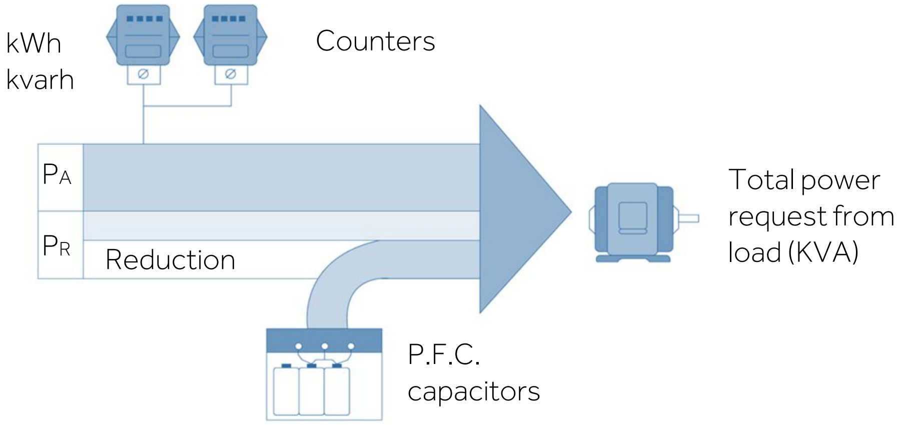
Power Factor

Consider an alternating current circuit, consisting of an electrical power source and a load: the voltage and current waveforms are of a sinusoidal type.
For its operation, the load consumes active energy (kWh), necessary to produce work and reactive energy (kvarh) that does not contribute to the performance of the work, but causes an increase in unwanted consumption.



Most of the loads, in today's electrical distribution systems, are inductive, requiring two types of power:

- **Active Power (P_A)** that performs the work of the machine (eg mechanical, hydraulic, ...) and is measured in kW (kilowatt);

- **Reactive Power (P_R)** which constantly flows towards the load and then returns to the source and is measured in kvar (kilovolt-ampere reactive).

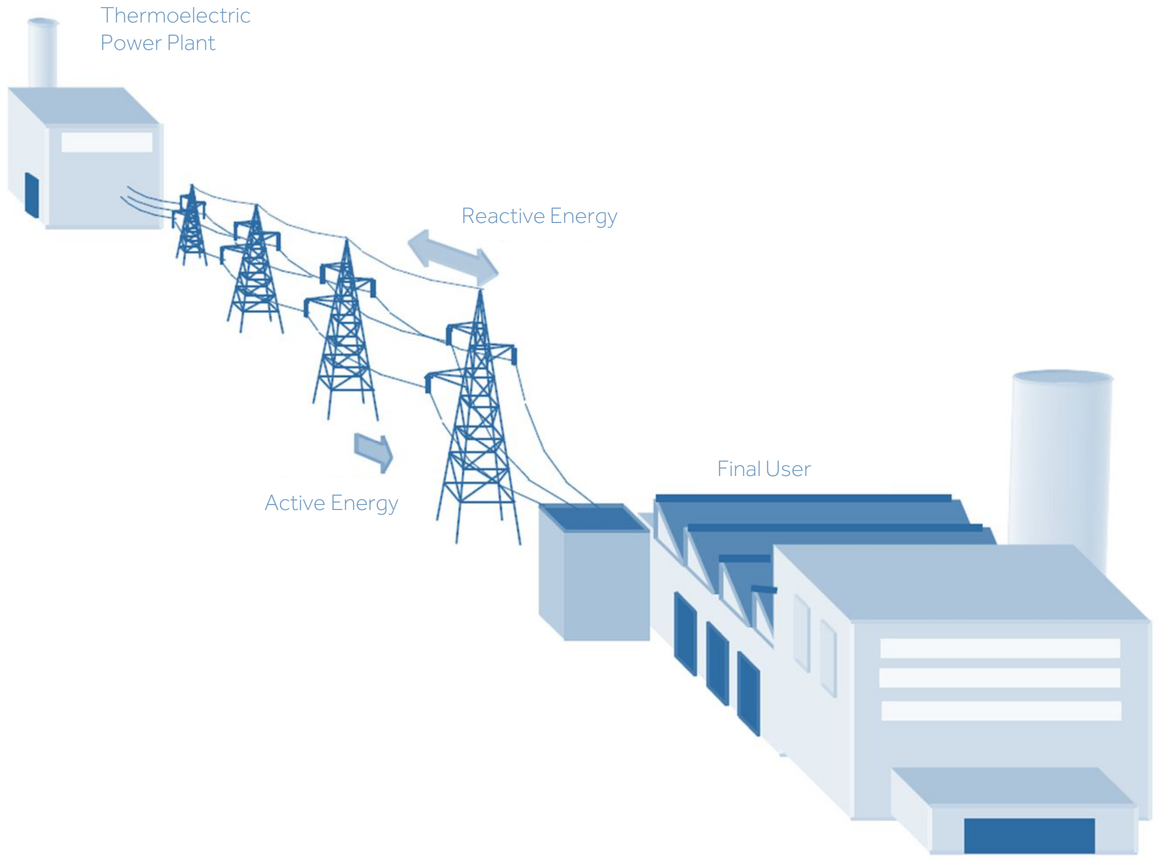
Active Power and Reactive Power constitute the **Apparent Power** that is measured in kVA (kilovolt ampere). **Power Factor (cosφ)** is simply the ratio between Active Power and Apparent Power:

$$\cos\varphi = \frac{kW}{kVA}$$

A high Reactive Power leads to an increase in the problems of managing electrical systems; the main ones include the need to oversize transformers, cables and other elements in the power supply circuit as a result of increased heating and voltage drop. This causes an increase in installation costs.

The solution to these problems is given by the **Power Factor Correction**: a measure to improve the power factor of a load, in order to reduce the value of the current flowing on the network to the same active power (kW). Re-phasing, therefore, means **decreasing the reactive power absorbed by the load** that passes through a certain section of the network, until it is canceled at **cosφ = 1.00**.

Energy distributor impose a minimum limit to cosφ in order to reduce the circulation of reactive energy along the power lines.



The maximum possible power factor is 1.00, which means that 100% of the power delivered to the load is the active power converted into useful energy. Any value less than 1.00 indicates that the load supply system must be oversized.

Traditionally, concern for the power factor has been almost exclusively linked to the use of induction motors. Today, however, this is extended to other non-linear loads, such as power electronic devices (e.g. variable speed drives, uninterruptible power supplies), induction furnaces, arc welding machines, ...

Why is P.F.C. important?

Electric capacitors are one of the most cheap and simple sources of energy saving currently known, which allow both the distributor and the company to save money.

Power factor correction determines a **rational use of electric power**, reducing the undesired effects of load currents such as motors, transformers, etc., and **losses due to the joule effect** in the cables and devices (switches, transformers) present on the energy transport system.

The additional costs that would be incurred, without P.F.C., are so high that they determine a return on investment of 12/15 months. Indeed, increasing the power factor of electrical systems offers the following advantages:

Reduction of the costs of electric users

The difference between active and apparent power forces the electricity supply company to supercharge the distribution system: the penalties therefore want to incentivize the customer to improve the low power factor.

Increased available power

By reducing the kvar demand on the load side and installing the capacitors, the maximum power that can be supplied by the generators and transformers is available.

Improvement of the voltage

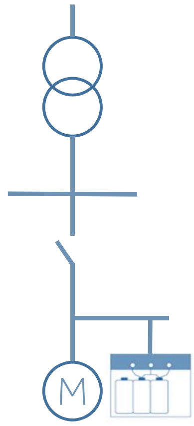
The demand for high load kvar increases the voltage drops between the transformers, cables and other system components, with a consequent reduction and flickering of voltage at the equipment.

Reduction of losses due to cable heating

The circuit current is reduced in direct proportion to the increase of the power factor, the I^2R loss or the resistive loss in the circuit is inversely proportional to the square of the current.

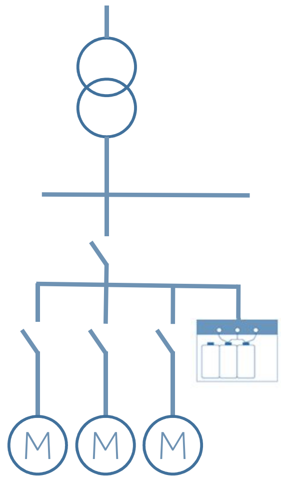
Distributed power factor correction

The power factor correction equipment is installed close to the individual loads and sized for the required reactive power. Considering that the effect of the capacitors is affected upstream of the installation point, it is the ideal solution to compensate for high inductive currents.



P.F.C. of groups of loads

Automatic systems, guarantee the P.F.C. of several users, following the request for reactive energy. For high power users, the choice of correcting locally large loads and centrally the remaining power, is usually the most advantageous technical-economic solution.



Centralized power factor correction

Installation of a single automatic panel, typically at the transformer or energy delivery point, is the most used and the easiest solution to implement.
It is ideal for small and medium-sized companies and the savings for the user are directed essentially to the elimination of the penalties on the bills.