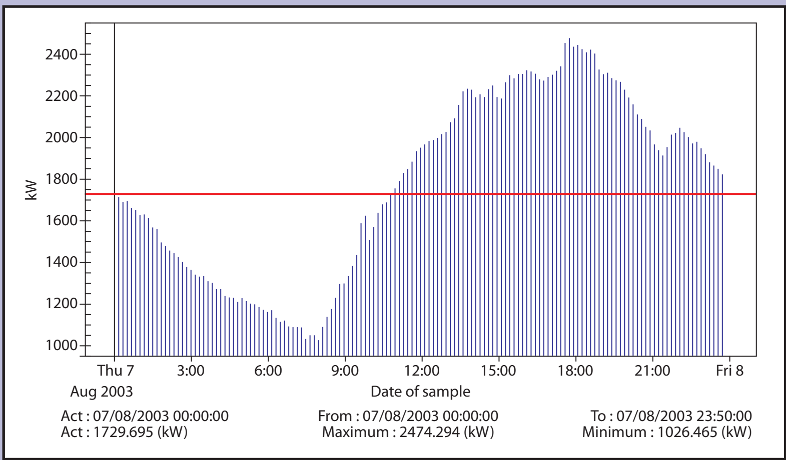
Case study

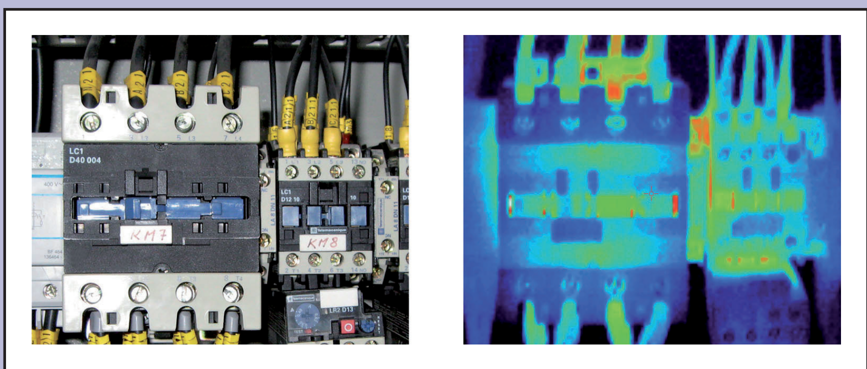
Maintenance as a tool to increase the electric power availability, reduce running costs and prevent damage to people and property

Leonardo ENERGY



Matteo Granziero,
Technical Communication
Socomec UPS

October 2007



european COPPER institute

Maintenance as a tool to increase the electric power availability, reduce running costs and prevent damage to people and property

Abstract: A lack of preventive maintenance on electrical systems can cause poor quality and wasted power or even danger for people and property. Scheduling annual inspections by experienced personnel is the solution to maintain high levels of electric power and safety for the enterprise.

1. Relationship between availability and prevention

„The availability of a system or a component is the time during which it works correctly and is available to the user" [1]. The formal definition of availability is:

$$A = \left(\frac{MTBF}{MTBF + MTTR} \right) \cdot 100 = \left(1 - \frac{MTTR}{MTBF + MTTR} \right) \cdot 100 \cong \left(1 - \frac{MTTR}{MTBF} \right) \cdot 100 \ \ [\%] \qquad (1)$$

where MTBF (Mean Time Between Failures) is a statistical quantity that identifies the mean time between failures and MTTR (Mean Time To Repair) that, also statistically, is the time needed for the repair starting from the instant of the inefficiency therefore including the time to act, obtain any spare parts and do the actual work on the equipment.

It is obvious how the availability of the electric supply affects the availability of the whole system. Any malfunctioning of the mains or safety devices and wear of the components or contacts reduces the availability of the power and the system with it. In the best hypothesis a server user cannot access the data and in the worst one will lose them completely. The industrial user will risk downtime or potential damage to the machinery.

For the electric power to be „available" it is not enough for it to reach the equipment but it must be of such quality as to be able to be usable by the user. The difference between good and bad quality electric power is the same as that between drinkable and undrinkable water.

The reasons for which water might not be drinkable can be bacteria, debris or chemical substances just as for electric power we can talk about harmonics and values of voltage or frequency far removed from the nominal ones.

Availability therefore includes the concept of quality: „dirty" power is not usable by the user and therefore the system cannot carry out the required operations.

There are different solutions to the problems of availability for the quality of the end result and costs: filters, static or dynamic uninterruptible power supplies, redundancy of the sources and many others. As good as they may be, these solutions are integrated in a system and as such they affect and are affected by the system. They can eliminate the harmonics from and to the load but they cannot do anything against cables loosening or wear of the various system components. The „solutions" are moreover subject to wear just as much as the other system components.

To maximize availability it is necessary to act on the MTBF and on the MTTR. The latter must be as short as possible and to obtain this it is necessary to have fast, automatic signalling systems, assistance near to the place of installation of the system, spare parts to hand and careful system design ensuring easy access to the components for fast replacement.

Whereas the MTBF must be as long as possible and is affected not only by the quality of the components used and by careful design that minimizes bottlenecks or more technically the „single points of failure" but also by periodic maintenance that anticipates the occurrence of problems and regular in-depth inspections of the site of installation to detect the onset of failures before they cause any halts in production.

2. Costs

No matter how well a system may have been designed, the passing of time or an increase in loads can make it obsolete or simply not suitable for the new requirements. A non-optimized system causes:

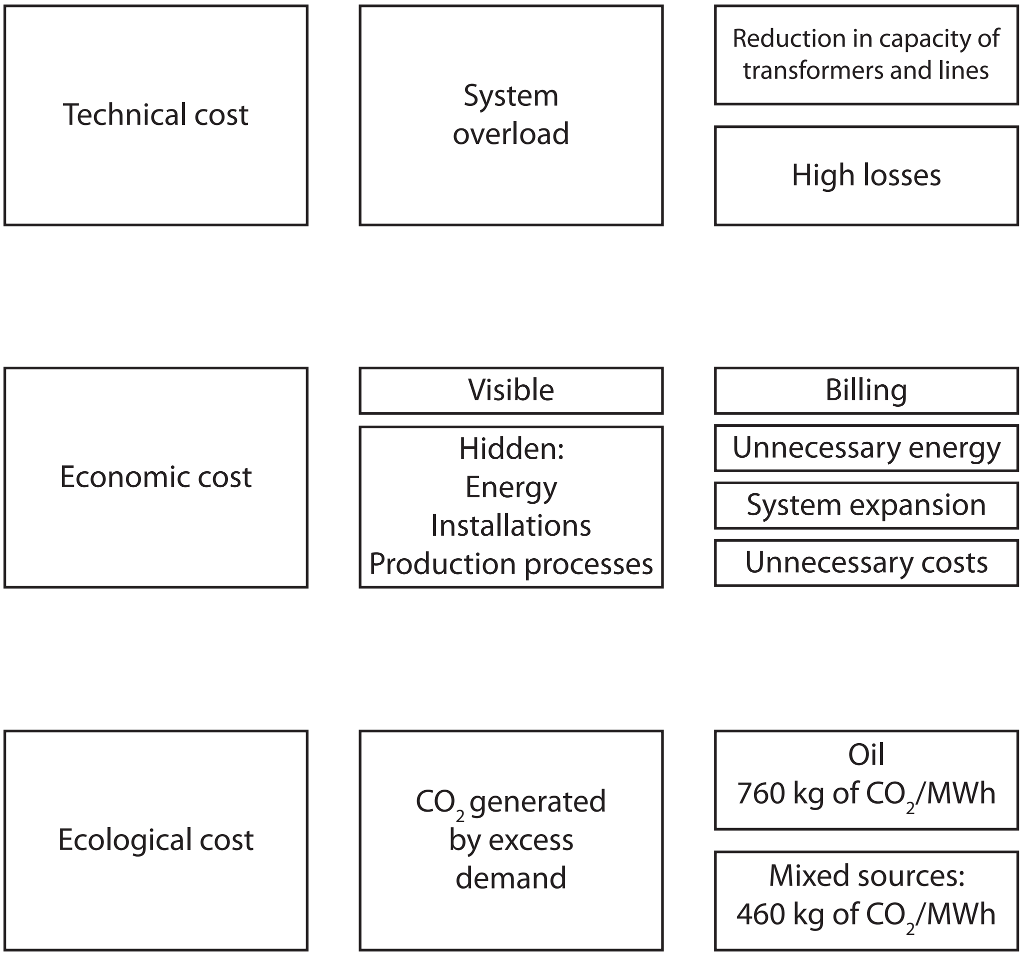


Diagram 1 - Technical, economic and ecological costs of an installation.

The elements on which to act in order to limit costs are:

- Optimization of the supply contract;
- Demand management;
- Measurement of system performance;
- Increase in productivity.

3. Safety

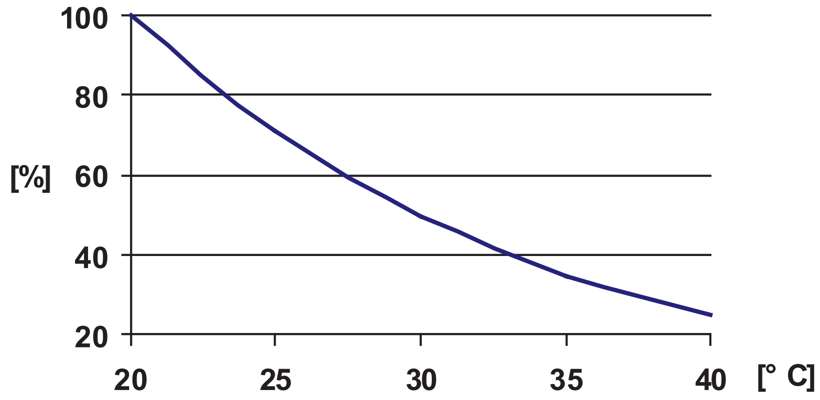
The U.S. Fire Association declares that in 2001 more than 10% of the causes of fire in non-residential buildings in the United States are linked to the distribution of electricity with an economic loss of $17.5M and 22 human lives. Again according to the USFA prevention enabled reducing the number of fires between the years 1992 and 2001 by over 20%[3].

4. Preventive maintenance of the UPS

The components subject to wear in the static UPS are, in order of severity of failure: batteries, electrolytic capacitors and fans. Expert technicians and automatic tests on the uninterruptible power supplies identify the problems from the very first signs.

4.1 Batteries

The problems with the batteries can be a reduction in capacity and, sometimes, spillage of electrolyte (sulphuric acid based solution). The former reflects on the availability of the electric power since reduced battery capacity means reduced autonomy and it depends on its normal use. The manufacturers give an estimate of battery life based on a temperature at the place of installation of 20°C and no working cycles. It is clear how this classification has a comparative value for battery performance but it is not realistic.



Graph 1 - Percentage of theoretical expected life depending on the temperatures of the installation environment. [4]

- Besides temperature the battery is subject to ordinary use: each charge-discharge cycle shortens the life of the accumulator.

Spillage of electrolyte is possible only if the resin sealing the battery cover (for some reason) is not airtight, or if the safety valves are defective. It reflects on the availability of the electric power but, above all, on the safety of the place of installation. Percolating acid, combined with residues of corrosion originating in the conductive materials in the pole and in its connections, could form a conductive channel along the insulating body of the accumulator between the pole and the metal parts of the casing. An electric current may form that is initially weak but enough to cause phenomena of overheating, erosion and micro-combustion of the plastic material of the battery. Modern UPSs, to improve performance and output, work with no transformer using the battery with voltages even higher than 400V. If there are no periodic checks or they are not performed sufficiently expertly, there is a greater risk that the above described events may over time degenerate into phenomena of overheating and melting of the plastic of which the batteries are made.

For these reasons it is advisable to proceed with:

- a self-test run by the UPS on the batteries every 30-60 days;
- an annual check made by expert technicians;
- renewal of the component at 80% of its theoretical life.

4.2 Electrolytic Capacitors

The expected theoretical life of a capacitor depends on its electric and thermal stress. The symptoms of aging are a reduction in performance and swelling of the casing until the safety valve opens. The capacitor has a shorter life than the expected life of the UPS. It is recommended to renew the component every 4-7 years depending on the temperature of the working environment.

4.3 Fans

Among the parts subject to wear the fan is the one with less serious and dangerous risks but it is still a component of the utmost importance for the availability of electric power.

In the event of poor ventilation, as the UPS overheats, the electric supply will be switched over onto bypass that is the load will be supplied straight from the mains, exposing the load to the related risks. In order to prevent any trouble, it is recommended to renew the fans every 2-4 years according to the conditions of the environment in which the UPS operates.

5. System Inspections

There is a wide range of symptomatic situations with less than optimal operation of the system. These situations can remain as they are or degenerate into failures causing in both cases continual or *one-off* economic losses.

Visual analysis is the most classic type of inspection still necessary to identify some problems. No matter how simple it may seem, it must be done by expert personnel to detect even the smallest faults that anyone inexperienced could miss.

One of the most effective tools of preventive maintenance is „Thermographics." It highlights any abnormal symptoms of thermal behaviour starting a process of investigation of the causes to be done with the cooperation of technical analysts and process experts.

Monitoring the electric parameters of the system completes the tools for optimizing the system. It detects overloads, malfunctioning and possible use sanctioned by the electricity grid manager.

5.1 Visual analysis

Visual analysis is useful to detect deterioration or wear of the various components or of the surface treatments.

Typical visible defects are wear of the surface treatments such as painting or tropicalization, leakage of liquids that can come from batteries or piping, casings no longer able to guarantee the protection class (IP) of the supply and corrosion, fungus or mould.

5.2 Thermographics

Some components for which thermographics can be used to monitor their state of health are:

- Transformers;
- Electric panels;
- Filtering and power factor correction systems;
- Distribution cables and connections;
- Safety devices, disconnecting switches, fuses, switches
- Terminals;
- Inverters and converters;
- Batteries;
- Motors, drives and lighting systems.

Photo 1 shows how the screw of the highlighted terminal has probably loosened and must be tightened with the appropriate torque setting.

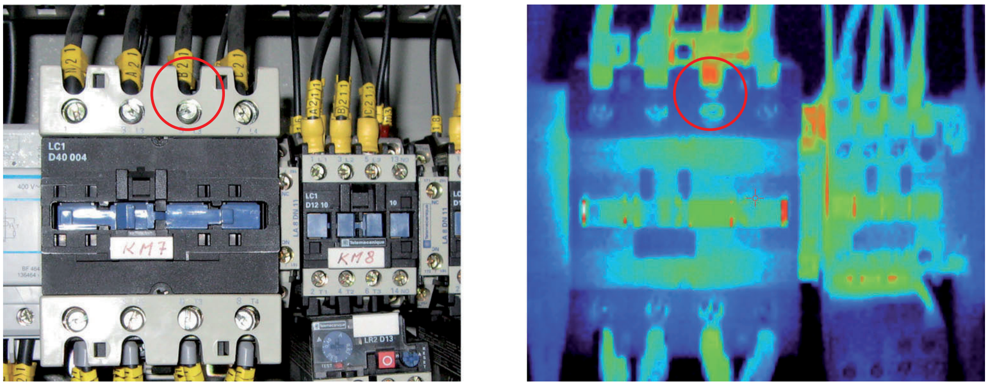


Photo 1 - Hot point due to probable inadequate fixing of the terminal.

Anywhere there is a hot point there is a waste of energy and a reduction in the overall efficiency of the system. Again using the analogy with water it is like buying it and then carrying it in a bucket with a hole in it. Besides wasting the resource we will have to worry about draining off the leaks to prevent them damaging the surrounding equipment.

In the sphere of electricity, in addition, high temperature and resistance are two concepts that often go hand in hand as the one is a possible cause of the other and vice versa. Hot points are to be associated with parasite resistances that cause undesired drops in voltage potentially exceeding the limits tolerated by the load and stopping the system as a result.

5.3 Monitoring the electric parameters

The distribution of electricity is in some aspects similar to that of water. As a first approximation we can think of cables as pipes. They can be used for the entire available cross-section or only a part of it reducing the flow rate. What affects the exploitation of the system, besides the supply as could be expected, are the users themselves. They can be a cause of harmonics and/or excessive phase displacement between voltage and current (reduced cos φ). For these phenomena the electric user can be sanctioned by the national grid manager (GRTN).

With a view to cost cutting, monitoring the mains enables, among other things, recording:

- the use of power during the day;
- any unbalance between the phases;
- order and strength of any harmonics present;
- cos φ and/or power factor of each single phase.

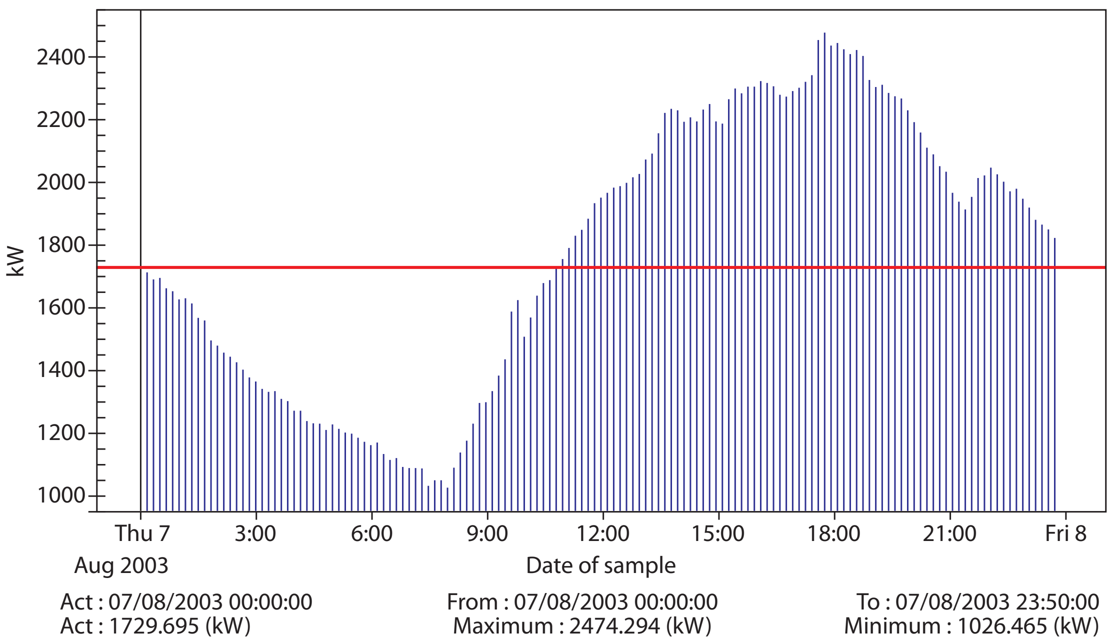


Photo 2: Graph of active power drawn from the mains with the limit of the supply contract.

With these measurements it is possible to decide, for instance, whether to increase the limit of the electricity supply contract or redistribute the operation of the loads during the day, whether to divide the unbalanced loads differently on the various phases for the most efficient use of the system and what solution to utilize to reduce the harmonics (e.g. active filters, passive filters or UPS). All this by properly choosing where to install the solution in order to get the greatest benefit: the power factor correction benches should be installed at the minimum distance from reactive loads.

Bibliography

1. *Marshall G., Chapman D., Resilience - Resilience, Reliability and Redundancy, p. 12.*
2. *http://www.epa.gov/solar/emissions.htm.*
3. *FEMA, Fire in the United States 1992-2001 Thirteenth Edition, October 2004, p. 116.*
4. *Eurobat, The Eurobat guide for the specification of valve regulated lead-acid stationary cells and batteries - p. 6.*

Matteo Granziero

Electrical Engineer at Socomec UPS, part of Groupe Socomec. Currently in charge of Technical Communication for Socomec UPS, Matteo Granziero has experience in rotating induction motors and brushless linear motors. Matteo Granziero obtained his Master degree in Electrical Engineering from the University of Padua (Italy).