white paper

Energy Cost Reduction through Load Balancing & Load Shedding

SCR controllers firing in phase angle degrade the power factor while increasing harmonics and electrical noise. A poor power factor drives increased power generation resulting in high energy costs and more CO2 emissions. Predictive Load Management (PLM) eliminates these drawbacks resulting in more effective performance through load balancing and load shedding strategies.

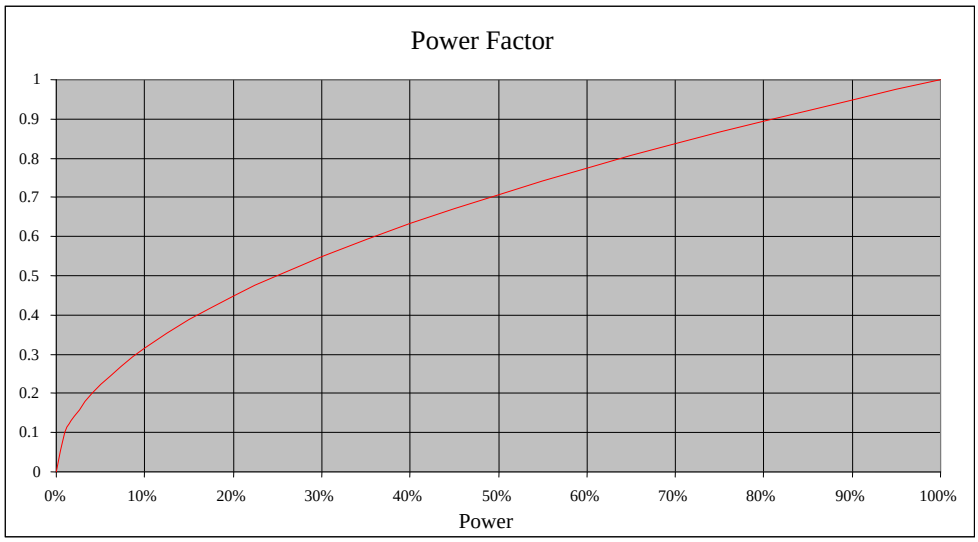
Power Factor is an important aspect that drives up energy costs. This especially applies to SCR Power controllers firing in Phase Angle.

Most utility companies apply a surcharge when the power factor goes below 0.9 (or 90%). By the end of the year this can translate in thousands or even tens of thousands of dollars, depending on the size of the installation.

The Demand Charge represents the cost per KW multiplied by the greatest 15-minute demand reached in KW during the month for which the bill is rendered. However the demand is subject to power factor adjustment. Utility companies reserve the right to measure such power factor at any time. Should measurements indicate that the average power factor is less than 90%; the adjusted demand will be the demand as recorded by the demand meter multiplied by 90% and divided by the percent power factor.

For example with the greatest demand at 500KW and a power factor at 0.7, the demand charge would be increased by 28%. At $9.72/KW, that's a $17,000 penalty a year with this relatively low demand example (see below). It's obviously in the customer's benefit to maintain a good power factor at any time.

As a matter of fact, with Phase Angle firing, the power factor decreases rapidly with output power.



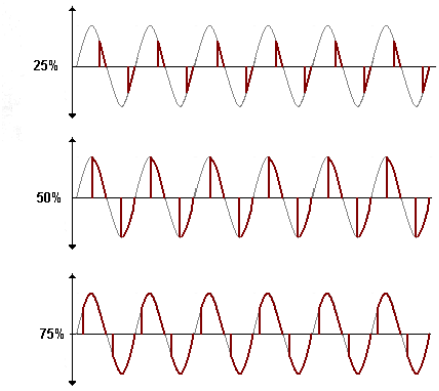
At 50% power, the power factor is only 0.7. At 25% power, the same power factor decreases even more at 0.5 meaning even more penalties.

Moreover, Phase Angle firing creates all sorts of disturbances on the grid, such as harmonics, RFI, line losses, energy waste (KVAR) and transformer overheating. The manufacturer will eventually be forced to increase the capacity of their equipment to compensate for these disturbances, for example by installing active or passive systems such as costly capacitors.

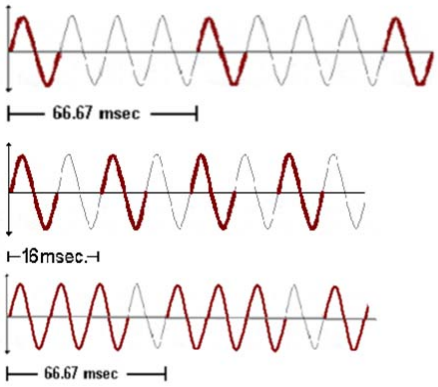
Eurotherm introduced the EPower™ SCR Controller with patented PLM (Predictive Load Management) function to help manufacturers reduce energy cost, lower operational expenses and get a cleaner and balanced power supply while also eventually reduce CO2 emissions.

What is the easiest way to increase the power factor?

The easiest way to increase the power factor is to switch from phase angle to burst firing, also called **zero cross** or full cycle firing.



Phase Angle



Zero Cross

Unfortunately, this switch could introduce a separate set of issues. Zero cross could introduce a flicker effect (main voltage variation) which in turn could affect motors and create a visual disturbance (light flicker, similar to fluorescent lights). More importantly, if not properly monitored, this may lead to high peaks of power. Many random zones firing at the same time will increase the power consumption and in some cases exceed the power capacity of the installation resulting in a black-out. Nonetheless, the benefits of switching over from Phase Angle to Zero cross will eventually outweigh any obstacle.

How to switch to zero cross without any drawbacks?

The EPower controller with its patented PLM function makes it easy and reliable to switch to zero cross by improving the power factor resulting in cost reduction while eliminating any of the drawbacks mentioned above.

Two key components are included in the PLM function: Load Balancing (or Load Sharing) and Load Shedding.

LOAD BALANCING: Distributing Power - Balancing Consumption

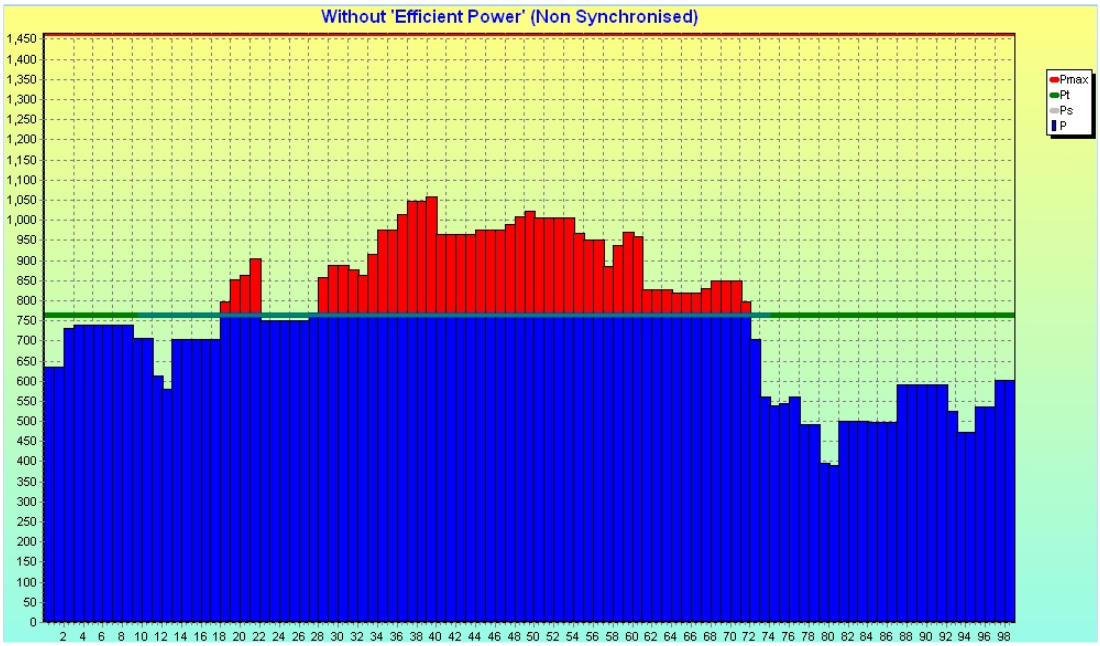
Load balancing is a strategy of equally distributing power of different loads to obtain an overall power consumption as stable and balanced as possible thus eliminating peaks of power. This is in contrast to a random firing system.

Each heating zone controlled by an EPower SCR controller, is defined by an output power, cycle time and a maximum power (max capacity), which can be pictured as a rectangle. Rather than letting these rectangles pile up randomly, the EPower controller uniformly distributes them thereby ensuring that at any given moment the overall power is as stable and balanced as possible.
In the field, up to 64 heating zones can be synchronized together with the help of a fast CAN network, separate from optional fieldbus such as Ethernet or Profibus.

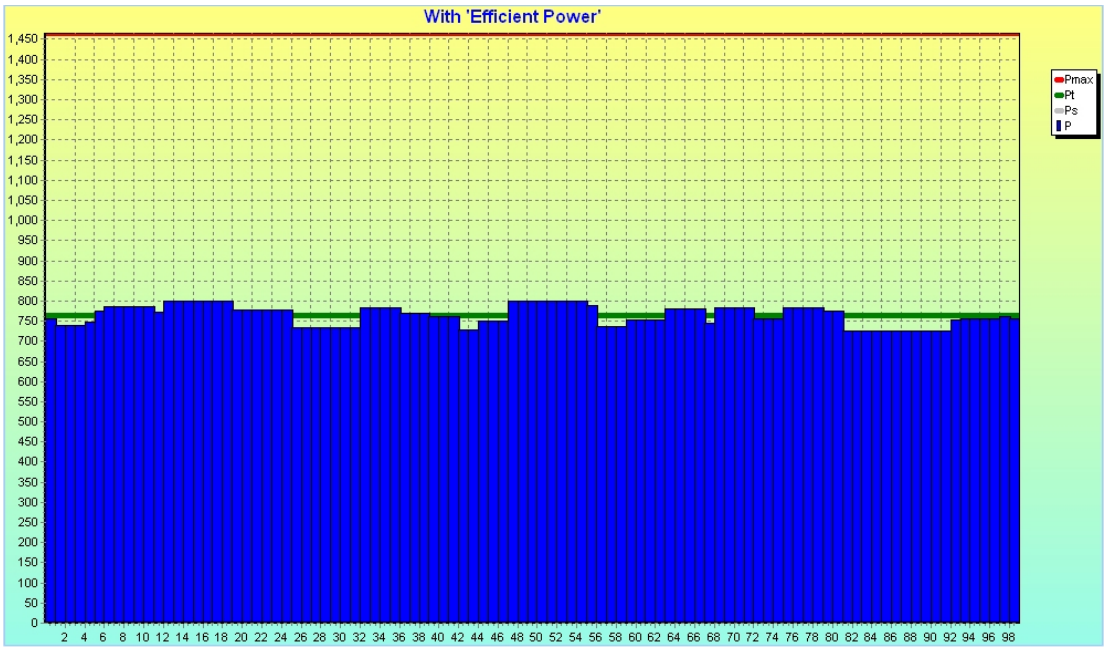
These zones can be monitored on one furnace, across several furnaces or even plant-wide realizing the most effective results on the main network. The PLM function takes care of the disparity between zones and considers the fact that a zone of 10KW does not have the same impact as a 100KW zone when distributing power.

It is important to understand that the PLM function does not change the output power but rather balances and shifts the power evenly hereby eliminating any sort of disturbance.

The result is optimum load management through intelligent load balancing and load sharing, a strategy that will eliminate peaks and flicker and even out overall power usage.



Without Load management



With PLM function

By using the EPower controller with its PLM function, manufacturers are now able to use zero cross firing for their system without any drawbacks. Eliminating Phase Angle firing significantly improves the power factor which in turn results in substantial savings.

An example using electricity General Service rate on a relative small scale shows a furnace with 4 heating zones of 125KW each (total 500KW):

Furnace 500KW	Phase Angle		Zero Cross with EPOWER Load Balancing	
Basic Facilities Charge		$332.50		$332.50
Demand in KW	500KW		500KW	
Power Factor	**0.7**		**>0.9**	
Demand Correction KW	**643KW**		**500KW**	
Demand Charge: $9.72 per KW		$6,249.96		$4,860.00
Hour of operation	720		720	
Consumption per month (avg 50%)	180.000KWh		180.000KWh	
Energy Charge:				
First 100 kWh per Kw	$.0529/KWh	$5,290.00	$.0529/KWh	$5,290.00
Next 200 kWh per kW	$.0495/KWh	$3,960.00	$.0495/KWh	$3,960.00
Monthly Energy Cost		$15,832.46		$14,442.50
Annual Energy Cost		$189,989.52		$173,310.00
Annual Savings				**$16,679.52**
				-9%

Moving from Phase Angle to Zero Cross firing with the EPower controller avoids the facility power factor correction surcharge, thereby achieving an annual savings of nearly $17K.

Additionally, using energy more efficiently (i.e. substantially decreasing the reactive power (KVAR)) results in less power generated by the utility company. In fact, we should consider that consuming reactive power is in the end simply a waste of energy. While a bad power factor forces the utility company to generate this extra reactive power, it will be of absolutely no use to the end user. Besides saving costs, implementing a best practice of efficient energy consumption also results in considerably less CO2 emissions released in the atmosphere.

Increased Quality of Main Power Supply

While an efficient load strategy can result in substantial savings and an improved environment, using synchronized SCRs will drastically increase the quality of the main supply. As described above, eliminating phase angle will remove harmful harmonics and RFI generation, which for example could disturb the IT infrastructure or overheat transformers.

For customers already using Zero Cross, the PLM function achieves constant perfect power balance without the flicker effect. Moreover, PLM can be of critical importance in installations where the overall installed power of the heating elements exceeds the capacity of the main transformer. In such cases non-synchronized firing may result in a total black out, caused by tripped overloaded main circuit breakers. The PLM function will avoid heavy peaks of power that could overload the system by constantly monitoring and balancing the firing.

Even after implementing a strategy that stabilizes overall power consumption, PLM's second key feature can come into play to save even more.

LOAD SHEDDING: Demand reduction and load control strategy

The load shedding is completely embedded with the Load Balancing strategy. However, this function will only act when necessary or desired. Load shedding is totally dynamic and fully adjustable while not requiring external hardware, a PLC or control system.

The shedding function allows limiting and shifting the overall energy consumption all together or with fully adjustable user-defined priorities. Adjustments can be made through fieldbus communication (Profibus, DeviceNet and Ethernet) enabling adjustments in view of ON peak period surcharges.

1. The Load Shedding feature can be used in systems previously mentioned, where overall power exceeds the capacity of the main transformer. After the Load Balance has achieved perfect synchronization across the SCRs, the load shedding function will limit the power **only** if power demand would exceed the maximum capacity of the main supply thus avoiding a black out.

2. By dynamically adjusting the maximum threshold for the installation, we can control the maximum Demand Charge resulting in additional substantial savings.

   For example, this can be applied if two furnaces start up simultaneously, thereby significantly increasing the demand in KW. The maximum demand in KW is based on usage within a 15 minute moving window. This eventually translates into penalties applied by the utility companies for exceeding or increasing demand. The maximum allowable demand is now raised by the utility company and the surcharge will be applied to the current billing month for up to the next 11 following months depending on the contract. So, exceeding the maximum demand **once** can result in a penalty applied for up to 12 months.

   Monitoring and controlling demand can drastically reduce energy cost. The PLM function allows setting up user priorities, which in turn allows the shifting of power on as needed basis.

   Looking at previous example with a furnace of 500KW:

Furnace 500KW	Phase Angle		Zero Cross with EPOWER Load Balancing		Zero Cross with EPOWER Load Balacing + Shedding	
Basic Facilities Charge		$332.50		$332.50		$332.50
Demand in KW	500KW		500KW		350KW	
Power Factor	**0.7**		**>0.9**		**>0.9**	
Demand Correction KW	**643KW**		**500KW**		**350KW**	
Demand Charge: $9.72 per KW		$6,249.96		$4,860.00		$3,402.00
Hour of operation	720		720		720	
Consumption per month (avg 50%)	180.000KWh		180.000KWh		180.000KWh	
Energy Charge:						
First 100 kWh per Kw	$.0529/KWh	$5,290.00	$.0529/KWh	$5,290.00	$.0529/KWh	$5,290.00
Next 200 kWh per kW	$.0495/KWh	$3,960.00	$.0495/KWh	$3,960.00	$.0495/KWh	$3,960.00
Monthly Energy Cost		$15,832.46		$14,442.50		$12,984.50
Annual Energy Cost		$189,989.52		$173,310.00		$155,814.00
Annual Savings				**$16,679.52**		**$34,175.52**
				-9%		**-18%**

Limiting the Demand charge to 350KW instead of 500KW combined with the power factor savings; the example above gives an annual saving of over $34K.

For installation already using zero cross, limiting and shifting the demand through Load Shedding also translates into substantial savings. The above example gives a savings close to $18K.

3. Moreover, with a General Service Time of Day contract , the same technique can be applied to dynamically control the demand and energy consumption by limiting the overall output based on period of days or seasons when energy cost are much higher.

Conclusion:

Improving the power factor, controlling the Demand Charge and reducing Peak Consumption during ON peak times will result in substantial savings. In addition the PLM function helps to improve the quality of the main power supply and ultimately also reduces CO2 emissions.

More information on EPower can be found at http://www.eurotherm.com/products/power/epower.htm

Note: for applications where Phase Angle **must** be used due to nature of the heating elements, Eurotherm can provide energy cost reduction solutions with the LTC (Load Tap Changer) function of EPower.
(See paper on LTC).

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