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WHITE PAPER

PEAK DEMAND MANAGEMENT – THE COST SAVING POWER OF POWERGUARD®

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This technical white paper provides detailed information on the functioning of PowerOptimal's PowerGuard® peak demand management technology.

Overview

In spite of the continuing dramatic increases in electricity rates, business often pays little attention to energy costs in general and electricity costs in particular, because they are possibly regarded as not manageable. Closer examination of new technology employing Peak Demand Management proves it is possible to achieve significant savings in overhead costs with no adverse effect on productivity, thereby resulting in a much smaller carbon footprint to boot.

Modern Peak Demand Management

Since electricity is difficult to store, it follows that the generation of electricity occurs at the same rate at which it is consumed. Because of this special characteristic, the electricity supply system **has to be designed for the maximum expected demand** at any time. It is the maximum demand that is often the main driver of fixed operating costs. It is the ultimate "just in time" product. It must be consumed the instant it is created.

This means that if it is possible to modify timing and the amount of the electricity consumed, and still provide the same useful effect, the value of the energy service itself remains unchanged. Based on this principle, Peak Demand Management techniques have been developed to influence the electricity demand and increase the utilisation and operating efficiency of existing supply facilities. It is not a new idea and has been around for almost as long as electricity itself. However, it is notoriously difficult to do right [1].

Peak Demand Management can be defined as any action that modifies the load profile in order to reduce peak demand, thereby improving the load factor and overall efficiency of the network. It has been noted that peak demand *mismanagement* often leads to the creation of a larger peak than the one that you were originally trying to avoid [2].

Energy conservation has been a focus for several years now and significant progress has been made. However the savings potential is far from being exhausted, as shown by several benchmark initiatives. This raises the question of what is holding industry back from investment in energy efficiency? The reason is certainly not because of a lack of available technology. Technologies that enable reductions in a company's energy costs as well as greenhouse gas emissions do exist.

Intelligent Peak Demand Controllers

Such a technology was developed specifically for the South African market by PowerGuard®. The design philosophy was uncompromising and rigid. Some of the more important criteria were:

- The curtailed peak was not merely to be moved to a different time but actually eliminated.
- The components as well as the installation had to be cost effective and uncomplicated.
- Adjustments and programming should be easy for non computer literate installers.
- High build and component quality.
- It had to conform to various International Electrotechnical Commission (IEC) specifications.

That was quite a tall order but those criteria were admirably met and two distinct lines of *Intelligent Peak Demand Controllers* were designed and built, making use of the same philosophy.

Fixed Channel Control System

The PowerGuard® DPM range (See Figure 1) utilises a well researched and proven algorithm that manages various loads according to a set hierarchy or random selection combined with timing, load, supply and reserve power calculation by constantly

Figure 1: Arrangement of three 8-channel peak demand controllers

monitoring the total power to the installation. Units typically serve 2, 4, or 8 channel loads per phase.

The loads **can be connected into a hard-coded hierarchy** specifying the **relative importance of the different loads**. This hierarchy will determine which load ranks highest for electrical supply. Once switched on, the system constantly monitors the aggregate load of the entire electrical installation. **Alternatively, random algorithms** are available to manage, for example, air conditioner installations or underfloor heaters.

A set of current transformers (Figure 2) that accurately measures the amount of energy as it is being used is installed on the incoming electricity feed. Uncontrolled and controlled loads are measured to make sure the demand does not exceed the pre-set limit. This information is used by the second component, the demand controller itself, which determines the control actions.

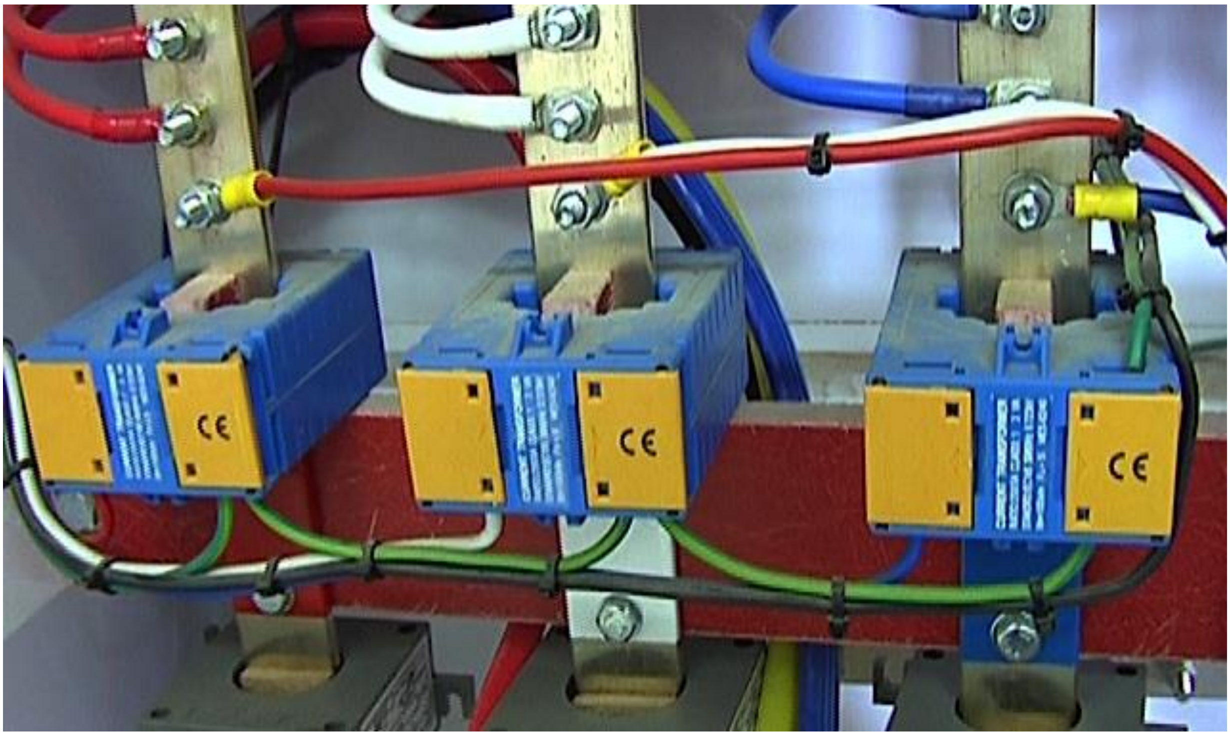

Figure 2: Current Transformers

As the demand climbs, the controller compares it to the pre-set demand limit and when that is reached, it searches for the lowest priority load and it **automatically turns off non-essential equipment** such as hot water geysers, underfloor heaters and air conditioners. If the demand is still too high it seeks the next lowest priority and so on until the demand is below the pre-set limit. Essential equipment such as computers, workshop machinery and lights are not affected.

At installation, the **customer can specify which loads should be controlled** and which are considered essential. It continuously sheds and restores loads as necessary to keep the demand peak from exceeding the limit that is set. Because excessive loads are not allowed to run simultaneously, high peak demand on the electrical grid is avoided.

Another significant benefit is the protection that the system affords when power is restored **after a power interruption**, for whatever reason. **All controlled loads** will be off when the power is restored and **are turned on sequentially in a controlled manner**, which avoids dangerous spikes and surges. As the overall load approaches the pre-set limit directly after restoration, the remaining inactive loads are inhibited until the network's diversity can accommodate further loading.

This is also of substantial benefit to the power utility as **the cold pick up is presented to a much reduced load**. Furthermore the system **automatically senses when the voltage is out of the operating range** and inhibits supply during such a condition, saving expensive equipment from ruin.

Unlimited Channel Control System

PowerOptimal manufactures the PowerGuard® CPM range of products mostly for bigger commercial applications where insufficient supply as well as expensive peak demand need to be addressed. Unlike the DPM range described above, this unit is **capable of controlling an unlimited number of loads**.

Addition and removal of receivers can be accommodated without affecting the system. In order to comply with the design criterion that calls for simplicity, the designers elected to make extensive use of fuzzy logic, a technology that is usually reserved for artificial intelligence.

It culminated in the capability to **control an unlimited number of receivers with a normal two-core cable**, which is polarity insensitive and short circuit proof. The control signal is **phase conscious** and only addresses the applicable units, which means that all three phases are controlled via the two core cable. It was a major breakthrough and a unique capability of the PowerGuard® technology.

The PowerGuard® 3PC Mk 2 controller (Figure 3) also uses a set of current transformers to measure the overall load.

Consider an array of typical wall mounted air conditioners, which are notoriously sensitive to unsympathetic switching. The receiver is installed close to the equipment and once instructions are received from the controller, its intelligent logic responds with the relevant actions.

When the controller senses an overload condition and sends out a shed instruction, only a fixed percentage on the applicable phase responds to each shed instruction. **The controller has the ability to shed the phase with the highest load first** to assist in balancing the phases of the installation.

In order to simplify installation as well as additions to the system, **the receivers do not need to be programmed** as the controller can determine each receiver's phase relationship. This means that it can track the migrations to a different phase of any receiver after installation automatically.

Should the overload condition persist, the controller sends out a new set of instructions but only the applicable receivers respond. This process is repeated until the demand drops to a level that satisfies the controller where shedding instructions as well as the relevant phase being shed are displayed.

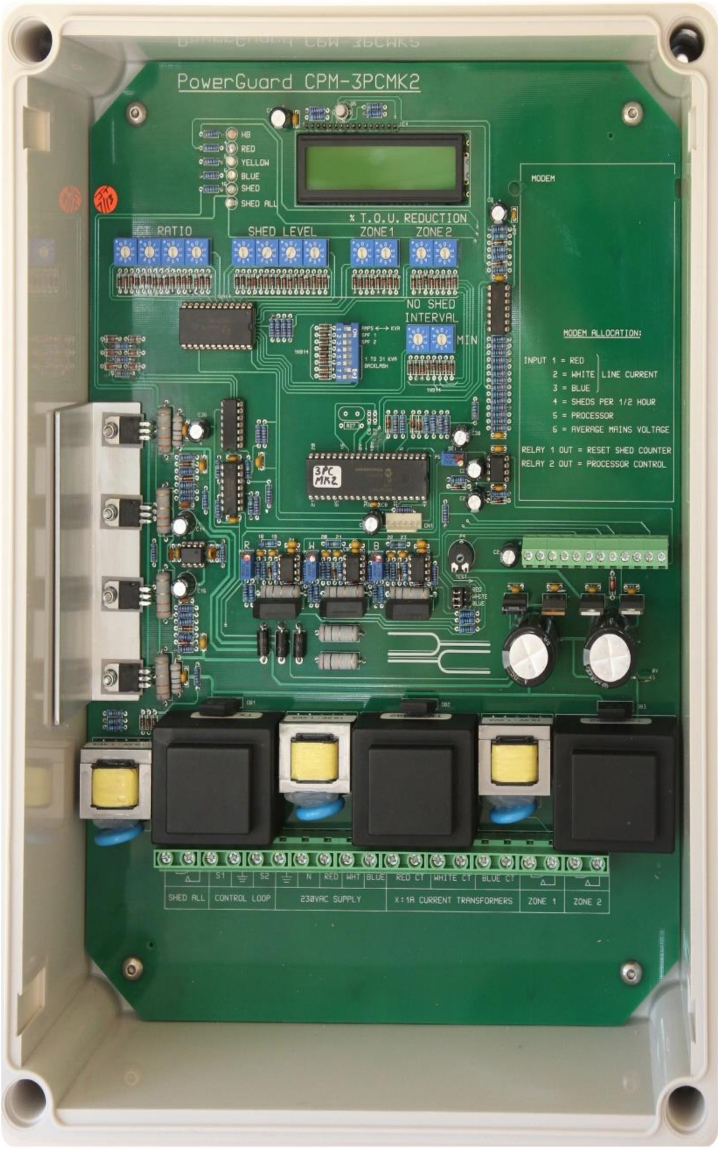

Figure 3: The PowerGuard™ 3PC Mk 2

For suitably equipped air conditioners the system will only control the compressor and leave the evaporator running, which in all but the most extreme cases maintain comfort levels.

When demand has been reduced and the controller begins restoring loads, the system reverses but the system's intelligent logic recognizes minimum off times and prevents the compressor from being short cycled. Requirements for any other specialised equipment can be programmed in the same way.

Even though PowerGuard® is fully automated, it is of paramount importance to monitor the performance of the system in order to achieve sustainability. High integrity output data is presented to a **GSM network based modem**, which is in constant communication with the company's server. Access to the server is possible with a unique password where the present as well as the full history of the site can be accessed. This information is vital for phase management as well as for optimization of the installation's settings.

Avoiding Secondary Peaks

It is important to break up sheddable loads into the smallest element to make optimum use of all available energy. Switching off unnecessary large loads lead to bigger restoration loads than the peaks that you were trying to curb in the first place.

In order to manage a boiler, for example, it is important to switch at single element level to ensure that all available energy is used instead of shedding the entire load. This minimises the supply requirement when more power becomes available to avoid secondary peaks.

Figure 4 (on the left) illustrates the installation at a hotel in Johannesburg where a 200kW boiler array is controlled at element level by four 16-channel PowerGuard® units.

Figure 4: 200 kVA boiler array controlled by 16-channel units at a Johannesburg hotel.

Where shedding is required because of marginalized supply, it is important to note the phase of the shed signals to assist in balancing peak loads.

Case Studies

When shedding air conditioners, it can be seen that unlike geysers, the air conditioner does not have to make up heat or cooling during the night. The hours shed during peak periods therefore **contribute to kWh savings** as well. This principle is well illustrated when you examine the accounts and graphs generated by the monitoring system at the headquarters of a major defence contractor.

Figure 5: Two of the fourteen 16-channel controllers at defence contractor.

A network of fourteen 16-channel PowerGuard® units (Figure 5) was established, which control 250 air conditioners. All these units are of the reverse cycle type, which place a big demand on the electrical system.

Figure 6 shows that the maximum demand at this particular client was 530kVA. That is represented by the dotted red line. In this instance the control unit was adjusted to limit the demand to 400kVA and that is represented by the dotted blue line.

The demand started to escalate around eight o’clock in the morning. As soon as that happened, the controller commenced sending shed requests, as indicated by the line at the bottom of the graph and kept the demand from exceeding the preset limit of 400kVA.

Not only did it ease the load on the national power grid by 130 kVA (**approximately 25% reduction in peak demand**), it saved the client a huge amount of money.

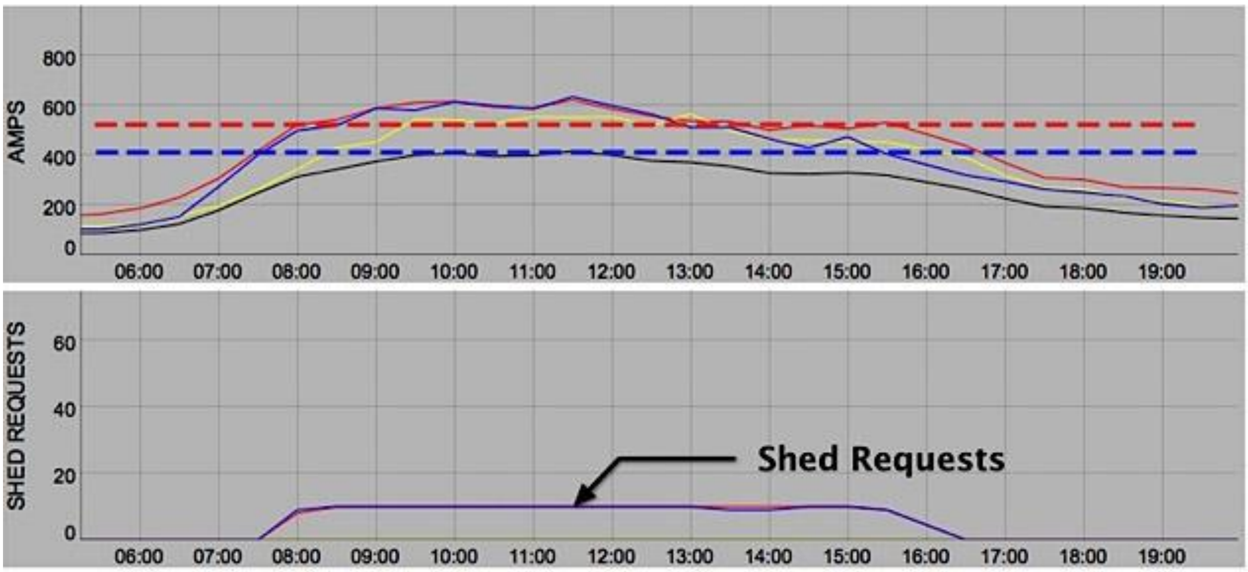

Figure 6: Red line indicates maximum demand. Blue line indicates limit at which controller is set. Black line, top graph, represents kVA.

There are two major components of any commercial or industrial electricity bill, namely Energy charge expressed as kWh and Demand charge expressed as kVA.

The saving referred to above is confirmed by a comparison of bills for the same month pre- and post-PowerGuard® installation. The actual saving was 146kVA, which translated to a R28 962 saving for the month.

A reduction in energy consumption of 13,000kWh was observed for the same month. That was worth R 12 397. Added to the kVA saving, it amounted to R41 359 or a **17.9% saving on the total bill**.

A study at Sakata, producers of the wonderful range of Mayford seeds, well known to any gardener, produced a similar result. Over a five month period the **average financial saving was 16.8%**. Significantly, the average savings in terms of kVA and kWh were 17.5% kVA and 13.8% kWh.

This trend is illustrated by Figures 7 and 8 where the graphs printed at the bottom of Eskom's bills are superimposed. The red line represents 2011 and the blue line, 2012. The vertical dotted line indicates the date at which PowerGuard® was installed. Both graphs dramatically diverge after the installation date.

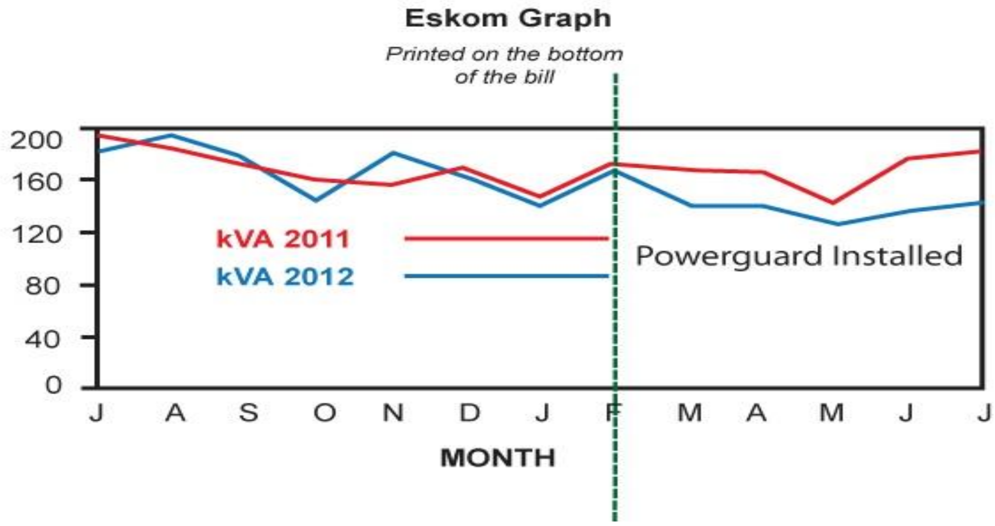

Figure 7: Superimposed Eskom Graphs indicating kVA.

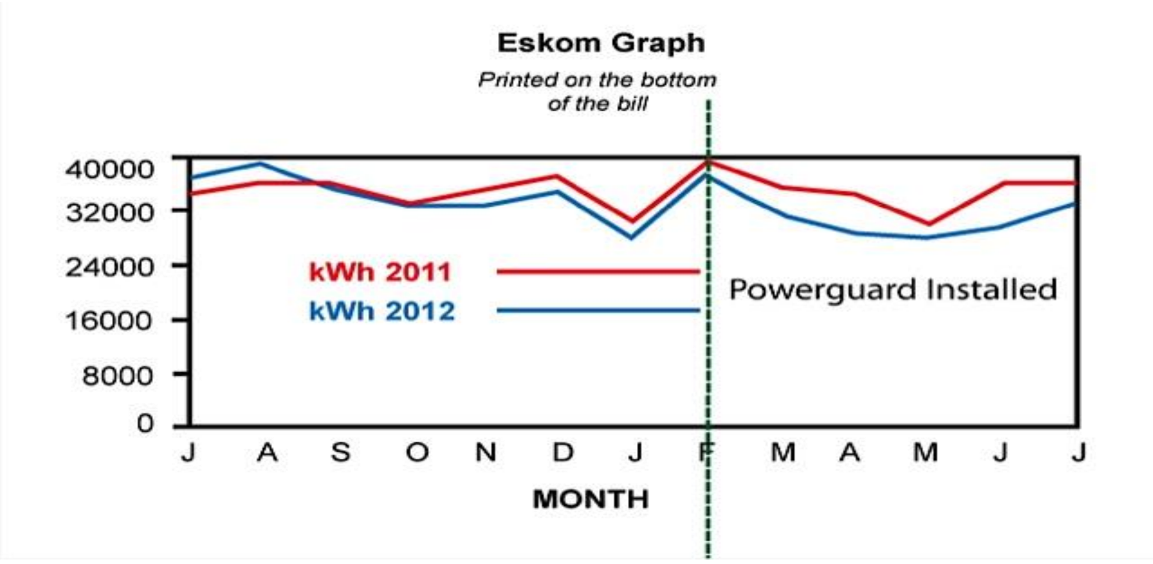

Figure 8: Superimposed Eskom Graphs indicating kWh.

Conclusion

With the benefits far outweighing the disadvantages and an excellent return on investment (ROI), it is astonishing that more people do not see the economic benefits of investing in energy efficiency. Successful Peak Demand Management allows both customers and utilities to benefit from the efficient use of the network and generation without adversely affecting the energy service.

References

[1] Loughran DS and Kulick J. 2004. Demand-Side Management and Energy Efficiency in the United States. *The Energy Journal* 25(1):19-43.

[2] Dunn R. 2003. Electric Utility Demand-Side Management 1999. US Energy Information Administration.