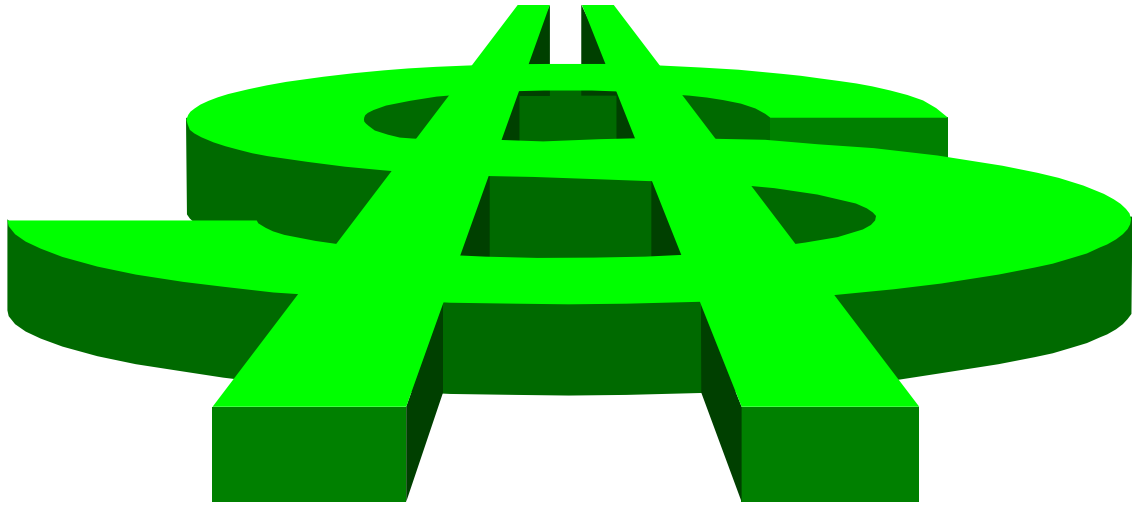
Power Factor Fundamentals

Federal Pioneer
Merlin Gerin
Modicon
Square D
Telemecanique



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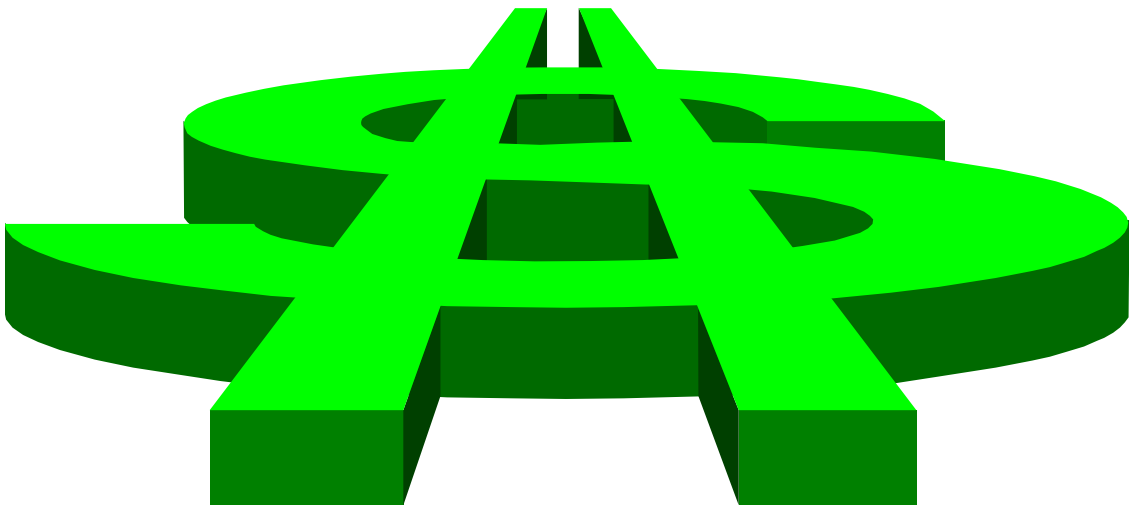
What we will learn:

- Most Industrial loads require both Real power and Reactive power to produce useful work
- You pay for BOTH types of power
- Capacitors can supply the REACTIVE power thus the utility doesn't need to
- Capacitors save you money!

Why Apply PFC's?

- **Power Factor Correction Saves Money!**
  - » Reduces Power Bills
  - » Reduces I^2R losses in conductors
  - » Reduces loading on transformers
  - » Improves voltage drop

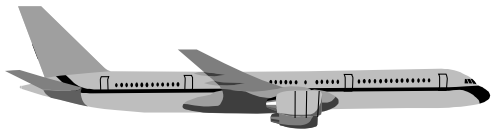


What is PF ?

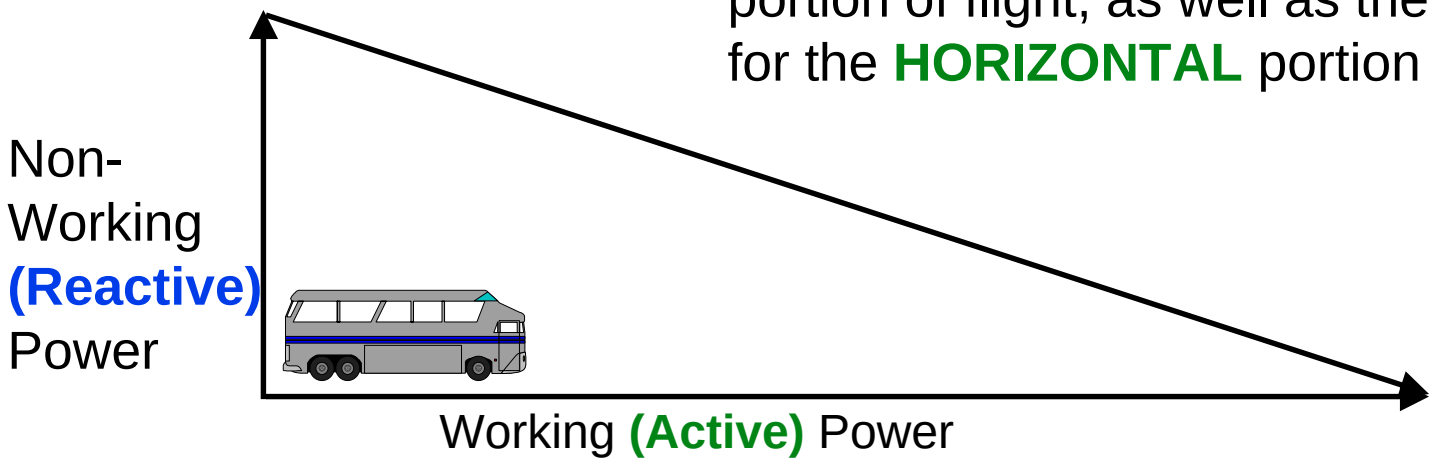
- **Introduction:**
  - » Most plant loads are *Inductive* and require a magnetic field to operate:
    - – Motors
    - – Transformers
    - – Florescent lighting
  - » The magnetic field is necessary, but produces no useful work
  - » The utility must supply the power to produce the magnetic field and the power to produce the useful work: You pay for all of it!
  - » These two types of current are the **ACTIVE** and **REACTIVE** components

The Basics:

The Power Triangle:



You pay for fuel for the **VERTICAL** portion of flight, as well as the fuel for the **HORIZONTAL** portion of flight.



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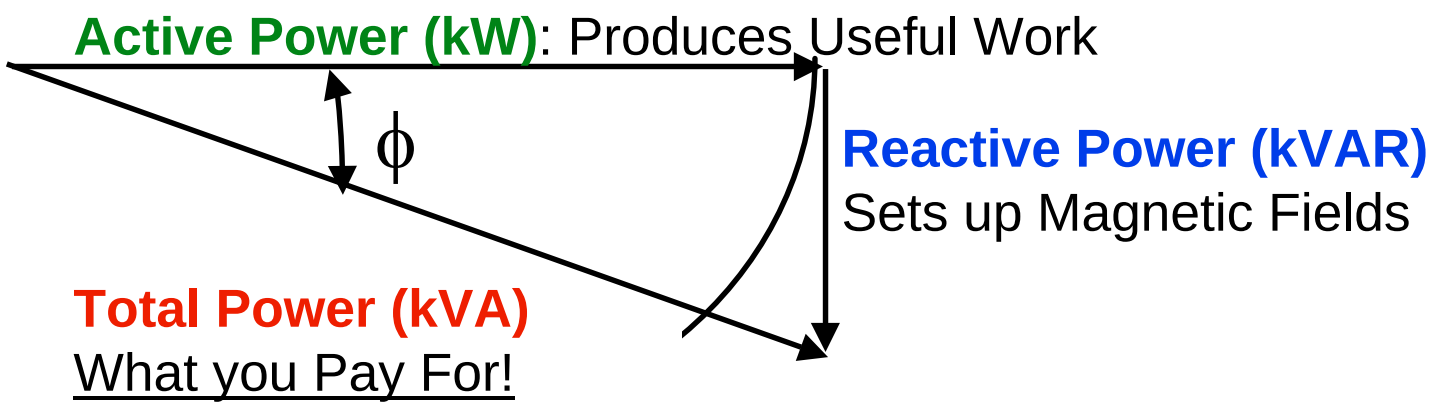
ReactiVar ENGINEERED CAPACITOR SYSTEMS

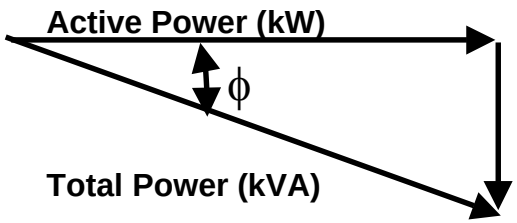
The Power Triangle:

- **Similarly, motors require REACTIVE power to set up the magnetic field while the ACTIVE power produces the useful work (shaft horsepower). Total Power is the vector sum of the two & represents what you pay for:**



The Power Triangle:

- **Power Factor is the ratio of Active Power to Total Power:**

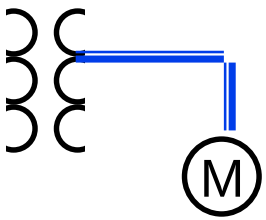


$$\text{Power Factor} = \frac{\text{Active (Real) Power}}{\text{Total Power}} = \frac{\text{kW}}{\text{kVA}} = \text{Cosine } (\theta)$$

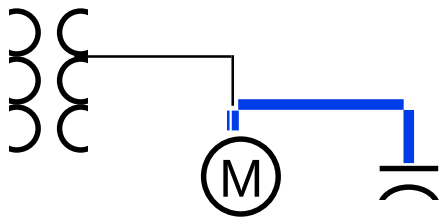
- **Power Factor is a measure of efficiency (Output/Input)**

Why do we Install Capacitors?

- **Capacitors supply, for free, the reactive energy required by inductive loads.**
  - » You only have to pay for the capacitor !
  - » Since the utility doesn't supply it (kVAR), you don't pay for it!



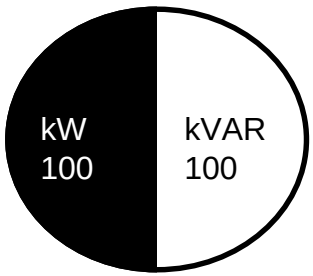
Utility Supplies Reactive Current



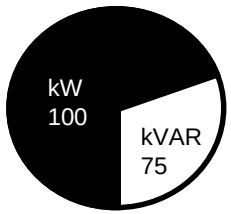
Capacitor Supplies Reactive Current

Other Benefits:

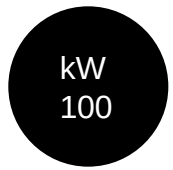
- **Released system capacity:**
  - » The effect of PF on current drawn is shown below:



kVA = 141
PF = 70%



kVA = 125
PF = 80%



kVA = 100
PF = 100%

- ❑ **Decreasing size of conductors required to carry the same 100kW load at P.F. ranging from 70% to 100%**

Other Benefits:

- **Reduced Power Losses:**
  - » As current flows through conductors, the conductors heat. This heating is power loss
  - » Power loss is proportional to current squared ($P_{Loss}=I^2 R$)
  - » Current is proportional to P.F.:
  - » Conductor loss can account for as much as 2-5% of total load
- **Capacitors can reduce losses by 1-2% of the total load**

$$\% \text{ Loss Reduction} = 100 \times 1 - \frac{(\text{Original P.F.})^2}{(\text{Desired P.F.})^2}$$

Other Benefits:

- **Voltage Improvement:**
  - » When capacitors are added, voltage will increase
  - » Typically only a few percent
    - – Not a significant economic or system benefit

Severe over-correction (P.F.>1) will cause a voltage rise that can damage insulation & equipment; or result in utility surcharges!

- – Usually a result of large fixed capacitors at mains

$$\% \text{ Voltage Rise} = \frac{\text{Capacitor kVAR x XFMR \%Z}}{\text{XFMR kVA}}$$

Summary of Benefits:

- **Reduced Power Costs**:
  - » Since Capacitors supply reactive power, you don't pay the utility for it
  - » You can calculate the savings
- **Off-load transformers**
  - » Defer buying a larger transformer when adding loads
- **Reduce voltage drop at loads**
  - » Only if capacitors are applied at loads
  - » (minimal benefit at best)

What we learned..

- Most Industrial loads (i.e. motors)are Inductive and draw REACTIVE power
- The Utility supplies this energy therefore you pay for it
- Power Factor Capacitors supply REACTIVE energy thus the utility doesn't need to
- Power Factor Capacitors save money
- There are other benefits to correcting power factor,
  - » reduced heating in cables
  - » reduced heating in transformer(s)
  - » frees up system capacity