


The role of Energy Management System based on ISO 50001 for Energy-Cost Saving and Reduction of CO₂-Emission: A review of implementation, benefits, and challenges

Abstract. Increasing demand of energy consumption lead to significant support effort to support the sustainable supply by exploring a new resource, development technology, and strategy of energy-mix. In line with this, the development and implementation of management systems in energy utilization play an important role. Based on several studies the implementation of ISO 50001 has significant to improve the performance of energy management, saving of the energy cost, and reduction of CO₂ emission. This paper will be reviewed the state of the art of implementation of this standard, benefits, and challenges based on literature studies from several scientific journals and publications released by international organizations, associations, and government policies. Some selected case studies describing quantitative energy performance affected by the implementation of ISO 50001 at the international level with different sectors and some role models from Indonesia are described. Moreover, the challenges and difficulties facing by the implementation of this standard were also reviewed 



1. Introduction

Availability of energy is the main prerequisite for national development. With the increasing of people's living standards and economic growth, energy supply management plays a very important role. In the perspective of energy supply, there are various energy options to meet the energy consumption, but until now mostly is still based on fossils. Many efforts on developing renewable energy like biomass-based energy, biohydrogen, solar cell, biorefinery offered a good prospect in the near future [1-3]. The significant thing related to energy supply is that it is in accordance with market needs, such as safe, affordable prices, and environmentally friendly. Another thing that is not less important is climate change which has become a major concern in various countries for 2 decades. This has prompted the international community to continuously take appropriate measures to mitigate greenhouse gases, especially carbon dioxide, methane, as well as sulfur dioxide, and nitrous oxide. Emissions of these gases are mostly caused by the use of fossil fuels as the main energy source. Regulation and standardization play a significant role in maximizing efficiency and reduce the environmental impact. To illustrate the quantitative data, the International Energy Agency, IAE (2014) reported in 2013 only 22% of the energy consumed worldwide came from renewable energy sources. Based on these facts, many government initiatives in the world are carried out to mitigate climate change and reduce energy-related spending that can reduce environmental, social, and economic burdens [4-6].

At the practical level in industrial activity, energy management is a key factor for the operation of many industries or organizations. Variety Energy consumption generally varies between companies or organizations because it depends on their activities. And efforts to reduce energy consumption are not easy to implement because price fluctuations often occur in a relatively short time, so the best choice is to optimize activities and reduce energy costs. At the same time improving the management system based on spending data. It should be emphasized that reducing energy costs not only benefits the organization but also provides other benefits such as contributing to environmental issues. One of the international standards that are widely applied in various companies or organizations is ISO 50001 which is issued by the International Organization for Standardization (ISO). ISO 50001 is an Energy Management System standard that aims to improve the energy performance of all types of companies and organizations. Some of the advantages are reduced energy consumption, energy costs, and systematic reduction of carbon emissions [7].

2. Methodology

The method used in this review is descriptive-analytic based on literature studies from several scientific journals and publications released by international organizations, associations, and government policy. Selected topic related to the state of the art and trend energy supply, energy management, energy policy, and case studies of some selected role models in implementation of the energy management system. The roles of the energy management system are identified and a description of ISO 50001 is summarized. The trend implementation of ISO 50001 worldwide and their role on improvement of energy performance and reduction of the impact on climate change are summarized, For the more quantitative performance of the implementation of the standard, some role models as case studies are selected from Clean Energy Ministerial (CEM) Energy Management Leadership Awards. The performance of role models from Indonesian companies in the different sectors can give the illustration of the implementation of standards that affected energy performance improvement, energy saving, energy cost-saving, and reduction of CO₂ emission. The cost to implementation of standard and time period needed for implementation from 2016 to 2020 also identified, Moreover, the challenge, difficulties, and opportunities for more improvement in energy management are described.

3. Standard for Energy Management and Description of the Standard ISO 50001

Many success stories show that the standardization play important role in development platform requirements of goods, services, process, management system and also person's competency. To support the good implementation need the conformity assessment incl. certification and accreditation, as well as metrology when it is related to the measurement. Standard ISO 50001 belongs to the management system (EnMS) which was already published in 2011 and review in 2018. This standard belongs to a high-level structure and is connected and integrated with another standard management system, like environmental management systems, quality management systems, and others [8,9].

All management system standards generally are subjected to increase the effectiveness of management and efficiency of the business process. There are some key elements such as strategy, tool, process, technology. These elements can be used to ensure the full integration of energy efficiency improvements into the production or manufacturing process [10]. A systematic and in-depth review of academic articles shows that different EnMS exert substantially different energy-saving effects, in particular, that energy-saving performance is correlated with the function of the EnMS used [11]. From several case studies of the implementation of the ISO 50001 standard shows an increase in energy performance indicators and encourages continuous improvement to implement the standard [12]. Another study also found that the implementation of ISO 50001 had a positive effect on monetary savings, motivating other organizations to implement it [13,14]. For environmental improvement efforts, the implementation of ISO 50001 can contribute to the mitigation of CO₂ emissions, the implementation of a green and low-carbon supply management system [15]. In other cases, the implementation of ISO 50001:2018 proves that it is a good practice that company vulnerabilities can be reduced and mitigated through the implementation of a comprehensive management system concept. Matters of significant

importance also involve quality, safety and health, environmental management, energy efficiency, and other risk components, following the achievement of the main target in reducing significant energy consumption [16,17].

The standard on Energy Management Systems ISO 50001 was created by the International Organization for Standardization (ISO). The ISO is an independent international non-governmental organization and has a membership of 161 national standards bodies from various parts of the world. Has published more than 22 000 standards. The ISO 50001 gives organizations a recognized framework for developing an effective energy management system. Generally, the principle of the “ Plan-Do-Check-Act ” is the main tool to gain continual improvement. A set of requirements is provided for the organization and allows it to take several actions such as 1). develop policies to achieve more efficient energy use; 2). set realistic targets and objectives to meet the outlined policies; 3) collect data to better understand and use it as a basis for making decisions regarding energy use; 4). measure the results achieved; 4). reviewing the effectiveness of the established policies, and 5). carry out continuous improvement of energy management. ISO 50001 version 2018 (ISO 50001: 2018) is revised from version 2011 (ISO 5001: 2011).As with all ISO standards, ISO 50001 is reviewed every five years with the aim of ensuring it is in line with dynamic developments including market needs. In addition, this review and update of ISO 50001 are to align it with ISO requirements for management system standards, as this standard includes High-Level-Structure (HLS). Within this structure, the framework designed allows the integration of other management systems into the existing management systems defined by the organization. Important changes in the latest version compared to the previous edition include a stronger emphasis on the role of senior management, updates to terms and definitions. Other changes were also made to the normalization and clarification of energy performance indicators and basic energy narratives to provide a better understanding of these concepts [7,18].

As mentioned earlier, ISO 50001 is designed based on the HLS structure, so integration with other standards that are close together is possible. For example, ISO 9001 (Quality Management System), ISO 14001 (Environmental Management System), ISO 37001 (Anti-Bribery Management System), ISO 27001 (Information Security Management System) [7,19]. One thing that is important in HLS is the principle of Plan Do Check Action. Figure 1. Describe the PDCA diagram and the clauses in the ISO 50001.



Figure 1. The PDCA diagram and the clauses in the ISO 50001:2018

4. Implementation of Energy Management System based ISO 50001

As already mentioned before, that like the other management system standard, the ISO 50001 standard is subjected as a tool which able to improve the better practice for energy management. Their implementation can help to manage energy performance and efficiency. It depends on the need and regulation the implementation of this standard can be certified by external organizations in order to get objectives results of compliance through suitable assessment. The best assessment is in general by a certification company accredited by International Accreditation Forum (IAF) [19].

Indicators of standard implementation can be seen from the number of certifications in a country. As an illustration in 2015, ISO 50001 accounted for 11,985 registered organizations. The data before that, certification showed a significant rapid development, recorded from 459 in 2011 to 1981 in 2012. It was also reported that the total growth was calculated at around 332% per year. Given these factual conditions, the growth of ISO 50001 and ISO 14001, also referred to as meta-standards, and on the other hand because of the importance of promoting energy management for cleaner production, is a more systematic and detailed study that analyzes the causal relationship between incentives, difficulties, and benefits. required [20]. In 2019, recorded 18,277 certificates in around 42,215 sites worldwide achieved ISO 50001. The growth of ISO 50001 is expected to accelerate as an increasing number of companies integrate ISO 50001 into their corporate sustainability strategies and supplier requirements [20,21].

Based on the trend of the implementation of ISO 50001 it is predictable for the benefit of the company in terms of cost savings from energy consumption, and also the important contribution to reducing CO₂ emissions. Based on the report of McKane et al. [22] who analyzes future energy needs concludes that based on a scenario with 50% projected energy consumption, especially in the global industrial and service sectors with the implementation of the ISO 50001 management system, in 2030 the cumulative primary energy needs will be saved around 105 EJ, saving costs nearly US\$700 billion (discounted to 2016 net present value). CO₂ emission reductions of around 6,500 million metric tons (Mt) will be achieved. The annual CO₂ emissions avoided by 2030 alone would be equivalent to removing 210 million passenger vehicles from the road [23-25].

To give more detail the illustration of the benefit of the implementation of ISO 50001, published about the profile of winner of reported the case study by annual program CEM Energy Management Leadership Awards. Clean Energy Ministerial (CEM) is a high-level international forum that carries out activities to promote policies and programs that encourage actions that promote clean energy. This program carried every year since 2016 and involving representatives around the world Data of the case study of the winner from 2016 to 2020 indicate that benefits related to energy saving, environmental improvement, and significant business performance achieved by various types of organizations that apply this management system concept More than 75 percent of award recipients in 2020 are in the industrial sector, 17 percent in the commercial sector, and the rest in the public sector (city, airport, and school). The majority of 2020 award recipients represent a single business activity, but 28 percent have utilized energy management systems in various businesses that have successfully multiplied their savings. Overall, 46 winner in 2020 winners (representing 368 business activities in 14 countries) reported energy cost savings of up to USD 37 million annually. As for the emission reductions reported up to 452,000 metric tons of carbon dioxide. This value is equivalent to removing 95,000 passenger vehicles from the road. As shown in Table 1, the benefits gained by the implementation of ISO 50001 for different sectors ad different locations in 5 contingent are described which interconnected with other measures. . The energy performance improvement as a result of the implementation of ISO 50001 depend on the Industry sector from service, education hospitality, transplantation to heavy manufacture, Interestingly, the multinational company which has a location in many country show also that energy reduction and CO₂ emission very significant high. In Table 2, show the profile of companies from Indonesia that participation in energy management leadership awards from 2016 to 2020 [26].

Table 1. Case study of Energy Performance Improvement after Implementation of ISO 50001 from the selected company from the winner of CEM Energy Management Leadership Awards.

No	Company 's Name	Industry Type (Country)	Cost Saving (US\$\$)	CO ₂ Reduction (Metric Tons)	Periode (year)	Pay back time or Cost)
1	Hilton	Hospitality Global Over 5,100 sites globally	\$783.7 million	769,356 metric tons	2008-2016	<1 year
2	Magnitogorsk Iron & Steel Works	Iron Steel and Fabricated Metals (Russia)	38.6 million	698,186	over 3 year	>1 month
3	3M	Manufacturing (30 sites in 7 Countries)	13,500,000	330,000	3 (2016-2018)	2,000,000
4	ABB Buenos Aires	Electrical Equipment (Argentina)	55,000	894	over 5 years	2.2 years
6	Google HQ and 12 more sites across 6 countries	Information Technology Global: USA, Belgium, Ireland, Finland, Singapore, Taiwan	>\$1 billion	3.8 million metric tons	over 3 years	<1 year
7	Abu Dhabi Municipality Buildings	Municipality Buildings (United Arab Emirates)	86,398	354,443	over 1 year	<10 months
8	Banco de Crédito e Inversiones -Edificio Corporativo	Financial Services (Chile)	\$7,640	25 metric tons	over 1 year	5.8 years
9	Beijing Capital International Airport Co., Ltd.	Public Transportation (China)	9.3 million	43,225	over 3 years	~10 months
10	China National Heavy Duty Truck Group Co., Ltd (16 sites)	Automotive (China)	59.1 million	99,600	over 4 years	1.2 years
11	Dubai Municipality -Al Tawar Center	Municipality (United Arab Emirates)	423,652	2,087.2	over 6 years	5 months
12	Dublin City University-5 campuses	Educational Services (Ireland)	> 10 million	50,000	over 11 years	<1 year
13	El Araby Company for Trading and Manufacturing	Electrical Equipment (Egypt)	\$1.7 million	7,901	over 3 years	1.1 years
14	General Motors Ómnibus BB Transportes S.A-7 sites in Ecuador	Automotive (Ecuador)	617,626	20,463	over 5 years	<8 months

15	LG Display -2 sites in Republic of Korea	Electrical Equipment Republic of Korea	\$11.77 million over 1 year	169,511 metric tons	over 1 year	<5 months
16	Makstil AD 2 sites in Republic of Macedonia	Iron Steel and Fabricated Metals (Republic of Macedonia)	\$200,000	2,424 metric tons	over 2 years	<4 months
17	Mastellone Hnos. S.A. 2 sites in Argentina	Food and Beverage((Argentina)	\$65,658	263 metric tons	over 1 year	<8 months
18	Misr Fertilizers Production Company (MOPCO)	Chemicals (Egypt)	\$5.4 million	125,844 metric tons	over 2 years	<4 months
19	Municipality of Sovizzo property management	Municipality (Italy)	\$96,251	146.5 metric tons	over 4 years	3.7 years
20	Nissan North America, Inc. -3 sites in United States	Automotive (United States)	\$9.42 million	132,199 metric tons	over 3 years	<1 month
21	Raymond Limited -Vapi Unit	Textiles India	\$671,142	4,137 metric tons	over 1 year	<6 months
22	Roads and Transport Authority Dubai (RTA)	Public Transportation United Arab Emirates	\$12.2 million	81,362 metric tons	over 4 years	~3 months

Representative of industry sector involving and location give profile about energy performance improvement, total energy cost saving, total energy saving, and CO₂ Reduction, moreover also reported about the cost spending for the implementation of ISO 50001, and time needed for the implementation. In terms of energy performance varied from 3.6 % to 37.5. in which the high value recorded for industry footwear manufacturing. It is also notified that the sector of power plan generation (Indramayu) has very high total energy saving and can reach 46,110,419 USD, energy saving for 17,174,515 GJ, and CO₂ Reduction emission reached 474,016.62 metric tons for five years operation, even the cost implementation also relative high 9,318,090 USD. Almost the same number in terms of CO₂ reduction 443,565 metric tons recorded petrochemical Industry in East Kalimantan), This was archived for 2.5 years of implementation with a spend of 91,830 USD. The energy-saving reached 3,921,855 USD and 866,262 GJ, and energy performance improvement is 3.76 % [26].

Based on the facts it is undeniable that ISO 50001 has been proven to be able to contribute to the Sustainable Development Goals (SDGs) by saving energy and reducing GHG emissions, however, according to several literature reviews, there are still many challenges to be faced. Some of the challenges that can be identified are a). insufficient resources (infrastructure, technology, finance, and time), b). insufficient data or difficult to determine energy and energy performance baseline, c). low qualification of human resources (competence, knowledge, and ability), d). low commitment and support from the management, e). inconsistency and unclear policies (organizational or governmental), f). trouble in quantitatively measuring the benefits resulting from the adoption of ISO 50001, g). technical and managerial barriers to achieving the full energy and carbon efficiency that ISO 50001 allows, h). difficulty in finding external consultants, i). problems in obtaining third-party international certification, j). poor documentation management, k). trouble in maintaining certification [27-29].

In the future, dissemination and promotion of the implementation of ISO 50001 will be very important to achieve maximum benefits. Building awareness among organizations and companies, the public, and decision-makers is an important driving factor [30-32]. Thus, the benefits offered from implementing this standard can be optimized. Benefits that can be taken include increasing the efficiency and effectiveness of managing energy assets and energy resources, adopting new technologies, speed in decision making, building employee awareness about energy and environmental issues, compliance with

applicable laws and regulations, providing and increasing linkages within the framework of energy efficiency throughout the supply chain [33-35]. Besides, to be much more efficient, it is very possible to integrate with other management systems such as environment, quality, and health and safety [36,37].

Table 2. Case study of Energy Performance Improvement after Implementation of ISO 50001 from the selected Indonesian company from the winner of CEM Energy Management Leadership Awards, 2016 to 2020).

No	Company's Name/ Location	Industry Type/ Products	Cost for EnMS (Periode of Implementaion)	Energy Performan- ce Improve- ment	Energy Cost Saving (Total Energy Saving)	CO ₂ Reduction	Report Relea- se Year
1	PT Petrokimia Gresik Plant 1 A	Fertilizer (Ammonia)	53.021 USD (1 year)	3.16%	3,261,914 USD (512,880 GJ)	46,583 met- ric tons	2020
2	PT Indofood CBP Sukses Makmur Tbk. Pasuruan, Sema-rang Bandung	Food and Beverage Division Noodle	50,850 USD 3 years (2017-2020)	10.7 % Aggregate	830,400 USD (154.707 GJ)	25,526 metric tons	2020
3	PLTU Indramayu Indramayu, WestJava	Power Generation (Electricity)	9,318,090 USD (5 year)	6%	46,110,419 USD (17,174,515 GJ)	474,016.62 metric tons	2020
4	PT Chandra Asri Petrochemical Tbk (CAP) Cilegon, Banten,	Petro- chemical (Olefin, Polypro- pylene, Polyethylene)	89,400 USD 2 Years	3.76% (aggregate)	6,360,000 USD (771,838 GJ)	55,697 Metric Ton	2019
5	PT Pupuk Kalimantan Timur (PUPUK KALTIM) -PKT-3 Plant	Petro-chemical Ammonia, Urea, and Utility	91,830 USD 2.5 years (PKT-3 1 year (PKT- 1A)	3.76% (aggregate)	3,921,855 (866,262 GJ)	443,565 metric tons	2019
6	PT. Cheil Jedang Indonesia- Pasuruan Plant	Chemicals Amino acid (Lysine)	3 years (2014-2017)	4.99%	10,752,751 USD (139,574.28 GJ)	61,052.99 metric ton	218
7	PT. Pembangkitan Jawa-Bali Paiton	Power Generation	8,170,000 USD 5 years	4,56 %	32,090,000 USD (13,110,000 GJ)	3,320,000 metric tons	2018
8	PT Great Giant Pineapple Lampung	Food Industry Canned Pineapple	137.314,61 USD 2 Years	5.77%	528,070.48 USD (221,535.41 GJ)	18,908.87 metric tons	2017
9	PT Schneider Indonesia EJIP Cikarang Selatan Bekasi	Electronic & Electrical MV & LV switch-gear	8,076 USD 2014 - 2016	10.5%	32,480 USD (512,880 GJ)	206.51 met- ric tons	2017

10	PT Indah Kiat Pulp Paper Tangerang	Paper Manufacturer Colored paper	2,3 00,00 USD	15.2%	1,600,00 USD/year	Not available	2016
11	PT. KMK GLOBAL SPORTS Cikupa	Manufacturing Footwear Mfg.	2,000,0000 USD 5 years	37.5%	1,000,000 USD/year (13,110,000 GJ)	Not available	2016
13	PT. Apac Inti Corpora	Yarn, Greige and Denim	339.782 USD	13.52%	318.752 USD/year	Not available	2016

5. Conclusion

Based on literature studies from several scientific journals and publications released by international organizations, associations, government policy, and several case studies from some role models, there are some significant effects on the improvement of energy performance and reduction of the impact on climate change by reduction of CO₂ emission by the implementation of energy management system ISO 50001. The positive correlation between improvement energy performance and total energy cost saving is also identified. The cost of implementation of this standard is varies depending on the business model, sector, and period of implementation. Besides that implementation of this standard also have a positive influence on the management of energy assets, evaluate and prioritize the use of energy-efficient technologies, and drive efficiency throughout the supply chain. However, some challenges that must be overcome are also identified as influenced by the commitment of management and awareness.

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