Power factor correction

July 2004

Economical and environmentally friendly

Power factor correction with PhaseCaps can reduce power consumption significantly. This not only yields considerable cost benefits, but also takes some of the strain off the environment.

Optimized use of electrical energy is an effective way of reducing noxious emissions. So power factor correction (PFC) with power capacitors is important not only as a cost issue, but also for improved environmental protection.

How reactive currents are produced

Many electrical machines such as AC and three-phase motors use both active and reactive current. Whereas active power is converted into mechanical power, the reactive current attends to the necessary magnetization and demagnetization, and thus commutes periodically between the generator and load. As the PFC system is situated as close as possible to the load, less apparent current - the sum of active and reactive current - flows in the power grid. This reduces losses as well as the need for primary energy. Lower CO_2 emissions are the ultimate result. Power capacitors from EPCOS for power factor correction are used both in typical PFC applications, such as fixed compensation, power factor controllers and filter circuits, and in applications such as wind parks and uninterruptible power supplies (UPS). EPCOS power capacitors of the PhaseCap® Premium and HD, WindCap™ and PhiCap series are now making a contribution to environmental protection worldwide. But power factor correction offers economic benefits as well. Lower losses mean higher profits. In terms of power factor correction, that means:

- Less expense on reactive power
- Reduced resistance losses and thus lower costs per kilowatt-hour
- Avoidance of costly capacity expansion in power distribution installations
- Higher transmission capacities for effective power
- Reduction of down times and maintenance costs
- Improvement of power quality

- Reduced operating costs

High savings potential

A practical example will illustrate potential savings. An industrial plant has an average power factor (cos) of 0.7 for an average consumption of 500 kW and 4000 hours of operation annually. In terms of active power, the company draws 50% of its reactive power at no cost. Without this reactive power, a power factor of 0.9 demanded by the public utility would have been achieved. The remaining 1 040 408 kvarh cost EUR 9575 annually at an estimated operating price of EUR 0.0092/kvarh.

Power factor correction of 268 kvar would be required to raise the power factor to 0.9. The complete installation of a 300 kvar system would require capital expenditure of EUR 7670. This means that a return on investment is already obtained after less than ten months ➔ 1. Assuming that a PFC system has an average operating life of ten years, this represents a cost reduction of just under EUR 90 000.

1 | Example of energy calculation (selected annual values)

Work done at daytime rate	2 000 000 kWh
Reactive power at daytime rate	2 040 408 kvarh
Reactive power free	1 000 000 kvarh
Reactive power remaining	1 040 408 kvarh
1 040 408 kvarh × EUR 0.0092/kvarh	EUR 9 575
Power factor correction,	**268 kvar**
calculated	300 kvar
Standard PFC system, selected	EUR 7 670
Capex incl. installation	9.6
Payback period (months)	

1 This sample calculation shows that installation of a PFC system cuts costs and produces a return on investment after less than ten months.

Reducing resistance losses

Active energy costs are incurred for every electrical load due to losses in its own grid. Reduction of apparent power in the grid by means of power factor correction cuts both losses and the costs of active energy → 2, because the savings in reactive energy costs realized by fitting a PFC system also reduce the active energy costs caused by power losses by more than EUR 750 annually.

Applications & Cases

2 Example of cost and loss evaluation

Transformer output	800 kVA
Apparent power installed	714 kVA
Transformer and line losses	10.0 kW
Power factor correction	**268 kvar**
Apparent power compensated	556 kVA
Transformer and line losses compensated	6.8 kW
Gross loss reduction	3.2 kW
Losses caused by power factor correction	0.6 kW
Net loss reduction	2.6 kW
Loss reduction in active energy	10 232 kWh/a
Active energy costs	EUR 0.0766/kWh
Cost reduction	EUR 783/a

2 By reducing active losses, power factor correction opens up further savings potential.

Cutting capital expenditure

If the customer in example → 2 plans to increase existing loads from 500 to 700 kW, the existing 800 kVA transformer will no longer suffice. Reduction of apparent power by means of power factor correction would dispense with expensive power grid extension with a transformer, switchgear, etc. As → 3 shows, acquisition of a PFC system is significantly more economical than grid extension.

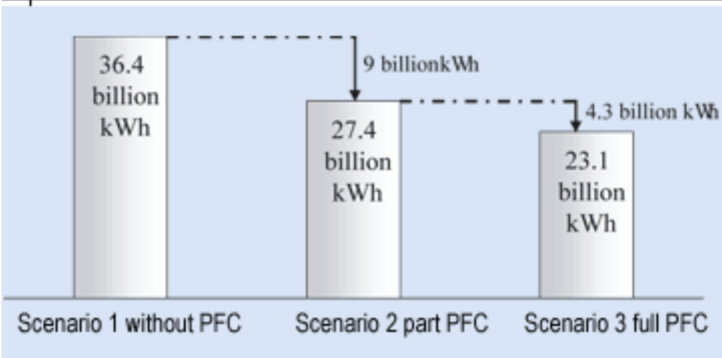
3 Example of capital expenditure for grid extension

Active power installed	500 kW
Power factor	0.7
Apparent power installed	714 kVA
Transformer output	800 kVA
Transformer load	89%
Active power after extension	700 kW
Power factor	0.7
Apparent power after extension	1 000 kVA
Transformer output	800 kVA
Transformer load	125%
Capex for extension	EUR 40 000
Power factor correction	375 kvar
Active power after extension	700 kW
Apparent power after extension	778 kVA
Transformer load	97%
PFC system	400 kvar
Capex incl. installation	EUR 10 000
Savings compared with network extension	EUR 30 000

3 Significant savings are also produced by power factor correction in the case of plant extensions, as installation costs can be significantly reduced or avoided altogether.

Power factor correction also offers unsuspected savings potential in macro-economic terms as well. Power losses in Germany, for example, are shown in → 4 in three scenarios based on figures for 2003.

4 How PFC can reduce grid losses caused by reactive power in Germany



4 In Germany alone, for example, power losses of 13.3 billion kWh can be saved with full power factor correction. This corresponds to the annual output of nine coal-fired power plants.

Scenario 1 shows the loss balance without any power factor correction, scenario 2 shows partial state-of-the-art correction with a power factor of about 0.9, whereas scenario 3 shows full power factor correction.

Partial power factor correction alone leads to a reduction of grid losses by 9 billion kWh. This corresponds to the power generated by six coal-fired power plants or consumed by 2.7 million households. If full power factor correction were made, the annual output of another three or so coal-fired power plants could be saved, corresponding to a further 4.3 billion kWh.

Conclusions

Power factor correction reduces not only CO_2 emissions, but also the cost of supplying electricity to loads. Another advantage is that utilities then need to supply less reactive power. The examples described above are based on conventional PFC systems comprising power capacitors and PFC controllers. Consistent ongoing development of these static systems has led to dynamic PFC systems. In addition to the benefits of static PFC, they offer further ways of reducing power consumption and costs in applications such as welding equipment, industrial presses, wind power farms, elevators and cranes. To these must be added the significant improvement of power quality, which is important to sensitive applications.

For both conventional and dynamic systems, EPCOS offers one-stop shopping for all key PFC components, such as capacitors, PFC controllers, contactors, thyristor modules and reactors.