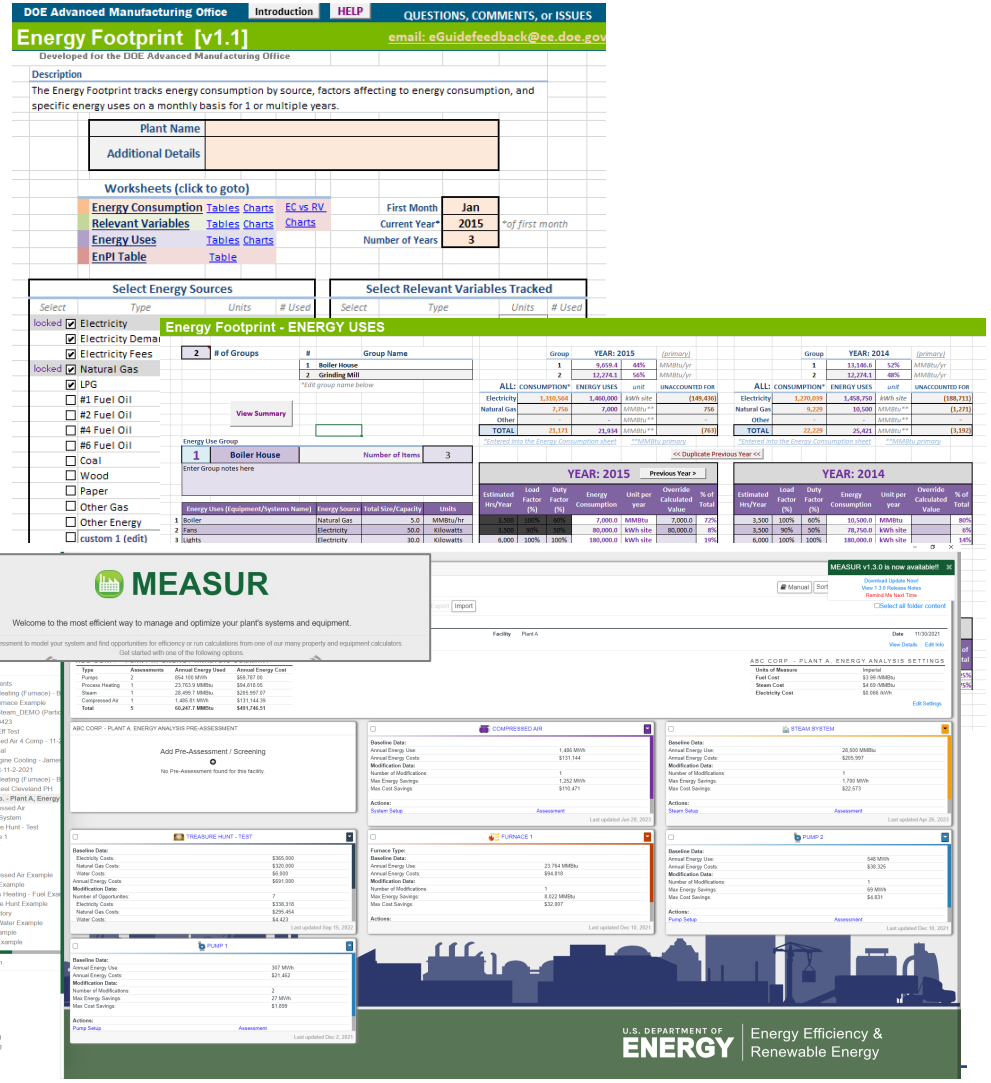
IAC Industrial Assessment Protocol

STEP 1: Pre-Assessment Information Gathering
STEP 2: Ensure that key plant personnel are involved
STEP 3: Pre-Assessment Analysis
STEP 4: Day of the Assessment
STEP 5: Post Assessment Activities

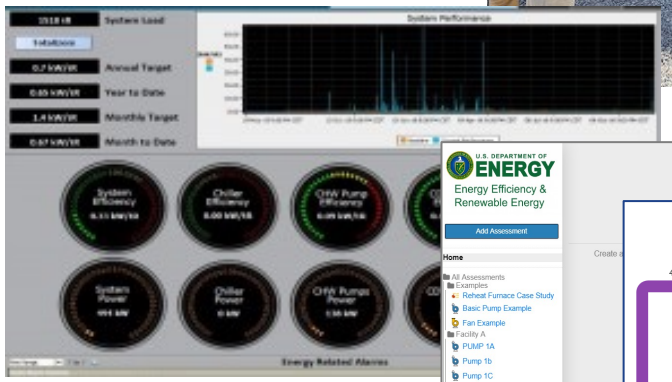
Identifying Significant Energy Users

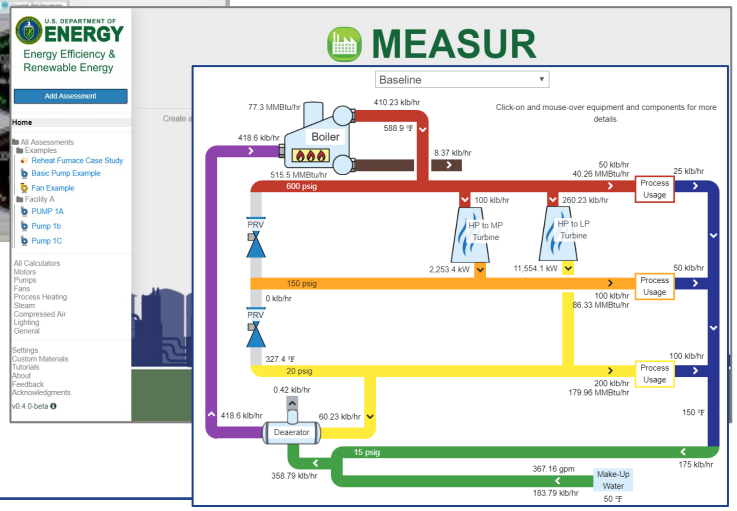
- Identify **Significant Energy Users**
  - Systems that are major energy consumers
  - Considerable opportunity for improvement
- Identify energy and emissions reduction opportunities
- Identify and monitor **relevant variables**
  - Help to determine energy performance of SEUs
- Identify the people that influence or affect the operation of SEUs
- Better Plants Resources
  - MEASUR
  - Energy Footprint Tool



Performing SEU System Assessment

- **Baselining** and **Benchmarking** the SEUs
- Explore integration of **SMART** platform
  - Digital Twin
  - EnMS and FDD
  - Software as a Service (SaaS)
  - Machine learning
- Implement identified opportunities
- Better Plants Resources
  - In-plant trainings
  - Virtual in-plant trainings
  - MEASUR





Questions?