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The Level of Influence of the Relationship Between Six Non-Formal Factors and Six IAM Subject Groups in the Implementation of Asset Management in PT PLN Group

El nivel de influencia de la relación entre seis factores no formales y seis grupos de sujetos de IAM en la implementación de la gestión de activos en el grupo PT PLN

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ABSTRACT

Introduction: many companies, including PT PLN Group, use asset management to help manage their assets to achieve stable, effective, and efficient company performance. In the concept model introduced by IAM, companies are introduced to six subject groups that are important factors in asset management (AM) implementation.

Method: this study used the PLS-SEM test to measure the level of influence and relationship of six non-formal factors and six groups of IAM subjects with the implementation of AM.

Results: the results obtained were that six non-formal factors significantly impacted the six groups of IAM subjects. Six non-formal factors and six IAM subject groups were proven to influence the implementation of AM significantly and positively. The acceptance of this hypothesis is supported by several field practices that PT PLN Group has carried out to support the success of AM.

Conclusions: the analysis results show that the transfer of knowledge and competence of human resources in 6 non-formal factors significantly influence the implementation of AM in PT PLN Group. Organizational culture and life cycle delivery factors of the Company in six IAM subject groups have the most dominant influence on the success of AM in PT PLN Group. The optimal implementation of AM at PT PLN Group can increase the nation's competitiveness by providing comprehensive and equitable electrical energy to the people of Indonesia.

Keywords: Non-Formal Factors; IAM Subject Groups; Asset Management Implementation.

RESUMEN

Introducción: muchas empresas, incluido PT PLN Group, utilizan la gestión de activos para ayudar a administrar sus activos y lograr un rendimiento empresarial estable, eficaz y eficiente. En el modelo conceptual introducido por IAM, se presentan a las empresas seis grupos de sujetos que son factores importantes en la implementación de la gestión de activos (AM).

Método: este estudio utilizó la prueba PLS-SEM para medir el nivel de influencia y la relación de seis factores no formales y seis grupos de sujetos de IAM con la implementación de AM.

Resultados: los resultados obtenidos fueron que seis factores no formales impactaron significativamente en los seis grupos de sujetos de IAM. Se demostró que seis factores no formales y seis grupos de sujetos de IAM

influyen en la implementación de AM de manera significativa y positiva. La aceptación de esta hipótesis está respaldada por varias prácticas de campo que PT PLN Group ha llevado a cabo para respaldar el éxito de AM. **Conclusiones:** los resultados del análisis muestran que la transferencia de conocimientos y competencias de los recursos humanos en 6 factores no formales influyen significativamente en la implementación de AM en PT PLN Group. La cultura organizacional y los factores de entrega del ciclo de vida de la empresa en seis grupos de temas de IAM tienen la influencia más dominante en el éxito de AM en PT PLN Group.

Palabras clave: Factores No Formales; Grupos de Sujetos de IAM; Implementación de Gestión de Activos.

INTRODUCTION

The reliability of a company in managing its assets can influence the achievement of company performance and its ability to capture new opportunities in the future.[1,2] The uncertain and complex economic environment encourages companies to act quickly and change existing business strategies.[3] Asset management (AM) is an effort by companies to manage their assets effectively and efficiently in the long term.[4] At a more strategic implementation level, AM is used as an organizational competitive strategy and is one of the drivers of business movements and digital transformation Asset Performance Management for Power Grids.[5,6]

Not a few of the companies have succeeded in implementing AM or have not succeeded in doing it. Jooste (2015) suggests that organizational leadership commitment and communication play an important role in implementing AM.[7] In addition, competent human resources, internal controls, and the Regional Asset Management Information System are other important factors in the effectiveness of implementation.[8]

The Institute of Asset Management (IAM) creates a conceptual model of AM that can be re-customized by companies that want to use AM according to the conditions of their respective business processes. IAM (2015) determined that six groups of subjects (formal factors) in the AM landscape play an important role in the success of the implementation process, namely Strategy planning, decision making, life cycle delivery, asset information, organization people, and risk review.[9] PT PLN Group is one of the companies that adopted the IAM framework model, which includes a generation plan, risk and control management, life-cycle-delivery-asset, information management system, and people and work culture.

ISO 55000 is one of the standards used in asset management that is generally accepted. However, according to ISO 55000, not all asset management activities can be formalized through an asset management system. Aspects such as leadership, culture, motivation, and behavior, which can significantly influence the achievement of asset management goals, can be managed by the organization using settings outside the asset management system. Some of these things will be further explored according to the specifications of the generation business at PT PLN Group.

In a preliminary study conducted by the researcher, interviews related to the implementation process at PT PLN Group were conducted with AM Actors. Researchers chose them because of their contributions, which consistently run AM, starting from the executive level at initiation to a higher position level when AM is mature. The interview results found several keywords that can be used to classify non-formal factors that affect the effectiveness of implementing asset management for generation. The keywords are obtained from the frequent appearance of these words during the interview process. These keywords include policy, human resource competence, commitment, knowledge transfer, technology, and finance. These keywords are then used to determine the factors that the researcher determines. They influence the effectiveness of implementing AM generation in units and generation subsidiaries owned by PT PLN Group. The researcher has obtained data on non-formal factors that also affect the success of the AM implementation process and has proven the emergence of AM implementation gaps within PT PLN Group.

Several previous studies have shown that the implementation of AM is used as an organizational competitive strategy and is one of the drivers of business movements and digital transformation.[6,10] Implementing AM requires the synergy of the existing formal approach with the external factor approach. Previous research on ISO 55001 sets out requirements in an organization's AM policy development process consisting of five categories: consistency, accuracy, commitment, framework, and communication. However, the relationship between non-formal factors and IAM subject groups in implementing AM has not been studied empirically. This phenomenon encourages researchers to conduct more in-depth research on differences in performance achievements even though companies have implemented AM. Based on the above background, the researcher writes the following problem formulation:

1. What is the influence of the six factors of IAM subject groups on the successful implementation of asset management in PT PLN Group?
2. How do six non-formal factors affect the successful implementation of asset management in PT PLN Group?
3. What is the relationship between the six non-formal factors and the six IAM subject groups in asset

management?

This research is urgent in supporting the operational sustainability of PT PLN Group through the implementation of asset management. This research can provide important findings to bridge the gap in formal aspects and non-formal factors in implementing AM, especially in PT PLN Group. In addition, the development of a management model is not only beneficial for PT PLN Group but also for similar industries at the national and global levels. This research can be the basis for improving the adaptability of companies in facing operational challenges and changes in the business environment.

Literature Review
AM Implementation

Companies use AM to obtain several benefits, such as reducing operational costs, improving operational performance levels, minimizing environmental effects, and reducing legal risks in asset management.[11,12] AM can also help organizations have assets that suit their business needs and provide support services as companions to operate effectively.[4] To get these benefits, decision-makers must understand that asset management focuses not on the asset itself but on managing such assets so that the assets can optimally provide value to the organization as expected by stakeholders.[4] The focus of the primary goal of asset management is sometimes not facilitated because the required implementation aspects are not met.

In 2014, ISO 55000 was published as one of the international standards in the field of AM, in addition to PAS 55, which can help practitioners achieve perfect implementation. In clause 3.2.1, ISO 55001 defines an asset as an object, suitable, or entity with potential or actual value for an organization. This definition is the same as the British Standard BSI standard publication. EN 16646:2014 (2014) states that assets are anything that has potential or actual value for an organization.[13] The value will vary between different organizations and their stakeholders and can be tangible or intangible, financial or non-financial. Greco et al. (2013) also define assets into several categories where assets are defined as 'something of value' if they can explore existing opportunities and/or neutralize emerging threats, 'rare' if the Company's current and potential competitors are tough to own the asset, 'unreplicable' if the assets owned by the organization cannot be perfectly replicated with other resources, and 'irreplaceable' when other resources cannot replace assets but are not scarce and cannot be perfectly imitated.[14]

Non-Formal Factors

Non-formal factors found through the interview process include policy, human resource competence, commitment, transfer of knowledge, technology, and finance. Policy formulation in the implementation of AM contains an integrated and multidisciplinary approach that can provide clear direction for the implementation of AM.[15] The policies referred to in this discussion are the priorities that influence the outcome most and can help practitioners feel the results are quick wins. Policy priorities focus on lifecycle delivery, organizational support, and KPI management as a reward process and consequences for those in management and implementation. The process of reward and consequences itself has an important role in achieving organizational goals.[16,17] In addition, commitment is a form of determination by an organization's top management to carry out the policies that have been agreed upon.[18] A strong commitment will ensure that the organization allocates all resources and regularly conducts training.[19] The commitment given by the Company will ensure that the existing procedures follow the standards to maintain the integrity and credibility of the Company.[20]

Finance is a tool that determines the Company's capacity to plan, allocate, and manage resources from existing assets. Research conducted by Feng (2023) explains that an adequate financial budget opens up opportunities for organizations to carry out technological updates and develop more competent human resources.[21] The technological factors referred to here are information technology, manufacturer technology, and Operating and maintenance (OM) technology.[22] The plant has an approach with updated OM technology in the subsidiary organization that focuses on OM. This is supported by the investment policy in procuring such equipment, which tends to be not cheap, such as predictive maintenance equipment (vibration analysis, tribology, thermography, and current analysis), owned almost the same way in all units. Research from Kepka (2024) explains that information technology provides asset data results integrated with the asset life cycle, predictive analysis, and data collection recommendations.[23]

Transferring knowledge involves sharing information, skills, and best practices between individuals or organizational units to instill AM values consistently. Research Compagnucci (2024) shows that effective transfer of knowledge involves not only the delivery of explicit information but also the cultivation of tacit knowledge, such as experience and intuition related to asset management.[24] Research conducted by Villani (2024) confirms that the success of knowledge transfer is highly dependent on a strong work culture and a continuous training system.[25] Organizations that encourage collaboration and open communication can better maintain AM values at all levels of the organization.[26] The human resource competency factor includes the technical expertise, knowledge, and managerial abilities required to manage assets effectively. Research by Pea-Assounga (2024)

confirms that placing employees according to their qualifications is a fundamental step to ensure the efficient implementation of AM.[27] Appropriate employee placement helps reduce operational errors and increase productivity.[28] In addition, work culture and mindset that supports innovation and collaboration also play a significant role in asset management. Highlights the importance of building a work culture oriented towards improving asset quality and mutual understanding of AM values.[29] Based on the presentation of the findings on non-formal factors outside the IAM subject group in the implementation of AM, a research hypothesis was formed and described as follows:

H1: Non-formal factors to the six IAM Subject Groups

H2: Non-formal factors towards AM Implementation

IAM Subject Group Factors

In line with the global AM landscape model that shows the breadth of activities within the scope of AM, various studies on AM implementation show variations in their respective levels of depth. At a more strategic implementation level, AM is used as an organizational competitive strategy and is one of the drivers of business movements and digital transformation.[5,6] Therefore, an organization must understand how strategic AM is, including its influence in shaping business processes and organizational structures.[30] The strategic implementation of AM is felt at the company and at a more significant level (e.g., government). Giglio (2018) state that the role of AM can be used to assist in public policy-making in managing the interests of a country.[31] A similar statement has been included in several other studies that decision-makers use the policies and guidelines contained in the AM concept in a state to help them determine the future policy direction of the state.[32,33] Ultimately, the role of this use of AM will lead to the creation of several strategies and regulations and a specific regulation-oriented model.[35] IAM (2015) determined that six groups of subjects in the AM landscape play an important role in the success of the implementation process, namely Strategy planning, decision making, life cycle delivery, asset information, organization people, and risk review.[36] International Standard In addition, there are similarities in the IAM model landscape used by PT PLN Group among people and work culture, generation plan, plant performance, information management system, life cycle delivery-asset, risk and control management. Based on the previous research that explained the IAM subject group, the hypothesis in this study is as follows:

H3: Non-formal factors Outside the IAM Group were significantly correlated with the Six IAM Subject Groups

H4: Six IAM subject groups were significantly correlated with AM Implementation

Based on the development of the hypothesis, the theoretical framework in the study is as follows:
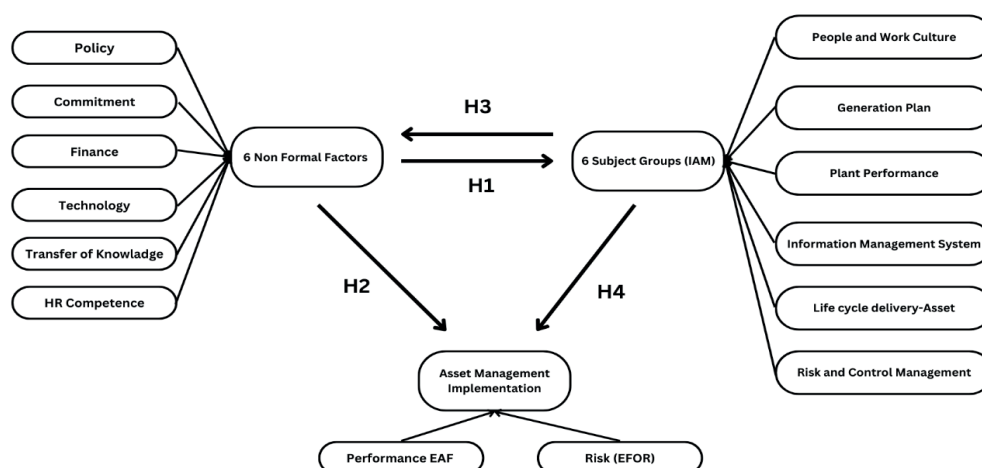

Figure 1. Research outline

METHOD

The researcher uses quantitative data analysis methods to help analyze the phenomena that occur in the concept framework of the implementation of generation AM in the PLN Group. The sampling was taken from PT PLN Group's subsidiaries, namely PT PJB, PT Indonesia Power, and PT PJBS as the Company's grandson. The data was collected using direct and indirect interview techniques with 31 respondents. For secondary data, the researcher uses data from various sources, including data obtained from reports belonging to PT PLN Group in the form of data on the results of the Maturity Level Management Asset Assessment, annual reports on PT PLN Group's performance 2019 – 2022, the proportion of KPIs related to generation and the organizational structure of generation managers at PT PLN Group. The data collection in this study was obtained from interviews on

external factor variables outside the IAM subject group and data from the assessment results of six groups of IAM subjects in the implementation of AM, where the data was in the form of a scale of 1 to 6.

The researcher emphasizes using quantitative and SEM analysis techniques as data processing tools. This technique is then applied using SmartPLS software as a means of SEM data processing. The purpose of this analysis technique is to help researchers analyze the pattern of relationships between variables and their indicators, variables with each other, and to be able to directly find measurement errors in obtaining a comprehensive model picture. SEM can also help researchers analyze unobservable variables that are measured indirectly with indicators.[37] The researcher used the SEM test tool to measure the level of influence and relationship of external factor variables outside the IAM subject group and 6 IAM subject groups with the implementation of AM. On the other hand, researchers use SEM based on the limited number of samples, but the model to be built is relatively complex.

RESULTS

The researcher collected data using an interview technique on 31 respondents with the qualifications required in this study. The respondents felt that they had a breadth and depth of understanding of the situation and conditions of the AM implementation process from 2011 to 2015 until the data collection process of this research was underway (2023). It is known that at the beginning of the implementation process, these 31 respondents stated that they had the following positions: Manager (16 people), General Manager (3 people) and Staff (5 people). During the research period, the position structure was more diverse, including new positions such as President Director (5 people) and Vice President Director (9 people). This change in position reflects organizational dynamics, restructuring, and increasing the complexity of roles in supporting the process of implementing asset management in PT PLN Group.

Structural Equation Modeling (SEM)

In the analysis of the formation of the implementation framework, the researcher tried to combine the flow of thought or the relationship between the variables in the Plant Governance Modification Model and the non-formal factors of AM that were outside the 39 primary subjects in AM found from the results of interviews at the beginning of the study.

In the group of subjects containing people and work culture, generation plan, risk and control management, life cycle delivery, information management system, performance management, and accumulation of resources, the researcher aims to analyze how dominant the influence of each subject is on the results of EAF and its EFOR. The analysis process carried out using SEM will later produce numbers showing each subject's priority. Factors that are felt to influence the AM implementation process will also be known at the priority level based on how many respondents provide information or statements on the influence of each of these factors in the implementation of AM.

The results of the SEM analysis that was carried out on the construction of the plant governance model with the maturity level data are then displayed by the researcher in the two tables below. From the figures listed in the two tables (tables 1 and 2), it is known that the researcher has succeeded in obtaining original sample data that informs about the dominant influence between latent variables. On the other hand, when the researcher's purpose is to find out the final performance results of EAF and FOR, the display can be seen in table 3. The final performance result after obtaining the amount of the dominance value of the latent variable is then grouped by the researcher into three groups, namely large, medium, and low.

Table 1. Results of model construct analysis and maturity level data using SEM analysis			
Variables	**Original Sample (O)**	**T Statistics (O/ST Dev)**	**p Values**
Generation Plan -) Technology	0,34	0,99	0,00
Information Management System -) Policy	0,99	0,70	0,00
Finance -) Plan Performance	0,12	0,70	0,00
Life Cycle Delivery -) Policy	1,04	0,29	0,00
Risk & Control Management -) Policy	0,98	0,96	0,00
EFOR -) Generation Plan	0,02	0,95	0,00
HR Competence -) EFOR	0,92	0,70	0,00
HR Competence -) Generation Plan	0,82	0,95	0,00
Plan Performance -) Policy	0,02	0,19	0,00
Technology -) EAF	0,02	0,70	0,00
Transfer of Knowledge -) Life Cycle Delivery	1,03	0,70	0,00
Transfer of Knowledge -) EAF	1,02	0,95	0,00

Transfer of Knowledge -) Risk & Control Management	0,72	0,70	0,00
EAF -) Policy	0,07	0,11	0,00
HR Competence -) Information Management System	0,57	0,11	0,00
HR Competence -) People and Work Culture	1,22	0,11	0,00
EAF -) Transfer of Knowledge	0,05	0,12	0,00
Information Management System -) Technology	0,05	0,12	0,00
Policy -) EAF	0,99	0,29	0,00
Technology -) Generation Plan	0,28	0,12	0,00
Transfer of Knowledge -) Plan Performance	0,55	0,12	0,00
EFOR -) Technology	0,53	0,16	0,00
Commitment -) People and Work Culture	1,16	0,16	0,00
EAF -) HR Competence	0,22	4,55	0,00
Information Management System -) EAF	0,22	4,55	0,00
Information Management System -) Finance	0,22	4,55	0,00
Finance -) EAF	0,22	4,55	0,00
Commitment -) EFOR	0,82	4,55	0,00
HR Competence -) Life Cycle Delivery	1,12	4,55	0,00
HR Competence -) Risk & Control Management	0,22	4,55	0,00
Life Cycle Delivery -) Finance	0,22	4,55	0,00
Risk & Control Management -) Finance	0,22	4,55	0,00
Transfer of Knowledge -) EFOR	0,98	4,55	0,00
Policy -) Life Cycle Delivery	1,03	0,19	0,00
Policy -) Risk & Control Management	0,83	0,29	0,00
People and Work Culture -) Technology	0,03	3,35	0,00
Technology -) EFOR	0,03	0,96	0,00

Table 2. Results of model construct analysis and maturity level data using SEM analysis,			
Variables	Original Sample (O)	T Statistics (O/ ST Dev)	p Values
Generation Plan -) Policy	0,14	0,20	0,00
Finance -) Life Cycle Delivery	0,74	0,20	0,00
Finance -) Risk & Control Management	0,14	0,20	0,00
People and Work Culture -) EAF	0,14	0,20	0,00
Transfer of Knowledge -) People and Work Culture	1,36	5,54	0,00
EAF -) Generation Plan	0,03	0,55	0,00
Information Management System -) Transfer of Knowledge	0,99	0,55	0,00
Commitment -) Plan Performance	0,03	0,55	0,00
People and Work Culture -) Commitment	1,03	0,99	0,00
Technology -) Information Management System	0,13	0,55	0,00
Technology -) People and Work Culture	0,43	0,55	0,00
EAF -) Information Management System	0,00	0,67	0,00
EAF -) People and Work Culture	0,00	0,67	0,00
EFOR -) Transfer of Knowledge	1,00	0,67	0,00
Finance -) Information Management System	0,21	0,67	0,00
Finance -) People and Work Culture	0,11	0,67	0,00
Commitment -) Generation Plan	0,20	0,67	0,00
HR Competence -) EAF	0,90	0,67	0,00
People and Work Culture -) HR Competence	0,84	0,67	0,00
Plan Performance -) Technology	0,00	0,67	0,00
EAF -) Commitment	0,72	0,69	0,00
Finance -) EFOR	0,02	0,69	0,00
Technology -) Life Cycle Delivery	0,32	0,69	0,00
Technology -) Risk & Control Management	0,52	0,69	0,00
Transfer of Knowledge -) Information Management System	0,82	0,69	0,00
EFOR -) Information Management System	0,47	3,35	0,00
Policy -) People and Work Culture	1,15	3,35	0,00
EAF -) Technology	0,70	0,99	0,00

EAF -) Finance	0,53	3,77	0,00
EFOR -) Commitment	0,53	3,77	0,00
EFOR -) HR Competence	0,99	0,99	0,00
Life Cycle Delivery -) HR Competence	0,99	3,77	0,00
Life Cycle Delivery -) Transfer of Knowledge	1,99	0,99	0,00
Risk & Control Management -) HR Competence	0,53	3,77	0,00
Risk & Control Management -) Transfer of Knowledge	0,89	0,99	0,00
EFOR -) People and Work Culture	0,14	0,29	0,00
Generation Plan -) Finance	0,14	0,29	0,00
Information Management System -) HR Competence	0,94	0,29	0,00
Policy -) Information Management System	0,84	0,29	0,00
Policy -) Plan Performance	0,94	0,29	0,00
EFOR -) Policy	1,07	0,28	0,00
Generation Plan -) Transfer of Knowledge	0,97	0,28	0,00
Commitment -) Information Management System	0,87	0,28	0,00
Life Cycle Delivery -) EAF	0,07	0,28	0,00
Life Cycle Delivery -) Commitment	1,00	0,28	0,00
People and Work Culture -) Finance	0,07	0,28	0,00
Plan Performance -) Transfer of Knowledge	0,97	0,28	0,00
Risk & Control Management -) Commitment	0,07	0,28	0,00
People and Work Culture -) Transfer of Knowledge	0,85	5,54	0,00
Generation Plan -) Commitment	0,93	4,28	0,00
Plan Performance -) Commitment	0,93	4,28	0,00
EFOR -) Life Cycle Delivery	0,95	0,98	0,00
Transfer of Knowledge -) Generation Plan	0,95	0,98	0,00
Policy -) EFOR	1,15	0,11	0,00
Commitment -) Life Cycle Delivery	1,15	0,11	0,00
Commitment -) Risk & Control Management	0,15	0,11	0,00
People and Work Culture -) Policy	0,96	0,55	0,00
Information Management System -) Commitment	0,98	0,98	0,00
Technology -) Plan Performance	0,98	0,98	0,00
Generation Plan -) HR Competence	0,99	0,93	0,00
Plan Performance -) HR Competence	0,99	0,93	0,00
Policy -) Generation Plan	0,99	0,98	0,00
Commitment -) EAF	0,99	0,98	0,00
Plan Performance -) Finance	0,99	0,98	0,00
EFOR -) Finance	0,69	0,95	0,00
Generation Plan -) EAF	0,99	0,95	0,00
Life Cycle Delivery -) Technology	0,79	0,95	0,00
Risk & Control Management -) Technology	0,99	0,95	0,00
EAF -) Life Cycle Delivery	0,70	0,69	0,00
Finance -) Generation Plan	0,80	0,69	0,00
HR Competence -) Plan Performance	0,78	0,69	0,00

Table 3. The value of latent variables that affect the results of SEM analysis to determine the performance of EAF and EFOR.

People and Work Culture	Generation Plan	Risk and Control Management	Life Cycle Delivery	Information Management System	Plant Performance
0,989	0,933	0,979	0,987	0,967	0,958
Policy	Commitment	HR Competencies	Finance	Technology	Transfer of Knowledge
0,934	0,967	0,989	0,856	0,912	0,996

Referring to the table above, it is known that each subject group has variables that are very influential in the AM implementation process. In the non-formal subject group, the transfer of knowledge and human resource competency variables have a very significant influence. On the other hand, in the formal subject group, the people and work culture and life cycle delivery variables are two factors that have a significant influence. the percentage

amount that appears means how much influence the variable has on the final results of the EAF and EFOR.

An explanation of how much influence these variables can be seen from the relationship between the variables of human work culture and life cycle delivery. Changes in human/organizational work culture in AM management supported by procedural processes in life cycle delivery are the main determinants to improve the effectiveness of AM implementation, the results of which will be visible in a relatively short time. Simply put, creating best practices in life cycle delivery can be effective by changing the implementation from unplanned to planned.

The information management system and risk management and control variables have quite an influence on the EAF and EFOR results. Information management system variables have an impact on cultural change in decision making and the use of single data of truth. Risk management and control are sustainability factors that will ensure cultural change in the management of the delivery life cycle. This change will later help the organization to survive from generation to generation and be well embedded in the AM management process at PT PLN Group. Thus, it can be said that the information management system and risk management and control variables also have a supporting role in the implementation of life cycle delivery variables and cultural change.

Performance management and generation plan variables have a low influence. The meaning of this low level indicates that the level of maturity of its implementation still needs to be improved in order to have a positive impact on the EAF and EFOR of the generator. Generation planning is part of the RKAP (Company Work Plan and Budget) process, namely AM activity planning, especially life cycle delivery variables including financial planning. Variables that have a low influence need to be evaluated and redesigned in an effort to optimize asset management.

After knowing which variables are in a group with a certain degree of dominance and why, the researcher combines the information with information that includes non-formal factors into a table. This information combination aims to determine the priority scale of the relationship between the six non-formal factors and the subject groups based on calculating the original sample result. The results of the preparation of the priority scale can be seen in table 4.

Table 4. Results of constant calculation from non-formal factors and subject groups in the implementation of AM in PT PLN group						
Non-Formal Factors **Groups in the IAM**	**People and Work Culture**	**Generation Plan**	**Risk and Control Management**	**Life Cycle Delivery**	**Information Management System**	**Plant Performance**
Policy	1,15	0,99	0,83	1,03	0,84	0,94
Commitment	1,16	0,20	0,15	1,15	0,87	0,03
HR Competencies	1,22	0,82	0,22	1,12	0,57	0,78
Finance	0,11	0,25	0,14	0,74	0,21	0,12
Technology	0,43	0,28	0,52	0,32	0,13	0,98
Transfer of Knowledge	1,36	0,95	0,72	1,03	0,82	0,55

When displayed as a curve, the priority scale grouping using AM subject groups and non-formal factors will look like figure 2.
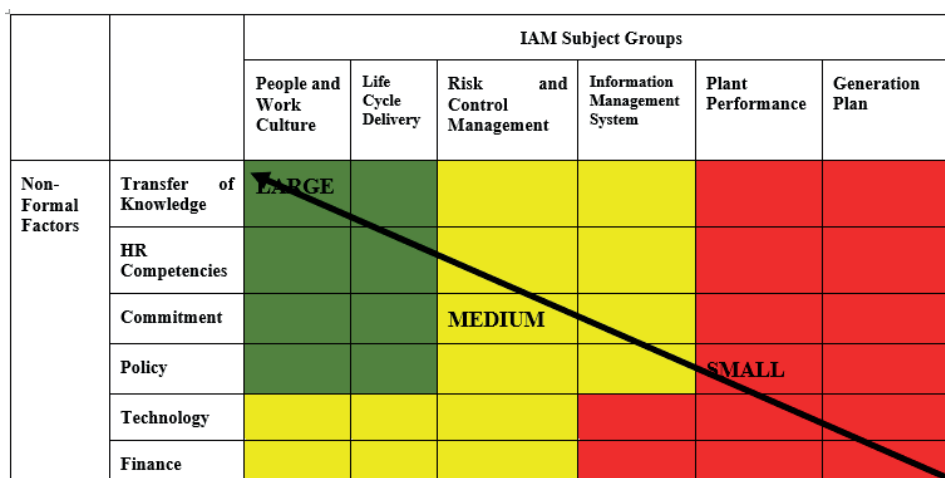

Figure 2. Clustering curve of priority scale of influential factors in the implementation of each AM subject group

To improve performance (EAF and EFOR) in a limited period, implementers should focus on programs or

action plans that significantly influence performance results. Meanwhile, in obtaining sustainability capabilities, programs or action plans must be carried out thoroughly throughout the program. To know and understand what steps should be taken, the analysis results using a series of analyses, such as in figure 3, can help the researcher make a priority order and group variables that influence the results of the expected performance assets, namely EAF and EFOR.
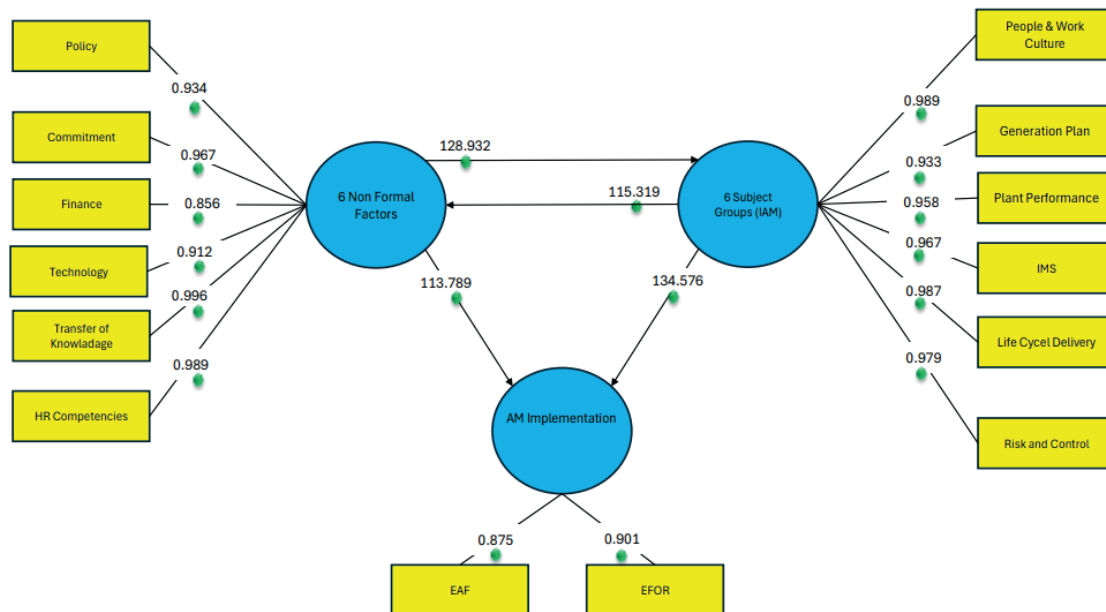

Figure 3. Path analysis

DISCUSSION

H1: Non-Formal Factors Outside the IAM Subject Group significantly had a relationship with the Six IAM Subject Groups

The findings of this study illustrate that non-subject factors in IAM significantly impact six groups of IAM subjects. The non-formal factors include policy, commitment, finance, technology, transfer of knowledge, and human resources competence. The research findings support the hypothesis proposed: Non-formal factors are important apart from technical factors, namely the IAM subject group. This significant relationship reflects that the success of asset management is not only determined by technical aspects but also greatly influenced by organizational and human factors involving various subject groups, such as managers, executives, and operational staff.

The acceptance of this hypothesis is supported by several implementations or field practices that PT PLN Group has carried out. First, six non-formal factors of PT PLN Group are prioritized when implementing a fast and adaptive strategy. The strategy implementation at PT PLN Group is carried out to ensure that the results achieved continue to motivate elected officials. The Board of Directors of PLN and its subsidiaries experienced an average turnover of 3 years, while the significant results of the implementation of AM averaged 5 years. Therefore, prioritization in implementation is important in producing faster achievements and motivating leaders to make programs. In PJB units, results can often be achieved faster than in other units, providing examples of success that can be a benchmark for development across PLN units.

Second, the transfer of knowledge from six non-formal factors emerged as the factor with the most significant influence. The implementation results at PLN show that knowledge transfer is the key to success. This transformation mainly focuses on improving the skills and knowledge of all parties involved so that employees have a uniform understanding. This makes the implementation process easier and more effective. In addition, a change in mindset is an important aspect, especially for leaders at PLN. This change in mindset is closely related to a commitment to learn and develop better approaches, such as Root Cause Failure Analysis (RCFA) and Reliability Centered Failure-Based Maintenance (RCFB). This process requires continuous improvement in implementation and training strategies.

On the strategic side, this implementation includes the preparation of a framework in a learning plan or governance that can be applied to all units. The Strategy aims to create a structured and acceptable approach at all levels of the organization. Good operations and maintenance aspects, especially predictive maintenance, are integral to the asset management strategy developed. Careful planning and extensive knowledge transfer allow all parties to understand their duties. When knowledge is evenly distributed across units, implementation

challenges can be better addressed.

Six non-formal factors, consisting of policy, commitment, finance, technology, transfer of knowledge, and human resource competence, have a wedge with six IAM subject groups. Policies reflect Strategy planning and risk review through a long-term vision and risk evaluation. Commitment supports decision-making and organization of people through team engagement and strategic decision-making. Finance reflects the life cycle delivery and risk review with efficient funding. Technology supports asset information and Strategy planning through data modernization. The transfer of knowledge and competencies of HR strengthens the organization's people and risk review, ensuring integrated and sustainable asset management.

The findings of this study are supported by several previous studies, namely the position of non-formal factors in line with the IAM subject group. Research conducted by Power (2016) shows that developing non-formal factors regarding CP5 earthworks policy optimization and determining key inputs for DST can reduce asset portfolio damage.[38] In addition, other research shows that non-formal factors outside the IAM subject group are related to employee engagement and environmental commitment of certified airlines, which will improve company performance.[39] Similar research reveals that external technology-related factors can create value for asset management activities and more efficient asset life cycles.[40]

H2: Non-Formal Factors Outside the IAM Subject Group are significantly correlated with AM Implementation

Its non-formal factors have been proven to affect the implementation of AM significantly and positively. This significant correlation shows that informal elements create an important foundation in building relationships between different perspectives of an effective and sustainable asset management system. Structured policies provide a clear framework for AM implementation. In addition, strong commitment from all levels of the organization ensures alignment in policy execution.

The acceptance of this hypothesis is supported by several implementations or field practices that PT PLN Group has carried out. The Company has realized the contribution of non-formal factors in strengthening the asset management process in PT PLN Group. First, PT PLN Group designed a planned knowledge transfer program. This process is an important element in the life cycle delivery, where all systems and procedures are designed using the Work Breakdown Structure (WBS) approach. Implementing WBS improves operational efficiency and optimizes the organization's overall performance. With better procedures, PLN can plan and execute its operations in a more targeted manner, resulting in a significant increase in performance. Second, organizational adjustment requires sufficient procedures and time to form a small team as a person in charge of a PIC for a structural task that should already be available. Small teams created can develop into structural parts of an organization with more significant roles under direct supervision within two years. This shows that the organization's commitment is realized through strengthening a structure responsive to asset management implementation needs.

Third, PT PLN Group provides support in financial decision-making. Well-planned finances through the Company Work Plan and Budget (RKAP) mechanism. A budget plan can ensure the entire asset management process is adequately funded. High-quality information is the basis for determining resource allocation, including investments in relevant technologies. Fourth, the use of technology that supports the modernization of asset management processes. The adoption of this technology requires substantial financial support while also having a significant impact on operational efficiency and effectiveness. The adopted technology enables better data collection and analysis, supports more informed decision-making, and improves the organization's ability to face complex asset management challenges.

The analysis results show that the transfer of knowledge and human resource competence have the most significant influence on the implementation of asset management in PT PLN Group. These two factors contribute directly to improving asset management performance, especially in the EAF (Equivalent Availability Factor) and EFOR (Equivalent Forced Outage Rate) indicators. This underscores the importance of structured and sustainable efforts to achieve optimal asset management results. Knowledge transfer requires intensive efforts through mentoring programs carried out by the head office team. The mentoring model implemented by PT PLN Group is a parenting unit that consistently visits other units. The parenting method has been proven to be more effective than short training. In the PJB environment, for example, continuous mentoring improves staff understanding and technical skills, ultimately impacting operational efficiency. Instead, the approach of short training like LPNs, where staff is only trained for 1-2 weeks; the existence of parenting programs from experts from the head office and world best practice experts; Benchmarking activities with companies in similar industries have a limited and less significant impact on mindset changes and improvement of technical capabilities. Developing HR competencies also creates a solid foundation for implementing policies that support innovation and efficiency in asset management. Decisions made by competent staff are based on experience and supported by knowledge gained through mentoring programs. This accelerates adapting to new technologies and improves the overall quality of asset management. Therefore, these findings emphasize the importance of intensive and sustainable knowledge transfer programs, especially those that involve direct interaction and mentoring from

central teams. This program is not just training but also a means to create fundamental changes in mindset, improve HR competencies, and optimize asset management to achieve better performance.

The findings of this study are supported by several previous studies conducted by Desbalo (2024), providing information that the conceptual framework in its non-formal factors, namely data-based information technology, can improve the performance of building asset management at the State University in Addis Ababa, Ethiopia.[41] Existing research can develop an asset management framework based on non-formal factors that can apply core practices of physical asset management in water management agencies in Malawi.[42] Another study shows that financial regulation as an external aspect of Chinese banking through the New Asset Management Regulation (NAMR) significantly impacts the synchronization of the stock prices of companies listed on the China Stock Exchange A.[43]

H3: Six IAM Subject Groups significantly have a relationship with Non-Formal Factors

Six groups of IAM subjects were also shown to have a significant impact and relationship with six non-formal factors. The results showed that six groups of IAM subjects, namely people and work culture, generation plan, plant performance, information management system, life cycle delivery-asset, and risk and control management, had a significant relationship with six non-formal factors outside the IAM subject group: policy, commitment, finance, technology, transfer of knowledge, and human resource competence. The six IAM subject groups directly relate to asset management and cover various operational, strategic, and organizational culture areas. Meanwhile, non-formal factors refer to indirect elements that affect the success of asset management implementation.

The acceptance of this hypothesis is supported by several implementations or field practices that PT PLN Group has carried out. In the practice found in the field, other factors such as policies and commitments are important in implementing the Company's strategies. However, these two factors are greatly influenced by the local wisdom of a particular community group or organization, which is the basis for an assessment of giving awards or appreciation to workers for their work. At PT PLN Group, this assessment practice combines local wisdom and best business practices in the same industry. Local wisdom is an important foundation in this assessment because it reflects cultural values and unique characteristics relevant to each operational area. This assessment is then included in the KPI in each unit so that it can be measured clearly and uniformly to achieve the same performance targets. In addition, these KPIs provide strategic guidance for each unit to improve operational efficiency, service quality, and overall business sustainability. This integration creates a holistic approach to performance appraisal that encourages collaboration and innovation across the PT PLN Group.

The findings of this study are supported by several similar studies that state similar things, such as the factors in the IAM subject group having a direct impact on the Company's asset management. A study by Candón (2019) stated that applying an Intelligent Asset Management System (IAMS) in an industrial 4.0 manufacturing environment can accurately structure information based on the analytical capacity of value and risk management.[44] Candón (2024), in another study, also explained that the combination of the Internet of Things (IoT)-based monitoring model with the Asset Health Index (AHI) model offers a holistic view of asset digitization and asset performance.[45] Other relevant research also revealed that applying digital twins as an infrastructure intelligent asset management (IAM) system in the railway industry significantly correlates with the efficiency of the work scheduling process at SNCF Réseau.[46]

H4: Six IAM Subject Groups were significantly correlated with AM Implementation

The results showed that six groups of IAM subjects (people and work culture, generation plan, plant performance, information management system, life cycle delivery-asset, and risk and control management) had a significant correlation with the implementation of AM. These findings support the hypothesis that IAM's subject group, which includes both strategic and operational dimensions, contributes substantially to the successful implementation of AM in PT PLN Group. In detail, researchers found that a well-run organizational culture can significantly influence a company's life-cycle delivery. Continuous improvement of information quality is a target that must be achieved to produce quality information to support life-cycle delivery. However, even though it has gone well, careful planning is still needed, as well as considering other accompanying aspects. The ultimate goal is to improve performance and reduce EFOR or risk. Based on the discussion of practices found in the field, the researcher knows that in the practice of the asset management framework owned by PT PLN Group, life-cycle delivery is the primary driver of the asset management implementation process.

Similar research results from other researchers also support the findings of this fourth hypothesis. Lafioune (2023) found that digital transformation in planning-based municipalities can improve the efficiency of the 44th municipality's infrastructure asset management in Canada.[47] Another research discovery found that developing pressurized hollow fiber membrane (PHFM) modules carried out at a full-scale water treatment plant in South Korea influenced the development of asset management methods that could improve the Company's operational

efficiency.[48] The results of a similar study show that the system with the IAM method has higher accuracy in data processing and can achieve better decision support in BP neural network-based power information data asset management.[49]

Future research in AM implementation should include a comprehensive approach with adaptive flexibility to 39 relevant subjects. Asset management is long-term, so that the results will be visible in five years or more. Therefore, asset management is important to integrate quick wins—achievements that can be achieved in 1–2 years. This can be done by choosing factors that affect quickly, such as knowledge transfer, technology application, or improving HR competence. Quick wins motivate stakeholders and reinforce commitment to long-term implementation, balancing short-term and long-term benefits.

CONCLUSIONS

This study confirms that six non-formal factors (policy, commitment, finance, technology, transfer of knowledge, and human resource competence) significantly correlate with the implementation of asset management in PT PLN Group. In addition, six IAM subject groups (people and work culture, generation plan, plant performance, information management system, life cycle delivery-asset, and risk and control management) also showed a significant relationship with the implementation of AM. These results show that the success of AM implementation is determined by technical and operational factors and external elements that support strategic integration and cross-functional collaboration within the organization. These findings highlight the importance of policy and organizational commitment in creating a strong foundation for AM implementation, supported by sound financial management, adoption of the latest technology, and sustainable knowledge transfer. Human resource competence has also proven to be key in supporting this process. AM generation in PLN Group aims to achieve EAF (equivalent availability factor) of power plants, reduce EFOR (equivalent forced outage rate) or the risk of plant outages, and reduce maintenance costs. This study enriches the literature on asset management by identifying significant relationships between informal factors and IAM subject groups and providing practical recommendations for organizations to improve AM implementation.

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