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Measurement of Supply Chain Management Performance in the Wood Pellet Industry Using the SCOR Method Based on AHP, OMAX, and Traffic Light System

Jeanny Shekinah Karani Putri[1*], Farida Pulansari[2]

Department of Industrial Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Jl. Rungkut Madya No.1, Gunung Anyar, Surabaya 60294 Indonesia

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A B S T R A C T

Wood pellets are one of the renewable fuels that are environmentally friendly and have the advantage of lower emission values than fossil fuels, so the increasing use of renewable energy fuels today. PT Yale Woodpellet Indonesia is one of the industries engaged in the production of wood pellets. Due to the increasing demand, PT Yale Woodpellet Indonesia once did not reach the production target. The approach that can be used to fix this problem is the SCOR (Supply Chain Operation Reference) model combined with AHP (Analytic Hierarchy Process), OMAX (Objective Matrix) and Traffic Light System to support the research. Based on the results of observations, interviews and distributing questionnaires to the company, 12 performance indicators were selected which were adjusted to the company's conditions. The results showed that there are two KPIs (Key Performance Indicator) that have not reached the target, which are in the yellow category so that corrective action needs to be taken to improve the company's supply chain performance. The KPIs are Qualification Accuracy of Raw Material (Slc) and Number of Trouble Machines (M2a).

***Corresponding Author**

Jeanny Shekinah Karani Putri
E-mail: jeannyskp.05@gmail.com

1. INTRODUCTION

The diminishing fossil fuels have made the exploration of the potential of biomass energy to find alternatives. Wood pellets are one of the biomass fuels that have the advantage of lower emission values when compared to fossil fuels (Indrayanti & Siska, 2021). To reduce global warming, countries in the world have a policy of using alternative energy such as wood pellets, so this has led to high productivity and increased demand for wood pellets (Setyawan et al., 2021). Indonesia is believed to be one of the countries that has the potential to play an important role in the world wood pellet industry. However, Indonesia's wood pellet production to date is still relatively small, at around 80,000 tons per year (Sari & Sitorus, 2021). Therefore, the Indonesian wood pellet industry needs to increase its productivity in order to compete well with other companies and even in the international market. Supply chain management is one of the aspects that

support the improvement of competition and company success (Makalew et al., 2019). Due to the high dependence on supply chain management practices, regular assessment and improvement are required to ensure supply chain effectiveness. Measuring Supply Chain Management performance as a basis for designing and evaluating when implementing supply chain management practices (Hidayat & Dahda, 2022).

PT Yale Woodpellet Indonesia is a manufacturing company that produces wood pellets. The company has experienced problems in the procurement, production, and delivery processes. The company has experienced delays in the production process schedule, namely in March 2022 once, in April 2022 and July 2022 twice, and in May 2022 three times, and has experienced a discrepancy in the quantity of products sent to consumers as much as 5 tons in July 2022. Kisanjani (2018) conducted research on measuring supply chain management performance using the SCOR and AHP methods. From the results of the study, it can be seen that the performance indicators that have not reached the target are score values smaller than 80 (<80) so that the root causes and proposed improvements can be analysed. This research complements previous research by forming new KPIs, so the novelty in this research is the KPI qualification accuracy of raw materials to determine the accuracy of raw materials in accordance with company qualifications. This is because the number of qualified raw materials can be one of the factors that affect the production schedule and the quantity of products that reach the target consumer demand. The company's raw material qualification is a 15% moisture level of sawdust, so drying is carried out in the sun to reduce the moisture of sawdust to the specified moisture limit, so that when the weather is uncertain this can hamper the production process.

Based on previous research, the SCOR method can be used to explain the supply chain in detail and classify the processes that form the indicators needed to measure supply chain efficiency, so that integrated measurement between company stakeholders can be achieved. With the AHP method, a complex problem can be broken down into groups in the form of a hierarchy so that the problem will be more systematic. With the OMAX method, the productivity measurement process is relatively simple, flexible, and the data is easy to obtain. By using the Traffic Light System, the company can use 3 colours to more easily assess whether the company's performance is on target or not (Putri & Surjasa, 2018). Therefore, this research was conducted using the SCOR method combined with AHP, OMAX, and Traffic Light System which can help analyse performance to measure the level of productivity of the company so that it can help find out the causes and overcome problems by knowing the company's performance that needs to be improved.

2. LITERATURE REVIEW

Supply Chain Management can be defined as the integration of business sources consisting of suppliers, manufacturers, warehouses, transporters, distributors, retailers, and consumers who operate effectively so that the products produced and distributed can meet the right quantity, quality, time and place (Lukman, 2021). SCOR is a reference model for supply chain processes. Plan, source, make, deliver, and return are the five core processes in SCOR (Hastuti et al., 2020). The SCOR model is able to describe parts of the supply chain with the activities of a company, which must organise and supervise calculations on the procurement and delivery of goods with regard to capital and profit obtained. SCOR serves to develop a business process framework, performance indicators, and support collaboration between stakeholders, so that the effectiveness of supply chain management and operations can be improved (Warella et al., 2021).

Supply Chain Management performance measurement begins with determining KPI (Key Performance Indicator). Determining the weight of each KPI can make it easier for companies to focus on achieving their performance targets (Hartini dkk., 2019). One of the basic approaches that can be used for decision making is the Analytic Hierarchy Process (AHP). The AHP method plays a role in weighting company KPIs based on KPIs that

have been identified in detail by the company. The AHP method also helps in determining the level of importance of KPIs (Jati et al., 2020). The OMAX (Objective Matrix) method can measure productivity partially on the production line. When OMAX is used partially, it will find detailed criteria that affect productivity levels. OMAX itself tends to be a performance that evaluates several criteria to obtain an overall company productivity index (Lesmana et al., 2020). The Traffic Light System indicator consists of three colours: red, yellow, and green. The red colour is interpreted as the performance has not reached the target so it is necessary to make improvements. Yellow colour means that the performance is close to the target but still has not reached the target. Green colour means that the performance has reached the target. Achievement of performance indicators is evaluated based on the achievement of performance values (Celina et al., 2022).

3. RESEARCH METHOD

This research was conducted at PT Yale Woodpellet Indonesia, which is located at Jl. Raya Mantup KM 16 Blok B No. 1, Pelang Village, Kembangbahu Sub-district, Lamongan Regency, East Java. The implementation of this research was carried out starting in February 2023 until the required data was sufficient. The data used in this research are primary data and secondary data. Primary data in the form of KPI selection questionnaire results and AHP weighting questionnaire results. While secondary data is actual data in accordance with the selected KPI which is in the period March 2022 to August 2022. The data collection was carried out by observation, interviews, and distributing questionnaires. the research stages can be seen in Fig. 1.

The first step in data processing is to identify the company's supply chain to find out the process flow and be able to classify it according to the SCOR model. After the supply chain activities in the company are known, then the classification of these activities is carried out to identify the Key Performance Indicator (KPI). After designing the performance indicators, the next step is to validate the performance indicators.

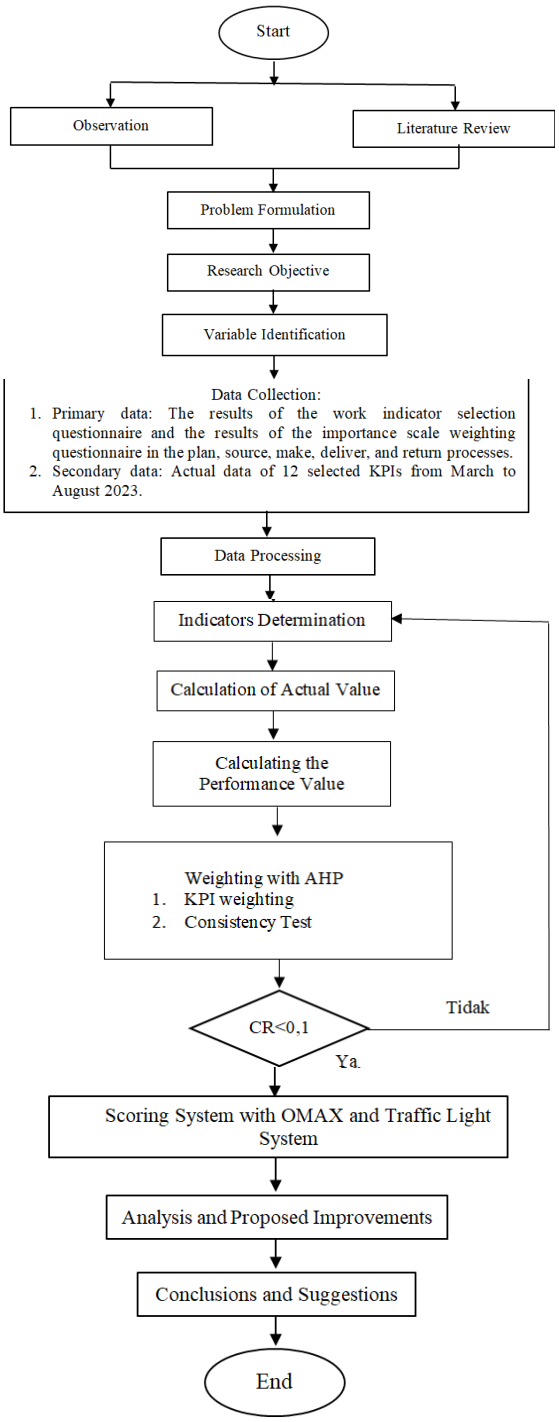

Fig. 1. Research flowchart

This process ensures that KPIs are aligned with the company's business processes and support continuous application. The resulting KPIs are verified by the company to obtain KPIs that the company can implement (Waaly et al., 2018). After the selected KPIs have been validated, the actual value calculation is carried out. This calculation is carried out on actual data

according to the selected KPI. The purpose of calculating the actual value is so that the company can measure and determine the level of achievement of each performance indicator (Subekti, 2020).

The next stage is weighting with AHP. The weighting of performance indicators consists of three levels. Level 1 consists of the plan, source, make, and deliver processes. Level 2 consists of reliability and responsiveness attributes in each supply chain process. Level 3 consists of KPIs for each attribute and process (Rianika, 2021). Next is the creation of the OMAX table. The OMAX table contains the results of the calculation of the performance value obtained from the actual value multiplied by the weight value from AHP. The score in the OMAX table consists of 10 levels (Wicaksana, 2020). These levels are then categorised according to the Traffic Light System. Levels 1 to 3 are red, levels 4 to 7 are yellow, and levels 8 to 10 are green

4. RESULT AND DISCUSSION

Supply chain identification is the initial stage in the form of a product flow framework in the company from raw materials to finished products distributed to consumers. After the supply chain activities in the company are known, then the classification of these activities is carried out to identify KPIs.

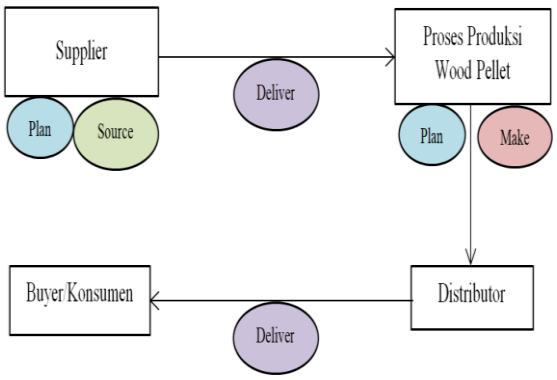

Fig. 2. SCM PT. Yale Woodpellet Indonesia

From Fig. 2, it is known that the plan process is in the supplier and wood pellet production process, where the plan process consists of planning the quantity of raw material purchases needed for production activities. The source process is in the supplier, which consists of selecting suppliers that have an environmental management system, raw materials that are delivered according to the time agreed by the supplier and the company, raw material inventory in the warehouse, and raw materials that meet the company's qualifications. The make process is in the wood pellet production process by paying attention to the accuracy of the production schedule and cases of machine damage. The deliver process here is about the delivery of raw materials from suppliers to the company by paying attention to timeliness and delivery of finished products from the company to consumers by paying attention to the timeliness and quantity of products received by consumers.

Based on the five core processes in the Supply Chain Operation Reference (SCOR), four core processes were selected to suit the company, namely plan, source, make, and deliver. For the dimensions of each core process, performance indicators, namely reliability and responsiveness, were obtained, which have been adjusted to the circumstances and objectives of the company. There are 12 performance indicators selected from 20 performance indicators designed. Performance indicators that are declared valid and can be applied in the company can be seen in Fig. 3.

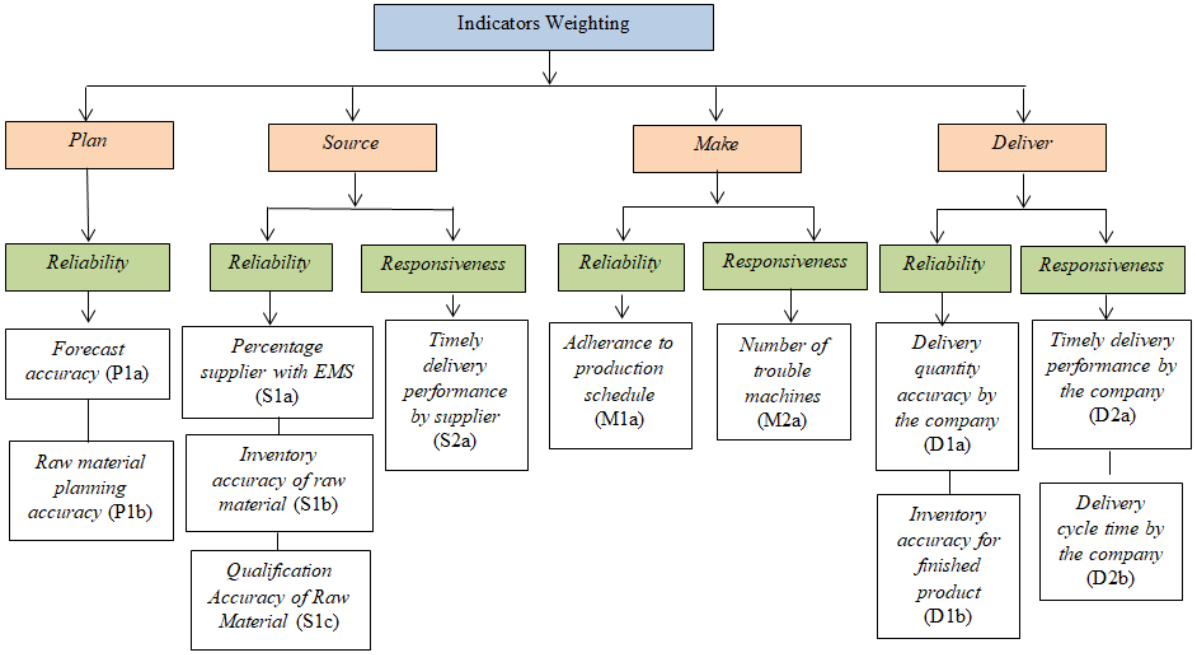

Figure 3. Validation of performance indicators

After the performance indicators have been validated, the next step is to calculate the actual value obtained from historical data from March 2022 - August 2022. The results of the calculation of the actual value of each performance indicator can be seen in Table 1 as follows.

Table 1. Calculation of actual value

KPI	Actual Value (%)
P1a	99,72
P1b	99,59
S1a	100
S1b	100
S1c	20,17
S2a	99,09
M1a	98,33
M2a	63,33
D1a	99,98
D1b	100
D2a	100
D2b	100

After the actual value is obtained, the performance value of each KPI is then calculated with the following formula.

$$KPI=\frac{Si-Smin}{(Smax-Smin)}x100 \quad (1)$$

Si is the actual value of the company's historical data. Smin is the worst performance achievement value and Smaxisthe best performance achievement value. The results of the calculation of the performance value can be seen in Table 2.

Table 2. Supply chain performance value

KPI	Si	Smin	Smax	Performance Value (%)
P1a	99,72	0	100	99,72
P1b	99,59	0	100	99,59
S1a	100	0	100	100
S1b	100	0	100	100
S1c	20,17	100	0	79,83
S2a	99,09	0	100	99,09
M1a	98,33	0	100	97,32
M2a	63,33	20	0	63,33
D1a	99,98	0	100	99,98
D1b	100	0	100	100
D2a	100	0	100	100
D2b	100	1	4	100

From the table above, it is known that there are two KPIs that are in the yellow category, namely Slc (qualification accuracy of raw materials) with a performance value of 79.83% and M2a (number of trouble machines) with a performance value of 63.33%, so that the two KPIs need to be improved. AHP weighting is obtained from the results of the weighting questionnaire filled out by the company. The weight is obtained from the calculation of the total weight matrix by adding the normalised weight of each row, then dividing by the number of processes or attributes, or KPIs. The

results of weighting at level 1, namely the plan, source, make, and deliver processes can be seen in table 3 as follows.

Table 3. Level 1 weighting results

Process	Weight
Plan	0,099
Source	0,471
Make	0,327
Deliver	0,104
Total	**1**

Based on the weighting results in the table above, it is known that the plan process obtained a weight of 0.099, the source process obtained a weight of 0.471, the make process obtained a weight of 0.327, and the deliver process obtained a weight of 0.104, so that the total weight on all processes is 1. At level 2, the weighting results can be seen in Table 4.

Table 4. Level 2 weighting results

Process	Attribute	Weight
Plan	*Reliability*	1
	Total	**1**
Source	*Reliability*	0,833
	Responsiveness	0,167
	Total	**1**
Make	*Reliability*	0,5
	Responsiveness	0,5
	Total	**1**
Deliver	*Reliability*	0,5
	Responsiveness	0,5
	Total	**1**

Based on the weighting results in the table above, it is known that the plan process on the reliability attribute has a weight of 1, in the process of sourcing the reliability attribute obtained a weight of 0.833 and the responsiveness attribute obtained a weight of 0.167, the make process on the reliability attribute and the responsiveness attribute obtained a weight of 0.5, the deliver process on the reliability attribute and the responsiveness attribute obtained a weight of 0.5 at level 3 obtained weighting results as in Table 5 as follows.

Table 5. Level 3 weighting results

Process	Attribute	KPI	Weight
Plan	*Reliability*	P1a	0,5
		P1b	0,5
	Total		**1**
Source	*Reliability*	S1a	0,062
		S1b	0,380
		S1c	0,380
	Responsiveness	S2a	0,178
	Total		**1**
Make	Reliability	M1a	0,5
	Responsiveness	M2a	0,5
	Total		**1**
Deliver	Reliability	D1a	0,326
		D1b	0,242
	Responsiveness	D2a	0,189
		D2b	0,242
	Total		**1**

At the scoring system stage, the OMAX table is formed based on the 4 processes and 12 KPIs selected. The score of each performance indicator obtained is then categorised according to the colour of the traffic light system. In order to be processed with predetermined KPI weights, the achievement value of each KPI has a performance score limit of level 0 to 10. The average calculation of the company's historical data from March 2022 to August 2022 is carried out to determine the performance standard. Level 0 is defined as the worst performance achievement score. On the other hand, to determine levels 4-9 and levels 1-2, interpolation was carried out (Puspitasari & Pulansari, 2023). The results of the scoring system for the plan process can be seen in Table 6.

Table 6. OMAX and TLS assessment of plan process

KPI	P1a	P1b
Performance	99,72%	99,59%
10	**100%**	**100%**
9	92,84%	92,84%
8	85,7%	85,7%
7	78,56%	78,56%
6	71,42%	71,42%
5	64,28%	64,28%
4	57,14%	57,14%
3	50%	50%
2	33,34%	33,34%
1	16,67%	16,67%
0	0%	0%
Level	9,96	9,95
Weight	0,5	0,5
Value	4,98	4,975

KPI Pla (forecast accuracy) with a score of 9.96 and KPI Plb (raw material planning accuracy) with a score of 9.95. Both KPIs in the plan process are in the green category so it can be interpreted that the performance has reached the company's target. Furthermore, the results of the source process scoring system can be seen in Table 7.

Table 7. OMAX and TLS assessment of source process

KPI	S1a	S1b	S1c	S2a
Performance	100%	100%	79,83%	99,09%
10	**100%**	**100%**	100%	**100%**
9	92,84%	92,84%	92,84%	92,84%
8	85,7%	85,7%	85,7%	85,7%
7	78,56%	78,56%	**78,56%**	78,56%
6	71,42%	71,42%	71,42%	71,42%
5	64,28%	64,28%	64,28%	64,28%
4	57,14%	57,14%	57,14%	57,14%
3	50%	50%	50%	50%
2	33,34%	33,34%	33,34%	33,34%
1	16,67%	16,67%	16,67%	16,67%
0	0%	0%	0%	0%
Level	10	10	7,6	9,88
Weight	0,06	0,38	0,38	0,18
Value	0,6	3,8	2,91	1,79

KPI Sla (percentage of suppliers with environmental management system) with a score of 10, KPI Slb (inventory accuracy of raw materials) with a score of 10, and KPI S2a (timely delivery performance by suppliers) with a score of 9.88 are in the green category where performance has reached the company's target. Meanwhile, KPI Slc (qualification accuracy of raw materials) with a score of 7.6 is in the yellow category where performance has not yet reached the company's target so that corrective steps need to be taken. The results of the scoring system for the make process can be seen in Table 8.

Table 8. OMAX and TLS assessment of make process

KPI	M1a	M2a
Performance	97,32%	63,33%
10	**100%**	100%
9	92,84%	92,84%
8	85,7%	85,7%
7	78,56%	78,56%
6	71,42%	71,42%
5	64,28%	**64,28%**
4	57,14%	57,14%
KPI	M1a	M2a
Performance	97,32%	63,33%
3	50%	50%
2	33,34%	33,34%
1	16,67%	16,67%
0	0%	0%
Level	9,73	4,88
Weight	0,5	0,5
Value	4,865	2,44

KPI Mla (adherance to production schedule) with a score of 9.73 is in the green category where performance has reached the company's target. While KPI M2a (number of trouble machines) with a score of 4.88 is in the yellow category where performance has not reached the company's target so that corrective steps need to be taken. KPI The results of the scoring system for the deliver process can be seen in Table 9 as follows.

Table 9. OMAX and TLS assessment of the deliver process

KPI	D1a	D1b	D2a	D2b
Performance	99,98 %	100%	100%	100%
10	**100%**	**100%**	**100%**	**100%**
9	92,84 %	92,84 %	92,84 %	92,84 %
8	85,7%	85,7%	85,7%	85,7%
7	78,56 %	78,56 %	78,56 %	78,56 %
6	71,42 %	71,42 %	71,42 %	71,42 %
5	64,28 %	64,28 %	64,28 %	64,28 %
4	57,14 %	57,14 %	57,14 %	57,14 %
3	50%	50%	50%	50%
KPI	D1a	D1b	D2a	D2b
Performance	99,98 %	100%	100%	100%
2	33,34 %	33,34 %	33,34 %	33,34 %
1	16,67 %	16,67 %	16,67 %	16,67 %
0	0%	0%	0%	0%
Level	9,99	10	10	10
Weight	0,326	0,242	0,189	0,242
Value	3,326	2,42	1,89	2,42

Dla (delivery quantity accuracy by the company) with a score of 9.99,KPI D1b (inventory accuracy for finished products) with a score of 10, KPI D2a (timely delivery performance by the company) with a score of 10, and KPI D2b (delivery cycle time by the company) with a score of 10 are in the green category where performance has reached the company's target. The company's supply chain performance measurement scheme obtained a total index which can be seen in Table 10.

Tabel 10. Supply chain performance measurement scheme

Core Process's Weight (A)	Performance Attribute's Weight (B)	KPI's Weight	KPI's Value	KPI's Total Value (C)	Performance Attribute's Value (D=BxC)	Core Process's Value (E=DxA)
Plan (0,099)	*Reliability* (1)	P1a (0,5) P1b (0,5)	4,98 4,975	9,955	9,955	0,986
Source (0,471)	*Reliability* (0,833)	S1a (0,062) S1b (0,380) S1c (0,380)	0,6 3,8 2,91	9,1	7,580	4,286
	Responsiveness (0,167)	S2a (0,178)	1,79		1,5197	
Make (0,327)	*Reliability* (0,5)	M1a (0,5)	4,865	7,305	3,6525	2,389
	Responsiveness (0,50)	M2a (0,5)	2,44		3,6525	
Deliver (0,104)	*Reliability* (0,5)	D1a (0,326) D1b (0,242)	3,326 2,42	10,056	5,028	1,046
	Responsiveness (0,50	D2a (0,189) D2b (0,242)	1,89 2,42		5,028	
		***Index* Total**				**8,706**

5. CONCLUSION

Based on data collection and processing, it can be concluded that the performance level at PT Yale Woodpellet Indonesia consists of 10 green KPIs and 2 yellow KPIs. Green KPIs mean that they have reached the target. KPIs that have not reached the target or in the yellow category are Qualification Accuracy of Raw Material (S1c) and Number of Trouble Machines (M2a). This research only uses two attributes, namely reliability and responsiveness, because the focus of this research is to minimise waste in the supply chain, so that future research can add flexibility, assets, and cost attributes to the performance indicators in order to obtain more detailed performance measurement results. The implication of this research is that companies can find out performance indicators that need improvement so that when these performance indicators are optimal, production delays and the number of products can reach the target because the raw materials are in accordance with production needs.

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