Determining Key Factors for Continuous Improvement of Environmental Management System (EMS) at Geothermal Power Plant *(Case Study of PT. Pertamina Geothermal Energy Karaha Area)*

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Abstract. Environmental Management Systems (EMS) play a pivotal role in addressing environmental issues. While organizations strive for EMS certification, achieving excellence in continuous improvement remains a challenge due to the lack of defined procedures and guidelines. This paper aims to address this challenge through a case study conducted at PT Pertamina Geothermal Energy (PGE) Karaha Area, an energy supply company. By analyzing audit findings, we identified technical aspects as obstacles to continuous improvement. Consequently, we seek to identify key factors that significantly influence the continuous improvement process. To achieve this, we employ the Matrix of Cross Impact Multiplication Applied to a Classification (MICMAC) structural analysis method developed by Godet. Our study aims to (i) identify EMS determinants, (ii) analyze the relationships between determinants, and (iii) categorize key factors that drive continuous improvement. Key continuous improvement factors include communication, production process, training, emergency preparedness and response, and document control. Recommendations for improvement include the implementation of coaching and feedback, motivation, and consistency to improve the communication process; the implementation of LCA analysis to improve the production process; the implementation of e-learning to improve training and emergency preparedness; and the implementation of electronic document management system in the document control process.

Keywords: EMS, Continuous improvement, PLTP, Key factors, MICMAC

1 Introduction

Geothermal energy is an environmentally friendly renewable energy that is and can be used as an alternative to fossil energy (Mary, Armawi, Hadna, & Pitoyo, 2017). Indonesia is a country that has the largest geothermal energy potential in the world (Ministry of Energy and Mineral Resources, 2018) so the Indonesian government has a goal to develop geothermal energy use following the National Energy General Plan (RUEN). Despite its advantages, the use of

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geothermal energy can potentially cause environmental changes. Thus, appropriate control measures are needed on environmental issues that may occur from the geothermal energy utilization process, one of the control steps is implementing an ISO 14001: Environmental Management System (Hilman & Kristiningrum, 2008).

Environmental Management Systems (EMS) play a pivotal role in addressing environmental issues (Sinding, 2000). Environmental Management Systems can be applied to different types of organizations and sectors of government. An organization is successful in implementing EMS if it has fulfilled all the requirements in the ISO 14001 clause and is proven in a conformity certification or audit activity. One aspect that organizations find difficult to prove in certification activities is the continuous improvement aspect because it does not have specific definitions or clear guidelines to follow (Ejdys, Matuszak-Flejszman, Szymanski, Ustionovichius, Shevchenko, & Lulewicz-Sas, 2016). Continuous improvement actions should not be limited to programs to improve on previous findings, but also programs that can be applied to all parts of the organization in the long term.

In this article, a case study was conducted at PT Pertamina Geothermal Energy (PGE) Karaha Area, a company engaged in energy supply (Pertamina, 2020). PT PGE Area Karaha regularly performs internal audits once a year to ensure the conformity of EMS implementation to the ISO 14001 clauses. Based on an analysis of the audit findings at PT PGE Area Karaha, technical aspects are one of the aspects that have become obstacles in the process of continuous improvement. Thus, it is necessary to analyze the factors that have the most significant influence (key factors) on the continuous improvement process which can be used as a reference for the focus to support the technical aspects of the company so that it can improve its environmental performance. This study used structural analysis of the Matrix of Cross Impact Multiplication Applied to a Classification (MICMAC) to assist strategy design (Godet, 2006). The result of MICMAC structural analysis is a key factor identification that has a crucial influence on the continuous improvement process (Nazarko, Ejdys, Katarzyna Halicka, Kononiuk, & Olszewska, 2017). To solve the problem at hand, an analysis is carried out to (i) identify EMS determinants, (ii) analyze the relationships between determinants, and (iii) categorize key factors that drive continuous improvement.

Through this research, we aim to provide valuable insights into enhancing EMS performance, specifically targeting technical aspects, at PT PGE Area Karaha and similar organizations operating in environmentally sensitive sectors. The findings will inform strategies to better control environmental impact and foster sustainable practices in the geothermal energy industry.

2 Material and Methods

An Environmental Management System (EMS) is a branch of a management system that focuses on controlling environmental issues. An organization is said to have successfully implemented EMS if it can meet all the requirements of the ISO 14001 clause. ISO 14001 is an international standard to identify, manage, and control environmental issues. ISO 14001 refers to the Plan-Do-Check-Action (PDCA) cycle as a repeating cycle (SNI ISO 14001, 2016).
To determine the factors key in the continuous improvement process, the Matrix of Cross Impact Multiplication Applied to a Classification (MICMAC) structural analysis method created by M.

Godet is used as a strategy design tool (Godet, 2000). MICMAC analysis consists of three main steps as follows:

2.1 Identification of Determinants

The determinants factor is a factor that contributes to a system (Ejdys, Matuszak-Flejszman, Szymanski, Ustionovichius, Shevchenko, & Lulewicz-Sas, 2016). Identification of determinants is carried out through the study of literature.

2.2 Analysis of Relationships between Determinant Factors

Analysis of the relationship between determinants is carried out to determine the strength of the influence of a factor (driving force) on the system and the amount of dependence on other factors (dependent force) so that it can be identified the role of each factor in a system. There are three main steps in the analysis of the relationship between determinant factors including the weighting of determinant factors, the formation of a direct influence graph, and the identification of the driving force and dependence force of each factor as follows:

i Weighting of Determinant Factors

The weighting of determinants is carried out to determine the magnitude of influence and dependence of each factor. The weighting of determinant factors is done by answering questions (Nazarko, Ejdys, Katarzyna Halicka, Kononiuk, & Olszewska, 2017): (i) does the Ci factor (in column or vertical arrangement) have any influence on the Cn factor (in a row or horizontal)? (ii) when it has an effect, how much influence does the Ci factor have on the Cn factor (small, medium, or crucial)? The weighting of determining factors is carried out by parties who have competed in the field. The weighting of determinant factors is carried out through the direct influence matrix in the MICMAC software shown in **Figure 1.** An example of filling in the direct influence matrix is shown in **Figure 2.** The terms of the scale used in the weighting of the matrix are listed in Table 1.

Table 1 Weighting Scale

Scale	Information
0	The Ci factor does not affect the Cn factor
1	The Ci factor has little effect on the Cn factor
2	The Ci factor influences the Cn factor but is not crucial
3	The Ci factor has a crucial effect on the Cn factor
P	Ci factor has the potential to affect the Cn factor

Table 2. Arrow Legend

Arrow Color	Information
	The Ci factor has the most influence on the Cn factor
	The Ci factor has a large relative influence on the Cn factor
	Ci factor has an average influence on the Cn factor
	The Ci factor has little effect on the Cn factor
	The Ci factor has the least influence on the Cn factor

ii Direct Influence Chart Formation

Direct influence graph formation is used to visualize the relationship between determinants (Ejdys, Matuszak-Flejszman, Szymanski, Ustionovichius, Shevchenko, & Lulewicz-Sas, 2016). These graphs are composed of determinants that are interconnected with arrows consisting of five different colors. The direction of the arrow coming out of the Ci factor towards the Cn factor indicates that the Ci factor influences the Cn factor. Conversely, the direction of the incoming arrow towards the Cn factor indicates that the Cn factor is dependent on the Ci factor. The formation of direct influence charts is carried out using MICMAC software version 5.3.0. A direct influence chart example is shown in **Figure 1**. The color description arrow is shown in Table 2.

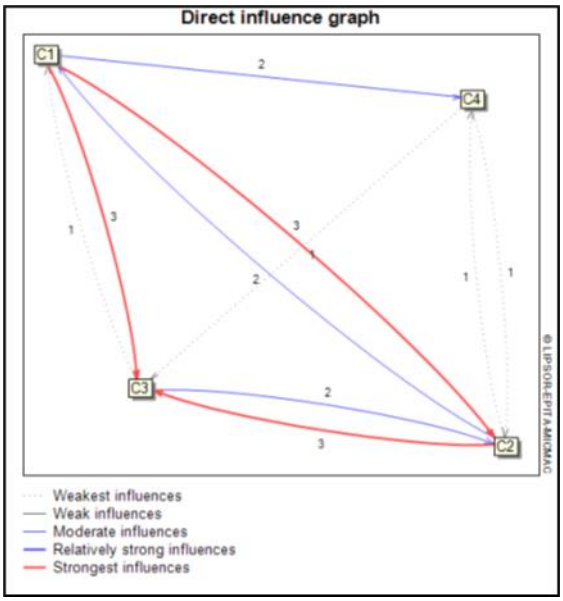

Fig 1. Direct-Influence Graphics

iii Identify the Driving Force and Dependence of each Factor

After the formation of the direct influence chart, further identification of the driving force and the dependence force of each factor was carried out to facilitate the reading of the direct influence graph (Ejdys, Matuszak-Flejszman, Szymanski, Ustionovichius, Shevchenko, & Lulewicz-Sas, 2016) using MICMAC software version 5.3.0. The driving force and dependence of each factor are shown in **Figure 2** and **Figure 3**.

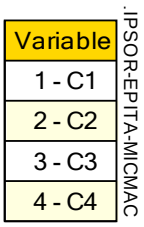

Fig 2. The Driving Force of Each Factor

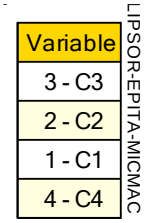

Fig 3. Dependency Forces of Each Factor

2.3 Factor Category Identification

Identification of factor categories was carried out to determine the role of each factor in the system (Ejdys, Matuszak-Flejszman, Szymanski, Ustionovichius, Shevchenko, & Lulewicz-Sas, 2016). Identification of factor categories is carried out through influence-dependence map formation using MICMAC software version 5.3.0 shown in **Figure 2.6** as follows:

i. **Influential Variables**
The moving factor is a factor that has a high influence value on the system and a low dependence value on the system. Thus, the moving factor is a factor that acts as a system controller (Ahmad, Tang, Qiu, & Ahmad, 2018).

ii. **Relay Variables**
A connecting factor is a factor that has a high value of influence and dependence on the system. This connecting factor is unstable. Any action given to the connecting factor would impact other factors and conditions to support or strengthen the initial pulse (Saxena, Sushil, & Vrats, 1990). According to Godet (2000), the key factor is a factor whose nature has an influence and dependence on the system, so it plays an essential role in the development of the system. Thus, the connecting factor is a key factor of the system that requires further attention.

iii. **Dependent Factors (Output Variables)**
A dependent factor is a factor that has a low moving value and a high dependency value. In general, dependent factors have a high dependency on other factors and the system (Saxena, Sushil, & Vrats, 1990).

iv. **Excluded Factors (Autonomous Variables)**
Excluded factors are those that have low driving and dependency values. Thus, this factor is relatively unrelated or out of the system (Saxena, Sushil, & Vrats, 1990).

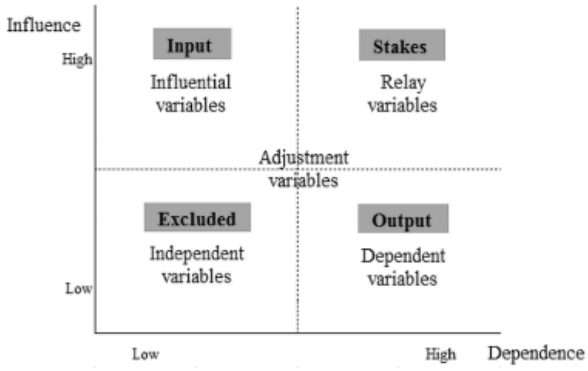

Fig 4. Factor Category Identification

3 Results and Discussions

Existing Conditions of EMS Implementation in PT PGE Area Karaha

PT Pertamina Geothermal Energy (PGE) Karaha Area is a company engaged in the provision of energy in the form of oil and gas, new and renewable energy, and other activities related to energy supply (Pertamina, 2020). PT PGE Karaha Area officially operated in 2018. Vision and mission of PT PGE Area Karaha is a world-class green energy company withal managing the company according to international standards that are environmentally sound. Thus, PT PGE Karaha Area implements an environmental management system to control the environmental impacts that have the potential to occur during the geothermal energy utilization process.

PT PGE Karaha Area adopts ISO 14001 standard in the form of a Geothermal Integrated Management System (GIMS) document. The GIMS document describes the procedures of PT PGE Area Karaha in fulfilling all the requirements of the ISO 14001 clause along with applicable regulations in Indonesia. In 2018, PT PGE Karaha Area started implementing EMS and successfully obtained an ISO certificate in 2019. ISO certification at PT PGE Karaha Area is conducted every three years and be carried out again in 2022.

In that span, PT PGE Area Karaha routinely conducts EMS internal audits as a part of continuous improvement actions. Audit activities aim to identify improvements or changes needed to improve environmental performance and to ensure the suitability and effectiveness of EMS performance. The results of audit activities at PT PGE Area Karaha are error-finding identification and error-cause identification during the implementation of EMS in all parts of the company and the preparation of programs to correct these findings. PT PGE Karaha Area routinely conducts audit activities once a year. Until now, PT PGE Karaha Area has conducted audits twice, namely in 2019 and 2020.

Based on the analysis of EMS implementation and audit findings, PT PGE Area Karaha has successfully adopted the requirements of the ISO 14001 clause in the form of GIMS documents

as evidenced by the acquisition of ISO certificates in 2019. However, based on the audit findings, some discrepancies were found between the operational activities carried out and the procedures set by the company. Thus, the technical aspects of implementing operational activities are obstacles to the continuous improvement process.

Identification of Determinants

Determinants are factors that can determine (Ejdys, Matuszak-Flejszman, Szymanski, Ustionovichius, Shevchenko, & Lulewicz-Sas, 2016) the success of EMS implementation. Determination of determinant factors is carried out through the study of literature. Based on the results of the literature study, the determinants of EMS success are divided into 16 factors referring to the ISO 14001 clause listed in Table 1 as follows:

Top Management Commitment and Support

Top management is the personnel tasked with controlling the organization at the highest level (ISO 14001, 2015). The involvement of top management is a sign of the organization's commitment to the environment (Jayashree, Malarvizhi, Mayel, & Rasti, 2015). The top management has a major role in ensuring the effectiveness of EMS implementation (Feng, Terziovski, & Samson, 2007), by setting strategies to achieve goals, providing freedom, and facilitating workers to improve the environment (ISO 14001, 2015). Worker participation can occur if top management is highly committed. Therefore, the non-involvement of top management commitments and support can be one of the main causes of quality failures as well as environmental efforts.

The top management of PT PGE Karaha Area demonstrates its commitment by:

a) Take full responsibility for accident prevention, occupational diseases, and environmental protection and are committed to customers.
b) Forming a company policy.
c) Ensuring the running of management system requirements during business processes.
d) Support the implementation of Enterprise Risk Management (ERM), a set of procedures, systems, and methodologies used to identify risks, risk mitigation, and response plans.
e) Ensuring the availability of resources by forming an organizational structure, ensuring the suitability of the number and competence of personnel, as well as ensuring the availability of a budget and infrastructure supporting the company's performance.
f) Support personnel to participate in the implementation of EMS.
g) Ensure and communicate the suitability of EMS implementation through hall meetings, Performance Dialogues, War Rooms, BOD meetings, and Quality Board Meetings and Management Reviews.
h) Promote the improvement of the K3 system and the environment.

Environmental Goals and Policy

Environmental policy is a device that regulates the mutual relationship between humans and the environment (Benson & Jordan, 2015). Environmental policy is a form of organizational commitment to protecting the environment and improving environmental quality (Hessami,

Golsefid-Alavi, Shekaf, & Mavi, 2012). Environmental policies contain clear directives and are in line with established strategies to achieve organizational goals (ISO 14001, 2015), so they can be one of the key factors in the success of EMS. Top management plays a role in planning strategies to reduce the environmental impact of activities (Verghese & Lewis, 2007) by establishing, implementing, and maintaining environmental policies (ISO 14001, 2015).

Company policy prepared by PT PGE Area Karaha reflects the company's commitment and determination to achieving the company's vision, mission, and values. PT PGE Karaha Area prioritizes quality, occupational health, safety, and environmental security and protection (K3LL) aspects in geothermal business processes. Thus, PT PGE Area Karaha sets out the company's general policies including:

a) Comply with and implement the provisions of laws and regulations and the principles of Good Corporate Governance while establishing good relationships with stakeholders.
b) Optimizing the quality and quantity of products produced by maintaining the reliability of operating facilities.
c) Implement risk management to prevent environmental pollution by identifying, evaluating, controlling, and monitoring potential hazards and threats.
d) Making K3LL a corporate culture.
e) Protecting the environment through natural resource conservation, energy efficiency, water efficiency, reducing the burden of water pollutants, reducing emissions, reducing, and utilizing Hazardous Waste and non-hazardous Waste, and protecting biodiversity.
f) Conveying information following the principles of transparency and accountability.

Management Review

The management review serves to ensure the suitability and effectiveness of EMS performance (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012), identify improvements that can be made or changes needed to improve environmental performance, as well as to ensure environmental policy conformity (ISO 14001, 2015). Management review is carried out by conducting supervision of related parties at certain intervals. The result of a management review is a continuous improvement (ISO 14001, 2015), so management review can be one of the key factors in EMS success.

PT PGE Area Karaha conducts management reviews in a planned manner to ensure the suitability, sustainability, and effectiveness of the organization's strategic direction. Management reviews are carried out through quality board meetings, performance dialogues, war rooms, and other meetings related to the management system. The results of the management review must be maintained and communicated to all interested parties. Some of the topics of discussion in management review activities include:

a) The status of the results of previous management reviews that have not been completed and communicated to all company personnel.
b) Changes in internal and external issues, including follow-up on internal and external issues according to company priorities.

c) The performance and effectiveness of EMS implementation obtained through customer and interested party feedback are measured through:
    a. Customer satisfaction surveys are conducted to find out the fulfillment of customer needs and expectations.
    b. Acquisition of PROPER targets.
    c. Reporting and dissemination of discrepancies.
    d. Reporting on compliance with legislation.
    e. The status of follow-up audit findings.
d) Identify opportunities for improvement.

Market Pressure

Market pressures can be expressed with consumer and supplier demand or expectations as well as the level of global competition (Firouzabadi & Laya Olfat, 2010). According to Lee in Hessami, Golsefid-Alavi, Shekaf, & Mavi (2012), market pressures can encourage organizations to further improve environmental performance. Thus, market pressure can be one of the key factors in EMS implementation.

To improve customer satisfaction, PT PGE Area Karaha conducts customer satisfaction surveys aimed at ensuring the conformity of customer expectations and interested parties to the quality of service and the benefits of the company's presence. Customer satisfaction surveys are conducted through the distribution of questionnaires to customers and interested parties every six months of the year. Some of the things that are the needs and expectations of interested parties include:

a) Compliance with applicable environmental regulations.
b) There is no environmental pollution felt by the community.
c) The environmental impact caused by production activities does not exceed predetermined limits.

Environmental Regulations

Environmental regulation is a device created by the government that can be used to prevent and avoid environmental damage and control environmental impacts (Mavi, Golsefid-Alavi, Shekaf, Hessami, & Soleimani-Nezhad, 2012), by controlling the level of pollution and utilization of hazardous materials (Percival, 1998). Environmental regulations arise alongside global environmental issues that require organizations to continuously improve environmental performance and meet environmental regulations (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012). Thus, environmental regulations can help companies in achieving EMS success.

Environmental regulations used as a reference by PT PGE Karaha Area consist of regulations and laws relating to the activities of companies that can potentially cause environmental impacts. Environmental regulations adopted by PT PGE Karaha Area consist of:

a) Law Number 32 of 2009 concerning Environmental Protection and Management which consists of: (i) Article 13 which explains that organizations must control pollution and environmental damage including prevention, countermeasures, and recovery activities; (ii) Article 20 which explains that the organization must not violate the quality standards specified in the regulations.

b) Law Number 5 of 1990 concerning Conservation of Natural Resources and Their Ecosystems Article 19 which explains that organizations are prohibited from carrying out activities that can result in environmental changes including reduction, elimination of functions and area of natural reserves, as well as adding non-native species of plants or animals.

Customer Requirements

Customer requirements are the needs or expectations of customers that must be met by the organization (ISO 14001, 2015). Currently, customer awareness regarding environmental protection is increasing, resulting in lifestyle changes, such as the shift to green products (Horani & Tong, 2018). To meet customer expectations and achieve customer satisfaction, organizations began to adopt EMS and improve environmental performance (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012). Thus, customer requirements can be one of the success factors of EMS.

To meet customer requirements, PT PGE Area Karaha is committed to focusing on customers by:

a) Ensure that customer requirements are by applicable regulations.
b) Ensure that all company personnel are fully responsible for carrying out their duties by applicable regulations.
c) Committed to fulfilling customer requirements as stated in the Steam Sale and Purchase Agreement (PJBU) and Electricity Sale and Purchase Agreement (PJBL).

Relationship between Workers

Worker involvement is one of the keys to the effectiveness of EMS (Ann, Zailani, & Wahid, 2006). Organizations that are committed to the environment can attract workers with good environmental consistency and competence (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012). This can improve relations between workers so that it can facilitate the implementation of EMS (Mavi, Golsefid-Alavi, Shekaf, Hessami, & Soleimani-Nezhad, 2012). One of the relationships between workers can be improved through effective communication.

Training and Awareness

Public awareness regarding environmental aspects has increased (Zhu, Geng, Fujita, & Hashimoto, 2010) so that workers must understand and be aware of the environmental impacts caused by all activities carried out (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012) to meet community expectations. Training is one of the aspects that is believed to be a key factor in the successful implementation of EMS (Jain & Pant, 2010). Training related to environmental concerns needs to be carried out to introduce organizational objectives, environmental policies, and specific skills so that workers can carry out their responsibilities properly to achieve EMS effectiveness (Chavan, 2005). Organizations should educate workers on environmental impacts to raise environmental awareness (Mavi, Golsefid-Alavi, Shekaf, Hessami, & Soleimani-Nezhad, 2012).

Implementation of worker training at PT PGE Karaha Area includes:

a) Training planning activities consisting of worker development proposals on people review and incidental training proposals. Workers will be asked to conduct a self-assessment and

have discussions with superiors about gap competencies carried out in people review activities.

b) Providing training program proposals by superiors that are needed to fill the competency gap.
c) The provision of training is carried out through:
    - Coaching when people review is carried out where each company personnel will get feedback regarding competencies that must be improved.
    - Implementation of special assignments carried out to introduce new competencies to the personnel of the company.
    - Mapping through competency tests and people reviews conducted to identify gap competencies owned by company personnel.
    - Implementation of domestic and foreign study tasks.
    - Conduct a self-assessment program.

Document Control

Document control is carried out to ensure the availability of the latest version of environmental documents and communicated to all members of the organization (Liyin, Hong, & Griffith, 2006). All objectives, targets, environmental policies, procedures, and responsibilities must be maintained in the form of documented information so that it can be used as evidence that can be seen by workers and the public (Chavan, 2005). Thus, the availability of documents can be one of the important factors in EMS implementation.

Documented information owned by PT PGE Area Karaha is in the form of data, records, or information made or received during the implementation of EMS which is prepared to support the effectiveness of EMS. During the process of creating and updating documented information, PT PGE Area Karaha always ensures the accuracy of identification and description of documents, and document formats, as well as review and approval of the suitability of documents. There are two types of documents owned by PT PGE Area Karaha, which an external document consisting of documents from outside the company as well as internal documents consisting of a work order system (STK), memos, letters, presentation materials, and the PGE portal. Hierarchically, PT PGE Karaha Area has five levels of documents including:

a) Level one is in the form of a company policy document that contains company policies regarding the company's strategic direction in achieving the vision and mission, including in fulfilling EMS requirements.
b) Level two is in the form of a Geothermal Integrated Management System (GIMS) document which contains a framework standard that refers to EMS requirements as a reference for companies in implementing EMS.
c) Level three is a work process document that contains sequential processes or SOPs as a reference needed at the work site.
d) Level four is in the form of supporting documents (support documents) used as controlling documents including SNI, UU, ISO, and others.
e) Level five is a form used to record data or reporting during EMS implementation.

Reaction and Preparedness for Emergencies

Emergency conditions have the potential to occur so organizations must establish and maintain procedures to recognize potential problems and respond to emergencies (Panchapakesan, Ganesh, & Rajendran, 2008). Organizations must also improve, establish, and maintain procedures to prevent environmental impacts that may occur in conjunction with emergencies that occur (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012).

PT PGE Karaha Area established a work order system (STK) to identify potential emergencies related to safety and the environment and how to respond, prevent, and minimize the impact. To implement preparedness actions against the state of emergencies, PT PGE Karaha Area compiles information documents related to emergency preparedness including:

a) Emergency preparedness and response guidelines that describe emergency response procedures.
b) Emergency response training that serves to provide competence to company personnel in dealing with emergencies.
c) Emergency response simulation results that serve as records during emergency response training.
d) Evaluation of emergency response stimulation that serves to provide feedback or improvements to the emergency response training carried out.
e) Evidence of emergency socialization to company personnel and interested parties.
f) Emergency phone number.

Communication

Communication is one of the effective tools to increase environmental awareness for workers (Mavi, Golsefid-Alavi, Shekaf, Hessami, & Soleimani-Nezhad, 2012). Communication can improve workers' understanding of environmental policies, goals, targets, and organizational plans. In addition, communication can be a link to introduce existing environmental problems as well as countermeasures that can be applied in the organization (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012). Thus, communication is believed to be one of the aspects that can be a key factor in the successful implementation of EMS.

Communication carried out by PT PGE Karaha Area covers both internal and external communications. Internal communication includes the delivery of the results of the EMS implementation achievements, the necessary corrective actions, errors found during the audit process, as well as applicable environmental regulations. External communication is carried out with relevant external parties such as contractors and stakeholders. The process of conveying information carried out by PT PGE Karaha Area is conducted through management meetings, telephone, correspondence, announcements, and available technology (*social media*).

Precautions against Nonconformities

Precautions relate to the organization's response to potential discrepancies. Organizations must establish, implement, and maintain procedures in the face of potential discrepancies (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012). Organizations should also evaluate what should be done to prevent discrepancies (ISO 14001, 2015). ISO 14001 certification can stimulate the

development of environmental damage prevention measures and improve the quality of products and services (Mavi, Golsefid-Alavi, Shekaf, Hessami, & Soleimani-Nezhad, 2012).

To carry out prevention against discrepancies, PT PGE Karaha Area actions include:

a) Identify discrepancies or potential discrepancies
b) Take action to correct any discrepancies and address the consequences.
c) Assess the need for action to ensure that discrepancies are not repeated by analyzing and determining the root cause of the discrepancies.
d) Implement a follow-up remediation program.
e) Evaluate the effectiveness of follow-up improvements.
f) Renew the risks and opportunities specified during planning.
g) Make changes to the management system if necessary.
h) Documenting and communicating the results of corrective and preventive actions.

Improved Production Process

Operational performance during the production process is one of the indicators of a company's ability to utilize resources effectively (Mavi, Golsefid-Alavi, Shekaf, Hessami, & Soleimani-Nezhad, 2012). The improvement of the production process is related to the effectiveness and efficiency of production means in producing products with the minimum possible emissions. Thus, the production process must be constantly improved so that industrial activities are more environmentally friendly.

Improving the production process in line with the vision and mission of PT PGE Area Karaha is managing the company according to international standards that are environmentally sound. Some of the things that PT PGE Karaha Area to improve the production process are as follows:

a) Utilizing new technological innovations according to the needs of the production process.
b) Carry out equipment maintenance that has an impact on suppressing the value of emissions produced contained in the work procedure stem document (STK).
c) Managing the work environment as a support for the production process which includes public facilities and housing.

Monitoring and Measurement Equipment

Organizations should have monitoring and measurement tools in place to monitor and measure all activities that can cause important impacts on the environment (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012). In addition, organizations must monitor and measure performance parameters to determine the occurrence of declines so that control can be carried out to achieve the expected results (Mavi, Golsefid-Alavi, Shekaf, Hessami, & Soleimani-Nezhad, 2012).

To carry out monitoring and measurement activities, PT PGE Karaha Area makes the following efforts:

a) Provide the necessary resources to obtain accurate measurement results so that they can be used to verify compliance with regulations.
b) Calibrate measurement tools within a specific period that refers to national or international measurement standards.
c) Ensuring the ability of measuring instruments to identify environmental quality.

d) Prepare documents related to monitoring and measurement activities

Environmental Specialist

Environmental specialists act as experts to assist in understanding and assessing technical problems from operating activities that have the potential to cause environmental impacts (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012). Environmental specialists should develop and establish actions that can be taken to improve environmental works so they can assist organizations in meeting environmental regulations (Chavan, 2005).

To achieve the company's goals, PT PGE Karaha Area provides human resources by:

a) Ensuring responsibility and authority for relevant roles through Human Capital (HC) functions.
b) Ensuring that responsible human resources in jobs that have the potential to result in important environmental impacts have competence through appropriate education, training, skills, and experience as evidenced by records.
c) Stores documented information related to human resources.

Cost

Cost sub-factors include initial set-up costs as well as repair and maintenance costs. Quality cost is one aspect that can determine organizational performance (Panchapakesan, Ganesh, & Rajendran, 2008). One of the advantages of implementing EMS is the increase in product prices along with a decrease in quality costs (Hessami, Golsefid-Alavi, Shekaf, & Mavi, 2012). To manage the company's finances, PT PGE Karaha Area establishes a financial function tasked with ensuring the availability of new technology procurement costs or maintenance.

Analysis of Relationships Between Determinant Factors

Analysis of the relationship between determinants is carried out to determine the strength of the influence of one factor (driving force) on the system and the amount of dependence on other factors (dependent force) so the role of each factor in one system can be identified.

Weighting of Determinant Factors

The weighting of determinants is carried out to determine the magnitude of influence and dependence between factors by answering questions (Nazarko, Ejdys, Katarzyna Halicka, Kononiuk, & Olszewska, 2017): (i) does factor A (in vertical arrangement) have an influence on factor B (in horizontal arrangement)? (ii) if it has an effect, how much influence does factor A have on factor B (small, medium, or crucial)? Weighting is carried out using a scale of 0-3 and Potential (P) values. Scale 0 indicates the absence of influence of factor A on factor B, scale 1 indicates a weak influence of factor A on factor B, scale 2 indicates the influence of factor A on factor B but is not essential, and scale 3 indicates the presence of a crucial influence of factor A on factor B. P value is given when there is a possibility that factor A can affect factor B even though it has never happened (Godet, 2000). The weighting is carried out by the top

management of HSSE PT PGE Karaha Area as the controller of EMS at the highest level. The weighting results are shown in **Figure 5.**

	1 : Komitmen	2 : Kebijakan	3 : Tinjauan	4 : Tekanan	5 : Peraturan	6 : Syarat	7 : Hubungan	8 : Pelatihan	9 : Dokumen	10 : Siapsiaga	11 : Komunikasi	12 : Pencegahan	13 : Produksi	14 : Monitoring	15 : Spesialis	16 : Biaya
1 : Komitmen	0	3	3	2	P	0	2	3	3	3	3	3	3	2	3	3
2 : Kebijakan	2	0	3	2	P	0	2	3	3	3	3	2	3	2	3	0
3 : Tinjauan	2	2	0	0	0	0	0	1	3	1	3	2	3	0	1	0
4 : Tekanan	0	0	2	0	0	P	2	0	2	1	1	0	0	1	1	0
5 : Peraturan	3	3	3	2	0	3	2	3	3	3	3	3	3	3	3	0
6 : Syarat	3	3	3	P	0	0	2	2	3	1	3	0	3	1	3	3
7 : Hubungan	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0
8 : Pelatihan	1	1	3	2	0	0	1	0	3	3	2	3	3	3	3	3
9 : Dokumen	2	2	2	2	2	2	0	2	0	2	2	2	2	2	2	2
10 : Siapsiaga	1	1	3	0	0	0	2	3	3	0	3	0	2	1	2	2
11 : Komunikasi	1	1	3	2	P	0	3	1	3	3	0	2	2	3	3	3
12 : Pencegahan	1	1	3	0	0	0	0	3	3	3	3	0	1	3	3	3
13 : Produksi	1	1	3	2	P	0	0	3	3	2	2	0	0	3	3	3
14 : Monitoring	0	0	2	0	0	0	0	3	3	0	2	2	3	0	3	3
15 : Spesialis	1	1	3	0	0	0	0	2	2	2	2	1	3	2	0	1
16 : Biaya	1	0	3	0	0	0	0	2	0	2	0	0	2	2	2	0

Fig 5. 1 Direct Influence Matrix (MICMAC Software Version 5.3.0)

Direct-Influence Chart Formation

After weighing each factor, a Direct Influence Graph is then formed to visualize the relationship between factors. The direction of the arrow heading out of one factor indicates that the factor influences another. The direction of the incoming arrow towards one factor indicates that the factor is influenced by another factor. The more directions of the arrows coming out toward other factors indicate that the factor has a high driving force. On the contrary, the more directions of the arrows that go into the factor, indicate that the factor is easily affected. The red color on the arrows indicates the most driving force. The thick purple color on the arrows indicates a relatively large driving force. The thin purple color on the arrows indicates the average driving force. The black color on the arrows indicates a relatively small driving force. The dotted black arrow line indicates the smallest driving force. The Direct Influence Graph is shown in **Figure 7** as follows:

a) Environmental regulatory factors are the factors that have the highest driving force against the system marked with red and purple arrows that predominantly point out the factor.

b) The relationship factor between workers is the factor that has the lowest driving force in the system characterized by a relatively small number of arrows pointing out of the factor.
c) The management review factor is the factor that has the highest force of dependence on the system which is marked by red and purple arrows whose dominant direction enters the factor.
d) Environmental regulatory factors are the factors that have the lowest dependence on a system characterized by a relatively small number of arrows with relatively few entry directions into the factor.

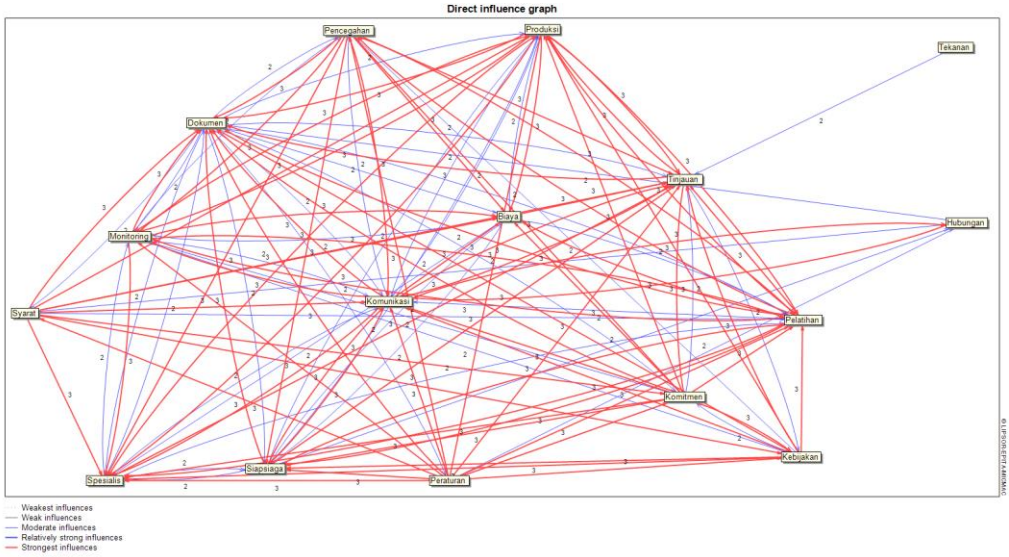

Fig 6. Direct Influence Graph (MICMAC Software Version 5. 3.0)

Identify the Driving Force-Dependence of each Factor

After a graph of the relationship between factors is formed, to facilitate the reading of the strength of the driving factor, the identification of the magnitude of the driving force and the strength of dependence of each factor is carried out. The magnitude of the driving force and the force of dependence are shown in **Figure 7** and **Figure 8** as follows:

a) Environmental regulation is the factor that has the highest driving force and the lowest dependency force in the system. This shows that environmental regulation is a factor that is independent (stand-alone) and acts as a regulator of the system.
b) Top management commitment is a factor that has a driving force on the second place and a dependency force on the 11th place. This shows that top management commitments can influence the system well and tend to be easily influenced by other factors in the system.
c) Environmental policy is a factor that has a driving force in the third 3rd place and the force of dependence in the 12th place. This suggests that environmental policies can influence the system well and tend to be easily influenced by other factors in the system.
d) Worker training is a factor that has a driving force on the 4th place and a force of dependence on the 6th place. This suggests that worker training can affect the system well and potentially be influenced by other factors in the system.

e) Customer requirements are factors that have a driving force in the 5th place and a force of dependence in the 15th place. This shows that customer requirements can affect the system well and are not easily influenced by other factors, so they tend to be independent (stand-alone).
f) Communication is a factor that has a driving force on the 6th place and a dependency force on the 3rd place. This suggests that communication has the potential to be able to influence other factors and is not easily influenced by other factors in the system.
g) Documented information is a factor that has a driving force in 7th place and a force of dependence in the 2nd place. This suggests that documented information has the potential to affect other factors and is easily influenced by other factors in the system.
h) Prevention against nonconformity is a factor that has a driving force in the 8th place and the force of dependence in the 10th place. This suggests that prevention of nonconformities has the potential to affect other factors and be influenced by other factors in the system so it tends to be unstable.
i) The improvement of the production process is a factor that has a driving force in the 9th place and a dependence force in the 5th place. This suggests that improved production processes have the potential to be able to affect other factors and be easily influenced by other factors in the system.
j) Preparedness action against emergencies is a factor that has a driving force in 10th place and a dependence force in 7th place. This suggests that standby measures have the potential to affect other factors and be influenced by other factors in the system so that they are unstable.
k) Environmental monitoring and monitoring activities are factors that have a driving force in the 11th place and a dependence force in the 8th place. This suggests that monitoring activities tend unable to affect other factors and are potentially influenced by other factors in the system.
l) An environmental specialist is a factor that has a driving force in 12th place and the force of dependence in 4th place. This suggests that environmental specialists tend to be unable to influence other factors and are easily influenced by other factors.
m) Management review is the factor that has the driving force in the 13th place and dependence force in the 1st place. This suggests that management reviews tend to be unable to influence other factors and are easily influenced by other factors.
n) Cost is the factor that has the driving force in the 14th place and the force of dependence in the 9th place. This suggests that costs are less likely to affect other factors and could potentially be influenced by other factors in the system.
o) Market pressure is a factor that has a driving force in the 15th place and a dependence force in the 14th place. This shows that market pressures tend to be unable to influence and are influenced by other factors in the system, so they tend to exit the system.
p) The relationship between workers is a factor that has a driving force in the 16th place and the dependence force in the 13th place. This shows that the relationship between workers tends not to be able to influence and is influenced by other factors in the system so its nature tends to go out of the system.

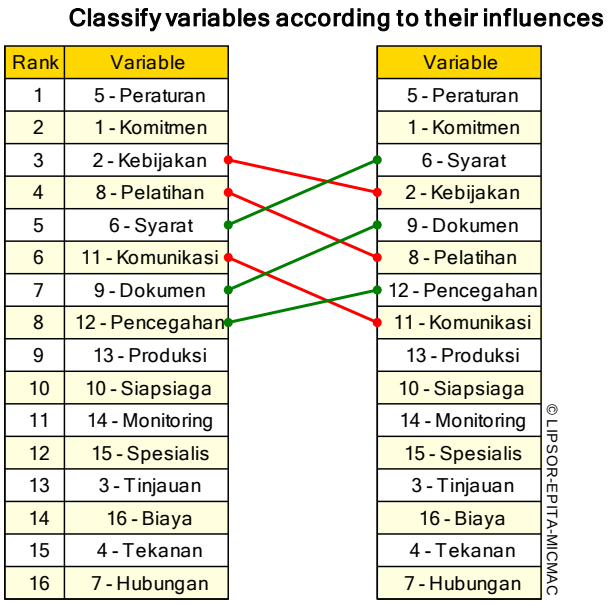

Fig 7. Classification of Driving Force of each Factor

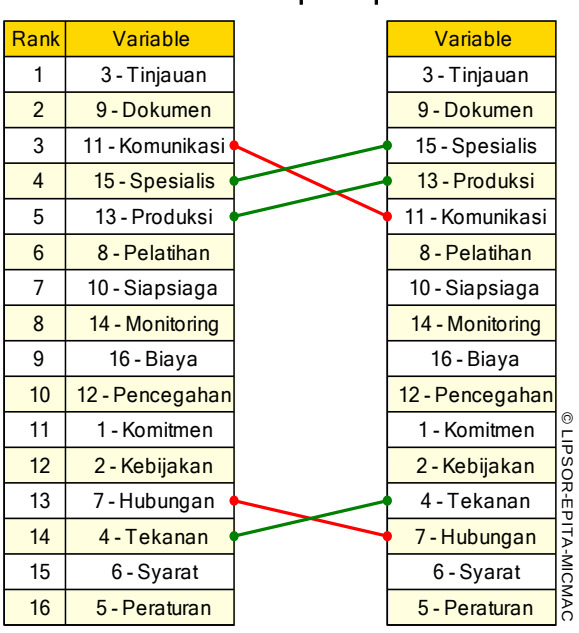

Fig 8. Classification of Dependency Force of each Factor

Factor Category Identification

Factor category identification is performed to determine the role of each factor in the system. The results of the identification of factor categories are shown in **Figure 8.** as follows:

a) Driving Factors

The driving factor is a factor that has a high driving force (influence) on the system and a low dependence (dependence) on the system. The driving factor can affect other factors but is not easily influenced by other factors, so the driving factor acts as the controller (governance) of the entire system. The driving factor can be a factor that becomes the standard reference and the purpose of the organization. Thus, the fulfillment of the requirements on the driving factor becomes a determinant of the sustainability of EMS. The driving factor is in the second quadrant. From the results of the determinant factor analysis, the driving factors are environmental regulations, top management commitments, preventive measures against non-conformities, and customer requirements.

b) Connecting Factors

A connecting factor is a factor that has a high value of influence and dependence on the system. The connecting factor is unstable. Any action given to the connecting factor will have an impact on other factors and have an impact on its condition to support or strengthen the initial pulse (Saxena, Sushil, & Vrats, 1990). In other words, improvements to the effectiveness of connecting factors can contribute to meeting the criteria of driving factors to create sustainability. The connecting factor is in quadrant one. From the results of the analysis of determinant factors, the connecting factors are worker training, communication, improvement of production processes, documented information, as well as preparedness actions against emergencies.

c) Dependent Factors

Dependent factors are factors that have a low value of influence on the system and a high dependence on the system. Dependent factors are outputs that result from efforts to improve key factors because of their high dependence on other factors in the system and act as supporters or facilitators who can support other factors in the system. From the results of the determinant factor analysis, the dependent factors are the review of top management, costs, monitoring and measurement equipment, and environmental specialists.

d) Autonomous Factor

The excluded factor is the factor that has the least driving force and dependence on the system. This actor has no significant role in the system (out of the system). Included in the excluded factor are market pressures and relations between workers.

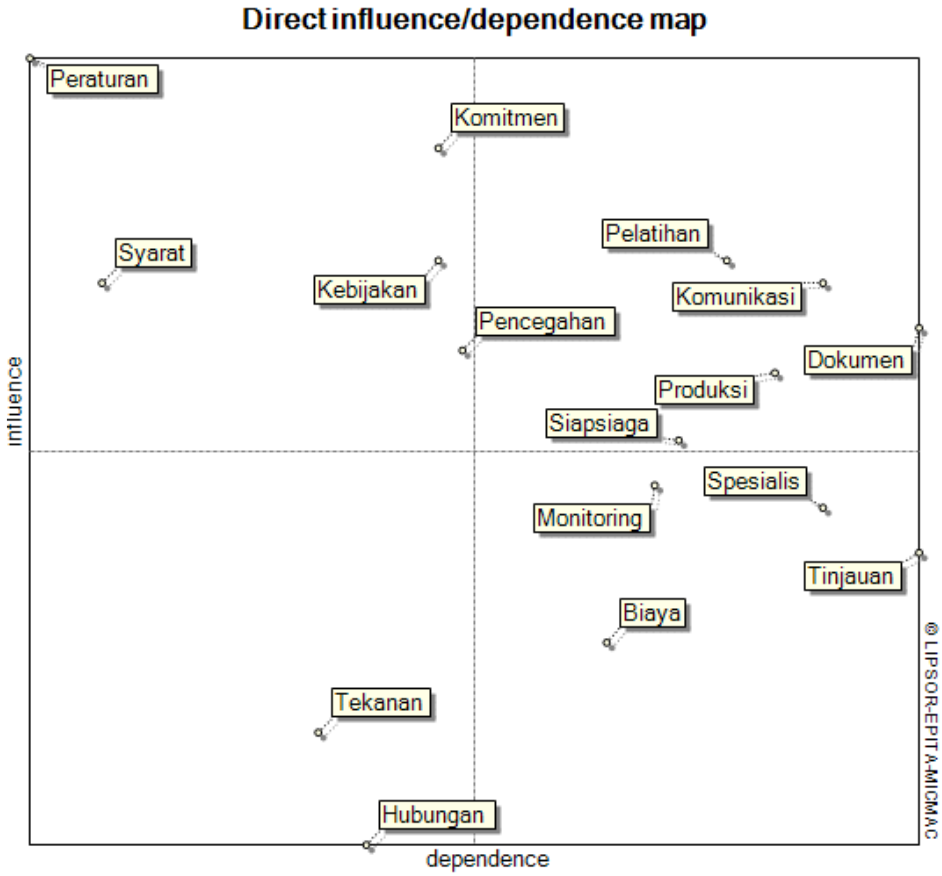

Fig 9. Direct Influence/Dependence Map (MICMAC Software Version 5.3.0)

Key Factors and Recommendations for Improvement

Godet (2000) defines key factors as those capable of influencing (influential) and being dependent (dependent) on the system. Such factors, possessing both properties, fall into the category of connecting factors. Connecting factors are inherently unstable, as intervening actions can trigger repercussions across the system, either reinforcing or weakening the initial impulse (Saxena, Sushil, & Vrats, 1990). Key factors within the continuous improvement of Environmental Management Systems (EMS) encompass communication, worker training, production process enhancement, emergency preparedness, and documented information management.

Communication

Effective communication is pivotal, ensuring that company personnel understand:
a) Company policies, fostering comprehension of obligations and organizational goals.

b) Company targets, progress, and achievements, aiding self-assessment for compliance with environmental regulations.
c) Continuous improvement procedures, enabling corrective actions for error prevention.

Constraints in communication effectiveness can lead to operational errors. PT PGE Karaha Area employs various communication channels, including meetings, telecommunication, written correspondence, announcements, and modern technology like social media. Effective communication, according to Shannon (2018), hinges on coaching and feedback, motivation, and consistency.

Worker Training and Preparedness Actions

Effective worker training achieves several goals:
a) Ensuring personnel understand roles and responsibilities for regulatory compliance.
b) Raising environmental awareness for compliance with regulations and policies.
c) Enhancing competence to minimize discrepancies and foster sustainability.

Simulated emergency response and effective readiness actions contribute to:
a) Fulfilling Enterprise Risk Management (ERM) and top management's commitment to safety.
b) Error prevention during operations.

Ineffective training delivery may lead to operational errors. To maintain worker engagement, concise training is preferred, as found in a survey by Jevana (2017). PT PGE Area Karaha employs various training methods, including coaching, competency tests, and assessments. Implementing internet-based training (E-Learning) could enhance accessibility and knowledge-sharing.

Improved Production Process

Efficient production process improvement aligns with objectives such as:
a) Environmentally sound operations.
b) Efficiency and reliability of facilities for product quality and quantity optimization.
c) Compliance with environmentally friendly technology and stakeholder expectations.

PT PGE Karaha Area improves production through technology adoption and operational balance. Travessini (2013) suggests a Life Cycle Assessment (LCA) analysis to minimize emissions during production. LCA involves four stages: defining objectives and scope, inventory analysis, impact assessment, and interpretation (ISO 14040, 200).

Document Control

Effective document control involves storage, tracking, and information dissemination to:

a) Enhance personnel understanding of environmental policies and EMS requirements.
b) Clarify EMS implementation processes and job roles for regulatory compliance.

Challenges in document control hinder information flow. Implementing an electronic document management system (EDMS) can address these issues (Chaikosvska & Stolyarchuk, 2018). EDMS offers document creation, storage, version control, workflow management, and various document delivery formats.

4 Conclusions

This study identified 16 determinants that significantly impact the process of continuous improvement within Environmental Management Systems (EMS). These determinants encompass a wide range of factors, including top management commitment, environmental policy, management review, environmental regulations, market pressures, customer requirements, production process improvement, preventive measures, document control, inter-worker relations, communications, worker training, preparedness measures, monitoring and measurement equipment, environmental specialists, and costs. Among these determinants, environmental regulation emerged as the most influential, exerting the highest driving force. Conversely, the relationship between workers exhibited the lowest driving force. Documented information displayed the highest dependency force, while management review had the lowest dependency force. These determinants were further categorized into four distinct groups: driving factors, connecting factors, supporting factors, and excluded factors. The driving factors included environmental regulations, top management commitments, environmental policies, preventive measures, and customer requirements. Connecting factors encompassed communication, production process improvement, worker training, document control, and emergency preparedness measures. Supporting factors comprised management reviews, costs, environmental specialists, and monitoring and measurement tools, while excluded factors pertained to relationships between workers and market pressures.

From factor analysis of categories, we identified the key factors crucial for enhancing continuous improvement within EMS. These key factors include communication, production process improvement, worker training, document control, and emergency preparedness measures. While this study primarily draws from ISO 14001 for determining determinant factors, there remains an opportunity for further research. Future investigations can extend beyond the confines of ISO 14001 clauses to encompass additional determinants, potentially yielding more comprehensive and refined recommendations for improvement within EMS practices. Such endeavors hold the promise of enhancing environmental performance and sustainability in organizations beyond the scope of this study.

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