CLIMA 2016 - proceedings of the 12th REHVA World Congress

volume 3

Heiselberg, Per Kvols

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Towards Developing An Exergy Management System Standard and Its Application to a University Building

Arif Hepbasli

Department of Energy Systems Engineering, Faculty of Engineering, Yasar University,
35100 Bornova, Izmir, Turkey
arif.hepbasli@yasar.edu.tr & arifhepbasli@gmail.com

Abstract
In June 2011, the International Organization for Standardization (ISO) released ISO 50001, Energy Management Systems – Requirements with guidance for use while EN 16001, the European standard for Energy Management Systems, was issued in July 2009. The ISO 50001 standard advocates continuous improvement of energy performance (energy efficiency, energy consumption and energy use) and provides requirements for an energy management system (EnMS) for achieving this continuous improvement. Exergy can be considered to be one of the key issues for sustainability. Exergy analysis has been widely used by many investigators and practicing engineers as powerful tools for analyzing, assessing, simulating, designing, improving and optimizing systems and processes. Benefits of exergy analysis are numerous, especially compared to energy analysis. The exergy concept is useful to pinpoint magnitudes and locations of thermodynamic imperfections occurring through an energy supply chain. The main idea behind establishing an EnMS structure is based on the energetic performance improvement in a continuous way while exergy analysis helps deduce the areas for possible improvements in any energy system. The main objectives of this study are twofold, namely (i) to propose a new exergy management system (ExMS) standard for the first time in the open literature to the best of the author's knowledge by explaining how to develop, and (ii) to briefly apply the milestones of the proposed standard to a campus building of Yasar University located in Izmir, Turkey, which achieved TS EN ISO 50001:2011 certification as the first university in Turkey on 5 January 2016.

Keywords – exergy policy; exergy manager; exergy management; exergy management system standard; exergetic performance indicators

1. Introduction

The 2013 ISO Survey of Management System Standard Certifications has reported that the number of ISO 50001certifications reached 4,826 over a period of eighteen months after the standard's initial publication. Based on more recent data of public sectors, now more than 10,000 ISO 50001 certifications are estimated. The growth of ISO 50001 is expected to

continue to accelerate as more companies integrate ISO 50001 into their corporate sustainability strategies and supplier requirements [1].

At the university level, University College Cork (UCC) in Ireland has become the first university in the world to achieve the ISO 50001 standard. It was reported that this feat was achieved in just 4 months. Since then, various universities worldwide have attempted to obtain ISO 50001 Certification. The number of these universities is very low compared to other institutions.

In this regard, Yasar University, one of the foundation universities in Turkey, achieved the TS EN ISO 50001:2011 EnMS standard certification on 5 January 2016, where TS means Turkish Standard. The certification covers the buildings on the Selcuk Yasar campus and the dormitory buildings. This enabled Yasar University to be the first university in Turkey to receive the ISO 50001 certification to the best of the author's knowledge.

There are various management systems, such as ISO 9001 (quality management), ISO 14001 (environmental management), ISO 22000 (food safety), and ISO/IEC 27001 (information security), which complement each other. In particular, ISO 50001 (or BS EN 16001) follows the Plan-Do-Check-Act (PDCA) process for continual improvement of the energy management system, as indicated in Fig. 1 [2]. These similar or common characteristics enable organizations to integrate exergy management with their overall efforts to improve quality, energy, environmental management and other challenges addressed by their management systems.

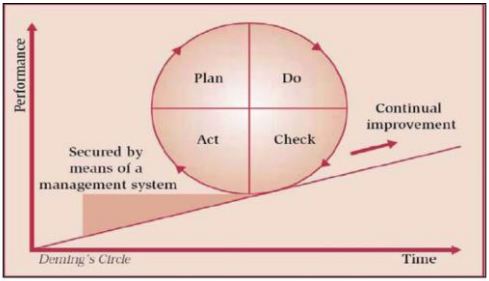

Fig. 1 Overview of an energy management system [2]

When searching the words "exergy management system standard" on the Internet on 26 January 2016, only one link belonging to the author appears, as indicated in Fig. 2. In this context, the author highlighted in the last national energy efficiency week held every year in the second week of January in Turkey that an exergy management standard would be established in the coming years and could be combined with other management system standards in enterprises.

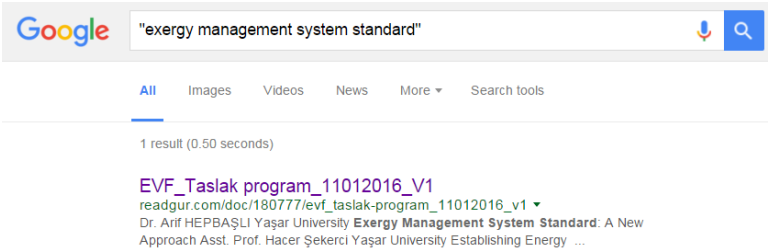

Fig. 2 Searching "exergy management system standard" on the Internet

2. Exergy Management System Versus Environmental and Energy Management Systems

Table 1 makes a comparison between environmental, energy [3] and exergy management systems in terms of some issues. As highlighted by Rosen [4], energy conservation, although widely used, is an odd term. Its use is prone to be confusing and often misleading. It is nothing more than a statement of the principle of conservation of energy, which is embodied in the first law of thermodynamics. In this context, exergy can help clarify this confusion by preserving the appropriate use of the term energy conservation as a statement of a scientific principle. Exergy is based on the first and second laws of thermodynamics. It is the second law defining an ideal or perfect process or device as one that is reversible. If one aims for thermodynamic perfection, exergy conservation is a logical and meaningful target. Of course, one can never in reality achieve the ideality associated with exergy conservation, but knowing of its hypothetical existence certainly provides a clear upper limit for conservation efforts [4].

Table 1. Exergy management system versus environmental and energy management systems

Environmental management system focuses on [3]	Energy management system focuses on [3]	Exergy management system focuses on (proposed in this study)
Environmental protection	Energy efficiency	Exergy efficiency
Prevention of pollution	Energy conservation	Exergy conservation
Waste management	Energy management	Exergy management
Environmental performance	Energy performance	Exergy performance

3. Integration of ExMS

Exergy management includes many aspects of energy management while it establishes an exergy policy. It also helps x-ray the whole system considered because it deals with some charcatericts such as exergy baseline, exergy analysis/balance, exergy audit while energy management covers those such as energy baseline [5], energy analysis/balance and energy audit [6]. The acronym of exergy management proposed by the author is indicated in Fig. 3.

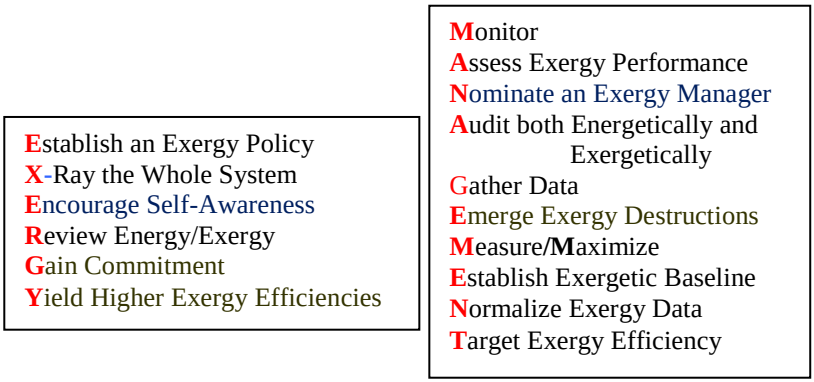

Fig. 3 Acronym of exergy management proposed by the author

Energy audit considers the First Law of Thermodynamics-based analysis and provides the performance of an energy system based on conservation of energy. Exergy audit is related to the Second Law analysis, i.e., exergy analysis, determines the magnitude and direction of irreversible processes in a system and thereby provides an indicator that points the direction in which engineers should concentrate their efforts to improve the performance of the considered system [7].

If there are various management systems established in any enterprise, it is recommended to integrate them with each other. Implementation is easier for enterprises which have already put a management model into practice, it is also much more logical from the point of view of efficiency to integrate the requirements of various management systems instead of introducing them concurrently to one another [8]. When integrating ExMS requirements into the already existing management systems, enterprises can get some benefits from a reduction in personnel, as well as in temporal and financial expenditure. The successful integration of ExMS requires a company's successful consolidation of responsibilities for energy, safety, quality and environmental protection. According to the size of the company,

it is a good idea for one person in-charge to be made accountable for all management systems. Further clarity can be achieved if all the aspects are consolidated at a higher managerial level responsible for all management systems and corresponding department experts are made accountable for the individual technical aspects, as indicated in Fig. 4.

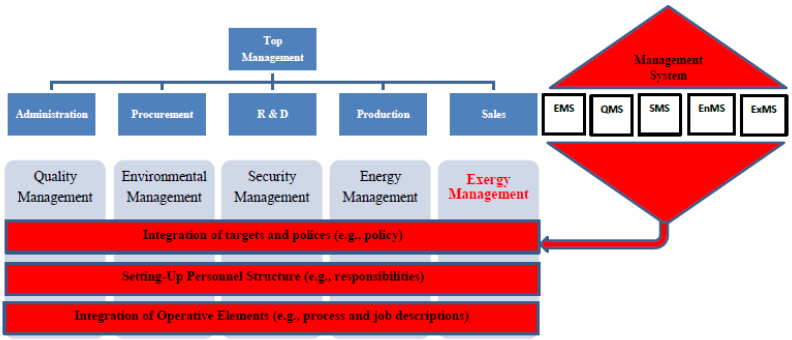

Fig. 4 Integration of exergy management system (Adapted from [8])

4. Proposing an ExMS Standard Approach

The method of the proposed exergy management system standard uses an exergetic approach while there are no words including exergy in the ISO 50001 standard. As shown in Fig. 5, the proposed ExMS standard significantly differs from the EnMS standard, especially in the Plan stage of the PDCA process while other steps are mostly identical for both EnMS and proposed ExMS standards.

4.1. Exergy (or Exergetic) Performance

The concept of energy performance stated in the ISO 50001 standard includes energy use, energy efficiency and energy consumption. Any organization can choose from a wide range of energy performance activities. For example, the organization could reduce its peak demand, utilize surplus or waste energy or improve the operations of its systems, processes or equipment.

In this regard, the concept of exergy performance covers exergy use (or utilization), exergy efficiency and exergy consumption. Considering that energy is never produced or consumed, one knows that the term energy consumption is technically incorrect. When one asks, what is consumed ? The answer to this would be that exergy is consumed and this is technically correct. Exergy use is also calculated by considering energy use multiplied by an exergetic factor [9,10] while exergy efficiency is more meaningful

compared to energy efficiency [11,12].

ISO 50001	Proposed ExMS
1	
Establish energy policy	Establish exergy policy
2	
Appoint energy manager	Appoint exergy manager
3	
Form energy management team	Form exergy management team
4	
Conduct energy review	Conduct exergy review
5	
Establish energy baseline	Establish exergy baseline
6	
Establish energy performance indicators	Establish exergy performance indicators
7	
Establish energy objectives and targets	Establish exergy objectives and targets
8	
Establish energy management action plans	Establish exergy management action plans
Goto ''DO''	

Fig. 5 Main elements of the plan stage for both ISO 50001 and proposed ExMS standards

4.2. Exergetic Indicators

As far as buildings are concerned, some exergetic indicators may be used for these purposes, as explained in more detail elsewhere [13] while EnMS standard considers some energetic indices such as energy utilization index, building energy index. Among exergetic ones, exergy flexibility factor [14] and exergetic normalized performance indicator proposed by Hepbasli and Arkon [13] are worthy.

4.3. Energetic and Exergetic Terms Used in EnMS Published and ExMS Proposed Standards

To better understand the similarities between EnMS published and ExMS proposed standards, the widely used terms are reviewed and listed in Table 2. In this context, 32 various terms are included. It should be noted that some terms such energy [5]/exergy baselines, energy [5]/exergy performance indicators, energy [6]/exergy audits have also been prepared as the ISO 50001 family of standards. Another complementary standard of energy balance may be needed while a methodology on exergy balance is presented elsewhere [15] by the author. Some training courses/mechanisms should also be arranged for the certification of exergy managers.

Table 2. A list of energetic and exergetic terms used in both EnMS and ExMS

Item #	EnMS standard published	ExMS standard proposed
1	Energy	Exergy
2	Energy analysis	Exergy analysis
3	Energy audit	Exergy audit
4	Energy auditor	Exergy auditor
5	Energy awareness	Exergy awareness
6	Energy balance	Exergy balance
7	Energy baseline	Exergy baseline
8	Energy consumption	Exergy consumption
9	Energetic design	Exergetic design
10	Energy data	Exergy data
11	Energy efficiency	Exergy efficiency
12	Energy flow (Sankey) diagram	Exergy loss and flow (Grassmann) diagram
13	Energy management (EnM)	Exergy management (ExM)
14	Energy manager	Exergy manager
15	Energy management action plan	Exergy management action plan
16	Energy management system	Energy management system
17	Energy management team	Exergy management team
18	Energy management system standard	Exergy management system standard
19	Energy objective	Exergy objective
20	Energy performance	Exergy performance
21	Energy performance evaluation	Exergy performance evaluation
22	Energy performance indicator	Exergy performance indicator
23	Energy performance improvement	Exergy performance improvement
24	Energy planning	Exergy planning
25	Energy policy	Exergy policy
26	Energy price	Exergy price
27	Energy review	Exergy review
28	Energy supply	Exergy supply
29	Energy service	Exergy service
30	Energy target	Exergy target
31	Energy use/consumption	Exergy use/consumption
32	Significant energy use (SEU)	Significant exergy use (SExU)

5. An Illustrative Example of Yasar University

Yasar university became the first university in Turkey in terms of achieving the TS EN ISO 50001 Standard:2011 [16], as also recently released publicly [17]. In establishing an exergy management structure, the PDCA process along with Fig. 5 and considering Table 2 may be applied to the university. In the following, some items are explained.

a) *Exergy policy:* Yasar University's existing energy policy [18] can be combined with its exergy policy, which was yellow-highlighted and indicated in the parenthesis in Fig. 6.

As Yasar University, we are committed to continuously improving our energy (exergy) performance in all our activities with an awareness of carrying the responsibility for the energy (exergy) management system. In order to achieve the above mentioned objective, we will make every effort to:

- Reduce energy (exergy) and water usage in all our activities;
- Raise cultural awareness about energy (exergy) efficiency in our university by continuously organizing trainings/seminars;
- Continuously monitor and report our energy (exergy) consumption targets by defining them;
- Perform regular energy (exergy) efficiency audits for defining energy (exergy) efficiency improvement areas;
- Follow up updated legal statutes related to energy (exergy) and water usage, and meet their requirements;
- Include energy (exergy) performance improvements in the design stages of projects;
- Purchase and effectively utilize energy (exergy)-efficient products and services.

Fig. 6 Integrated energy and exergy policy of Yasar University

b) *Exergy performance indicator:* This consists of exergy use, exergy consumption and exergy efficiency. Considering the exergy efficiency, which may be defined in various ways and using the lowex approach (pre-design sheet for an exergy optimized building design) [14], total exergy system efficiency (exergy demand room/total exergy input) and exergy flexibility factor (exergy demand of air heating equipment/total exergy input) were calculated for the following campus building in the heating mode:

Indoor and outdoor (design) air temperatures: 22/0 ^{o}C
Net floor area : 18259 m^2
Heat demand : 500 kW
Condensing boilers and an air handling unit are used.

Total exergy system efficiency and exergy flexibility factor were obtained to be 2.2% and 9.9%, respectively while energy and exergy flows from the primary energy production to the building envelope are indicated in Fig. 7.

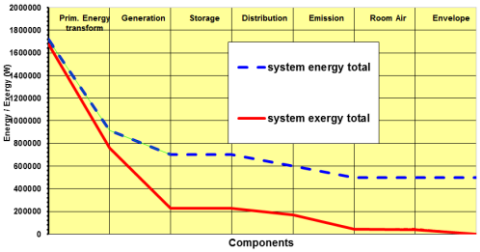

Fig. 7 Energy and exergy flow diagrams of the building considered

6. Concluding Remarks

In this study, a new exergy-based management system standard, the so-called exergy management system (ExMS) standard, has been proposed for the first time in the open literature to the best of the author's knowledge. In this regard, the main differences of the ExMS standard from the ISO 50001 standard have been given. The ExMS standard has been conceptually applied to the campus buildings of Yasar University in Izmir, Turkey where the TS EN ISO 50001 [19] energy management system standard activities have been implemented since 11 December 2014 with an energy management team consisting of 11 persons, of whom 6 are certified energy managers [19,20].

Some concluding remarks drawn from the results of the present study may be summarized as follows:

a) Especially after releasing ISO 50001 energy management system standard, performance indicators for buildings have gained great importance due to the requirement to document the methodology for determining and updating these indicators.
b) In the coming years, moving from the energy management system standard to the exergy management system standard in enterprises will also increase the importance of the establishment and development of exergy-based indicators along with certified exergy managers.
c) The author expects that the methodology presented here will help make some attempts in considering and developing an exergy management system standard.
d) Sharing lessons learned from building an ISO 50001 in a Turkish university for the first time will be very beneficial to those who want to make these kinds of attempts on their campus buildings.
e) It may be concluded that although the PDCA process seems to be conceptually very simple, its implementation requires really more efforts, as we faced during establishing an energy management system standard.

References

[1] G. Siciliano, A. McKane A and P. De Los Reyes. Promoting strong ISO 50001 outcomes with supportive national infrastructure. Presented at the 2015 ACEEE Summer Study on Energy Efficiency in Industry Buffalo, NY August 2015 and to be published in the Proceedings (2015).

[2] UNIDO. Two day energy management training. Student manual. *Practical Guide for Implementing an Energy Management System.* (2011), 58 pages.

[3] V. Barron. BS EN 16001 Energy management systems. file:///C:/Users/Win7/Downloads/091204lueg-crsb-bs-en-16001.pdf, 29 pages. Access date: 27 Jan. 2016.

[4] M.A. Rosen. Exergy conservation: an alternative to conserving the already conserved quantity energy. Exergy, an Int. J. 2 (2002) 59–61.

[5] International Standard. ISO 50006. Energy management systems- Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)-General principles and guidance. ISO/FDIS 50006:2014(E)

[6] International Standard. ISO 50002. Energy audits-requirements with guidance for use. First edition 2014-07-01. ISO 50002:2014(E).

[7] M.S. Murthy and R.D. Misra. Say no to energy audit, welcome exergy audit. http://www.indiacore.com/bulletin/papers-tpi2009/M-S-Murthy-SSBTCOET-Say-No-to-Energy-Audit.pdf, Access date: 27 January 2016.

[8] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). DIN EN 16001: Energy Management Systems in Practice A Guide for Companies and Organisations.https://www.adelphi.de/sites/default/files/mediathek/bilder/uploads/andere/pdf/application/pdf/ema_3_auflage_web_en.pdf, Access date: 25 January 2016, 104 pages.

[9] Z. Utlu and A. Hepbasli. Analysis of energy and exergy use of the Turkish residential-commercial sector. Building and Environment 40(5) (2005) 641-655.

[10] **A.** Hepbasli. A study on estimating the energetic and exergetic prices of various residential energy sources. Energy and Buildings 40(3) (2008) 308-315.

[11] Z. Utlu and A. Hepbasli. Estimating the energy and exergy utilization efficiencies for the residential-commercial sector: an application. Energy Policy 34 (2006) 1097-1105.

[12] A. Hepbasli. A key review on exergetic analysis and assessment of renewable energy resources for a sustainable future. Renewable & Sustainable Energy Reviews 12(3) (2008) 593-661.

[13] A. Hepbasli and A.C. Arkon. A new exergy-based index for performance assessment of buildings. CLIMAMED 15, *The Eighth Mediterranean Congress of Heating Ventilation and Air-Conditioning*, September 10-11, Antibes Juan-les Pins, France (2015).

[14] A. Hepbasli. Low exergy (LowEx) heating and cooling systems for sustainable buildings and societies. Renewable and Sustainable Energy Reviews 16 (2012) 73-104.

[15] A. Hepbasli. 2010. Energy Efficiency and Management System: Approaches and Applications. Schneider Electric Energy Efficiency Series (in Turkish), Esen Matbaacilik, Istanbul, Turkey, 1008 pages.

[16] Yasar University. News. The first university with the TS EN ISO 50001 certificate (in Turkish).http://haber.yasar.edu.tr/basari/ts-en-iso-50001-belgeli-ilk-universite.html. Access date: 30 January 2016.

[17] TSE Turkish Standard. TS EN ISO 50001 Energy Management Systems-Requirements with Guidance for Use (in Turkish). February 2013.

[18] Yasar University. Energy policy of our university. http://evy.yasar.edu.tr/en/energy-policy/, Access date: 30 January 2016.

[19] Yasar University-Energy Efficiency and Management. evy.yasar.edu.tr/en (in English). Access date: 30 January 2016.

[20] Yaşar Üniversitesi-Enerji Verimliliği ve Yönetimi. evy.yasar.edu.tr (in Turkish). Access date: 30 January 2016.