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Key pillars of successful energy saving projects in small and medium industrial enterprises

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ABSTRACT

Commonly used approaches in energy management have been found to be insufficient in many small and medium industrial enterprises. The benefits of energy saving solutions can be rather limited. A lack of procedures providing optimal solutions is noticeable from a literature review. Systematic and critical observations of numerous energy saving projects performed by the authors revealed that it is possible to specify four pillars which are crucial for successfully implementing these projects. They should be applied as much as possible and can be specified as follows:

1. Technical expertise: Knowledge of industrial facility and possible savings based on experience
2. Good operational data: The acquisition of data in a facility
3. Modeling, simulation and optimisation: Assessment of various options and the selection of the most beneficial one
4. Methodology: A systematic approach including all three remaining pillars

The benefits of each pillar have been demonstrated by several publications. This paper summarizes the pillars in a review study and introduces a systematic approach based on them. The four pillars were applied on various case studies. One of them is presented in the article. The application of all the pillars provides an efficient way to conduct energy saving projects.

1. Introduction

EU (European Union) policy has for a long time targeted increase in efficiency of industrial processes and related decrease in use of energy resources. Energy efficiency is one of the pillars of EU Energy Strategy; the Energy Strategy targets to decrease greenhouse gas emissions by 20%, increase share of renewable sources of energy by 20% and increase efficiency of energy sources by 20% by 2020 [1]. The European Commission discusses the issues of “energy efficiency first” as the standard for the 2020–2030. The Commission further proposes to amend the directive on energy efficiency (2012/27/EU) and increase the binding numbers to 30%. Energy efficiency is to be considered as a source of energy on its own. Energy not used is the cheapest, cleanest and safest energy there is [2].

Final energy consumption in industry dropped in the EU-28 from 328 Mtoe in 2005 to 275 Mtoe in 2017 (more than 16% decrease) [3]. However, there is still a significant potential for future savings. Use of available technologies may lead to 4–10% energy savings with a payback period of less than 5 years [4]. There are dozens of measures that may be taken, especially on a national level but financial tools, such as subsidies and tax relief, dominate. Other, successfully implemented tools include emission trading schemes, energy audits, energy efficiency management, networking and development of public-private partnerships [5].

Implementation of saving measures in small and medium-sized enterprises (SME) is another form how to support energy savings in industry. SME have various definitions in various countries and mostly rely on number of employees and or annual sales. A complex approach to energy savings must involve all systems consuming energy. This means that energy consumption includes both the primary energy consumption of the processes as well as common operational consumption of the buildings (such as HVAC, lighting, etc.). SME in Europe account for more than 99% of all entrepreneurs

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conducting business in non-financial sector, and generate ca. EUR 3.7 trillion of added value [4]. SME also consume a significant portion of energy resources. Estimated potential for energy savings of SME ranges from 10 to 20% while more than 50% of SME are industrial enterprises (for example, food, metal and plastics industries) [6]. Lack of awareness and willingness on part of the SME management [7], lack of financial and human resources as well as different priorities amount to some of the major reasons behind the unused potential for energy savings [4].

For the purposes of this paper, we will specify the target sector as small and medium industrial enterprises with power or heat demand ranging from dozens of kW to units of MW. Our own experience proves that owners of these enterprises highly stress reliability of their facilities and are not willing to jeopardize it by risky projects with uncertain financial outcomes. Unfortunately, there are not many tools available that could make the decision-making process easier for the owners, which further leads to uneconomical use of energy. The first reaction of the authors was a paper [8] which introduced a novel and complex approach to projects for energy savings, see Fig. 1. This complex approach includes scientific procedures which are used in real industrial projects. This results in the development of new methods and tools which, simultaneously, make the work more systematic and more efficient.

The following chapters further elaborate on the theme of this study and bring a definition of the four pillars for efficient energy saving projects that may be applied in industrial enterprises.

2. State of the art in energy savings in industrial enterprises

In industry, the real-time monitoring of energy intensity, use of mathematical modeling and detailed consumption analyses are widely applied for improving energy efficiency [9]. In-depth analyses of facilities' energy efficiency contribute to the quality of the energy saving measures, but they are rather time consuming. The sophisticated approach to energy saving projects is developed predominantly for large-sized facilities with dozens to hundreds MW performance. These facilities closely observe efficiency of the production and heat and power consumption since these parameters have a direct impact on economics of the facility [10]. Process integration method is a set of methods used for optimised design and operations of complex industrial systems. Process integration is focused on energy saving as well as on environmental aspects of the facility's operations, especially the greenhouse gas emissions in flue gas [11]. These methods provide excellent results in optimisation of heat exchanger networks (the so called heat integration) and hence they have been further used in other areas, such as treatment of water, oxygen and hydrogen [12]. Recently, there has been a trend to make use of the so called total site heat integration methods which include heat regeneration, use of waste heat and integration of renewable energy sources. A comprehensive

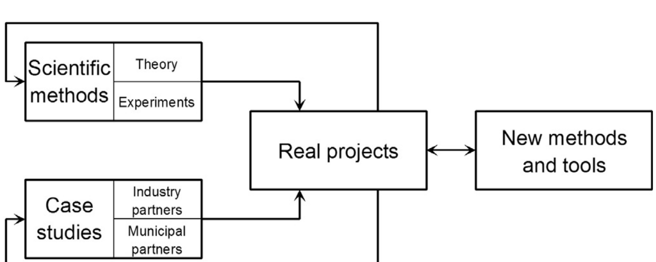

Fig. 1. Complex approach for energy efficiency of medium-sized industrial enterprises and large building complexes [8].

overview of the integration and optimisation methods for efficient use of resources in process industry is provided by Klemes et al. [13]. Publications discussing concrete industrial application show benefits of these methods [14]. However, facilities and processes with performance ranging from dozens of kW to units of MW, which are the subject of this paper, cannot fully take advantage of the methods described above. Medium-sized systems have relatively few apparatuses that use a very limited amount of working media and temperatures. And yet, the technical solution to their energy efficiency may still be a challenge. Actual consumption of these facilities depends on several operating and economic factors. Individual apparatuses may be quite complicated units, they may have a significantly variable nature of consumptions, and they may be interdependent.

Scope of technical solutions is large and selection of a suitable measure calls for high degree of expertise. The selection and implementation of a particular saving measure is a difficult task for owners of enterprises. There is a lack of effective procedures. Energy management (EM) and energy performance contracting (EPC) are among the most used in practice. These procedures are provided by specialized companies know as Energy Service Companies (ESCo).

EM is a general tool that manages and reduces energy consumption effectively. Authors went through many scientific papers as well as the comprehensive review paper [15]. It is general knowledge that adaptation levels of energy management are very low. This discrepancy between optimal and actual implementation is often referred to as the *energy efficiency gap* [16]. One of the reasons is that proposed solutions for energy management are not usually suitable for industrial companies. To adopt energy efficient measures in the industrial sector, it is necessary to acquire real-time monitoring of key process parameters together with their online visualisation and evaluation. Benchmarking must be standardized and enhanced benchmarking tools must be developed to provide more comprehensive information either on company, plant or process unit level [17]. EM systems do not provide saving actions tailored to a particular energy system. EM implementation is usually investment-free; however, it is a challenge for a facility management to make it work. As it can be found in a systematic review [18] the papers mostly present case studies describing particular saving measures but without an evaluation of the benefits or only on a short-term level. One of the exceptions is a study by Chen et al. [19] which presents a new software tool for implementation of EM in SME, and Cai et al. [20] proposing a novel method utilizing a multi-objective energy benchmark. Both of these studies focus on production processes. Energy audit is a very practical part of EM and is a major tool for assessment of energy efficiency of energy facilities [21]. But the energy audits may be superficial and may present only general guidelines which are far from optimum solutions. Scope and actual tasks done during the energy audit may be tailor made to suit a particular facility; however, that would require either a thorough acquaintance with the facility or a thorough analysis. Energy audits in industrial facilities therefore heavily depend on the relevant auditor and mostly rely on their expertise level [22].

The other method for decreasing energy consumption is EPC. EPC may be a helpful tool for financing the investments which is always useful when there may be a shortage of capital [23]. The EPC is still not common in the industrial sphere. This may be due to the rather problematic justification of the investments and long payback period [24]. Energy systems in industry consist of various technologies and processes, various parts of a system interact with each other, there is the accumulation of heat, exothermic processes, and so on. Commonly used approaches do not usually result in the optimal solution. These projects call for skilled experts and