Measurement of Green Supply Chain Management Performance with Supply Chain Operation Reference (SCOR) and Analytical Hierarchy Process (AHP) Approach at PT XYZ

Nur Asikin[1], Yulinda Tarigan[2]

Batam State Polytechnic
Business Management
Jl. Ahmad Yani Batam Kota. Kota Batam, Kepulauan Riau, Indonesia
E-mail: email.nurasikin@gmail.com, yulinda@polibatam.ac.id

Abstrak

PT XYZ merupakan perusahaan jasa laboratorium pengujian *mechanical* dan *metallurgist*. Saat ini perusahaan sedang menghadapi tantangan lingkungan dari proses bisnisnya yang menghasilkan limbah kertas, sisa bahan kimia pengujian, sisa material pengujian, serta perilaku karyawan yang tidak ramah lingkungan. Untuk mengatasi hal ini, perlu dilakukan pengukuran kinerja *green supply chain management* (GSCM) dengan menggunakan metode *supply chain operation reference* (SCOR) dan *analytical hierarchy process* (AHP). Berdasarkan hasil pengukuran menunjukkan bahwa kinerja PT XYZ masuk kategori *good* dengan nilai 76,17. Namun, dari 26 KPI terdapat 7 KPI masuk kategori kuning dan 1 KPI masuk kategori merah sehingga perlu adanya perbaikan. Perbaikan KPI yang disarankan diantaranya *environmental education provided, % machine maintenance and calibration, % testing off schedule, accuracy in report delivery, delivery report cycle time, % sample return rate, return cycle time,* dan % *solid waste recycling.*

Kata kunci: Pengukuran Kinerja, *Green Supply Chain Management* (GSCM), *Supply Chain Operation Reference* (SCOR), *Analytical Hierarchy Process* (AHP)

Abstract

PT XYZ is a mechanical and metallurgical testing laboratory service company. Currently, the company is facing the environmental challenges of its business processes that produce paper waste, test chemical residue, test material residue, and environmentally unfriendly employee behavior. To overcome this, it is necessary to measure the performance of green supply chain management (GSCM) using the methods of supply-chain operation reference (SCOR) and analytical hierarchy processes. (AHP). Based on the results of the measurement, it appears that the performance of PT XYZ is in the good category, with a score of 76,17. However, out of the 26 KPI, there are 7 KPI in the yellow category and 1 KPI in the red category, which requires some improvement. Recommended KPI improvements include environmental education provided, % machine maintenance and calibration, % testing off schedule, accuracy in report delivery, delivery report cycle time, % sample return rate, return cycle time, and % solid waste recycling.

Keywords: Performance Measurement, *Green Supply Chain Management* (GSCM), *Supply Chain Operation Reference* (SCOR), *Analytical Hierarchy Process* (AHP)

1. Introduction

Supply chain management in an industry is an integrated model that regulates the flow of products from suppliers, producers, and distributors to end consumers (Patradhiani et al., 2023). Implementing supply chain management does not always have a positive impact to generate a competitive advantage but it can also have a negative impact, such as causing significant waste problems. Therefore, in addition to implementing supply chain management, the industry also needs to adopt a green supply chain management approach to ensure that waste generated during the

production process can be handled responsibly.

PT XYZ is one of the laboratory services of mechanical testing and metallurgist and has never performed performance measurement of supply chain management or green supply chain management. Companies are currently facing challenges related to green supply chain management practices in terms of high paper use for day-to-day business needs such as testing reporting, customer requests, work orders, preliminary report and original report that potentially generate paper waste after the archive period expires. In addition, PT XYZ also uses hazardous chemicals such as sulfuric acid (H2SO4) in testing processes that pose a risk of environmental pollution if waste is not properly managed. There are other waste types of sample material after testing and other environmental problems than the behavior of employees who often dump garbage carelessly because of the lack of socialization of the environment by the company, as well as the unavailability of an effective waste place such as three-color trash trays so this is often still happening.

Seeing the existence of environmental issues in the supply chain or business process of PT XYZ, it is necessary to have a performance measurement as one of the aspects of implementing green supply chain management in the company. Performance measurement is a process to assess the extent to which a system is achieving its goals (Yuniarti et al., 2018). Through performance measurements, companies can identify areas that need improvement and enable sub-sectoral performance improvements to be achieved. Green supply chain management is a concept of reducing sustainable performance that integrates environmental aspects into supply chains ranging from product design, raw material procurement, production, product distribution to consumers, and end-use management of products (Purnomo et al., 2019). Green supply chain management has become one of the key steps for PT XYZ to address environmental issues and improve the efficiency of supply chains. Although PT XYZ has not yet obtained ISO 14001 certification, this practice can be a first step towards improving environmental practices, building a sustainable culture, and preparing companies for future certification. In addition, green supply chain management helps PT XYZ comply with the regulations of the Ministry of the Environment of the Republic of Indonesia Regulation No. 1 of the year 2021 on the company performance rating program in environmental management.

In this context, it is important to carry out analysis using the supply chain operation reference model (SCOR). The SCOR model is used to map or group the business processes that are part of green supply chain management to get an overview of the company's supply chains and business processes (Suryaningrat et al., 2021). In determining performance evaluation priorities, a decision-making method called the Analytic Hierarchy Process (AHP) is also needed. AHP is a pair-based comparative evaluation method used in complex and unstructured situations (Munawir et al., 2021). The use of SCOR and AHP methods is an effective way to evaluate the supply chain, taking into account the actual business configuration while raising awareness of environmental issues to improve the competitiveness of the company.

There are many similar studies using the SCOR and AHP models to measure the performance of green supply chain management, including a study conducted by Patradhiani et al., (2023) that found that green supply chain management performance reached 79.4 in the “good” category, but there are 6 of 24 KPIs that need improvement. The research by Henry & Nusranigrum, (2020) received a score of 67.95 in the average category, and there are two stages of SCM, namely manufacture and distribution, that obtain low KPI values and need to be improved. Meanwhile, the Yudiansyah & Imaroh, (2020) obtained a performance rating on PT.XYZ in 2017 of 75.4 and in 2018 of 72.3, which is still below target 80. In 2019, the performance score dropped to 46.6, indicating the need for significant improvements, with 9 out of 17 KPI requiring improvements.

From the description of the results of the above research, it can be seen that there are varying results from the performance measurements carried out, so it is necessary to explore further research to investigate the importance of measurement of green supply chain management to be done by each industry in order to know the performance of each industry, including in the PT XYZ, who have not performed the measuring of supply chain management or green supply chain management. Measuring the performance of green supply chain management can help PT XYZ improve the efficiency of business processes, reduce the environmental impact of environmental issues experienced, and lead to environmentally friendly practices. The research will develop new performance indicators according to the needs and scope of the business run by PT XYZ, a different mechanical and metallurgist testing laboratory service company from previous research focused on the manufacturing sector. The aim of this study is to measure the performance of green supply chain management at PT XYZ using SCOR and AHP approaches as well as provide recommendations for improvement after identifying indicators that require improvement in environmentally friendly supply chains according to the company's capabilities.

2. Theory Review

2.1 *Supply Chain Management*

Supply chain management is a set of integrated processes and activities aimed at planning, implementing, controlling, and monitoring the movement of goods, services, and information from the beginning to the end of the supply chain. The focus is on ensuring the availability of products or services on time, in the right quantity, at the optimal cost, and achieving a high level of customer satisfaction. Supply chain management involves a wide range of parties involved in the flow of goods and information, including suppliers, producers, distributors, diluents, and consumers (Syamil et al., 2023).

2.2 *Green Supply Chain Management* (GSCM)

Green supply chain management is a management approach that aims to minimize the environmental and social impact of a product or service, so it should strive to improve the balance between supply performance and environmental issues such as reducing pollution, minimizing waste, and saving energy. The purpose of green supply chain management is to evaluate the environmental consequences or impacts derived from the company's activities, including environmental impacts ranging from raw materials to finished products and final disposal (Hastuti et al., 2023).

2.3 *Performance Measurement Green Supply Chain Management*

Performance measurement is a process to assess how far a system is from reaching its target. Measuring the performance of a green supply chain is crucial to evaluating the implementation and achievement of an environmentally friendly design. Through the measurement of performance, a company can make decisions about the suitability and sustainability of the strategy adopted, as well as determine whether or not a change in strategy is needed (Yuniarti et al., 2018).

2.4 ISO 14001

ISO 14001 is an international standard governing environmental management systems (EMS). It provides a framework for organizations to manage their environmental responsibilities in a systematic manner, which contributes to the environmental sustainability pillar. ISO 14001 certification is essential for organizations that want to demonstrate their commitment to environmental management (Consultant, 2024).

2.5 *Supply Chain Operation Reference* (SCOR)

The Supply Chain Operation Reference (SCOR) is a structure to describe business activities between the elements of the supply chain, starting from suppliers to customers, to accommodate and target customers as well as the chain itself. The SCOR model consists of five main components in managing a process, namely plan, source, make, delivery, and return (Febrianti et al., 2018). The SCOR model has performance attributes and rules consisting of reliability, responsiveness, flexibility, cost and asset (Yudiansyah & Imaroh, 2020).

2.6 *Analytical Hierarchy Process* (AHP)

The Analytical Hierarchy Process (AHP) is a model

that helps in the decision-making phase, designed by Thomas L. Saaty. It is used to break down problems involving a variety of factors or criteria into a more organized hierarchical structure. The Analytical Hierarchy Process (AHP) is a method of evaluating various actions by comparing several alternative options. The purpose of using AHP is to determine the importance of each level and indicator (Supriadi et al., 2018).

3. Research Methods

This research uses quantitative methodology with a descriptive approach. The descriptive approach in quantitative research aims to describe, explain, or summarize various conditions, situations, phenomena, or variables of research as they exist, which can be observed, interviewed, or expressed through documents and reference materials (Estuti et al., 2021). The reason the researchers chose this method is because the main focus of this research is to provide a clear description and picture of the performance of GSCM at PT XYZ using the green supply chain operation reference (SCOR) and analytical hierarchy process (AHP) approach, which is supported by data-formed figures produced from the actual situation.

3.1 Operational Variables and Their Measurement

The study uses six main variables that include plan, source, make, delivery, return, and waste. In addition, the study also uses three main attributes that include reliability, responsiveness, and flexibility.

3.2 Techniques of Withdrawal and Determining Sample Size

The sampling technique used in this study is non-probability sampling with purposive sampling. Purposive sampling is a technique for taking samples based on special consideration. (Saputra et al., 2022). As for the sample criteria in this study, an expert or company management person who knows in detail the supply chain activity or business activity of the company and has a job desk related to key performance indicators. The total sample in this study consisted of five experts, including quality assurance managers, purchasing officers, testing coordinators, testing assistant coordinators, and HSE officers.

3.3 Data Collection Techniques

Data collection techniques used in research include observations, interviews, questionnaires, and documentation studies. Observations are carried out directly at the research site to collect data based on observations. Interviews are conducted with company management experts to obtain information directly. Documentation studies are performed to gather the actual values of performance indicators. Respondents were also asked to complete a validation questionnaire of performance indicators and AHP with a number of comparison questions covering all variable indicators, using a pair comparison scale from 1 to 9.

3.4 Data Processing Techniques

The data processing techniques applied in this study include the following steps.

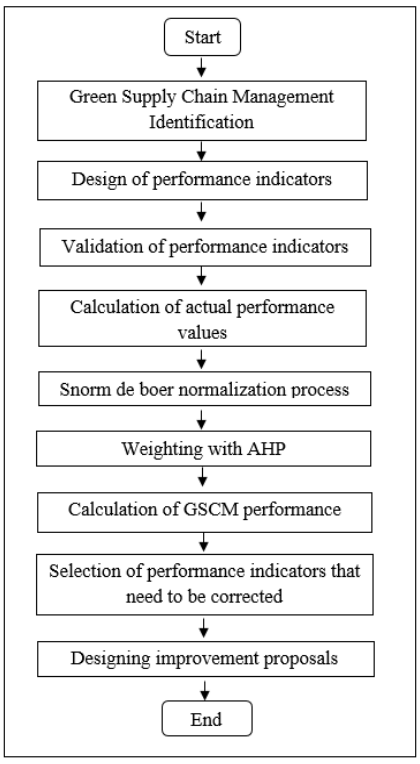

Figure 1. Data Processing Techniques

Source : (Patradhiani et al., 2023)

3.5 Data Analysis Techniques

1. Identify business processes to design key performance indicators (KPI) for green supply chain management (GSCM).

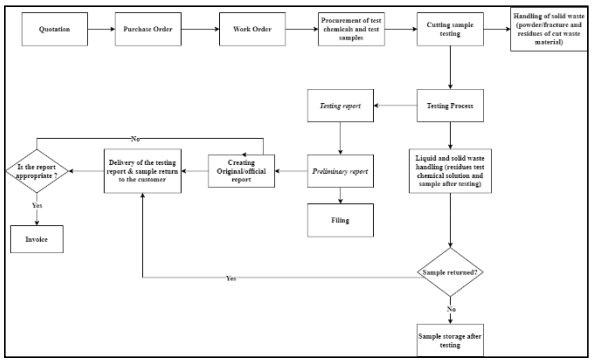

Figure 2. PT XYZ Business Process

Source : (Data Processing, 2024)

From Figure 2, you can see the business processes that are run indirectly, containing elements of the supply chain operation reference model (SCOR) involving the process plan, source, make, deliver, return, plus the waste process. The plan process is characterized by the presence of a quotation, purchase order, and work order that includes the planning of testing services, identifying the needs of customers, and planning the work to be done. The source process is marked by the procurement of testing chemicals and testing samples, which are the resource stages, where materials and samples are obtained to carry out the planned work. The make process is characterized by sample cutting and testing. The delivery process is marked by sending the report of the test results and returning the sample to the customer, where the output of the testing service is delivered to the client. The return process is marked by sample returns, giving the buyer the option to return the samples. Waste processes are characterized by solid and liquid waste handling after sampling and testing.

2. Design Hierarchy Key Performance Indicators (KPI)

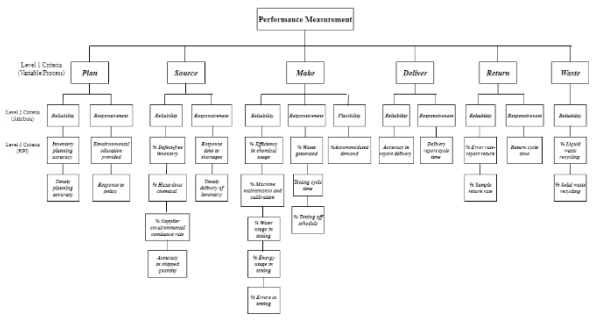

Figure 3. Hierarki *Key Performance Indicators* (KPI)

Source : (Data Processing, 2024)

3. Snorm de Boer

According to Patradhiani et al., (2023) the process of applying normalization through the snorm de boer formula aims to match the size scale of the actual performance value, given that each performance indicator has a different or different measurement scale. The snorm de boer equation formula used in this study is:

$$Snorm = \frac{(Si - Smin)}{(Smax - Smin)} X\ 100 \quad (1)$$

Source : (Patradhiani et al., 2023)

Description :

Si : The value of the actual indicator achieved

S*min* : The worst performance value of the performance indicator

S*max* : The best performance value of the performance indicator

Here is Table 1 showing the system monitoring the melting of performance indicators.

Table 1

Performance Indicators Monitoring System

Monitoring System	Performance Indicators
< 40	Poor
40 – 50	Marginal
50 – 70	Average
70 – 90	Good
>90	Excellent

Source : (Febrianti et al., 2018)

4. Weighting *Analytical Hierarchy Process* (AHP)

The weighing process is based on filling out comparison questionnaires in pairs. Weighing aims to assess the level of importance between indicators on a weighted scale from 1 to 9. If the Consistency Ratio (CR) value is less than or equal to 0.1, then the weighting of the criterion is considered acceptable, and vice versa (Suryaningrat et al., 2021).

According to Cahyawati, (2021) the consistency ratio has the following formula:

$$CR = \frac{CI}{RI} \quad (2)$$

Source : (Cahyawati, 2021)

Description :

RI : Random index

CI : Consistency index

5. Performance Calculation

According to Suryaningrat et al., (2021) the final value of the green supply chain performance is calculated from the green-based supply chain performance metrics SCOR on the level 1 indicator, which is then cumulated to obtain the total GSCM performance value using the following formula:

$$Pi = \sum_{j=i}^{n} SIJ\ Wj \quad (3)$$

Source : (Suryaningrat et al., 2021)

Description :

Pi = Total supply chain performance –*i*

n = Number of performance object

Sij = Supply chain score to i in performance lens to i

Wj = Weight of performance objective

4. Results and Discussion

4.1 Validasi Indikator

Based on the results of interviews and indicator validation questionnaires given to 5 respondents, it was found that the 26 indicators designed by the researchers for 6 business processes of the company consisting of plan, source, make, deliver, return, and waste are valid. It is marked with as many as 5 respondents answering yes from the validation questionnaire details and no respondents responding no to the questionnaire questions. These results show that these indicators are considered relevant and can be used as a basis for further analysis when performing green supply chain management (GSCM) performance measurements. The following is a diagram image of the questionnaire completed by the respondents.

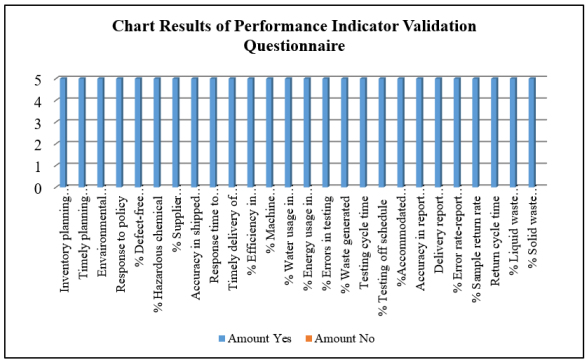

Figure 4. Indicator Validation Questionnaire Outcome Chart

Source : (Data Processing, 2024)

4.2 Actual Performance Value Calculation

This calculation of the actual performance value is based on the actual data of the company. Here are the results of a validated performance indicator's actual performance calculation.

Table 2

Results of Actual Performance Value Calculation

Variable	KPI	Actual Performance Value
Plan	Inventory planning accuracy	81,03%
	Timely planning accuracy	100,00%
	Environmental education provided	4,76%
	Response to policy	100,00%
Source	% Defect-free inventory	99,87%
	% Hazardous chemical	27,27%
	% Supplier environmental comliance rate	100,00%
	Accuracy in shipped quantity	100,00%
	Response time to shortages	100,00%
	Timely delivery of inventory	95,15%
Make	% Efficiency in chemical usage	42,50%
	% Machine maintenance and calibration	79,85%
	% Water usage in testing	38,00%
	% Energy usage in testing	79,05%
	% Errors in testing	3,48%
	% Waste generated	89,84%
	Testing cycle time	100,00%
	% Testing off schedule	7,87%
	%Accommodated demand	98,46%
Deliver	Accuracy in report delivery	74,79%
	Delivery report cycle time	77,89%
Return	% Error rate-report return	0,68%
	% Sample return rate	7,06%
	Return cycle time	79,37%
Waste	% Liquid waste recycling	100,00%
	% Solid waste recycling	60,11%

Source : (Data Processing, 2024)

4.3 Normalization of Snorm de Boer

Snorm de Beor normalization is used to equate the measurement scale of acute performance indicators. Each actual performance value is converted to a scale of 0-100, where 0 means worst performance and 100 means best performance. After normalization, the results are categorized using the traffic light system as red, yellow, and green. The red color indicates performance below the target with a snorm value <40,

yellow for snorm values ⩽ 40-79, which means performance has not reached the target, and green for Snorm value ⩾80, which indicates achieved performance. Here is a calculation of the normalization of snorm de beor from the actual performance value obtained.

Table 3

Normalization of Snorm de Boer

KPI	Actual Value (Si)	S Min	S Max	Snorm
Inventory planning accuracy	81,03%	0,00%	100,00%	81,03
Timely planning accuracy	100,00%	0,00%	100,00%	100,00
Environmental education provided	4,76%	0,00%	100,00%	4,76
Response to policy	100,00%	0,00%	100,00%	100,00
% Defect-free inventory	99,87%	98,78%	100,00%	89,15
% Hazardous chemical	27,27%	100,00%	27,27%	100,00
% Supplier environmental comliance rate	100,00%	0,00%	100,00%	100,00
Accuracy in shipped quantity	100,00%	0,00%	100,00%	100,00
Response time to shortages	100,00%	0,00%	100,00%	100,00
Timely delivery of inventory	95,15%	66,67%	100,00%	85,45
% Efficiency in chemical usage	42,50%	69,84%	35,78%	80,27
% Machine maintenance and calibration	79,85%	69,70%	90,00%	50,00
% Water usage in testing	38,00%	71,43%	30,00%	80,68
% Energy usage in testing	79,05%	50,52%	85,72%	81,05
% Errors in testing	3,48%	9,64%	2,02%	80,82
% Waste generated	89,84%	0,00%	100,00%	89,84
Testing cycle time	100,00%	0,00%	100,00%	100,00
% Testing off schedule	7,87%	26,92%	0,00%	70,75
%Accommodated demand	98,46%	90,29%	100,00%	84,17
Accuracy in report delivery	74,79%	47,44%	100,00%	52,03
Delivery report cycle time	77,89%	50,00%	100,00%	55,77
% Error rate-report return	0,68%	3,53%	0,00%	80,79
% Sample return rate	7,06%	0,93%	14,97%	43,63
Return cycle time	79,37%	33,33%	100,00%	69,05
% Liquid waste recycling	100,00%	0,00%	100,00%	100,00
% Solid waste recycling	60,11%	16,11%	100,00%	52,13

Source : (Data Processing, 2024)

4.4 Weighting the Analytical Hierarchy Process (AHP)

The analytical hierarchy process (AHP) weighing aims to measure the importance of various performance indicators based on data from pairs of comparison questionnaires completed by five respondents from PT XYZ. Weighing is carried out on three levels of criteria with the help of expert choice software. The weighting result for each criterion is then multiplied to get the final weight on each performance indicator. Here's a weighting of the level of interest for each criterion level.

Tabel 4

Weighting of Analytical Hierarchy Process (AHP)

Level 1 Weight Value	Level 2 Weight Value	Level 3 Weight Value	Final Weight Value
0,094	0,540	0,491	0,025
		0,509	0,026
	0,460	0,411	0,018
		0,589	0,025
0,158	0,460	0,273	0,020
		0,198	0,014
		0,246	0,018
		0,283	0,021
	0,540	0,599	0,051
		0,401	0,034
0,193	0,282	0,170	0,009
		0,324	0,018
		0,103	0,006
		0,171	0,009
		0,232	0,013
	0,479	0,142	0,013
		0,488	0,045
		0,370	0,034
	0,239	1,000	0,046
0,202	0,171	1,000	0,035
	0,829	1,000	0,167
0,114	0,297	0,589	0,020
		0,411	0,014
	0,703	1,000	0,080
0,238	1,000	0,589	0,140
		0,411	0,098

Source : (Data Processing, 2024)

After obtaining the weighting results of each criterion level, a consistency test is carried out by looking at the overall index of consistencies, which can be seen in Figure 5.

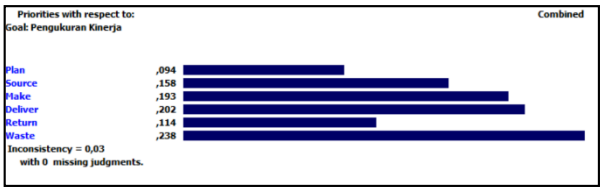

Figure 5. Index of Consistency Values of Weighting

Source : (Data Processing, 2024)

Based on Figure 5, it can be seen that the overall

weighting inconsistency value is 0.03, which means this value is less than 0.1. So it shows that the overall weighting results are consistent and can be justified for calculating green supply chain management (GSCM) performance.

4.5 Green Supply Chain Management (GSCM) Performance Value Calculation

The performance value of green supply chain management (GSCM) can be determined by multiplying the final value of the performance indicator of the result of snorm de boer normalization with the final weight value of each performance. Here are the results of the calculation of GSCM performance values at PT XYZ.

Table 5
Green Supply Chain Management (GSCM) Performance Value Calculation

Varibel	KPI	Snorm	Nilai Bobot Akhir	Nilai Kinerja GSCM
Plan	Inventory planning accuracy	81,03	0,025	2,02
	Timely planning accuracy	100,00	0,026	2,58
	Environmental education provided	4,76	0,018	0,08
	Response to policy	100,00	0,025	2,55
Source	% Defect-free inventory	89,15	0,020	1,77
	% Hazardous chemical	100,00	0,014	1,44
	% Supplier environmental comliance rate	100,00	0,018	1,79
	Accuracy in shipped quantity	100,00	0,021	2,06
	Response time to shortages	100,00	0,051	5,11
	Timely delivery of inventory	85,45	0,034	2,92
Make	% Efficiency in chemical usage	80,27	0,009	0,74
	% Machine maintenance and calibration	50,00	0,018	0,88
	% Water usage in testing	80,68	0,006	0,45
	% Energy usage in testing	81,05	0,009	0,75
	% Errors in testing	80,82	0,013	1,02
	% Waste generated	89,84	0,013	1,18
	Testing cycle time	100,00	0,045	4,51
	% Testing off schedule	70,75	0,034	2,42
	%Accommodated demand	84,17	0,046	3,88
Deliver	Accuracy in report delivery	52,03	0,035	1,80
	Delivery report cycle time	55,77	0,167	9,34
Return	% Error rate-report return	80,79	0,020	1,61
	% Sample return rate	43,63	0,014	0,61
	Return cycle time	69,05	0,080	5,53
Waste	% Liquid waste recycling	100,00	0,140	14,02
	% Solid waste recycling	52,13	0,098	5,10
Total Nilai Kinerja GSCM				**76,17**

Source : (Data Processing, 2024)

Based on the calculation in Table 5, the overall green supply chain management performance value in PT XYZ was 76.17, which means this value falls into the good category. The following is an explanation of the results of the calculations after processing the data on each performance indicator.

a) Plan Process Analysis

In the plan process, there are four KPI, inventory planning accuracy, timely planning accuracy, environmental education provided, and response to policy. Of the four KPIs, three of them are in the green categories, including inventory plan accuracy, timely planning accuracy, and responses to policy, which means that the performance of the third KPI has reached the target. Whereas KPI environmental education provided is in the red category with a score of 4.76. This is because the company has not provided environmental training to all employees, leading to a lack of employee awareness of environmental sustainability characterized by employee actions that discard garbage that is not in place, such as putting plastic garbage into the waste dump of sample material residues and discarding cigarette dots into a flower pot. Furthermore, the lack of socialization of the environment by HSE and the unavailability of efficient garbage disposal facilities such as three-colored trash trays further aggravate employee environmental awareness.

Based on the problems experienced in the KPI environmental education provided shows that the integration of the principles of green supply chain management in operational is not optimal. Green supply chain management is essential in decision-

making that takes environmental criteria into account and builds long-term, environmentally friendly relationships (Hastuti et al., 2023). The lack of environmental education and training for employees as well as the lack of efficient garbage disposal facilities reflect the unfinished implementation of environmentally-friendly planning processes. In addition, the low performance associated with KPIs also demonstrates the importance of improving the implementation of green supply chain management as an initial step in the company's preparation for ISO 14001 certification, focusing on environmental policy formulation, environmental management plan implementation including employee training, and building documented working procedures (Consultant, 2024).

b) Source Process Analysis

On the source process, there are six KPIs: % defect-free inventory, % hazardous chemical, % supplier environmental compliance rate, accuracy in shipped quantity, response time to shortages, and timely delivery of inventory. The six KPIs on this source process are in the green category, which indicates that the KPI performance has reached the target. Although it has achieved the target, it shows that KPI's performance at the source level is good in operational management. However, to ensure long-term environmental sustainability, companies need to strengthen the implementation of green supply chain management as a preparatory step for ISO 14001 certification, both from the side of comprehensive documentation and recording such as audits and monitoring reports, in order to reduce pollution, minimize waste, and create environmentally friendly supply chain (Consultant, 2024)

c) Make Process Analysis

In the make process there are nine KPIs, namely % efficiency in chemical usage, % machine maintenance and calibration, % water usage in testing, % energy use in testing, % errors in test, % waste generated, testing cycle time, % testing off schedule, and % accommodated demand. Of the nine KPIs, seven out of nine are in the green category, which indicates that the performance of the KPI has reached the target. While there are two KPI's in the yellow category, % machine maintenance and calibration with a value of 50 and % testing off schedule with a score of 70,75. For KPI % machine maintenance and calibration have not reached the target because 10 out of 33 test machines are not calibrated due to cost factors. While KPI % testing off schedule is caused by a customer suddenly asking to make changes to the schedule, the customer arrives without making a previous request, and the customer often sends an e-mail request to the testing coordinator but forgets to communicate it to the testing admin to make the scheduling.

Problems on the KPI of % machine maintenance and calibration and % testing off schedule in the make process highlight the company's need to improve the implementation of green supply chain management. Green supply chain management emphasizes operational efficiency to minimize environmental impact, including timely maintenance and calibration of test machines and efficient test scheduling (Hastuti et al., 2023). Machines that are not properly calibrated tend to work less efficiently and can cause more accuracy errors in testing from sample used, thus enabling repetition of testing that produces additional sample material waste. In addition, untimely scheduling can also lead to inefficient resource use, such as longer operating times for machines and labor than necessary or operating under suboptimal conditions, increasing energy consumption and emissions. So, given the conditions experienced by both KPIs, the integration of green supply chain management practices is required to help reduce energy consumption, waste, and carbon emissions in the company's operations. In addition, improvements such as documentation of working procedures and performance evaluation in accordance with the provisions are needed to prepare for ISO 14001 certification in ensuring compliance with environmental standards and sustainable operational efficiency (Consultant, 2024).

d) Deliver Process Analysis

In the delivery process, there are two KPIs: accuracy in report delivery and delivery report cycle time. Both

KPI's in this process are in the yellow category, with values of 52,03 and 55,77. This is due to the frequent occurrence of delays in the delivery of the report to the customer because there is one driver who resigns suddenly, and there is a factor of delay in carrying out the review report resulting in more and longer reporting to the client from the time of the specified cycle.

The problem with KPI accuracy in report delivery and delivery report cycle time in the delivery process indicates the need to implement green supply chain management to improve distribution efficiency and minimize environmental impact. By optimizing human resources and review processes, companies can improve distribution efficiency, reduce waiting times, and achieve green supply chain management goals to minimize pollution (Mustaniroh et al., 2019). Meanwhile, these two KPIs are also closely linked to the ISO 14001 standard in the context of environmental management, which encourages companies to undertake certification preparations through regular performance evaluations and systematic process improvements. By preparing and complying with these standards, companies can ensure that their environmental governance not only focuses on sustainability aspects, but also operational efficiency, which directly impacts customer satisfaction and overall company performance (Darmasakti, 2023).

e) Return Process Analysis

In the return process, there are three KPI's: % error rate-report return, % sample return rate, and return cycle time. For KPI % error rates-reports return is in the green category, which indicates that the performance of the KPI has reached the target. Meanwhile, the KPI % sample return rate falls into the yellow category with a value of 43.63. This is because there are still a few customers who want to request samples returned after the test is completed. This leads to the presence of solid waste non refund sample material. The return cycle time falls into the yellow category with a value of 69,05. This is due to the length of time spent revising the report returned by the customer.

Problems on the KPI, % sample return rate and return cycle time highlight the importance of implementing green supply chain management to reduce waste and improve operational efficiency. The low rate of sample material return results in an increase in solid waste, which is contrary to the principle of green supply chain management that promotes material reuse and recycling. Meanwhile, a long review of the return of the test report could extend the process time and increase the consumption of carbon emission resources from the repeated shipment transportation process (Mustaniroh et al., 2019). Furthermore, it is important for organizations to ensure that these delivery processes are managed effectively in accordance with the principles of ISO 14001 including an evaluation of performance and the implementation of appropriate improvement measures as an initial step in preparing future certification to meet commitments to environmental sustainability that advance waste reduction and resource efficiency (Darmasakti, 2023).

f) Waste Process Analysis

In the waste process there are two KPIs, namely % liquid waste recycling and % solid waste recycling. For KPI, % liquid waste recycling is in the green category, which means that the performance of the KPI has reached the target, while % solid waste recycling is in the yellow category with a value of 52.13. This is due to the high use of paper by companies and little recycling. The company is still using a paper system in its business activities, especially in making work orders, preliminary and original reports, which are carried out every day, resulting in a lot of paper usage, which ultimately becomes solid waste. Apart from that, errors often occur in printing preliminary and original reports, which results in more paper being recycled. Meanwhile, recycling is only done for internal needs, not to be shown to customers, and is used less.

The problem of KPI %solid waste recycling indicates the need to implement green supply chain management to reduce environmental impact. Green supply chain management emphasizes waste reduction and resource efficiency, by reducing overuse of paper and improving recycling practices (Mustaniroh et al., 2019). In this

case, companies need to develop more stringent environmental policy implementation to reduce paper use, improve recycling programs, and ensure documented working procedures to guide employees in environmentally friendly practices. Thus, with this policy, companies can conduct environmental management system evaluations, including monitoring of paper use and the effectiveness of recycling programs, as a first step in preparing for ISO 14001 certification requirements in support of efforts towards better environmental sustainability (Consultant, 2024).

4.6 Selection of Performance Indicators and Planning of Improvement Proposals

From the performance measurements that have been carried out, some KPIs have obtained a value below the target and need to be improved. Improvements have been made to KPI falling in the red and yellow color categories with final performance values <80. Here is a proposed improvement of KPI that has a performance value under the target based on the company's circumstances or problems.

Table 6
Selection of Performance Indicators and Planning of Improvement Proposals

KPI	Improvement Proposals	Previous Research References
Environmental education provided	a) Immediately carry out training for all employees to educate them on the importance of environmental sustainability. b) Providing effective waste disposal facilities, such as three-colored garbage cans and installing poster warning signs. c) Conducting routine socialization by HSE to ensure environmental awareness is continuously enhanced by employees.	Febrianti et al., (2018) and Henry & Nusranigrum, (2020)
% Machine maintenance and calibration	a) Adequate budget allocation and cost separation when approaching the calibration due date b) Seeking options to work with more affordable calibration service providers c) Investing in training and internal calibrating equipment to reduce the cost of calibrating in the long term.	Purnomo et al., (2019)
% Testing off schedule	a) Create procedures that set deadlines for sending requests for testing, scheduling, and confirmation of a reschedule by the customer b) Use one official email platform specifically for receiving customer requests c) Implement a double confirmation procedure for each test schedule, either to the coordinator, team, or customer.	Patradhiani et al., (2023)
Accuracy in report delivery dan delivery report cycle time	a) Create an automated notification system for follow-up and as a time reminder in review reports. b) Implement a checklist in the review process to accelerate the verification of common errors and report content. c) Recruit additional drivers	Patradhiani et al., (2023) and Purnomo et al., (2019)
% Sample return rate	Improve communication with customers and conduct surveys to comply with the reason behind low sample return requests.	Data Processing, (2024)
Return cycle time	a) Re-examine to identify the obstacles that make the old revision process b) Improve communication and collaboration between testing engineering teams to help testing admin in the revision of reports be more efficient and in line with cycle time limits.	Purnomo et al., (2019)
% Solid waste recycling	Companies can switch to digital systems for creating work orders, preliminary reports, and original reports to reduce dependency on paper usage and minimize solid waste. Enterprises can use digital collaboration tools and electronic document management systems, such as PDFs and digital signatures.	Patradhiani et al., (2023) and Purnomo et al., (2019)

Source : (Data Processing, 2024)

5. Conclusion

Based on the results of the measurement of the performance of green supply chain management using the SCOR and AHP method, the result was obtained that PT XYZ entered the good category with a score of 76.17 out of 100. There are eight of the 26 indicators that need to be improved including environmental education provided, % machine maintenance and calibration, % testing off schedule, accuracy in report delivery, delivery report cycle time, % sample return rate, return cycle Time, and % solid waste recycling. The recommendations for improvements were to provide environmental training to employees, provide three-color garbage cans, socialize the environment on a routine basis by HSE, allocate and separate calibration funds, work with affordable calibrations service providers, invest in training and internal calibrating equipment, create deadline procedures for

sending requests and reschedule, use one official email in receiving requests, create double confirmation procedures, use automatic follow-up systems, implement checklist review systems, recruit new drivers, conduct surveys related to low returns of samples, carry out review of congestion revisions of returns reports, strengthen communication and collaboration between testing and testing engineering, and switch to digital systems to reduce paper accounting.

6. Suggestion

The following are the recommendations that can be given to the company and further researchers as follows:

1. The company is expected to periodically make improvements to the performance of green supply chain management (GSCM) based on the improvement proposals that have been designed to support the development of the company.
2. It is important for companies to quickly prepare and obtain ISO 14001 certification by integrating the principles of green supply chain management (GSCM) into their daily operations. This certification will ensure compliance of the company with international environmental standards, improve operational efficiency, and strengthen the company's reputation.
3. Further researchers are expected to expand the hierarchy by incorporating cost and asset management aspects that are consistent with the concept of green supply chain management (GSCM), as well as designing information systems to help in performance measurement.

References

Cahyawati, A. N. (2021). *Pengukuran Kinerja dengan Menggunakan Metode Performance Prism* (A. Rofiq (ed.)). Jakad Media Publishing. https://books.google.co.id/books?id=wrgvEAAAQBAJ

Consultant, O. (2024). *Dokumen dan Rekaman Wajib Dalam ISO: Kepatuhan dan Implementasi*. Ohs Consultant. https://books.google.co.id/books?id=dBUMEQAAQBAJ

Darmasakti. (2023). *Menciptakan Green Profit Dengan ESG Framework*. Nas Media Pustaka. https://books.google.co.id/books?id=DcHnEAAAQBAJ

Estuti, E. P., Fauziyanti, W., & Hendrayanti, S. (2021). *Analisis Deskriptif dan Kuantitatif Produktivitas Garam Indonesia: Studi Kasus pada Petani Garam Kabupaten Pati*. Penerbit NEM. https://books.google.co.id/books?id=RXVHEAAAQBAJ

Febrianti, F. F., Eka Putra, I. G. J., & Raditya Putra, I. G. L. A. (2018). Penerapan Model Green SCOR untuk Pengukuran Kinerja Green Supply Chain Management pada PT. XYZ. *J I M P - Jurnal Informatika Merdeka Pasuruan*, *3*(3), 39–43. https://doi.org/10.37438/jimp.v3i3.164

Hastuti, D., Saleh, W., Fakhruddin, I., Simanihuruk, P., Apriadi, H., Tinambunan, A. P., Setiawan, Z., Alhazami, L., Tamrin, M., Haslindah, H., & Anti, R. D. F. (2023). *PENGANTAR BISNIS (Manajemen Era Digital & Sustainability)* (E. Efitra & S. Seprino (eds.); Pertama). PT. Sonpedia Publishing Indonesia. https://books.google.co.id/books?id=RRSyEAAAQBAJ

Henry, H., & Nusranigrum, D. (2020). Performance Analysis of Green Supply Chain Management of Diaper Raw Materails. *Dinasti Internasional Journal of Digital Business Management*, *1*(3), 328–341. https://doi.org/10.31933/DIJDBM

Munawir, H., Mabrukah, P. R., Djunaidi, M., & Suranto. (2021). Analysis of green supply chain management performance with green supply chain operation reference at the batik enterprise. *Economic Annals-XXI*, *187*(1–2), 139–145. https://doi.org/10.21003/EA.V187-14

Mustaniroh, S. A., Kurniawan, Z. A. F., & Deoranto, P. (2019). Evaluasi Kinerja pada Green Supply

Chain Management Susu Pasteurisasi di Koperasi Agro Niaga Jabung. *Industria: Jurnal Teknologi Dan Manajemen Agroindustri*, *8*(1), 57–66. https://doi.org/10.21776/ub.industria.2019.008.01.7

Patradhiani, R., Anugrah, B., Wisudawati, N., & Yasmin, Y. (2023). Model Penilaian Kinerja Green Supply Chain Management dengan Pendekatan Green Supply Chain Operation Reference Untuk Mengurangi Pencemaran Lingkungan. *Integrasi : Jurnal Ilmiah Teknik Industri*, *8*(1), 23–31. https://doi.org/10.32502/js.v8i1.5996

Purnomo, H., Kisanjani, A., Kurnia, W. I., & Suwarto, S. (2019). Pengukuran Kinerja Green Supply Chain Management Pada Industri Penyamakan Kulit Yogyakarta. *Jurnal Ilmiah Teknik Industri*, *18*(2), 161–169. https://doi.org/10.23917/jiti.v18i2.8535

Saputra, D. N., Listyaningrum, N., Apriani, A., Rokhayati, T., Asnah, A., & Leuhoe, Y. J. . (2022). *BUKU AJAR METODOLOGI PENELITIAN*. Feniks Muda Sejahtera. https://books.google.co.id/books?id=sWJlEAAAQBAJ

Supriadi, A., Rustandi, A., Komarlina, D. H. L., & Ardiani, G. T. (2018). Analytical Hierarchy Process (AHP) Teknik Penentuan Strategi Daya Saing Kerajinan Bordir. In *Advanced Decision Making for HVAC Engineers* (Pertama). Deepublish Publisher.

Suryaningrat, I. B., A, E. R., & Novita, E. (2021). Penerapan Metode Green Supply Chain Operation Reference (GSCOR) Pada Pengolahan Ribbed Smoke Sheet (RSS) (Studi Kasus di PTPN XII Sumber Tengah Silo, Jember). *Jurnal Agrointek*, *15*(1), 282–293. https://doi.org/10.21107/agrointek.v15i1.7688

Syamil, A., Danial, D. M., Saori, S., Waty, E., Fahmi, M. A., Hartati, V., Ishak, R. P., Dewi, C., Padilah, H., Fauzi, M., & Haryadi, R. M. (2023). *BUKU AJAR MANAJEMEN RANTAI PASOK* (E. Efitra & S. Sepriono (eds.); Pertama). PT. Sonpedia Publishing Indonesia. https://books.google.co.id/books?id=jWHSEAAAQBAJ

Yudiansyah, Y., & Imaroh, T. S. (2020). Analysis of Production Performance Based on Green Supply Chain Management Criteria. *Dijemss (Dinasti International Journal of Education Management and Social Since*, *1*(6), 878–890. https://doi.org/10.31933/DIJEMSS

Yuniarti, R., Tama, I. P., Eunike, A., & Sumantri, Y. (2018). *Green Supply Chain Management dan Studi Kasus di Dunia Industri* (Pertama). Universitas Brawijaya Press. https://books.google.co.id/books?id=DSmJDwAAQBAJ