Performance Analysis of the Cement Industry Based on Green Supply Chain Management

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Abstract. This study aims to provide information to companies regarding the latest performance conditions of environmentally friendly supply chain management through the design of the green supply operation reference and analytical hierarchy process (AHP) performance measurement system model, as well as to assess the company's GSCM performance which is then used to formulate recommendations for improving performance indicators that are considered inadequate good. The results of this study identified 18 performance indicators from 5 appropriate processes used in measuring the performance of PT XYZ's GSCM. Overall, the company's GSCM performance got a score of 77 which was included in the good category, but there were five indicators that had poor performance scores and recommendations for improvement were needed.

Keyword : GSCM, AHP, Performance Indicators

1 Introduction

Rapid economic growth triggers an increase in the number of industries, an increase in the number of industries has a negative impact on increasing the amount of hazardous and toxic waste. Various industrial activities also cause greenhouse gas emissions. According to the greenhouse gas inventory report in the Industrial Processes and Product Use (IPPU) sector, the mineral industry is the industry that contributes the most emissions. In the mineral industry group, the cement industry contributed the most greenhouse gas emissions. In response to this, Indonesia through the Paris Agreement has committed to reducing emissions before 2030. The government's efforts to manage business and industrial waste are carried out through regulation, collaboration and assessment through various mechanisms including PROPER. PROPER is a program for monitoring and evaluating company performance in managing the environment, including waste management. One of the cement factories that also responds to this and strives to become a more environmentally friendly company is PT XYZ. In an effort to become an environmentally friendly company, PT XYZ always makes a long-term plan or Company Work Plan and Budget (CWPB) every year. The actual condition shows that energy consumption in cement production exceeds the CWPB that has been made so that the emissions released during production also increase. In addition, PT XYZ does not yet have a

performance measurement system that focuses its benchmarks on Green Supply Chain Management (GSCM) so it cannot know which parts of the supply chain need improvement to create a comprehensive and sustainable increase in environmental management in the company's supply chain activities. GSCM is an environmentally friendly manufacturing process, material management, distribution and marketing that are also environmentally friendly [11]. In addition, GSCM is the integration of natural environmental concerns into SCM through the implementation of various environmentally friendly solutions and practices such as green design, life cycle analysis, green purchasing, green logistics, environmental technology, and collaborative practices with suppliers, distributors, and customers [4, 5]. The purpose of environmental management is to prevent and minimize the negative impact of decreasing ambient air quality which in turn can have an impact on the sustainability of environmental health [6]. This study aims to design an environmental performance measurement system by tracing the company's GSCM performance factors. The company's environmental performance can provide information about the current performance condition of environmentally friendly supply chain management. Supply chain performance will be used as the basis for formulating GSCM performance improvement strategies. This improvement in GSCM performance is a measure of improving the quality of operational activities and the company's environment in a sustainable manner.

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2 Literature review

2.1 Green Supply Chain Management

Green supply chain is an activity that ranges from green purchasing to an integrated supply chain starting from suppliers, manufactures, to consumers and reverse logistics, which as a whole will form a "closing the loop" [14]. Green supply chain management must incorporate environmental aspects into every stage of the product life cycle [11]. This includes design, acquisition, production, distribution of products, use, reuse and manufacture. All of these activities, from designing a product or service to product distribution and reverse logistics, must be covered by green supply chain management. Green supply chain management must cover all phases of the life cycle of a product, starting from the purchase of raw materials, then product design, and up to the disposal of the product [13]. Furthermore, as an amalgamation of the definitions above, green supply chain management is more than just providing green practices for certain activities; the environmental performance of all levels of the supply chain management should be improved starting from the factory level [2]. It is the duty of green supply chain management to minimize all negative impacts of products and services on the environment.

2.2 Green Supply Chain Operation Reference

The Supply Chain Operation Reference (SCOR) is a high-level framework for obtaining a holistic view of supply chain business processes [9]. This model was designed by the Supply Chain Council as a reference model to describe business processes in the supply chain [8]. To take a holistic and effective approach to environmental management and supply chain aspects so that environmental analysis involves the entire supply chain and conversely the supply chain considers all environmental aspects, a combination of the two concepts is made and the Green SCOR model is formed [1].

2.3 Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) is a tool developed in the 1970s by Thomas L. Saaty and helps decision makers find the best choice from many selected elements. To create a matrix that defines the comparison between one element and all other elements, AHP uses pairwise comparisons. The benefit of AHP compared to others is due to its hierarchical structure, down to the most detailed sub-criteria as a consequence of the selected criteria. Pay attention to the validity to the limit of tolerance for the contradictions of various parameters and alternatives chosen by the decision maker.

2.4 Snorm de Boer

Each indicator has different weights with different parameters, so a process of equalizing parameters is

needed by means of normalization. The normalization process is carried out using the Snorm de Boer normalization formula. Normalization plays an important role in achieving the final value of performance measurement. The following is an equation regarding the normalization of Snorm de Boer [12] namely:

For the Larger the Better size

$$Snorm(skor) = \frac{(SI - S_{min})}{S_{max} - S_{min}} \times 100 \quad (1)$$

For Lower the Better

$$Snorm(skor) = \frac{(S_{max} - SI)}{S_{max} - S_{min}} \times 100 \quad (2)$$

Information:

SI: Actual indicator value that has been achieved

Smax: The value of achieving the best performance

Smin: Worst performance achievement score

Each indicator weight is converted into a certain value interval, namely 0 to 100. A value of 0 is interpreted as the worst while a value of 100 is said to be the best. So that the parameters of each indicator are the same, the following shows the performance indicator monitoring system.

Table 1. Performance Indicator Monitoring System

Monitoring System	Performance Indicator
< 40	<i>Poor</i>
40 – 50	<i>Marginal</i>
50 – 70	<i>Average</i>
70 – 90	<i>Good</i>
> 90	<i>Excellent</i>

Source : Trienekens, J. H & Hvolby, H.H (2000)

3 Methods

The focus of this research study is the measurement of GSCM performance using the Green SCOR model. At the initial stage of field identification, observing the initial condition of the company, observing the company's activities related to its responsibility to the environment, and conducting a literature study. Field research methods, measuring and designing the GSCM Model Green SCOR Performance Measurement System. The design of the GSCM performance measurement system with the Green SCOR model is carried out by identifying the Supply Chain Management (SCM) performance measurement matrix based on literature studies that can be used to assess the company's supply chain activities. The performance measurement system designed consists of level 1, namely business processes, level 2, namely performance attributes, and level 3, namely indicators which are detailed descriptions of business processes and performance attributes. Validation of performance indicators is carried out through brainstorming with experts to determine whether the assessment indicators made by researchers are in accordance with SCM in the company. Then, a pairwise comparison questionnaire

was distributed to five experts, namely managers in related fields who could represent the company's supply chain performance. This questionnaire aims to determine the priority of the company's GSCM performance indicators and determine the weights at each level in the SCOR method. Weighting with the Analytical Hierarchy Process (AHP), this weighting process is carried out at the level of the Green SCOR process (level 1) and at the level of performance attributes (level 2) and also indicators (level 3). The weighting at the level of the Green SCOR process is carried out by means of pairwise comparisons on all aspects contained at this level, namely Plan, Source, Make, Delivery, and Return along with their attributes and indicators. Performance appraisal measurement is carried out through document studies on each performance indicator activity. Then carry out the normalization process on each performance indicator that has been assessed. The level of performance fulfilment is defined by the normalization of the performance indicators [10]. Each indicator has different weights with different size scales, so a parameter equation process is needed, namely the Snorm de Boer normalization formula. GSCM Model Green SCOR Key Performance Indicator (KPI) Design.

Table 1. Design of KPI GSCM Model Green SCOR

Aim	Matrix	Indicator
Conserve resources by using less energy	Reliability	Sustainability mission plan
Conserve resources by recycling waste	Reliability	Thermal substitution rate
	Reliability	Raw material substitution rate
Reduce adverse impacts of quarrying	Responsiveness	Biodiversity auditing system
Reduce source deficiency	Reliability	Supplier with an ISO 14001 certification
	Reliability	Supplier meeting environments criteria
	Reliability	Hazardous material in inventory
	Responsiveness	Kiln feed material usage
Reduce emissions	Reliability	Net CO2 per tonne of cement
	Reliability	Power consumption
	Reliability	Heat consumption
Resource usage maximalization	Asset	Overall Equipment Effectiveness
	Asset	Clinker factor
	Responsiveness	Water consumption
Environmentally friendly operational transportation	Asset	Vehicle emission for distribution and material handling

Reduce inefficiency delivery	Reliability	Vehicle fuel derived from alternative fuels
	Reliability	Delivery quantity accuracy
Reduce environmental waste streams	Asset	Non-product output
	Asset	Recyclable waste / scrap
	Asset	Manageable hazardous waste

4 Result and discussion

4.1 GSCM Performance Indicator validation

Based on the results of research and interviews as well as brainstorming that has been carried out with experts at PT XYZ, the results obtained are that of the 20 GSCM indicator designs obtained through a literature study, 18 performance indicators were found that are in accordance with the business processes of the cement industry company. This discussion uses measurements of 18 environmental performance indicators for the cement industry company PT XYZ.

Table 3. Results of Validation of GSCM Performance Indicators

Business process	Rating Indicator	Code
Plan	Sustainability mission plan	P1
	Thermal substitution rate	P2
	Raw material substitution rate	P3
	Biodiversity auditing system	P4
Source	Supplier meeting environmental metrics/criteria	S1
	Supplier with an ISO 14001 certification	S2
	Kiln feed material usage	S3
Make	Net CO2 per tonne of cement	M1
	Power consumption	M2
	Heat consumption	M3
	Water consumption	M4
	Overall Equipment Effectiveness (OEE)	M5
	Clinker Factor	M6
Deliver	Vehicle emission for distribution and material handling	D1
	Delivery quantity accuracy	D2
Return	Non-product output	R1
	Recyclable waste / scrap	R2
	Manageable hazardous waste	R3

The results of the validation of these performance indicators are then weighted using the AHP method to determine the level of importance of each process and GSCM performance indicators at PT XYZ.

4.2 AHP Weighting GSCM Performance Indicators Using Expert Choice

The first step is to enter the identities of 5 expert respondents in the performance indicator weighting through the "Go" menu on the Expert Choice initial screen, then select "edit" then "add N participants" to set the number of respondents to be included in the indicator weighting calculation, after setting the number (N) respondents, then the terms Facilitator, Combined, P2, P3, P4, P5, and P6 appear in the "Table participant". The next check the Combined column, which means that the weights will be combined later or the final value of the criteria weights is the average result of the five expert respondents. Then also check the Participating column

on Expert respondents 1-5 to activate any expert respondents whose weighting values (judgment) are used. After that, input the pairwise comparison data for each process and the GSCM performance indicators of each expert respondent from the questionnaires that have been distributed to obtain the process weights and performance indicators of each expert. After the results of the weighting of the GSCM process and performance indicators from each expert respondent are completed, the combined weight calculation is carried out by selecting the "Assessment" menu then selecting "Combine Participants Judgment/Data" then selecting "Entire Hierarchy", and finally selecting "Judgement Only".

Table 4. GSCM Performance Indicator Weighting Results

Business process	Weight	Matrix	Weight	Indicator	Indicator weight
Plan	0,191	Reliability	0,431	P1	0,57
		Reliability		P2	0,176
		Reliability		P3	0,254
		Responsiveness	0,569	P4	1
Source	0,16	Reliability	0,608	S1	0,398
		Reliability		S2	0,602
		Responsiveness	0,392	S3	1
Make	0,31	Reliability	0,303	M1	0,395
		Reliability		M2	0,367
		Reliability		M3	0,238
		Responsiveness	0,326	M4	1
		Asset	0,371	M5	0,5
		Asset		M6	0,5
Deliver	0,088	Reliability	1	D1	0,589
		Reliability		D2	0,411
Return	0,251	Asset	1	R1	0,244
		Asset		R2	0,252
		Asset		R3	0,504

The combined consistency index value from the weighting results of the five experts is 0.03 and less than 0.1. This shows that the results of process weighting and GSCM performance indicators at PT XYZ are consistently reliable and can be used for the next research stage, namely measuring the performance value of each process and GSCM indicators.

4.3 GSCM Performance Value Measurement

The measurement of the GSCM performance value is carried out by collecting performance data using

document study techniques from historical performance data that has been recapitulated as a company database. In addition, to determine the minimum and maximum values of each performance indicator as a reference for measuring the value of the current GSCM performance results, obtained from the RKAP that has been made by PT XYZ, interviews with managers in related fields, and literature studies of quality standard regulations in Indonesia.

Table 5. Measurement of GSCM Performance Value

Indicator Code	Scale		Performance Value	Actual	Unit	Performance Characteristics
	Minimum limit	Maximum limit				
P1	0	1	1		Document	<i>larger the better</i>
P2	1	72	41		%	<i>larger the better</i>
P3	4	15	10,21		%	<i>larger the better</i>
P4	0	1	1		Document	<i>larger the better</i>
S1	0	48	48		Supplier	<i>larger the better</i>
S2	0	48	20		Supplier	<i>larger the better</i>
S3	1,55	1,67	1,57		ton kiln feed / ton clinker	<i>smaller the better</i>
M1	634	750	634,44		kg CO ₂	<i>smaller the better</i>
M2	32,26	100	32,49		kWh/ton	<i>smaller the better</i>
M3	0	860	876,59		kCal/kg	<i>smaller the better</i>
M4	0,00075	0,25	0,001		m ³ /ton	<i>smaller the better</i>
M5	75	100	86,31		%	<i>larger the better</i>
M6	81	94	92		%	<i>smaller the better</i>
D1	0	70	37		% Pollutant	<i>smaller the better</i>
D2	90	100	98,49		%	<i>larger the better</i>
R1	0	10514	8357		ton	<i>larger the better</i>
R2	0	100	79		%	<i>larger the better</i>
R3	0	100	100		%	<i>larger the better</i>

After obtaining the performance value data in Table 5, then each performance indicator needs to be equated with the parameter scale value using the Snorm de Boer normalization model. This model is used so that different size scales in actual performance can achieve

the same value parameter scale as all GSCM performance indicators, so that the performance conditions of each GSCM indicator can be known through the definition of values that have been normalized.

Table 6. Normalization of Snorm de Boer

Code	Original Scale		Actual Performance Value	Normalization Value
	Minimum limit	Maximum limit		
P1	0	1	1	100
P2	1	72	41	56,34
P3	4	15	10,21	56,45
P4	0	1	1	100
S1	0	48	48	100
S2	0	48	20	41,67
S3	1,55	2	1,57	83,33
M1	634	750	634	99,62
M2	32,26	100	32	99,66
M3	0	860	877	-1,93
M4	0,00075	0	0	99,90
M5	75,0	100	86,31	45,24
M6	81	94	92	15,38
D1	0	70	37	47,14
D2	90	100	98,49	84,90
R1	0	10514	8357	79,48
R2	0	100	79	79,00
R3	0	100	100	100,00

Furthermore, the value of the normalization results for each performance indicator is multiplied by the weight

of each performance indicator and the GSCM process previously obtained from the AHP weighting results.

Table 7. Final Value of GSCM Performance

Code	Normalization Value	Indicator Weight x Matrix	Indicator Score	Process Value	Process Weight	Process Score	GSCM Performance Value
P1	100	0,246	24,567	91,92	0,197	18,11	77,4
P2	56,34	0,076	4,274				
P3	56	0,109	6,180				
P4	100	0,569	56,900				
S1	100	0,242	24,198	72,17	0,17	12,26	
S2	41,67	0,366	15,251				
S3	83,3	0,392	32,667				
M1	99,62	0,120	11,923	66,68	0,297	19,80	
M2	99,7	0,111	11,082				
M3	-1,93	0,072	-0,139				
M4	99,90	0,326	32,567				
M5	45,24	0,186	8,392				
M6	15,38	0,186	2,854				
D1	47,14	0,589	27,767	62,66	0,104	6,52	
D2	84,9	0,411	34,894				
R1	79,48	0,244	19,394	89,7	0,231	20,72	
R2	79,0	0,252	19,908				
R3	100,0	0,504	50,400				

4.3.1 GSCM Performance Improvement Analysis and Recommendations

From the final GSCM performance value shown in table 7 above, it can be concluded that the overall GSCM performance at PT XYZ is in the "Good" category even though there are two GSCM processes that fall into the "Average" category, namely Make and Deliver. However, the two GSCM performance values were helped by the Plan process which was included in the "Excellent" and Return categories with a value close to "Excellent" i.e., 89. From the entire GSCM process at PT XYZ, there were five performance indicators that had values in the category below "Average" and become a burden on the company's overall current GSCM performance value. The five performance indicators that have the potential to improve GSCM performance in the future because the current performance value is not good enough on the Supplier with an ISO 14001 certification (S2) indicator, Heat consumption (M3), Overall Equipment Effectiveness (M5), Clinker factor (M6), and Vehicle emission for distribution and material handling (D1). To find out the conditions that cause poor performance achievement on indicators with not good enough categories, effective recommendations for improvement can be formulated. The formulation of recommendations for improving GSCM performance is carried out on the following three performance indicators.

4.3.2 Supplier with an ISO 14001 certification (S2)

Most of PT XYZ's suppliers are local goods and service providers who pay less attention to environmental management system certification, but the company has an obligation to prioritize local goods and services entrepreneurs as one of the actions to comply with regulations regarding domestic content levels. Thus, recommendations for improvement that can be given to companies are to design and provide socialization to local suppliers who are registered but do not yet have environmental management certification about the benefits of ISO 14001 certification on cooperation between suppliers and companies as an effort to increase supplier awareness before the company makes environmental management system certification a priority supplier tender term.

4.3.3 Heat consumption (M3)

Energy wastage due to combustion gases released into the atmosphere can be overcome by controlling excess air flow to remain below 20% to minimize wasted heat. The need for thermal energy can be minimized by increasing the percentage of alternative fuels. The use of alternative fuels as a substitute for fuel is done to reduce carbon emissions. In addition, PT XYZ can also carry out maintenance on the pulverized weigher on a regular basis so that product failures do not occur due to improperly measured new bricks and utilize the wasted

hot gas to be reused in waste heat recovery power generation.

4.3.4 Overall Equipment Effectiveness (OEE)

Many factors affect the performance and effectiveness of kiln machines, including lumpy material, unresponsive field operators, SOPs that have not worked well, dirty equipment and lack of maintenance. So that the increase in machine effectiveness that PT XYZ can do is to perform machine maintenance, provide training programs to operators, monitor material quality regularly, manage factory waste in an environmentally friendly manner and innovate production machine technology.

4.3.5 Clinker factor (M6)

Determining the maximum clinker ratio in cement is an effort to reduce negative impacts on the environment and health. Not only can it reduce energy use and CO2 emissions, the reduction and measurement of clinker factor also aims to reduce and control the environmental impact of industrial supporting products such as fly ash, slag, and silica fumes. Currently PT XYZ still relies on clinker as the main additional raw material in cement production because of its easy source and low price. As an effort to reduce the use of clinker PT XYZ can use materials such as blast furnace slag, fly ash, natural pozzolanas or limestone meal, with the right quantity that can be used as a substitute for clinker in cement and optimize the combination of calcined clays and ground limestone as cement additives. allows clinker reduction of up to 50% while maintaining the quality of the existing cement.

4.3.6 Vehicle emission for distribution and material handling (D1)

Distribution and material handling activities have an impact on the environment in the form of exhaust emissions due to the use of transport vehicles. Recommendations that can be given to vehicle emission levels for distribution and material handling which are still high is to overcome air pollution by exhaust gas emissions from company vehicles including monitoring the compliance with exhaust emission thresholds, checking exhaust emissions for new types of motorized vehicles and emission testing. for old motor vehicles, monitoring the quality of ambient air quality around the operating area, and routine maintenance in accordance with the vehicle usage instructions to improve combustion efficiency to reduce exhaust gases. In addition, PT XYZ can also prioritize transportation and material handling service contractors who use modern environmentally friendly machine technology.

5 Conclusion

The GSCM performance measurement system in accordance with PT XYZ's business processes consists

of 18 performance indicators. Each process has a weight of importance sequentially from the largest, namely, the Make process with a weight of 0.297, the Return process with a weight of 0.231, the Plan process with a weight of 0.197, the Source process with a weight of 0.17, and the Deliver process with a weight of 0.104. The overall GSCM performance at PT XYZ is in the "Good" category. The performance details on the Plan process are in the "Excellent" category, the Source and Deliver processes are in the "Good" category, the Make and Deliver processes are in the "Average" category. There are 5 indicators that have poor performance scores, namely the S2, M5, and D1 indicators which fall into the "Marginal" category, as well as the M3 and M6 indicators with the "Poor" category. The indicators that fall into the category under "Average" are then used as the basis for recommending the direction of improving PT XYZ's performance.

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