The Evaluation of Reverse Logistic as Indicator of the Green Material Management Performance in a Construction Project: A Literature Review

Sherly A Wardani and Naniek Utami Handayani
Industrial Engineering Departement
Diponegoro University
Semarang, Indonesia
sherlyayuwardani@students.undip.ac.id, naniekh@ft.undip.ac.id

Mochamad Agung Wibowo
Civil Engineering Departement
Diponegoro University
Semarang, Indonesia
agung.wibowo@ft.undip.ac.id

Abstract
Green supply chain management (GSCM) is an approach to minimize negative impacts on the environment during the construction process. Green material management (GMM) is a phase of the project life cycle that has a significant effect on GSCM performance. GMM dimensions consist of green procurement, green transportation, green warehousing, and reverse logistics (RL). The application of RL in the construction is difficult because of the lack of awareness. The difficulties of RL application because RL not integrated along the supply chain. In construction, RL viewed as an independent system. The ease of RL implementation requires performance evaluation as a start to determine the initial steps in efforts to improve performance. Previous performance evaluations on GMM did not include RL as a dimension in measuring performance, so the purpose of this study is to develop and added an RL indicator for GMM performance evaluation. The weakness of the previous research is a measurement not to use a quantitative approach. The purpose of this research is to develop indicators and added an RL indicator for GMM performance evaluation. The result of this study is a framework of GMM concepts in the construction that consists of four dimensions, ten elements, and 38 indicators.

Keywords
Reverse Logistics, Green Material Management, Construction Project.

1. Introduction
The construction industry is an essential sector in infrastructure development for Shakantu et al. (2008) supporting the growth of a country (Luangcharoenrat et al. 2019). During the process of infrastructure development, the construction consumes a lot of non-renewable material Wong et al. (2016) which will be emerging a significant impact on the environment (Shakantu et al. 2008; Wong et al. 2016). The construction industry produces solid waste (rubbish, mud, air pollution, CO_2 emissions), and non-solid waste (delay, rework, high cost, etc.) (Wibowo et al. 2018; Wibowo et al. 2017). The construction of the utilization of 35% of energy will release 40% of CO_2 gas into the atmosphere, it shows the role of the building in environmental degradation, and it requires more environmentally friendly practices management throughout its business processes (Luangcharoenrat et al. 2019).

GSCM in the construction sector has a goal to achieve good quality, cost, time, and environmental performance. Therefore, GSCM implementation must be integrated with PLC. The concept of integration is the result of research conducted by Wibowo et al. (2018). The GSCM concept with the PLC approach includes green initiation, green design, green material management, green construction, and green operations & maintenance (Wibowo et al. 2018; Farida et al. 2019; Wibowo et al. 2018). Each phase during the project life cycle will produce different waste, so it will need such amelioration through the supply chain to reduce the waste and improve the performance of a construction project (Wibowo et al. 2018; Nur et al. 2018).

RL is an approach used to improve the problems of waste generated during the construction process. RL is an activity carried out in the green construction phase within the green supply chain management framework. Recycle, reuse and deconstruction are sub-activities in RL (Farida et al. 2019). The application of RL in the green construction phase is difficult. The difficulties are due to the Lack of awareness of reverse RL and the problem in carrying out the deconstruction process. Lack of understanding from RL because RL in the construction sector is not integrated along the supply chain Chinda (2017) and Hosseini (2015), while the difficulty of the deconstruction process is because of the building not designed to carry out the deconstruction process (Chinda 2017). RL is an approach that supports the purpose of GSCM to reduce costs and environmental impacts, so it must be integrated along the supply chain and involve all stakeholders (Hosseini 2015).

Through the PLC on the implementation of GSCM in the CS, the green initiation and green design phases are essential stages (Wibowo et al. 2019). Although a necessary stage of implementing green supply chain management is the green initiation stage and green design stage, the most influential phase on supply chain performance is the GMM phase, which is related to green procurement activities (Ferreira 2015). Events on green procurement are very influential for the achievement of sustainable construction projects (Wong et al. 2016). The procurement process enables the use of deconstruction material and components from the reverse logistics approach (Ajayi and Oyedele 2018). The application of RL and green procurement integrated with the GMM phase. Parameterizing performance is the key to success in making such an improvement and reducing waste (Jagan et al. 2019). Performance measurement in the GMM phase will have a significant impact on whole supply chain performance. Performance measurement is the first step to determine the right strategy to make improvements.

Research about GSCM assessment indicators at certain phases was carried out by Ferreira et al. (2015); Wong et al. (2016); Kusrini et al. (2018); Farida et al. (2019) and Hammes et al. (2019). Research by Ferreira et al. (2014) makes purchasing portfolio models, using perceptual-based assessment (Ferreira 2015). Research about the success of the implementation of green procurement conducted by Wong et al. (2016). The output of this research is a strategy that must be implemented by every stakeholder so that every stage of green procurement can implement successfully (Wong et al. 2016). Research from Ajayi et al. (2018) shows that the material procurement process in the construction sector becomes a critical stage when managing waste. From this study, at the tendering stage, the purchase of new materials could be replaced by recycled material from the reverse logistics process (Ajayi 2018). Research from Wong et al. (2016) and Ajayi et al. (2018) does not integrate it with the performance of GMM along the construction supply chain.

Reuse of construction waste can do with the RL process. This study by Hosseini et al. (2013) and Hammes et al. (2019). The result from Hosseini et al. (2013) consists of the RL implementation benefits and criticizes that RL must integrate with construction design (Kusrini 2018). Research about RL performance in the construction sector was carried out by Hammes et al. (2019), this study reviews performance from three sides: suppliers, internal logistics, and waste management. The benefit of this research is that the parameter is not based on perception only but uses data calculation from each specified indicator. This study solely focuses on reverse logistic evaluation performance so that it still needs improvement in the measurement of other activities through the GSCM process (Hammes 2019). Both kinds of research on reverse logistics show that the concept of reverse logistics must be integrated into the supply chain and involve various stakeholders.

Farida et al. (2018) develop GMM performance evaluations based on material planning, packaging, green transportation, material storage, and material handling. This study's weakness still used perception to parameterize each indicator based on expert opinion (Nur et al. 2018). The study about materials warehouse performance conducted by Kusrini et al. (2018). The performance measure from receive material, storing, sorting, picking orders, and shipping. The advantage of using these indicators is it is not only based on perception or judgment by experts (Kusrini et al. 2018). The dimensions of material storage and material handling in the study of Farida et al. (2018) can merge the dimensions of green warehousing, as in Kusrini et al. (2019) research.

Framework performance parameterizes GMM used as a reference in this study as research from Farida et al. (2018). The differences between this research and previous research are (i) Having the dimension reduction {sub process of material planning, packing and purchasing will be combined into green procurement dimension, and subprocess of material storage and material handling will combine into green warehousing); (ii) The augmentation of supplier audit indicators regarded to green initiatives, green practices and environmental performance and utilization the usage of recyclable/reusable packing in the green purchasing dimension; (iii) Augmenting the indicators related to receiving, put away, storage, order picking and shipping on the green warehousing dimension and (iv) adding the indicators associated with supplier safety performance on the green procurement dimension; (v) Adding a Reverse Logistic dimension to parameterize the performance. The abundance of this study is that the assessment used to parameterize the performance is no based-on perception. The purpose of this study is to develop indicators used to evaluate GSCM performance in the construction sector's green material management phase.

2. Literature Review

2.1. Project Life Cycle

Projects in the construction sector are known as project life cycle (PLC). PLC starts from the beginning of the project until the project completed. Based on a previous study conducted by Wibowo et al. (2018), PLC includes several phases the initiation, design, material management, construction, and operation & maintenance phases (Wibowo et al. 2018). According to Wibowo et al. (2017), the project life cycle scheme in the construction sector illustrated in Figure 1. The project life cycle consists of four stages: The idea, the idea stage includes a feasibility study, makes a design scheme, and defines the problems of the project. The design stage provides design development activities, scheduling projects, making estimates of construction projects. The construction stage covers the entire process of building infrastructure construction. Project closure includes the operation/maintenance consist of review the result from construction phase and doing building maintenance (Wibowo et al. 2017).

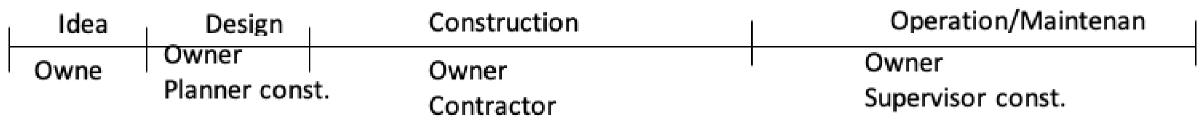

Figure 1. Project life cycle (Wibowo et al. 2017).

2.2. Green Supply Chain Management in Construction Sector

Green supply chain management has implemented by the manufacturing, automobile, electric, food, and construction sectors. Green supply chain management in the construction sector has a unique character that is fragmented and complex. Critical aspects of the GSCM concept in the construction sector are related to information flow and material flow (Balasubramanian and Shukla 2017). Figure 2 shows flow in the CS SCM.

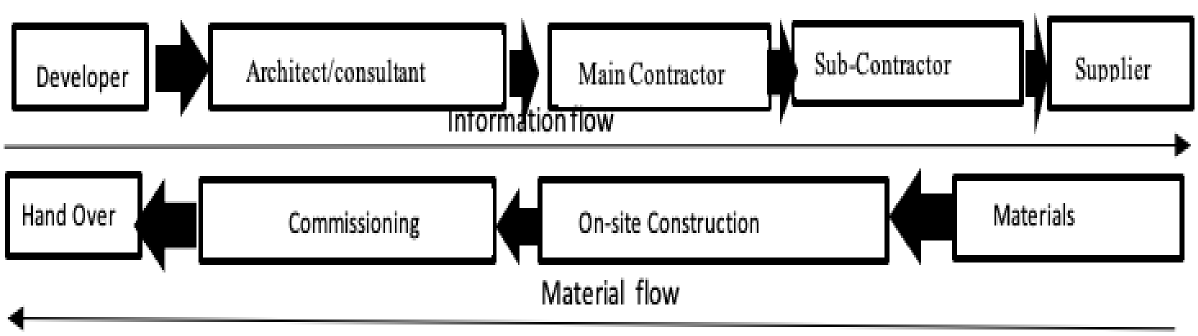

Figure 2. Construction supply chain flow (Balasubramanian and Shukla 2017).

2.2.1. Green Material Management

Green material management is an activity replacing hazardous materials with more environmentally friendly materials (Wibowo et al. 2018). In green material management, subprocesses include green material planning, green purchasing, packaging, green transportation, material storage, and material handling (Nur et al. 2018). Improvements in the green material management phase will have a significant impact on overall supply chain performance (Wong et al. 2016).

2.2.2. Reverse Logistics

The definition of reverse logistics in the construction industry was adopted from the manufacturing industry. The concept of reverse logistics includes reuse, deconstruction, closed-loop supply chain, and some recycling cases (Hosseini et al. 2014). The definition from reuse components is extracted components from the demolition of one project in a new building. This form of reuse is sometimes called 'Component reuse.' Structural elements such as beams, columns, or non-structural components such as cladding panels, bricks, or staircases are taken from one project and used in another (Gorgolewski 2008). Deconstruction defined as the process of dismantling a structure in an environmentally, economically, and socially responsible manner. The purpose of deconstruction to optimize the recovery of materials for reuse and recycling (Kanters 2018). The closed-loop supply chain in the construction sector defined as the processed materials that can be reused at their original quality level. The quantity of waste to be disposed of can be minimized (Mulder et al. 2007). Recycling is the recycling and sorting of waste material recycled during the construction process. Recycle comes from packaging; the rest of new and old material and debris are all potentially recoverable materials (Hiete et al. 2011). In reverse logistic model from figure 2, material from the deconstruction process can recycle as a raw material in the procurement stage. Then component can be reused on the construction phase, so the waste from construction projects can reduce. The process flow in reverse logistics illustrated in Figure 3.

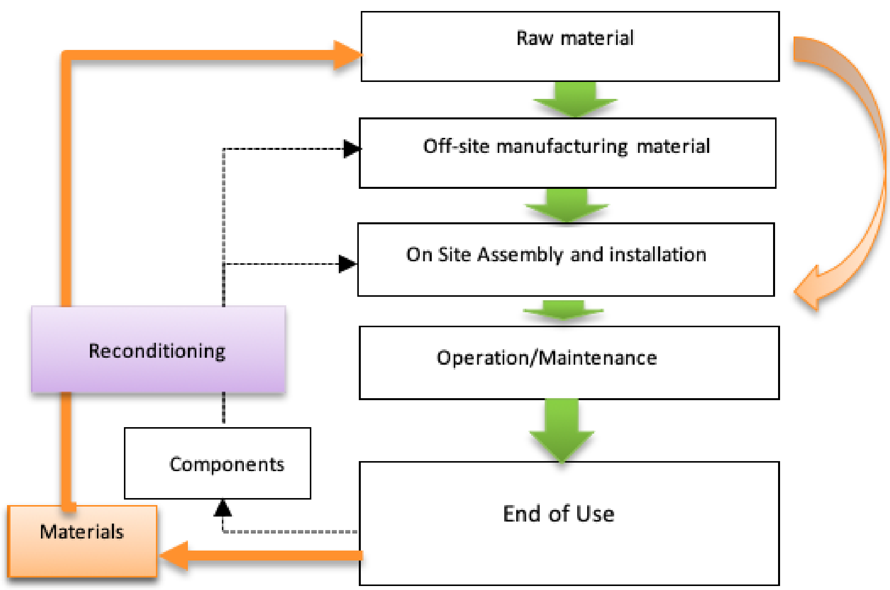

Figure 3. Simple model reverse logistics (Hosseini et al. 2015).

3. Methods

In this study, indicators to determine the performance of the GMM phase obtained by conducting a systematic literature review. The systematic literature review is a distinctive methodology used to find existing studies, select and evaluate contributions, analyse and synthesize data, and report evidence so that conclusions can be drawn quite clearly (Rüdiger et al. 2016). The results of the literature review carried out the indicators compiled in table 1.

4. Results and Analysis

RL in the previous research was considered an individual process. Based on the literature study carried out, the implementation of the integrated RL with the design phase and the GMM phase. In the GMM phase, RL aims to create demand opportunities for deconstructed materials in green procurement and evaluate the implementation of RL from the supplier side. Previous research indicators still use perception, thus allowing the subjectivity of respondents. The indicators in this research will use quantitative measurements. Indicators from the results of the literature review, such as appendix A, are used to evaluate the performance of GMM.

5. Discussion

Performance measurement in the green material management phase must accommodate all related processes in this phase. Preliminary studies on measuring the performance of green material management in construction use five dimensions: material planning, packaging, green transportation, material storage, and material handling. The dimension related to the stakeholders involved, suppliers, and contractors (construction sites). The green packaging and transportation dimensions are handled with supplier performance while the contractor (construction planning) discusses using material planning, material storage, and material handling (Nur et al. 2018). Reverse logistics related to material management and waste management, starting from the procurement process until waste management on the supplier side. RL is a process that must be measured when evaluating the performance of green material management (Wong et al. 2016; Bohari et al. 2017). The previous study did not use the RL dimension to measure the performance so that this study will add this dimension. Initial research uses indicators based on perceptions to create subjectivity in performance assessment. This research will develop indicators that use available data during the construction project implementation in the discussion.

The dimensions of material planning and packing can merge into green procurement dimensions. The reduction from these dimensions based on Bohari et al. (2017) and Wong et al. (2016) research, where green procurement includes green material planning, packaging, green purchasing, and supplier development. This dimension represents the activity of the material design plan, material cost control, and purchasing regulation (Shen et al. 2017). All activities related to the procurement of goods and supplier performance to support GSCM implementation in the green material management phase represented by 13 indicators on the green procurement dimension.

The performance of the green transportation dimension will be assessed using six indicators. The dimensions of material handling and material storage in this study will be reduced to green warehousing, this reduction based on previous studies conducted by Ali et al. (2019) and Kusrini et al. (2019). The concept of Green warehousing includes activities ranging from receiving materials, storing materials in the warehouse to shipping materials to construction sites. This method can be said that material handling and material storage are represented in the concept of green warehousing (Kusrini et al. 2018; Ali et al. 2019). There are 12 indicators used to assess the performance of green material management based on the dimensions of green warehousing.

The reverse logistic dimension is a dimension added to the green material management phase. Based on research conducted by Wibowo et al. (2018) reverse logistics is a dimension used to assess GSCM performance in the green construction phase, this phase associated with the contractor's efforts to implement a green supply chain (Farida et al. 2019; Wibowo et al. 2018). A study conducted by Hammes et al. (2019) shows that reverse logistics performance is not only related to contractors on construction sites, but reverse logistics is also associated with suppliers (Hammes et al. 2019). Performance evaluation of green material management must include dimensions related to suppliers or site construction contractors, so reverse logistics must also be assessed in this phase. There are 12 indicators used to evaluate Reverse logistics in the green material management phase. RL is considered as a practical approach to reduce costs, meet requirements related to environmental performance, and meet consumer demand. RL implementation must be integrated along the supply chain and start from the beginning of the construction project. Based on the results of the study of Hosseini et al. (2014), it can conclude that the RL aspect must also be included in the evaluation of the performance of the phase green material management so that in this study, the RL aspect will be added (Hosseini et al.2014). The assessment framework in this study illustrated in Figure 4.

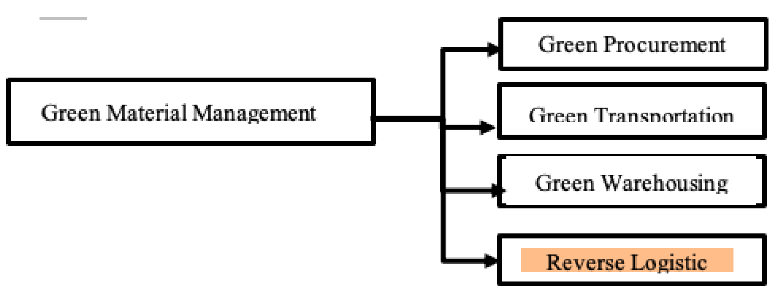

Figure 1. Framework green material management.

6. Conclusion

The result of this study is three dimensions from the reduction process and one new additional dimension. In this study's dimension reduced from 5 dimensions into three dimensions: green procurement, green transportation, and green warehousing. Material planning, packaging, and green purchasing merge into green procurement dimension.

Material storage and material handling combine into green warehousing. The results from this study include reverse logistics as a new dimension to measure performance in the GMM phase.

Based on the literature review that has carried out the framework of performance evaluation of green material management consists of four dimensions: green procurement, green transportation, green warehousing, and reverse logistics. This study produces 38 indicators used to assess the performance of green material management. Proposed indicators in this study can evaluate RL performance, but validation still needs through further research. Further research can do validation the indicators or generate more indicators.

Acknowledgements

This research was financially supported by PDUPT Grants from the Directorate of Research a Community Service (DRPM), Ministry of Research, Technology, and Higher Education, Republic of Indonesia

References

Ajayi, S.O. and Oyedele L.O., Waste-efficient materials procurement for construction projects: A structural equation modelling of critical success factors, *Waste Management*, May 2018, vol. 75, pp. 60-69, 2018.

Ali, Y., Saad, T Bin., Sabir, M., Muhammad N, Salman A, Zeb, K., Integration of green supply chain management practices in construction supply chain of CPEC. *Management of Environmental Quality An International Journal*. vol. 31, no. 1, pp. 185-200, 2020.

Bohari, A.A.M., Skitmore, M., Xia, B., and Teo, M., Green oriented procurement for building projects: Preliminary findings from Malaysia. *Journal of Cleaner Production*. vol. 148, pp. 690-700, 2017.

Balasubramanian, S., and Shukla V., Green supply chain management: the case of the construction sector in the United Arab Emirates (UAE), *Production Planning & Control*, vol. 28, no. 14, pp. 1116-1138, 2017.

Chinda, T., Examination of Factors Influencing the Successful Implementation of Reverse Logistics in the Construction Industry: Pilot Study. *Procedia Engineering*. vol. 182, pp. 99-105, 2017.

Farida, N., Handayani, N. U., and Wibowo, M. A., Developing Indicators of Green Construction of Green Supply Chain Management in Construction Industry: a Literature Review. *IOP Conference Series: Materials Science and Engineering*. vol. 598, pp. 012021, 2019.

Ferreira, L.M.D.F., Arantes, A., and Kharlamov, and A.A., Development of a purchasing portfolio model for the construction industry: An empirical study, *Production Planning & Control*. vol. 26, no. 5, pp. 377-392, 2015.

Gorgolewski, M., Designing with reused building components: Some challenges. *Building Research and Information*. vol. 36, no. 2, pp. 175-188, 2008.

Hammes, G., Souza, E.D.De., Rodriguez, C.M.T., Millan, R.H.R., Herazo, J.C.M., Evaluation of the reverse logistics performance in civil construction. *Journal of Cleaner Production*. vol. 248, pp. 119-212, 2019.

Hosseini, M. R., Chileshe, N., Rameezdeen, R., and Lehmann, S., Reverse logistics for the construction industry: Lessons from the manufacturing context. *International conference on civil engineering, architecture and Urban Sustainable Development*, December 2014, vol. 3, no. 3, pp. 75-90, 2014.

Hosseini, M. R., Rameezdeen, R., Chileshe, N., and Lehmann, S., Reverse logistics in the construction industry. *Waste Management & Research*, vol. 33, no. 6, pp. 499-514, 2015

Hiete, M., Stengel, J., Ludwig, J., and Schultmann, F., Matching construction and demolition waste supply to recycling demand: A regional management chain model, vol. 39, no. 4, pp. 333-351, 2011.

Jagan Mohan Reddy, K., Neelakanteswara, Rao A., and Krishnanand, L., A review on supply chain performance measurement systems. *Procedia Manufacturing*. vol. 30, pp. 40-47, 2019.

Kanters, J., Design for deconstruction in the design process: State of the art, *Buildings*, vol. 8, no. 11, pp. 150, 2018.

Kusrini, E., Novendri, F., and Helia, V. N., Determining key performance indicators for warehouse performance measurement - A case study in construction materials warehouse, *MATEC Web of Conferences*. vol. 154, pp. 6-9, 2018.

Luangcharoenrat, C., Intrachooto, S., Peansupap, V., Sutthinarakorn, W., Factors influencing construction waste generation in building construction: Thailand's perspective. *Sustainable*. vol. 11, no. 13, pp. 3638, 2019.

Mulder, E., de Jong, T.P.R., and Feenstra, L., Closed Cycle Construction: An integrated process for the separation and reuse of C&D waste, *Waste Management*, vol. 27, no. 10, pp. 1409-1415, 2007.

Nur, F., Handayani, N. U., and Wibowo, M. A., Developing Indicators to Implementing Green Material Management in Construction Industry: A Literature Review, *E3S Web of Conferences*, vol. 73, pp. 08009, 2018.

Rüdiger, D., Schön, A., and Dobers, K., Managing Greenhouse Gas Emissions from Warehousing and Transshipment with Environmental Performance Indicators, *Transportation Research Procedia*, vol. 14, pp. 886-895, 2016.

Shakantu, W., Muya, M,, Tookey, J., and Bowen, P., Flow modelling of construction site materials and waste logistics: A case study from Cape Town, South Africa, *Engineering, Construction and Architectural Management*, vol. 15, no. 5, pp. 423-439, 2008.

Shen, L., Zhang, Z., and Zhang, X., Key factors affecting green procurement in real estate development: a China study, *Journal of Cleaner Production*, vol. 153, pp. 372-383, 2017.

Wong, J. K. W., Chan, J. K. S., and Wadu, M. J., Facilitating effective green procurement in construction projects: An empirical study of the enablers, *Journal of Cleaner Production*. vol. 135, pp. 859-871, 2016.

Wibowo, M. A., Handayani, N. U., Nurdiana, A., Sholeh, M. N., and Pamungkas, G. S., Mapping of information and identification of construction waste at project life cycle, *AIP Conference Proceedings*, Available: https://doi.org/10.1063/1.5028107, March 2018.

Wibowo, M. A., Handayani, N. U., Nurdiana, A., and Sholeh, M. N., The identification of waste construction at construction project life cycle, *Advanced Science Letters*, March 2017, vol. 23, no. 3, pp. 2633-2635, 2017.

Wibowo, M. A., Handayani, N. U., and Mustikasari, A., Factors for implementing green supply chain management in the construction industry, *Journal of Industrial Engineering and Management*, vol. 11, no. 4, pp. 651-679, 2018.

Wibowo, M. A., Handayani, N. U., and Nurdiana, A., Developing Indicators of Green Initiation and Green Design of Green Supply Chain Management in Construction Industry, *E3S Web of Conferences*. vol. 115, pp. 02006, 2019.

Yahya, R., Utami Handayani, N., Purwanggono, B., Analysis of OHSAS 18001: 2007 standard renewal towards ISO 45001: 2018 at PT. Power Plant Indonesia by using gap analysis method, *SHS Web of Conferences*. vol. 49, pp. 01009, 2018.

Appendices

Appendix A. Indicator Comparation Result.

Construct Green Material Management						
Managing material management with the principle of environmentally friendly. Reducing the use of hazardous materials for the environment.						
1. Dimensi: Green Procurement						
No	Element	Definition	Indicator	Definition	Measurement	Ref
1	Material Planning	Choose materials that fit the specification and choose suppliers according to established criteria.	Use eco-friendly material	Use eco-friendly material	$\frac{sum\ of\ recycle\ material}{Sum\ of\ all\ \ material\ usage} x100\%$	(Nur et al. 2018)
			A contract with supplier	A contract with supplier	$\frac{Sum\ of\ hazardous\ material}{Sum\ of\ al\ material\ usage} x100\%$	(Nur et al. 2018)
			Choose suppliers who are ISO 14001 certified.	Choose suppliers who are ISO 14001 certified.	$\frac{Total\ ISO\ certified}{Total\ all\ supplier} x100\%$ ISO 14001, scoring system 1□ The company doesn't understand the importance of ISO 14001 and doesn't conduct certification. 2□ The company understands the importance of ISO 14001 but doesn't implement it. 3□ The company has certification but does not implement it, or the company has certification, implements but does not document it. 4□ The company applies ISO 14001, but the implementation is not consistent. 5□ The company applies ISO 14001 and implements it consistently.	(Nur et al. 2018)
			Material quality control	Material quality control	$\frac{Total\ good\ material\ in\ receiving}{Total\ all\ receiving\ material} x1$	(Nur et al. 2018)
			Safety	Choose suppliers who are ISO 45001"2018 certified.	$\frac{Total\ ISO\ certified}{Total\ all\ supplier} x100\%$ ISO 45001 scoring system same as the scoring system ISO 14001.	(Yahya et al. 2018)
2	Packing	Packing uses eco-friendly design.	Packaging design	The packaging can be reused, recycled, and easily disposed to landfill.	$Rate\ Reuseable\&recycle\ waste: \frac{actual\ reuseable\ \&\ recyclable\ mate}{total\ construction\ waste}$	(Nur et al. 2018)
3	*Green purchasing*	Buy eco-friendly materials from green suppliers.	Choose suppliers according to their green initiatives.	Choose suppliers according to their green initiatives	Already represented by environmentally friendly materials, choosing suppliers who implement ISO 14001 and 45001.	(Ali et al. 2019)
			Regularly audit supplier's green initiatives, practices, and environmental performance.	Regularly audit supplier's green initiatives, practices, and environmental performance.	Supplier maturity level based on company standard.	(Ali et al. 2019)
Dimension: Green Transportation						
4	*Green Transportation*	The practice of minimizing environmental impacts due to transportation activities	Emission reduction	Emission reduction	$\frac{Total\ local\ supplier}{Total\ all\ \ supplier} x100\%$	(Nur et al. 2018)
					$\frac{Total\ fleet\ worth\ the\ road}{Total\ fleet\ owned\ by\ the\ company}$x100%	(Nur et al. 2018)
			Risks in the transportation process	Risks in the transportation process	$\frac{Total\ damaged\ goods\ delivery}{Total\ \ goods\ shipped} x10$	(Nur et al. 2018)
			Project locations are difficult to reach by vehicles	Project locations are difficult to reach by vehicles	$\frac{The\ amound\ of\ late\ delivery\ of\ goo}{Total\ delivery\ in\ one\ month}$	(Nur et al. 2018)

(Continued)

No	Element	Definition	Indicator	Definition	Measurement	Ref
			Lack of protection during the unloading process	Lack of protection during the unloading process	$\frac{Total\ material\ damage\ when\ unloa}{Total\ unloading\ material}$	(Nur et al. 2018)
			Unloading method not efficient	Unloading method not efficient	$\frac{Actual\ process\ time\ unloading}{standard\ process\ time\ unloading}x$	(Nur et al. 2018)
Dimension: Green Warehousing						
5	*Material Storage*	Minimize waste during	Unsuitable storage space on the site -	Unsuitable storage space on the site -	$\frac{Total\ material\ rusak\ karena\ penyimpanan}{Total\ keseluruhan\ material}x1$	(Nur et al. 2018)
			warehousing activities.	causes damage or value degradation.	causes damage or value degradation.	(Nur et al. 2018)
			Incorrect storage method	Incorrect storage method	There is an SOP regarding material storage.	(Nur et al. 2018)
6	*Green warehousing*	Minimizing waste from receiving material to shipping material	*Receiving*	% dock usage	(1). % dock usage;(2). % Quality of goods when receiving *(3). Actual process time compared to standard.*	(Kusrini et al. 2018)
			Put away	% compared to labour usage and equipment.	(1.) % utilization of labour/equipment during the process of laying material in the warehouse;(2.) % Material damaged during put away *(3) Actual process time compared to standard.*	
			Storage	% of available locations (insufficient or not)	(1) % area used to store material. (2) The actual storage period of the material compared to the standard	(Kusrini et al. 2018)
			Order Picking	% of the equipment used for the order picking process	(1). % Utilization of labour/equipment during the order picking process; (2). % Material damaged during the order picking process (3). Actual process time compared to the standard.	(Ali et al. 2019)
			Shipping	% *shipping container usage*	(1). % Shipping container utilization; (2) % of the fulfilment of goods delivery; (3). Accuracy in the delivery schedule.	
			Utilize recyclable/reusable packaging	*Utilize recyclable/reusable packaging*	Same with packing indicator in *green procurement.*	(Ali et al. 2019)
			Effectively sell off used products and scrap components	*Effectively sell off used products and scrap components*	Same with indicator in RL waste management.	(Ali et al. 2019)
7	*Material Handling (MH)*	Minimizing waste and environmental impacts arising from MH activities.	Method of transportation on-site from the storage to the application point	Method of transportation on-site from the storage to the application point	$\frac{Total\ material\ damage\ due\ to\ hand}{Total\ overall\ handling\ material}$	(Nur et al. 2018)
			Inadequate material handling	The amount of material damage. Improper material handling methods cause it.	$\frac{Total\ material\ damage\ due\ to\ hand}{Total\ overall\ material}$	(Nur et al. 2018)
			Effective material handling (MH)	% container utilization	Shipping indicators have represented active MH.	(Nur et al. 2018)
			Logistics gas emission	Total CO_2 gas from transportation activities	Same with an indicator in RL waste management RL side.	(Rüdiger et al. 2016)
Dimension: Reverse Logistic						

(Continued)

No	Element	Definition	Indicator	Definition	Measurement	Ref
8	Reverse Logistic (RL)*supplier side*	Same with an indicator in the RL waste management RL side.	*Green purchase*	Percentage of total supplier products that implement RL	$\frac{Product\ allowing\ RL}{Total\ of\ product} x100\%$	(Hammes et al. 2019)
9	RL internal side	View the implementation of RL from the supplier internal side.	Use of material	The percentage of actual material usage compared to material use planning.	$\frac{consumed\ material}{actual\ material\ usage} x100\%$	(Hammes et al. 2019)
			Reuse material	Percentage of material reuse in construction projects	$\frac{Qty\ of\ reuse\ material}{Qty\ of\ used\ material} x100\%$	(Hammes et al. 2019)
			Return of investment	The rate of return on investment if implementing RL	((profit on sales of waste + saving in purchasing of material that are reused)/capital invested in RL)) *100%	(Hammes et al. 2019)
			Customer Satisfaction	Number of customers who continue to buy products from companies that practice RL	Does the waste management affect his or her choice of purchase? (Positive answer/ Total answer) *100%	(Hammes et al. 2019)
10	RL waste management side	Assess Implementation of RL from waste management between companies and suppliers.	Storage 1	Percentage of waste that has a particular place/area to put it.	$\frac{N\ of\ bay}{Total\ number\ of\ different\ wastes}$	
			Storage 2	Percentage of waste placed outside the area it should be placed.	$100 - \frac{Volume\ of\ waste\ yin\ the\ bay\ "x"}{Total\ number\ of\ waste\ "x"}$	
			Transportation 1	The total area of the truck used to transport material.	$\frac{Volume\ of\ transported\ material}{Truct\ capacity} x1$	
			Transportation 2	Waste that appears during the activity of moving material from the mileage.	$\frac{volume\ reaching\ destination}{Volume\ leaving\ the\ construction\ si}$	
			Transportation 3	Carbon emissions used during waste removal.	Kilometre’s travelled * emission of fuel per kilometre.	
			Worker awareness 1	Percentage of certified workers.	$\frac{N\ of\ skilled\ workers}{Total\ of\ company's workers} x100\%$	
			Worker awareness 2	Percentage of workers who understand the environmental impacts that arise during the construction process.	Do you find waste management important? $\frac{Positive\ answers}{Total\ of\ answers} x100\%$	