Implementation of energy management with compact circuit-breaker – application in Industry 4.0

CARINA BEERMANN, PETR MASTNY
Faculty of electrical engineering and communication (FEEC)
Brno University of Technology
Antonínská 548/1, 601 90 Brno-střed
CZECH REPUBLIK

Abstract: This paper deals with the implementation of Industry 4.0 with regard to the question of how relevant digitalisation, visualisation and storage of energy data is today. Today, a large part of society is dependent on resources such as electricity, gas, oil and water. Without these resources, daily life would be unimaginable, but awareness is needed.
It is important that we humans use resources responsibly.
For everyday life, suggestions and legal regulations have been created for dealing with the scarcity of resources and sustainability. In industry, guidelines and laws regulate the use of resources such as electrical energy. However, these regulations do not only apply in Germany, but - usually initiated by the European Union (EU) - for all member states of the EU.
A short explanation of the most important laws and guidelines such as DIN EN ISO 50001 and DIN EN 16247-1 are part of this paper, as it is to be examined in particular whether data collection, visualisation and transparency for energy management in industry can create more efficiency through the use of special components through intelligent monitoring. The focus is on a compact circuit-breaker.

Keywords: DIN EN ISO 50001, DIN EN16247-1, Energymonitoring, Energymanagement-System

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1. Introduction

In the age of Industry 4.0 (21st century), the ever-advancing networking of our environment plays a decisive role. The World Wide Web is developing into the Internet of Things or the Internet of Services through networking and is being used increasingly. Thus, visualisation and digitalisation are at the centre of the fourth phase of the industrial revolution.

The term Industry 4.0 is associated with speed, efficiency, individuality and flexibility.

In order to achieve the goal of efficient energy management, future plants must be planned according to the requirements and existing plants must be modernised, if necessary from the ground up. Efficiency and cost savings in the field of energy play a major role today as well as in the future. With the trend towards renewable energies, the legislative and guideline process is being intensified in order to save energy [1]. The associated effort of mandatory data collection and data storage is relatively costly and can be greatly facilitated by an energy monitoring/energy management system. Often, plants fed with electrical energy already have a so-called energy management system in order to reduce energy costs and comply with legal requirements. The 3VA2 compact circuit-breaker with communication capability plays a key role here. However, the optimum can only be achieved with a constantly individually adapted energy management concept; this means that a review of the systems takes place at short intervals in order to offer continuous improvement. The implementation of energy monitoring as part of the energy audit or energy management is therefore of fundamental importance.

2. Legal Requirements

2.1 General Information

Global climate change, scarce energy resources and the increase in energy consumption make action urgently necessary [2].
In its Energy Concept 2050, the German government has set the goal of halving primary energy demand by 2050. Already by 2020, a 10% reduction in electricity consumption and a 20% reduction in total energy consumption were targeted [3].
In order to achieve these goals, industry and commerce in particular are requested to make their contribution and reduce their energy consumption by investing in energy-efficient production processes and technologies.
In order to achieve these goals, politicians have enacted various regulatory instruments and support measures. The "magic word" is "energy efficiency".
In June 2014, the deadline for transposing the European Energy Efficiency Directive (EED), which has been in force since 4 December 2014, into German law expired [4].

2.2 Legal framework for the enforcement of energy efficiency

Based on the EU's strategic goals for the year 2050:

- **Reduction of greenhouse gas emissions by 55% (2030); 70% (2040); 80% (2050) - in each case compared to 1990**
- **Increase the share of renewable energies in gross electricity consumption 65% (2030); 70% (2040); 80% (2050)**
- **Reduction of gross final energy consumption 30% (2030), 45% (2040), 60% (2050)**
- **Reduction of primary energy consumption by 50%.**
- **Conventional energy sources are continuously replaced by renewable ones**

the topic is embedded in the energy and climate policy strategy [5].

The following important guidelines have been issued to implement these goals:

Table 1: Implementing directives

EU	Germany
Energy Services Directive (ESD) of 2006 (Directive 2006/32/EC of 5 April 2006) [6]	Act on Energy Services and Other Energy Efficiency Measures (EDL-G) 2010 implemented [7]
Ecodesign Directive and Energy Consuming Products Act (EuP Directive) [8]	Energy-Using Products Act (EVPG) [9] formerly Energy-Using Products Act (EBPG)
Emissions certificate trading [10]	Greenhouse Gas Emissions Trading Act (TEHG) [11]
Building Performance Directive (Directive 2010/31 of 8 July 2010) [12]	Building Energy Act (GEG) of 1st November 2020 [13]
Energy Efficiency Directive (EED Directive 2012/27/EU of 4 December 2012) [4]	Laws on Energy Services and Other Energy Efficiency Measures (EDL-G in the version of 12.02.2016) [3]

2.3 Energy audit DIN EN 16247-1 and energy management system according to DIN EN ISO 50001

Exempted from the obligation to conduct an energy audit according to DIN EN 16247-1 are those companies that either implement an energy management system according to DIN EN ISO 50001, edition December 2011 (§ 8 par. 3 no. 1 in conjunction with § 2 no. 17 EDL-G [14]) or an environmental management system within the meaning of Regulation (EC) no. 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a community eco-management and audit scheme and repealing EMAS (§ 8 par. 3 No. 2 ELD-G). No.2 ELD-G [14]).

The difference between an energy audit and an energy management system is that an energy audit is usually repeated every four years and technical energy efficiency measures are identified.

An energy management system, on the other hand, is geared towards a continuous improvement process and is linked to a commitment by top management. The aim is to improve energy efficiency permanently and continuously, to take it into account in all processes and strategic decisions.

The energy assessment to be carried out within the framework of DIN EN 50001 [15] corresponds in principle to a detailed energy analysis, as also required by DIN EN 16247-1 [16]. In this respect, the energy audit can also be understood as a preliminary stage or first basis for an energy management system. Both the energy assessment and the energy analysis are possible with the appropriate measurement technology and software, while for the energy assessment according to DIN EN ISO 50001, eligible stationary measurement technology and software must be available.

With the increasing international importance of the topic of energy efficiency, the standards organisation ISO (International Organization for Standardization) has issued further standards in the 50000 series and, for example, with ISO 50003:2014 "Energy management systems- Requirements for bodies providing audit and certification of energy management systems", has published an international set of rules for certification bodies. The German version of ISO 50003:2014 was published in November 2016. It also stipulates that all accreditations must be converted to ISO 50003:2014 by 14 October 2017 [17].

The developed programm is intended to support small and medium-sized enterprises (SMEs) in obtaining state benefits within the framework of the peak compensation (cf. § 55 EnStG (Energy Tax Act) [18] and § 10 StromStG (Electricity Tax Act) [19] and SpaEfV (Peak Compensation Efficiency System Ordinance) [20]. It is intended to support non-SME companies in the implementation of a meaningful, effective and efficient energy management system with regard to the energy assessment.

3. Compact Circuit Breaker (SENTRON 3VA2)

3.1 Technical data and functions of the 3VA2

Compliance with the regulations and a valuable monitoring of energy data such as current, voltage, power, phase angle could also be realised with a commercial measuring device and current transformer. However, in an existing installation, there may be a lack of space, so that in many cases it is not possible to realise/perform suitable and compliant energy monitoring on site.

The compact circuit-breaker is characterised by its selectivity behaviour, integrated measuring function for energy values, very high switching capacity and the rotary double-breaker.

4. Application Example

4.1 Preparation and consideration for proframming

Successful energy management is not possible without energy measuring components with subsequent archiving and visualisation.

With the development of certain components and the development of a smoothly running programme, the reading, digitisation, storage and visualisation of the data could be realised.

The following energy and operating data as well as service and maintenance information were selected with regard to monitoring the energy data:

Table 2: Energy and operation data

Energy and operating data	**Service and maintenance information**
Current	Number of temperature trips
Voltage	Number of G-triggers
Voltage against N-conductor	Number of I-triggers
Active power total and per phase	Number of L-triggers
Apparent power total and per phase	Number of N-triggers
Actual frequency	Number of all trips
fundamental power factor	Mechanical switching cycles
referred active power of the last Periode	Reason for last trip (flashing on trip)

Fig. 1: Active power total and per phase

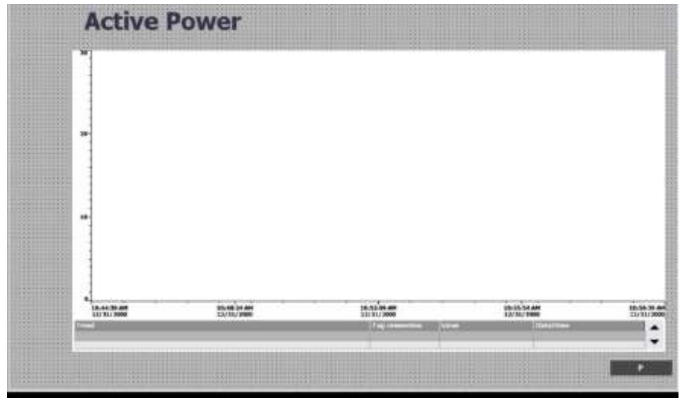

Fig. 2: Active Power total and per phase "Trend" display

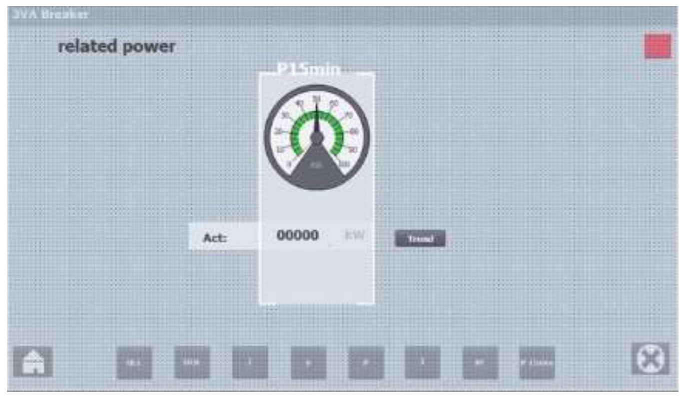

Figure 3: Active power drawn during the last period (15 min)

Fig. 4: Service and Maintenance information

The added value of a compact circuit-breaker with communication capability compared to a measuring device is the evaluation of service and maintenance information. For the application example, however, only a certain selection of the service and maintenance information (see above: Table 2 Energy and operation data) was shown.

The most important prerequisite for successful energy monitoring is data storage, which in this application example is realised on the basis of a visualisation - HMI with USB port for a subsequent data storage option. The energy data is saved as a *.csv file; this archiving can then be used for further energy analyses.

4.2 Application example – Description -

The developed programme/ application example gives the user the possibility to record (read), process (digitise), store and visualise measured energy values of the communication-capable compact circuit-breaker.

It is important that the inputs are correctly described and that static variables (the desired measured data) are defined in advance, which subsequently act as data pointers.

The visualisation and storage of the digitised energy and operating data as well as the service and maintenance information play a very important role in the area of energy monitoring and energy management, because only with the stored and always retrievable measured values is a comparison possible. These comparisons are fundamentally important for efficient energy management (PDCA cycle).

The measurement data can be stored via "archives" in the HMI panel, whereby a commercially available USB stick is sufficient as a storage medium.

The archived measurement data of the HMI panel (*.csv file) can be opened in Excel. This gives the user the option of creating his or her own diagrams for an "evaluation overview..

In addition, the data read out is interesting for service and maintenance information, because it can eliminate production downtimes, e.g. due to failures. With the information about the service and maintenance information during a event of a triggering, the visualisation can promptly determine which triggering it is. Furthermore, the visualisation has the advantage that the operator can perceive fluctuations, peaks and failures through the real-time imaging display; the system can be monitored without great effort.

When the compact circuit-breaker is put into operation and the programme with the corresponding components is started, the HOME menu is accessed, in which a selection can be made between the energy and operating data or service and maintenance work can be made. In addition, by plugging in a USB stick and pressing the "archive button", there is the option to save the desired data.

If the user chooses to observe the energy and operating data, a window for displaying the currents, in which it is possible to display the temporal progressions of the last 15 minutes opens.

If a trip occurs, a red rectangle flashes in the upper right corner, regardless of which window you are in. If the flashing red rectangle is pressed, the service and maintenance information is displayed, in which the tripping that has occurred is also shown flashing red.

Once the fault has been rectified, an "acknowledgement button" can be pressed the triggering is acknowledged and the flashing goes out.

5. Discussion

Based on the question to what extent digitisation, visualisation and storage of energy data is relevant in today's world, it should be investigated with which special technical components of the SENTRON series from Siemens, in particular the SENTRON compact circuit breaker, and a programme to be specially developed, the reading of data, the digitisation, the storage and the visualisation of the data could be realised.

The programme developed for this task should enable the user to record, process, store and visualise measured energy values of the communication-capable SENTRON 3VA compact circuit-breaker.

In the course of testing the programme, it was found that all requirements for the programme and the communication-capable 3VA2 compact circuit-breaker were met. Thus, visualisation and storage of the digitised energy and operating data as well as service and maintenance information was possible. This is an important prerequisite for efficient and real-time energy monitoring and energy management, since only with the read-out and available measurement data is a comparison possible, also within the framework of the PDCA cycle. In addition, impending production downtimes, e.g. due to failures, could be detected and eliminated at an early stage. Thanks to the visualisation, every operator has the advantage of being able to recognise fluctuations, peaks and failures through real-time imaging. In other words, the system can be monitored without much effort. In practical applications, the 3VA2 compact circuit-breaker is an effective aid for energy monitoring or energy management.

6. Conclusion

Directives, laws and standards primarily determine the behaviour of society and industry with regard to the handling of electrical energy. The legal requirements are obligations and must be complied with.

At the same time, however, they also create incentives that have a motivating influence to invest in energy efficiency in a future-oriented manner beyond the legal requirements. The digital evaluation, visualisation and storage of measurement data significantly supports the energy management system and can thus fulfil the energy policy requirements. With the appropriate components, e.g. a communication-capable compact circuit-breaker, energy savings, cost savings, quality of supply, security of supply and energy efficiency can be guaranteed.

Successful energy monitoring is also possible at the level of the DIN EN 16247-1 energy audit, which is realised through the continuous recording, evaluation and visualisation of relevant measurement data.

If a company uses the optimal components for an energy monitoring system, the effort is reduced and a basis is created for operational energy management according to DIN EN ISO 50001.

With maximum plant safety, highest plant availability, short amortisation time, permanent cost reduction (energy savings in plant and cost savings through e.g. avoidance of financial sanctions such as fines), the company benefits in many ways. All these features are determined by the advancing digitalisation, which makes the above-mentioned characteristics and advantages transparent and comprehensible.

Ultimately, by reporting the system statuses and measured values to higher-level management systems, the system utilisation can be optimised, the savings potential can be identified and the energy efficiency can be increased (transparency of the status of the energy distribution and its energy flows). Compact circuit-breaker supports the energy management of companies.

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