Power Quality

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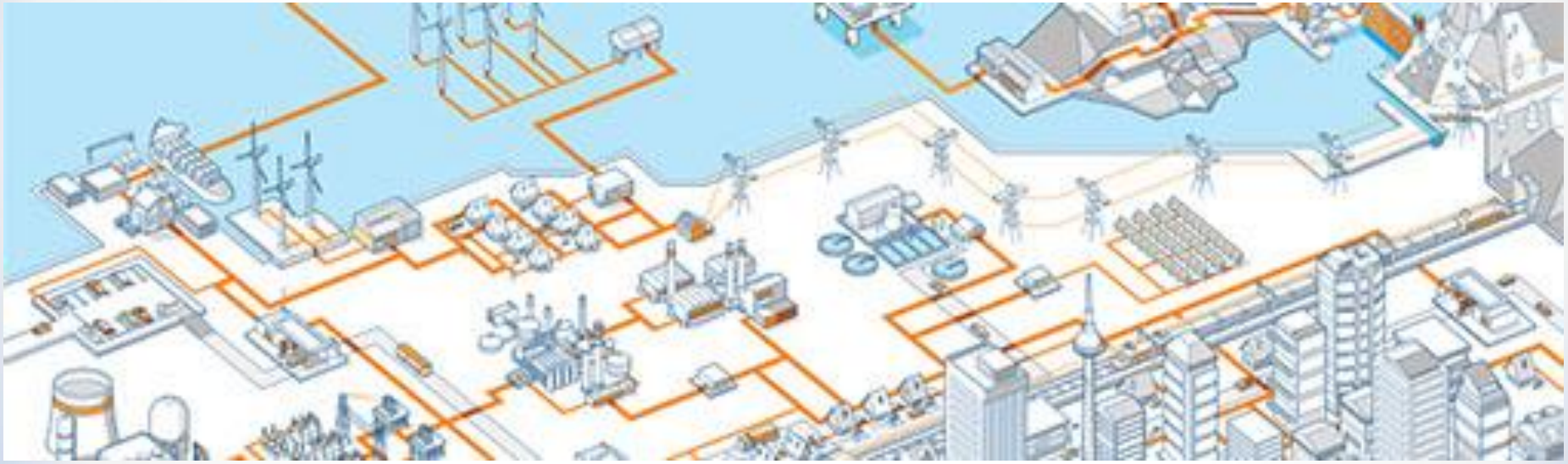

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Power Quality Introduction

- Access to power is fundamental for survival in todays society. Therefore its crucial to understand your sites power quality.

- Power quality can affect your triple bottom line
  - Economic Impact
    - Savings off your electricity bill
    - Improve longevity and efficiency of your equipment
    - Increase capacity without major infrastructure investment
  - Environmental Impact
    - By improving your power quality you are having a positive impact on the environment and adding value to your brand
  - Social Impact
    - By reducing the burden on your neighbours and local network you are actively engaging in the community and improving your social identity.

Power Quality Introduction

- Power Factor
  - Utilising power efficiently, leading to cost savings and better resource management
- Harmonics
  - Distortion in the network caused by non linear loads adversely affecting equipment and productivity
- Power Stability
  - Voltage sags, spikes, dips and outages
  - Needs to be looked at from a grid perspective first

PQ issues can contribute to equipment failure, production losses, safety concerns, increased carbon footprint, non compliance with utility regulations

Power Factor Correction:

What is Power Factor?

- Power factor is related to electrical efficiency
- Low power factor means poor electrical efficiency and a higher apparent power drawn from the electricity network
- Supply company needs to install & maintain larger generation capacity through transmission lines, cables, transformers & other distribution devices.
- This increased capital and operating cost is commonly transferred to the consumer through kVA tariffs.

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Power Factor Correction:

What is Power Factor?

- As a result electrical supply companies are driving a reduction in reactive loads in their network through improved power factor
- This is a key factor in the transition to cost reflective tariffs being pushed by the Australian Energy Market Commission
- Electricity users with poor power factor will be penalised with higher costs

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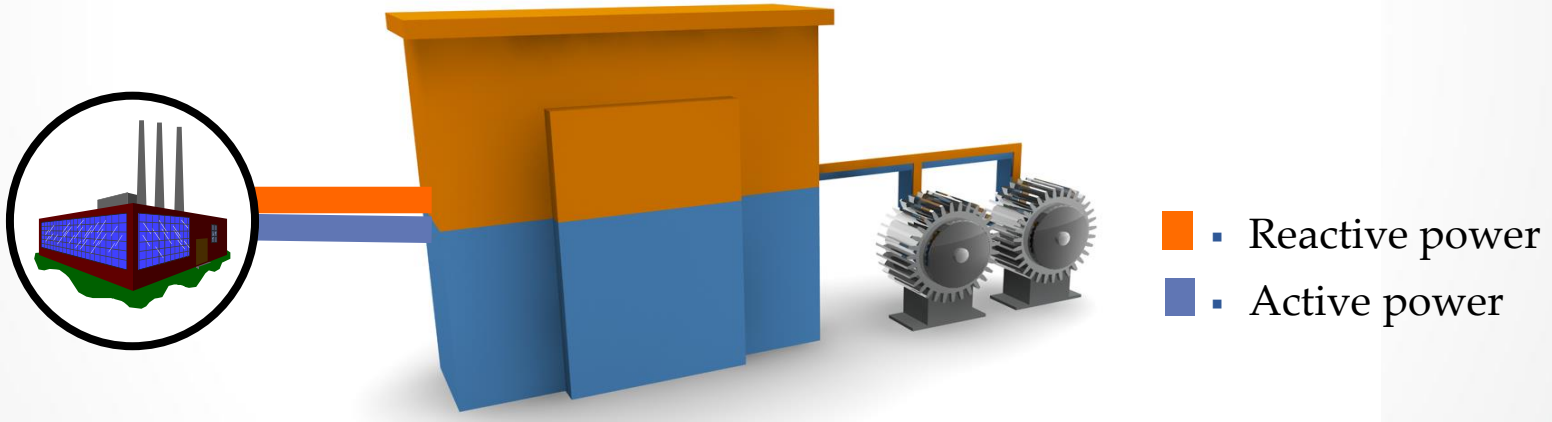
Power Factor Correction:

Inductive loads need active and reactive power

- All inductive loads require real power (kW) to do the actual work and reactive power (kVAr) to maintain the electromagnetic field.



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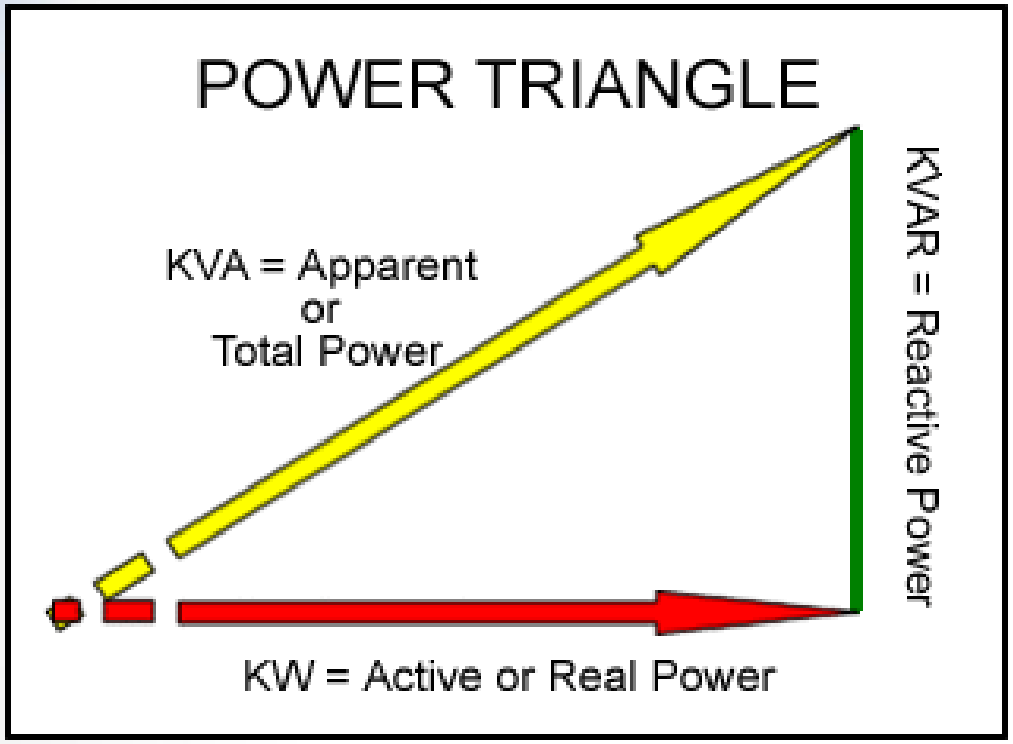
Power Factor Correction:



kW : Real Power

kVAr: Reactive Power needed to generate magnetic fields for inductive loads

kVA: Total Power – Resultant Apparent Power

Power Factor : The relationship between Real power (kW) and Apparent Power (kVA) consumed

$$\frac{Active\ Power\,(kW)}{Apparent\,Power\,(kVA)}$$

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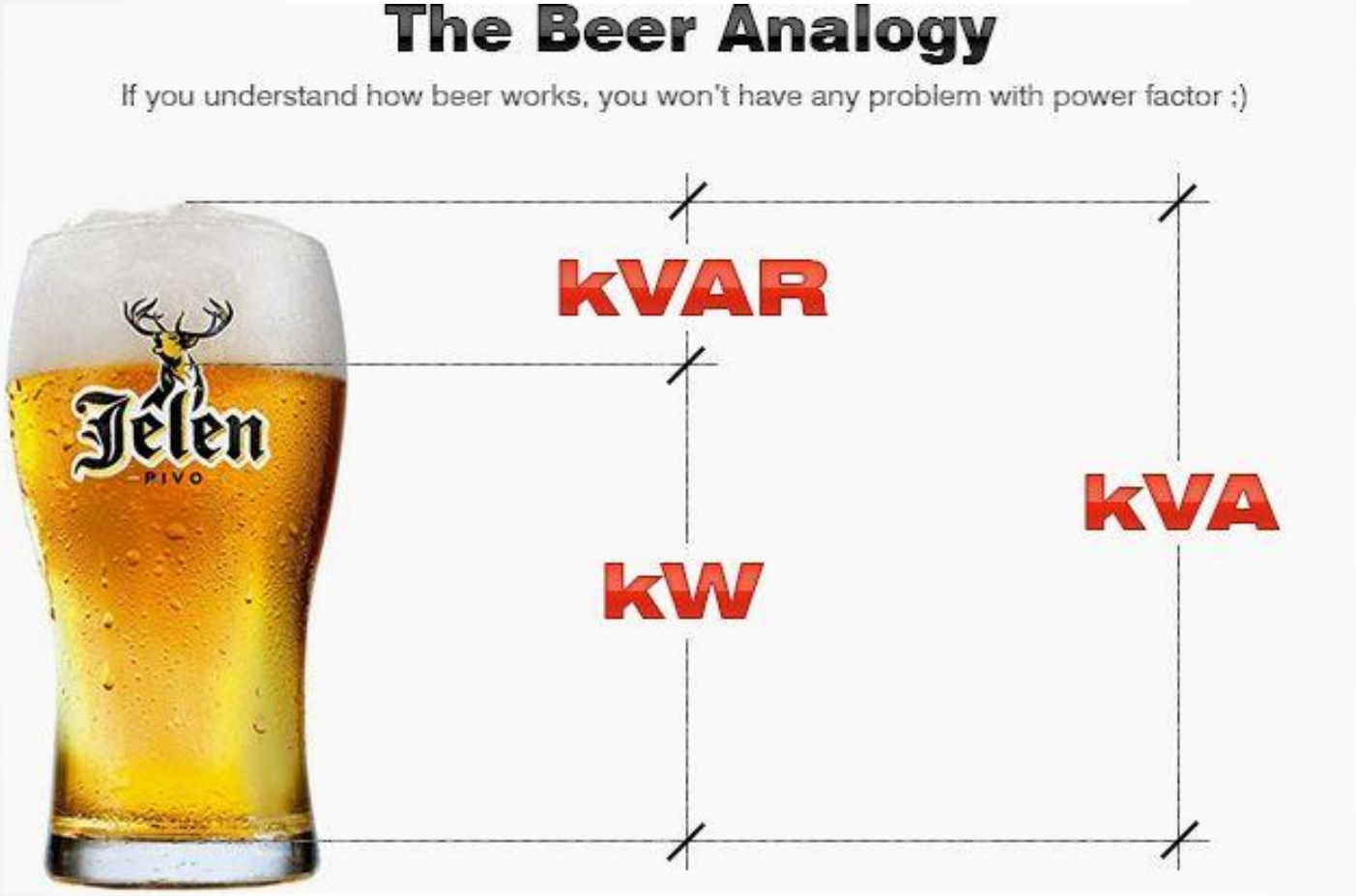
Power Factor Correction:



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Power Factor Correction:

Reactive Power Compensation (Q)

- A PFC unit supplies the reactive power needed by your site locally rather than relying on the energy supplier
- A PFC unit monitors your sites power usage and automatically turns on capacitor banks that supply the reactive power needed
    - Slow and fast changing loads must be considered when selecting PFC unit
- As with all electrical equipment there are variances of quality

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Power Factor Correction:

Equipment with reactive power requirement

- Transformers
- Induction Motors
- Fluorescent Lighting
- Welding Equipment

Component	Reactive power requirement
Transformer	Approx 0.05 kvar / kVA
Induction motor	0.5-0.9 kvar / kW
Fluorescent light	Approx 2 kvar / kW
Welding Equipment	0.3-0.7 kvar / kW

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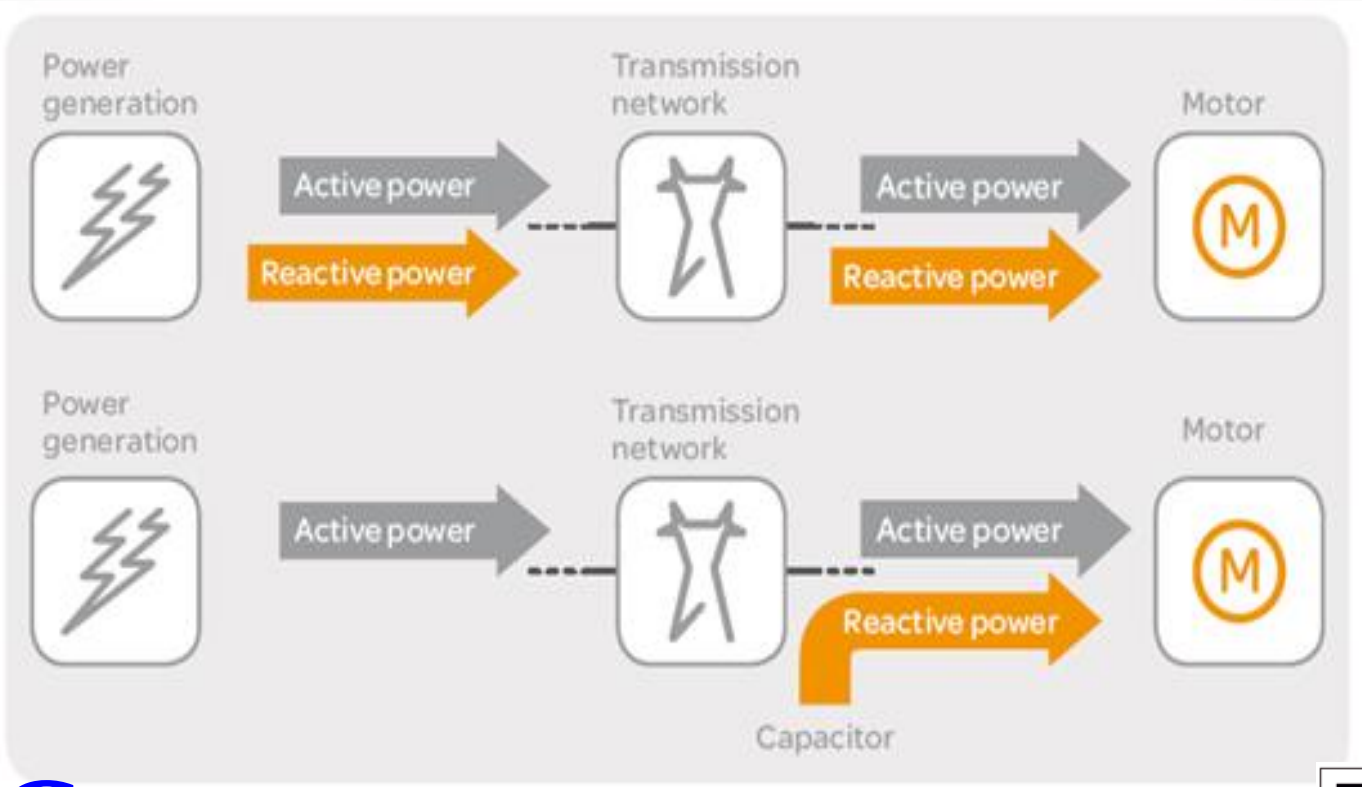
Power Factor Correction:

Reactive Power Compensation (Q)

- Capacitors can supply the reactive power needed locally



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Power Factor Correction:

Benefits

- **Reduce demand charges. Save on your electricity costs**
- Increase Capacity – this may allow the installation of additional equipment without upgrading the network
- Comply with Regulation
- Increase the life of your equipment
- Reduce your Carbon footprint

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Power Factor Correction:

AEMC transition to cost reflective tariffs

- AEMC ruling on distribution network pricing. "…the new pricing objective and pricing principles will start no later than 2017."
  - kVA tariffs to be introduced if not already
  - Essentially the ruling is to protect consumers from being overcharged
  - However consumers with poor efficiency will be penalised.
- Different business and usage classifications
- Price variations across the states and territories.
- Discuss with your electricity retailer

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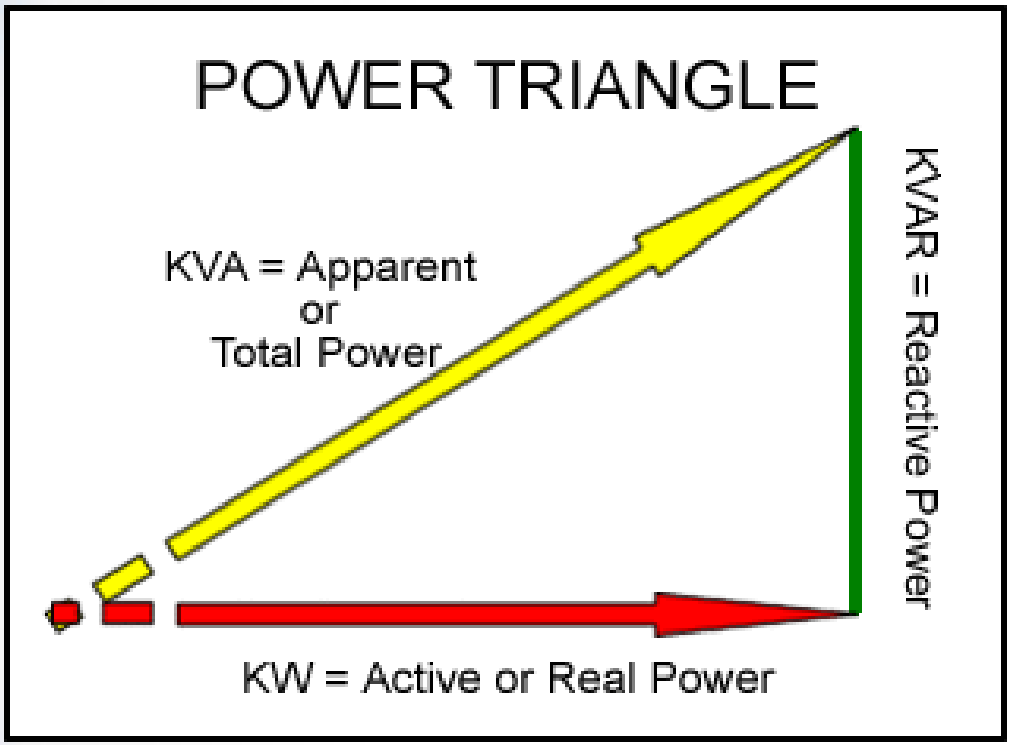
Power Factor Correction:

Cost Savings



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$$\frac{Active\ Power\ (kW)}{Apparent\ Power\ (kVA)}$$

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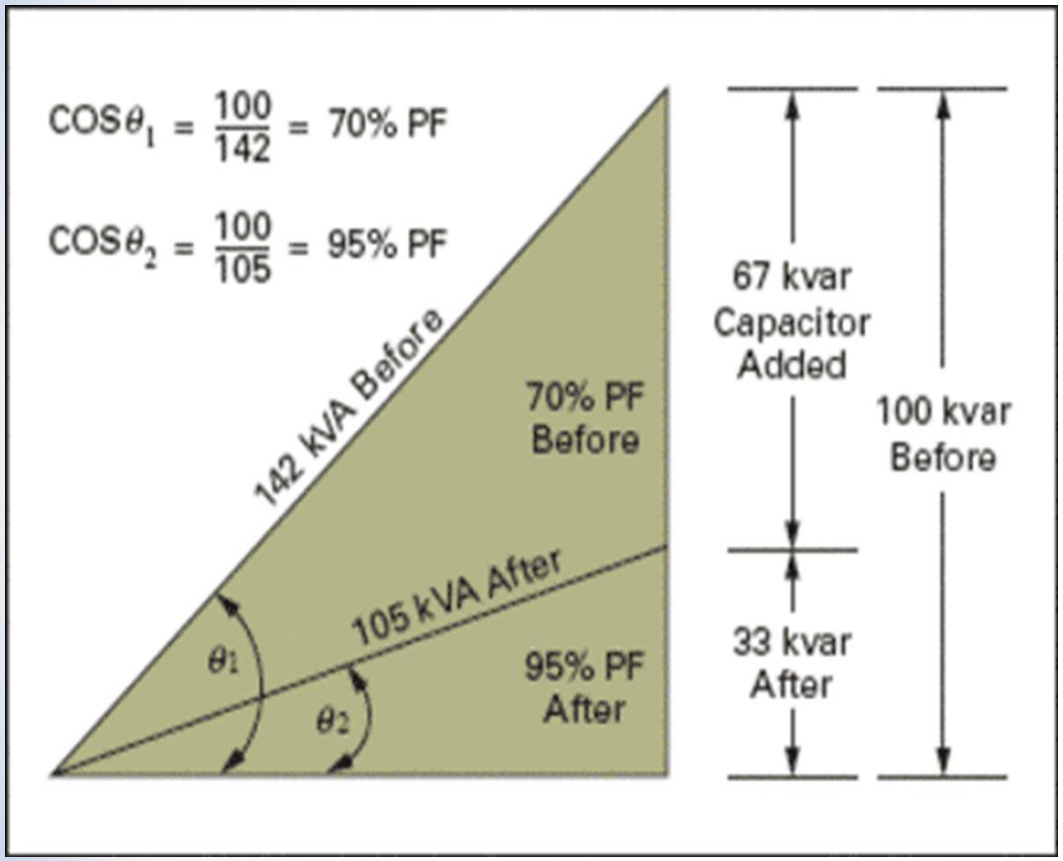
Power Factor Correction:

Cost Savings



kW : remains unchanged

kVA: 37kVA reduction. At $14/kVA per month that is over $500.00 savings

kVAr: 100kVAr supplied by the network now only 33kVAr needs to be supplied

Power Factor : Supplying 67kVAr locally improved PF from 0.7 to 0.9

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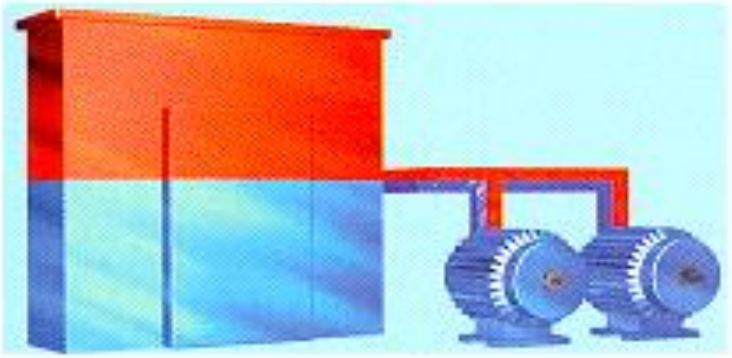
Power Factor Correction:

Increased Capacity

Without Capacitors/s



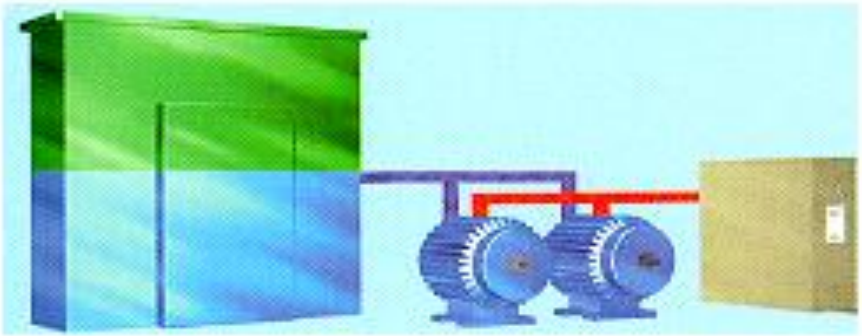
Transformer Motors

Reactive power

Active power

Increased transformer capacity

With Capacitor/s



Capacitor

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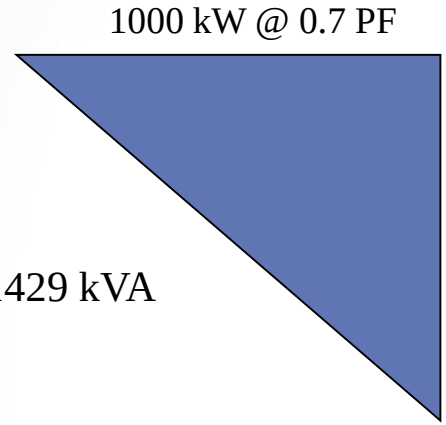
Power Factor Correction:

Increased Capacity kVA



1020KVAr

Recovered capacity
=0 kVA

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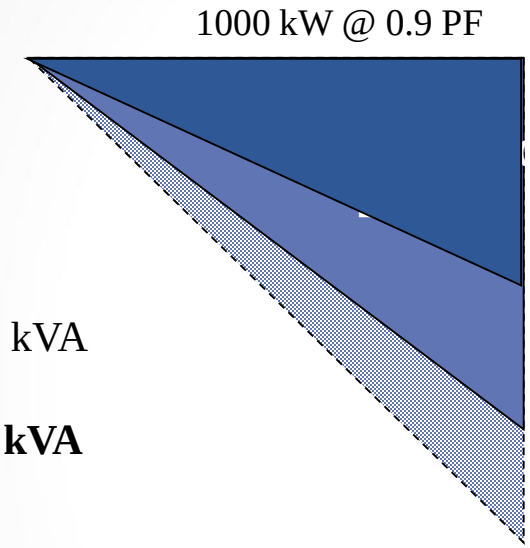
Power Factor Correction:

Increased Capacity kVA



Recovered Capacity =**318 kVA**
(22.19%)

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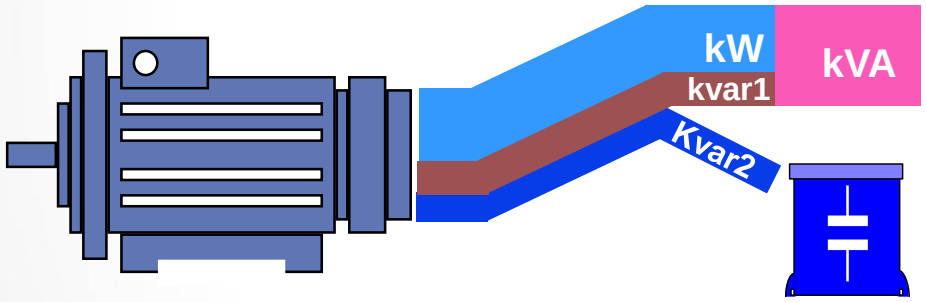
Power Factor Correction:

Increased Capacity kVA & A

- A consumer using 500 kW at a 0.5 power factor compared with a similar 500 kW consumer but , at a 0.98 power factor.



- 500kW load at 0.5 power factor
  - 1000 kVA
  - 1391 A
- 500kW load at 0.98 power factor
  - 510 kVA
  - 710A

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Power Factor Correction:

Design and considerations:

- **The target power** factor should be between 0.95 to 1 depending on the size, costs and environment
- Current usage including maximum demand and load cycle.
- Customers are often billed according to peak demand not usage
- Environment, i.e Location, Ambient temp, Dust, other air particles
  - Units must be periodically serviced to ensure longevity
  - Should have a 20 year life span

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Power Factor Correction:

Design and considerations:

- Electrical considerations:
  - Circuit Breaker availability /sizing. Can be within PFC unit or on main board. Must comply
  - Type and size of loads
  - Point of connection (close to load) and measurement (CT location)
- Harmonics
  - Harmonics present on site can cause damage to PFC unit
  - Causes electrical disturbance through heat, nuisance tripping, light flickering etc
  - PFC can measure harmonics and alarms can be set if harmonic limits are exceeded.

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Power Factor Correction:

What are harmonics?

- Harmonics are caused by non linear loads such as variable speed drives
- Currents flow out of the individual loads at frequencies higher than the 50 Hz fundamental
- These currents are known as Harmonic Currents they flow thru the connecting cables and produce a harmonic Voltage at the same frequency.
- This boost in voltage can cause damage to the capacitors in the PFC unit

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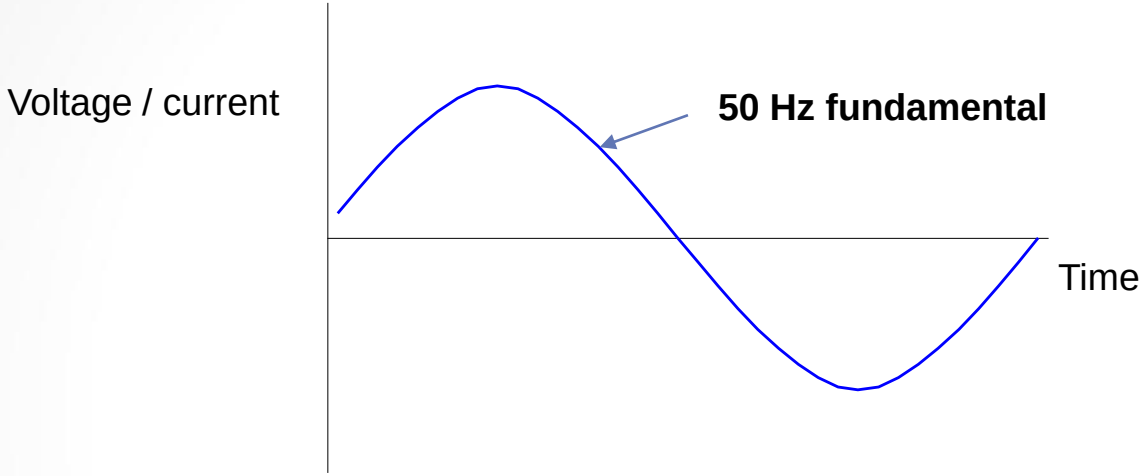
Power Factor Correction:

What are harmonics?



Sinusoidal 50 Hz wave form

In reality pure 50 Hz sin waves are rare,
Networks are polluted with harmonics.

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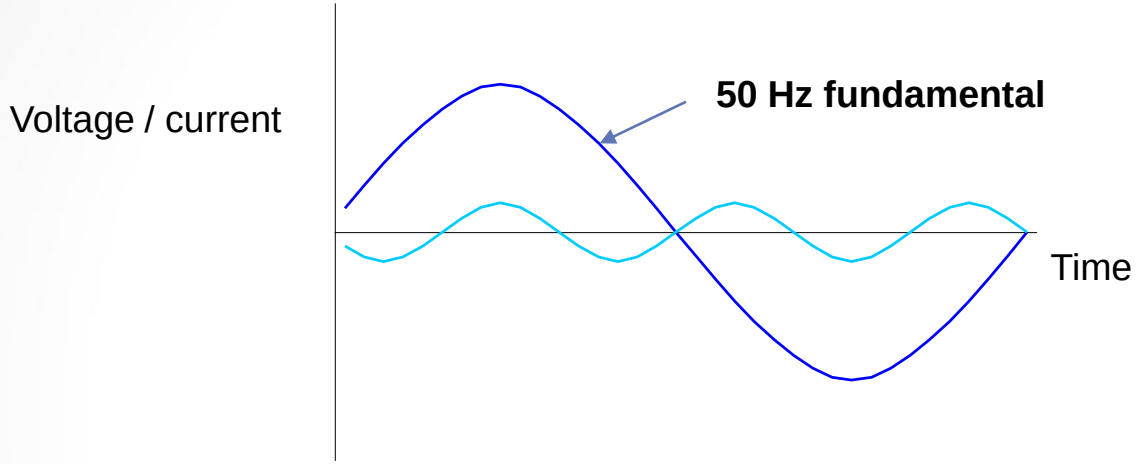
Power Factor Correction:

What are harmonics?



Sinusoidal 50 Hz wave form with 3rd harmonic

This sin wave has a frequency of 150 Hz and is referred to as the third harmonic.

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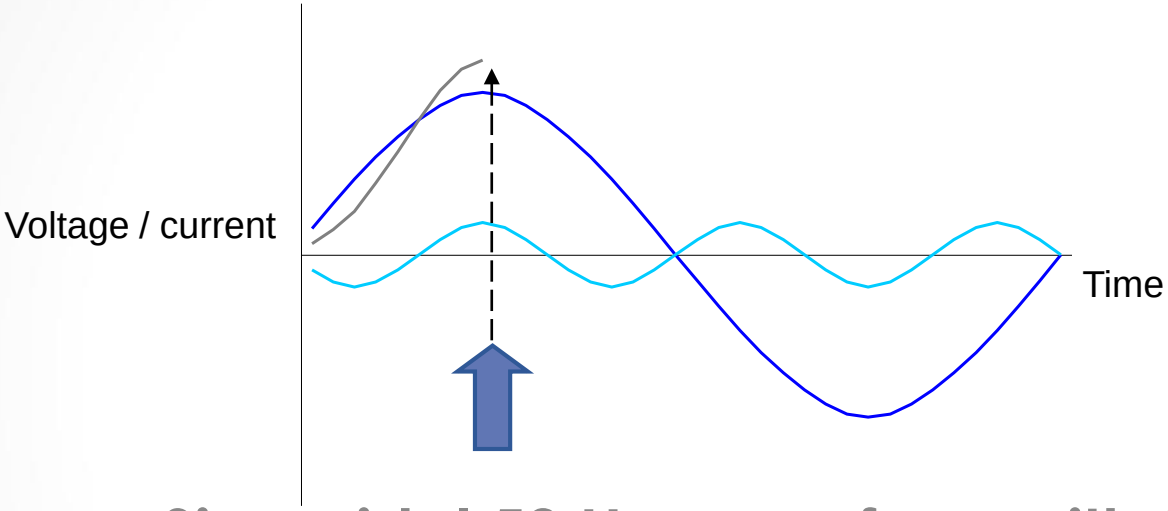
Power Factor Correction:

What are harmonics?



Sinusoidal 50 Hz wave form with 3rd harmonic and resultant

The result will be the sum of two waves at any instance.

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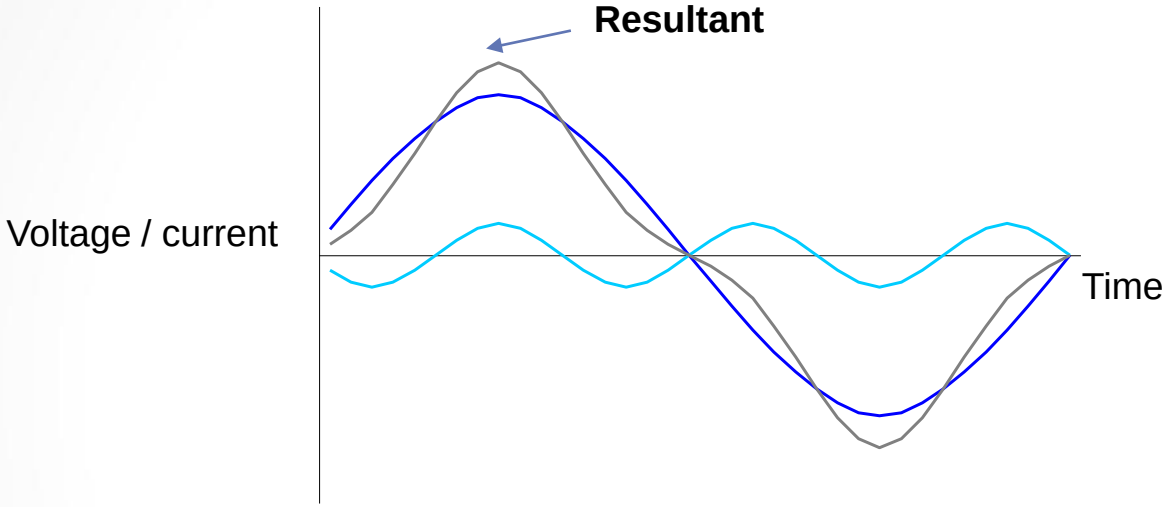
Power Factor Correction:

What are harmonics?



Sinusoidal 50 Hz wave form with 3rd harmonic and resultant

The resultant will become more complex if several harmonics are present.

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Power Factor Correction:

Effects of harmonics

INCREASING LOSSES

DECREASING EQUIPMENT LIFE TIME

- Overheating of transformers, cables, motors, capacitors and other devices
- Tripping of circuit breakers
- Fuses blowing
- Overloading capacitors
- Interference or damage of electronic equipment
- Premature ageing of equipment

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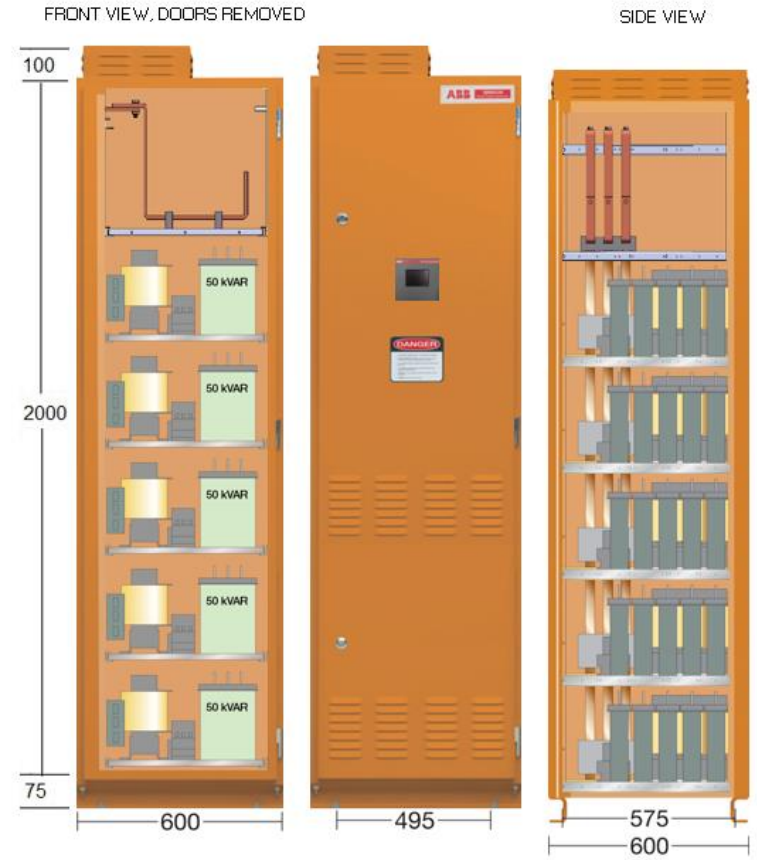
Power Factor Correction:

Components - Cubicle



- Indoor or outdoor installation
- Space available for installation
- Isolation
- Number of stages
- Cable entry
- Environment – extra protection for dust/particles etc

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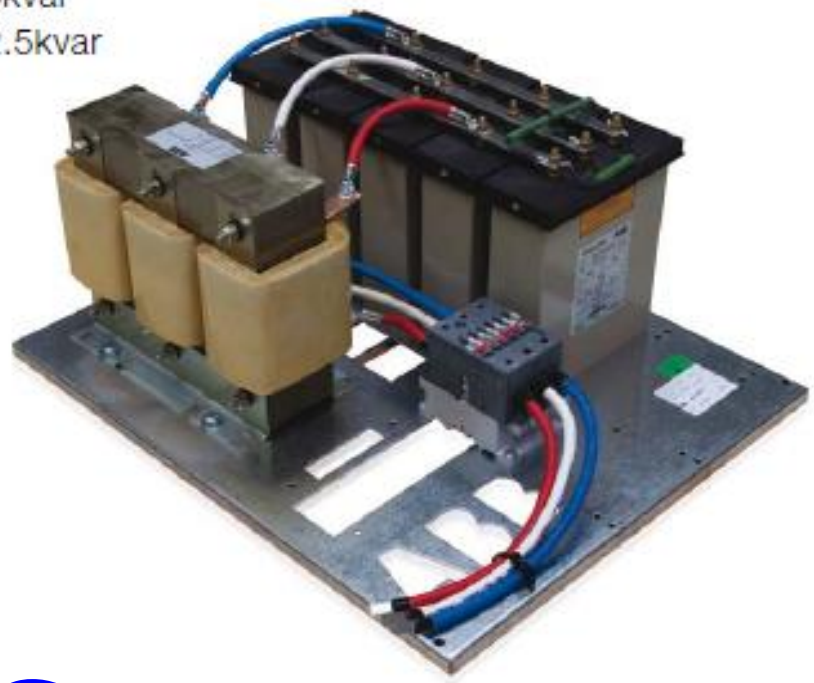
Power Factor Correction:

Components – Step sizes

Standard step size

- 50kvar
- 25kvar
- 12.5kvar



- Capacitors
- Reactors
- Contactor
- Cabling and fuses

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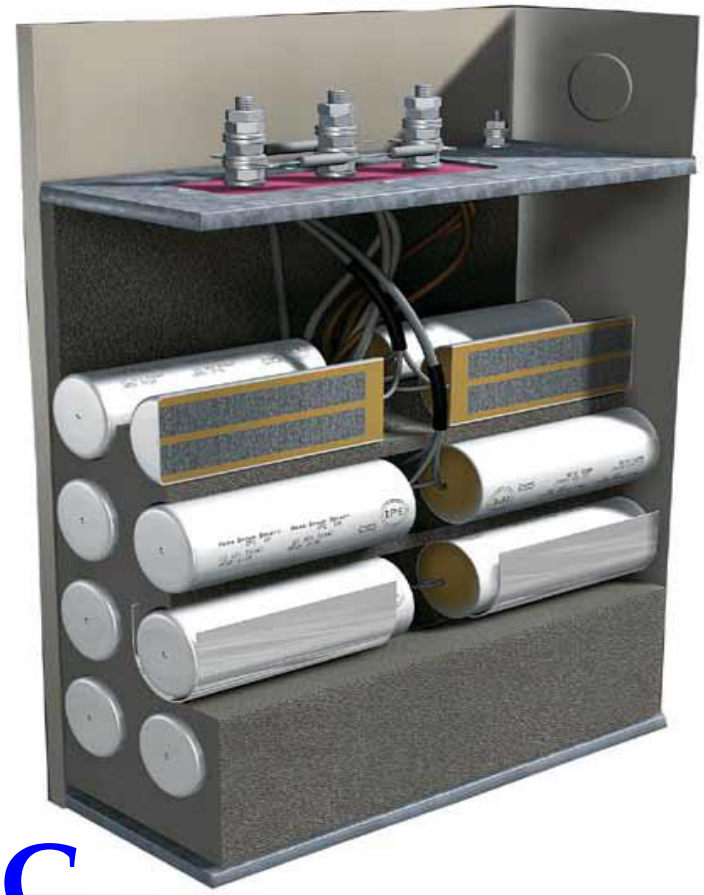
Power Factor Correction:

Components – Capacitors



- Discharge resistors – dissipate stored energy
- Self healing dielectric - A failed element means loss of only one element (i.e. only a small part of the capacitor is lost)
- Fire protection. Good quality capacitors should be surrounded by vermiculite which is a fire proof and non toxic granular material. In the event of any failure the vermiculite absorbs safely the energy produced within the capacitor box and extinguishes any possible flames.
- Should be rated at 525V to withstand voltage fluctuations

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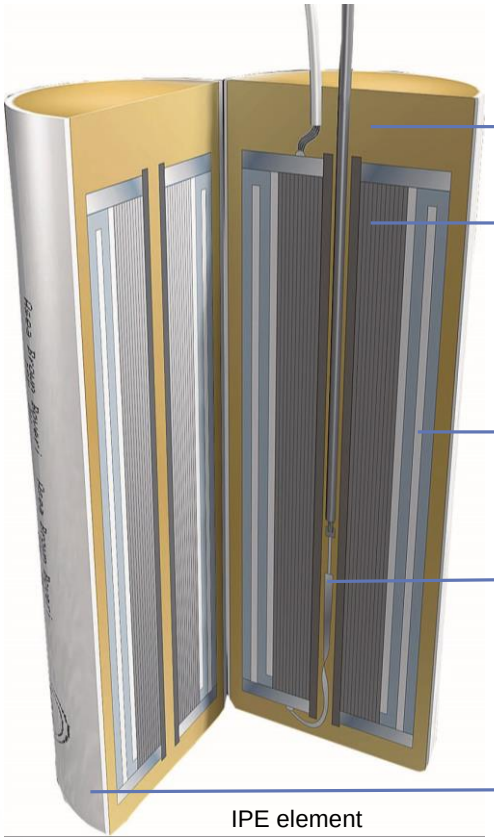
Power Factor Correction:

Components – Capacitors



Resin encapsulation for perfect insulation

In-house metalized polypropylene film for superior robustness

Secondary foil for unique thermal protection

Internal fuse for fast and safe electrical disconnection

Plastic case

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Power Factor Correction:

Components – Reactor and contactors

Detuning Reactors (Also known as blocking reactors) -
Protecting the capacitors against higher frequency voltages

Suitably rated contactors – sized to withstand a permanent current that can reach 1.5 times the nominal current of the capacitor bank
- The short but high peak current on pole closing
- High number of operations

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Power Factor Correction:

Automated controllers

- Monitor the load through a CT
- Smart switching automatically turn on capacitor banks
- Things to consider:
  - Ease of commissioning
  - Measurement and display of Voltage, Current, Power Factor, ThiD and THvD
  - Event and Alarm logging
  - Communication features

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Power Factor Correction:

Commercial and Operational business case

- **Return on investment**
- PFC installation aims for a ROI of less than 3 years
- Increase capacity and electrical efficiency
- Power Factor Correction applies to most installations other than Residential.
- Free power analysis

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