Chapter 9

Retrofitting for Energy Management: Using IoT Technologies

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ABSTRACT

According to ISO 50001, energy management systems are increasingly being implemented in companies, with the continuous measurement of energy consumption playing an important role. At the same time, energy meters are increasingly becoming cyber-physical systems (CPS) in the IoT age. LPWAN radio networks and IoT clouds open up new possibilities for retrofitting meters and industrial components. By using these technologies, the measurement infrastructure of an energy monitoring system can be cost-effectively expanded. This section presents the technologies relevant for energy management and shows their application using selected use cases for LoRaWAN, OPC UA, and the combination of optical character recognition (OCR) and IoT Cloud.

INTRODUCTION

Systematic energy management is a common instrument for continuously improving energy efficiency in companies and organizations. Effective energy management saves money, strengthens the competitiveness of companies and lowers their carbon footprint. Therefore, energy efficiency is also an important policy instrument to achieve climate goals. In many European countries, the energy efficiency of companies has been demanded and promoted not only since the European Energy Efficiency Directive (EED) (European Parliament, 2012). A good energy management system provides information on where energy saving potential is in a company and influences organizational and technical processes. Hence, systematic energy management is used in many companies worldwide. From an economic viewpoint, improved energy efficiency not only reduces the company’s overall energy consumption, but also the company’s emissions and consumption of raw material. Energy improvements often bring additional advantages through non-energy benefits (Krutwig & Starosta, 2017). A systematic energy management

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system based on the ISO 50001 standard or the Eco-Management and Audit Scheme (EMAS) enables companies to meet their energy policy commitments and continuously improve their energy performance through a systematic approach (Hillary, 1993). It comprises the necessary organizational and information structures, including the necessary tools. A central component of energy management is the monitoring of energy flows through temporary or permanent measurements, estimates, or calculations. With energy monitoring, potential savings are discovered and the savings already achieved through implemented efficiency measures can be checked.

The standard ISO 50001, published in June 2011, is the first established international standard for energy management systems. ISO 50001 is not sector-specific and can be applied by a variety of organizations, from small and medium-sized enterprises to large companies and public authorities. According to the standard, defined user groups and defined tasks with fixed deadlines are recorded and checked. The formal requirements for functions and tasks of systematic energy management must naturally cover a broad spectrum. In principle, the approach regarding energy balance limits and various energy sources must be pursued holistically. It is up to the respective company to tailor the various design options of the management system, as described in ISO 50001, to its own needs. Like most management systems that aim for continuous improvements, ISO 50001 is based on a plan-do-check-act (PDCA) cycle. It can be implemented independently of existing management systems or integrated into existing management systems, such as ISO 9001. Although energy monitoring via measurements is not mandatory according to the standard, temporary or permanent measuring equipment is used in many energy management systems today. Regular measurements are important for good transparency of energy flows. This is achieved by connecting the measuring devices and automatically transmitting the measured values to an energy monitoring system. In this process, the Internet of Things (IoT) opens up new possibilities.

The IoT can be described as a network consisting of numerous so-called cyber-physical systems (CPS) (Baheti & Gill, 2011; Monostori et al., 2016; Schlick, 2012; Wolf, 2009) that exchange information via M2M (machine-to-machine) communication. According to the CPS concept, objects become “intelligent”. Therefore, a physical object has virtual representations that can be addressed on the Internet of Things. These self-describing cyber objects provide an interface to the data and services of the physical objects. Hereby, CPS is enabling so-called “smart” infrastructures: smart productions, smart cities, smart services, smart grids, smart healthcare, and many more. In this “4th Industrial Revolution,” smart factories can reconfigure themselves quickly and flexibly and adapt to producing new and highly customizable products (ElMaraghy, 2005). In addition, IoT industrial applications can bring further added value to companies (Jeschke et al., 2017). In (Fantana et al., 2013), the prerequisites and possibilities of IoT use are described from the point of view of the industry sector. The concepts in this article can also be referred to as “smart retrofit” due to the use of CPS, a term that differs from “traditional Retrofitting by not only replacing old components in the machine regarding their energy efficiency” (Guerreiro et al., 2017).

The use of the IoT from the device to the application can be described via a technology stack (Figure 1). The device thus has software for providing the device-specific services and a communication interface. Communication usually takes place via the IP protocol and can also take place via various wired or wireless media. The cyber object is then globally available in the cloud platform. In our case, the cloud application shown in the stack is the software for energy monitoring or energy management. To achieve interoperability of all components, it is necessary to standardize the device software, the communication protocols, and the virtual representatives. Open Platform Communications Unified Architecture (OPC UA) (Mahnke, Leitner, & Damm, 2009), is a suitable and widely used key technology for this purpose.