
Designing A Sustainable Business Model Using BMC, SWOT, and TLBMC to Strengthen Biomass Supply Chain Resilience in Indonesia

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Abstract:

Indonesia's energy transition is accelerating the integration of biomass through co-firing in coal-fired power plants (PLTU), with a national target of 10 million tons of biomass utilization by 2025. However, supply inconsistency, quality variability, and logistical inefficiencies remain key obstacles. This study aims to develop a sustainable business model for a local biomass supplier by integrating the Triple Layered Business Model Canvas (TLBMC), Value Proposition Canvas (VPC), and SWOT analysis. This qualitative research adopts a case study design, with data collected through in-depth interviews, field observations, and document analysis. Informants include internal stakeholders from the supplier, state-owned electricity entities, and related institutional actors. The analysis identifies strategic strengths and weaknesses of the current model, external opportunities and threats, as well as gaps in quality control, dependency on external partners, and insufficient integration of environmental and social dimensions. By constructing a modified TLBMC–VPC framework based on SWOT findings, the study proposes a more resilient and efficient business model aligned with national decarbonization goals and inclusive supply chain engagement. The results contribute to enhancing supplier readiness and improving strategic alignment with Indonesia's low-carbon energy transition agenda.

Keywords: biomass supplier; sustainable business model; TLBMC; VPC; SWOT analysis; supply chain resilience

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INTRODUCTION

Indonesia's commitment to achieving Net Zero Emissions (NZE) by 2060 has placed unprecedented emphasis on renewable energy integration, particularly biomass co-firing in coal-fired power plants (PLTU). Recent data from the Ministry of Energy and Mineral Resources (ESDM) show that as of December 2024, Indonesia has achieved only 1.73 million tons of biomass utilization for co-firing—significantly below the national target of 10 million tons by 2025 (Ministerial Regulation of Energy and Mineral Resources No. 12/2023). This gap represents not merely a supply shortfall but a systemic challenge rooted in inconsistent feedstock quality, fragmented logistics networks, and inadequate governance frameworks. Furthermore, according to PLN's 2024 Sustainability Report, only 42% of PLTUs designated for co-firing have achieved their minimum 5% biomass blend ratio, highlighting structural inefficiencies that threaten the credibility of Indonesia's decarbonization agenda. These figures underscore the urgent need for transformative business models capable of addressing both operational bottlenecks and sustainability imperatives across the biomass supply chain.

Indonesia is facing major challenges in the energy transition to a low-carbon system, with a target of ten million tons of biomass utilization for cofiring at coal-fired power plants by 2025. Although this program reflects a progressive policy direction, its implementation still encounters several fundamental obstacles, particularly concerning supply instability, variability in raw material quality, and coordination inefficiencies (Dian et al., 2023; Firmansyah et al., 2023). The reliance on local

partners without standardized quality assurance frameworks has further compounded the situation. Therefore, efforts to strengthen business models that are not only economically viable but also oriented toward social and environmental sustainability are urgently required (Effendi et al., 2024).

One of the key suppliers involved in this initiative operates across regions with a wide distribution network and engages directly in feedstock processing. Despite this strategic position, the supplier's current business model remains transactional and lacks systematic integration of sustainability principles. This context offers a relevant and practical basis for developing a more adaptive and collaborative sustainable business model tailored to the challenges of the biomass supply chain.

This study focuses on the development of a sustainable business model for local biomass suppliers by integrating the Business Model Canvas (BMC) and SWOT analysis as foundational frameworks. These are further strengthened through the application of the Triple Layered Business Model Canvas (TLBMC) and the Value Proposition Canvas (VPC), both designed to ensure a strong alignment between the value offered and the needs of key corporate customers such as PLN IP and PLN EPI (Joyce & Paquin, 2016; Osterwalder et al., 2015). The interconnection between economic, social, and environmental dimensions forms the basis for evaluating how the business model can enhance supply chain resilience, distribution efficiency, and contribute to the decarbonization of the energy sector. This approach emphasizes not only business model innovation but also the strategic and systemic integration of sustainability-driven value creation.

Previous research, such as that presented by (Ahl et al., 2019; Zahraee et al., 2020b), has underscored the importance of sustainability in biomass supply chains, especially in relation to environmental and operational complexities in biomass logistics and value creation. However, despite growing attention to sustainability and the renewable energy transition, integrated frameworks such as the Triple Layered Business Model Canvas (TLBMC) and the Value Proposition Canvas (VPC) remain underutilized in the specific context of local biomass suppliers. Studies by (Amour et al., 2024) and (Hartati et al., 2023), for example, have applied the Basic Business Model Canvas (BMC) in assessing business development strategies in SMEs and energy-related sectors but lacked depth in integrating environmental and social dimensions. This gap reinforces the urgency for a more holistic and contextual approach for suppliers who face both market and operational uncertainties while playing a pivotal role in supporting Indonesia's energy transition agenda through the provision of sustainable biomass (Basile, 2021; Effendi et al., 2024; Joyce & Paquin, 2016).

The novelty of this research lies in three key contributions: (1) the development of a context-specific, triple-layered business model prototype that integrates economic viability, environmental accountability, and social inclusivity within Indonesia's biomass co-firing supply chain; (2) the systematic application of VPC to validate alignment between supplier capabilities and customer needs, ensuring strategic coherence across BMC elements; and (3) the provision of actionable insights derived from real-world stakeholder engagement with PLN entities, governmental regulators, and community-based partners, making the findings directly applicable to policy formulation and operational implementation.

This research contributes to the field by developing a prototype of a sustainable business model that integrates TLBMC and VPC within the biomass co-firing supply chain. Practically, the study provides a replicable framework for improving supplier readiness, enhancing supply chain governance through digitalized quality systems and service-level agreements (SLAs), and directly supporting national decarbonization targets aligned with Indonesia's Enhanced Nationally Determined Contribution (NDC) commitments. From an academic perspective, it expands the application of layered

business model frameworks in the community-based energy sector, offering theoretical advancement in sustainable business model innovation literature, particularly in emerging economy contexts characterized by fragmented supply chains and evolving regulatory landscapes.

The primary objective of this research is to design and validate a sustainable business model prototype that is strategically relevant to the real-world challenges and operational projections of biomass suppliers engaged in Indonesia's national energy transition. Specific objectives include: (1) mapping the existing business model using BMC and diagnosing its strategic strengths and weaknesses through SWOT and TOWS analysis; (2) developing an integrated TLBMC framework that encompasses economic, environmental, and social dimensions tailored to biomass supply chain dynamics; (3) validating the coherence and alignment of the proposed business model through VPC to ensure fit with stakeholder needs; and (4) formulating strategic recommendations to enhance supply chain resilience, stakeholder inclusivity, and alignment with Indonesia's Net Zero Emissions (NZE) roadmap.

The expected benefits of this research are multifaceted. For practitioners, the study offers a practical blueprint for biomass suppliers to transition from transactional to collaborative and sustainability-oriented business models. For policymakers, it provides evidence-based insights to refine regulatory frameworks and improve coordination between public and private actors in renewable energy ecosystems. For academia, the research enriches the theoretical discourse on sustainable business model innovation by demonstrating the empirical application of TLBMC in a previously underexplored sector. Finally, for society and the environment, the proposed model contributes to more equitable rural development, waste valorization, carbon emission reduction, and the advancement of Indonesia's just energy transition agenda.

RESEARCH METHOD

This study employed a qualitative case study approach to design a sustainable business model for a local biomass supplier within Indonesia's co-firing program. The methodology integrated exploratory analysis with strategic tools such as the Business Model Canvas (BMC), SWOT, and the Triple Layered Business Model Canvas (TLBMC) to address multidimensional sustainability. Using a single-case embedded design, the research examined the supplier's operations within the broader ecosystem, collecting primary data through in-depth interviews and focus group discussions with key informants, as well as secondary data from company documents and regulations.

Data was collected from January to May 2025 at the supplier's head office and PLN sites in Java. The analysis followed a structured sequence, beginning with mapping the current business model using the BMC, followed by a strategic diagnosis using SWOT and evaluation matrices. This informed the development of strategies through the TOWS matrix and culminated in the design of a sustainable business model with the TLBMC. The final stage aligned and validated the proposed value propositions with stakeholder needs through the Value Proposition Canvas (VPC), ensuring the model reflected operational realities and supported national energy goals.

Table 1. Variable Operational Definitions

Variable	Indicator	Item	Source
Business Model Canvas (BMC)	9 Business Blocks	Value Proposition, Key Activities, Channels, etc.	(Osterwalder & Pigneur, 2010)
SWOT Analysis	Strength, Weakness, Opportunity, Threat	Internal and external factors influencing business operations	(David & David, 2017; Rangkuti, 2006)

Variable	Indicator	Item	Source
TLBMC	Economic, Environmental, Social dimensions	Layered approach to model sustainability	(Elkington, 1997; Joyce & Paquin, 2016)
Value Proposition Canvas	Customer Jobs, Pains, Gains, Value Map Elements	Fit between customer needs and offerings	(Osterwalder et al., 2015)

Source: Processed Data (2025)

This comprehensive methodology enables the context-specific formulation, implementation, and validation of a sustainable business model in support of Indonesia’s biomass-based energy transition.

RESULTS AND DISCUSSION

Respondent Characteristics

A total of 18 key informants participated in this study. Informants were purposively selected based on their involvement in strategic and operational aspects of the biomass supply chain and energy transition policies. The breakdown is as follows:

- a) Local Biomass Supplier (4 informants): Chief Executive Officer, Director of Operations, Operations Manager, and Operational Staff.
- b) PLN EPI (7 informants): Director of Bioenergy, Vice President of Biomass Development Strategy, Strategic Planning Manager, Assistant Manager, Operations Services Manager, Vice President of Production and Supply Chain, and Operations Manager.
- c) PLN IP (3 informants): Vice President of Performance, Performance Manager, and Vice President of PPC.
- d) PLN NP (2 informants): Vice President of Performance and Vice President of Primary Energy.
- e) DIVRSK PLN (1 informant): Technical Coordinator for Renewable Power Plant Engineering.
- f) EBTKE (1 informant): Head of Section for Bioenergy Program Analysis and Evaluation at the Ministry of Energy and Mineral Resources.

Each informant contributed distinct insights into the biomass supply chain system. The supplier represented the upstream sector responsible for sourcing, processing, and distributing biomass. PLN EPI served as the primary off-taker and program coordinator, managing procurement processes and co-firing implementation strategies. PLN IP and PLN NP acted as power plant operators and performance monitors, assessing the technical and sustainability aspects of co-firing projects. DIVRSK functioned as an internal regulatory unit within PLN, offering oversight on biomass governance and alignment with corporate strategies. Meanwhile, EBTKE represented the external regulatory body responsible for aligning the biomass agenda with national energy transition policies. This diversity of perspectives ensured a rich and multifaceted dataset reflective of both operational realities and strategic decision-making.

Business Model Diagnosis and Mapping

The results are organized according to the key components of the business model frameworks applied in this study. Figure 1 illustrates the conceptual linkages among SWOT, TAM–SAM–SOM, VPC, and TLBMC analyses in shaping supply chain resilience and supplier readiness within the biomass co-firing ecosystem.

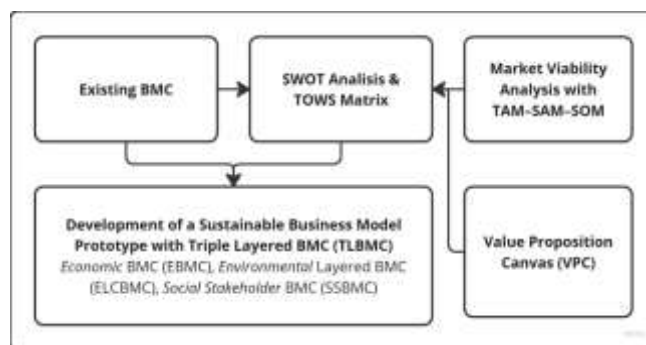


Figure 1 #Linkage among SWOT, TAM-SAM-SOM, VPC, and TLBMC

Source: (Rangkuti, 2006)

Thematic analysis from interviews revealed several important findings:

Existing BMC

To provide contextual clarity for the subsequent analysis, the study first examined the current business model of a local biomass supplier involved in PLN Group’s co-firing program. This supplier operates not merely as a commodity trader but as a feedstock manager and downstream quality controller. Its supply chain spans sourcing from sawmills, rice mills, and community enterprises, with direct partnerships structured through contractual agreements that emphasize legality and operational control.

The business model, mapped using the Business Model Canvas (BMC), reveals a value proposition centered on biomass reliability, quality assurance, and alignment with PLN’s decarbonization goals. The supplier’s key activities include feedstock aggregation, logistics supervision, and on-site quality monitoring using portable moisture testers. Key partners comprise legally registered suppliers, cooperatives, village-owned enterprises (BUMDes), and academic institutions such as IPB and ITB that contribute to research and mapping of energy crop potential. These interrelated elements are visually represented in Figure 2, which illustrates the current BMC structure of the local biomass supplier and serves as the analytical foundation for further strategic evaluation.

Revenue streams are primarily derived from biomass sales to PLN EPI, while the cost structure is dominated by logistics expenditures, infrastructure investments (e.g., weighbridges), and labor deployment. Despite its strategic role in the biomass supply chain, the supplier faces constraints such as short-term, volume-based contracts, limited pelletization capabilities, and high dependence on third-party logistics.

This business structure laid the groundwork for identifying internal strengths and weaknesses, which were further analyzed using the SWOT framework in the following section.

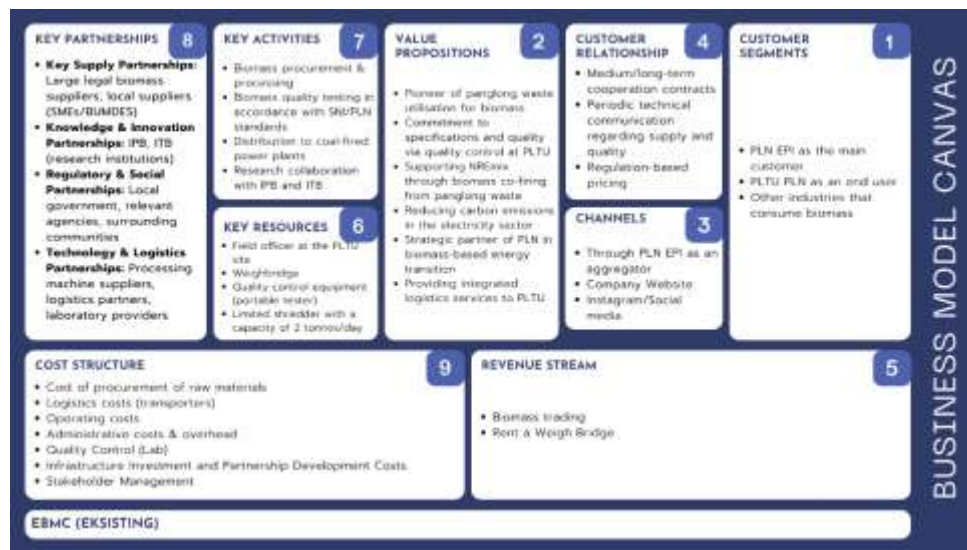


Figure 2. Existing Business Model Canvas Local Biomass Supplier

Source: Processed Data (2025)

SWOT Analysis and Strategic Matrix Synthesis

To structure a comprehensive understanding of the strategic position of the case company, a SWOT analysis was conducted by synthesizing thematic insights from in-depth interviews, monthly coordination meetings, and document reviews. This analysis was further supported by an Internal Factor Evaluation (IFE) and External Factor Evaluation (EFE), which formed the foundation of the strategic TOWS matrix.

The IFE analysis identified several key internal strengths, including a wide distribution network and logistical scale (S1), robust technical coordination mechanisms (S2), and strong institutional linkages within the PLN Group (S3). These internal strengths and their respective weightings are detailed in Table 2, which highlights the company's current capability profile and strategic leverage points. These strengths supported the formulation of strategic initiatives such as the expansion of integrated biomass services (SO1) and customized service segmentation based on the technical profiles of each PLTU (SO2).

Conversely, key internal weaknesses were identified, such as a high dependency on third-party operators without asset ownership (W1), limited operational control due to Cost, Insurance, and Freight (CIF)-based contracts (W2), and inconsistency in biomass quality (W3). These weaknesses were addressed through proposed strategies including the implementation of zonal distribution schemes (WO2) and the introduction of performance-based service-level agreements (WO3).

Table 2. Matrix IFE

NO	STRENGTHS	Weight	Rating	Score
1	Scale volume and distribution network	0,11	3,90	0,44
2	Technical capabilities & field coordination	0,12	3,50	0,40
3	Institutional relations within the PLN Group	0,12	3,30	0,39
4	PLN Group's readiness to utilize biomass	0,11	3,90	0,41
	Total	0,45		1,65
NO	WEAKNESSES	Weight	Rating	Score
1	Reliance on partners without self-managed assets	0,11	1,50	0,16
2	CIF schemes and limitations of logistics controls	0,12	1,60	0,19
3	Variability of supply quality	0,12	1,50	0,17
4	Volume-based contract scheme	0,10	1,70	0,17
5	Long supply chain	0,11	1,50	0,16
	Total	0,55		0,85

Total Weight x Score	1,00	2,50
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Source: Processed Data (2025)

The EFE matrix highlighted several external opportunities, including regulatory support from Ministerial Regulation of Energy and Mineral Resources (Permen ESDM) No. 12/2023 (O1), the emergence of segment-based market demands (O2), and the potential for utilizing partner-owned infrastructure to achieve economies of scale (O6). These external opportunities are mapped comprehensively in Table 3, which outlines the relative weight and rating of each factor, providing a structured understanding of the external environment influencing the business.

At the same time, external threats such as misalignment between policy and implementation (T1), infrastructure inconsistencies across different PLTUs (T3), and escalating logistics costs (T5) were strategically addressed through institutional advocacy and coordination with PLN entities (ST1), enhancement of technical preparedness (ST2), and the development of more robust performance monitoring systems (WT1).

Table 3. Matrix EFE

NO	OPPORTUNITIES	Weight	Rating	Score
1	Expansion of integrated biomass services	0,06	3,20	0,21
2	Segmentation of PLTU technical-based services	0,07	3,40	0,22
3	Supplier partner incentive scheme and operational area CSR	0,07	3,20	0,22
4	Synergy in the PLN Group ecosystem	0,07	3,50	0,25
5	Utilization of new raw material sources	0,07	3,60	0,26
6	Economies of scale of partner production facilities	0,07	3,60	0,25
7	Participation of PLTU IPP in the co-firing program	0,06	3,40	0,20
6	The use of idle land as a distribution facility	0,06	3,10	0,20
Total		0,53		1,80
NO	THREATS	Weight	Rating	Score
1	Inconsistency between regulations and business practices (FOB vs CIF)	0,07	2,60	0,18
2	Non-PLN biomass market competition	0,06	2,00	0,13
3	Unidentical PLTU infrastructure	0,07	2,50	0,17
4	Upstream supply uncertainty and legality issues	0,07	2,20	0,15
5	Rising logistics costs and environmental legality risks	0,07	2,50	0,17
6	The large scale of PLN's needs	0,07	2,10	0,15
7	Readiness of PLTU in co-firing optimization	0,06	2,30	0,14
Total		0,47		1,08
Total Weight x Score		1,00		2,88

Source: Processed Data (2025)

Mapping the weighted scores from the IFE and EFE matrix into the Internal–External (IE) matrix positioned the case company in Quadrant V – Hold and Maintain, indicating the need to strengthen operational effectiveness while expanding service coverage. This strategic positioning is visually represented in Figure 3, which illustrates the intersection of internal and external factor scores and guides the selection of appropriate strategic directions. The corresponding strategies derived from the TOWS matrix therefore focused on market penetration and product development as key approaches to enhance biomass supply chain resilience and improve overall supplier readiness.

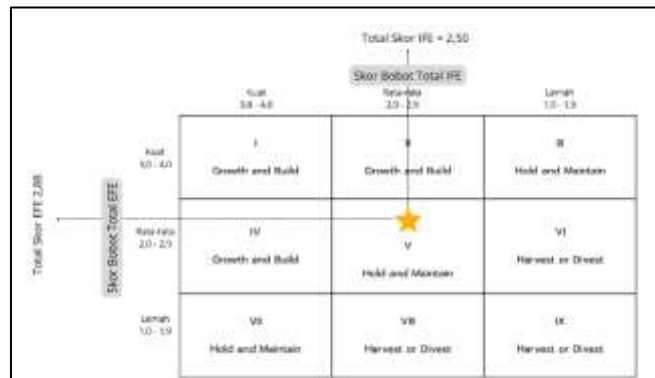


Figure 3. Matriks IE (Internal - Eksternal)

Source: Processed Data (2025)

Additionally, the SWOT analysis plotted into a Cartesian diagram reinforced this strategic position by placing the case company in Quadrant I, indicating strong potential for consolidative growth. This quadrant reflects a relatively high total score for opportunities and strengths, suggesting a strategic advantage that can be leveraged for expansion and capability enhancement. The graphical representation is presented in Figure 4, which visually confirms the positioning and provides further justification for pursuing integrative and growth-oriented strategies.

While external conditions remain favorable, internal performance requires further stabilization. This supports a proactive yet cautious strategic stance, emphasizing the need to strengthen internal governance, expand market segmentation, and build long-term resilience in response to regulatory dynamics and increasing biomass demand.

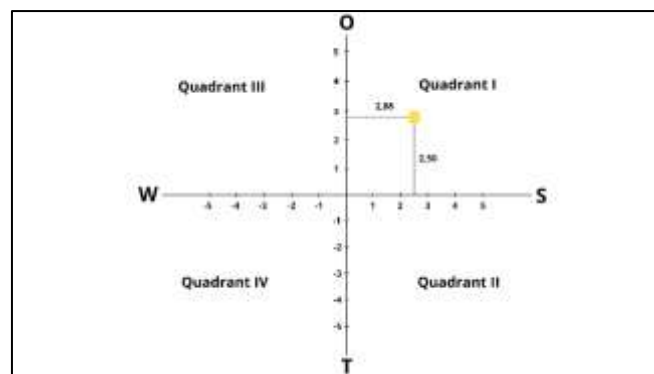


Figure 4. Diagram Analisis SWOT/Kartesian

Source: Processed Data (2025)

This strategic synthesis provided the foundation for aligning SWOT outcomes with the Value Proposition Canvas (VPC) and the development of the Triple Layered Business Model Canvas (TLBMC), ensuring coherence between internal capacities, external dynamics, and long-term sustainability orientation.

To guide this alignment, a comprehensive TOWS matrix was constructed to generate strategic options across four categories: Strength–Opportunity (SO), Weakness–Opportunity (WO), Strength–Threat (ST), and Weakness–Threat (WT). These strategies collectively serve as a roadmap for adaptive transformation, enabling the business to move beyond transactional operations toward a more collaborative and resilient supply chain model. The full mapping of these strategic formulations is presented in Table 4, which systematically integrates internal and external factors into actionable business model innovations tailored to Indonesia’s biomass-based energy transition.

Table 4. Matrix TOWS

		Strengths			Weakness
	S1	Scale volume and distribution networks	W1	Reliance on partners without self-managed assets	
	S2	Technical Capabilities & Field Coordination	W2	CIF scheme and limitations of logistics controls	
	S3	Institutional relations within PLN Group	W3	Variability of supply quality	
	S4	PLN Group's readiness to utilize biomass	W4	Volume-based contract scheme	
			W5	Long supply chain	
Opportunities	S-O Strategy			W-O Strategy	
O1	SO1	Expand the expansion of integrated biomass services through PLN's supply volume scale and institutional synergy. (S1, S3, O1, O4)	WO1	Build a filtering system and partner quality training to reduce supply quality variability. (W3, W1, O3, O5)	
O2	SO2	Service segmentation based on the type of PLTU operation and strengthening coordination and technical readiness. (S2, S4, O2, O4)	WO2	Convert logistics partnership schemes to distribution zoning to reduce CIF dependency and improve efficiency. (W2, W5, O6, O8)	
O3	SO3	Develop an integrated logistics system and self-contained quality testing to support supply efficiency and transparency. (S2, S8, O3, O5)	WO3	Implement quality-based SLA contracts to address the mismatch between volume and quality incentives. (W4, W3, O2, O3)	
O4	SO4	Optimize partner facilities and idle land to expand service coverage and improve distribution efficiency. (S1, O6, O8)			
O5	SO5	Develop products and strategic partnerships for compact packaging and biomass quality improvement. (S2, S4, S6, O5, O6)			
O6					
O7					
O8					
Threats	S-T Strategy			W-T Strategy	
T1	ST1	Use distribution networks and institutional strengths to advocate for revisions of price regulations, waste legality, and quality standards. (S1, S3, T1, T5)	WT1	Strengthen performance-based contract monitoring and reformulation systems to improve quality transparency, reduce manipulation, and ensure compliance with environmental standards. (W3, W4, T2, T5)	
T2	ST2	Strengthen PLN's technical readiness and coordination to deal with the imbalance in the readiness of coal-fired power plant infrastructure. (S2, S4, T3, T7)	WT2	Build performance-based logistics schemes and quick pay-off incentives to reduce social and administrative barriers. (W2, W5, T1, T6)	
T3			WT3	Initiation of coaching and selection of strategic partners to strengthen biomass processing in locations with limited infrastructure. (W1, W5, T3, T4)	
T4					
T5					
T6					
T7					

Source: Processed Data (2025)

Market Feasibility through TAM, SAM, and SOM Analysis

To evaluate the sustainability and scalability of the biomass supply business, a structured market assessment was conducted using the Total Addressable Market (TAM), Serviceable Available Market (SAM), and Serviceable Obtainable Market (SOM) framework. The TAM, derived from national energy transition targets as outlined in (Peraturan Menteri Energi Dan Sumber Daya Mineral Republik Indonesia Nomor 12 Tahun 2023, 2023), estimates biomass demand at 8–10 million tons per year through 2030.

The SAM for the case company was estimated at 2,5–3 million tons annually, based on its access to PLN Group’s operational network and infrastructure compatibility. In 2024, the company captured approximately 25,5% of the national biomass supply realization, amounting to 442.634 tons. For 2025, while the national target exceeds 3 million tons, the company’s projected contribution stands at 547.327 tons (18,1%). However, with improved coordination and based on historical SOM benchmarks, the company could realistically target a market share of over 800.000 tons.

These estimates reflect both the firm’s operational readiness and its competitive positioning within the broader context of PLN’s decarbonization and biomass co-firing agenda. The visualization of the TAM, SAM, and SOM estimations is presented in Figure 5, illustrating the company's current footprint and future growth potential within Indonesia’s biomass supply market.



Figure 5. Market Size Biomass Local Biomass Supplier 2025

Source: Processed Data (2025)

Value Proposition Canvas (VPC)

The case company aligned its business model with PLN’s operational needs by identifying key customer jobs such as supporting co-firing operations and ensuring a reliable biomass supply. It also mapped customer pains, including logistical challenges, regulatory uncertainty, and quality inconsistencies, as well as expected gains like competitive pricing and reliable long-term partnerships.

These were matched with a set of product and service offerings, including multiple types of biomass feedstock, rapid testing tools, and on-site quality control systems. In response to customer pains, the company offered pain relievers such as zonal distribution schemes, educational outreach to partners, and more flexible contract models. Additionally, gain creators included innovations in packaging and logistics, transparent reporting systems, and incentive mechanisms based on service-level agreements (SLAs).

This approach ensured a strong fit and coherence between customer expectations and business solutions, resulting in a more responsive and adaptive value proposition for PLN’s biomass co-firing agenda. The details of this mapping are illustrated in Figure 6, which outlines the alignment between customer profiles and the firm’s value offerings using the Value Proposition Canvas (VPC) framework.

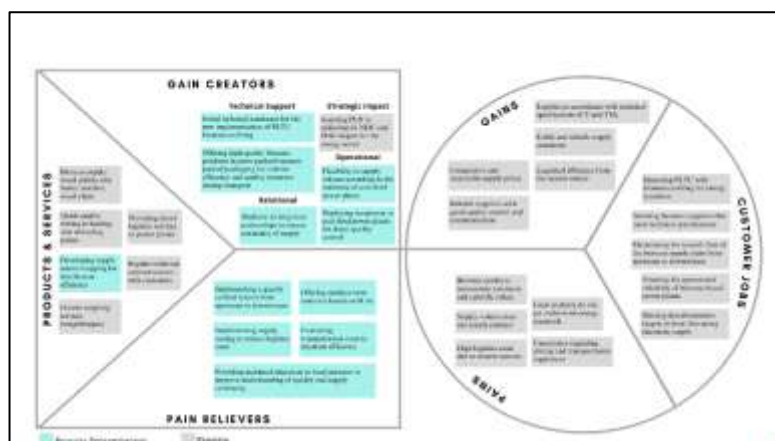


Figure 6. Value Proposition Canvas (VPC) Local Biomass Supplier

Source: Processed Data (2025)

Design of a Triple Layered Business Model Canvas (TLBMC) for a Local Biomass Supplier

To align with increasing sustainability demands, this study adopted the Triple Layered Business Model Canvas (TLBMC) framework by Joyce and Paquin (2016), which expands the traditional BMC by Osterwalder and Pigneur (2010) into three interconnected layers: economic, environmental, and social. The objective was to evaluate and enhance the business model of a local biomass supplier not only in terms of economic feasibility but also through its environmental and social impacts.

This holistic framework enabled the mapping of value creation across dimensions, revealing operational risks, environmental shortcomings (such as the absence of lifecycle assessments), and social engagement gaps (such as limited collaboration with farmer cooperatives). The development process integrated insights from SWOT analysis, Value Proposition Canvas (VPC), and TLBMC, ensuring strategic alignment between customer needs, organizational capabilities, and sustainability imperatives.

In this context, TLBMC served as a strategic blueprint for strengthening the role of the supplier as a resilient, socially inclusive, and environmentally aligned actor within Indonesia's biomass co-firing transition.

Economic Layer (EBMC)

This sub-section outlines the prototype of the Economic Business Model Canvas (EBMC), which represents a transformation from an existing transactional structure into a more collaborative, adaptive, and value-driven economic model. Each of the nine BMC elements was redesigned based on insights from the SWOT and TOWS analyses.

Key enhancements included the expansion of customer segments beyond the PLN Group to include Independent Power Producers (IPPs) and industrial users, aiming to diversify risk exposure (SO1). The value proposition was strengthened by integrating quality assurance services and introducing innovative biomass packaging formats, such as press-packed and vacuum-packed units (SO5). In parallel, digitalized service channels were adopted through the development of integrated dashboards (SO1, WO2).

The revenue model was broadened to incorporate consulting services and logistics-based offerings (SO5), while key activities were restructured to include carbon tracking and real-time data reporting (SO3, ST1). Strategic partnerships were enhanced through collaboration with local cooperatives (UMKM/BUMDes), research institutions (e.g., IPB and ITB), technology providers, and local governments (SO4, SO5).

Meanwhile, the cost structure evolved from being heavily operational to becoming more investment-oriented, focusing on infrastructure and quality control systems aligned with service-level agreement (SLA) frameworks (WO2, SO3).

This EBMC redefines the company's role not merely as a feedstock aggregator, but as an integrated service provider within Indonesia's biomass value chain. It aligns with a Hold and Maintain strategy through market penetration and product development, while demonstrating consolidative growth characteristics that emphasize governance strengthening, ecosystem partnerships, and operational efficiency throughout the value network.

The resulting configuration of the redesigned economic model is visually represented in Figure 7, which details the prototype of the Economic Business Model Canvas (EBMC) for the local biomass supplier.



Figure 7. Prototype Development Economic BMC Local Biomass Supplier
Source: Processed Data (2025)

Social Layer (SSBMC)

The Social Stakeholder Business Model Canvas (SSBMC) strengthens the social value of the business by embedding inclusive governance, community empowerment, and equitable benefit distribution throughout the biomass supply chain.

Social value is generated through initiatives such as waste-to-energy transformation, job creation, reduction of seasonal unemployment, and entrepreneurial programs targeted at rural communities (WT3). Employees are strategically positioned at critical control points and supported through capacity building and technical training, enhancing both quality assurance and inclusive local participation (WO1, WT3).

Governance mechanisms are reinforced through the implementation of SLA-based digital quality control and transparent auditing systems (WO1, WT1). Local communities are actively engaged in logistics, processing, and zonation-based distribution systems, which promote both ownership and spatial efficiency (WT3).

The societal culture component is addressed through clean energy education, institutional mentoring, and biomass-based social innovation, enabling community-driven transformation (WT3, SO4). The scale of outreach has expanded from 11 to over 15 PLTUs through phased, decentralized partnerships (SO1, WO2).

End users benefit from enhanced ESG reporting and decarbonization tracking services, improving both reputational standing and sustainability alignment (SO5). Social risks are mitigated through participatory risk monitoring, fairness schemes, and local resilience programs (WT2). Additional social benefits, such as improved welfare, open burning reduction, and value-added biomass product development (WT1, SO5), are formalized into key performance indicators (KPIs).

This SSBMC represents a comprehensive and proactive approach to institutionalizing social sustainability across the biomass ecosystem. In summary, the development of the SSBMC affirms that

social sustainability is not a peripheral concern but a core strategic pillar, supporting the company’s positioning as a socially responsible actor in Indonesia’s biomass energy transition, consistent with Hold and Maintain and Consolidative Growth strategies.

The detailed configuration of this socially embedded business model is presented in Figure 8, which illustrates the prototype of the Social Stakeholder Business Model Canvas (SSBMC) for the local biomass supplier.

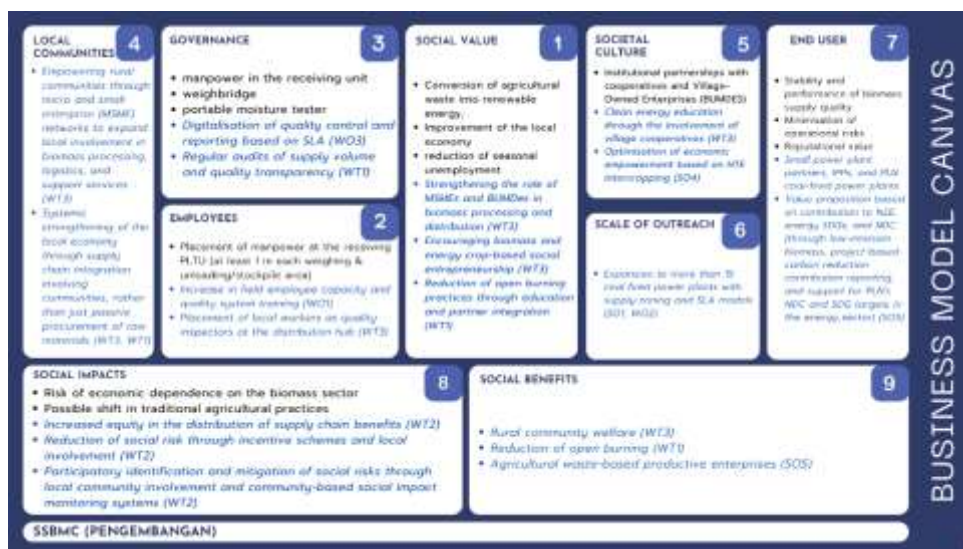


Figure 8. Prototype Development Social Stakeholder BMC Local Biomass Supplier
Source: Processed Data (2025)

Environmental Layer (ELCBMC)

The development of the Environmental Life Cycle Business Model Canvas (ELCBMC) marks a strategic shift from compliance-focused operations toward a performance-based sustainability model. This environmental layer of the Triple Layered Business Model Canvas (TLBMC) evaluates ecological value across all stages of the biomass value chain.

Functional value is enhanced through the provision of measurable, high-quality biomass that supports co-firing initiatives and contributes to national decarbonization targets (SO5, ST1). Material inputs are diversified by incorporating energy crops and agroforestry sources, while promoting traceable and community-based sustainable sourcing (SO4, WO1).

Production processes have been modernized and standardized through the implementation of energy and environmental audits, joint standard operating procedures (SOPs), and technical segmentation aligned with specific PLTU requirements (SO2, WO3). Improvements in biomass packaging, traceability certification, and inclusive outsourcing models contribute to enhanced distribution performance while reducing emissions and product loss (SO5, WT1).

To further improve environmental performance, real-time logistics tracking and adherence to emission standards have been introduced, ensuring transparency and minimizing impact during transportation (WO2, WT1). In the use phase, collaboration on SOPs and the development of early warning systems ensure that biomass utilization meets technical and environmental performance standards (SO2, WO3).

In the end-of-life stage, efforts are underway to develop ash valorization pathways in collaboration with research institutions, promoting circular economy principles (ST1). Additionally, environmental reporting systems are being developed for lifecycle carbon accounting, verification, and policy advocacy (ST1, WT1).

The cumulative environmental benefits of this model include greenhouse gas (GHG) reduction, open burning prevention, and ecosystem protection through localized sourcing and land restoration initiatives (SO1, WO2).

Overall, the ELCBMC reflects a structured and integrated response to ecological challenges, repositioning the company’s environmental role from reactive compliance to that of a strategic contributor in Indonesia’s sustainable energy transition.

A detailed visualization of this environmental business prototype is presented in Figure 9, which illustrates the Environmental Life Cycle Business Model Canvas (ELCBMC) developed for the local biomass supplier.

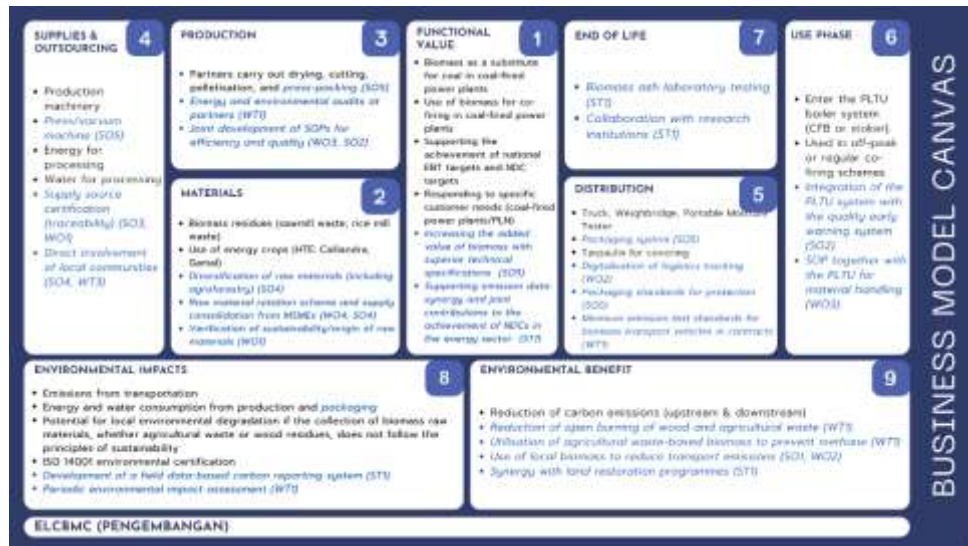


Figure 9. Prototype Development Environmental Life Cycle BMC Local Biomass Supplier
Source: Processed Data (2025)

Vertical Coherence Across TLBMC Layers

This section emphasizes the importance of vertical coherence within the Triple Layered Business Model Canvas (TLBMC), ensuring that economic, social, and environmental aspects are systematically aligned. Seven key strategic elements were selected for cross-layer analysis: Value Proposition, Key Activities, Key Partnerships, Channels, Customer Relationships, Revenue Streams, and Cost Structure. Each element demonstrates synergy and integration across layers:

1. Value Proposition combines operational reliability (EBMC), community empowerment (SSBMC), and carbon reduction efforts (ELCBMC).
2. Key Activities emphasize logistical efficiency while integrating local labor participation and minimizing environmental footprints.
3. Key Partnerships involve village-owned enterprises (BUMDEs), research institutions, and other sustainability-oriented actors to strengthen supply optimization and promote circular practices.
4. Channels merge digital dashboards with educational platforms and transparent sustainability reporting systems.
5. Customer Relationships go beyond service quality, encompassing sustainability performance disclosure and stakeholder training initiatives.
6. Revenue Streams are diversified, incorporating both core business services and sustainability-linked offerings such as carbon tracking and consulting.
7. Cost Structure reflects operational necessities alongside social investment and environmental monitoring expenditures.

Together, these elements illustrate that the company’s business model transformation is integrative, each innovation reinforces resilience, stakeholder inclusivity, and environmental accountability, aligned through a unified sustainability lens.

Validation of Prototype Coherence of Business Model Canvas Development through Value Proposition Canvas (VPC)

This subchapter validates the alignment between the Business Model Canvas (BMC) and the Value Proposition Canvas (VPC) in the context of business model development for a local biomass supplier. The analysis focuses on how the business model responds strategically to the needs and challenges of key customers such as PLN EPI, PLTU units, Independent Power Producers (IPPs), and other actors in the renewable energy sector.

The findings show that customer jobs, such as maintaining sustainable biomass supply, achieving decarbonization targets, and ensuring technical compliance, have been addressed through strong value propositions, digital quality assurance, zonal distribution, and training for local partners. Customer gains, including competitive pricing, supply reliability, and logistical efficiency, are supported by revenue diversification and medium-term service-level agreements (SLAs). Meanwhile, customer pains, such as inconsistent quality, high logistics costs, and regulatory uncertainty, are mitigated through quality capacity building, transparent control systems, and data-informed policy advocacy.

While the validation demonstrates a strong fit between customer expectations and the redesigned business model elements, it is important to acknowledge that this validation is based primarily on qualitative data from interviews and document analysis. No quantitative testing (e.g., statistical modeling or structural equation analysis) was conducted to empirically measure causal relationships. Therefore, the robustness of this validation remains limited to the depth and representativeness of stakeholder perspectives involved in this study.

Nevertheless, the triangulation of multiple qualitative sources, including key informant interviews, internal PLN documentation, and regulatory frameworks, ensures that the prototype reflects both operational realities and strategic aspirations of biomass supply chain stakeholders.

This validation affirms that the proposed business model is internally coherent, strategically aligned with stakeholder needs, and well-positioned to serve as a scalable and context-specific prototype supporting Indonesia's renewable energy transition.

Strategic Implications and Sustainability Impact

The development of the Triple Layered Business Model Canvas (TLBMC) offers significant strategic implications for the biomass supply business. The transition from a transactional to a collaborative business model has resulted in enhanced operational efficiency and a more holistic value proposition.

From an economic standpoint, the application of SLA-based service models, digitalized quality systems, and market segmentation based on PLTU readiness has enabled greater flexibility and cost efficiency. On the social dimension, the empowerment of local SMEs, involvement of village-owned enterprises (BUMDes), and capacity-building programs have fostered inclusive growth and contributed to supply chain stability. On the environmental side, the model aligns with national Net Zero Emissions (NZE) and Sustainable Development Goals (SDGs) targets through carbon reporting, waste valorization, and emission tracking initiatives.

By adopting Hold and Maintain and consolidative growth strategies, the company is able to preserve its core strengths while selectively expanding into emerging markets, such as IPP-operated PLTUs and cross-sectoral partnerships. These integrated efforts distinguish the business from conventional biomass suppliers that focus primarily on price and volume.

Synthesis and Confirmation of Research Objectives

This chapter synthesized the development of a sustainable business model for a local biomass supplier using multiple strategic frameworks, including Business Model Canvas (BMC), SWOT analysis, TOWS matrix, and Value Proposition Canvas (VPC). The research began by diagnosing the existing business model, analyzing internal and external factors, and formulating strategies aligned with key customer needs.

The Triple Layered Business Model Canvas (TLBMC) was then applied to construct an integrative model across economic (EBMC), environmental (ELCBMC), and social (SSBMC)

dimensions. The analysis of vertical coherence across these layers demonstrated a synergistic relationship that reinforces economic efficiency, community empowerment, and carbon reduction simultaneously.

The findings confirm that the research objectives, to design a sustainable business model for local biomass suppliers supporting PLN's co-firing program, have been successfully achieved both conceptually and strategically. The proposed model not only demonstrates high practical feasibility, but also offers a valuable reference for replication in similar energy transition initiatives across Indonesia.

Discussion

This section aims to contextualize the research findings within the broader academic discourse on sustainable business models, particularly in the biomass supply sector. By comparing these findings with existing studies, the discussion highlights theoretical contributions, practical relevance, and the strategic implications of the developed model.

Economic Dimension: EBMC

The Economic Business Model Canvas (EBMC) prototype reflects a strategic shift from a transactional to a collaborative and integrative business model. This finding is in line with (Amour et al., 2024; Azizah & Budi Handoko, 2020; Effendi et al., 2024), who emphasize the importance of ecosystem partnerships and adaptive organizational structures for renewable energy supply chains. Unlike prior studies that predominantly emphasize pricing mechanisms, this research incorporates quality assurance protocols, service-level agreements (SLAs), and decentralized supply systems as part of a holistic economic strategy for biomass supply.

Environmental Dimension: ELCBMC

The development of the Environmental Life Cycle Business Model Canvas (ELCBMC) affirms a commitment to lifecycle-based environmental performance, aligning with the insights of (Kementerian Lingkungan Hidup dan Kehutanan (KLHK), 2022; Olivier et al., 2021; Zahraee et al., 2020a) and (Zahraee et al., 2020a). By integrating waste valorization, localized sourcing, and ecological restoration initiatives, the model advances beyond generic environmental templates by embedding context-specific solutions into the biomass value chain.

Social Dimension: SSBMC

Within the Social Stakeholder Business Model Canvas (SSBMC), the role of community empowerment is consistent with the findings of (Lestari & Muttaqin, 2024; Schoneveld, 2020), who underscore the significance of inclusive governance in rural bioenergy systems. The introduction of digital auditing tools and participatory certification schemes in this model serves as a scalable social governance mechanism that can enhance accountability and transparency in decentralized supply chains.

Vertical Coherence Across Layers

The analysis of vertical coherence, particularly across the value proposition, key activities, and customer segments, reaffirms the theoretical foundation established by (Geissdoerfer et al., 2018; Joyce & Paquin, 2016). The presence of zonal distribution schemes, integrated digital dashboards, and circular logistics models illustrates how systemic alignment across economic, social, and environmental dimensions strengthens organizational adaptability and coherence.

Value Proposition Canvas (VPC) Validation

The Value Proposition Canvas (VPC) validation aligns with the conceptual framework by (Osterwalder et al., 2015; Pramudita et al., 2024) and empirical findings by (Pramudita et al., 2024)) confirming that the developed business model effectively addresses customer jobs, pains, and gains in the context of biomass-based energy supply. Through emission monitoring dashboards, stakeholder training, and continuous communication mechanisms, the model ensures that performance delivery aligns with customer expectations and regulatory trends.

Integrative Strategic Perspective

In conclusion, the proposed business model supports resilience and sustainability by aligning internal capabilities with external stakeholder expectations. The adoption of a Hold and Maintain strategy, combined with product innovation and cross-sectoral collaboration, provides a scalable and adaptable blueprint for other biomass enterprises aiming to contribute meaningfully to Indonesia's energy transition and long-term sustainability goals.

CONCLUSION

This study developed a sustainable business model for a local biomass supplier to support Indonesia's energy transition through the PLN co-firing program by integrating the Business Model Canvas (BMC), SWOT analysis, TOWS Matrix, Triple Layered Business Model Canvas (TLBMC), and Value Proposition Canvas (VPC). The analysis showed that the existing model was largely transactional, with limited emphasis on quality assurance and sustainability practices, but restructuring each element introduced innovations such as SLA-based services, digitalized quality control, and collaborative stakeholder engagement, thereby enhancing resilience and alignment with national decarbonization goals. The application of the TLBMC strengthened the integration of economic, environmental, and social dimensions, while VPC validation confirmed strong stakeholder alignment. Overall, the study contributes both theoretically and practically to sustainable business model innovation in the biomass sector. Future research should apply quantitative validation, pilot implementation, and longitudinal assessments to examine the scalability, financial feasibility, and long-term impact of the proposed model within Indonesia's Net Zero Emissions (NZE) roadmap.

REFERENCES

- Ahl, A., Goto, M., & Yarime, M. (2019). Smart technology applications in the woody biomass supply chain: interview insights and potential in Japan. *Sustainability Science*, *15*, 1531–1553.
- Amour, S. A. Z. K., Fatimatusalwa, S., & Bastomi, M. (2024). Efisiensi dan Efektivitas Pengembangan Bisnis Melalui Pendekatan Business Model Canvas (BMC) dan Analisis SWOT. *Revenue : Jurnal Lentera Bisnis Manajemen JLBM*, *02(03)*, 90–102.
- Azizah, S., & Budi Handoko, H. (2020). Analysis of Rabbit fillet business with the business model canvas approach at Azhar Farm. *Jurnal Ilmu-Ilmu Peternakan*, *30(3)*, 237–245. <https://doi.org/10.21776/ub.jiip.2020.030.03.09>
- Basile, V. (2021). *The triple layered business model canvas in smart agriculture: the case of Evja startup*.
- David, R. , F., & David, R. F. (2017). *Strategic Management, 16th Global Edition*.
- Dian, J., Rhamadhan, F. Z., & ... (2023). Analysis of Co-firing in Bolok Coal-fired Power Plant Using Woodchips to Support Decarbonization. *2023 6th International*
- Effendi, P. L., Wirjodirdjo, B., & Rosdaniah, S. I. (2024). Influence factors on sustainable business models for renewable energy supply: Indonesian electricity industry. In *Cogent Business and Management* (Vol. 11, Issue 1). Cogent OA. <https://doi.org/10.1080/23311975.2023.2293303>
- Elkington, J. (1997). Triple bottom line. In *Environmental Quality Management* (Vol. 8, Issue 1).
- Firmansyah, V., Adinarayana, M. K., Tetrisyanda, R., & Wibawa, G. (2023). Scenario of renewable energy transition from fossil energy resources towards net zero emission in Indonesia. *E3S Web of Conferences*, *467*. <https://doi.org/10.1051/e3sconf/202346704005>
- Geissdoerfer, M., Vladimirova, D., & Evans, S. (2018). Sustainable business model innovation : A review. *Journal of Cleaner Production*, *198*, 401–416. <https://doi.org/10.1016/j.jclepro.2018.06.240>
- Hartati, S., Kuswarno, E., Hadisiwi, P., & Elita, F. M. (2023). *Business Model Canvas: SMEs Recovery during the COVID-19 Pandemic*. 2437–2437. <https://doi.org/10.46254/na07.20220538>

- Joyce, A., & Paquin, R. L. (2016). The triple layered business model canvas: A tool to design more sustainable business models. *Journal of Cleaner Production*, 135(November 2017), 1474–1486. <https://doi.org/10.1016/j.jclepro.2016.06.067>
- Kementerian Lingkungan Hidup dan Kehutanan (KLHK). (2022). *Enhanced Nationally Determined Contribution Republic of Indonesia* (Vol. 11, Issue 1, pp. 1–14).
- Lestari, F., & Muttaqin, R. (2024). Formulation of Business Development Strategy Through SWOT Approach and Business Model Canvas (Case Study on MSMEs in Padamulya Village). *International Journal of Finance ...*
- Olivier, J., Guizzardi, D., Schaaf, E., Solazzo, E., Crippa, M., Vignati, E., Banja, M., Muntean, M., Grassi, G., Monforti-Ferrario, F., & Rossi, S. (2021). *GHG emissions of all world – 2021 report* (E. C. J. R. Centre, Ed.). Publications Office of the European Union. <https://doi.org/doi/10.2760/173513>
- Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation*.
- Osterwalder, A., Pigneur, Y., Bernarda, G., & Smith, A. (2015). *Value proposition design: How to create products and services customers want*. John Wiley & Sons.
- Peraturan Menteri Energi Dan Sumber Daya Mineral Republik Indonesia Nomor 12 Tahun 2023 (2023).
- Pramudita, A., Auliya, A. W., Andarini, S., & ... (2024). Analisis Strategi Perencanaan dan Pengembangan Bisnis Melalui Media Analisis SWOT dan Business Model Canvas. *MERDEKA: Jurnal ...*
- Rangkuti, F. (2006). *Analisis SWOT: Teknik Membedah Kasus Bisnis*. PT Gramedia Pusataka Utama.
- Schoneveld, G. C. (2020). Sustainable business models for inclusive growth: Towards a conceptual foundation of inclusive business. *Journal of Cleaner Production*, 277, 124062. <https://doi.org/10.1016/j.jclepro.2020.124062>
- Zahraee, S. M., Shiwakoti, N., & Stasinopoulos, P. (2020a). Biomass supply chain environmental and socio-economic analysis: 40-Years comprehensive review of methods, decision issues, sustainability challenges, and the *Biomass and Bioenergy*.
- Zahraee, S. M., Shiwakoti, N., & Stasinopoulos, P. (2020b). Biomass supply chain environmental and socio-economic analysis: 40-Years comprehensive review of methods, decision issues, sustainability challenges, and the way forward. *Biomass and Bioenergy*, 142(January), 105777. <https://doi.org/10.1016/j.biombioe.2020.105777>