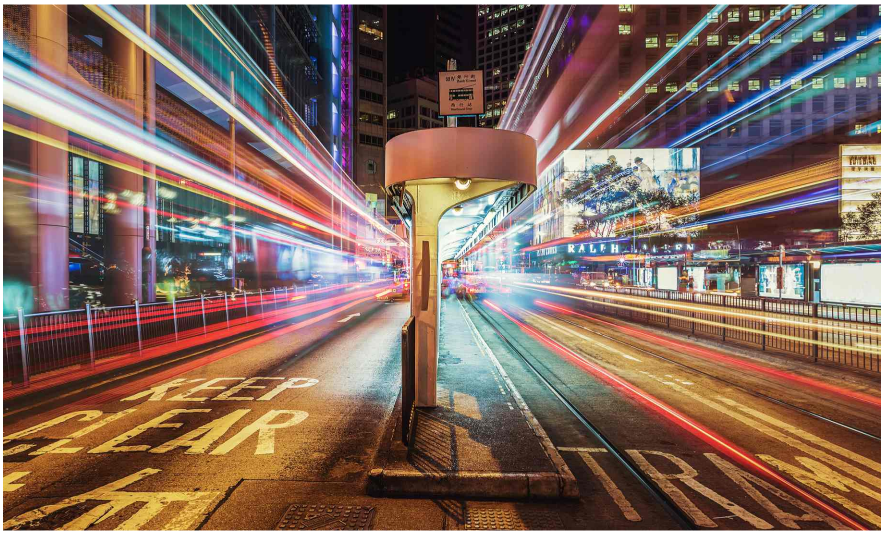

The Principle of Power Factor Correction

功率因数校正原理

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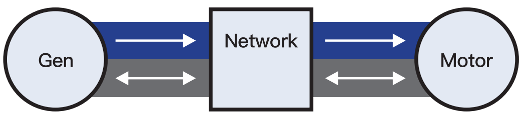
How Reactive Power Originates

Many electrical devices, such as AC single-phase and 3-phase motors, require both active power and reactive power. The active power is converted into useful mechanical power, while the reactive power is needed to maintain the device's magnetic fields. This reactive power is transferred periodically in both directions between the generator and the load.

无功功率如何产生

许多电气设备，如交流单相,三相电动机都需要消耗有功功率和无功功率。有功功率被转换成有用的机械功率，而无功功率是需要维持设备的磁场能量。无功功率在发电机和负载之间被周期性传输。



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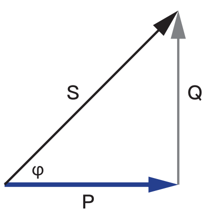
Effects of Reactive Power

Vector addition of the active power P and the reactive power Q gives the apparent power S. Power generators and transmission network operators must make this apparent power available and transmit it. This means that generators, transformers, power lines, switchgear, etc. must be sized for greater power ratings than if the load only drew active power.
Power supply companies are therefore faced with extra expenditure on plant and additional power losses. They therefore make additional charges for reactive power if this exceeds a certain threshold. Usually a certain target power factor cos φ of between 1.0 and 0.9 (lagging) is specified.

无功功率的影响

有功功率P和无功功率Q的矢量相加得到视在功率S。
发电设备和输电电网必须提供和传输这种视在功率。这个意味着发电机、变压器、电力线、开关设备等的规格必须比负载实际消耗有功功率时的额定功率更大。
因而，供电公司面临着额外的设备支出和额外的电力损失。因此，如果无功功率超过某个阈值，它们会对无功功率收取额外费用。通常规定的目标功率因数cosφ在1.0和0.9(滞后)之间。



Apparent power 视在功率
$S^2 = P^2 + Q^2$

Active power 有功功率
$P = S \cdot \cos\varphi$

Reactive power 无功功率
$Q = S \cdot \sin\varphi$

Example: 3-phase motor		
Active power	500 kW	有功功率500kW
Reactive power	510 kVAr (ind)	无功功率510 kVAr
Resulting apparent power	714 kVA	计算结果：视在功率741 kVA

Although the motor's mechanical power output only calls for 500 kW, the supply network loading is an apparent power of 714 kVA, i.e. it has to transmit 143% of the active power.
虽然电机的机械功率输出只需500 kW, 供电网络负荷却是714 kVA的视在功率，即传输143%的有功功率。

Active power is the electric power available for conversion to a different form of power, e.g. mechanical, thermal, chemical, optical, or acoustic power.
Reactive power is electric power required for the generation of magnetic fields (e.g. in motors or transformers) or electric fields (e.g. in capacitors). In a chiefly magnetic field, reactive power is inductive; in a chiefly electric field, it is capacitive.
Apparent power is the geometric sum of the active and reactive power.
The power factor cosφ is the quotient of the active power and the apparent power.

有功功率是可转换为不同形式功率的电力，例如：机械的、热的、化学的、光学的或声学的动力。
无功功率是产生磁场所需的电功率（例如，在电动机或变压器中）或电场（如电容器）。
在磁场中，无功功率是感性的；在电场中，它是容性的。
视在功率是有功功率和无功功率的矢量和。
功率因数cosφ是有功功率和视在功率的商。

The Principle of Power Factor Correction
功率因数校正原理

Power Factor Correction

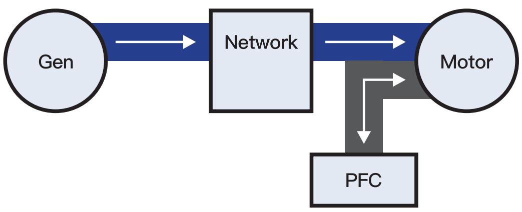
If the lagging power factor is corrected, for example by installing a capacitor at the load, this totally or partially eliminates the reactive power draw at the power supply company. Power factor correction is at its most effective when it is physically near to the load and uses state-of-the-art technology.

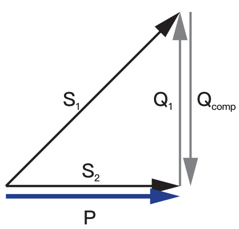
The inductive reactive power Q_1 is compensated for totally or partially by the capacitive reactive power Q_{comp}, the apparent power thus being reduced from S_1 to S_2.

功率因数校正

如果校正滞后功率因数，例如通过在负载上安装电容器，这将完全或部分消除供电公司的无功功率消耗。功率因数校正是最有效的，是采用先进的技术，使得它在物理上接近负载所消耗的无功功率。

感性无功功率Q_1全部或部分由容性无功功率Q_{comp}补偿，此时视在功率从S_1降低到S_2。





Power Factor Correction

Example: 3-phase motor with power factor correction (PFC)		
Active power	有功功率	500 kW
Reactive power	无功功率	510 kVAr (lagging/滞后)
Power factor correction	功率因数校正	510 kVAr (leading/超前)
Resultant reactive power	合成无功功率	0 kVAr
giving apparent power	视在功率	500 kVA

The motor draws an active power of 500 kW as before, but its reactive power is fully compensated for and the supply network needs to transmit an apparent power of 500 kVA, i.e. 100% of the active power. Power factor correction in this case therefore reduces the transmission load by 43% of the nominal active power (i.e. from 143% to 100%).

电动机的有功功率和以前一样为500kw，但其无功功率是完全无功的补偿后，供电网络需要传输500kVA的视在功率，即：100%的有功功率。因此，在这种情况下，功率因数校正可将传输负载降低标称有功功率的43%（即从143%降至100%）

Economic Benefits of Power Factor Correction

功率因数校正的经济效益

Economic Benefits of Power Factor Correction

功率因数校正的经济效益

Saving the Costs of Reactive Energy

As an example we can take an industrial company with an average power of 500 kW, operating for 4000 hours perannum at an average cosφ of 0.7. The power supply tariff allows the user to draw 50% of the active energy as reactive energy at no extra charge, corresponding to a target cosφ of 0.9. Without power factor correction, the company pays the power supply company 9000 kVArh annually for reactive power.

功率因数校正的经济效益

例如，我们取一家平均功率为500kW的工业公司为例，该公司每年运行4000小时，平均cosφ=0.7。供电电价允许用户在不额外收费的情况下提取50%的有功电能作为无功电能，对应于0.9的目标cosφ。在不进行功率因数校正的情况下，公司每年向供电公司支付约9000kVArh的无功补偿费。

Additional Savings Through Reduced Active Power Losses

The company taken as example has power losses in its own distribution network, and, like every other consumer, must pay the cost of the active energy lost.
The use of power factor correction reduces the apparent power in the company network, and hence also the power losses and the costs for active energy. An evalu-ation of the net benefits must also take into account the internal losses in the power factor correction system.
In addition to saving reactive energy costs, the power factor correction system in this example also reduces the costs for the active power expended on network losses.

通过减少有功功率损耗实现额外节约

以该公司为例，它自己的配电网络中存在电力损耗，并且与其他所有用户一样，必须支付有功电能损耗的成本。
功率因数校正的使用降低公司网络中的视在功率，因此也降低了功率损耗和有功能量成本。净效益的评估还必须考虑功率因数校正系统的内部损失。
除了节省无功能量成本外，本例中的功率因数校正系统还降低了消耗在网损上的有功功率成本。

Power factor correction reduces both energy costs and investment costs.
功率因数校正降低了能源成本和投资成本