Power factor correction devices: Can they really reduce your electricity bill?

Mohit Arora - June 01, 2012

So-called "Power Saver Devices" (known by different names) are nothing but Power Factor Correction (PFC) devices that would connect to the mains and improve power factor measured by your electricity meter. However it is important to note that utilities bill a residential user based on real power that does not factor in Power factor and thus none of these devices would really reduce your monthly bill.

The so-called "Power Saving" device may be useful for industrial applications, where utilities charge the user based on PFC rather than real power.

How is Power measured?
Power measured in Watts (W) and Volt-Ampd (VA) is often used interchangeability and is often considered to the same. This is far from true in a practical scenario:

Real Power (W) = Voltage (V) x Current (I) over time.

Note that Real power is measured in Watts (W) and represents the actual work done by an electric current or actual energy consumed by a load.

Electrical systems usually have inductors and capacitors, which are referred to as reactive components. So this specific power is the Reactive power and measured in Volt-Amps-Reactive (VAR). The combination of real (active) power, and reactive power makes up apparent (or total) power, measured in Volt-Amps (VA).

Understanding Power Factor
Power Factor (PF) by definition is the ratio of real power to apparent power:

Power Factor (PF) = Real Power (Watts) ÷ Apparent Power (VA)

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Power \ Factor = \frac{RealPower(Watts)}{ApparentPower(VA)}
\]

People often convert Watts to VA (Watts = VA), which is not true unless the Power Factor of a device is 1.

For the purely resistive circuit - for example, an incandescent light bulb - the power factor is 1 because the reactive power equals zero.

Power factor can be an important aspect to consider in an AC circuit; because any power factor less
than 1 means that the circuit’s wiring has to carry more current than what would be necessary to deliver the same amount of (true) power.

Let’s consider two motors with the following characteristics.

Motor 1: 2KW, 230V, PF = 0.7 Motor 2: 2KW, 230V, PF = 1

Current dissipated in both the motors would be as follows

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\text{Motor 1}(I) = \frac{(2KW)}{(230V \times 0.7)} = 12.4A \\
\text{Motor 2}(I) = \frac{(2KW)}{(230V \times 1.0)} = 8.69A
\]

From above, it is clear that Motor 1 with poor power factor needs to carry more current for the same power, though overall power consumption (2KW) is the same in both cases.

Usually electrical equipment with a non-resistive load has a power factor of less than 1. As an example, CFL (compact fluorescent lamp) bulbs have a Power Factor of between 0.5 and 0.7, depending on maker and wattage, while incandescent light bulbs have a power factor of 1.

Note that what a residential consumer is billed is for real power and not for reactive power that is a result of power factor, so a CFL usage is, purely from an electrical consumption point of view, good for the consumer but bad for the power company. In the home the amount of power consumed for the same level of lighting is highly reduced. The utility must transport the power to the home and if the reactive power gets higher it means more losses in the lines and transformers, etc., along the way.

Electric motors, fluorescent lamps, refrigerator, air conditioning and consumer electronics (such as televisions and computers) are examples of appliances that have power factors of less than one. This is because they include some type of storage element such as a capacitance or inductance.

**Power Factor Correction**

So a power factor correction device typically includes nothing but a capacitor that is to be connected in parallel as the additional load. The effect of these two opposing reactances in parallel is to bring the circuit’s total reactive power close to zero.

This correction, of course, will not change the amount of true power consumed by the load, but it will result in a substantial reduction of apparent power, and of the total current drawn from the 230 Volt source.

This is the principle behind most of the Power Saver devices available in the open market. As explained earlier, this does not impact the real power, and since residential consumers are billed on real power this has no impact on the monthly bill.

Even though a PFC device may not reduce the electricity bill, it does not change the fact that inductive loads run more efficiently with corrected or at least improved power factors and thus means less wear and tear of the appliance (i.e., the motor since current drawn by the motor is reduced), improving product life.
One situation where PFC can be extremely useful for residential situations is in the design of a backup energy system like a Home Inverter or UPS (Uninterruptible Power Supply). Correcting the power factor from 0.65 to 1 results in a 35% reduction in the size (VA rating), thus a less expensive inverter can be chosen though power consumption remains the same.

In homes today, and particularly since Energy Star-rated appliances have hit the market, motor driven appliances like air conditioners already have an appropriate sized capacitor attached to them.

Energy Star products not only define maximum real power an appliance can draw in various modes but also define the minimum power factor the appliance must satisfy to get Energy Star certification. For example, Energy Star version 5.1 for game console/computer requires power factor to be greater than 0.9 at 100% rated output, or maximum rated output of less than 75W to be able to meet the requirements.

By purchasing another PFC and connecting it to your electric meter, you are basically adding a redundant device into your home than your appliance can use, so there is really no monetary savings by doing so and is certainly a marketing gimmick.

I would like to hear from the tech/engineering community if they think otherwise? Are there any cities/states that bill residential users on KVA, charging them for reactive power? Is the trend expected to change in the future with residential locations being billed for reactive power?