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Development of the lean and green balanced scorecard performance management system in electronic component industry

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Abstract: The electronic component industry is facing pressure to enhance sustainability while maintaining operational efficiency. Therefore, this research aims to develop the lean and green balanced scorecard (LG-BSC) performance management system (PMS) through the integration of lean manufacturing and numerous principles with sustainability. The LG-BSC PMS combines four balanced scorecard (BSC) perspectives with sustainable value stream mapping (SVSM) to comprehensively evaluate both efficiency and sustainability performance. Implementing LG-BSC PMS in an electronics company can evaluate natural resource efficiency, green procurement, and operational performance. The result showed that the key performance indicators (KPIs) met the target company, with the financial, business process, customer satisfaction, and learning perspectives at 113.17%, 154.66%, 111.4%, and 113.88%. The results confirm that LG-BSC PMS provides a holistic and integrated method for evaluating company performance, balancing strategic management with environmental sustainability.

Keywords: lean; green; sustainability; scorecard; performance; electronic industry.

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1 Introduction

Performance measurement plays a crucial role in ensuring organisational effectiveness and long-term sustainability. The balanced scorecard (BSC), introduced by Kaplan and Norton (1992), is a widely recognised strategic performance management tool that integrates financial and non-financial indicators across four perspectives: financial, customer, internal processes, and learning and growth. Globally, BSC implementation has evolved to incorporate innovation, autonomy, and real-time analytics (Rhodes et al., 2008; Simbolon, 2018; Erawan et al., 2022), while in Indonesia it emphasises accountability and compliance, particularly in public sector performance management.

Recent studies have increasingly emphasised the importance of integrating sustainability into performance measurement systems, especially in logistics and supply chain management. Kumar et al. (2025) argue that sustainability-oriented performance measurement enhances both operational efficiency and long-term competitiveness.

In parallel, the integration of lean and green approaches has gained significant attention as organisations seek to simultaneously improve efficiency and reduce environmental impact. Recent studies emphasise that combining lean and green practices is critical for achieving competitiveness in industrial systems (Andreazza de Freitas et al., 2025; Sharma et al., 2024). These studies show that environmentally sustainable value stream mapping (SVSM) and lean waste reduction techniques can significantly improve both operational and environmental performance. Similar findings have also been reported in Indonesian industrial contexts, highlighting the relevance of integrating lean and green practices in local manufacturing systems (Lestari et al., 2024; Samiun and Damau, 2024).

Studies confirm that the BSC remains a robust framework for evaluating supply chain performance when extended to incorporate sustainability dimensions (Khorasani and Almasifard, 2020; Ghasemi and Hejazi, 2018). In addition, prior research highlights the applicability of BSC-based performance dashboards in linking operational and financial performance (Peidaie and Sadeghimanesh, 2017), as well as the increasing importance of green supply chains and Industry 4.0 in enhancing sustainable and lean manufacturing systems (Shahbaz et al., 2024; Daniel et al., 2024). Furthermore, integrating lean and green practices within structured performance measurement systems has been shown to significantly improve both operational efficiency and environmental performance (Garcia-Buendia et al., 2022; Faulkner and Badurdeen, 2014).

Despite these advancements, existing studies predominantly examine lean manufacturing, green sustainability, and performance measurement frameworks in a fragmented manner. Lean approaches mainly focus on operational efficiency and waste reduction, while green practices emphasise environmental impact and resource sustainability. Meanwhile, the BSC framework is widely used to align strategy with performance indicators but often lacks detailed operational and environmental integration. Although several studies have attempted to combine lean and green practices or extend the BSC with sustainability indicators, there remains limited research that systematically integrates these three dimensions into a unified performance management system (PMS). In particular, the incorporation of SVSM into a structured BSC framework remains under explored.

This research gap is especially relevant in high-precision manufacturing industries, such as electronic component manufacturing, where efficiency, quality, and environmental performance must be optimised simultaneously. Therefore, there is a need for an integrated framework that combines lean, green, and strategic performance measurement into a comprehensive and practical system.

Accordingly, this study proposes a lean and green (LG)-BSC PMS that integrates SVSM with the four BSC perspectives. This framework aims to measure and manage both productivity and sustainability outcomes while aligning operational improvements with strategic objectives.

The objectives of this study are:

1. to develop a LG-BSC PMS for an Indonesian electronic component manufacturer
2. to integrate sustainability and lean principles into performance measurement indicators
3. to evaluate the effectiveness of the proposed system in improving financial performance, operational efficiency, customer satisfaction, and resource sustainability.

2 Literature review

2.1 BSC in performance measurement

The BSC has been widely adopted as a strategic performance management tool that translates organisational vision and strategy into measurable indicators. Numerous studies demonstrate its effectiveness in improving organisational performance across manufacturing sectors (Mahmoud, 2014; Saniuk et al., 2012; Habidin et al., 2012). Key success factors include leadership commitment, employee training, communication, and gradual implementation.

In Indonesia, BSC implementation has been used to identify inefficiencies, improve quality systems, and enhance strategic alignment. However, challenges remain, including limited technological infrastructure, difficulties in key performance indicators (KPIs) development, and resistance to non-financial performance metrics (Simbolon, 2018; Putri and Suhendra, 2023; Praptapa et al., 2016).

2.2 Lean and green integration

Lean manufacturing focuses on eliminating waste and improving process efficiency, while green manufacturing emphasises environmental sustainability, including emission reduction and resource efficiency. The integration of lean and green approaches has been widely recognised as a strategy for achieving sustainable operational performance (Faulkner et al., 2012; Faulkner and Badurdeen, 2014; Ikatrinasari et al., 2018).

Organisations increasingly adopt lean-green practices to simultaneously improve productivity and reduce environmental impact. These approaches enable firms to identify non-value-added activities while minimising environmental footprint, creating a synergy between efficiency and sustainability.

The LG-BSC integrates lean efficiency and environmental sustainability into the BSC framework. Previous studies have explored the theoretical foundations of this integration, highlighting causal relationships between lean practices and environmental performance (Duarte et al., 2011; Carvalho et al., 2011; Duarte and Machado, 2015).

More recent studies have introduced advanced methods such as DEMATEL and Delphi techniques to prioritise sustainability-related KPIs (Nurcahyo et al., 2018; Garcia-Buendia, 2022), as well as dynamic modelling approaches to capture complex interdependencies among performance indicators (Tsalis, 2015). Despite these developments, practical implementation in specific industrial contexts remains limited.

2.3 Sustainable value stream mapping

SVSM extends traditional value stream mapping by incorporating environmental and sustainability metrics. It provides a comprehensive visualisation of material and information flows while integrating indicators such as energy consumption, emissions, and resource efficiency (Faulkner et al., 2012; Faulkner and Badurdeen, 2014; Ikatrinasari et al., 2018).

SVSM has evolved through various approaches, including life cycle mapping, supply chain extensions, and integration with advanced technologies such as life cycle assessment (LCA), discrete event simulation (DES), IoT, and RFID (Paju et al., 2010; Sparks and Badurdeen, 2014; Djatna and Prasetyo, 2019). Applications across industries – including agribusiness, electronics, apparel, and SMEs – have demonstrated its effectiveness in improving energy efficiency, reducing emissions, and optimising lead times (Andreazza de Freitas et al., 2025; Sharma et al., 2024; Mishra et al., 2020).

3 Methodology

3.1 Research design

This study adopts a single-site case study approach combined with a quantitative descriptive research design to develop and evaluate a LG-BSC PMS in an electronic component manufacturing company in Indonesia. The case study approach is appropriate as it enables an in-depth examination of the integration of lean practices, environmental sustainability, and performance measurement within a real industrial context. The research is designed not only to describe performance outcomes but also to develop a structured performance measurement framework that integrates operational efficiency and environmental sustainability into a unified system.

A descriptive analytical approach was employed due to the practical and applied nature of the study, which emphasises real-world implementation rather than predictive modelling. This approach facilitates a comprehensive evaluation of KPI performance and provides actionable insights to support managerial decision-making.

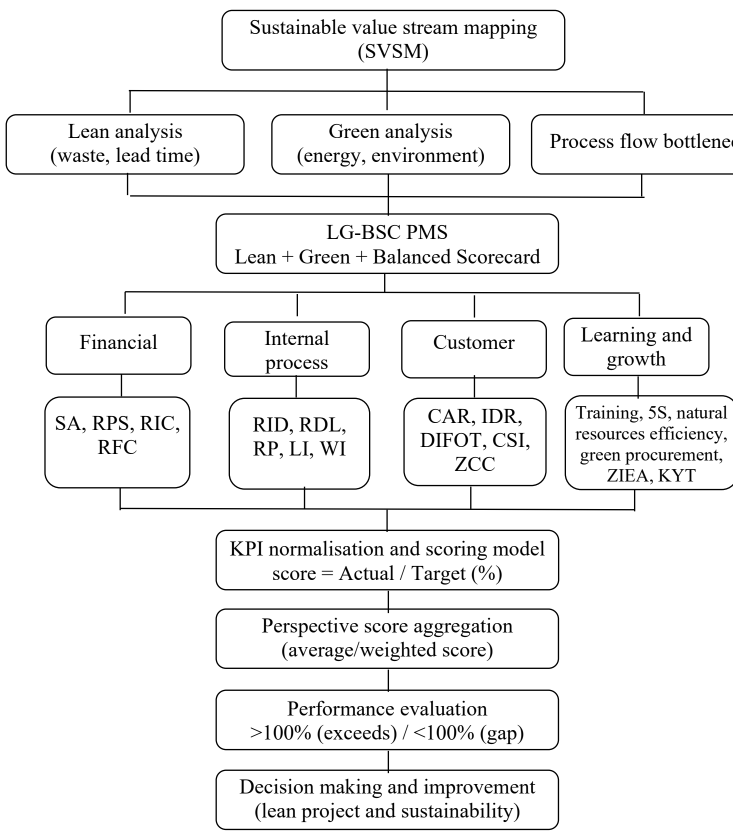
3.2 Research framework

The conceptual framework of this study integrates three main components:

1. lean principles, focusing on waste reduction and process efficiency
2. green practices, emphasising environmental sustainability and resource efficiency
3. BSC, structuring performance measurement into four perspectives: financial, customer, internal business process, and learning and growth

These components are operationalised through SVSM, which serves as the primary analytical tool to identify operational inefficiencies and environmental hotspots. The overall framework of the LG-BSC PMS is illustrated in Figure 1.

Figure 1 LG-BSC framework



3.3 Data collection

Data used in this study consist of secondary operational and environmental data obtained from internal company records, as well as supporting data from external sources.

1 internal company data: production volume, defect reports, inspection and failure cost data, delay lot records, lean project documentation (VSM initiatives)

2 environmental performance data were collected monthly, including: electricity consumption (kWh), LPG usage (kg), water consumption (m^3), wastewater treatment (WWT) sludge

3 organisational data include: training records, 5S and safety audit scores, compliance checklist data, customer complaint records.

Additional data were obtained from relevant standards and academic literature to define KPI formulations, establish performance benchmarks and support the development of the LG-BSC framework.

3.4 Development of LG-BSC PMS model

The LG-BSC PMS model was developed through the integration of SVSM outputs into structured KPIs aligned with the four BSC perspectives. KPIs were derived from operational and environmental performance metrics, including:

1 financial perspective: sales amount (SA), ratio product scrap (RPS), ratio inspection cost (RIC), ratio failure cost (RFC)

2 internal process perspective: internal defect ratio (RID), delay lot ratio, productivity ratio, process efficiency

3 customer perspective: delivery in full on time (DIFOT), customer complaints

4 learning and growth perspective: training effectiveness, 5S score, Safety performance, compliance indicators

3.5 KPI measurement and scoring model

The KPI measurement and scoring model in this study is designed to evaluate organisational performance in a structured and transparent manner based on the LG-BSC PMS. The measurement framework integrates financial, customer, internal business process, and learning and growth perspectives by translating operational and sustainability indicators into standardised performance metrics.

Table 1 presents the KPIs and their corresponding measurement formulas used in this study. Each KPI is calculated using ratio-based or index-based formulas to ensure comparability across different operational units and performance perspectives. Financial indicators, such as RPS, RIC, and RFC, are expressed as cost proportions relative to total production output. Customer and internal process indicators are primarily calculated as percentage achievement levels or defect ratios (parts per million), reflecting service reliability, responsiveness, and process quality. Meanwhile, learning and growth indicators include training completion rates, resource efficiency ratios, compliance levels, and safety performance metrics.

Table 1 KPI measurement formulas

KPI code	*Key performance indicator (KPI)*	*Measurement formula*	*Unit*
Financial perspective			
F1	Sales amount (SA)	Total monthly sales value	Currency
F2	Ratio product scrap (RPS)	(Scrap cost / total production) × 100%	%
F3	Ratio inspection cost (RIC)	(Inspection cost / total production) × 100%	%
F4	Ratio failure cost (RFC)	(Failure cost / total production) × 100%	%
Internal business process			
B1	Internal defect ratio (RID)	(Internal defects / total production) × 10^6	PPM
B2	Delay lot ratio (RDL)	(Delay cases / total shipments) × 100%	%
B3	Productivity ratio (RP)	(Actual output / target output) × 100%	%
B4	Lean implementation (LI)	(Completed lean projects / target projects) × 100%	%
B5	Work instruction simplification	(Completed simplifications / target) × 100%	%
Customer satisfaction			
C1	Corrective action response (CAR)	(On-time actions / total actions) × 100%	%
C2	Internal defect reply (IDR)	(On-time responses / total cases) × 100%	%
C3	Delivery in full on time (DIFOT)	(On-time deliveries / total deliveries) × 100%	%
C4	Zero customer complaints (ZCC)	(Target complaints / actual complaints) × 100%	%
C5	Customer satisfaction index (CSI)	Survey-based satisfaction score	%
Learning and growth			
L1	Education and training	(Completed training / planned training) × 100%	%
L2	Electricity efficiency	Production output / electricity consumption	Ratio
	LPG efficiency	Production output / LPG consumption	Ratio
	Water efficiency	Production output / water consumption	Ratio
	WWT sludge efficiency	Production output / sludge generated	Ratio
	Paper efficiency	Production output / paper usage	Ratio
L3	Compliance obligation (CO)	(Fulfilled requirements / total requirements) × 100%	%
L4	5S and safety patrol	Audit score	%
L5	Zero injuries and environmental accidents (ZIEA)	(Target / actual accidents) × 100%	%
L6	Kiken Yochi training (KYT)	(Completed KYT / target) × 100%	%

To ensure consistency in performance evaluation, all KPI values are normalised into percentage scores by comparing actual performance against predefined targets. The general scoring principle is defined as follows:

- for benefit-type KPIs (higher is better):

$$\text{Score} = (\text{Actual value}/\text{Target value}) \times 100\%$$

- for cost-type KPIs (lower is better):

$$\text{Score} = (\text{Target value}/\text{Actual value}) \times 100\%$$

This normalisation approach enables the comparison of different KPIs within a unified scale, where a score above 100% indicates performance exceeding the target, while a score below 100% indicates underperformance.

The overall performance score for each BSC perspective is calculated as the average of all KPI scores within the respective perspective. In this study, an unweighted aggregation approach is applied, assuming equal importance of each KPI due to the exploratory and implementation-oriented nature of the research. The aggregate score for each perspective is calculated as:

$$\text{Perspective score} = \left(\sum \text{KPI scores}\right) \Big/ \text{Number of KPIs}$$

Furthermore, to support managerial decision-making, KPI results are interpreted based on deviation thresholds. KPIs with deviations greater than ±20% from the target are considered significant and require further investigation through root cause analysis. This approach ensures that performance measurement is not only descriptive but also diagnostic, enabling continuous improvement aligned with lean and green principles.

Overall, the KPI measurement and scoring model provides a systematic and reproducible mechanism to evaluate the effectiveness of the LG-BSC PMS, ensuring alignment between operational performance, environmental sustainability, and strategic objectives.

4 Results and discussion

4.1 Financial perspective

The financial perspective presented in Table 2 demonstrates that overall performance exceeded the predefined targets, with an aggregate score of 113.17%. This indicates that the organisation has achieved a favourable level of financial efficiency following the implementation of the LG-BSC PMS.

KPIs such as SA, product scrap ratio (RPS), and RFC show strong performance improvements. The RPS reached 245%, reflecting a substantial reduction in scrap costs relative to the maximum allowable target. This result suggests that lean initiatives – particularly those targeting waste elimination and process improvement – have been effective in minimising material losses. Similarly, the RFC achieved 134.2%, indicating successful control of failure-related costs. These findings indicate that lean initiatives significantly contributed to improved financial performance by reducing operational waste and enhancing revenue generation.

Table 2 Financial perspective LG-BSC PMS

KPI		*Target*	*Realisation*	*%*
Sales amount (SA)/F1		2,100,000	2,300,000	109.5
Product scrap ratio (RPS)/F2		*Max 98*	*40*	245
A	MFG 1 – assembly	79	55	143.6
B	MFG 2 – stamping	53	19	278.9
C	MFG 3 – moulding	301	176	171.0
D	MFG 4 – plating	76	24	316.7
E	MFG 5 – brazing	1	0.1	1000
F	Non-MFG	15	1	1500
Inspection cost ratio (RIC)/F3		*Max 4,600*	*4,800*	95.8
A	MFG 1 – assembly	2,704	3,063	88.3
B	MFG 2 – stamping	543	644	84.3
C	MFG 3 – moulding	6,666	8,411	79.3
D	MFG 4 – plating	9,069	11,627	78.0
E	MFG 5 – brazing	8,084	8,955	90.3
F	Non-MFG	0	0	100
Ratio failure cost (RFC)/F4		*Max 3,550*	*2,645*	134.2
A	MFG 1 – assembly	13,537	10,466	129.3
B	MFG 2 – stamping	904	670	134.9
C	MFG 3 – moulding	2,109	2,024	104.2
D	MFG 4 – plating	849	1,193	71.2
E	MFG 5 – brazing	603	186	324.2
F	Non-MFG	0	8	0
Total financial perspective performance				*113.17*

Despite these positive results, the RIC did not meet the target, achieving only 95.8%. This indicates that inspection-related costs remain relatively high, suggesting inefficiencies in quality control processes. A more detailed sub-unit analysis reveals performance variations across production units. Assembly and Stamping units recorded relatively higher inspection costs, while other units showed fluctuating results. This condition implies that the company may still rely heavily on inspection activities rather than preventive quality control approaches. From a managerial perspective, shifting toward upstream quality improvement – such as process stabilisation and defect prevention – could help reduce inspection dependency and improve cost efficiency.

It should be noted that several sub-units, particularly in the brazing and non-manufacturing functions, exhibit very high KPI scores (e.g., exceeding 1000%). These results reflect significantly improved performance compared to the predefined maximum targets. For instance, in the Brazing unit, the product scrap ratio (RPS) achieved a value of 0.1 against a target of 1, while in non-manufacturing functions, the actual scrap value of 1 was substantially lower than the maximum target of 15. These findings indicate that lean initiatives have been highly effective in minimising material waste across both production and support activities.

However, it is important to recognise that ratio-based normalisation may amplify KPI scores when actual values are significantly lower than their targets, particularly in cases where baseline values are small. Therefore, while these high scores represent strong operational performance, their magnitude should be interpreted cautiously, as they may overstate the proportional improvement. This highlights the need for careful interpretation of extreme values and suggests that future evaluations may benefit from applying normalised scoring limits or capped values to ensure more balanced performance representation.

Overall, the financial performance results confirm that the integration of lean practices within the LG-BSC PMS contributes significantly to cost reduction and financial efficiency. At the same time, the presence of inefficiencies in inspection-related costs indicates that further improvements are required to achieve a more balanced and sustainable financial performance.

These findings are consistent with previous studies, which highlight that lean implementation significantly reduces operational waste and improves financial performance in manufacturing systems (Sharma et al., 2024; Andreazza de Freitas et al., 2025). This study further extends prior research by demonstrating how integrating lean practices within a structured LG-BSC framework enhances financial control in high-precision industries.

4.2 Internal business process perspective

The internal business process perspective presented in Table 3 achieved the highest aggregate score of 154.66%, indicating substantial improvements in operational efficiency following the implementation of the LG-BSC PMS. This result suggests that process optimisation initiatives, particularly those derived from SVSM, have effectively reduced operational inefficiencies and enhanced workflow performance.

KPIs demonstrate consistent improvements across multiple dimensions. The internal defect ratio (RID) achieved 110%, reflecting a reduction in defect levels compared to the maximum allowable target. This indicates that process improvements and quality control measures have contributed to minimising rework and waste. Similarly, the ratio delay lot (RDL) reached 192%, suggesting a significant reduction in delivery delays. This improvement is closely associated with better process flow synchronisation and bottleneck reduction, as identified through SVSM analysis. The productivity ratio (RP) slightly exceeded the minimum target at 101%, indicating stable and controlled production output without overburdening resources.

From a lean perspective, these results confirm that eliminating non-value-added activities and improving process flow directly enhance operational performance. The integration of SVSM enables the identification of inefficiencies not only in time but also in energy and resource utilisation, thereby supporting both lean and green objectives within the production system.

Lean implementation (LI) emerged as the most significant contributor, achieving an overall score of 270%. This indicates a strong commitment to continuous improvement across the organisation. However, substantial variation exists between units. For instance, the Brazing unit achieved an exceptionally high score of 1036%, while other units such as Plating reached comparatively lower values (195%). The high performance in Brazing suggests intensive implementation of lean projects, potentially focusing on waste elimination and process redesign. However, similar to other ratio-based KPIs, extremely high values may also be influenced by relatively small baseline targets, which can amplify the resulting score.

Table 3 Business process perspective LG-BSC PMS

KPI	*Target*	*Realisation*	*%*
Internal defect ratio/B1	*Max 89*	*81*	*110*
A 70	51	137	143.6
B 35	38	92	278.9
C 217	191	114	171.0
D 85	65	130	316.7
E 125	161	77	1000
F 8	5	160	1500
Ratio delay lot (RDL)/B2	*Max 1.1*	*0.57*	*192*
Productivity ratio (RP)/B3	*Min 148*	*150*	*101*
A 26	26	100	88.3
B 146	136	93	84.3
C 85	86	101	79.3
D 92	118	125	78.0
E 37	37	100	90.3
F 651	635	97	100
Lean implementation (LI)/B4	*Min 399*	*1,078*	*270*
A 56	85	151	129.3
B 54	174	322	134.9
C 60	87	145	104.2
D 42	82	195	71.2
E 19	197	1036	324.2
F 169	454	256	0
Simplify working instruction	*50*	*50.16*	*100.3*
A 10	10.5	105	129.3
B 10	10.1	101	134.9
C 10	10.5	105	104.2
D 10	10.3	103	71.2
E 10	10.2	102	324.2
Total financial perspective performance			*154.66*

Therefore, while these results indicate outstanding performance, they should be interpreted with caution. The variation across units highlights uneven adoption of lean practices, suggesting that certain departments may have more advanced capabilities or stronger managerial support for continuous improvement initiatives. This indicates the need for knowledge transfer and standardisation of best practices across all production units.

In addition, the simplification of working instructions achieved 100.3%, indicating that standardisation efforts have been successfully implemented. This supports process consistency and reduces variability in operations, which is a critical component of lean systems.

Overall, the results of the internal business process perspective confirm that the integration of SVSM and lean implementation within the LG-BSC PMS significantly enhances process efficiency and operational control. Furthermore, improvements in internal processes are expected to positively influence customer satisfaction and financial performance, consistent with the causal relationships proposed in the BSC framework.

These findings support previous studies, which show that lean practices such as value stream mapping and continuous improvement initiatives significantly enhance process efficiency and reduce operational waste (Samiun and Damau, 2024; Sharma et al., 2024). Compared to prior research, this study provides a more structured integration by linking lean implementation directly with KPI-based performance measurement within the LG-BSC framework.

4.3 Customer satisfaction performance

The customer satisfaction perspective presented in Table 4 achieved an aggregate score of 111.4%, indicating that overall customer-related performance exceeded the predefined targets. This reflects the organisation's ability to deliver products consistently while maintaining high responsiveness to customer requirements following the implementation of the LG-BSC PMS.

Table 4 Customer satisfaction perspective LG-BSC PMS

KPI		*Target*	*Realisation*	*%*
Corrective action response/C1		100	100	100
Internal defect reply (IDR)/C2		*100*	*100*	*100*
Delivery in full – on time/C3		100	100	100
Zero customer complaints /ZCC/C4		*Max 11*	*7.0*	157
A	MFG 1 – assembly	Max 3.5	2.0	175
B	MFG 2 – stamping	Max 1.4	1.0	140
C	MFG 3 – moulding	Max 0.8	0.0	800
D	MFG 4 – plating	Max 1.5	3.0	50
E	MFG 5 – brazing	Max 1.0	0.0	100
F	Non-MFG	Max 2.8	1.0	280
Customer satisfaction index (CSI)/C5		80	80	100
Total performance customer satisfaction perspective				*111.4*

KPIs such as corrective action response (CAR), internal defect reply (IDR), DIFOT, and customer satisfaction index (CSI) all achieved 100%, demonstrating effective communication, timely response to quality issues, and reliable delivery performance. These results indicate that improvements in internal processes – particularly defect reduction and delay minimisation – have been successfully translated into enhanced service quality from the customer's perspective.

From a BSC standpoint, this finding confirms the causal relationship between internal business process improvements and customer satisfaction. The reduction of operational inefficiencies identified through lean and SVSM-based interventions contributes directly to improved delivery reliability and product quality, which are critical determinants of customer trust.

The zero customer complaints (ZCC) KPI further supports this outcome, achieving an overall score of 157%. Several units, including assembly, stamping, and non-manufacturing, exceeded targets significantly, indicating strong performance in minimising customer complaints. In particular, the moulding and brazing units achieved zero complaints, resulting in very high scores (e.g., up to 800%). These results reflect excellent product quality and effective defect prevention mechanisms.

However, similar to other ratio-based KPIs, extremely high scores in ZCC should be interpreted with caution. These values are influenced by very low or zero complaint levels relative to predefined maximum thresholds, which mathematically inflate the performance ratio. Therefore, while these results indicate outstanding performance, they may not proportionally represent the magnitude of improvement.

In contrast, the plating unit recorded a ZCC score of only 50%, indicating the presence of persistent quality issues in this production line. This underperformance suggests that process improvements in Plating have not yet been fully effective. Possible causes include process variability, insufficient quality control, or incomplete implementation of lean practices.

From a managerial perspective, this gap highlights the need for targeted corrective actions in the plating unit. These may include root cause analysis, tighter process control, enhanced operator training, and the application of preventive quality improvement strategies. Ensuring consistency across all production units is essential to sustain overall customer satisfaction performance.

Overall, the results confirm that the integration of lean and green practices within the LG-BSC PMS enhances customer satisfaction by improving responsiveness, delivery reliability, and product quality. However, achieving uniform performance across all units remains a key challenge that must be addressed to fully optimise customer value.

These results are consistent with prior studies, which emphasise that improvements in internal processes and quality management directly enhance customer satisfaction and service performance (Lestari et al., 2024). This study extends existing literature by demonstrating how integrating lean and green indicators within the BSC framework strengthens customer-related outcomes in manufacturing systems.

4.4 Learning and growth perspective

The learning and growth perspective presented in Table 5 achieved an aggregate score of 113.88%, indicating that the organisation has generally met and exceeded its targets in developing organisational capabilities and supporting sustainability initiatives. This perspective plays a critical role as the foundation for continuous improvement, enabling enhancements in internal processes and, ultimately, overall organisational performance.

From an environmental sustainability standpoint, the natural resources efficiency (NRE) indicator achieved a score of 111.5%, reflecting effective resource management across several dimensions. Indicators such as LPG efficiency and WWT sludge discharge met or slightly exceeded targets, while additional initiatives – including the transition from CFC to non-CFC materials and reduced paper consumption – demonstrated strong environmental commitment. These results indicate that green practices have been successfully integrated into operational activities, contributing to resource optimisation without compromising production performance.

Table 5 Learning and growth perspective LG-BSC PMS

KPI		*Target*	*Realisation*	*%*
Education and training/L1		34.5		
A	On the job training	83%	96%	116
B	Fire fighting training	Min 2	2	100
C	First aid training	Min 1	1	100
D	Emergency drills	Min 1	0	0
Natural resources efficiency/L2				111.5
A	Electricity efficiency	487	464	95.3
B	LPG efficiency	7,755	7,764	100.1
C	Water consumption	20,413	19,325	94.7
D	WWT sludge discharge	21,294	21,382	100.4
E	Compressor air leakage	100%	100%	100
F	Paper consumption ratio	13,088	11,824	90.3
G	Change cfc to non-CFC program	7	14	200
Green procuremen/L3		*Min 100*	*100*	*100*
A	Material	100	100	100
B	Sub material	100	100	100
5S and safety patrol/L4		*Min 90*	*96*	*106.7*
A	MFG 1 – assembly	90	97	107.7
B	MFG 2 – stamping	90	89.6	99.5
C	MFG 3 – moulding	90	95	105.6
D	MFG 4 – plating	90	93	103.3
E	MFG 5 – brazing	90	98	108.9
F	Non-MFG	90	97	107.8
Zero injuries and environmental accidents (ZIEA)/L5				
A	MFG 1 – assembly	*Max 0*	*4*	~
B	MFG 2 – stamping	0	0	100
C	MFG 3 – moulding	0	0	100
D	MFG 4 – plating	0	1	~
E	MFG 5 – brazing	0	1	~
F	Non-MFG	0	0	100
Kiken Yochi training (KYT)/L6		*9*	*19.5*	*216*
A	MFG 1 – assembly	1	1.1	110
B	MFG 2 – stamping	1	1.1	110
C	MFG 3 – moulding	1	1.4	140
D	MFG 4 – plating	1	2.0	200
E	MFG 5 – brazing	1	1.0	100
F	Non-MFG	4	12.9	322.5
Total learning and growth perspective				*113.88*

However, certain indicators, such as electricity efficiency (95.3%) and water consumption (94.7%), fell slightly below target. This suggests that while overall environmental performance is strong, there remain opportunities to further improve energy and water management through more efficient technologies or stricter consumption control.

On the human capital side, performance is more varied. The education and training (E&T) KPI achieved only 34.5%, primarily due to the absence of emergency drills, which resulted in a score of zero for this sub-indicator. Although other training activities – such as on-the-job training, firefighting, and first aid – met or exceeded targets, the lack of emergency preparedness highlights a critical gap in organisational readiness and safety culture.

Similarly, the zero injuries and environmental accidents (ZIEA) indicator was not fully achieved, as incidents were still reported in assembly, plating, and brazing units. This indicates that, despite improvements in operational and environmental performance, workplace safety has not yet reached the expected standard. From a managerial perspective, this suggests the need for stronger safety enforcement, risk assessment practices, and preventive measures to reduce workplace incidents.

In contrast, Kiken Yochi training (KYT) demonstrated strong performance, achieving 216%. This reflects active engagement in hazard identification and risk awareness programs across units. However, similar to other ratio-based KPIs, high scores may be influenced by relatively low baseline targets, which can amplify percentage results. Therefore, while these results indicate positive engagement in safety awareness activities, their magnitude should be interpreted cautiously.

The 5S and safety patrol indicator also achieved a high score of 106.7%, indicating effective implementation of workplace organisation and safety monitoring practices. This supports a structured and disciplined work environment, which is essential for sustaining lean operations.

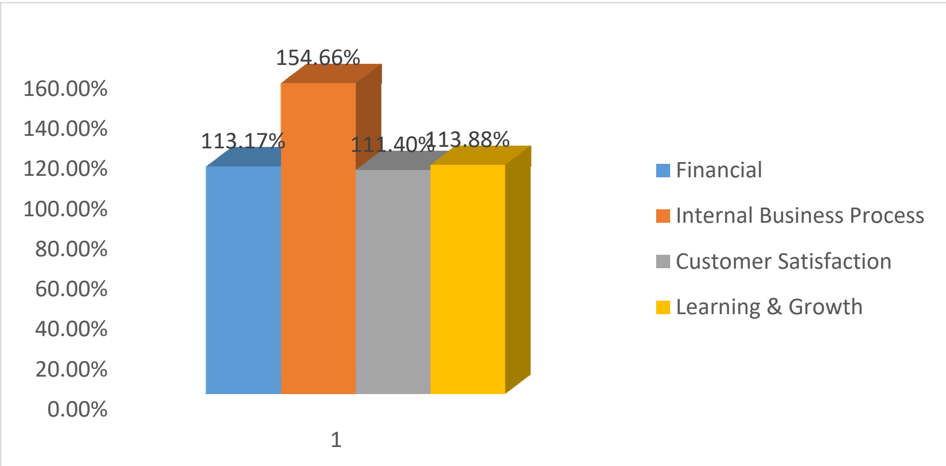
From a BSC perspective, these findings highlight that learning and growth capabilities – particularly in training, safety awareness, and sustainability practices – serve as key enablers for improving internal business processes. However, the imbalance between strong environmental performance and weaker safety outcomes suggests that further alignment is required to ensure holistic organisational development.

Overall, the results confirm that the integration of lean and green practices within the LG-BSC PMS supports both sustainability and capability development. Nevertheless, strengthening safety training, emergency preparedness, and accident prevention remains essential to achieve a more balanced and resilient organisational performance.

These findings are aligned with previous research, which shows that integrating sustainability and resource efficiency into PMS enhances both environmental and organisational performance (Kumar et al., 2025). This study contributes further by demonstrating how sustainability indicators can be operationalised within the LG-BSC PMS framework.

Figure 2 shows that the internal business process perspective achieved the highest performance, indicating the strong impact of lean implementation on operational efficiency. The remaining perspectives – financial, customer, and learning and growth – also exceeded their targets, demonstrating that process improvements were successfully translated into broader organisational performance outcomes. This result supports previous findings that operational efficiency plays a central role in enhancing financial and customer performance.

Figure 2 Overall performance across LG-BSC perspectives (see online version for colours)



A brief consideration of digital integration is also important for enhancing the applicability of the proposed LG-BSC PMS. In practice, the framework can be integrated with enterprise systems such as enterprise resource planning (ERP) and digital sustainability monitoring platforms to enable real-time KPI tracking and data-driven decision-making. The integration with Industry 4.0 technologies, including IoT-based data collection and automated reporting systems, would further improve the accuracy, responsiveness, and scalability of performance measurement. This digital alignment ensures that the LG-BSC PMS remains relevant in modern manufacturing environments where data integration and real-time analytics are increasingly essential.

5 Conclusions

This study achieved its primary objectives by successfully developing and implementing a LG-BSC PMS tailored for an Indonesian electronic component manufacturer. First, the study developed a structured performance management framework by integrating SVSM with the four perspectives of the BSC. This integration enabled the systematic translation of operational and environmental insights into measurable KPIs, providing a comprehensive tool for performance monitoring.

Second, the study successfully integrated lean and green principles into performance measurement indicators. Lean concepts were reflected in efficiency-related KPIs such as defect reduction, delay minimisation, and productivity improvement, while green aspects were incorporated through environmental indicators such as energy consumption, resource efficiency, and waste management. This demonstrates that operational efficiency and environmental sustainability can be effectively aligned within a unified performance measurement system.

Third, the evaluation results confirmed the effectiveness of the LG-BSC PMS in improving organisational performance across multiple dimensions. Financial performance exceeded targets through cost reduction and improved sales outcomes. Internal business processes showed significant improvements, particularly in defect reduction, process flow efficiency, and lean implementation. Customer satisfaction performance was enhanced through reliable delivery and effective responsiveness, although localised issues in specific units, such as plating, indicate the need for further improvement. In addition, sustainability performance improved through better resource utilisation and environmental management practices.

From a theoretical perspective, this study contributes to the development of performance management literature by extending the BSC framework to incorporate both lean and green dimensions in an integrated manner. The proposed LG-BSC PMS provides a structured approach for linking operational efficiency, sustainability, and strategic performance within a single framework.

From a managerial perspective, the findings suggest that organisations can use the LG-BSC PMS as a practical tool to align strategy with operational and environmental objectives. Managers can leverage the system to identify performance gaps, prioritise improvement initiatives, and ensure consistent implementation of lean and green practices across different units.

Despite these contributions, this study has several limitations. The research was conducted as a single case study within one manufacturing company, which may limit the generalisability of the findings. In addition, the analysis relies on historical company data, which may be influenced by internal reporting practices.

Future research is recommended to validate the LG-BSC PMS in different industrial sectors and organisational contexts. Further studies may also explore the application of advanced analytical methods, such as multi-criteria decision-making or dynamic modelling, to enhance KPI weighting and performance evaluation. Additionally, integrating digital technologies such as real-time monitoring systems could further improve the effectiveness of the performance management framework.

Declarations

All authors declare that they have no conflicts of interest.

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