Critical Success Factors Evaluation of the ISO 50001 Energy Management System Implementation (Case study: PT. APAC INTI CORPOR A, Bawen, Semarang Indonesia)

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Abstract. Rapid growth makes the industrial sectors contribute as a significant greenhouse gasses producer. According to the Indonesian Ministry of Industry data, the industrial sectors dominate energy consumption with a share of 49.4% of total national energy consumption. These energy needs tend to increase along with economic growth and global population rise. Based on this problem, development of standards related to energy management system is needed for the industrial sector. PT. APAC INTI CORPOR A (AIC) is a textile company, located in Bawen, Semarang Indonesia. PT. AIC has implemented ISO 50001 since 2014 as an energy management system to improve the company’s service quality and financial benefit. In this study, Critical Success Factors from the application of ISO 5001 at PT. AIC will be evaluated to assist companies in implementing a more optimal energy management system. A critical success factor is an area in the form of indicators that identify the success of an organization's performance. Data processing resulted in 8 improvement strategy points based on importance weights (AHP Method) and performance values (Performance Rating) for each subfactor. Through the Delphi method, the improvement strategies is adjusted to the company's conditions and reduced to 6 strategy points.

1. Introduction
Rapid industrial growth is a good indicator of economic development. However, the use of energy makes the industrial sector a significant producer of greenhouse gases in Indonesia, the industrial sector dominates energy use with a portion reaching 49.4% of the total national energy consumption [1]. These energy needs will continue to increase along with economic growth and global population rise. This problem then underlies the development of standards related to energy management systems.

PT. APAC INTI CORPOR A (AIC) is a textile company, located in Bawen, Semarang, Central Java. PT. AIC produces 3 types of products: yarn, fabric (greige) and denim. PT. AIC is ISO 9001: 2008 Quality, ISO 14001: 2008 Environmental Management and ISO 50001: 2011 Energy Management Systems certified. PT. AIC has received ISO 50001 certification since 2014 from the TÜV SUD certification body. This certification is based on the Minister of Energy and Mineral Resources Regulation no. 14 of 2012 about energy management implementation for the industries with energy use greater than or equal to 6000 ToE.

Critical Success Factor (CSF) is known as a method used to measure performance in an organization to achieve company targets [2]. Critical Success Factors (CSF) consists of several criteria that are used as guidelines in determining critical factors. Critical factors can act as indicators to ensure that a
process/system implemented by the company has been running optimally. In this study, critical success factors from the implementation of ISO 50001 at PT. AIC will be evaluated so that the company can take appropriate steps in taking corrective actions.

This study aims to identify and measure the importance weight of critical success factors that influence the implementation of the ISO 50001 energy management system at PT. AIC by utilizing the AHP method questionnaire; assess the performance of each of the critical success factors and develop an improvement strategy for implementing the ISO 50001 energy management system at PT. AIC using the Delphi method.

2. Literature review
The International Organization for Standardization (ISO) in 2011 released ISO 50001, a standard for energy management systems. The standard aims to help organizations build systems and processes to improve performance, efficiency and energy consumption. The overall goal of ISO 50001 is to support organizations in their efforts to develop and implement a comprehensive energy management system and to continue to improve their energy performance. Based on compliance with legal requirements, identification, and analysis of all matters relating to energy considerations, making energy transparency, saving costs, and reducing greenhouse gas emissions. ISO 50001 helps organizations achieve goals that are related to energy systematically, comprehensively, oriented towards sustainable goals and objectives [3]. Several aspects of the company will be improved such as management, legal, sales, operational and finance. Company will gain environmental reputation, legalized, better energy usage and improved procurement procedure [4]. Implementing ISO 50001 can be a great investment for company, one of the cases, The Royal Mint Ltd., a British-owned coin and medal-producing business entity, managed to reduce costs by as much as 6% of the total energy costs to be incurred which summed by 72 Billion IDR in the first year of certification [5].

| ISO 50001 Principle | ISO 50001 Elements |
|---------------------|-------------------|
| General Requirements |                   |
| Management Responsibility | Top Management |
|                      | Management Representative |
| Energy Policy        | Energy Policy |
|                      | Legislation and Other Terms |
|                      | Energy Review |
| Energy Planning      | Energy Baseline |
|                      | Energy Performance Indicator |
|                      | Objectives, Targets and Energy Management Plans |
|                      | Competence, Training and Awareness |
| Implementation and Operation | Communication |
|                      | Documentation |
|                      | Operational Control |
|                      | Design |
|                      | Procurement of Energy Products and Services |
|                      | Monitoring, Measurement and Analysis |
| Checking             | Legislation and Other Terms Evaluation |
|                      | Energy Management System Internal Audit |
|                      | Nonconformities, Correction, Improvement dan Prevention |
|                      | Document Control |
| Management Review    | Management Review Input |
|                      | Management Review Output |
Figure 1. ISO 50001 Implementation critical success factors
Critical Success Factors were introduced by John F. Rockart and MIT Sloan School of Management in 1979 in order to assist senior executives in defining information needs in managing organizations. A critical success factor is an area that identifies the success of an organization's performance [6]. This CSF area describes managerial preferences by considering key financial and non-financial variables under certain conditions. Critical Success Factors can be used as performance indicators or enter in setting work indicators. Based on the levels of management, CSF is divided into: Industrial CSF, Organizational CSF, Divisional CSF, Operational Unit CSF and Individual CSF [7].

According to one of the energy conservation consultants from the the United Nations Industrial Development Organization in Indonesia, there are 4 factors and 18 sub-factors that have influence in implementing ISO 50001. These factors and sub-factors are then validated by the company to determine its relevance to the company's condition. Critical Success Factors and Sub-factors of implementing the ISO 50001 Energy Management System at PT. AIC can be seen in Figure 1:

Analytical Hierarchy Process (AHP) is a method developed by Thomas L. Saaty in 1990. This method is a framework for effective decision making of complex problems by simplifying and accelerating the decision making process by dividing the problem into its parts, then compiling these parts or variables into hierarchical arrangements, assess value to subjective considerations about the importance of each variable and determine which variable is the highest priority so that it affects the outcome of the problem [8]. Table 2 shown below explains about AHP Value Comparison Scale:

Importance-Performance Analysis (IPA) was first introduced by Martilla and James in 1977 to measure customer satisfaction with a product or service. The IPA approach pays attention to the function of 2 components, the interests of a product or service to consumers and the value of the performance of a business in providing the product or service [9]. The combination of interests and performance values from consumers can provide information on customer satisfaction clearly, directed and concentrated. Each quadrant explanation are shown above in Figure 2.

**Table 2. Comparison Scale**

| Value | Definition | Information |
|-------|------------|-------------|
| 1     | Equally importance | Both factors have the same importance |
| 3     | Weak importance of one over another | Experience and assessment are very favourable to one factor compared to another |
| 5     | Essential or strong importance | One factor is more important than the other |
| 7     | Demonstrated importance | One factor is clearly more important than another element |
| 9     | Extreme importance | One factor is absolutely important than the other elements |
| 2,4,6,8 | Intermediate values between the two adjacent judgments | Values between two values of adjacent considerations |

**Figure 2. IPA matrix**
Importance Matrix - Performance Analysis consists of 2 axes, namely the x-axis that defines performance and the y-axis that defines the interests of different elements. Each quadrant combines the interests and performance values provided by its users on a product/service. 4 quadrants in Importance-Performance Analysis defines [9]:

a) "Concentrate management here" explains high importance with low-performance values. Requires immediate treatment for improvement and is a major weakness.

b) "Keep up the good work" explains high importance with high-performance values. Indicates the opportunity to achieve or maintain competitive strength and is a great power.

c) "Low priority" explains low importance with low-performance values. It is a small weakness and does not require more effort.

"Possible overkill" explains low importance but with high-performance values. Indicates excessive attributes and can harm company resources.

The Delphi method was first used in the early 1960s by RAND, a research institute in America. The Delphi method is a method that forms a group of experts to discuss a problem, generally, experts from the problem areas discussed. The process in the Delphi Method consists of 2 versions. The first version is known as "Paper and Pencil" or Conventional Delphi, where a drafting team designs a questionnaire that will be submitted to experts as respondents. After the respondent gives an answer, the respondent is given the opportunity to evaluate their answers, then a conclusion can be obtained. Based on these conclusions, the drafting team will redesign the next phase of the questionnaire by combining several answers from the experts as respondents and then returning to the respondents [10].

3. Research Methodologies

Variables used in this study are based on the ISO 50001 Implementation Framework, these variables will be validated to the company to find out the relevance of the variable to the implementation of the ISO 5001 energy management system in the company.

There are 5 Stages of Data Collection in this study:

1. Validation Questionnaire to ensure the variables used are appropriate with company conditions, this questionnaire will be distributed to 3 respondents consisting of energy manager, internal audit manager and internal audit staff. The data obtained will then be calculated for a median value. If there is a sub-factor with ≤ 4 median value is considered inappropriate and will be discarded.

2. Pairwise Comparison (AHP) Questionnaire to achieve importance weight of each critical success factors and sub-factors from ISO 50001 implementation in the company. These questionnaire will be distributed to 7 respondents consisting of energy manager, internal audit manager, power distribution manager, 2 electric manager, boiler manager and compressor manager and equipped with a 1 – 9 scale. Then, questionnaire collected will be processed with Expert Choice as a supportive software to achieve the importance weight.

3. Performance Rating Questionnaire to assess performance value from each factors and sub-factors. These questionnaire will be distributed to 7 same respondents as the Pairwise Comparison Questionnaire but equipped with a 1–4 scale to state the performances. Questionnaire collected will be calculated with Microsoft Excel to achieve median values.

4. Data collected (Importance and Performance Rating) will become input to Importance-Performance Analysis Matrix. The Importance - Performance Analysis Matrix is divided into 4 quadrants which will explain each position of the quadrant.

Delphi Questionnaire to achieve relevant improvement strategies. Questionnaire will be distributed through 5 respondents consist of energy staff, audit staff, 2 electric staff and power distribution staff and equipped with Likert 1-5 scale. Any strategy with ≤ 4 median value is considered irrelevant and will be discarded.
4. Result and Discussion
Table 3 and Table 4 shown below shares the results of CSF Validation data processing. Market Demand Sub-factor (IEA 3) has a median value of ≤ 4 so that it will be removed from the ISO 50001 Implementation Assessment Framework.

| Table 3. Factors’ validation |
|-----------------------------|
| Factor                      | Value | Median |
|                             | R1    | R2    | R3    |
| Management Approach (MA)    | 4     | 5     | 4     | 4     |
| Internal and External Aspects (IEA) | 4     | 3     | 4     | 4     |
| Energy Planning (EP)        | 5     | 4     | 4     | 4     |
| Implementation and Operation (IO) | 5     | 5     | 4     | 5     |

| Table 4. Sub-factors validation |
|----------------------------------|
| Sub Factor                       | Value | Median |
|                                  | R1    | R2    | R3    |
| Management Commitment and Support (MA 1) | 5     | 5     | 4     | 5     |
| Objectives and Targets Determination (MA 2) | 5     | 3     | 4     | 4     |
| Energy Policies (MA 3)           | 5     | 4     | 4     | 4     |
| Management Review (MA 4)         | 4     | 5     | 4     | 4     |
| Legislation and Other Terms (IEA 1) | 5     | 4     | 5     | 5     |
| Financial Benefits from Energy Performance Improvement (IEA 2) | 5     | 5     | 5     | 5     |
| Market Demands (IEA 3)           | 3     | 2     | 3     | 3     |
| Environment Aspect (IEA 4)       | 4     | 4     | 4     | 4     |
| Energy Data Analysis (EP 1)      | 3     | 4     | 4     | 4     |
| EnPI (EP 2)                      | 3     | 5     | 5     | 5     |
| Significant Energy User (EP 3)   | 5     | 5     | 5     | 5     |
| Energy Savings Opportunities (EP 4) | 4     | 5     | 4     | 4     |
| Operation Control (IO 1)         | 5     | 4     | 4     | 4     |
| Documentation (IO 2)             | 5     | 5     | 4     | 5     |
| Checking (IO 3)                  | 3     | 5     | 4     | 4     |
| Procurement of Goods and Services that Consider Energy Efficiency (IO 4) | 5     | 5     | 5     | 5     |
| Energy Design (IO 5)             | 4     | 3     | 4     | 4     |
| Employee Competence (IO 6)       | 5     | 5     | 5     | 5     |

| Table 5. Factors’ weight |
|---------------------------|
| Factor                    | Global Weight |
| Implementation and Operation (IO) | 0.369 |
| Energy Planning (EP)      | 0.257         |
| Management Approach (MA)  | 0.229         |
| Internal and External Aspects (IEA) | 0.144 |


Table 6. Sub-factors’ weight

| Sub-factor                                                      | Global Weight |
|----------------------------------------------------------------|---------------|
| Significant Energy User (EP 3)                               | 0.077357      |
| Procurement of Goods and Services that Consider Energy Efficiency (IO 4) | 0.075276      |
| Employee Competence (IO 6)                                   | 0.070848      |
| Energy Savings Opportunities (EP 4)                           | 0.069904      |
| Energy Design (IO 5)                                          | 0.069741      |
| Management Commitment and Support (MA 1)                     | 0.069616      |
| Management Review (MA 4)                                     | 0.059769      |
| Energy Data Analysis (EP 1)                                   | 0.059367      |
| Checking (IO 3)                                               | 0.056088      |
| Energy Policies (MA 3)                                        | 0.054731      |
| Operation Control (IO 1)                                     | 0.052398      |
| Legislation and Other Terms (IEA 1)                          | 0.050832      |
| EnPI (EP 2)                                                   | 0.050372      |
| Financial Benefits from Energy Performance Improvement (IEA 2) | 0.049680      |
| Objectives and Targets Determination (MA 2)                   | 0.044884      |
| Documentation (IO 2)                                         | 0.044649      |
| Environment Aspect (IEA 4)                                   | 0.043344      |

Table 7. Performance rating

| Sub-Factor                                                      | Performance Rating |
|----------------------------------------------------------------|-------------------|
| Management Commitment and Support (MA 1)                       | 4                 |
| Environment Aspect (IEA 4)                                     | 4                 |
| Objectives and Targets Determination (MA 2)                    | 3                 |
| Energy Policies (MA 3)                                        | 3                 |
| Management Review (MA 4)                                      | 3                 |
| Legislation and Other Terms (IEA 1)                           | 3                 |
| Financial Benefits from Energy Performance Improvement (IEA 2) | 3                 |
| Energy Data Analysis (EP 1)                                   | 3                 |
| EnPI (EP 2)                                                    | 3                 |
| Energy Savings Opportunities (EP 4)                            | 3                 |
| Operation Control (IO 1)                                      | 3                 |
| Documentation (IO 2)                                          | 3                 |
| Checking (IO 3)                                                | 3                 |
| Energy Design (IO 5)                                          | 3                 |
| Employee Competence (IO 6)                                    | 3                 |
| Significant Energy User (EP 3)                                | 2                 |
| Procurement of Goods and Services that Consider Energy Efficiency (IO 4) | 2                 |

IPA Matrix shows the sectors that need to be improved based on the position of the sub-factor on the matrix quadrant. Based on Figure 3. Importance-Performance Analysis Matrix, it can be concluded that:

- Significant Energy User Sub-factors (EP 3); Procurement of Goods and Services that Consider Energy Efficiency (IO 4) is in quadrant A which indicates that these sub-factors have a high level of importance but with a low performance value so an immediate improvement strategy is needed. Besides that, the Energy Design sub-factor (IO 5); Employee Competence (IO 6); Energy Savings Opportunities (EP 4); Management Review (MA 4); Energy Data Analysis (EP 1) is at the boundary between quadrant A and B. So that these five sub-factors are needed prevention strategies in order to become preventive actions in the event of a decline in performance.
Management Commitment and Support (MA 1) sub-factor is in quadrant B which shows that the sub-factor has a high level of importance but the value of the company's performance towards the sub-factor is good so it needs to be maintained.

Environmental Aspect Sub-factors (IEA 3) are in the D quadrant which indicates that these sub-factors have low performance values with low interest rates so that the company does not need to be overlooked.

Energy Policy Sub-factor (MA 3); Operation Control (IO 1); EnPI (EP 2); Documentation (IO 2); Objective and Target Determination (MA 2); Legislation and other requirements (IEA 1); Financial gains from Energy Performance Improvement (IEA 2) are between the C and D quadrants which indicate that these sub-factors have a fairly good performance value but low importance so that they can be considered excessive and the company needs to concentrate more on other sub-factors that need improvement.

![Importance-performance analysis matrix](image)

**Figure 3. Importance-performance analysis matrix**

Table 8 shown below list the strategies suited for each sub factor. There are improvement strategies and preventive strategies.

**Table 8. Strategies for selected quadrant**

| Strategy     | Sub-factor                                              | Program                                                                 |
|--------------|----------------------------------------------------------|------------------------------------------------------------------------|
| Improvement  | Significant Energy User (EP 3)                          | Identify, review, evaluate and periodically document facilities, equipment, systems, processes and workers that have a significant effect on the company's energy consumption |
| Improvement  | Procurement of Goods and Services that Consider Energy Efficiency (IO 4) | Coordinate engineering, quality control and procurement in purchasing goods, services and designs that consider energy efficiency. |
| Improvement  | Energy Design (IO 5)                                    | Cooperate with ESCO (Energy Service Company) companies in the context of investing in the procurement of goods or services that are more energy efficient |
| Prevention   | Employee Competence (IO 6)                              | Review and design new facilities, equipment, systems and processes that are more energy efficient to support periodic energy performance improvements. |
| Prevention   | EnPI (EP 2)                                             | Improve employee competency through internal and external training related to energy management systems especially for employees of the company's energy conservation team. |
Energy Savings Opportunities (EP 4)
Identify energy saving opportunities through new energy sources or other energy alternatives and review energy saving opportunities through company audit results.

Management Review (MA 4)
Review energy policies, energy performance, EnPI regularly and evaluating the implementation of the energy management system with applicable regulations.

Energy Data Analysis (EP 1)
Periodically evaluate energy consumption, review and document its implementation.

Table 9 shown below list the strategies selected by using the Delphi Questionnaire, any strategy with median value ≤ 4 will be excluded from the recommendation.

| Strategy         | Program                                                                                                                                  | Median |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------|--------|
| Improvement      | Identify, review, evaluate and periodically document facilities, equipment, systems, processes and workers that have a significant effect on the company's energy consumption | 4      |
|                  | Coordinate engineering, quality control and procurement in purchasing goods, services and designs that consider energy efficiency.           | 4      |
|                  | Cooperate with ESCO (Energy Service Company) companies in the context of investing in the procurement of goods or services that are more energy efficient | 5      |
| Prevention       | Review and design new facilities, equipment, systems and processes that are more energy efficient to support periodic energy performance improvements. | 4      |
|                  | Improve employee competency through internal and external training related to energy management systems especially for employees of the company's energy conservation team. | 4      |
|                  | Identify energy saving opportunities through new energy sources or other energy alternatives and review energy saving opportunities through company audit results. | 3      |
|                  | Review energy policies, energy performance, EnPI regularly and evaluating the implementation of the energy management system with applicable regulations. | 4      |
|                  | Periodically evaluate energy consumption, review and document its implementation.                                                               | 3      |

5. Conclusions
Critical success factor that are the most important weight in implementing ISO 50001 at PT. AIC is Implementation and Operation factor with a global weight value of 0.369. While for the subfactor with the most important weight in implementing ISO 50001 at PT. AIC is a Significant Energy User subfactor with a global weight value of 0.077357.

On the other hand, sub critical factors the highest performance rating at PT. AIC is Management Commitment and Support and Environmental Aspects sub factors with a performance value of 4 on a scale of 1 - 4. As for the sub-critical success factors with the lowest performance value at PT. AIC is a sub factor of Significant Energy Users; and Inspection and Procurement of Goods and Services that Pay Attention to Energy Efficiency with a performance value of 2 on a scale of 1 - 4.

Based on the results of processing the Delphi questionnaire data, 6 of the 8 programs that the company should prioritize are: Identify, review, evaluate and periodically document facilities, equipment, systems, processes and workers that have a significant effect on the company's energy consumption; Coordinate engineering, quality control and procurement in purchasing goods, services
and designs that consider energy efficiency; Cooperate with ESCO (Energy Service Company) companies in the context of investing in the procurement of goods or services that are more energy efficient; Review and design new facilities, equipment, systems and processes that are more energy efficient to support periodic energy performance improvements; Improve employee competency through internal and external training related to energy management systems especially for employees of the company's energy conservation team; Review energy policies, energy performance, EnPI regularly and evaluating the implementation of the energy management system with applicable regulations.

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