DOI: 10.7251/EMC1502315C
Datum prijema rada: 30. septembar 2015.
Datum prihvatanja rada: 10. decembar 2015.

STRUČNI RAD

UDK: 005:620.9
Časopis za ekonomiju i tržišne komunikacije

Godina **V** • broj **II**
str. 337-355

ENERGY MANAGEMENT MODEL – AN INNOVATIVE TOOL FOR BENCHMARKING THE ENERGY MANAGEMENT SYSTEM IN INDUSTRIAL COMPANIES

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Abstract: *Energy management is becoming an important topic for companies around the world. It influences organizational and technical processes and behaviors in the company in order to reduce the operational total energy consumption, improve resource efficiency, implement legislative requirements, and improve their corporate image. ISO 50001 International Standard was introduced as a global standard for managing energy use through that provides the unified framework for energy management. This paper introduces and describes model methodology and innovative software tool for benchmarking the energy management system in industrial companies. The software is designed to illustrate the current energy management situation in the company, the estimation of target state and to identify the energy efficiency potentials. Using the benchmark methodology, the energy management is summarized in an assessment profile. The results can be used as a reference guide for Energy Managers or extern consultants to understand the requirements and to implement ISO Standard 50001 in their company. A case study of an Austrian foundry is empirically tested and presented in order to evaluate the efficiency of the developed model.*

Keywords: *energy management; energy efficiency; ISO Standard 50001; Energy Assessment Tool; Benchmarking*

INTRODUCTION

Due to a rise energy costs, limited raw material reserves and global warming through CO2 emissions questions about efficient use of energy in Europe are becoming increasingly important. A sustainable energy supply is therefore crucial for a prosperous economy and a key prerequisite for a high quality of life. Moreover, efficient energy use in production processes and the reducing energy consumption substantially are significant components of nearly all energy, environment and climate policies. Today, EU countries are faced with an increasing energy demand, fluctuating prices and supply shortages. The dependence of EU countries on imports of fossil fuels is unsustainable, resulting in their loss of purchasing power and benefits. Therefore, one of the essential elements of the European Union policy is a clear energy strategy with three main objectives: (1) security of supply, (2) competitiveness and (3) sustainability (European Commission, 2010). In order to achieve the objectives the EU Commission introduced in 2008, a strategy for smart, sustainable and inclusive growth, the climate/energy targets, were defined. According to the strategy, the EU's greenhouse gas emissions should be reduced by 20 percent until 2020, compared to the reference year 1990, further the share of renewables in the EU energy rise to 20 percent and energy consumption to be reduced by 20 percent until 2020, compared to the reference scenario (European Commission, 2010). Consequently, the European Commission (EC) focuses on energy efficiency and outlines the need for a new energy efficiency strategy that enables all Member States to decouple energy use from economic growth. In this context, the EC has launched the Directive on Energy Efficiency 2012/27/EU (EED) and repealing Directives 2004/8 / EC and 2006/32 / EC 22. The main goal of the new Directive was to establish a common framework of measures for the promotion of energy efficiency within the Union. Furthermore, it defined directions to minimize the obstacles in the energy market, to overcome market failures that impede the efficiency in the supply and use of energy, and provide national energy efficiency targets (European Commission (2012). For instance, the EED contains the obligations that each Member State shall set an indicative national energy efficiency target based on either primary or final energy consumption, primary or final energy savings, or energy intensity. The implementation of energy efficiency reduces energy costs, the capital outflow in exporting countries for oil and gas and solves significant investment for the domestic economy.

However, energy savings and energy efficiency policies are not only relevant for the political decisions, but also for all stakeholders. Researchers, industries and politicians are required to make significant efforts in this field. In this context, Andreassi L. (2009) discusses that, even if policy is an important mean, it cannot be the only one and it is necessary to spread the knowledge on energy systems, energy saving options and energy use rationalization. It is important that the main energy users, as industries, realize that energy is not a fixed operating cost and that saving energy is actually one of the most significant ways to reduce costs, besides preserving the environment (Andreassi et al., 2009). After transport, the industry is a major consumer of energy in Europe (figure 1), with a share of 26%. , It consumes over 280 million tons of oil equivalents in final consumption. Between 1990 and 2012, the final energy consumption in EU28 increased by 2.3% (6.5% in EEA countries). The introduction of energy efficiency measurements has already yielded results. For instance, the services sector is the only sector in which the energy consumption increased by 3.5% between 2005 and 2012. Between 2005 and 2012, the energy consumption dropped by 14% in industry, by 5.1% in transport and by 4% in households (European Environmental Agency, 2015).

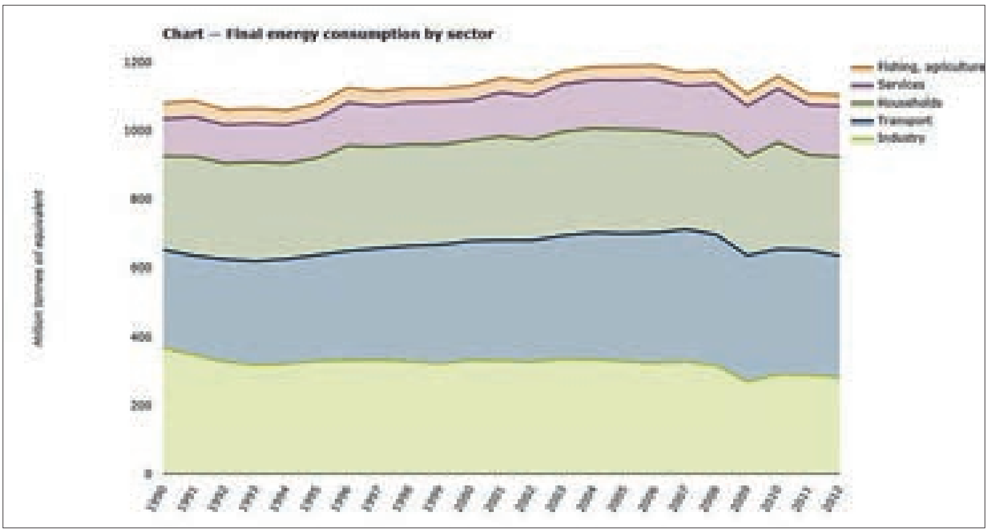

Figure 1. Final energy consumption by sectors. (European Environmental Agency, 2015).

Energy saving and energy efficiency are key challenges for many industries. Therefore, the measurement of energy efficiency is an essential step towards the control of energy consumption and energy costs (Giacone E. and Manco S., 2012). From a business perspective, energy conservation is cost reduction. In recent years, numerous studies have focused on industrial energy use and energy efficiency in various manufacturing sectors. Research in relation to energy efficiency has been conducted in the area of the quantification of extended energy efficiency gap in the Swedish electricity-intensive industry (Paramonova S. et al., 2015), a model development that calculates the gap between the actual level of energy efficiency and what theoretically could be reached (Coss S. et al., 2015), as well as the operation optimization of a distributed energy system considering energy costs and exergy efficiency (Di Somma M. et al., 2015). The results confirm that, due to various factors, such as complex industrial sites and energy flows, multiple products and fuels, and the influence of the production rate on energy efficiency, there is a need for the usage of a structured framework to define and measure energy efficiency more precisely (Giacone E. and Manco S., 2012). An Energy Management System is an example of structured a framework that could offer many advantages, such as energy consumption and cost reductions, an improvement of the corporate image, and environmental impact reduction (Introna V. et al., 2014). Schulze M. et al. (2015) argue that one of the most promising means of reducing energy consumption and related energy costs is implementing energy management in an organization. Furthermore, they offer a comprehensive systematic review of previous findings within energy management and introduce an integrative conceptual framework. (Schulze M. et al., 2015). The aim of this paper is to introduce energy management, describe various models, and provide an innovative software tool for benchmarking the energy management system in industrial companies.

THEORETICAL FRAMEWORK

Energy management as a support system in companies has been developed notably within the last two decades. This has several reasons: On one hand, there is the implementation of various legal requirements (e.g. energy efficiency regulations and laws), on the other hand, there are the rising energy prices. Especially the energy-intensive industries have realized that energy management can be an effective system for enhancing their production systems and operations towards an improved energy efficiency, thereby reducing energy use and related energy costs (Schulze M. et al., 2015). Hence, energy management influences organizational, economic and technical processes and behaviors in order to reduce the consumption of basic and additional materials. Moreover, it functions as a predictive, organized and systematic coordination procurement for conversion, distribution and the use of energy that meets the requirements by taking account of environmental and economic objectives. Simply put, the term describes the actions for the purpose of the efficient use of energy (Austrian Energy Agency, 2007; ISO Standards, 2015).

Today, various analytical and systematic models are applied to analyze and implement an energy management system within companies. In this paper, we introduce three framework/models that are relevant for the development of our benchmarking methodology:

1. ISO Standard 50001:2011 Standard on Energy management systems (International Organization of Standardization, 2011)
2. Holistic Energy Management Model for industrial enterprises (Posch W., 2010)
3. Energy Management Maturity Model (Introna et al., 2014)

ISO 50001:2011 Standard on Energy management systems

Published in June 2011 by the International Organization of Standardization, the ISO Standard 50001 Energy Management System (EnMS) standard is a globally accepted framework for managing energy, providing technical and management strategies for enterprises to increase energy efficiency, reduce costs, and improve their environmental performance (International Organization of Standardization, 2011).(According to the German Federal Environment Agency until May 2014, 7.346 company sites worldwide had already certified to the ISO Standard 50001 (German Federal Environment Agency, 2015).) According to the German Federal Environment Agency, 7.346 company sites worldwide had already certified to the ISO 50001 standard by May 2014 (German Federal Environment Agency, 2015).

This standard is based on the management system model of continual improvement also used for other well-known standards such as ISO 9001 or ISO 14001. It allows organizations to integrate energy management into their overall efforts, to improve quality and environmental management, and provides a framework of requirements for organizations to: (ISO Standards, 2015)

- develop a policy for more efficient use of energy
- fix targets and objectives to meet the policy
- use data to better understand and make decisions about energy use
- measure the results
- review how well the policy works, and
- continually improve energy management.

In particular, ISO Standard 50001 follows the Plan-Do-Check-Act process for a continual improvement of the energy management system. This relationship between its main elements is illustrated in figure 2 and can be described as follows:

- **Plan:** Conduction of the energy review and establishment of the baseline, calculation of energy performance indicators (EnPIs), setting the objectives, targets and action plans necessary to deliver results in accordance with opportunities to improve energy performance and the organization's energy policy.
- **Do:** Implementation the energy management action plans.
- **Check:** Monitoring and measurement of processes and the key characteristics of operations that determine the energy performance against the energy policy and objectives and report the results.
- **Act:** taking the actions for a continual improvement of energy performance and the EnMS.

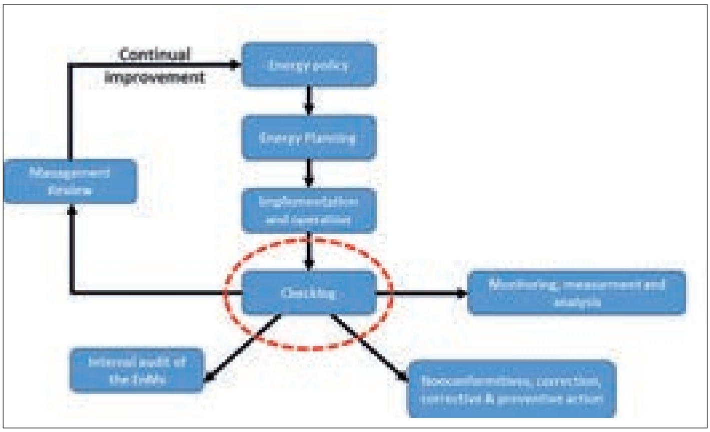

Figure 2. Main elements of energy management system. (International Organization of Standardization, 2011)

Holistic Energy Management Model for Industrial Enterprises

The Holistic Energy Management Model (based on concepts of decision-orientated business economics) developed by Wolfgang Posch (2010) allows industrial enterprises the implementation of a customized and holistic energy management system. The model represented as an Energy pentagon, encompasses three dimensions (figure 3). The first dimension covers the three levels of management (normative, strategic and operational), in the second dimension, the segmentation takes place in the five management functions (planning, organization, human resource management, information and control), and in the last dimension, the dynamic element of continuous development is included. Through the superimposition of the model dimensions, the individual elements of the model are obtained. This practice-oriented model covers all aspects of energy management and allows by the model instruments and by its viability a very good integration in the company. The assessment tool developed within this model includes a series of quantities and qualitative questions and allows the benchmarking of energy management for the investigated company (Posch W., 2010).

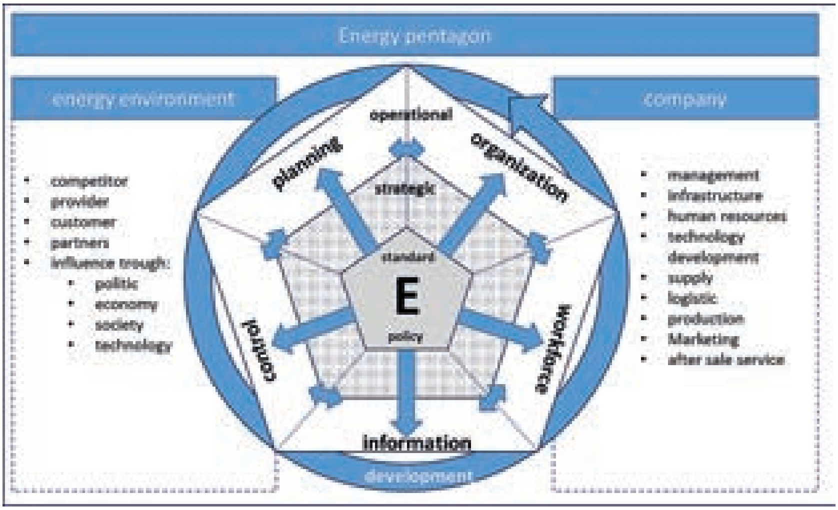

Figure 3. Holistic Energy Management Model for industrial enterprises (Posch W., 2010)

Energy Management Maturity Model

The third Model relevant for our study is the Energy Management Maturity Model introduced by Introna V. et al (2014). Maturity Models are tools that are used to assess the level of maturity of an organization, providing a systematic framework for carrying out benchmarking and performance improvement. This model allows companies to self-assess their maturity level of energy management and consequently develop their own growth plan, contributing to the diffusion of an Energy Efficiency culture (figure 4). It consists of five development stages (initial, occasional, planning, managerial, and optimal) and five dimensions (Awareness, knowledge and skills, Methodological approach, Energy performance management and information system, Organizational structure, and Strategy and alignment). Each level can contain aspects affecting different dimensions of maturity, but the skills required by the different dimensions grow in intensity and complexity with the maturity level (Introna V. et al (2014). Furthermore, the assessment tool for this model accomplishes several characteristics: (1) it is based on a qualitative questionnaire (40 closed questions); (2) it is reliable (tested on a sample of companies); it is universal (it is applicable to several organization types, industries and service sectors); (3) it is effective (it analyzes the key issues for the management of energy consumption, in accordance with ISO Standard

50001); it can be used to develop a growth plan (the model provides a detailed evaluation that allows the identification of important actions for growth in the short and medium term) (Introna V. et al (2014).

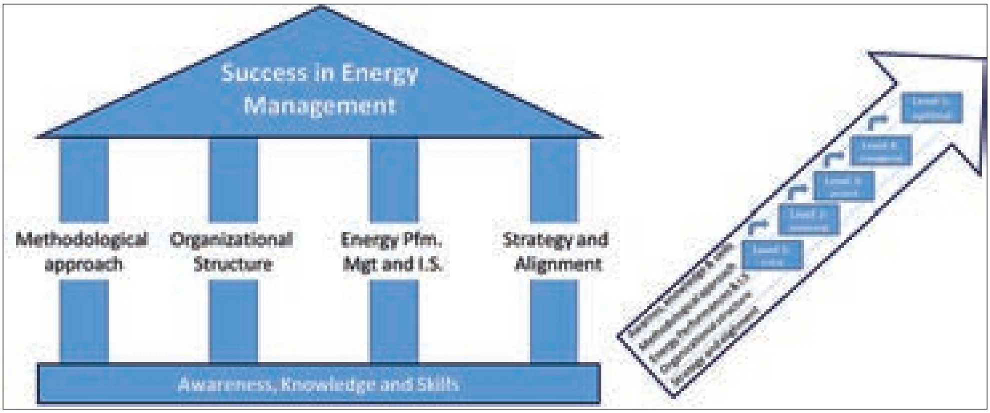

Figure 4. Energy Management Maturity Model (Introna et al., 2014)

METHODOLOGY AND MODEL DESIGN

The overall research was conducted within the research project "EnEffGieß - development of a life-cycle-based approach to evaluation of energy-efficient, sustainable foundry products" at the Chair of Economic and Business Management / University of Leoben in Austria. This project encompasses research on efficiency potential in the foundry industries and introduces a new modular-based, multilevel model. The model development was generated through a collaboration between the experience and know-how of the Austrian Economic Chamber – the Association of Austrian foundry industry and their commercial partners, and science, i.e. the University of Leoben and the Austrian Foundry Research Institute (ÖGI). The model methodology identifies energy efficiency potentials and merges them to a model-based approach for the planning, evaluation and optimization of energy consumption in the foundry industry (Coss S. et al., 2015). Two methodological approaches are relevant for this project: the economical approach (top down) and (2) the technical one (bottom up). The top-down approach follows the principle of using economic data in order to characterize energy utilization and energy efficiency analysis. On the other hand, the bottom-up approach applies the actual energy utilization based on thermodynamic relationships and physical properties (Coss S. et al., 2015). Separate assessment tools (so called "Quick Check Tools") are developed for both approaches.

The energy management data was collected through comprehensive on-site research within several foundries, whereby notable data was collected through questionnaires delivered to the companies, through a review of literature and workshops that were conducted by the companies. Furthermore, the methodology used in this paper follows the benchmarking methodology adopted within the project, where the indicators and criteria have been identified, supplemented and designed around the model components.

An essential part of the assessment tool for the top down approach is a model for the benchmarking energy management system of the company (figure 5). Based on the three methodological approaches introduced in capital 2, this model is developed to give a first overall assessment of the actual status of energy management system. Furthermore, the tool additionally offers a possibility to define the target state of energy management development with a dynamic evaluation of the current state. The developed methodology was tested in 6 Austrian foundries.

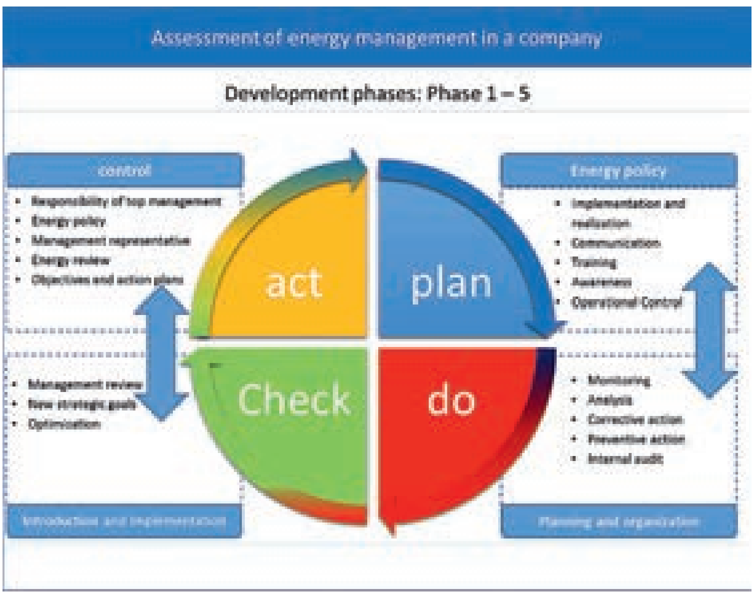

Figure 5. Model for benchmarking the energy management system in the industrial company

The model dimensions have been developed in accordance with the ISO Standard 50001 and defined by identifying the essential criteria for planning, the organization and the implementation of energy management, as well as the regular control mechanism. The framework distinguishes four dimensions for the analysis of energy management: energy policy, planning and organization, introduction and implementation and control. These categories are selected according to a series of qualitative criteria.

Energy policy

The first dimension outlines the overall Energy Management System and provides guidelines for its implementation and control. It represents the basic category and should emphasize a commitment to continual improvement in energy performance and ensure the availability of information and resources (ISO Standards, 2015). Active top management involvement is essential for any successful implementation of EnMS, ensures the creation of general energy-economic goals and checks and verifies the progress. Another important part of this dimension is defining an energy policy that is based on the goals and commitment of the company to improve the system. It should state the company's energy priorities and must therefore be documented and understood by all employees. In order to achieve a noteworthy improvement in performance, it is necessary to have well documented all significant energy users and processes within the company. They should receive special attention by establishing energy objectives, targets, and action plans. The next relevant action should be setting the Energy performance indicators (EnPIs). They are measured parameters, ratios, or models that help quantify energy use and efficiency improvements in the organization, facility, system, process, or equipment level (ISO Standards, 2015). Once the foundation and the solid basis for energy improvement are created and organized, energy objectives and targets for meeting the energy policy or performance commitment need to be set. They need to be in accordance with the general energy goals and should guide future strategies and activities. In order to achieve an effective system for each objective, specific targets should be outlined. The final part of this dimension is an overall verification of the existence and content of the action plan. An energy-management action plan is a comprehensive guide that was developed by the energy management team and communicated with all responsible parties, in addition to being approved by the top management.

Energy planning and organization

The second dimension verifies the process of putting the plan into action. The selection of right objectives and procedures is central to planning and organization, in order to achieve the best results. This includes a systematic and structured preparation and documentation. In this context, the ISO Standard requests evidence of a conducted and documented planning process that will encourage improvements in energy performance. In order to fulfil the requirements of the EnMS, two types of information need to be controlled: documents that lay out expectations for energy-management actions and behaviors; and records which provide evidence of the results of these efforts. For this purpose, it is crucial to verify the existence of an energy management team. The ISO Standard further suggests that, in order to obtain the needed skills, knowledge, and relevant expertise, an energy-management project relies on a team approach. A team provides diverse perspectives, distributes the workload, eases implementation, promotes wider acceptance, and improves the potential for sustaining the system. In order to achieve an implementation, it is necessary to verify how often the operative energy planning is carried out and how energy efficiency potentials are identified. In order to comply with the ISO Standard, a company needs to define energy procurement specifications which may include quality and quantity requirements, characteristics (e.g., fuel composition, moisture, and energy content), approximate cost, delivery schedule, resource reliability, and voltage, current, and/or electricity peaking times (ISO Standards, 2015).

Introduction and implementation

Internal communication is an essential part of the effective EnMS and of making management change. It keeps the employees well informed about energy-management activities, incentives and successes, which strengthens commitment and participation. In order to achieve efficiency, it is necessary to verify the existence and content of a communication plan within the company. The communication plan should include multiple pathways for disseminating information. The implementation of energy management relies on an active participation of the employees. The workforce involved in the collection and analysis of energy data should understand significant energy users and related controls; energy objectives, targets, and action plans, as well as the defined energy performance indicators. Therefore, it is important to conduct regular trainings and educate the responsible employees first, before evaluating the training and the employees. Furthermore, success is guaranteed by ensuring the interdisciplinary cooperation in the solution of energy problems. The finial component of this dimension is the implementation of reporting measurements. The ISO Standard obliges the companies to establish energy monitoring, measurement, and an analysis plan. The existence of unique energy-specific reporting guidelines and the frequency of reporting are one of the key elements of ensuring an effective energy management system (ISO Standards, 2015).

Control

Success is only achieved if the correct and proper control mechanism are implemented and if they are effective. This can be achieved by conducting continues energy audits. The ISO Standard defines audit as a systematic, documented process that verifies that the EnMS meets the organization's criteria, is effectively implemented and maintained, supports the energy objectives and targets, and improves the energy performance. Moreover, it carefully checks the effectivity of the applied measurements and compares the current sate with the target state. During this process, an auditor (mostly extern) conducts interviews with the employees, observes activities, reviews documents and examines records and data (ISO Standards, 2015). Control is further achieved by periodically conducting reviews and evaluating its activities and energy performance, in order to identify opportunities for improvement.

Development phases

The planning and developing of an energy management system in a company is in direct coherence with the continuous improvement and optimization of internal processes and can be seen as a series of innovation projects. Therefore, the introduction of energy management can be based on the phase approach, in which new phases permanently have higher technical levels than the previous phases. This method is referred to as a maturity process, which represents an indication of how closely a developing process needs to be completed, in addition to being capable of continual improvement through qualitative measures and feedback. The maturity of the energy management within our model is defined by the five stages of development, from Phase 1 (least mature) to Phase 5 (most mature).

Phase 1: The ground level 1 represents the company that is mostly not interested in an energy management system development. In top management, energy is only seen as a cost unit, the energy performances are neither measured, analyzed nor evaluated. The company has no concern for the development of energy policies, plans and efficiency measurements.

Phase 2: The company shows a first interest regarding energy consumption. The basic energy policy is defined in top management, but is not communicated internally. The energy efficiency goals are only partially entitled (based on experience) and they are not checked. Energy management is sporadic and without a fixed organizational structure. The energy consumption is documented thorough energy reports for the major consumer; however the energy audits are not conducted yet. Based on the collected consumption and cost data, energy efficiency measures are defined first and implemented for energy-intensive installations. The effectivity of the measures is not evaluated and analyzed.

Phase 3: Based on the internal energy policy, organization develops its first energy strategy and energy concept, defines the goals and specific targets for the reduction of consumption and appointes a person responsible for energy management. The energy consumption and costs are documented and prepared for budgeting and energy audits for the major consumer are made. The strategic planning is conducted in a period of three years and is in rough coordination with the production strategy. Energy management is a covered process and incorporated in a company's process map. The additional education courses are held sporadically for the operative management and technical personal. The energy management has set the criteria for the efficient acquisition of new of machinery, equipment and energy. The energy efficiency measures are used for energy-intensive installations. In addition, measurements and analyses are carried out irregularly. The first control mechanisms are implemented, for instance by creating regular energy management reports, however without a deviation analysis.

Phase 4: The company recognizes the importance of energy management. The reduction of energy consumption and cost and energy efficiency is not only oriented on specific energy project, but is also implemented in daily business. The Energy Team has the primary responsibility for energy management and is defined a clear management structure. Energy management goals, targets and measurements for the major process are regularly evaluated and reviewed. Program to raise awareness of employees with regard to energy efficiency are implemented and accepted by the employees. Consumption monitoring and reporting becomes a standard activity. The workers are frequently educated; on the one hand, operational management is trained in the field of control and analysis of energy efficiency and energy costs, on the other hand, the technical staff is qualified for the operation of energy-consuming equipment and measuring devices.

Phase 5: A company has a fully implemented energy management system. The results of the energy management are visible in organizational performances and are presented outside of the company. The energy efficiency audits are performed by external auditor in regular intervals. Furthermore, energy efficiency measures are used for all installations and are evaluated at regular periods. The deviation analysis between the current and the target state are frequently assessed for the entire company, for products, employees and for machines and equipment.

Assessment Tool:

In order to identify and describe the current and the target state of energy management in a specific industrial company, we have developed a supporting tool, namely the phase model of energy management. The aim of this energy benchmark indicator based assessment tool is to provide an overview of the current energy performance, to reveal which aspects perform well and which do not , in order to point the way to the next steps on the road to improvement and to allow benchmarking between the current and the target state.

The assessment tool is developed in accordance with the energy management model and ISO Standard 50001. The evaluation of the maturity level is obtained through 40 qualitative questions divided into four model dimensions. Every dimension is tested with 10 questions and every question has five possible answers (Table 1). Table 1 shows as example, the set of qualitative questions for the assessment and measurement of energy performance within the company. The scoring system for the model follows the original models and is calculated by assigning the same value to each question. Moreover, for each of the criteria, there is a device that allows the different aspects of performance, whereby each one is ideally assessed by its own distinct and traceable criterion, to be combined into one indicator. This way, the resulting overall percentages are converted back into a qualitative assessment. Therefore, the qualitative assessment encompasses a five-phase scoring system. Each phase is color-coded by using a "traffic light" system, to assist with the rapid visual assessment of the tabulated data and to illustrate the areas of the system requiring immediate observation and reformation, expressed by the color red. Hence, the scoring scale follows the original path in which Phase I corresponds to an overall score in the range of 0-20% and is coded as red; Phase II to 21-40% and orange; Phase III to 41-60% and yellow; Phase IV to 61-80% light green; and Phase V to 81-100% dark green.

Table 1. Criterion questions for Assessment of the Energy Policy in company

No.	Qualitative question – Criterion for energy policy
1.1	Do you have an energy policy (strategy) formulated and is this communicated?
1.2	Do you have an energy concept for your company?
1.3	How is the energy management integrated into your corporate structure?
1.4	Do you have any goals of energy management set and evaluated?
1.5	How often are energy management goals evaluated and adopted?
1.6	Have you created energy audits in your company and are they performed regularly?
1.7	How is the financing of energy efficiency measures implemented in your company?
1.8	Exist the energy policy guidelines in your company?
1.9	How often energy analyzes are carried out?
1.10	What is included in the energy analysis?

For the practical usage and effectivity in the evaluation process, the assessment tool is implemented in the Microsoft Excel program. The results are presented is an assessment profile. The assessment profile is divided into two sections. The first section illustrates the evaluation profile of the company, presented by the model categories. This allows the end user to easier identify which phase of the development the company is in and where the "burning point" of further development is. Additionally, the target states is illustrated in order to show the deviation from the current developments and the objective status. The second part of the assessment profile consists of category analyses. Each category and its criteria are illustrated with the simple spider web chart. Through this illustration, the company can cleary identify the problems and set priorities of the appropriate energy plan, efficiency measurement, audit schemes, etc. The detailed analysis and illustration of the assessment profile is provided in the following chapter.

RESULTS AND DISCUSSION

In order to illustrate the evaluation within the assessment tool, a fictional example based on realistic data from the Austrian foundry industry will be presented. Due to the fact that the foundry industry is a high consumer of energy and energy management should be implemented in the company strategy, the following example will show the challenges the company meets.

The model company is an iron foundry with a cupola melting furnace with a production of 20,000 tons of products from 17,320 tons of melting iron. The production process includes the processes of smelting, casting, heat treatment, mechanical treatment, final control and numerous supporting processes (e.g. compressed air station, water station, buildings and other utilities, etc.). The site has an electric energy consumption of about 5.7 GWh/year, a natural gas consumption of about 11.5 GWh/year and a coke consumption of about 3,253 tons. The overall total cost of the energy carriers is about 2 M€/year, that is about 5 % of the total running costs. The company is not yet certified by the ISO Standard 50001.

The company officials within the conducted workshops and authors filled the questionnaire in order to ensure a correct interpretation of questions. Figure 6 shows the example of the qualitative questions implemented in the MS Excel based assessment tool.

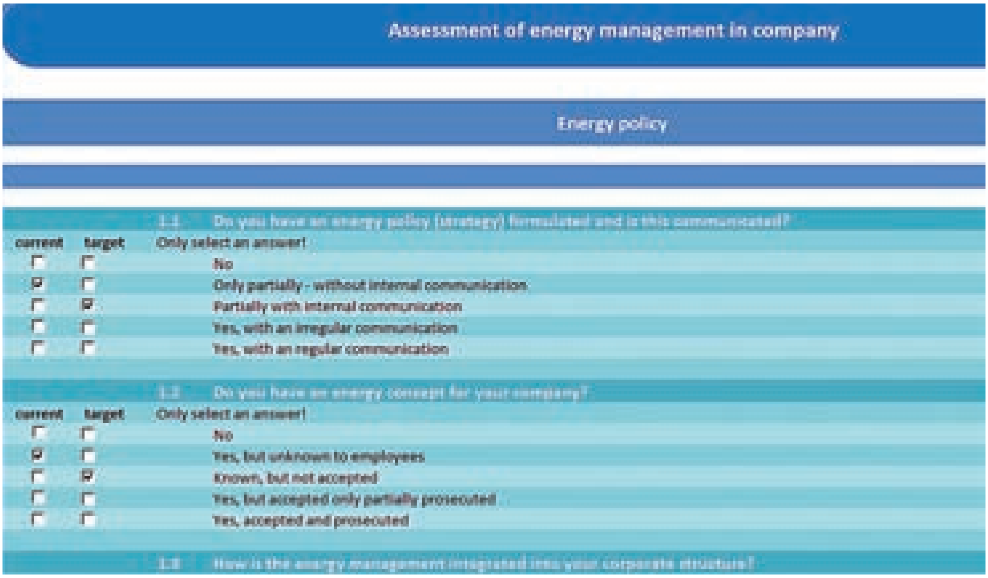

Figure 6. Example of qualitative questions implemented in MS Excel tool

The results presented in figure 7 illustrate that the company is currently in the 3. Phase of energy management development with a strong motive to improve the energy management system and archive the certification. However, the major obstacles are found in the category energy planning and organization.

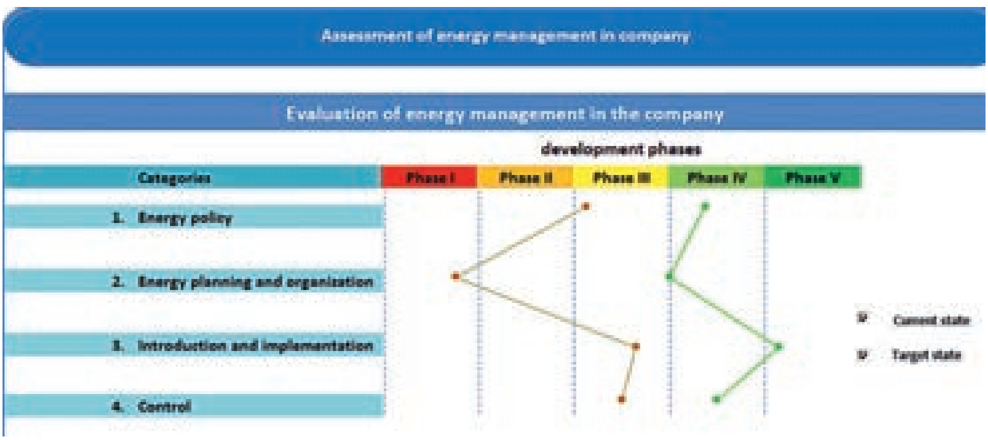

Figure 7. Evaluation of energy management in the company

The detailed analysis presented in figure 8 shows the development divided into categories and presented separately for each criterion on the spider web chart. The company already made the first steps for developing and implementing the energy policy. The energy strategy is recognized by the top management, however, the internal communication, energy concept and energy goals are defined sporadically and without a fixed organizational structure. Furthermore, the evaluation of the energy management goals is not implemented. The reporting scheme is identified in the company and a system for the measurement of the main energy consumers is developed. The companies possess the reasonable amount of energy data and regularly develop energy performance indicators. However, the financing of energy efficiency measures is only restricted for energy-intensive equipment and processes.

The results of the second dimension clearly illustrate challenges faced by energy planning and organization. Energy management is not incorporated in the company strategy, has no connection with other strategies and is not transferred into the operative level. Furthermore, the energy efficiency potentials are identified ad hoc by technical personnel. On the other hand, the communication concerning energy performances is implemented through the program for raising the awareness of employees with regard to energy efficiency. An energy manager is appointed and the energy management team is created. The additional education for operative management and technical personnel occur in irregular intervals. The

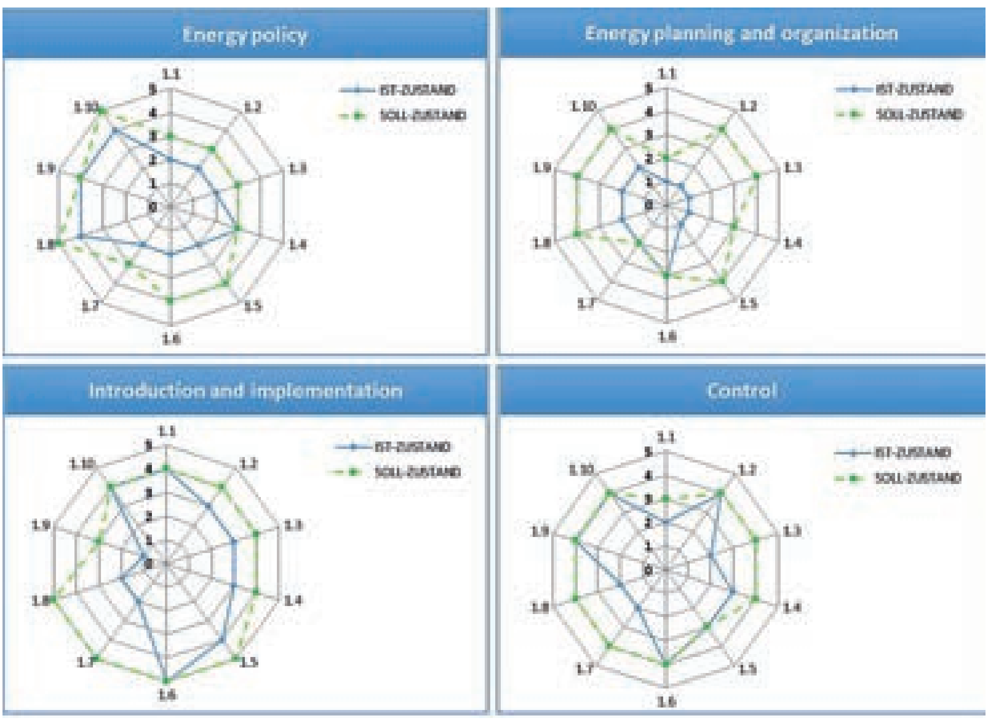

Figure 8. Category analysis of the energy management

human resources department conducts an evaluation of training in the context of comparative analysis. In order to raise awareness of energy efficiency among employees, the company offers monetary incentives for achieving energy-specific targets for employees. Furthermore, the energy management has set the criteria for the efficient acquisition of new of machinery, equipment and energy. These criteria are partially introduced and tested. The cumulative energy Management Review (Review) relating to energy management is conducted regularly with measures in accordance with energy policy, energy consumption and energy targets.

CONCLUSION

The implementation of effective and sustainable energy management in industrial companies is a process that is especially challenging. Major obstacles can be found in legal requirements, top management commitments and in practical implementation. This paper has introduced a model for benchmarking the energy management system in the industrial company based on three relevant models developed in this field, namely ISO Standard 50001, the Holistic Energy Management Model for industrial enterprises and the Energy Management Maturity Model. The model methodology outlines the benchmark indicator set to characterize the phase of the development of the energy management system in the researched company. Additionally, a MS Excel-based assessment tool was introduced that can be considered as an effective way to help companies self-assess their development phase and consequently develop and regularly evaluate their own plan for future developments and the achievement of the target state (e.g. the implementation of the Energy Management System and certification by ISO Standard 50001). The discussed example of the tool's implementation to the model company (in this case foundry in Austria) illustrates its applicability.

The final assessment profile clearly shows developments of energy management at different levels within the company: either the "burning" components which have to be improved immediately, or the "green" indicators which lead the development. Therefore, the application of the this model and assessment tool can be recommended in order to evaluate the current state of development and to identify the challenges, weaknesses, opportunities and threats for the company. The results of the findings can help decision-makers suggest, justify, propose and implement further strategic frameworks and transform challenges into opportunities. The application for the model is not exclusively reserved for industrial companies, as it can be applied to any service company or single plant rather than to the entire organization.

REFERENCES

Austrian Energy Agency (2007). Manual - step by step instructions for implementation of energy management. Austrian Energy Agency.

Coss, S., Topic, M., Tschiggerl, K., Raupenstrauch, H. (2015). Development and Application of a modular- based, multi- level approach for increasing energy efficiency. Journal of Thermal Engineering, Vol. 1 Special Issue 1, 355-366.

Giacone, E., Mancò, S. (2012). Energy efficiency measurement in industrial processes. In Energy 38 p. 331-345, 2012.

European Commission (2010). Communication from the Commission, Europe 2020. A strategy for smart, sustainable and inclusive growth. Brussels.

European Commission (2012). Directive of the European Parliament and of the Coun-cil on energy efficiency, 2012, 2012/27/EU.

Europen Enviromental Agency (2015). Final energy consumption by sector and fuel. Online access on 23.09.2015. http://www.eea.europa.eu/data-and-maps/indicators/final-energy-consumption-by-sector-8/assessment-2

German Federal Environment Agency (2014). Number of ISO 50001 Certified Sites Worldwide. Online access on 23.09.2015 www.nagus.din.de/sixcms_upload/media/2612/2014-05-30% 20Chart%20ISO%2050001%20Worldwide.pdf.

International Organization of Standardization (2011). ISO 50001:2011, Energy Management Systems – Requirments with Guidence for Use.

ISO Standards (2015). ISO 50001 - Energy management. Online access on 23.09.2015. http://www.iso.org/iso/home/standards/management-standards/iso50001.htm

Andreassi, L., Ciminelli, M.V., Feola, M., Ubertini, S. (2009). Innovative method for energy management: Modelling and optimal operation of energy systems. In Energy and Buildings 41 p. 436–444.

Di Somma, M., Yan, B., Bianco, N., Graditi, G., Luh, P.B., Mongibello, L., Naso, V. (2015). Operation optimization of a distributed energy system considering energy costs and exergy efficiency. In Energy Conversion and Management Vol. 103 p.1 739-751.

Schulze, M., Nehler, H., Ottosson, M., Thollander, P. (2015). Energy management in industry e a systematic review of previous findings and an integrative conceptual framework. Article in press in Journal of Cleaner Production, p.1-17.

Paramonova, S., Thollander, P., Ottosson, M. (2015). Quantifying the extended energy efficiency gap-evidence from Swedish electricity-intensive industries. In Renewable and Sustainable Energy Reviews Vol 51, p. 472-483.

Introna, V., Cesarotti, V., Benedetti, M., Biagiotti, S., Rotunno, R. (2014). Energy Management Maturity Model: an organizational tool to foster the continuous reduction of energy consumption in companies. In Journal of Cleaner Production, Vol83, p. 108-117.

Posch, W. (2010). Holistic Energy Management for Industrial Enterprises. Gabler Research, p. 364.