



**Gulf Coast Center
of Excellence**



Session 04: Finding your Baseline: Analyzing Utility Bills and Energy Usage

Digivijaysinh Barad

Ph.D. candidate, Industrial Training and Assessment Center,
Gulf Coast Center of Excellence

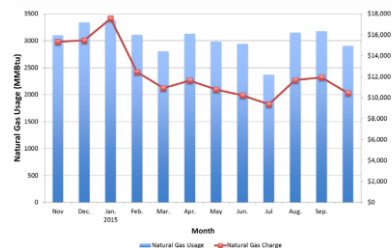
Session Overview



Gulf Coast Center
of Excellence

This session will address two major aspects of energy management:

- Energy Costs
 - Baselining energy usage
 - Understanding energy costs
 - Common opportunities for reducing costs
- Fundamentals of Energy Management Systems (EnMS)
 - Basic Principles
 - Tools for implementation





Understanding Energy Use and Costs

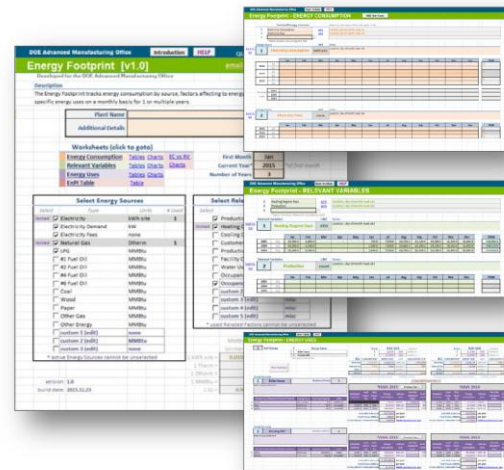
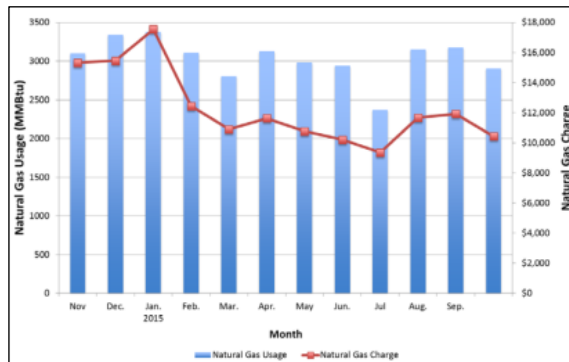
Understanding your energy costs!

Always begin with an analysis of the utility bills

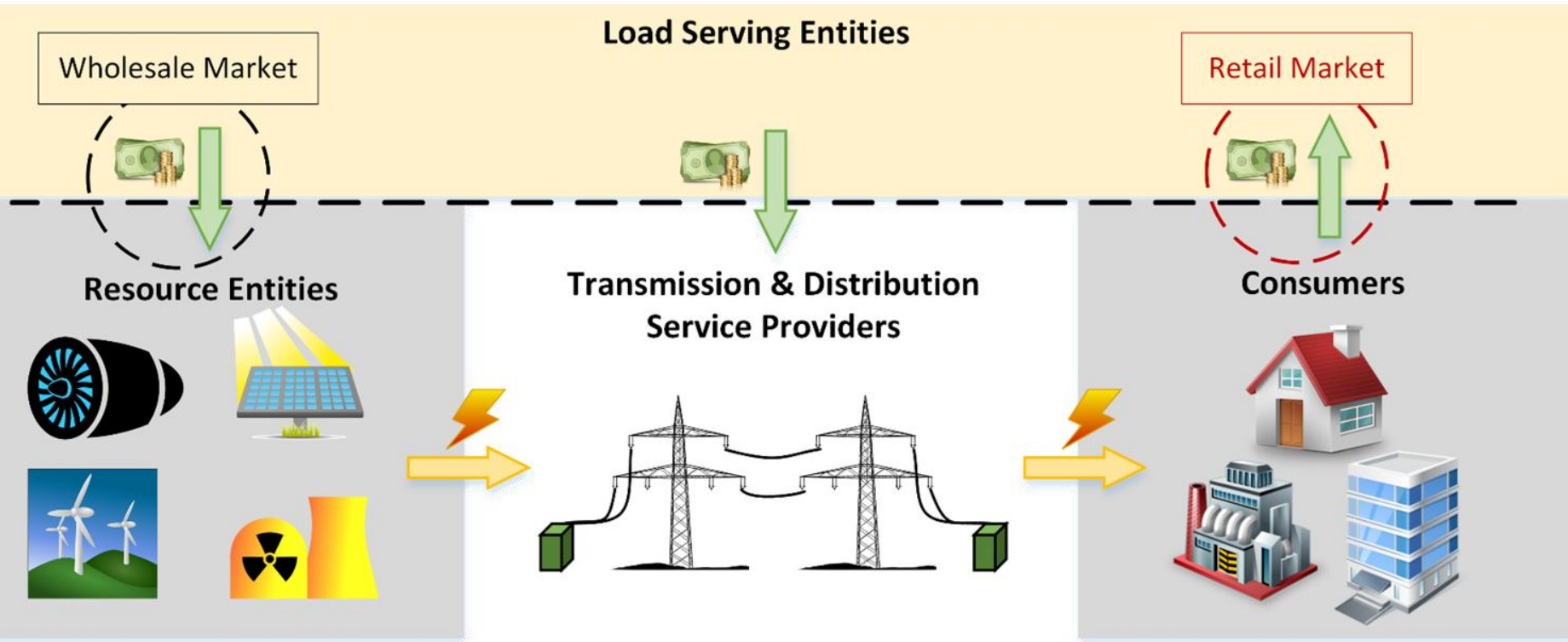
- Breakdown costs by:
 - kWh charges
 - kW charges
 - Independent charges
- Evaluate trends and causes:
 - Weather
 - Production
 - Equipment
- Also analyze:
 - Natural Gas, Propane, etc.
 - Water
 - Hazardous waste

Table 12.3: Breakdown of Electrical Costs by Month and by Consumption/Demand

Month	Oct '14	Nov	Dec	Jan '15	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Average
From	9/30/2014	10/31/2014	11/30/2014	12/31/2014	1/31/2015	2/28/2015	3/31/2015	4/30/2015	5/31/2015	6/30/2015	7/31/2015	8/31/2015	9/30/2015	
To	10/31/2014	11/30/2014	12/31/2014	1/31/2015	2/28/2015	3/31/2015	4/30/2015	5/31/2015	6/30/2015	7/31/2015	8/31/2015	9/30/2015	10/31/2015	
Days in Cycle	30	30	31	31	28	30	30	31	30	31	30	30	30	
Consumption (MWh) - Meter 77148A	900.967	742.015	792.730	706.803	727.140	846.633	677.020	809.264	506.920	886.211	740.532	677.936	9,137.091	758.758
Consumption (MWh) - Meter 77148B	525.340	483.111	395.618	525.933	463.552	453.739	455.346	424.647	468.142	505.797	490.931	497.174	5,742.750	478.562
Demand (kW)	2,192	2,123	2,059	2,177	2,184	2,339	2,327	2,243	2,344	2,362	2,308	2,322	26,116	2,176
Power Factor - Meter 77148A	0.90	0.90	0.89	0.91	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Power Factor - Meter 77148B	0.96	0.97	0.97	0.97	0.97	0.97	0.95	0.96	0.95	0.95	0.94	0.94	0.96	
Costs Associated with Consumption														
Actual Consumption Price	\$75,104.20	\$50,089.76	\$55,051.56	\$45,997.65	\$46,796.26	\$57,951.16	\$44,498.46	\$44,638.09	\$45,078.86	\$60,776.52	\$51,431.93	\$48,398.48	\$591,000.00	\$46,250.07
Energy Efficiency Cost	\$809.61	\$796.90	\$714.22	\$740.87	\$593.75	\$584.76	\$598.41	\$594.46	\$437.80	\$602.62	\$552.66	\$527.62	\$7,463.83	\$620.31
Reimbursement of PG&A	\$144.36	\$121.00	\$118.41	\$95.26	\$94.28	\$90.12	\$104.59	\$110.01	-	\$127.86	\$122.44	\$106.51	\$1,212.34	\$103.01
Total Cost Associated with Consumption	\$76,148.17	\$51,007.66	\$55,969.17	\$46,823.58	\$47,480.66	\$58,636.03	\$45,193.03	\$45,332.95	\$45,616.66	\$61,575.20	\$52,078.46	\$49,026.61	\$599,663.00	\$48,074.42
Costs Associated with Demand														
Distribution Charge	\$7,386.00	\$7,645.86	\$6,798.05	\$7,137.01	\$7,098.30	\$7,408.89	\$7,452.77	\$7,452.77	\$7,489.48	\$7,146.83	\$7,379.34	\$7,091.55	\$86,667.50	\$7,232.29
Distribution Cost Recovery Factor	\$4,603.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$50,977.92	\$4,461.88
Transmission Charge	\$4,603.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$50,977.92	\$4,461.88
Transmission Cost Recovery Factor	\$4,603.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$4,461.88	\$50,977.92	\$4,461.88
Nuclear Decommissioning Fee	\$4.20	\$4.21	\$4.06	\$4.27	\$4.22	\$4.46	\$4.45	\$4.45	\$4.47	\$4.27	\$4.41	\$4.32	\$51.78	\$4.30
System Restoration Charge	\$109.12	\$129.48	\$114.41	\$104.47	\$109.08	\$104.19	\$104.71	\$104.71	\$104.71	\$104.71	\$104.71	\$104.71	\$1,257.88	\$104.90
Transition Charge 1	\$2,648.50	\$2,688.76	\$2,567.81	\$2,891.10	\$2,891.10	\$2,891.10	\$2,891.10	\$2,891.10	\$2,891.10	\$2,891.10	\$2,891.10	\$2,891.10	\$33,511.35	\$2,732.60
Transition Charge 2	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$20,484.62	\$1,698.30
Transition Charge 3	\$2,670.02	\$2,791.86	\$3,881.66	\$3,881.66	\$3,881.66	\$3,881.66	\$3,881.66	\$3,881.66	\$3,881.66	\$3,881.66	\$3,881.66	\$3,881.66	\$46,884.48	\$3,881.66
Transition Charge 4	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$1,698.30	\$20,484.62	\$1,698.30
Utility Credits	\$(86.28)	\$(75.88)	\$(70.31)	\$(71.82)	\$(71.30)	\$(77.15)	\$(77.00)	\$(77.40)	\$(79.62)	\$(76.30)	\$(79.03)	\$(80.84)	\$(976.30)	\$(76.30)
Total Cost Associated with Demand	\$12,263.50	\$12,907.52	\$10,776.61	\$10,640.85	\$10,714.90	\$11,442.77	\$11,442.77	\$11,442.77	\$11,442.77	\$10,979.50	\$11,246.07	\$10,920.66	\$133,812.97	\$11,158.08
Costs Independent of Consumption and Demand														
Basic Customer Charge	\$65.83	\$65.83	\$65.83	\$65.83	\$65.83	\$65.83	\$65.83	\$65.83	\$65.83	\$65.83	\$65.83	\$65.83	\$789.96	\$65.83
WSP 2	\$1.00	\$1.00	\$1.00	\$1.00	\$1.00	\$1.00	\$1.00	\$1.00	\$1.00	\$1.00	\$1.00	\$1.00	\$12.00	\$1.00
Meter Charge	\$63.07	\$63.07	\$63.07	\$63.07	\$63.07	\$63.07	\$63.07	\$63.07	\$63.07	\$63.07	\$63.07	\$63.07	\$756.84	\$63.07
Sum of Independent Costs	\$129.90	\$129.90	\$129.90	\$129.90	\$129.90	\$129.90	\$129.90	\$129.90	\$129.90	\$129.90	\$129.90	\$129.90	\$1,558.80	\$129.90
Sum of Totals	\$188,195.13	\$173,715.46	\$173,446.29	\$165,299.26	\$165,493.13	\$180,193.48	\$160,193.48	\$160,193.48	\$160,193.48	\$173,245.30	\$163,446.29	\$160,193.48	\$1,934,124.84	\$173,715.46

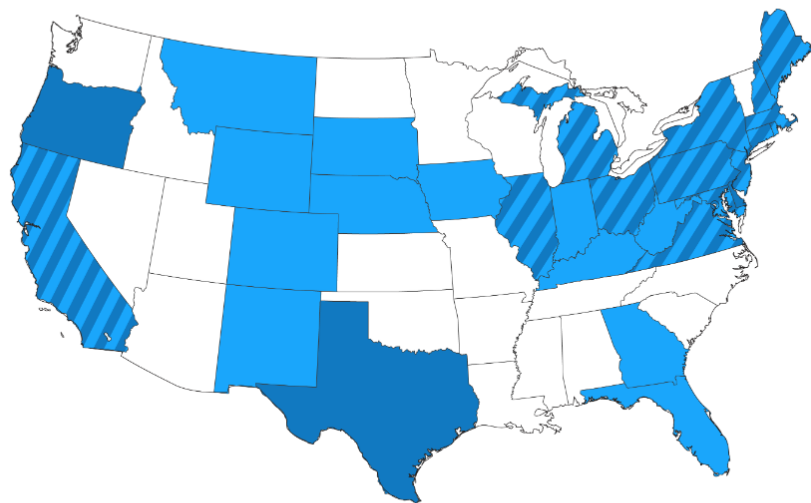


How electricity is produced, transmitted, and sold



Status of Electric Utility Deregulation

Deregulated Energy Markets in 2024



- Note: States may only be partially deregulated
- Example: Texas Electricity
 - Deregulated generation
 - Regulated transmission
 - Deregulated sales

Basic Concepts of Electrical Energy

- State-of-the-art electrical meters measure electrical current and voltage to determine **electrical power (kW or kVA)**
- This quantity is integrated over time to determine **electrical energy (kWh)**
- Smart meters measure and communicate the average power (kW) every 15 minutes

— **Energy (kWh)** = **Power (kW)** * 0.25 (hours)

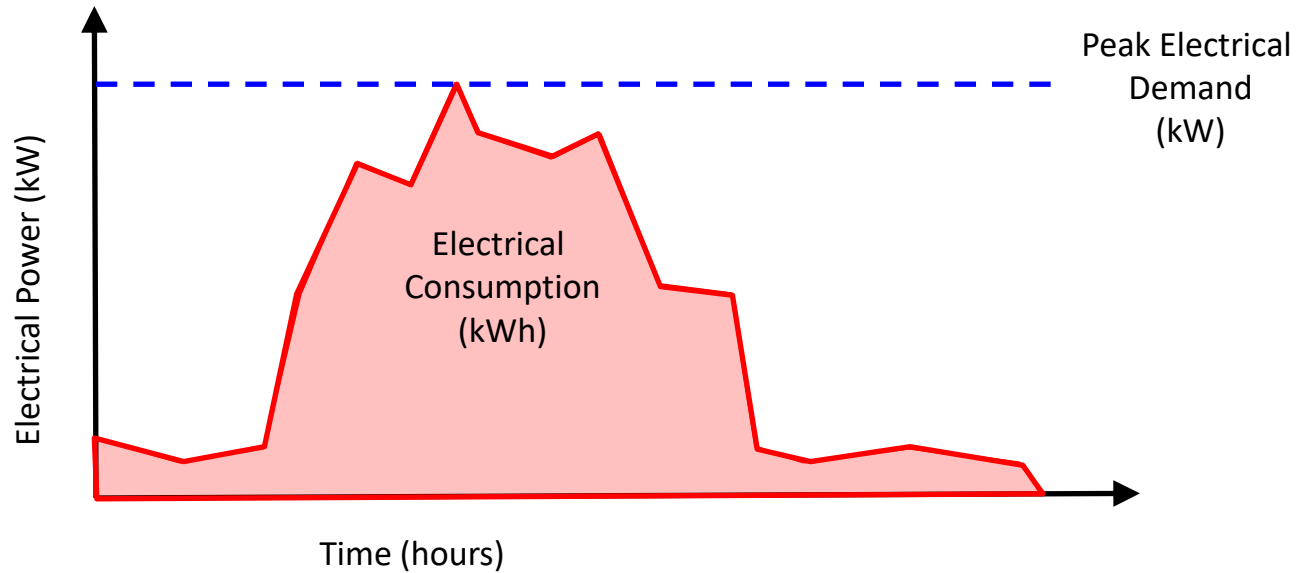
How are you charged for electricity?

- Electrical bills for small consumers (i.e. residential)
 - Billed based on **consumption (kWh)** only
- Electrical bills for large consumers (industrial and commercial)
 - Billed based on **consumption (kWh)** AND **demand (kW or kVA)**
 - Larger **demand** means bigger wires, and requires more infrastructure (i.e. **transmission and distribution charges**)
 - The utility company uses the highest 15 min average demand

How are you charged for electricity?

- Electric Rates may...
 - be based on **consumption (kWh)** AND **demand (kW or kVA)**
 - have different rates for winter and summer (seasonal rates)
 - have different rates for different hours of the day (time-of-use, TOU)
 - use block charges, where the size of the blocks depends on facility peak demand
 - Example: CPS Energy block structure for General Service rate schedule
 - Block 1: \$0.0695/kWh for first 1600 kWh + 200 kWh for every kW above 5 kW
 - Block 2: \$0.0325/kWh for all other
 - Results in a hidden penalty for high peak demand

Electrical Energy vs. Demand



Electrical Demand Analysis

The facility's billed demand may include charges based on:

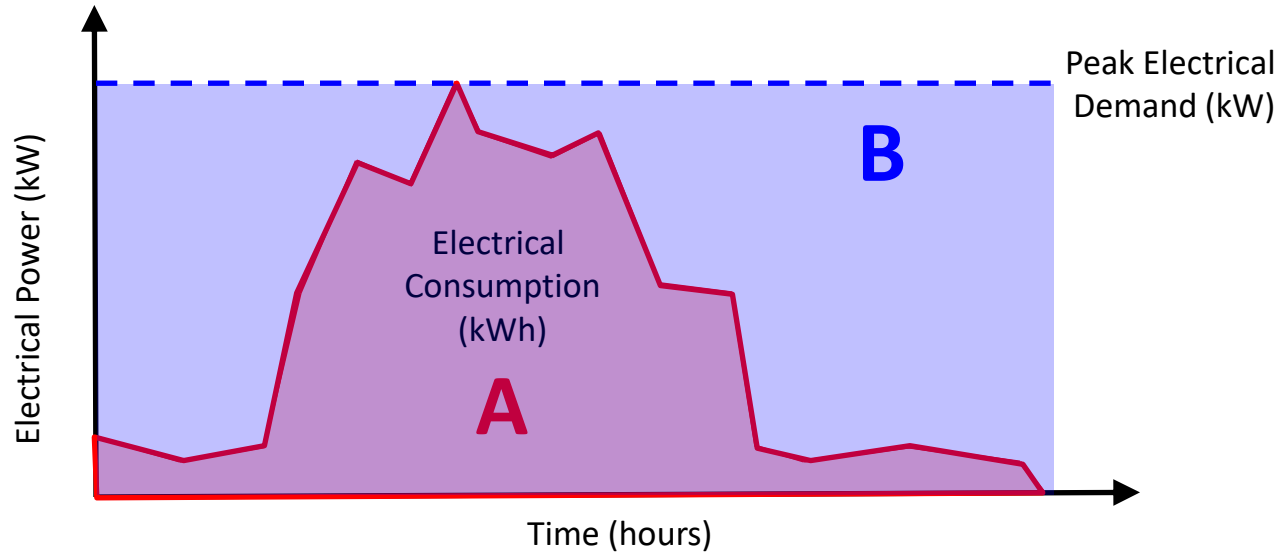
- **NCP** (non-coincident peak): The highest 15 minute average demand for the facility during the billing month.
- **4CP** (4 coincident peaks): The facility's demand during the 15 minutes highest grid demand during each 3 month period of the year.
- **Ratchet Clause**: The facility may be billed for their actual NCP demand, or 80% of the highest NCP for the past 12 months (whichever is higher).
- **Power Factor Penalty**: The facility may incur a demand penalty for low power factor.
- ... or some combination of these. Check to see if the utility provider has published a "rate schedule" or "rate tariff" that details how the facility will be charged.

Electrical Demand Analysis

- Analyzing electrical demand can help visualize plant operations, and reveal opportunities for cost savings
- 15-minute electrical demand data is best, but some information can be extracted from the monthly electrical bills alone

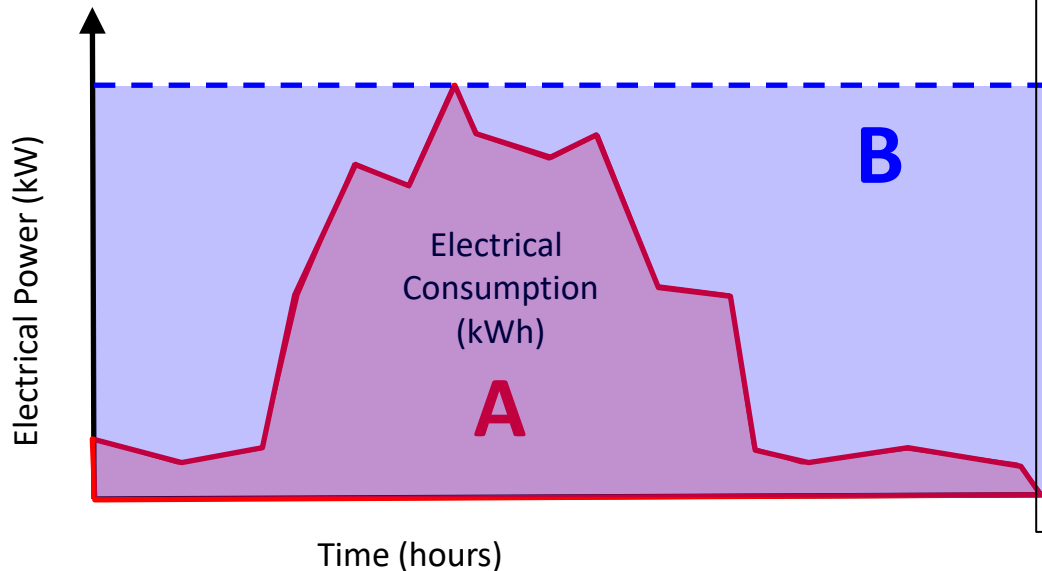
Load Factor Analysis

$$\text{Electrical Load Factor (ELF)} = \frac{A}{B}$$



Load Factor Analysis

$$\text{Electrical Load Factor (ELF)} = \frac{A}{B}$$

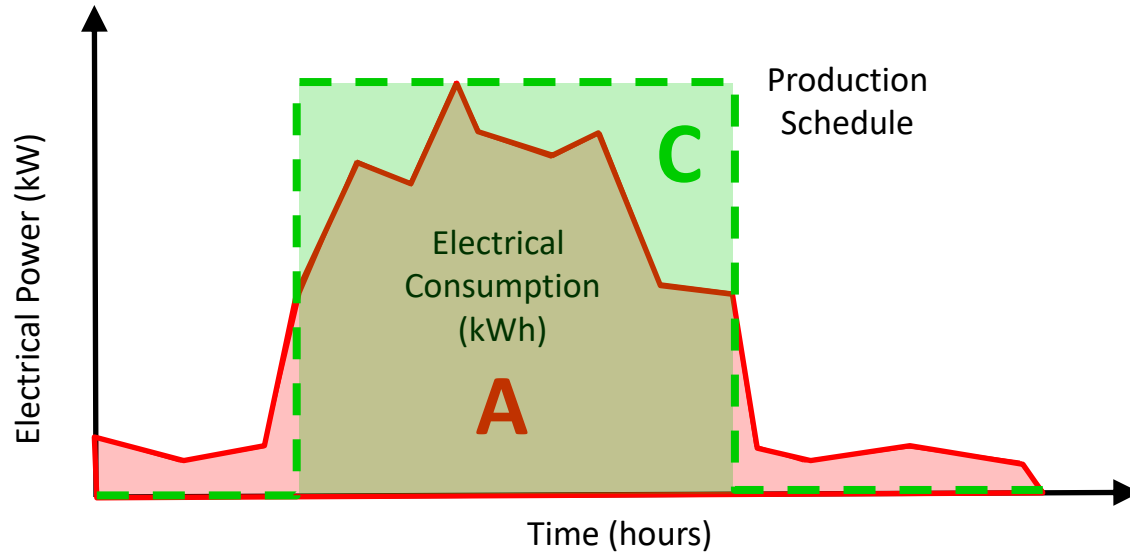


Basic Principles:

- $0 < ELF < 1$
- A **high ELF** indicates a plant with high operating hours, or that leaves equipment on during non-operational hours.
- A **low ELF** indicates a plant with low operating hours, or large spikes in peak demand.

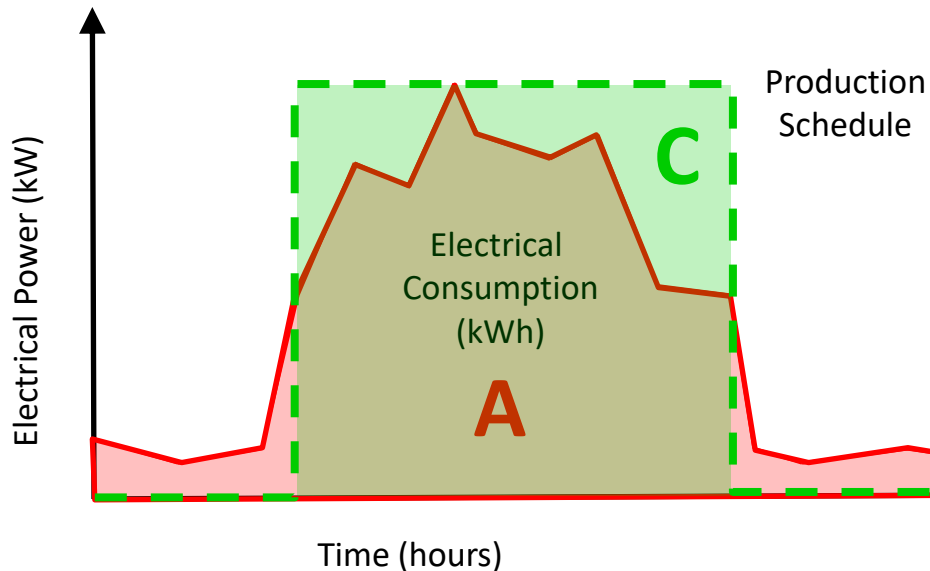
Load Factor Analysis

$$\text{Production Load Factor (PLF)} = \frac{A}{C}$$



Load Factor Analysis

$$\text{Production Load Factor (PLF)} = \frac{A}{C}$$

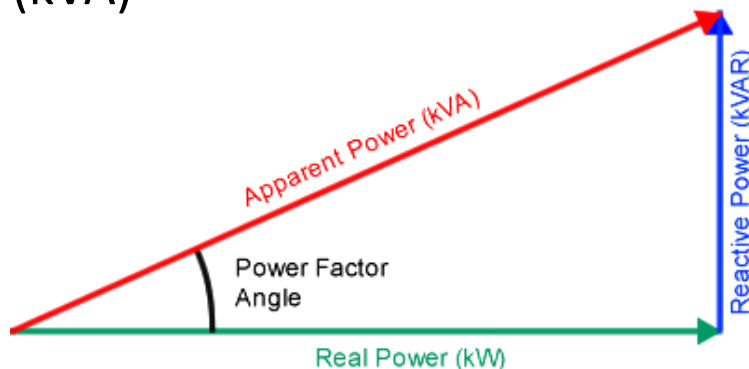


Basic Principles:

- $0 < PLF$
- A **high PLF** indicates a plant that leaves equipment on during non-operational hours.
- A **low PLF** indicates a plant with large spikes in peak demand.
- A **PLF=1** indicates a plant with neither problem, or both problems.

Power Factor

- Motors and other inductive loads result in difference between the power used by the facility to do work (kW) and the power provided by the utility (kVA)



$$\begin{aligned}\text{Power Factor} &= \frac{\text{Real Power (kW)}}{\text{Apparent Power (kVA)}} \\ &= \frac{\text{kW}}{\sqrt{\text{kW}^2 + \text{kVAR}^2}}\end{aligned}$$

- Utilities may explicitly (or implicitly) penalize customers with poor power factor

Potential Savings from Electric Bills

- Based on information from the electricity bills, auditors can identify simple possible recommendations:
 - Sales Tax Abatement 
 - Avoid Late Fees 
 - Power Factor Correction 
 - Change Rate Tariff 
 - Peak demand shifting (avoid ratchet clauses)
 - Minimize energy use during non-production hours
 - Demand Response Programs

Potential Savings from Natural Gas

- Natural Gas costs can be minimized:
 - Sales Tax Abatement
 - Accurate forecasting for pre-purchased contract amounts of NG
 - Some NG utilities have facilities pre-pay for a contracted amount of NG
 - Additional NG is purchased at market prices (higher)
 - Unused NG is sold back at a lower price

Potential Savings from Water

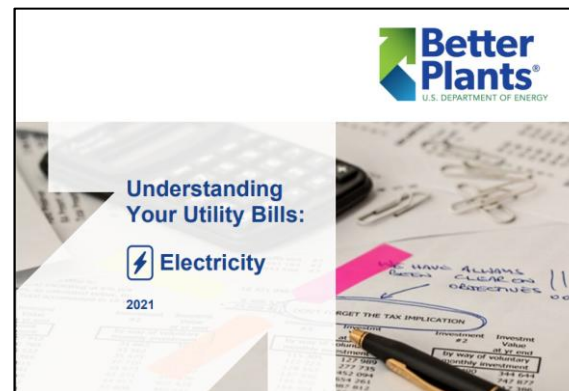
- Water and wastewater costs can be minimized:
 - If water is evaporated on-site or used in product (e.g. beverage manufacturing), then install a separate meter for wastewater

Additional Learning Resources

Available from Better Plants:

A set instructional manuals explaining how energy is billed for industrial facilities

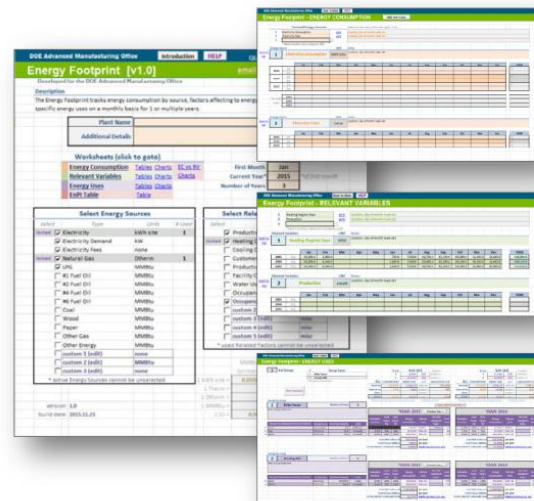
- *Understanding Your Utility Bills: Electricity*
- *Understanding Your Utility Bills: Natural Gas*
- *Understanding Your Utility Bills: Water*
- *Demand Response in Industrial Facilities: Peak Electric Demand*



<https://betterbuildingsolutioncenter.energy.gov/better%20plants/better-plants-resource-library>

Additional Tools from DOE

- **Energy Footprint Tool**
 - Track energy consumption, factors related to energy use, and significant energy end-uses
 - Specifically designed to support implementing the 50001 Ready Program
- **Verifi** 
 - Track, visualize, analyze and forecast facility utility data in industrial settings
 - Incorporates and expands on several existing DOE tools (EnPI, Energy Footprint Tool, Plant Energy Profiler)
- **Plant Water Profiler Tool (PWPEX)**
 - Understand the “true cost” of water and wastewater
 - Identify opportunities for reducing water use



<https://www.energy.gov/eere/amo/articles/energy-footprint-tool>

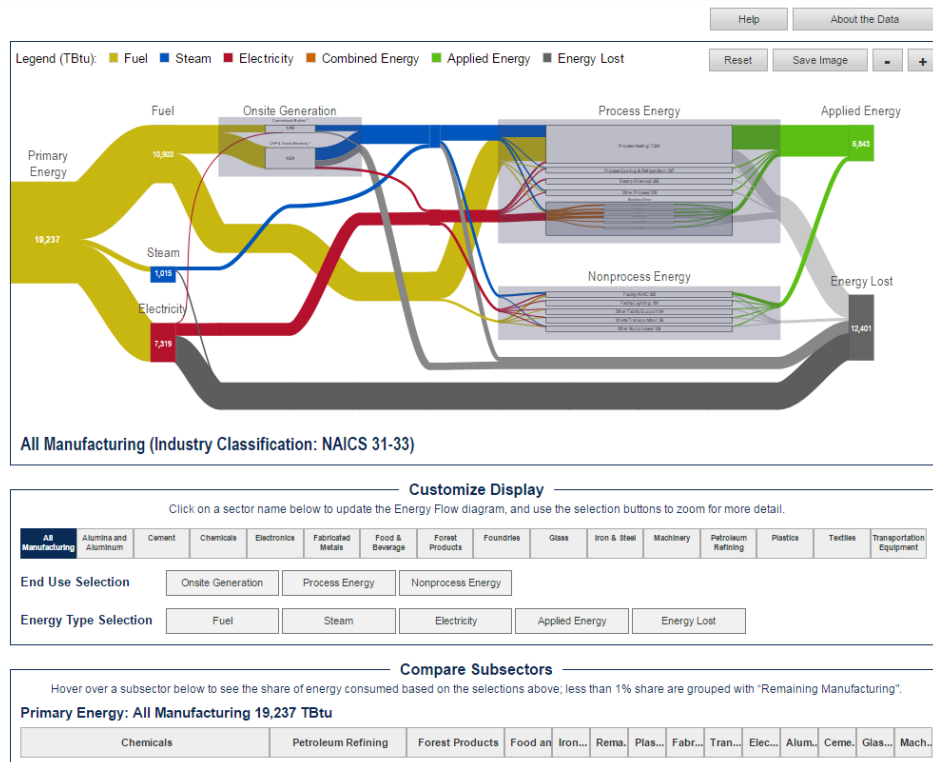
<https://verifi.ornl.gov/>

<https://www.energy.gov/eere/iedo/plant-water-profiler-tool-excel-version-10-pwpex-v10>

Additional Tools from DOE

- **Dynamic Manufacturing Sankey Tool**

- Understand typical energy uses for specific industries
- Helps identify major energy consumers
- Baseline for comparing plant energy profiles



<https://energy.gov/eere/amo/dynamic-manufacturing-energy-sankey-tool-2010-units-trillion-btu>



Energy Management Systems

Benefits of Energy Management Systems (EnMS)

Establishing an Energy Management System ensures:

- There are clear **goals** for energy and cost reductions
- There are **performance indicators** (EnPIs) that are measured and reported
- There is a **process** for identifying, prioritizing, and implementing energy efficiency projects
- There is management **commitment**
- There are adequate **resources**
- There is a **champion/team** assigned to execute the program

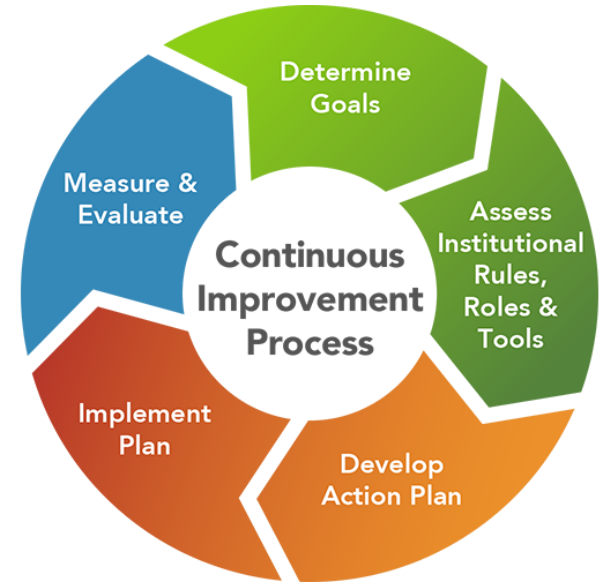
Principles of Energy Management Systems (EnMS)

- Energy is viewed as a value-added to the product, not an uncontrollable overhead cost
 - Track energy use per widget
 - Use DOE tools to determine how energy use varies with
 - Weather
 - Production amounts
 - Other? (waste)

Principles of Energy Management Systems (EnMS)

- Control and measure the primary energy functions
 - 80% of the energy savings potential is in the largest 20% of the process
 - Focus on energy intensive processes. Consider alternative technologies.
 - Focus on support equipment. Adopt best practices.
 - Motors and Drives
 - Air Compressors
 - Steam Systems
 - Process Heating
 - Process Cooling
 - Pumps and Fans

ISO 50001



ISO 50001 and 50001 Ready programs

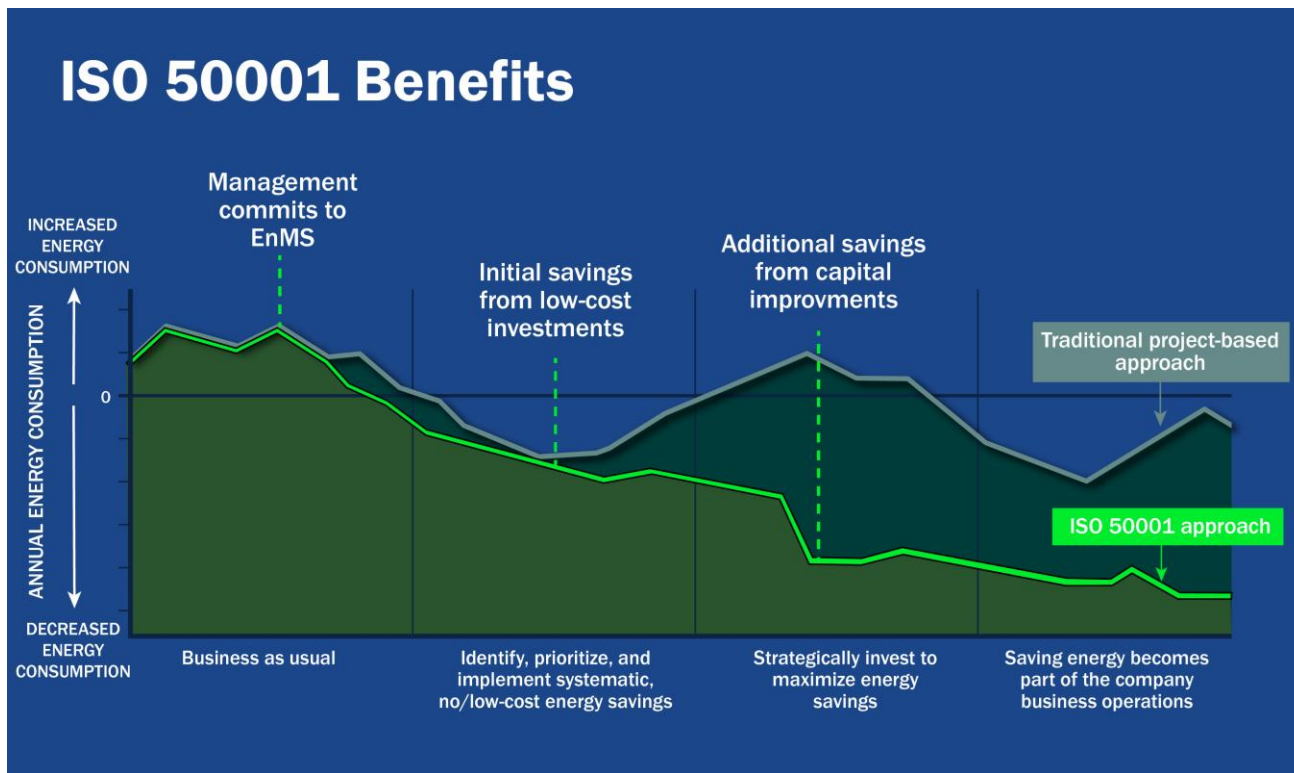


Figure Credit:
Berkeley Lab, 2024

Don't neglect ancillary benefits of energy efficiency



⚡ Energy savings



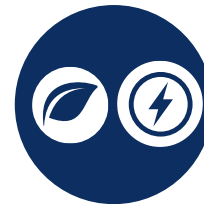
Financial return



Environmental,
health, & safety
benefits



Operational &
maintenance
impacts



Decarbonization
and Electrification

Additional Tools from DOE

50001 Ready Navigator

- Guides users through 25 actionable tasks, grouped into 7 sections, that correspond to ISO 50001 requirements
- Suite of materials, tools, and resources supports EnMS implementation
- Opportunities for training and recognition by the DOE
- No costs or third-party verification





Questions