Classification of Industrial Energy Management Practices: A case study of a Swedish foundry

Aida Sa, Svetlana Paramonova, Patrik Thollander and Enrico Cagno

Original Publication:

Aida Sa, Svetlana Paramonova, Patrik Thollander and Enrico Cagno, Classification of Industrial Energy Management Practices: A case study of a Swedish foundry, 2015, Energy Procedia, CLEAN, EFFICIENT AND AFFORDABLE ENERGY FOR A SUSTAINABLE FUTURE, (75), 2581-2588.
http://dx.doi.org/10.1016/j.egypro.2015.07.311

Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 75 (2015) 2581 – 2588

Energy Procedia

The 7th International Conference on Applied Energy – ICAE2015

Classification of Industrial Energy Management Practices

A case study of a Swedish foundry

Aida Sa[a,b]*, Svetlana Paramonova[b], Patrik Thollander[b], Enrico Cagno[a]

[a b]*Department of Management, Economics and Industrial Engineering, Politecnico di Milano, Via Lambuschini 4, Milano, Italy*
[b]*Department of Management and Engineering, Linköping University, SE-581 83 Linköping, Sweden*

Abstract

Environmental concerns, stricter legislation and inflated energy costs together yield improved energy efficiency as an important pillar in every industrial sector. Mindful of this challenge, energy management and its related practices are deemed to be one of the major instruments to improve energy efficiency within manufacturing companies. Despite the importance of this issue, there is no precise and unanimous definition for energy management practices. Moreover, very few papers investigate energy efficiency opportunities and/or energy management practices in foundry industry. This paper aims to identify, classify and characterize energy management practices through their definition, with respect to energy efficiency, that could take place in a foundry industry.

Peer-review under responsibility of Applied Energy Innovation Institute

Keywords:energy management; practices;foundry; classification

* Corresponding author. Tel.: 00393664547153
E-mail address: aida.salimnezhadgharehziaeddini@polimi.it

Peer-review under responsibility of Applied Energy Innovation Institute
doi:10.1016/j.egypro.2015.07.311

1. Introduction

Improved energy efficiency (EE) is recognized as an essential strategy in energy and climate change mitigation policies. However, the benefits of using energy more efficiently include not only greenhouse gas (GHG) emissions reductions, but also reducing investments in energy infrastructures, lower fossil fuel dependency, increased competitiveness and improved consumer welfare. The manufacturing sector is responsible for about one third of the primary energy use and for 38% of the CO2 emissions globally [1, 2]. The foundry sector is considered to be one of the most energy-intensive sectors in Sweden together with pulp and paper, steel and chemical industries and thus requires attention [3]. 5-15% of the added value is allocated to energy costs in foundries in Europe [3]. For sustainable and smart foundries and manufacturing industry in general, improved EE is therefore of a great importance [4].

Even though improved EE becomes of an increased importance for manufacturing industries, a number of barriers exist which inhibits deployment of the potential for improved EE. Examples in the literature and in the world of practice show that although the manufacturing sector has made continuous improvements in EE, the techno-economical potential is not yet fully exploited [5, 6, 7, 1, 8, 9]. This paradox or energy efficiency gap was first defined by Hirst and Brown (1990) [10] meaning that profitable investments into improved EE is not realized in companies because of the barriers to EE [11, 12, 6, 13, 14, 15]. A number of papers examined barriers to EE in industry, some of the high-ranked for whole sizes being technical risks, lack of options to improve energy management practices (EnMPs) [15] limited access to capital, lack of time or low priority given to EE by the management [6, 16, 18], poor information quality and/or lack of information [15] or high transaction costs [16].

Several studies have identified a low status of Energy Management (EnM) in industrial companies to be a barrier to EE [17, 3]. Implementing EnM can be a way to improve EE and to reduce the related CO_2 emissions [18, 19] and overcome barriers to EE. O'Callaghan and Probert (1977) [20] define 'Energy Management' as addressing "resources, as well as the supply, conversion and utilization of energy". EnMPs thus help to improve EE in industries by a systematized and continuous way of dealing with energy related aspects. However, despite of quite big attempts to classify EnMPs for improving EE in manufacturing industries there is still a room for improvements. To bridge this gap, the current study by emphasizing the role of EnM in improving EE aims to answer the following questions: 1) How are EnMPs defined in the academic literature? and 2) How are EnMPs classified and characterized?

2. Method

Literature review and a single case study, a foundry, which is conducted between 2009 and 2014, are applied in answering the research questions. The chosen case is defined as one of the most energy-efficient foundry in relation to improved EE [3]. Comparing the chosen case study's KPI (key Performance Indicator) in terms of energy use per tons of good castings with data from the six foundries presented in [21] reveals that the chosen case can be classified as one of the most energy-efficient examples in the field of foundries. The choice of methodology was also supported by our access to rich and comprehensive empirical sources. Also, the choice of context is grounded in the industry's international orientation and exposure to the issues of EnM. In addition, a certain level of industry representativeness in a chosen sector was considered for this study, for example, market share, sales volume, and international expertise. The primary form of data collection was a series of interviews with senior management and an EnM staff. Based on the perspective of the research questioned posed in this study, we look at the company's in-house EnM program from the perspective of Turner (2007) [22] and its main components. In addition to the interview, frequent site visits and documents research (industry statistics, annual reports, media, industry association data, and government environmental regulation reports) to examine and cross-checking qualitative data are conducted to increase research validity [23]. In the following section, the case of a Swedish foundry is analyzed from EnM point of view.

3. Results

3.1. Definition of energy management practices

There is no single, unique and cohesive definition for EnMPs as it can be seen from different disciplines and perspectives. Different researchers have different point of view about what EnMPs are. For instance Caffall (1995) [24] defines it as “relevant savings without capital or with limited investment (short payback time compared to that of a technical measure), and such savings could be immediately re-applied to finance subsequent investment in energy-efficient technologies”. However, from Christoffersen et al. (2006) [18] point of view EnMPs have so far mainly consisted in replacing inefficient equipment and then using different methods to estimate the obtained savings.

As mentioned above, some authors consider an EnMP as a technical procedure while other believes it is more managerial. However, we define *EnMPs as total continuous or frequent managerial and technical actions in a company which aim primarily to reduce energy cost or secure energy supply and secondary to reduce pollution.* Some authors believe that there is overlapping between EnMPs and EE measures. But apart from the existence of some overlaps it is possible to differentiate EnMPs from EE measure [14]. It is useful to list all EnMPs and group them based on where and how they improve the EE. Characterization of EnMP through the EnM definition can be a light to better understand what EnM is. Turner (2007) [24] clustered EnM strategies into five dimensions: Reliability, Efficiency, Low cost/No cost, Funding, and Awareness. In this study we try to group EnMPs in these five dimensions, inspired by Turner (2007) [24].

3.2. Xylem’s energy management practices characterization

Companies’ characteristics like energy intensity and size have a direct impact on energy activities. Xylem in Emmaboda, Sweden, with 1,200 employees and a manufacturing capacity of 140,000 pumps and 2,500 mixers is a large energy intensive company which it has been working continuously to improve EE since 1998. Information was accomplished by studying Xylem’s energy plan for 2013. The reason for choosing this company was the recognition of this company being highly involved in energy related questions which is also approved by the fact that they won the Swedish Foundry Association’s energy prize in 2006 [25] as well as were nominated to Sustainable Energy Europe & ManagEnergy Awards 2014 for the project “High Temperature Borehole Thermal Energy Storage at Xylem” [26].Figure 1, shows energy flow and annual trends in terms of energy and production.

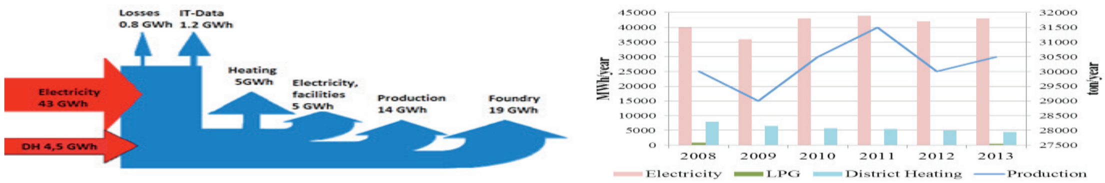


Figure 1. Left (a) Energy flows at Xylem. Right (b) Trends in annual EU and production at Xylem

In table 1 an in-house EnM program and in detail EnMPs used in the company are analyzed and characterized with respect to Turner (2007) [22]. Turner clustered energy related works in industries into five different targets: reliability, efficiency, low cost/no cost, funding, and awareness.

Table1. EnMPs characterization in Xylem

Strategy	Programs	Applied practices in reference case
Reliability	Maintenance program	Develop preventive maintenance plan by installing different class A, B, C alarm system for leaking or any other imperfection Develop connected system to prevent energy losses Develop maintenance program for each 3years
	Modernization	Sensor installment for weather adjustment Establish weather station in order to control humidity, wind direction and sun influence
	Operations	Establish borehole storage Heat exchangers Establish heat recovery system Establish sorption cooling technology Integrate LCC to procurement strategy
	Training	
	Contingency planning	Frequency convertor system for ventilation Frequency reduction for ovens and switch off the washers for about 15-20 min when electric load is about 11MW which brings 2MW energy use reduction Establish solar collector system and collecting about 35MWh per year Establish solar shelters Establish energy production system Collect volatiles and burn them to produce heat Take care of solvents burning heat in the foundry
Efficiency	Plant property evaluation	Develop a plan for updating inefficient equipment
	Measurement	24hours measurement for electricity in total and specifically for the furnaces, machinery area, water consumption and heat consumption Develop daily, monthly and annually reporting system for electricity, water and heat consumption Develop energy report for each working area, sub metering, like: electric motors department Develop EE index (energy use/ tonnage produced) then set EnM goal Develop annual evaluation program in terms of production rate and energy consumption Develop idling report (for monitoring idling drifts) Establish permanent instrumentation for energy measurement Procure necessary portable/ mobile instrument for measuring Frequency converter installed in order to monitor, energy use, operating time, investment analysis Identify and measure areas with significant energy use

	Control	Control by portable equipment in order to investigate possible energy reduction opportunities CO, CO2 and VOC controlling sensor in working area VSD control for fan's speed depending on air quality in working area CO control sensor in foundry connected to VSD for process ventilation CO2 control sensor in public area connected to VSD for ventilation Internet based controlling and monitoring system Waste water treatment control Heat recovery system connected to control system
	Energy organizational efficiency	
Low cost/ No cost	Alternatives for energy sources	
	Negotiation	Receive 40% government support for 1.5 years to install PVs to produce electricity Purchase green energy, biomass
	Time of use	Load management, use delays for some equipment Establish an electrical demand control system (in one sunny day it saves 5MWh)
	Elimination	Investigate areas which have significant energy losses Eliminate excessive heating demand
Funding	Stabilize funding	Identify and prioritize future projects based on improved energy efficiency and pay off (less than 3years)
	Return saving to customer	
	Short term funding	Receive 30% government support for a test program for verification of energy saving by borehole storage
	Economic analysis training	
Awareness	Training	Set a goal of 20 kWh/m2 electric demand for heating and ventilation through borehole storage Have high green policy Set goals for electricity, water and heating Avoid public water procurement for cooling in 2016 Improve electric efficiency by 5% till 2015 Decrease heating demand from 5GWh in 2012 to 2.5 GWh by 2015 Inform staff since eight years back about the importance of climate change Train staff to eliminate insignificant and unnecessary energy usages and minimize idling losses Displays to visualize energy trends

Communication	Form a network of energy committee between maintenance (the energy manager is in the maintenance group) and environment departments, machinery area and production line Involving in research program by Elforsk organization for electric demand reduction Networking with foundry organization and Scania once a year Established close network contact with Volvo's energy management Publicize energy activities, e.g. seminars
Behavior modification	
Program evaluation	

According to Turner, for better results in energy management programs, energy managers should be active in each target area to add the advantages of these targets to the company. It should be clear for the company what kind of advantages they can expect from the EnMPs they performed. For instance, maintenance program, modernization, developing operation procedure and contingency planning make company more reliable, but do not make company energy efficient. As it is visible in table 1, Xylem spread their action plan in almost every cluster. There are some vacant blocks such as: training for reliability target, energy organizational efficiency, alternatives for energy sources, return saving to customer, and economic analysis training.

4. Concluding discussion

Industrial companies strive for profit, and promoting EE can at times be difficult and not so prioritized [3]. Because many different policy instruments and pre-steps can and must be used if major improvements in EE are to take place moving industry towards improved sustainability, the results of this paper aimed to propose a comprehensive definition for EnMPs. Moreover, by characterizing EnMPs, the paper attempt to improve understanding of in-house EnM programs. Based on a literature review, there are indications that EnMPs are positively related to a top management support and ambitious, productivity, and firm's climate friendly R&D. However, large organizations often have some difficulties over SMEs in ensuring effective EnM [24]. In larger organizations, lines of communication are generally wider, organizational structures are complex enough, and access to a top management is rather difficult. All of these characteristics can be real disadvantages for effective EnM for large companies, especially for foundry industries which have more complex production process than, for example, non-energy intensive companies where the major energy use is found in the support processes. However, the same as what is running in the current studied reference case, proper meeting schedule between the energy group's members can be one means of overcoming the mentioned problems. Other tools for EnM success in large industries could be a centralized focus and energy manager's high desire to save energy and environment, as also found in Brunke et al. (2014) [15]. The energy manager's background is another important aspect which has had a direct impact on the EnM success at the studied company. Besides all these mentioned factors, there are drivers which motivate energy managers to improve EE in industries.

Acknowledgements

The authors warmly thank the Xylem's energy manager and environmental manager for giving freely of their time and attention to answer the questions, and Associate Professor Patrik Rohdin for his constructive suggestions and inputs.

References

[1] IEA, 2008. Assessing Measures of Energy Efficiency Performance and Their Application in Industry

[2] EIA, US. "Annual energy outlook 2013." US Energy Information Administration, Washington, DC (2013).

[3] Thollander, Patrik, and Mikael Ottosson. "Energy management practices in Swedish energy-intensive industries." Journal of Cleaner Production 18.12 (2010): 1125-1133.

[4] Thollander, Patrik, et al. "Beyond barriers–A case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain, and Sweden." Applied Energy 111 (2013): 636-643.

[5] EC, 2010. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Analysis of Options to Move beyond 20% Greenhouse Gas.

[6] Eichhammer, W., 2004. Industrial energy efficiency. Encyclopedia of Energy. Elsevier, New York, pp. 383-393.

[7] Enkvist, P.A., Naucler, T., Rosander, J., 2007. A Cost Curve for Greenhouse Gas Reduction. A Global Study of the Size and Cost of Measures to Reduce Greenhouse Gas Emissions Yields Important Insights for Businesses and PolicyMakers.

[8] lEA, C. O. "emissions from Fuel Combustion." (2009).

[9] Mundaca, L., 2008. Markets for energy efficiency: exploring the implications of an EU-wide 'tradable white certificate' scheme. Energy Economics 30, 3016e3043.

[10] Hirst, E., Brown, M., 1990. Closing the efficiency gap: barriers to the efficient use of energy. Resources, Conservation and Recycling, Vol. 3(4): 267-281.

[11] DeCanio, S.J., 1993. Barriers within firms to energy -efficient investments. Energy Policy, Vol. 21: 906-914.

[12] DeCanio, S.J., 1998. The efficiency paradox: bureaucratic and organizational barriers to profitable energy -saving investments. Energy Policy, Vol. 26: 441-454.

[13] Cagno, E., Trianni, A., 2013. Exploring drivers for energy efficiency within small-and medium-sized enterprises: first evidences from Italian manufacturing enterprises. Applied Energy, Vol. 104: 276-285.

[14] Trianni, Andrea, et al. "Barriers to industrial energy efficiency in foundries: a European comparison." Journal of Cleaner Production 40 (2013): 161-176.

[15] Brunke, J.-C., Johansson, M., Thollander, P., 2014. Empirical investigation of barriers and drivers to the adoption of energy conservation measures, energy management practices and energy services in the Swedish iron and steel industry. Journal of Cleaner Production, in Press.

[16] DeCanio, S.J., Watkins, W.F., 1998. Investment in energy efficiency: do the characteristics of firm matter? The review of Economics and statistics, Vol. 80: 95-107.

[17] Rohdin P., Thollander P., Solding P., 2007, Barriers to and drivers for energy efficiency in the Swedish foundry industry. Energy Policy, Vol. 35: 672–7.

[18] Christoffersen, L.B., Larsen, A., Togeby, M., Empirical analysis of energy management in Danish industry. Cleaner Production, Vol. 14: 516-526.

[19] Kannan, R., Boie, W., 2003. Energy management practices in SME – case study of a bakery in Germany. Energy Conversion and Management, Vol. 44 (6): 945-959.

[20] O'Callaghan, P., Probert, S., 1977. Energy management. Applied Energy, Vol. 3 (2): 127-138.

Rohdin and Thollander, 2006.

[21] Thollander, P., Karlsson, M., Söderström, M., Creutz, D., 2005. Reducing industrial energy costs through energy efficiency measures in a liberalized European electricity marketdcase study of a Swedish iron foundry. Applied Energy 81(2), 115e126.

[22] Turner, Wayne C., and Steve Doty. Energy management handbook. The Fairmont Press, Inc., 2007.

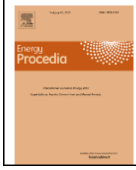
[23] Yin, Robert K. "Case Study Research: Design and Methods, (Applied Social Research Methods, Vol. 5)." (2002).

[24] Caffall, C., 1995. Learning from experiences with energy management in industry. Centre for the analysis and dissemination of demonstrated energy technologies

[25] Thollander, P., Rahimi, M., Ardkapan, S., Rosenqvist, J., Rohdin, P., Solding, P. 2010. In-depth evaluation of energy management in a Swedish iron foundry. In Proceedings of the Scientific Conference on Energy and IT at Alvsjo fair, Stockholm.

[26] EUSEW, 2014. European Union. Sustainable Energy Week. Awards Nominees 2014. Retrieved October 11, 2014 from the EUSEW's Web site: http://www.eusew.eu/awards-competition/awards-winners-2014?id=114

[27] Baudelaire, C., 2014. Overcoming the Energy Efficiency Gap: a Motivation, Opportunity and Ability Approach. Master thesis, National University of Singapore, Division of Engineering and Technology Management.



Biography

Aida Sa is an industrial engineering PhD candidate in Politecnico di Milano. She is interested in how to improve energy management programs for industries.