COURSE NAME | Session No.1

ELECTRICAL ENERGY MANAGEMENT

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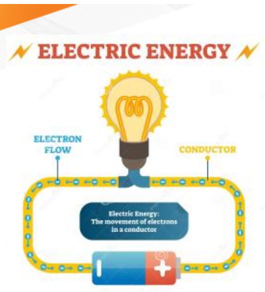
SESSION OBJECTIVES

- To define electrical energy in its useful forms and familiarize with the correct units for energy and power and its terminologies
- To obtain understanding on the operating principles and assessment of the performance of electrical equipment and associated systems
- To gain insights on emerging, cost-effective electrical technologies & efficient operating practices for enterprises to increase efficiency, reduce energy waste & carbon emission for a sustainable business growth



What is **Electric Energy** and why its **efficient use** and **effective management** are important?

Electrical Energy

- Electric energy is the energy derived from electric potential energy or kinetic energy of the charged particles. It is referred to as the energy that has been converted from electric potential energy.
- Is a form of energy associated with the flow of electric charge. It is the ability of an electric current to do work or produce an effect, such as generating light, heat, or powering electronic devices.

Electrical Energy

- Energy is the capacity of doing work or produce heat. Energy can be found in many different forms and transformed between them.
- The basic unit of energy in metric system is **joule (J)** and the basic unit of electrical energy is **watt-hour (Wh)**.

Unit of energy would be 1 joule (J), which is equal to 1 watt-hour (Wh).

Electrical Energy

- Electrical energy is often measured in units such as kilowatt-hours (**kWh**), and it is a crucial aspect of our daily lives, providing power for various applications, including lighting, heating, cooling, and motor driven equipment.

Energy = Power x Time Required

Energy - 1 kWh = 3,600 kJ = 3,412 BTU = 860.421 kcal

What is Power?

Refers to the rate at which work is done or energy is transferred or converted. Mathematically, power (P) is defined as the amount of work (W) done or energy (E) transferred or converted per unit time (t).

$$\text{Power} = \frac{\text{Work Done}}{\text{Time Required}} = \frac{\text{Energy}}{\text{Time Required}}$$

Unit of power would be 1 joule per second (J/s), which is equal to 1 watt (W) and 1 horsepower (Hp) is equal to 746 watts (W).

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What is Power?

Mechanical Power:

$P = \frac{W}{t}$

Where:

- P is power (measured in watts, W).
- W is the amount of work done (measured in joules, J).
- t is the time taken (measured in seconds, s).

Electrical Power:

$P = VI$

Where:

- P is power (measured in watts, W).
- V is voltage (measured in volts, V).
- I is current (measured in amperes, A).

Power - 1 TR = 3.517 kW = 3.517 kJ/s = 12,000 BTU/Hr = 4.716 Hp

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Republic of the Philippines
DEPARTMENT OF ENERGY
Energy Utilization Management Bureau

DESGNATED ESTABLISHMENTS

CONVERSION TABLE

No.	Fuel Type	Unit	Conversion Factor	Input Value[1]	kWh
1	Gasoline	L	3.245	1.000	3.245
2	Diesel	L	3.540	1.000	3.540
3	Fuel Oil	L	3.831	1.000	3.831
4	Kerosene	L	3.345	1.000	3.345
5	LPG	L	2.483	1.000	2.483
6	AVGAS	L	3.226	1.000	3.226
7	AVTURBO	L	3.345	1.000	3.345
8	Watse Oil	L	3.831	1.000	3.831

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Energy management is simply the process of improving energy efficiency within an organization.

Energy efficiency is the use of the minimum amount of energy required to maintain a certain level of activity or service. In other words, energy efficiency is all about doing more with less.

Energy management, on the other hand, describes the continuous effort to improve energy efficiency within an organization.

Energy conservation involves reducing overall energy consumption by adopting behaviors, practices, and policies that minimize energy waste and promote sustainable use of resources.

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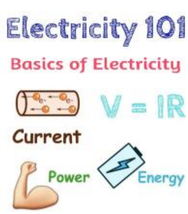
Fundamentals of Electrical Power Systems

- Voltage & Current (AC / DC)
- Single & Three Phase Power
- Resistive & Inductive Loads
- Power Quality
  - Sag/Swell
  - Transients
  - Harmonics
  - Power Factor



IEEE 519 Standard for harmonics including THD and TDD limits for voltage and current distortion.

IEEE 1159 – 2019 Recommended Practice for Monitoring Electric Power Quality

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Basic Units Used

Term	Description	Unit and Symbol
Voltage	The driving force that causes electrons to flow across a circuit (similar to pressure in a hydraulic circuit).	Volt [V]
Current	Electron flow measurement (like water flow in a hydraulic circuit)	Ampere [I]
Resistance	The effect of restricting current flow across a circuit (equivalent to a valve in a hydraulic circuit - the more closed, the greater the resistance, the less flow)	Ohm [Ω] and sometimes [R]
Ohm's Law	The relationship between voltage, current, and resistance in a simple circuit	V = I x R
Power (single phase)	Voltage, current, and power factor product	P = V x I x PF [Watt]
Energy	Work completed or energy used to complete a job	Energy = Power x Time [Wh]

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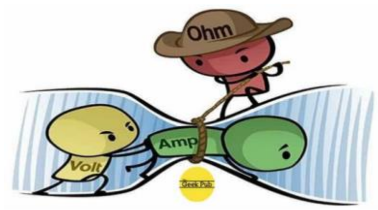
Voltage, Current & Resistance



Ohm's Law: $V = I \times R$

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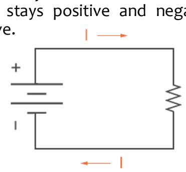
Types of Electric Current

Direct current (dc) is current that flows in one direction through a circuit. It is non-varying, unidirectional electric current. It is produced by sources of electricity whose positive (+) terminal always stays positive and negative (-) terminal always stays negative.



Direct Current (DC)

Ohm's law: $V = I \times R$

Joule's Law: $P = I^2 \times R$

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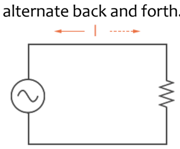
Types of Electric Current

Alternating current (ac) is current whose flow in a circuit periodically reverses direction. It is produced by a source of electricity whose positive and negative terminals switch or alternate back and forth.



Alternating Current (AC)

Single Phase Power: $P = V \times I \times$ Power Factor

Three Phase Power: $P = 1.732 \times V \times I \times$ Power Factor

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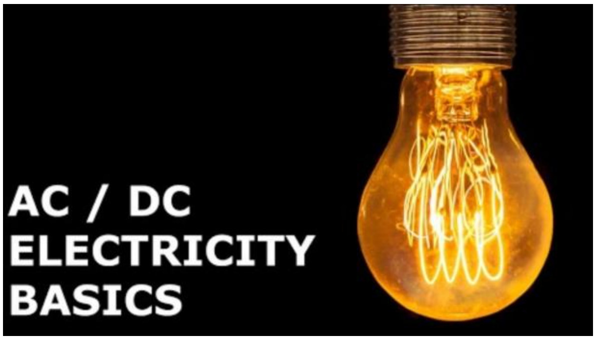
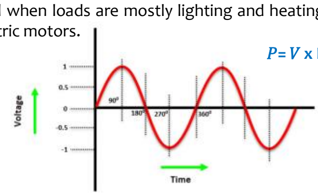


Single-Phase AC Electrical System

Single-phase electric power is the distribution of a two-wire alternating current electric power using a system in which all the voltages of the supply vary in unison. Single-phase distribution is used when loads are mostly lighting and heating, with few large electric motors.

$P = V \times I \times \text{Power Factor}$



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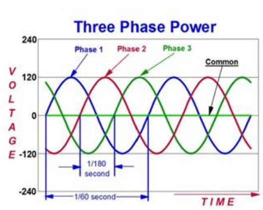
Three-Phase AC Electrical System

Three-phase electric power is a common type of alternating current (AC) used in electricity generation, transmission, and distribution. It is a type of system employing three wires (four or five including an optional neutral return wire plus a ground) and is the most common method used by electrical grids worldwide to transfer power.



$P = \sqrt{3} \times V \times I \times \text{Power Factor}$

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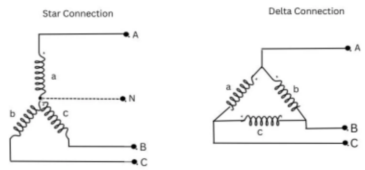
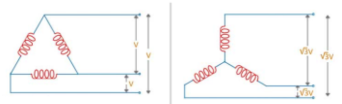
Typical Three-Phase AC Electrical System in a Facility



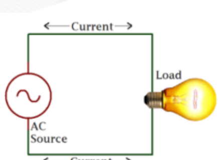
Three phase systems are very widely used for AC power distribution. The three phases may be delta connected or star connected with star point usually grounded.

Typical Three-Phase AC Electrical System



Configuration	Line and Phase Currents	Line and Phase Voltages	Typical Voltage Levels
4-Wire Wye	$I_L = I_P$	$V_L = \sqrt{3} \times V_P$	120/208V 277/480V
3-Wire Delta	$I_L = \sqrt{3} \times I_P$	$V_L = V_P$	240V 400V 480V

Types of Electric Current



ELECTRICAL FORMULAS

Quantity	Formula	Unit
Voltage	V = I R	Volt (V)
Current	I = V R	Ampere (A)
Resistance	R = V I	ohm (ω)
Power	P = VI	Watt (W)

Consider a purely resistive load: Power/Copper Loss

P = V*I, where V = I*R

Therefore; P = I*R*I

$P = I^2R$

Electrical Systems – Power Quality Issues

- **Sag/Swell** - Voltage sags/swell are defined as a deviation in which voltage is lower/exceeds than nominal voltage for multiple cycles. Causes of sags include a short circuit, overload, or the starting of large motors. A swell can happen when a large load is turned off.
- **Transients** - Transient (similar to the swell) is a condition in which the voltage on the electrical system is higher than the expected voltage, typically occurs with the electrical cycle & duration is less than 1/60th of a second.

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Electrical Systems – Power Quality Issues

- **Harmonics** - are distortions to voltage and current sine waves. If equipment in an industrial facility operates by altering sign wave behavior between AC and DC, it will cause harmonic distortion.
- **Power Factor** - Power factor (PF) is the ratio of real power to apparent power. When voltages and currents within a power system are in phase, the power factor is considered to be unity or 1.

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Electrical Systems – Effects of Harmonics

Harmonics in electrical systems can have various detrimental effects on both the system itself and the equipment connected to it.

Increased Equipment Heating: Harmonic currents flowing through electrical equipment result in increased heating due to the additional power losses caused by harmonics.

Reduced Power Quality: Harmonics can cause voltage and current waveforms to become distorted, leading to poor power quality.

Overloading of Neutral Conductors: In systems with unbalanced loads, harmonics can cause significant currents to flow in the neutral conductor, leading to overheating and potential damage.

Power Factor Reduction: Harmonic currents can contribute to a lower power factor in the system, leading to increased reactive power consumption and higher electricity bills.

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Strategies to minimize I^2R Loss or Copper Loss

Power factor also plays a key role in transformer losses. If load is having low lagging power factor, it may lead to high load current increasing I^2R losses. Whereas any reduction in current for the same kW load by improvement in power factor reduces load I^2R losses.

Strategies for Minimizing Power Losses in Low Voltage Electrical Networks

1. Utilizing Efficient Transformers to Reduce Power Losses.
2. Adapting Voltage Regulation Techniques for Lower Power Losses.
3. Enhancing Electrical Insulation to Minimize Energy Wastage.
4. Implementing Smart Grid Technology for Optimal Energy Distribution.

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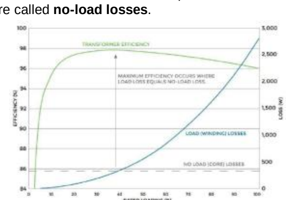
Transformer Losses

Are produced by the electrical current flowing in the coils and the magnetic field alternating in the core. The losses associated with the coils are called the **load losses**, while the losses produced in the core are called **no-load losses**.



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Instruments Used to Gather (Energy) Data

Power/Energy Meters & Submeters

Used to measure several relevant electrical energy data such as but not limited to the following:

- kWh, kW, kVA
- Voltage levels
- Current (amps)
- THD
- Power Factor, etc.

Ideally, significant load groups should be sub-metered separately from other load groups such as for Compressed dry air system, HVAC systems, production equipment, & lighting system, etc.

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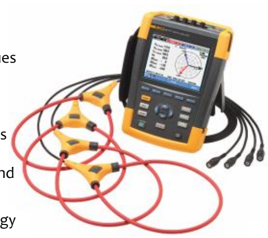
Instruments Used to Gather & Analyze Electrical Data

Power Quality Analyzer (PQA)

Power quality analyzers identify issues with power quality which typically manifest as dips, swells, harmonic distortion, unbalance, flicker, and transients. Power quality determines the suitability of electrical power to drive motors, machines and other end user devices.

This can also be used as power/energy data logger.



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Instruments Used to Gather & Analyze Data

Digital Multimeter & Clamp Meter
Portable instrument that is used to measure electrical data at the site:

- Voltage levels
- Current (amps)
- Resistance
- Continuity

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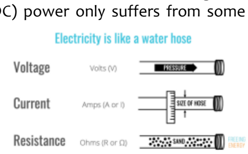
I^2R Loss or Copper Loss

Resistive, **capacitive** and **inductive** line losses do not only occur in high-voltage transmission, but also in low and medium voltage scenarios. All three of these types of line losses are caused, in part, by heat loss from power being impeded along power lines. AC power suffers from all three of these line losses, regardless of voltage, and direct current (DC) power only suffers from some types of resistive power losses.



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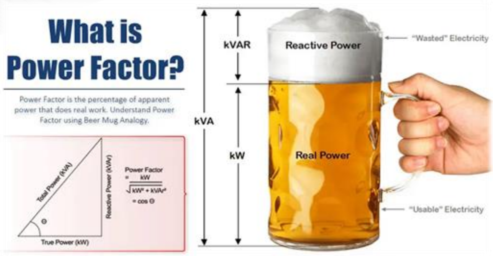

Power Factor is the percentage of Apparent Power that does real work.

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Power Factor (pf)

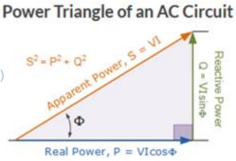
Power factor is defined as the percentage ratio between the true power, measured in kilowatts (kW), and apparent power, measured in kilovolt amperes (kVA).

$$\text{Power Factor (pf)} = \frac{\text{Real Power (P) in Watts}}{\text{Apparent Power (S) in volt-amps}}$$

$$\text{Real Power (P)} = \text{Apparent Power (S)} \times \text{Power Factor (pf)}$$

$$\text{Power Factor} = \frac{P}{S} = \frac{VI\cos\phi}{VI} = \cos\phi$$

Power Triangle of an AC Circuit



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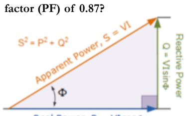
Power Factor (pf)

Sample Problem:

What is the apparent power in a facility with a real power demand of 600 kW and a power factor (PF) of 0.87?



$$\text{Power Factor (pf)} = \frac{\text{Real Power (P) in Watts}}{\text{Apparent Power (S) in volt-amps}}$$

$$\text{Real Power (P)} = \text{Apparant Power (S)} \times \text{Power Factor (pf)}$$

$$Apparent\ Power = \frac{Real\ Power}{Power\ Factor} = \frac{600}{0.87} = 690\ kVA$$

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Power Factor (pf) Correction

As per Philippine Distribution Code Requirements;

5.2.4 Power Factor

5.2.4.1 The User shall maintain a Power Factor not less than 85 percent lagging at the Connection Point in the Distribution System.

5.2.4.2 The Distributor shall correct feeder and substation feeder bus Reactive Power demand to a level that will economically reduce the Technical Loss.

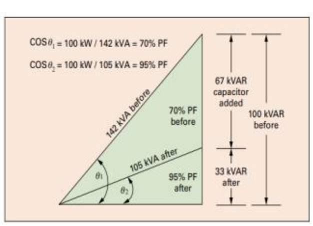
5.2.4.3 The Distributor may establish penalties and incentives for User Power Factor at the Connection Point based on the target level.

As per International Electrotechnical Commission;

IEC 61921:2017 is applicable to low-voltage AC shunt capacitor banks intended to be used for power factor correction purposes, possibly equipped with a built-in switchgear and control gear apparatus capable of connecting to or disconnecting from the mains part(s) of the bank with the aim to correct its power factor.

Power Factor (pf) Correction

- **Install power factor correction capacitors** to your in-plant distribution system.
- **Power capacitors serve as leading reactive current generators** and counter the lagging reactive current in the system
- **Sizing Power Capacitors**
  1) Obtain data for certain load
     a) real power (kW)
     b) power factor (existing & desired)
  2) Make use of the table
     a) proceed to the initial pf on the left
     b) look at the table factor below the chosen power factor

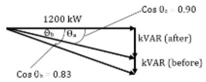


kVAR $_{needed}$ = Real Power (P) x Table Factor

Power Factor (pf) Correction

Sample Problem:

A facility has a power factor of 0.83 and would like to increase this to 0.90 by installing a capacitor bank. If the demand in the facility is 1,200 kW, what size capacitor bank should be connected?



A. 207 kVAR
B. 218 kVAR
C. 225 kVAR
D. 236 kVAR

The reactive power needed to improve the power factor from 0.83 to 0.90 is:

$$kVAR\ (before) - kVAR\ (after) = 1200\ x\ [tan\{cos^{-1}(0.83)\} - \tan\{cos^{-1}(0.90)\}] = \mathbf{225 kVAr}$$

Where: $kVAR_{0.83} = 806.37$ *and* $kVAR_{0.9} = 581.13$

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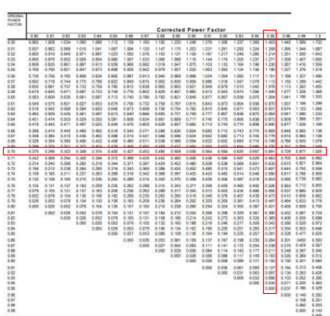
Power Factor (pf) Correction

Example:
Find the Qc in kVar if real power is 350 kW and PF is 0.7 to be improved to 0.95?

Solution:
Qc = 350 kW x 0.691 *(from the table)*
= 241.85 kVar
= **242 kVar** *(rounded off)*



Major Benefits of Power Factor (pf) Improvement

- Increased plant capacity
- Improvement of voltage supply
- Less power losses in feeders, transformers and distribution eqpt
- Reduced power factor "penalty" charges for the electric utility

Example of Increased Plant Capacity:

500kVA substation @ 70% PF, find max load @ 80% capacity:
P(kW) = S(kVA) x PF = 500 kVA x 0.7 x 0.8 = **280 kW**

500kVA substation @ 95% PF, find max load @ 80% capacity:
P(kW) = S(kVA) x PF = 500 kVA x 0.95 x 0.8 = **380 kW**

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Major Benefits of Power Factor (pf) Improvement

Example, Improvement of Voltage Supply:

Voltage Drop = Line Current x Total Wire Resistance

P = √3 x V x I x PF or I = P / (√3 x V x PF)

For 280 kW, 440V, @ 0.7 PF
I = 280 kw / (1.732 x 440 x 0.7)
I = 524 A

For 280 kW, 440V, @ 0.95 PF
I = 280 kw / (1.732 x 440 x 0.95)
I = 387 A

Since, **VD = I x R**
Then, the **higher PF** the **VD is low**
Therefore, the **system voltage is improved**

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Major Benefits of Power Factor (pf) Improvement

Example, Reduced I^2R Losses:

P = √3 x V x I x PF or I = P / (√3 x V x PF)

For 280 kW, 440V, @ 0.7 PF
I = 280 kw / (1.732 x 440 x 0.7)
I = 524 A

For 280 kW, 440V, @ 0.95 PF
I = 280 kw / (1.732 x 440 x 0.95)
I = 387 A

As the power factor (PF) is improved, the current flowing through the system is reduced, and the voltage level is maintained at a higher level. This reduction in current flow then ***reduces the energy losses*** and ***improves the efficiency*** of the system which also ***improves the overall system performance***.

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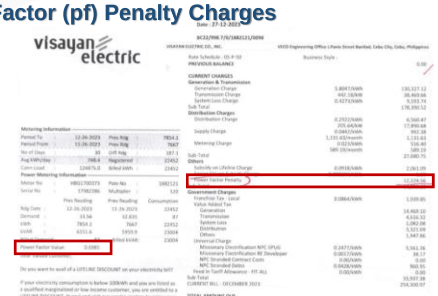
Power Factor (pf) Penalty Charges



Advantages of Individual Capacitors at the Load Includes the ff.

- Capacitors don't cause problems on the line during light load conditions.
- No need for separate switching.
- The motor always operates with its capacitor.
- Improved motor performance due to reduced voltage drops.
- Motors and capacitors can be easily relocated together.
- Easier to select the right capacitor for the load.
- Reduced line losses.
- Increased system capacity.

Advantages of Cap Bank Installation at the Feeder or Service Entry are:

- Lower cost per kVAr.
- Lower installation costs.
- Total plant power factor improves which reduces or eliminates utility power factor penalty charges.
- Total kVAr may be reduced, as all capacitors are on-line even when some motors are switched off
- Automatic switching ensures the exact amount of power factor correction and eliminates over-capacitance and resulting over-voltages

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Load Factor

Load factor is a measure of the utilization rate or efficiency of electrical energy usage. It is the ratio of total energy (kWh) used in the billing period divided by the possible total energy used within the period if used at the peak demand (kW) during the entire period.

Load Factor = Energy Consumed / (Peak Demand * hours in the period)

Load Factor = kWh / (kW x 30 days x 24 hrs.)

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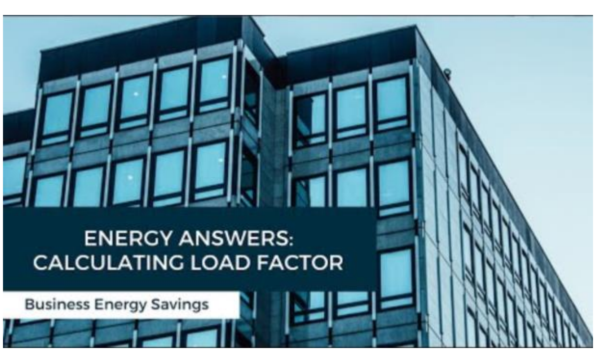

Load Factor

To calculate your load factor, take the total energy (kWh) used in the month and divide it by the product of peak demand (power, kW), the number of days in the billing cycle, and 24 hours in a day. The result is a ratio between zero and one.

An Electric demand Load Factor Calculation Example:

- Monthly Energy Use - 2000 kWh
- Monthly Peak Electric Demand - 35 kW
- Days in the Billing Month – 30 days
- Hours in a Day - 24 hours
- Load Factor (LF) = 2000 / (35*30*24) = .0794 x 100 = 7.94%

**you could benefit from better management of your energy usage.*

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Load Factor

	PERIOD COVERED		METER READING		DIFF	MULT	TOTAL REG'N
	FROM	TO	PRESENT	PREVIOUS			
DEMAND	07/25/2018	8/25/2018	1.7020			1,050	1787.1000
KWHRS	07/25/2018	8/25/2018	6093.9320	5161.8380	932.0940	1,050	978698.7000

Generation and Transmission		
Generation Charge	[illegible]	[illegible]
Transmission Charge	[illegible]	[illegible]
Transmission Charge per KW	[illegible]	[illegible]
System Loss Charge	[illegible]	[illegible]
Subtotal 1		[illegible]
Distribution Revenues		
Distribution Charge	[illegible]	[illegible]
Distribution Charge per KW	[illegible]	[illegible]
Supply Charge per KW	[illegible]	[illegible]
Metering Charge	[illegible]	[illegible]
Subtotal 2		[illegible]
Others		
Inter-Class Cross Subsidy	[illegible]	[illegible]
Lifeline Rate Subsidy	[illegible]	[illegible]
Subtotal 3		[illegible]
Government Revenues		
Value Added Tax		
Universal Charges-PSALM		
NPC Stranded Debt	[illegible]	[illegible]
NPC Stranded Cost	[illegible]	[illegible]
Missionary Electrification	[illegible]	[illegible]
Environmental Charge	[illegible]	[illegible]
Fit-All Renewable	[illegible]	[illegible]
Subtotal 4		[illegible]
Surcharge	[illegible]	[illegible]
GROSS AMOUNT		[illegible]
CURRENT AMOUNT		[illegible]
Overdue Amount		[illegible]
TOTAL AMOUNT DUE		[illegible]
Expanded W/Tax		[illegible]
NET AMOUNT DUE		[illegible]

Sample Problem: What is the LF for the billing period July - August 2018 with the following details below;

Energy Consumed – 978,698.70 kWh
Peak Demand – 1,787.10 kW

Load Factor = Energy Consumed / (Peak Demand * hours in the period)

Load Factor = 978,698.70 kWh / (1,787.10 kW * 31 days * 24 hours)

Load Factor = 978,698.70 kWh / 1,329,602.40 kWh

Load Factor = 0.74 or 74%

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How to Improve Load Factor?

The **higher the load factor the better**, but how do you get it closer to the 1 mark? Improving load factor is primarily about **controlling peak demand**. Lowering the peak demand will automatically help to increase the load factor percentage.

One way you can do this is by shifting some of your energy usage away from peak times. For example, you may want to shift your washing and drying of clothing to the late evening. A programable thermostat could also help by increasing your thermostat setting throughout the day when peak demand is high and then reducing it in the early evening. You'll be relieving the electric grid and your wallet at the same time.

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Peak Demand & Contracted Capacity

Demand is essentially the same as electrical power, although demand generally refers to the average power measured over a given time interval.

Peak Demand is the maximum demand experienced over a given time interval and is especially important in the way we purchase electricity.

Contracted demand/capacity is the amount of electric power that a customer demands from utility in a specified interval. It is the amount of electric power that the consumer agreed upon with the utility.

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Demand & Diversity Factor

Demand factor is the ratio of maximum demand to the connected load of the system. Demand factor is typically less than one.

Mathematically, demand factor is expressed as:

$$\text{Demand Factor (DF)} = \frac{\text{Maximum Demand}}{\text{Total Connected Load}}$$

Diversity factor is the ratio of sum of individual max demand to the max demand of the complete system. Diversity factor is usually more than one.

Mathematically, diversity factor is expressed as:

$$\text{Diversity Factor (DF)} = \frac{\text{Sum of Individual Maximum Demands}}{\text{Maximum Demand of the Complete System}}$$

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Demand & Diversity Factor

In summary, while **demand factor** focuses on the relationship between the maximum demand and the total connected load, **diversity factor** considers the variation in the simultaneous operation of individual loads within a system.

Both factors are essential for accurately sizing and designing electrical systems, but they address different aspects of load analysis and system planning.

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Demand-Side Management (DSM)

Electrical demand-side management (DSM) refers to a set of strategies and measures implemented by utilities or energy providers to control, influence, or manage the consumption of electricity by end-users.

The primary goal of DSM is to optimize the use of electricity resources, reduce overall energy consumption during peak demand periods, and improve the efficiency of the electrical grid. This helps to enhance grid reliability, minimize infrastructure costs, and mitigate environmental impacts associated with electricity generation.

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Demand-Side Management (DSM)

Key components and strategies of electrical demand-side management include:

Energy Efficiency Programs: Promoting energy-efficient technologies, appliances, and practices among consumers to reduce overall energy consumption.

Demand Response Programs: Incentivizing consumers to adjust their electricity consumption in response to signals from the utility or grid operator.

Time-of-Use (TOU) Pricing: Implementing pricing structures that vary based on the time of day, with higher rates during peak periods and lower rates during off-peak hours.

Smart Grid Technologies: Deploying advanced metering infrastructure (AMI), smart meters, and other grid management technologies to monitor, control, and optimize electricity distribution more effectively.

Distributed Energy Resources (DERs): Integrating decentralized energy resources such as rooftop solar panels, energy storage systems, and electric vehicle charging stations into the grid.

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Strategies for Cost Reduction

The following are some specific strategies that businesses and homeowners can implement to reduce the cost of their electrical systems:

- Conduct an energy audit. This will help to identify areas where energy is being wasted and opportunities for improvement.
- Upgrade to energy-efficient lighting. LED lighting is up to 90% more efficient than traditional incandescent lighting, and it lasts much longer.
- Install high-efficiency motors. Motors are used in a wide variety of equipment, from HVAC systems to industrial machinery. Upgrading to high-efficiency motors can save a significant amount of energy.

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Strategies for Cost Reduction

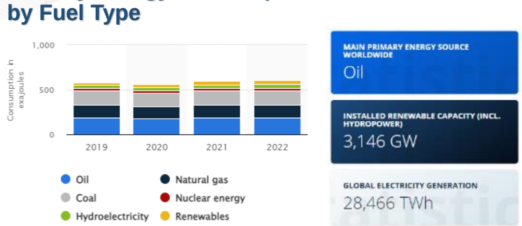
- Implement a power management system. This type of system can help to reduce energy consumption by automatically turning off lights and appliances when they're not in use.
- Use smart thermostats. Smart thermostats can learn your heating and cooling habits and adjust the temperature accordingly, which can save you money on your energy bills.
- Switch to renewable energy sources. Solar panels and wind turbines can generate electricity from renewable sources, which can help to reduce your reliance on the grid and save you money on your energy bills.

Benefits of Energy Efficiency

In addition to reducing costs, energy efficiency offers a number of other benefits, including:

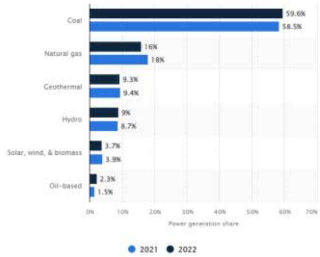
- Reduced environmental impact. Energy efficiency helps to reduce greenhouse gas emissions and other pollutants.
- Improved reliability. Energy-efficient systems are often more reliable and less prone to failure.
- Increased comfort. Energy-efficient systems can help to create a more comfortable environment for occupants.

Primary Energy Consumption Worldwide by Fuel Type



https://www.statista.com/markets/408/topic/436/energy/#overview

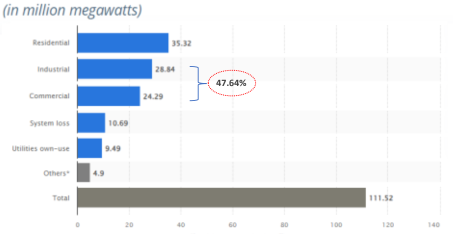
PH Power Generation Mix, 2021 & 2022 by Fuel Source



The energy sector in the **Philippines** is confronted with a significant challenge arising from the escalating power demand owing to population growth, rapid economic expansion, and a strong emphasis on digitalization. Despite efforts **to increase the utilization of renewable energy sources, fossil fuels, primarily coal,** continue to take up most of the power generation mix.

Total electricity consumption in the Philippines in 2022,

(in million megawatts)



https://www.statista.com/statistics/1266853/philippines-electricity-consumption-by-sector/

Top Energy Consuming devices

The top energy-consuming devices in the world vary across sectors, but some of the notable contributors include:

- **Data Centers**
- **Air Conditioning and Heating Systems**
- **Industrial Machineries**
- **Transportation**
- **Household Appliances**
- **Lighting**
- **Consumer Electronics**
- **Water heating systems**

Key Points

- Power factor correction (PFC) aims to improve power factor, and therefore power quality. It **reduces the load on the electrical distribution system**, **increases energy efficiency** and **reduces electricity costs**.
- Reduction in current for the same kW load by **improvement in power factor reduces load losses (I^2R losses)**.
- Energy-efficient motors are constructed with improved manufacturing techniques and superior materials; thus, they have **higher service factors**, **longer insulation and bearing lives**, **lower waste heat output**, and **less vibration**, all of which **increase reliability**.

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KNOWLEDGE REVIEW

1. The driving force that causes electrons to flow across a circuit ?
   a. Current
   b. Voltage
   c. Resistance

2. Type of electric current that flows in one direction through a circuit is ________ ?
   a. DC
   b. AC
   c. AC/DC

KNOWLEDGE REVIEW

3. ____________electric power is the distribution of a two-wire alternating current electric power using a system in which all the voltages of the supply vary in unison.
   a. Single Phase
   b. Three Phase
   c. Poly Phase

4. The reactive power is represented by what unit?
   a. kVA
   b. kW
   c. kVAr
   d. pf

KNOWLEDGE REVIEW

5. A power factor is the ratio of ____________?
   a. kW / kVA
   b. kVA / kW
   c. kVA / kVAr
   d. kVAr / kV

6. ___________a measure of the utilization rate or efficiency of electrical energy usage.
   a. Demand Factor
   b. Load Factor
   c. Peak Demand

KNOWLEDGE REVIEW

7. It is the maximum demand experienced over a given time interval.
   a. Demand Factor
   b. Contracted Demand
   c. Peak Demand

8. ___________ are distortions to voltage and current sine waves.
   a. Harmonics
   b. Power Factor
   c. Transients

THANK YOU!