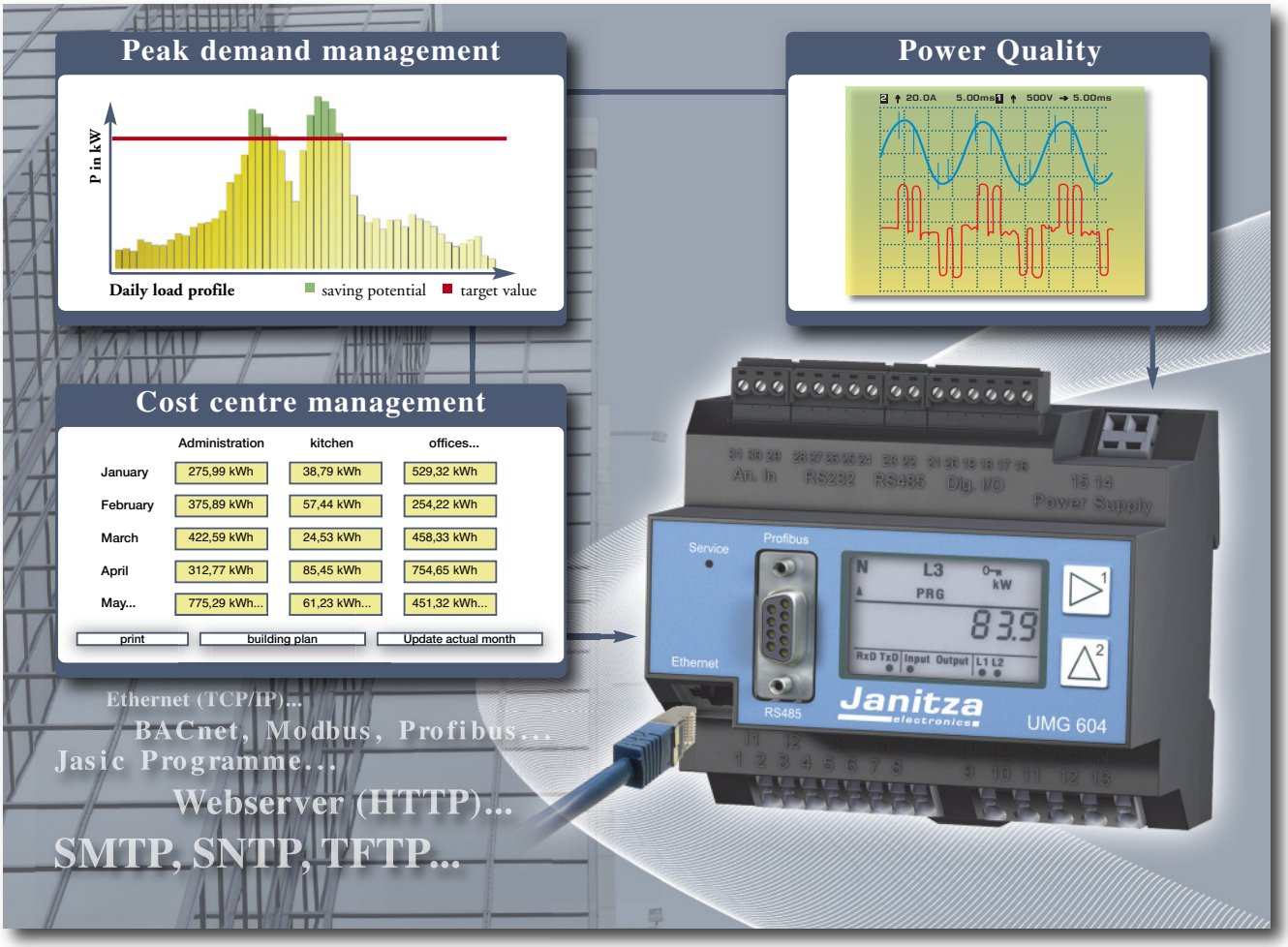
Application Note



AN1014/V01

Power Quality Monitoring

Cost reduction in

building facility management

Janitza electronics

Janitza electronics GmbH offers a collection of know-how based application notes with focus on power quality monitoring, power management and power quality solutions. Furthermore case studies and reference projects will be discussed in the application notes.

On one hand the goal of the application notes are to train and mediate a basic knowledge to our internal and external sales force and representatives. On the other hand it should be used to clarify frequently asked questions and to put new trends professionally well founded across.

Each individual application note touches a specific solution or a technical topic of general interest closed in itself. It is our intention to share the application know-how of Janitza electronics GmbH gained over many years to our world wide spread sales partners who are working in the fields of PM, PQS and PQM.

Our application notes are published in a sporadic cycle.

Modern network analyzers

Cost reduction in facility management

Sharply rising energy costs increasingly make energy a cost driver. The first step in dodging the cost trap in building facility management is to precisely record all energy data, electrical and power quality parameters. Modern energy meters and power analyzers ensure the required transparency in building power supply. Based on detailed data, concepts, for instance for electric energy reduction, can be developed and concrete measures can be introduced. With power analyzers, the improvements can be monitored and logged on top of that.

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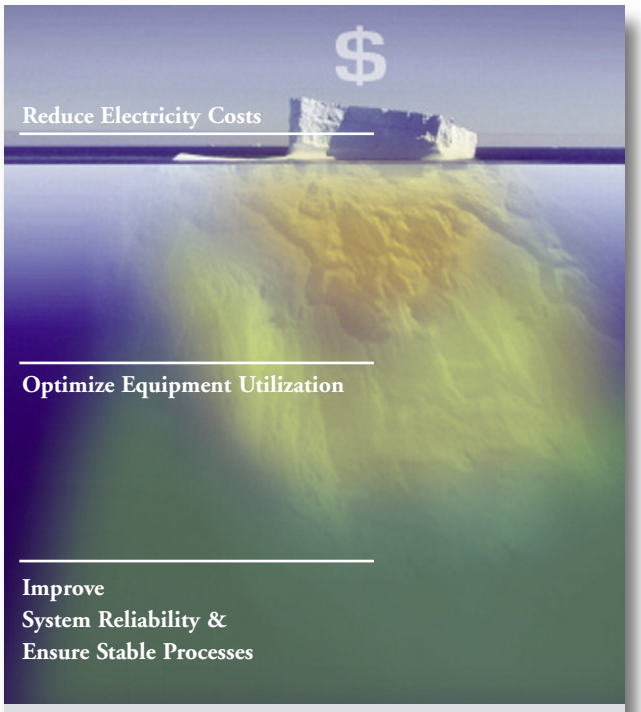
Contents

Hidden Cost Saving Potentials in Buildings

There are a great number of cost-saving potentials in building facility management. One important cost factor is the electricity bill for plant and equipment, buildings and the infrastructure. But the electric bill is merely the immediately noticeable part of costs, which can be much higher when one considers a 'dirty' and unreliable power supply. Along with the direct electricity costs, the effective utilization of power distribution plants and equipment along with a reliable power supply also play an important role in economic efficiency. As these costs are not as obvious, they are also referred to as 'hidden costs'.



Pic 1: Iceberg Analogy
Triple cost saving potential: Hidden cost for underutilized equipment and unreliable power supply offer tremendous cost saving potentials

Cost-saving potentials to be achieved with modern power analyzers:

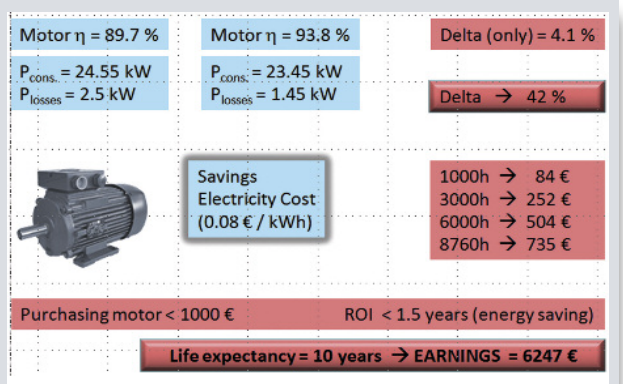
- **Reduction of electricity costs, 3fold:**
  - **kWh consumption reduction**
  - **Reduction of reactive power cost (improvement of poor power factor, reduction of penalties)**
  - **Eliminating demand charges**
- **Identify 'energy gluttons'**
- **Reduce maintenance costs**
- **Extend the service life of electronic and electric equipment**
- **Exactly register demand per cost centre (e. g. how much electricity is used in which office?)**
- **Stabilize the power supply to prevent computer downtimes**
- **Pro-active measures by means of a higher transparency of the electricity distribution**

Reduction of electricity costs – an real case example from Germany

Direct, consumption oriented energy costs can be significantly reduced:

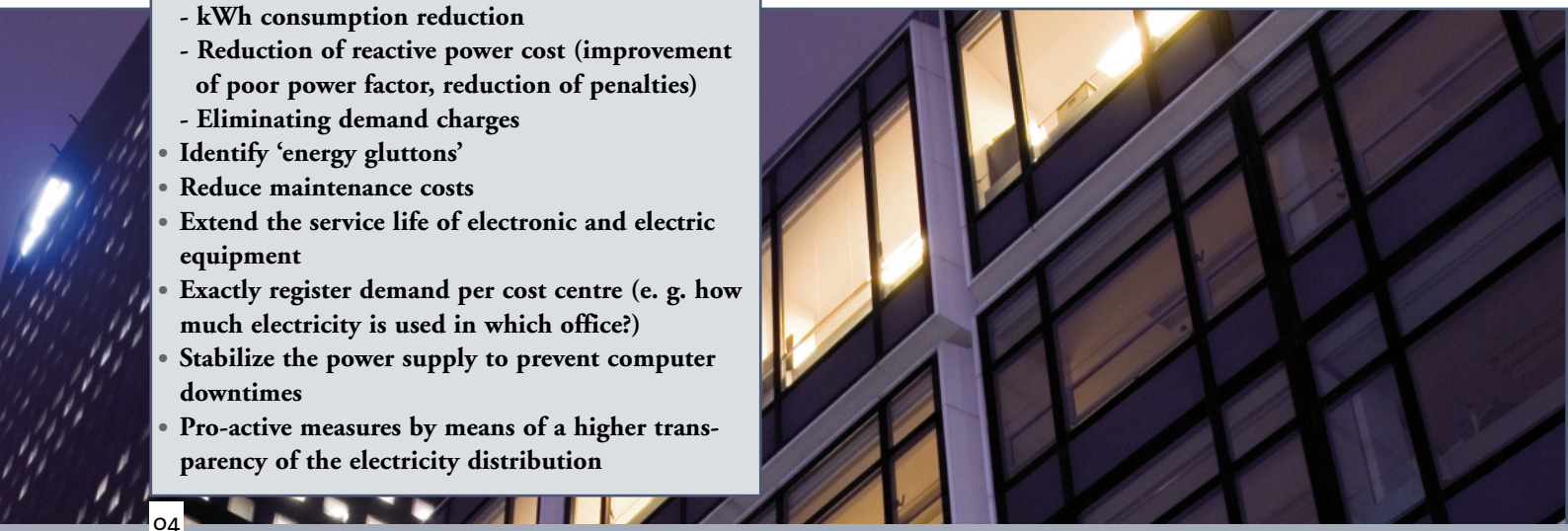
1) For property managers, that means improving the precision of the electricity sub-billing plus customer-oriented invoicing (cost - centre - management).
2) With appropriate power measurement engineering, energy consumption reports can be comfortably generated to verify the electricity bill from the power utility. On top this offers an excellent tool for a more precise forecasting of energy demand and allows negotiating tailor made energy supply contracts with Power Utilities which may cut-down electricity cost substantially.
3) Integrated power management systems across the various network levels facilitate detecting uneconomical consumers and energy wasting. Identifying energy ‚sinners' is only possible with the right network transparency and consequently initiating the corresponding countermeasures. See an example for this statement in Pic. 2 below:

Identify energy inefficiencies and waste of energy

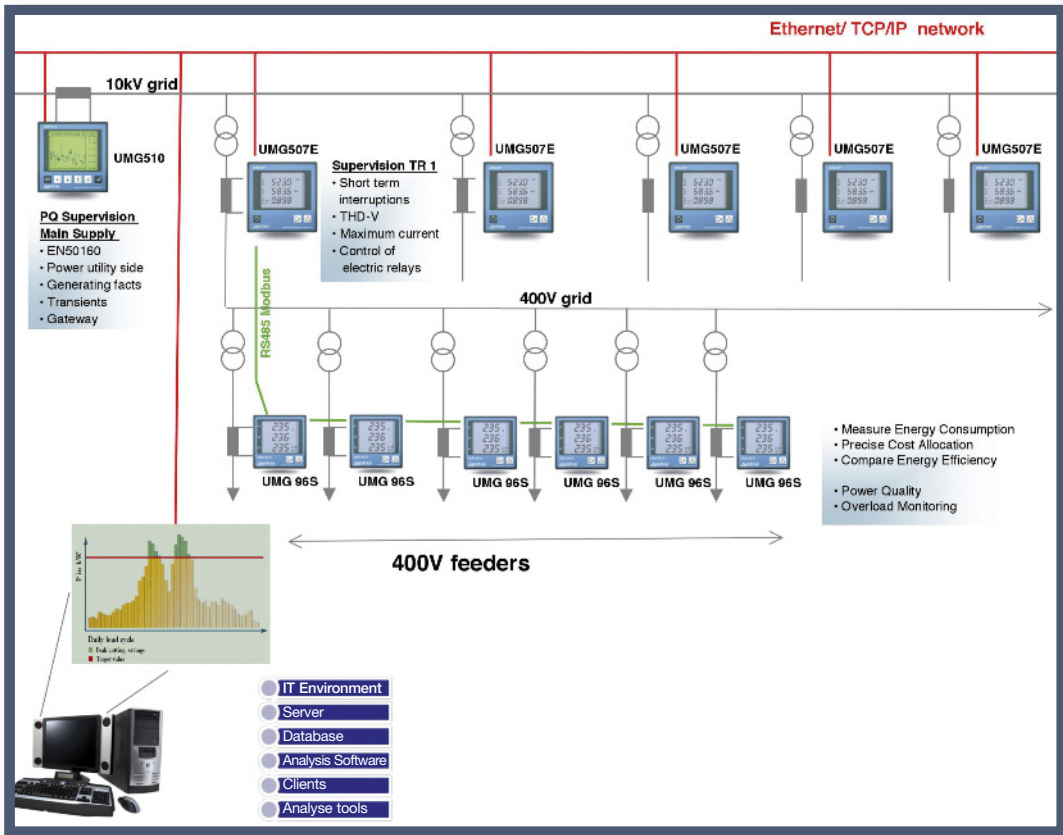


Pic 2: Identify energy inefficiencies
Only with a high level of transparency it is possible to figure out inefficient loads!

The following considerations of an office building complex in Germany, Lower Bavaria, will serve as an example: management requested the electricity department to explain the rising electricity costs and to illustrate potentials for savings.



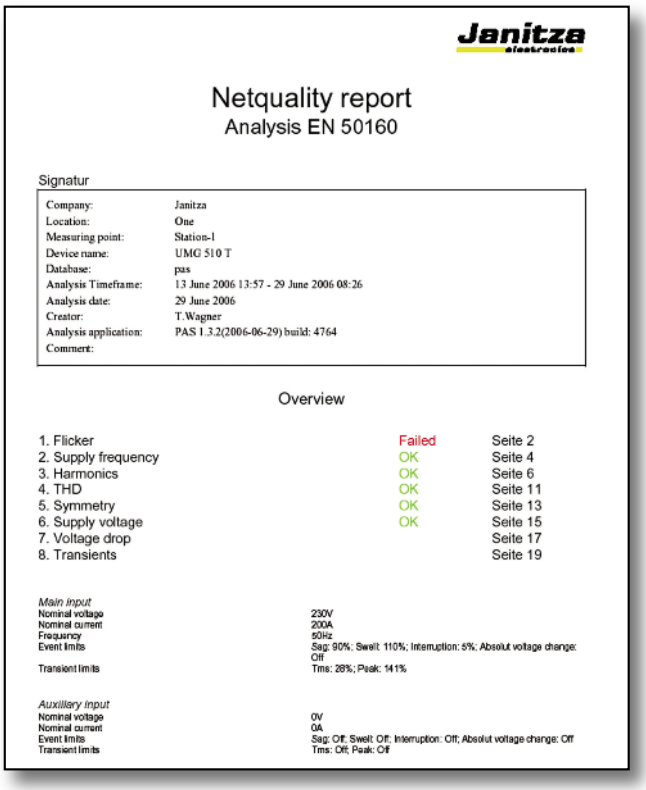
Up to then, the building had been using rather traditional measurement engineering with analogue moving core panel meters. The facility management decided to use UMG96S, UMG507E and UMG510 universal meters and network analyzers. The goal was to determine the energy consumption in the individual buildings, departments and the renting major clients as well as to monitor the overall power quality. To do that, first of all it was necessary to define the measuring points in the power distribution across all network levels. While doing so, a multi-staged concept was selected using a UMG510 power quality analyzer in the 10kV feed (PCC). This power quality analyzer verifies the power quality supply coming from the public utility based on the applicable power quality standard, EN50160. See an overview diagram, Pic. 3 below:



Pic 3: Office Building Overview SEMS Configuration (Smart Energy Management System)

For those responsible for the electricity supply, simple documentation of the voltage quality with continuous recording of all power quality parameters was important. The UMG510 network analyzer facilitates a complete network analysis for a user defined time period in accordance with the EN50160 standard at the a touch of a button. A comprehensive report (see Pic. 4) with all parameters is automatically generated and can be made available to the management upon request within a few minutes.

The electrical engineer in charge appreciated this solution as it was time saving for him with a limited man power in the service team, the quick information easily generated as well as the automatically generated comprehensive power quality report. So it is possible in case of a complaint of a tenant , e.g. about a supposed short term voltage interruption, to find out the real facts and root cause by return. The analysis of historical data out of the data base, generated by the SEMS, allows in case of power supply interruptions to generate concrete data and not just a guesswork for negotiation with the power distribution company.



Janitza electronics

Netquality report
Analysis EN 50160

Signatur

Company:	Janitza
Location:	One
Measuring point:	Station-1
Device name:	UMG 510 T
Database:	pas
Analysis Timeframe:	13 June 2006 13:57 - 29 June 2006 08:26
Analysis date:	29 June 2006
Creator:	T.Wagner
Analysis application:	PAS 1.3.2(2006-06-29) build: 4764
Comment:	

Overview

1. Flicker	Failed	Seite 2
2. Supply frequency	OK	Seite 4
3. Harmonics	OK	Seite 6
4. THD	OK	Seite 11
5. Symmetry	OK	Seite 13
6. Supply voltage	OK	Seite 15
7. Voltage drop		Seite 17
8. Transients		Seite 19

Main input

Nominal voltage	230V
Nominal current	200A
Frequency	50Hz
Event limits	Sag: 90%; Swell: 110%; Interruption: 5%; Absolut voltage change: Off
Transient limits	Tms: 28%; Peak: 141%

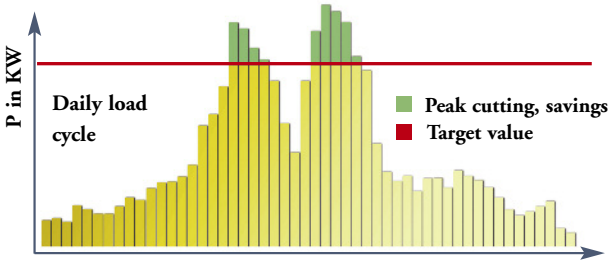
Auxiliary input

Nominal voltage	0V
Nominal current	0A
Event limits	Sag: Off; Swell: Off; Interruption: Off; Absolut voltage change: Off
Transient limits	Tms: Off; Peak: Off

Pic 4: Power Quality Report
Comprehensive power quality report, according EN50160, 20 pages long

Peak load monitoring helps to cut down demand charges

In the feeders of the incoming transformers UMG507E power analyzers have been used (see Pic 3). Priority hear was the monitoring of load profiles and power quality parameters (short term interruptions, harmonic loading, unbalanced loading, ...) as well as peak demand supervision. By temporary switching-off consumers, e.g., in the canteen kitchen, it was possible to lower the effective power maximum (demand), reducing the demand charges and consequently the electricity bill by up to 20%.



Pic 5: Peak demand control
24 hours load profile in an office tower, clearly visible peak loads during typical office hours, low load during night, reduced loading during lunch break

A demand controller is one of the most effective load management devices, because it pays off usually in a short time period of 6-24 month. After this period it earns money continuously without compromises!

Beside demand charges peak-load monitoring was also important for improved power distribution plant-utilization, e.g. to prevent overloading of certain heavily loaded power distribution network sections and to delay new investments in extension of distribution centres as well as heavy dynamic UPS systems for the IT centres involved, see Pic. 6 below:

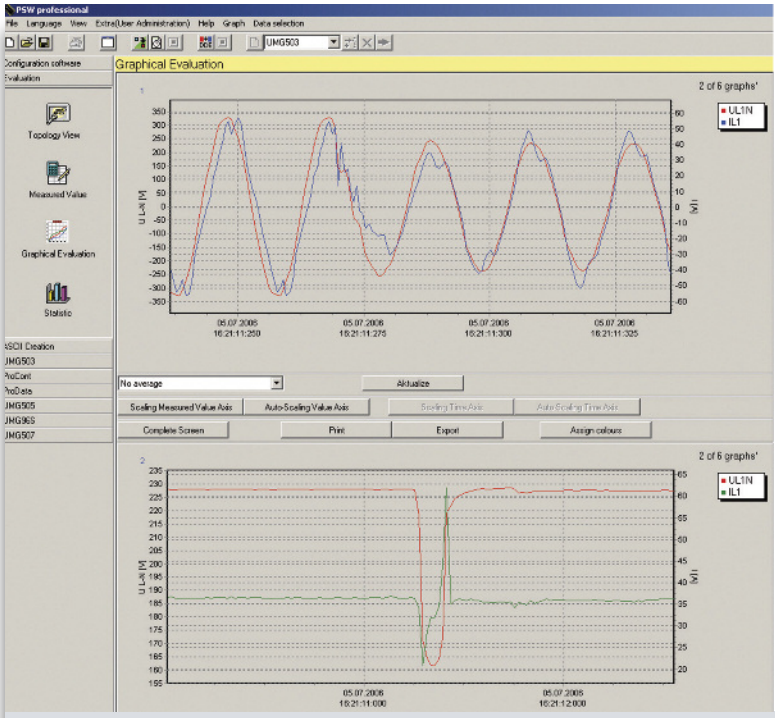
Pic 6: Dynamic (fly wheel) UPS
With a high level of transparency it was possible to reduce the number of costly UPS systems and distribution centres

The 400V sub-feeders to the individual offices and building sections were monitored using UMG96S power analyzers (see Pic 3) with interface and field bus communication. That improved the transparency and facilitated the corresponding allocation of the consumed electricity to the individual cost centres and tenants.

"For us the highest importance was allocating the individual electricity costs to the individual cost centres in order to create the awareness with departments and people in order to make a first step in energy saving. Furthermore, exact knowledge of the power consumption of individual consumers or consumer groups helped us a lot in discovering inefficient electrical loads (consumers) and in initiating countermeasures in energy saving."

Transparency in the distribution system helps to narrow down root causes

The most important information one gets is due to the achieved transparency of the electricity distribution system. During malfunctions, the selected multistage measurement concept across the various network levels proved indispensible in finding the root causes, i.e. for narrowing down the possible sources of faults. For instance, by making a comparison of chronologically synchronized devices, one can find out whether an short term voltage interruption is originating in the network side from the power distribution company or if it was caused by one's own consumers, e.g. through inrush current caused by capacitor switching or motor start-up or even a short-circuit happened.



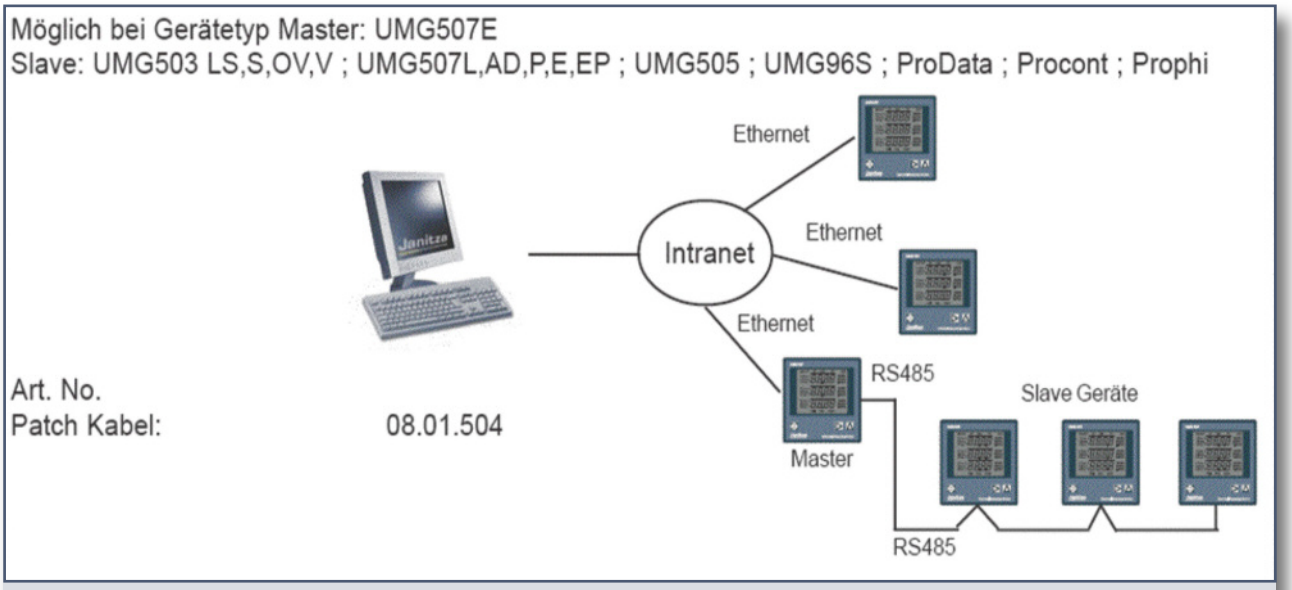
Pic 7: Graphical Evaluation
Root cause analysis via comparing various measurement points, time synchronized, e.g. low voltage and low current means a voltage drop from power utility side

Cost effective, swift and secure communication

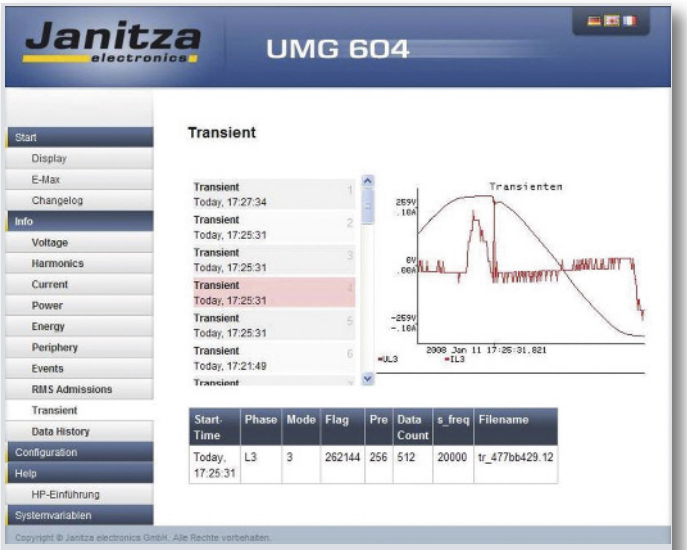
On top of that, networking the meters through a field bus enables automatic measurements downloading and makes them available for utilization in network control as well as for the management. To keep installation costs down (e.g., peripheries for the field busses), the decision fell in favour of Ethernet TCP/IP as the backbone for data communications. As network analyzers with Ethernet interfaces are expensive to acquire, and in companies sometimes monthly fees for each LAN point arise, one originally doubted that this could be implemented with the available budget.

The solution was to combine the UMG507E network analyzers with a Modbus gateway feature and the UMG96S Modbus devices, see Pic. 8 below. With that, one adapted the high-end UMG507E in the central feeding points to the increased requirements placed on the measurement technology. Simultaneously, with the UMG507E it was possible to connect the more economical UMG96S devices via Modbus to the Ethernet through the Modbus gateway function.
The EtherModbus gateway allows serial Modbus to communicate and interoperate with Modbus/TCP devices. The Modbus standard protocol is an asynchronous protocol designed to connect directly to computer asynchronous ports. Modbus has been extended to operate over Ethernet using the IP protocol suite. The Modbus gateway of the UMG507E converts between the Modbus TCP/IP protocol and Modbus RTU protocols transparently. With this method it is possible to combine field busses with Ethernet, which is growing rapidly, and showing it's strength is reliability, speed and availability.

Modbus Gateway (Intranet)



Pic 8: Modbus Gateway
A typical network configuration with a number of UMG507 Ethernet power analyzers, and one branch of UMG507E as master device and a number of UMG96S (e.g. for cost centre management) connected as slaves via Modbus RTU. With this topology even the Modbus devices can be read out via Ethernet.



Pic 9: UMG604 Homepage
A transient happened, via the device internal homepage this information can easily be retrieved even from remote areas

With this configuration cost can be reduced as no external COM-server (RS485 to Ethernet) is required.

Due to the integrated Modbus gateway function of the UMG507E, UMG510 and UMG604 also lower cost devices such as the UMG96S, as well as existing energy meters in an application, same as any other consumption meters with Modbus communication can be easily connected to Ethernet.

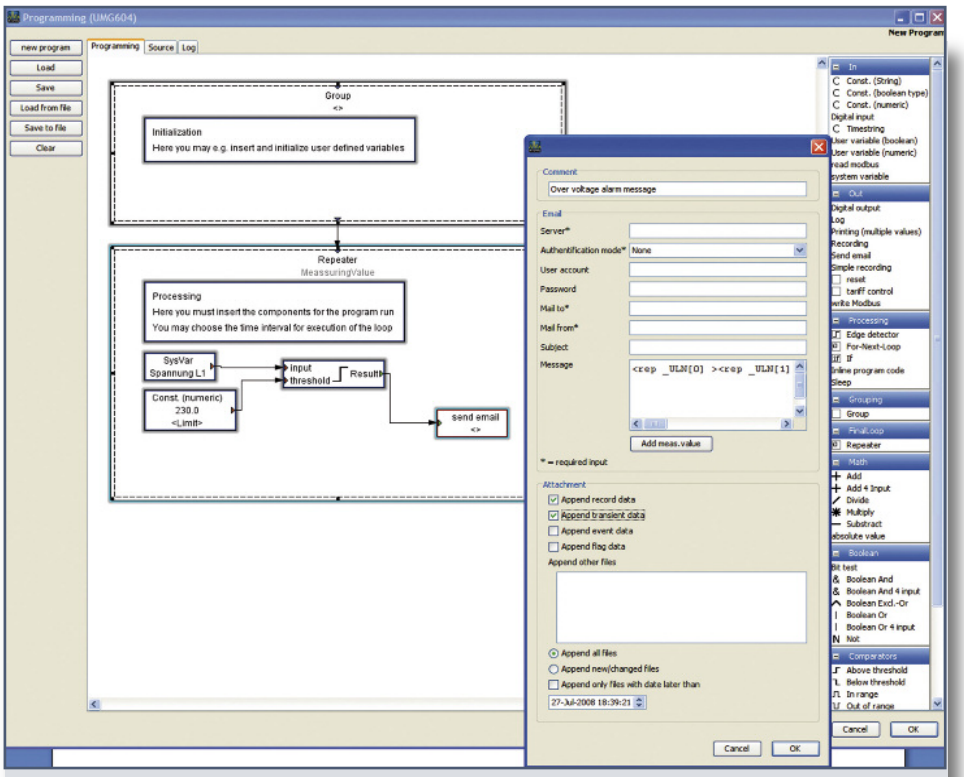
Get informed anywhere and anytime via email and homepage

Nearly everyone has experienced it: barely out of the office and the first calls come about problems in the computers, computers are failing or the power supply crashes – the web server integrated in the power analyzers create direct access to the data at the individual measuring points.

All authorized employees in the electrics department and the management can quickly get extensively informed directly through the homepage of each power analyzer. All you need to do that is a web browser and the IP addresses in the network assigned to each power analyzer. With the latest product development, the UMG604, even a complete costing tool has been implemented with the homepage.

Pic 10: UMG604 costing tool
Via Web browser direct access to the UMG604 power analyzer and it's costing tool for electricity cost analysis. Precise electricity cost overview at a click on your mouse.

Tolerance limits were set for the various parameters in addition. The responsible employee in the electrics department will be informed worldwide via email whenever the power supply is overloaded, short term supply voltage interruptions bring the computers to a standstill or impermissible harmonics threaten to reduce the service life of the equipment.



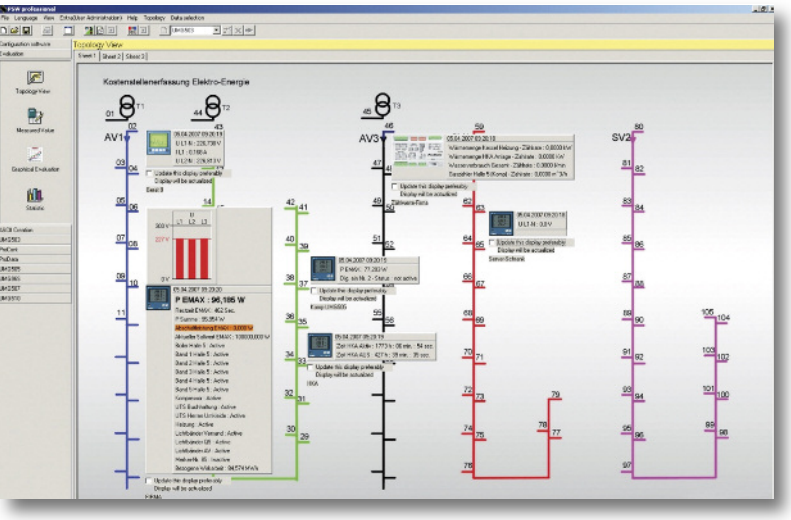
Pic 11: Overvoltage warning & Email message
UMG604 offers a graphical programming. Up to 7 user defined programmes in parallel. In this simple example monitoring 230 V as a maximum allowed voltage, exceeding will generate a warning message via Email.

With the UMG604 power analyzer this can be programmed with the GridVis software under the "Program device" menu point. With the UMG507 this can be done under configuration UMG507 in the PSWprofessional software.

With smart limit value settings for various parameters, e.g. maximum current, harmonics, demand limit …. and so on, the person in charge can be informed proactive, i.e. no need to wait for a problem to come but to react prior to this event and take counter measures in time, e. g. to prevent a possible current overloading scenario with a tripping of the main circuit breaker and a standstill of large scale areas in a building.

Collect, save and analyze data

The data gained from the various measuring points needed to be collected, saved, processed, visualized and made available. One first tool here is the topology view to get an overview of the running application. Measurement data can be freely selected and limits set to give a fast optical indication of any critical situation.

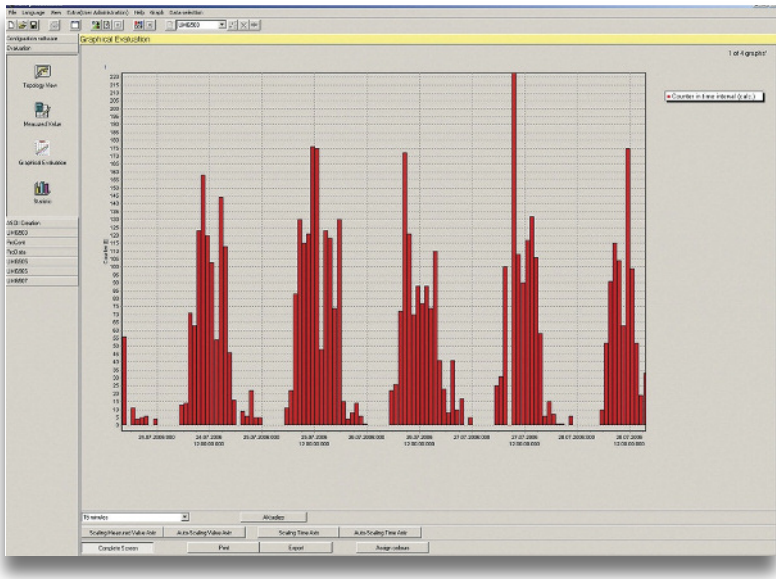


Pic 12: Topology View

Your distribution system at a glance. Alarms can be programmed upon customer requirement.

Online analysis tools for graphic analysis of the data, e.g., comparing load curves as well as analysis tools for historical data and report generation were installed. The measuring points were placed on the topology views and now provide a quick overview of the entire power distribution system. It is possible to localize network malfunctions by comparing the individual measuring points and in order to check the defined tolerances at a glance. By storing graphics files (e.g. JPG) with circuit diagrams and building plans, and by linking the associated meters with drag and drop to their actual locations, one can implement a cost effective and customer specific solution. Out of limit conditions (e.g. THD-V too high!) and conditions in the inputs and outputs can also be displayed.

A mySQL database was installed to save the data. The availability of historic data makes it simple for the electrics department employees to create load curves for the procurement department for negotiating with the public utility.



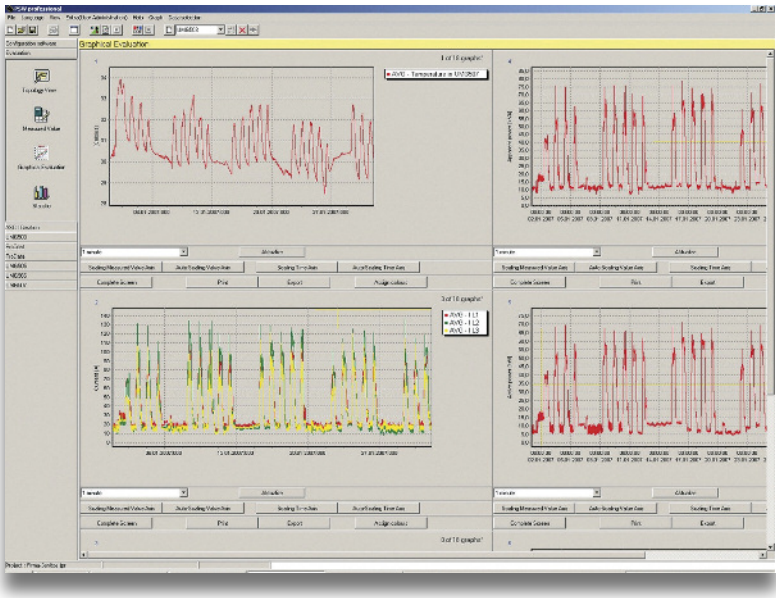
Pic 13: Graphical Evaluation

Load profile of one week

As costly electric supply interruptions had already occurred in the past, great importance was placed on a high degree of data reliability. For that reason, a separate data server with correspondingly high speed and redundancy was used in the data backups. The PSWprofessional energymanagement software was installed on the client computers in the electrics department and in the procurement department.

Online values and analyzing historical data

The graphic continuous-line recorder feature makes quick online display of selected measurements feasible. The chart in this function is continuously expanded with new measurements. By analyzing historical data, just a few mouse clicks are needed for, e.g., fault analysis by comparing various parameters.



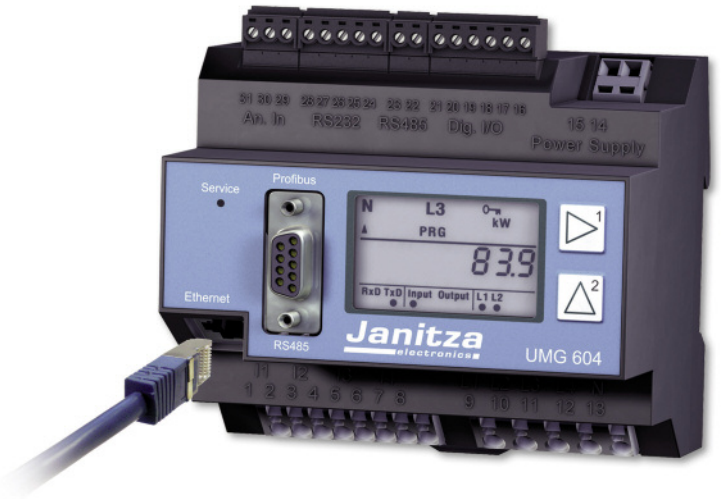
Pic 14: Graphical Evaluation

Future prospects

By integrating functionalities, modern power analyzers are advancing far beyond the limits of digital multimeters, e.g. including following functions all in one device:

- **Energy meter (kWh, kVArh)**
- **Harmonic analyzer**
- **Transient recorder**
- **Event recorder**
- **Demand controller**
- **PLC functions**
- **Data logger**
- **Condition monitoring**

Rapid improvements in the field of integrated circuits permit continuously faster and compacter network analyzers at affordable prices. So the brand-new UMG604 power analyzer, equipped with a 500MHz DSP (digital signal processor), is a power analyzer that is exceedingly fast and powerful while maintaining the smallest dimensions.



Constantly sampling the eight channels with 20kHz per channel facilitates registering all electrical parameters **(more than 800 values)**, min and max values, the basic power quality values such as harmonic content (up to 40th, per phase with direction detection) and short term voltage interruptions.

Even transients (> 50µs) can be reliably identified. By using modern communication architectures, integrated web servers and the supplied GridVis network analyzer software, comprehensive smart energy management systems (SEMS) for detecting and repairing potential power supply problems - often even before the fact happens - can be generated.

Significantly reduced hardware costs result from registering up to four power circuits with one single power analyzer.

Typical applications

- **Office buildings**
- **Commercial buildings**
- **Shopping malls**
- **IT and data centre**
- **Banks and insurances**
- **Hotels**
- **Universities**
- **Hospitals**
- **Infrastructure buildings**
- **…**

Customer benefits of Power Quality Monitoring in Building Management

- Reduction of electricity cost
  - kWh cost
  - high peak demand charges
  - low Power Factor penalties
- Sub billing to tenants
- Avoiding overload of energy distribution system, e.g. tripping of breakers or protection system
- Power quality improvement
- Transparency of energy distribution systems
- Possible lower dimensioning of electrical distribution equipment, e.g. less UPS systems
- Root cause analysis of power quality problems
- Precise demand forecast allows improved energy supply contracts
- Remote monitoring
- ....

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