Development of an Operational Readiness Assessment Model for Gas Engine Power Plants (PLTMG) to Use Gas as the Primary Fuel at PT PLN (Persero) in Maluku and North Maluku Regions

Apprilian Kurniawan[1,], Joko Siswanto [2]
[1,2] Faculty of Industrial Technology, Bandung Insitute of Technology
Email: 23422302@mahasiswa.itb.ac.id[1], j.siswanto@itb.ac.id[2]

Abstract. The enactment of Law No. 16 of 2016 on the Ratification of the Paris Agreement under the United Nations Framework Convention on Climate Change establishes a legal framework for Indonesia's commitment to addressing global climate change. One of Indonesia's key commitments is achieving the Nationally Determined Contribution (NDC) target of reducing greenhouse gas emissions by 29% by 2030, supported by the Electricity Supply Business Plan (RUPTL) through strategies for transitioning to clean energy. PT PLN (Persero) Unit Pelaksana Pembangkitan Maluku, which manages the Gas Engine Power Plant (PLTMG), plans to transition from using biodiesel (B35) to natural gas to reduce carbon emissions and support the NDC target. This study aims to evaluate the operational readiness of power generation units in the fuel transition process using a multidimensional approach encompassing the dimensions of Infrastructure & Technology, Organization, Operations, Human Capital, Regulatory, and Social & Economic. This approach provides a comprehensive assessment of technical readiness, human resources, policies, and socioeconomic aspects, which are particularly relevant for regions such as Maluku and North Maluku with complex infrastructure challenges.By adopting a readiness level model, this study provides a detailed overview of operational readiness stages and areas requiring improvement. The findings are expected to serve as a reference for PT PLN (Persero) in developing plans to enhance operational capacity based on clean energy, while also supporting the achievement of sustainable energy transition targets in Indonesia.

Keywords: *Readiness Model, Power Plant, Readiness Assessmnet*

1 Introduction

A total of 195 countries, including Indonesia, signed the Paris Agreement in 2015 to limit global temperature rise to below 2°C while striving to restrict it to 1.5°C above pre-industrial levels. Indonesia ratified this agreement through Law No. 16 of 2016, committing to a 29% reduction in greenhouse gas emissions by 2030. As part of its Long-Term Strategies for Low Carbon and Climate Resilience (LTS-LCCR) 2050, Indonesia has also set an aspiration to achieve Net Zero Emissions (NZE) by 2060 [1].

Received _____, Revised _____, Accepted for publication _____

PT PLN (Persero) plays a strategic role in supporting these targets through its energy transition programs, including diesel replacement (dedieselization) and gasification of power plants. Energy transition is defined as the process of transforming energy systems, involving a shift from the use of fossil fuel-based energy to renewable energy sources. Its primary objectives are to reduce greenhouse gas emissions, improve energy efficiency, and achieve economic and social sustainability [2]. A key initiative is the conversion of Gas Engine Power Plants (PLTMG) from biodiesel (B35) to natural gas. This program aims to reduce carbon emissions, improve energy efficiency, stabilize the trade balance, and bring economic benefits to local communities [1]

PLN UPK Maluku, responsible for operating power plants in Maluku and North Maluku, manages units designed to operate on both biodiesel and natural gas. However, these units currently rely entirely on B35. To meet the 2030 target for gas usage, PLN has developed a comprehensive roadmap covering short-term initiatives, including diesel replacement, coal-fired plant retirement, biomass cofiring, energy efficiency, grid loss reduction, gas expansion, and clean coal technology [1].

This study aims to evaluate the readiness of the PLTMG in transitioning to gas, identifying potential barriers, technical risks, and necessary mitigation measures. Such an assessment is essential to provide strategic guidance to PLN, ensuring a structured, effective, and sustainable energy transition aligned with the 2030 target. Failure to adequately prepare for the transition may lead to negative outcomes, such as increased costs due to delays, suboptimal implementation, and reputational risks. This research contributes to the development of gas-based energy transition strategies, particularly for regions like Maluku and North Maluku, which face unique infrastructure challenges.

2 Literature Review

2.1 Readiness Model

The readiness model is a multidimensional approach used to assess an organization's preparedness for change or innovation. This model encompasses various dimensions, including organizational structure, technology, human resource competencies, operational processes, and external environment, which collectively help identify the strengths and weaknesses of organizational readiness [3][4]. It enables organizations to design structured improvement steps before implementing significant changes.

Lichtblau et al. developed a readiness model for digital transformation in the context of Industry 4.0, highlighting the importance of technological readiness,

workforce skills, organizational culture, and change management as key elements in adopting digital technologies [5]. Alam et al. adapted the model to evaluate the readiness of Gulf Cooperation Council (GCC) countries for renewable energy transitions, emphasizing the role of policies and regulations in successfully implementing new energy systems[6]. Schumacher et al. [3] and Levovnik et al. [4] extended this concept to the manufacturing and industrial sectors. Schumacher focused on organizational readiness for automation and digitalization, while Levovnik emphasized operational readiness, including workplace safety and operational efficiency, which is relevant for the power generation sector. At the national level, Neofytou et al. [1] developed a model for sustainable energy transition, considering economic, environmental, and policy dimensions. Nunzia et al. [7] updated the model to evaluate organizational readiness for adopting technology-based smart working practices post-pandemic.

Overall, the readiness model has evolved into a holistic approach that includes policy, regulatory, and environmental dimensions. With measurable indicators, this model helps organizations understand their current position and the steps needed to achieve optimal readiness in addressing future challenges.

2.2 Comparisson of existing readiness model

Previous studies have offered various approaches and models for evaluating organizational readiness in the contexts of technological transformation, energy sustainability, and operational transitions. Each study presents unique focuses, dimensions, and methodologies tailored to the objectives and needs of their specific research subjects. In this study, the comparison with prior research aims to identify gaps, relevance, and the distinctiveness of the approach utilized. This research is designed to expand or deepen the conceptual framework of readiness models by emphasizing more specific and relevant dimensions, such as operational readiness in the context of power plant transitions to gas-based energy. Thus, this study is expected to complement existing literature while providing practical contributions to a more focused operational readiness framework.

Table 1. Comparisson of existing readiness model

No	Authors	Focus	Dimension	Object
1	Schumacher dkk (2016)	Industry 4.0 readiness	Strategy Leadership Costumer Products Operations Culture People Governance	Manufactuing Enterprises

No	Authors	Focus	Dimension	Object
			Technology	
2	H. Nefytou dkk (2020)	Sustainable energy transition readiness	Social Political-Regulatory Economic Technology	Country
3	Levovnik dkk (2018)	Operational readiness	Procedural subsystem Personel-Procedural Interface Personel subsystem Personnel Plant Interface Plant Interface Procedural-Plant Interface	Industry
4	Singh dkk (2018)	Organization sustainability readiness	Economic Environment Social Policy Product Process	Manufactur Company
5	Alam dkk (2015)	Countries renewable energy readiness	Infrastructure Institution Human Capital	Country
6	Nunzia dkk (2023)	Organizational readiness	Technology Digital Strategy Organization Culture	Healthcare Facilities
7	Al Yahya dkk (2018)	e-Tendering readiness	People Process Technology Work environment service provider	Construction Companies
8	Anchal dkk (2015)	Digitization readiness	Organizational Behavior Technology	Logistics Companies
9	Jostein dkk (2021)	Balanced readiness level assessment	Regulatory Readiness level Acceptance Readiness Level Organizational Readiness Level	Agricultural companies
10	Sabidussi dkk (2024)	Energy Transition Readiness	Resources Decision Process Manajerial Approaches Organizational Culture	Industry
11	Apprilian K (2024)	Power Plant Operations Readiness	Infrastructure & technology Organization Human capital Operatios Regulatory, social & economic	Powerplant

3 Material and Method

3.1 Development of Readiness Model

The development of readiness models is a key approach to evaluating an organization's preparedness for change or innovation. Among the widely used frameworks is the maturity model, which provides a structured tool for assessing readiness across dimensions like technology, processes, and human resources [1]. According to De Bruin et al. [10] and Becker et al. [11], maturity models are classified into three types: descriptive models, which evaluate current maturity levels and identify strengths and weaknesses; prescriptive models, which suggest steps for improvement; and comparative models, which facilitate benchmarking across organizations or regions. This study adopts a descriptive approach to assess readiness levels systematically.

De Bruin et al. [10] also developed a systematic framework comprising six key stages for designing an effective maturity model:

- **Scope:** this study adopting H. Neofytou et al. (2020), analyzes power plant operational readiness for transitioning to gas fuel. The model focuses on infrastructure & technology, organization, operations, human capital, regulatory social economic.
- **Design:** this stage defines the purpose and application of the model, following the readiness model design framework by De Bruin et al. [10]:
  Domain: The model evaluates power plant operational readiness using dimensions from prior studies: Infrastructure & Technology, Organization, Human Capital, Operations, and Regulatory, Social & Economic.
  Type: The study employs a development readiness model, combining evaluation with guidance for achieving higher readiness levels through dimensions, indicators, and readiness level descriptions.
  Architecture: A staged architecture is adopted, where readiness progresses sequentially, requiring completion of each level before advancing. Detailed descriptions of indicators at each level ensure clear guidance for progression.
- **Populate:** This stage organizes the readiness model into a hierarchy of dimensions and indicators by synthesizing assessment indicators from literature, identifying and grouping critical success factors (CSFs) for each dimension, and defining CSFs across readiness levels.
- **Test:** Validate the model's elements for completeness, often using content validity to ensure all critical aspects are covered.
- **Deploy:** Implement the model in the developing organization for initial testing, using feedback for refinement.

4 Result and Discussions

4.1 Indicator for Measuring Power Plant Operations Readiness

The operationalization of indicators in this study is derived from a comprehensive literature review. Relevant prior studies have been used as references to ensure that the selected indicators comprehensively represent the dimensions of operational readiness. This approach aims to ensure that each indicator is grounded in a robust theoretical foundation and is relevant to the research context.

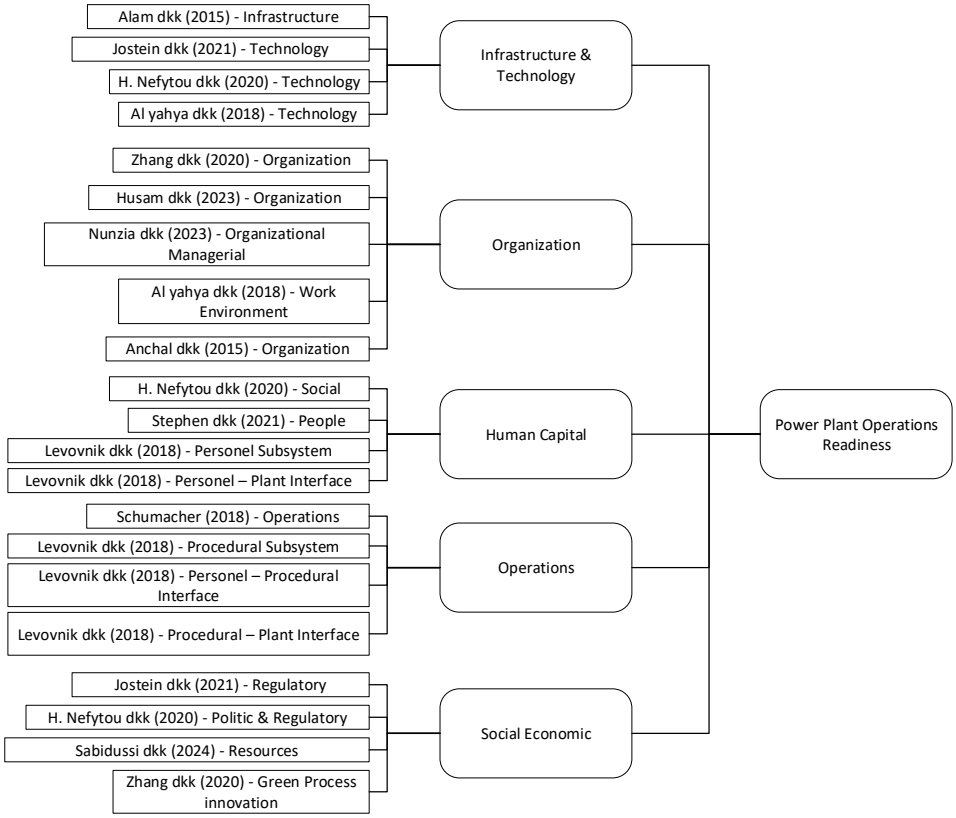

Figure 1. Power plant operations readiness model

4.2 Calculating Power Plant Operations Readiness Level

In line with the research objectives, readiness assessment is conducted based on a readiness model analysis of the research data. The readiness level is calculated using the mathematical equation proposed by Schumacher et al. [3]as follows:

$$R_D = \frac{\sum_{i=1}^{n} R_{DIi} \times g_{DIi}}{\sum_{i=1}^{n} g_{DIi}} \qquad (1)$$

Description: R = Readiness , D = Dimension, I = Item, i = indicator, g = Weighting Factor, n = Number of Maturity item

Based on the calculation results, the readiness score will be categorized into the following power plant readiness levels:

Table 2. Level of Power Plant Readiness by Readiness Score

Power Plant Readiness Level	Readiness Score
Unprepared Operations	1 - 1.9
Awareness Stage Operations	2 - 2.9
Basic Compliance Operations	3 - 3.9
Reliable Operations	4 - 4.9
Comprehensive Operations	5 - 5.49
Optimized Operations Leader	5.5 - 6.00

5 Conclusion

This study successfully develops and applies a multidimensional operational readiness assessment model to evaluate the transition of Gas Engine Power Plants (PLTMG) from biodiesel to natural gas in the Maluku and North Maluku regions. The model provides a detailed and systematic framework for assessing readiness levels across key dimensions, offering a clear roadmap for operational improvements.

The readiness model contributes to PT PLN's strategic objectives by identifying critical areas for enhancement and providing structured guidance to achieve optimized operations. By addressing technical, human resource, regulatory, and socioeconomic factors, the study not only supports the achievement of Indonesia's emission reduction targets but also ensures the sustainability and effectiveness of the energy transition process.

Furthermore, the staged readiness level framework allows for a gradual and measurable transition, reducing risks associated with implementation delays and resource inefficiencies. The findings of this study have broader applicability, offering a practical tool for other power generation units and organizations embarking on similar energy transition journeys.

Ultimately, this research highlights the importance of comprehensive and region-specific readiness assessments in achieving national and global clean energy goals. It underscores PT PLN's commitment to sustainable energy transitions while contributing to Indonesia's role as a global leader in combating climate change.

References

[1] PT PLN (Persero), "Consolidated ESG Performance Report", 2022.

[2] H. Neofytou, A. Nikas, and H. Doukas, "Sustainable energy transition readiness: A multicriteria assessment index," *Renewable and Sustainable Energy Reviews*, vol. 131, Oct. 2020, doi: 10.1016/j.rser.2020.109988.

[3] A. Schumacher, S. Erol, and W. Sihn, "A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises," in *Procedia CIRP*, Elsevier B.V., 2016, pp. 161–166. doi: 10.1016/j.procir.2016.07.040.

[4] D. Levovnik and M. Gerbec, "Operational readiness for the integrated management of changes in the industrial organizations – Assessment approach and results," *Saf Sci*, vol. 107, pp. 119–129, Aug. 2018, doi: 10.1016/j.ssci.2018.04.006.

[5] K. Lichtblau *et al.*, "INDUSTRIE 4.0 READINESS."

[6] M. A. H. Mondal, D. Hawila, S. Kennedy, and T. Mezher, "The GCC countries RE-readiness: Strengths and gaps for development of renewable energy technologies," Feb. 01, 2016, *Elsevier Ltd*. doi: 10.1016/j.rser.2015.10.098.

[7] A. Schumacher, S. Erol, and W. Sihn, "A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises," in *Procedia CIRP*, Elsevier B.V., 2016, pp. 161–166. doi: 10.1016/j.procir.2016.07.040.

[8] H. Neofytou, A. Nikas, and H. Doukas, "Sustainable energy transition readiness: A multicriteria assessment index," *Renewable and Sustainable Energy Reviews*, vol. 131, 2020, doi: 10.1016/j.rser.2020.109988.

[9] N. Carbonara, B. Scozzi, and R. Pellegrino, "Organizational readiness for smart working: a model and assessment tool," *Journal of Workplace Learning*, vol. 35, no. 6, pp. 540–561, Aug. 2023, doi: 10.1108/JWL-01-2023-0002.

[10] T. De Bruin *et al.*, "Australasian (ACIS) ACIS 2005 Proceedings Understanding the Main Phases of Developing a Maturity Assessment Model 16 th Australasian Conference on Information Systems Maturity Assessment Model Understanding the Main Phases of Developing a Maturity Assessment Model." [Online]. Available: http://aisel.aisnet.org/acis2005/109

[11] J. Becker, R. Knackstedt, and J. Pöppelbuß, "Developing Maturity Models for IT Management," *Business & Information Systems Engineering*, vol. 1, no. 3, pp. 213–222, Jun. 2009, doi: 10.1007/s12599-009-0044-5.