



Scientific Automation as the foundation for comprehensive energy monitoring, from individual machines to entire building sites

## Successful energy management based on integrated energy measurement

Beckhoff offers a broad portfolio of solutions from energy measurement to grid analysis for a wide range of applications, including machines and production equipment, factories and buildings, as well as wind and hydroelectric plants. The product range includes a stand-alone energy meter as a cost-effective solution configured from standard industrial components. Yet on the other hand, the Beckhoff Bus Terminal system offers ample scope to meet a wide range of requirements, both for individual applications as well as for integrated energy measurement.

Through continuous and intensive efforts, industrial productivity has already increased to a level where the potential for further improvements is limited, at least for the time being. In contrast, energy efficiency still offers immense potential for improvements. Without requiring major financial investments, cost savings can be achieved simply by making energy consumption more transparent and by optimizing production processes: a reduction in peak loads and corresponding agreements with the energy supplier can be sufficient to make substantial progress.

In addition, most companies in industrialized nations are coming under increasing political pressure to reduce their energy consumption and CO<sub>2</sub> emissions. For example, future repayments of the levy that resulted from the German Renewable Energy Act will be linked to the introduction of an energy management system (EnMS). A basic prerequisite for this is reliable and detailed data logging

of energy, which is why monitoring, measurement and analysis is defined in the EnMS model of the corresponding DIN EN ISO 50001 standard. Beckhoff solutions with integrated measurement functionality are ideal for implementing this. The solution consists of a modular I/O terminal system, TwinCAT automation software and open communication, e.g. via EtherCAT and OPC UA.

### Stand-alone and integrated energy measurement made easy

The Beckhoff solution, in the form of stand-alone energy meters, already offers advantages over conventional devices: The modular configuration, consisting, for example, of the compact CX8090 Embedded PC (with standard Ethernet connectivity) and the EL3403 power measurement terminal results in a highly customizable solution. The user benefits from reliable, cost-effective and standard industrial components (see figure 1).

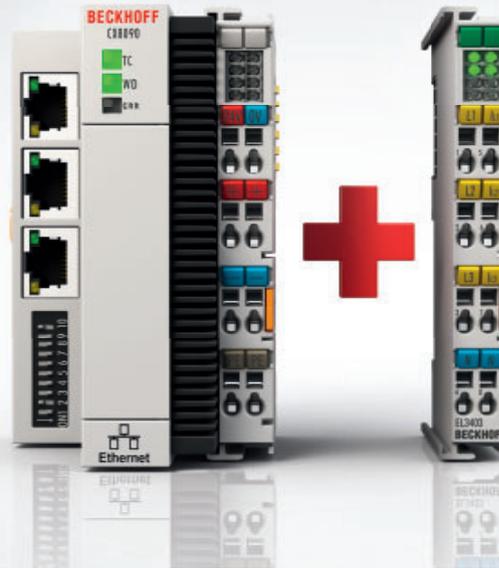


Figure 1: A stand-alone energy meter can be cost-effectively configured using standard components such as Embedded PCs and power measurement terminals.

The integrated approach, however, opens up significantly larger potential for efficiency improvements: The open and integrated Bus Terminal I/O and software system from Beckhoff enables simple and cost-effective energy measurement that is fully integrated in the system. The energy consumption of all consumers can be measured anywhere in a plant or building and at any number of locations. The benefit of this integration is that the power measurements are available directly in the I/O system, without the need for a separate automation system. The corresponding Bus Terminals and software modules can simply be added to the control system as required. On the one hand this reduces the efforts to implement comprehensive monitoring of energy consumption, and on the other hand it makes total consumption data available as well as the data for all sub-processes.

#### Modular and integrated measurement of energy data

The solution is based on a large number of I/O modules for energy data acquisition. For example, commonly used gas, water and heat meters can be integrated very easily via the KL6781 and KL6401 Bus Terminals and the M-Bus or LON interface. In addition, the compressed air supply can be monitored directly with the KM37xx differential pressure measuring terminal and the IP 67-rated EP3744 differential pressure measurement box, which can be deployed locally. In this way, the system can be monitored for energy-wasting leaks, for example. Electrical parameters can be monitored conveniently via the KL/EL3403 power measurement terminals. The EL3413 and EL3433 power measurement terminals and the EL3773 mains monitoring terminal offer further analysis functionality.

The different Bus Terminals can be used locally in the areas where they are required for precise measurements. This minimizes the wiring effort for measured data acquisition. A single EtherCAT cable (standard Ethernet media) can connect the individual stations, so that all data can be collected and analyzed in a central PC controller. In this way the energy consumption of individual components, sections or the whole plant can be fully monitored. The energy consumption data for the entire factory, offices and other buildings are also available.

#### Analyzing and utilizing consumption data via software

The logged energy consumption data are available in an open, PC-based system at all software levels via EtherCAT – or via any other fieldbuses as required. The TwinCAT automation suite can be directly deployed at the control system level, both for control parameter use and for condition monitoring and energy consumption analysis. Thanks to the system openness, connectivity to a higher-level energy management system can be provided via any of the established and open software standards such as OPC UA.

TwinCAT PLC software makes consumption data available directly for correcting control algorithms, in order to improve the energy balance of the machine, system or production process. The automation suite also offers useful tools for monitoring and analysis: The Beckhoff TwinCAT CMS Condition Monitoring library offers a modular system of mathematical algorithms for analyzing measurement readings, so that energy monitoring of machines and systems can be realized efficiently. The user can select components from this modular system

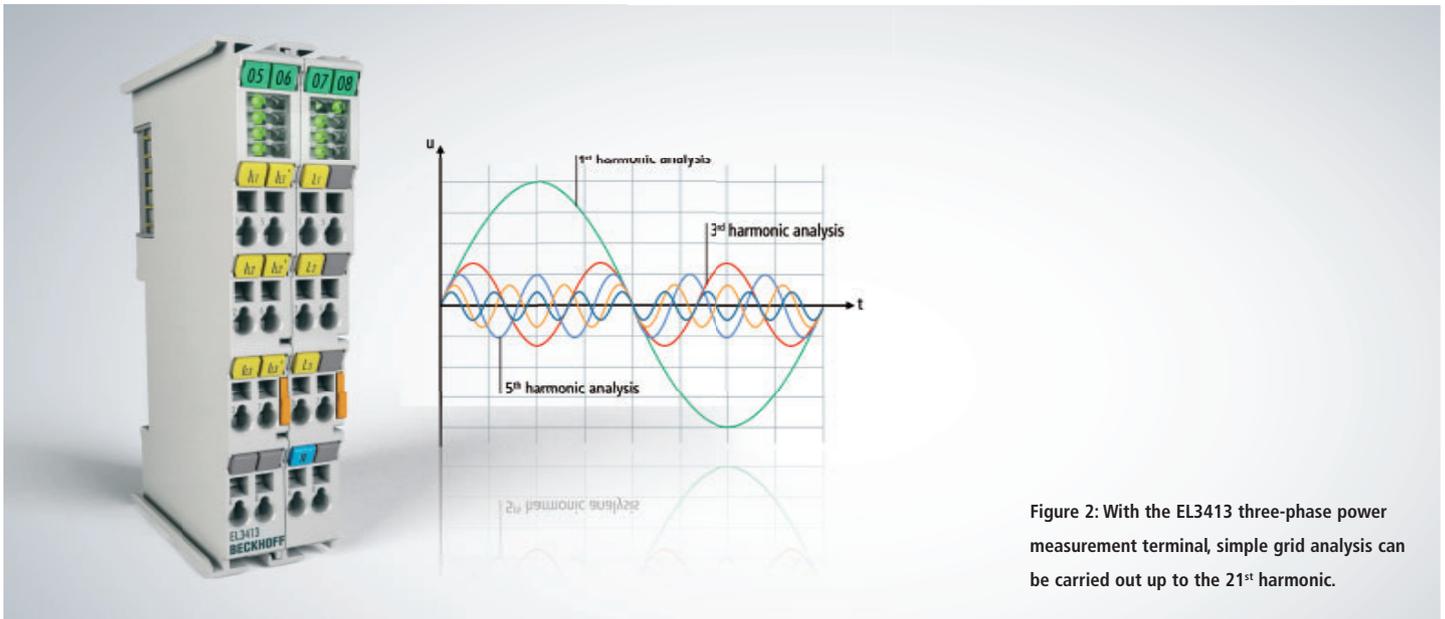


Figure 2: With the EL3413 three-phase power measurement terminal, simple grid analysis can be carried out up to the 21<sup>st</sup> harmonic.

as required for the respective application to develop solutions that are scalable for different platforms. The library's primary functions include: analysis, statistics and classification.

Comprehensive monitoring of energy data is also possible with the TwinCAT Scope software oscilloscope, which combines fast data logging with a powerful graphic display tool. The logger can process long-term recordings as well as very fast cycles in the  $\mu$ s range, e.g. from EtherCAT measuring terminals such as the EL3773 with oversampling function. The results are then displayed in the viewer section of the Scope. The viewer can display virtually any number of curves with high temporal resolution. In this way the user can reliably detect whether the voltage is sinusoidal or subject to harmonics. Thanks to the high temporal resolution, it is possible to analyze very short-term peaks, which are difficult to handle with conventional EMS/SCADA systems.

#### The versatility of integrated energy measurement technology

Energy costs are rising worldwide, which means that energy data logging is becoming more important in all industrial sectors. This puts monitoring and analysis in the spotlight and opens up the potential for savings in many areas. The EtherCAT power measurement terminals from Beckhoff with their different voltage ranges and optional features are suitable for a wide range of applications. They are ideally-suited to achieve cost-effective and efficient power data acquisition and analysis, enabling better system productivity through integrated measurement of current and voltage. The modular and distributed configuration enables the measurement of energy at any location in the system. The RMS value can be logged either directly by an EtherCAT Terminal or – in the case of the EL3773 – by a higher-level controller.

In this way it is possible to stabilize production processes, avoid production losses, detect stray couplings and identify power waste in areas such as machine

construction and plant engineering, the process industries, renewables as well as building and home automation. Other options include correct cost center allocation, supply monitoring, mains synchronization and current quality monitoring. The benefits of the holistic, integrated Beckhoff solution become particularly apparent if you look at a complete production hall, for example: Energy data for machines and systems, right down to individual motors and building services such as lighting and HVAC, can be logged in an integrated manner. These comprehensive data enable truly holistic energy management across the enterprise.

#### The KL/EL3403 "energy meter"

The KL3403 and EL3403 3-phase power measurement terminals enable the measurement of all relevant electrical data of the mains supply with a measuring voltage of up to 500 V AC. The mains voltage can be connected directly. The current measurement takes place via simple current transformers. The measurement readings for all currents and voltages are available as effective values directly in the terminal. For each phase the effective power, apparent power, reactive power, energy, frequency and phase shift angle  $\cos \varphi$  are all calculated.

The KL3403/EL3403 terminals provide reliable data for grid analysis and energy management. Thus they are ideal for distributed monitoring and logging of energy consumption in a production plant, for example. By identifying "power guzzlers" in the process cycle it contributes to reducing electricity costs and enables precise allocation of the respective electricity costs to the corresponding cost center. Detailed measured energy consumption data can also be used for control purposes, for increasing the stability of the production processes or avoiding production downtime, for example.

#### EL3413, the "feature-filled energy meter"

The EL3413 three-phase power measurement terminal, with a test voltage of up to 690 V AC (3-phase, 5 A), has electrically isolated current inputs. Thanks to

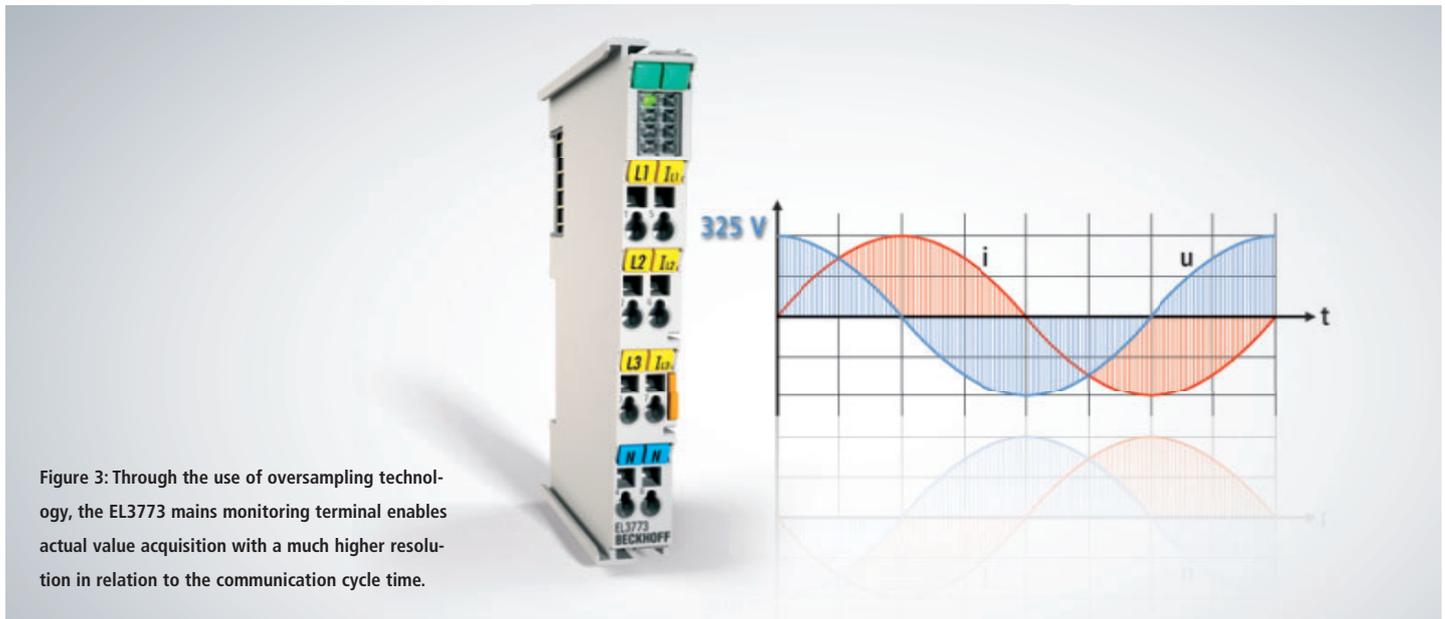


Figure 3: Through the use of oversampling technology, the EL3773 mains monitoring terminal enables actual value acquisition with a much higher resolution in relation to the communication cycle time.

the integrated calculation of harmonic oscillations, simple grid analysis up to the 21<sup>st</sup> harmonic can be carried out (see figure 2). With a higher test voltage of 690 V which is common in wind turbine applications the EL3403 is suitable for a feed-in monitoring of wind turbine generators, for example.

Harmonic analysis with the EL3413 is particularly advantageous with regard to the 3<sup>rd</sup> harmonic. Due to the increased deployment of non-linear electronic devices such as discharge lamps, computers and UPS systems, the stability of the mains can be affected, resulting in increased electrical losses in electric motors, for example. The corresponding 150 Hz currents of the individual phases add up in the neutral conductor and can result in a higher current than in the phase line. If the neutral conductor is dimensioned insufficiently, this may even result in increased fire hazard.

### EL3773, the “power oscilloscope”

The EL3773 mains monitoring terminal logs the actual values of current and voltage with very short sample times and is therefore ideally suited for high-end grid analysis and state monitoring of a 3-phase AC power supply system (see figure 3). For each of the phase voltages, up to 288 V<sub>eff</sub>/410 V DC and currents up to 1 A<sub>eff</sub>/1.5 A DC are sampled as instantaneous values with a resolution of 16 bit. The six channels are simultaneously sampled based on the EtherCAT oversampling principle with a temporal resolution of up to 100 μs, i.e. with a temporal resolution that is significantly higher than the communication cycle time.

These parameters are passed to the associated controller. With the high computing power of PC-based controls, the parameters can be used for true RMS or power calculation, and for processing complex user-specific algorithms. This enables the user to perform detailed calculations or analyses and to display the actual current and voltage curves using TwinCAT Scope software. These benefits are particularly significant for grid synchronization in hydroelectric plants, for example.

### Seamless integration of measurement technology even permits use in smart grid applications

With Scientific Automation, Beckhoff seamlessly combines the functionality of conventional control technology such as PLC, motion control and automation technology, with precise and fast measurement technology and engineering algorithms. The solution can be implemented on a standard, integrated platform and, thanks to the modularity of the systems, optimally adapted to the respective application and easily expanded at a later stage. It provides users with a compact and cost-effective alternative to make energy consumption highly transparent. This in turn is a prerequisite for maximizing energy efficiency and can serve as the basis for future smart-grid applications.

The stations become devices in the data network of a smart grid through the flexible expandability of the PC-based control technology from Beckhoff. It enables users to extend energy and state monitoring with remote control protocols. The systems, in office buildings, factories, substations in a distribution grid, windfarms, cogeneration or biogas plants, can be made “smart” with retrofits. In this way, an office building can generate negative balancing energy by means of a heat pump “charging” a heat store, for example. Positive balancing energy could be generated via a stand-by unit that is activated by the grid operator. Beckhoff technology is already capable of realizing this kind of balancing energy at sites that are configured as virtual power stations and equipped with Embedded PCs.

Further Information:

[www.beckhoff.com/power-measurement](http://www.beckhoff.com/power-measurement)

[www.beckhoff.com/TwinCAT](http://www.beckhoff.com/TwinCAT)