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CASES IN SUSTAINABILITY

Volume 2

System-Level and Structure-Based Approaches

Editors
Lawrence LOH
ANG Hui Min

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Editors: Lawrence LOH and ANG Hui Min
Case Authors: As listed in the cases

Editorial Assistants:
LOH Yan Yu, SOONG He Huan, GOH Boon Hao, LIM Hui En and Aditi JHA

This casebook arises from the assignments submitted by students from the Master of Science in Strategic Analysis and Innovation programme. They were enrolled in the course “Strategic Sustainability” offered at the National University of Singapore (NUS) Business School.

Published by the School’s Centre for Governance and Sustainability (CGS), this casebook represents the culmination of students’ work in applying strategic sustainability concepts to real-world scenarios.

March 2026

Preface

In our previous edition “Volume 1: Firm Level and Market-Based Approaches”, we examined how individual organisations integrate environmental, social, and governance considerations into their operations and strategies. As we advance through 2026, it has become increasingly clear that transformative sustainability outcomes require not only firm-level action but also system-level interventions and structural reforms across entire value chains.

The “Strategic Sustainability” course, which is part of the Master of Science in Strategic Analysis and Innovation programme offered at the National University of Singapore (NUS) Business School deepens students’ understanding of these broader sustainability paradigms. This edition focuses on approaches that go beyond individual firm boundaries, exploring how businesses drive change through infrastructure development, supply chain transformation, and multi-stakeholder collaboration.

The cases illustrate how organisations address sustainability through two critical dimensions: the scope of impact (environmental and institutional versus social and economic) and the position in value systems (upstream/infrastructure development versus downstream/delivery innovation). Students worked in teams to research and analyse these cases, with continued emphasis on Asian contexts and their global implications.

By way of synthesis, the businesses analysed can be categorised as follows:

	Upstream / Infrastructure	**Downstream / Delivery**
Environmental & Institutional Impact	CATL LONGi Green Energy Sembcorp	BYD Kia Toyota
Social & Economic Impact	ExxonMobil Social Stock Exchange SP Group	Asian Agri City Developments Limited F1 Singapore Grand Prix

We can understand corporate sustainability strategies through two interconnected dimensions that reveal how organisations position themselves within broader transformation pathways. The first dimension is scope of impact which distinguishes between firms driving **environmental and institutional impact** through clean energy

and governance practices, and those advancing **social and economic impact** through inclusive finance and community development. Environmental transition leaders often focus on renewable infrastructure and circular material flows, while social impact pioneers emphasise stakeholder inclusion and equitable access.

The second dimension is the firm's position in value systems which separates upstream and infrastructure-oriented approaches from downstream and delivery-focused strategies. **Upstream/Infrastructure** cases showcase organisations that enable systemic change through foundational investments in clean energy generation, battery technology or capital market infrastructure for impact investing. These firms shape the conditions under which downstream actors operate, creating the technological and institutional architecture for broader transformation.

Conversely, **Downstream/Delivery** cases highlight organisations that translate sustainability innovations into end-user applications whether through electric vehicles, green buildings or responsible agricultural products. These firms bridge the gap between infrastructure capabilities and consumer adoption, demonstrating how sustainability becomes tangible in everyday experiences.

However, these categories are inherently interdependent. Upstream innovators require downstream partners to create demand and validate their technologies, while downstream pioneers depend on upstream infrastructure to scale their solutions. Infrastructure developers in clean energy must collaborate with mobility providers and real estate developers, just as social impact platforms require both institutional frameworks and grassroots implementation partners. This interdependence highlights how meaningful sustainability progress requires coordinated actions across value systems and impact domains.

This casebook is designed for readers with foundational knowledge of strategic management and sustainability concepts who seek to understand how organisations drive systemic change beyond firm boundaries. Discussion questions at the end of each case encourage readers to critically examine the complexities of sustainability interventions, the role of collaboration, and trade-offs in different strategies. We hope this casebook inspires deeper thinking about how businesses can contribute to sustainability through firm excellence and its amplifier effect within broader systems.

Lawrence Loh
Director, Centre for Governance and Sustainability
Professor in Practice of Strategy & Policy
NUS Business School

Ang Hui Min
Communications Lead, Centre for Governance and Sustainability
NUS Business School

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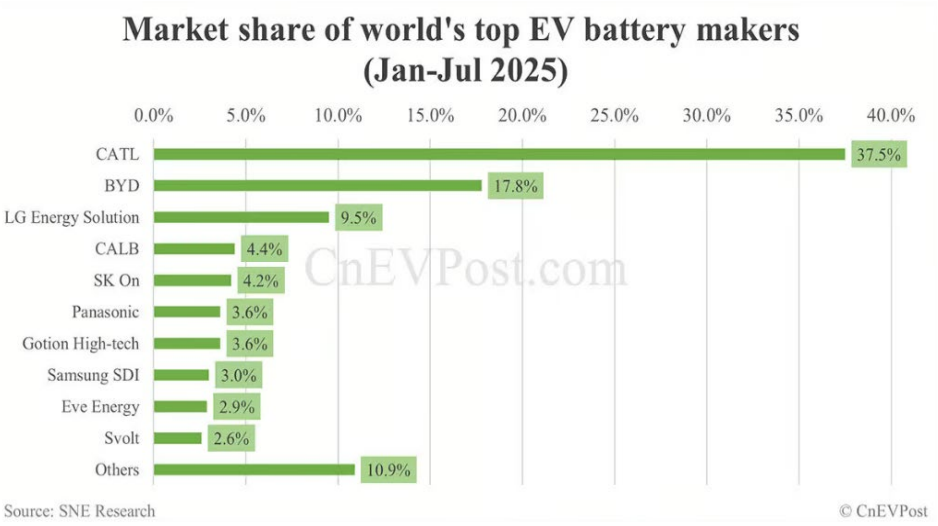
Introduction and Market Overview

The global electric vehicle industry has experienced rapid growth in recent years, driven by multiple factors such as increased environmental awareness, government incentives, and advances in clean energy technologies. By the end of 2024, the number of new electric vehicles in the world reached approximately 17.1 million, accounting for more than 20% of the total global new car sales (Lead Intelligent, 2025). More consumers choose electric vehicles because of their lower operating costs and technological innovations such as intelligent driving and fast charging. This surge in demand, in turn, has fuelled the rapid development of the lithium-ion battery industry.

In 2024, the global lithium-ion battery market was valued at about US$75.2 billion and expected to grow at a compound annual growth rate (CAGR) of 15.8% from 2025 to 2034 (Global Market Insights, 2025). This trajectory is driven by the rapidly growing demand for electric vehicles and grid-scale energy storage in mainstream markets such as China, the United States (US) and Europe. By mid-2025, Contemporary Amperex Technology Co. Limited (CATL) and BYD together account for more than half of the global electric vehicle battery market. At the same time, CATL's installed capacity of electric vehicle batteries reached 221.4 GWh, accounting for approximately 37.5% of the market share (Kang, 2025). This means that on average, one out of three electric vehicles uses CATL batteries.

Figure 1: Market Share of World's Top EV Battery Makers



Source: Kang, 2025

Company Background

CATL, founded in 2011, is a leading global developer and manufacturer of lithium-ion batteries. The company specialises in the research and development (R&D), production, and sale of power battery systems for new energy vehicles and energy

storage systems. In 2024, the company recorded an operating revenue of RMB362 billion and invested RMB18.6 billion in R&D (CATL, 2025b). As of the same year, CATL held over 43,000 patents and patent applications worldwide. The shipment volume of its energy storage systems reached 110 GWh, ranking first in the world (CATL, 2025b).

CATL partners with leading automakers such as Tesla, BMW, Volkswagen, Mercedes-Benz, XPeng and Li Auto. It has also established battery production bases and offices worldwide, including China, France, Germany and the United States.

Figure 2: The Revenue Composition of CATL in 2024

Unit: Thousand RMB

Item	2024		2023		YoY Change
	Amount	% of Total Revenue	Amount	% of Total Revenue	
Total Operating Revenue	362,012,554	100.00%	400,917,045	100.00%	-9.70%
By Industry					
Electrical Machinery and Equipment Manufacturing	356,519,551	98.48%	393,182,894	98.07%	-9.23%
Contracting and Installation Industry	5,493,003	1.52%	7,734,151	1.93%	-28.98%
By Product					
Power Battery Systems	253,041,337	69.90%	285,252,917	71.15%	-11.29%
Energy Storage Battery Systems	57,290,460	15.83%	59,900,522	14.94%	-4.36%
Battery Material Recycling	28,699,935	7.93%	33,602,284	8.38%	-14.59%
Battery Leasing and Services	5,493,003	1.52%	7,734,151	1.93%	-28.98%
Other Businesses	17,487,818	4.83%	14,427,171	3.60%	+21.22%
By Region					
Domestic	251,677,045	69.52%	269,924,895	67.33%	-6.76%
Overseas	110,335,509	30.48%	130,992,150	32.67%	-15.77%

Source: Adapted from CATL, 2025a

Among them, the factory located in Yibin, Sichuan Province, was recognised as a “Global Lighthouse Factory” by the World Economic Forum (WEF), representing the highest level of Industry 4.0 in the fields of digitalisation and intelligence. Not only that, the Yibin base is also the world’s first zero-carbon factory in the new energy industry which passed the PAS 2060 carbon neutrality certification (CATL, 2022). To achieve its zero-carbon goal, the Yibin factory has taken measures, including the comprehensive use of renewable energy such as hydropower and photovoltaic power, the construction of a distributed energy system, the deployment of an intelligent energy consumption monitoring platform, the optimisation of the logistics system and low-

carbon design of the park, supplemented by a carbon offset mechanism to cover the remaining emissions.

Sustainability Strategy

In support of the United Nations Sustainable Development Goals (SDGs), CATL integrates the concept of sustainable development management into its business operations. It seeks to adhere to ethical and compliance standards, and strengthen communication with stakeholders (CATL, 2025b). Through continuous improvement in environmental, social and governance (ESG) performance, CATL aims to build a responsible and innovative corporate culture that supports long-term sustainability.

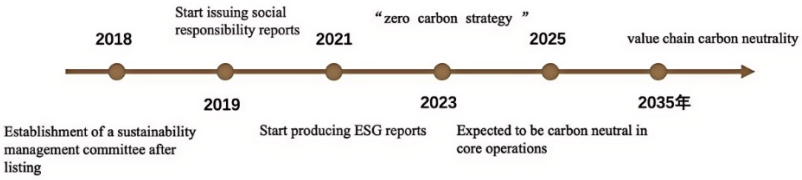
Under its sustainable strategy framework, CATL is committed to innovation in battery technology, utilising renewable energy generation and electrochemical energy storage to replace dependence on fossil energy, thus accelerating the global transition away from petrol. It also integrates electrification and intelligence, offering scalable and reliable energy systems. This helps to support regional zero-carbon ecosystems and the low-carbon transformation of various sectors.

Sustainability Progress

From a sustainability perspective, CATL promotes energy transition through its “electrification and digitalisation” strategy and has announced targets to achieve carbon neutrality in its core operations by 2025 and across its entire value chain by 2035 (Liu, 2025). This strategy ensures that CATL remains at the leading edge of market competition and strengthens its influence on the sustainable development of the battery industry.

For instance, the first “CATL ESG Forum: Industrial Chain Collaborative Innovation Seminar”, held by CATL in 2024, addressed emerging sustainability challenges in the battery industry and enhanced collaboration and innovation throughout the entire industrial chain (CATL, 2025b). Figure 3 illustrates the evolution of CATL’s main ESG movements from 2018. Since that year, CATL has regarded sustainable development as the foundation of its global expansion (Fan & Ding, 2025).

Figure 3: Development History of CATL’s ESG Practices

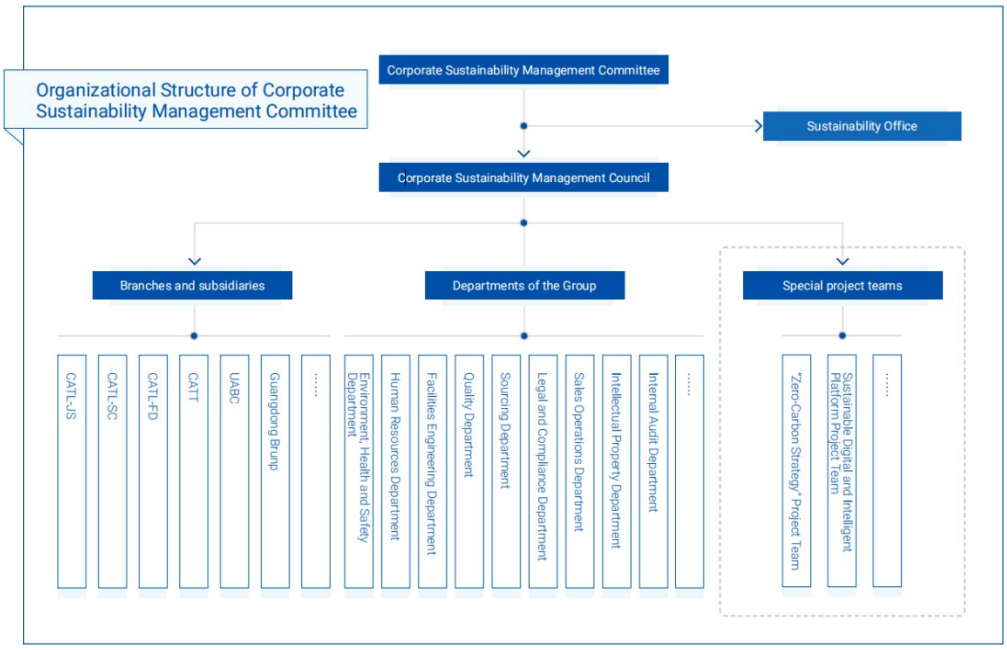


Source: Shu et al., 2024

Sustainability Management Structure

To better integrate its sustainability strategies into daily business operations, CATL has developed a top-down, company-wide sustainability management structure.

Figure 4: CATL's Sustainability Management Structure



Source: CATL, 2025b

The Corporate Sustainability Management Committee takes responsibility for planning and managing strategic decisions on the company's sustainability issues. These committee members include the Secretary of the Board of Directors, senior managers, and department heads under different functions.

Reporting directly to the Committee, the Corporate Sustainability Management Council consists of key personnel from different business units and oversees the implementation of sustainability strategies. In addition, several sustainability project teams operate under the Council to ensure effective execution of the company's sustainability strategies.

Environmental Performance

Zero-Carbon Strategy

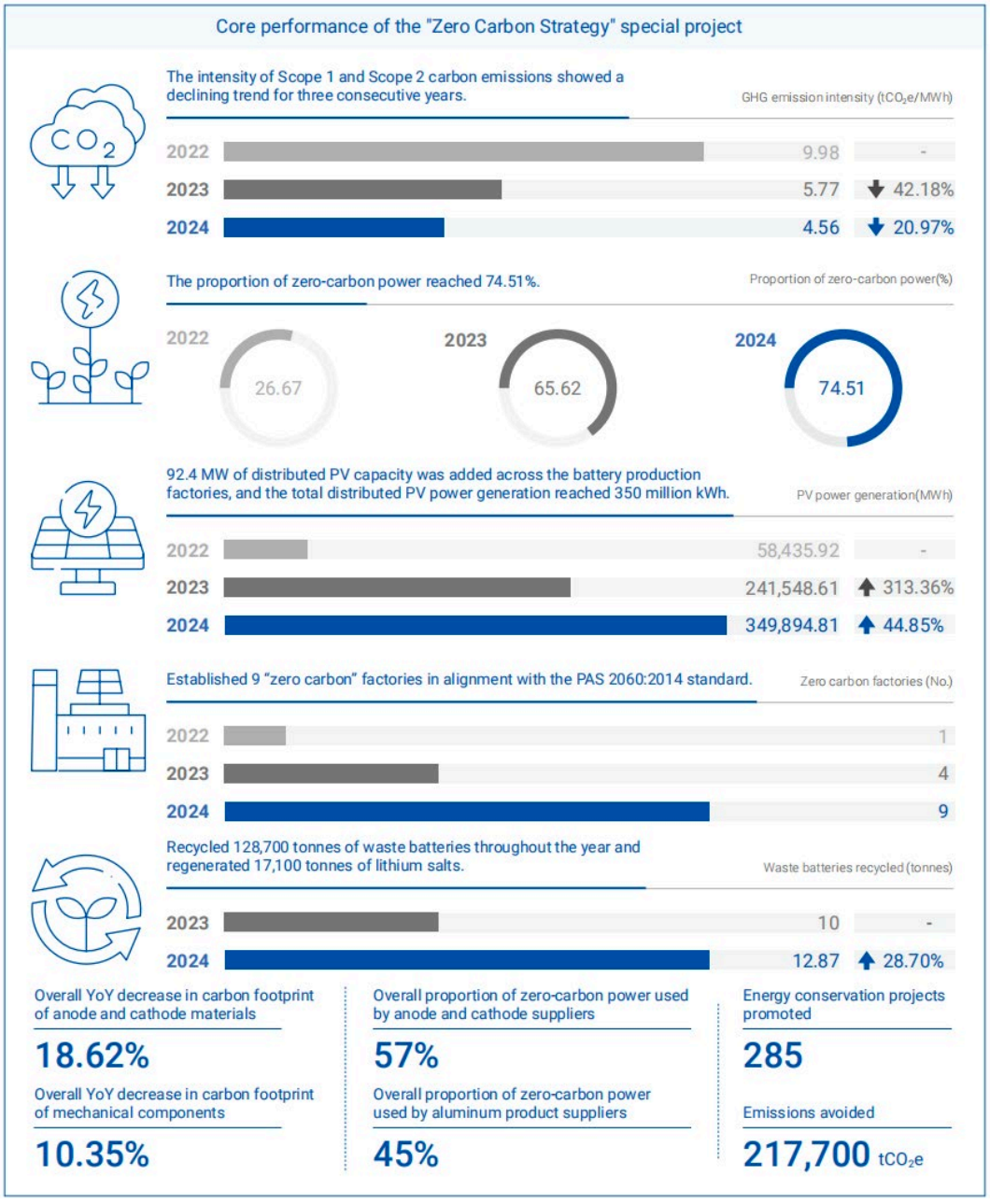
CATL's "Zero-Carbon Strategy" looks at achieving carbon neutrality in its core operations by 2025 and across the entire battery value chain by 2035. CATL also proposed six supporting strategies for its low-carbon transition: Zero-Carbon Design, Zero-Carbon Factories, Zero-Carbon Supply, Zero-Carbon Manufacturing, Zero-

Carbon Power, and Circular Ecosystem (CATL, 2025b). The “Zero-Carbon Strategy” has become a strong driver of CATL’s sustainability performance.

For instance, CATL’s Yibin factory is fully powered by hydropower. It reduces nearly 400,000 tonnes of carbon emissions every year and sets an industry benchmark for green manufacturing.

In 2024, CATL achieved significant progress, including emission reductions, increased zero-carbon power usage, expanded solar capacity, and nine certified zero-carbon factories, among other achievements.

Figure 5: Core Performance of the “Zero-Carbon Strategy” Special Project



Source: CATL, 2025b

CREDIT: Building a Sustainable Lithium-Ion Battery Value Chain

In 2022, CATL announced the “CREDIT” partnership plan, which stands for Carbon footprint, Recycling, Energy, Due diligence, Innovation, and Transparency. It intends to construct a sustainable lithium-ion battery value chain with comprehensive supplier engagement. It consists of 135 assessment criteria designed for both direct and indirect suppliers, evaluating their sustainability performance, identifying areas for improvement, and providing directions to improve their environmental and social responsibility (World Economic Forum, 2023).

By classifying the carbon footprints of more than 130 key suppliers, CATL has addressed the major sources of its emissions while maintaining steady growth in its core manufacturing operations (Tech in Asia, 2025).

Battery Materials and Recycling

Since 2021, CATL has improved its environmental performance by using recycled materials, optimising packaging, and cutting wood consumption. These initiatives raised solid waste recovery to 99.87% and kept major emissions within 75% of regulatory limits, enhancing overall resource and waste management efficiency (Shu et al., 2024).

Social Performance

Industrial Cooperation and Development

In 2024, CATL enhanced its global cooperation and sustainability leadership by partnering with 162 organisations to take part in the formulation of policy and industry standards. Moreover, CATL has become an industry benchmark in responsible sourcing, carbon reduction, and sustainable battery recycling (CATL, 2025b).

Talent Training and Development

CATL’s evolving talent strategy has strengthened the labour market and supported sustainable industrial growth. In 2023, the company focused on campus partnerships and targeted recruitment, hiring around 600 graduates through collaborations with more than 20 universities (CATL, 2024b). By 2024, the recruitment expanded to more than 6,000 employees. Its joint training programmes with leading institutions further enhanced workforce competence. Additionally, more than 4,000 internal job postings enabling career development were launched, marking CATL’s transition from basic sourcing of talents to an integrated talent development system (CATL, 2025b).

Charity and Volunteer Services

In 2024, CATL's philanthropic programmes significantly expanded, with total donations (RMB22.96 million) doubling the previous year's. Education funding grew to RMB20.35 million. Its "Zero-Carbon Smart Energy Rural Model" initiative also marked a shift towards integrated sustainability and rural empowerment (CATL, 2025b).

Governance Performance

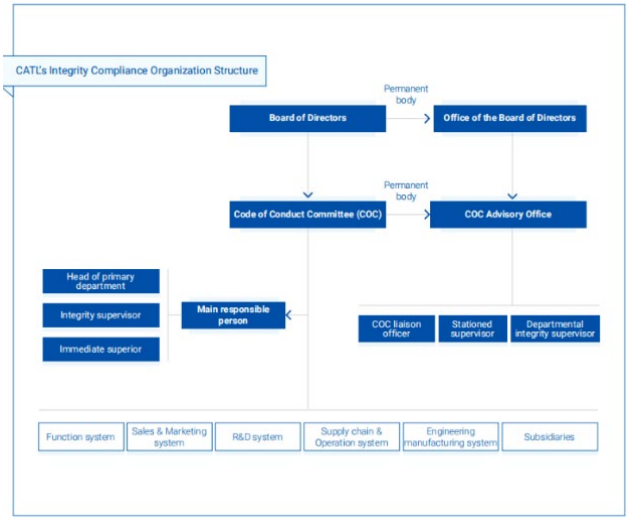
Corporate Governance Structure

CATL ensures transparency and compliance through sound corporate governance practices, including board oversight and external supervision. In 2024, CATL's nine-member board included three independent directors, supported by four specialised committees, reflecting accountability and decision-making efficiency (CATL, 2025b).

Integrity Framework

CATL had established an integrity and anti-corruption framework through forming the Code of Conduct Committee (COC) and the appointment of dedicated compliance supervisors (CATL, 2024b). The work is supported by regional compliance managers across Europe, Asia Pacific and North America. The company further adopted the International Organization for Standardization (ISO) 37001 Anti-Bribery Management System and introduced additional internal controls to enhance risk prevention, compliance oversight, and ethical education. With reporting and investigation rates reaching 100%, CATL has transitioned its compliance mechanism to a globally integrated and systematic integrity management model (CATL, 2024b; CATL 2025b).

Figure 6: CATL's 2024 Integrity Compliance Organisation Structure



Source: CATL, 2025b

Overview

In recent years, CATL's performance in both corporate earnings and ESG has demonstrated that strong ESG management can drive innovation, accelerate product and service iteration, and enhance corporate value, thus strengthening market competitiveness and expanding market share. Stable revenue growth and sustainability are mutually reinforcing (Chen et al., 2024).

CATL's sustainability programmes further illustrate a strategic evolution of China's battery industry. This industry initially expanded through government support, scale, and cost advantages. Now, having achieved market leadership, CATL is integrating environmental objectives into its business strategies, potentially setting new industry standards and further reinforcing China's position in the global electric vehicle supply chain (Tech in Asia, 2025).

The following sections provide a critical analysis of CATL's ESG performance, highlighting some of the controversies and challenges the company currently encounters in its sustainability efforts.

The ESG Assessment of CATL

The ESG of a company is not only a manifestation of its proactive social responsibility but is also subject to external supervision. As one of the major manufacturers of lithium-ion batteries in the world, the ESG performance of CATL has attracted attention from global capital markets, regulatory organisations, and the mass media. From the perspective of managers, the company's ESG performance will have a direct impact on its reputation, which in turn will have an impact on investor confidence. In the context of globalisation, the reputation of multinational corporations (MNCs) is also crucial for expanding their overseas markets. Poor ESG performance can weaken the international competitiveness of an MNC.

Evaluation by Rating Agencies

Rating agencies' ESG assessments are considered important indicators for evaluating the ESG performance of enterprises. Current major ESG rating agencies include Morgan Stanley Capital International (MSCI), Sustainalytics, and agencies from the local market. Their evaluations of CATL are shown in Table 1 and Table 2 below (CATL, 2025b).

Table 1: CATL's ESG Rating from International ESG Rating Agencies

Rating agency	Rating	Description
MSCI	AA	Outstanding performance in carbon reduction and recycling system, but insufficient gender diversity and independence of the board of directors.
Sustainalytics	19.2	The environmental risk is relatively low, and the social responsibility risk of the supply chain needs to be further controlled.

Source: Adapted from CATL, 2025b

Table 2: CATL's ESG Rating from Local ESG Rating Agencies

Year	WIND Rating	WIND Score	SinoSec Rating	SinoSec Score
2019	BBB	6.92	BBB	6
2020	A	7.65	BBB	6
2021	A	7.29	B	3.75
2022	A	8.07	BB	4.75
2023	AA	8.15	BBB	5.75

Source: Adapted from Liu, 2025

There are some differences in the focus of ESG performance evaluation among evaluation agencies, but they all provide valuable reference information for the public and investors. MSCI has rated CATL's 2024 ESG performance as AA, which reflects the company's strong performance in managing ESG risks and opportunities. Particularly in the environmental dimension, CATL is actively developing recycling systems which promote the full-cycle management of the industry. As one of the industry leaders, CATL's development strategy can play a strong demonstrative role for other companies. At the same time, the company has set clear goals for carbon neutrality in its future development.

Other sustainability assessments could focus more on risks. Sustainalytics gave CATL a rating of 19.2 for its ESG performance. This lower risk score suggests that CATL's performance is stable and sustainable. It also indicates that CATL's future goals are attainable, allowing for effective ESG strategy implementation.

Evaluation by Investor and Stakeholders

CATL's ESG performance has made the company a more attractive investment target to investors. In terms of technology and profitability, its performance in recent years has been impressive. In short, its innovation in green technology and energy recovery has supported its competitive position within the industry (Liu, 2025).

However, controversies also exist, such as human rights risks in CATL's supply chain. On 5 June 2024, several members of the US Congress sent a letter accusing CATL of being involved in the use of forced labour in Xinjiang, China. CATL has denied these allegations and said that it does not work with suppliers implicated in such practices. Nevertheless, some of its business operations in the US have been affected. For example, Ford planned to build a battery factory with CATL in the US, but because of the controversy, their collaboration now faces political risks which could cause huge potential losses in the future (Swanson & Ewing, 2023). To the critics, the company's supply chain lacks transparency. As it develops further, CATL must actively ensure the visibility of its supply chain, which will lend credence to its ESG performance.

Society and Media Evaluation

Outside the financial sector, the ESG practices of CATL have attracted the interest of the wider population and the press. In both the Chinese and international markets, public environmental awareness has increased over a short period. Besides pursuing its strategic environmental objectives, CATL has also expressed willingness to serve society by engaging in community development initiatives. For example, the company has assisted farmers through poverty alleviation projects (Liu, 2025). These activities have helped to enhance CATL's brand image and social influence.

CATL has also taken steps to improve employee welfare and development, providing training and career development for its employees. Media coverage of these activities has also boosted the company's image as an employer. At the same time, there have been some articles on social media criticising CATL for its ESG performance. The Business & Human Rights Resource Centre reported that the development of a Chinese-funded lithium-ion battery facility in Debrecen, Hungary is opposed by the locals, who worry about air pollution and the risk of the site turning into a "battery wasteland". 62% of around 200,000 people in Debrecen did not support the construction of the battery factory as they are afraid of pollution (Rutai, 2024). Thus, CATL is still facing ESG challenges and risks, which will be discussed in the next part.

To sum up, external ESG evaluation has shown that CATL ESG performance is comparatively successful. Being one of the leaders in the industry, its developed ESG strategy is not only beneficial to its brand image but also serves as an example to other businesses in this industry. ESG analysis agencies have rated CATL highly, increasing investor confidence in the company.

At the societal level, the company has demonstrated its social responsibility through several social initiatives. However, limitations in supply chain oversight remain a key weakness. Strengthening supplier screening and increasing supply chain disclosure would help establish a stronger and more credible ESG profile in the future.

CATL is likely to face increasingly complex political challenges and risks in the future. The company will need to stay calm and transparent. The next section will address challenges and outline recommendations for CATL's future development.

Outlook and Recommendations

Key Challenges

Supply Chain and Ethical Sourcing

CATL's participation in the Global Battery Alliance's Battery Passport pilot with two of its product lines has improved data collection and tracking for raw materials such as lithium, cobalt and nickel (CATL, 2024a). However, achieving full traceability and transparency across all supply chains remains challenging, particularly in mining, where risks related to unethical practices and labour rights abuses persist. Price volatility in materials is another pressure point. For example, the suspension of CATL's Jianxiawo lithium mine due to licensing issues reportedly raised the market price of lithium and forced CATL to procure some of its raw materials from the open market (S, 2025), thereby compressing its profit margins and elevating operational risk.

Energy-Intensive Production and Carbon Footprint

While the production and adoption of lithium-ion batteries are helping to decarbonise in many sectors, CATL faces trouble in minimising the carbon footprint of its own energy-intensive manufacturing processes. This progress is constrained by CATL's reliance on China's grid, which is not largely renewable, limiting CATL's ability to greatly reduce Scope 2 emissions. Moreover, Scope 3 emissions from various supply chains also contribute to its emissions. Consequently, its direct emissions rose by roughly 5% last year, even as output jumped by almost one-third (Bloomberg, 2025). This reliance may necessitate the purchase of carbon credits to meet the Science-Based Targets initiative (SBTi) requirements (L, 2024).

Battery End-of-Life and Recycling Systems

CATL has set up recycling capacity supported by its subsidiary Brunp, claiming high recovery rates and the ability to process large quantities of end-of-life batteries (Guerra, 2025). However, compared to other global models, CATL still has a long way to scale. For instance, Redwood Materials in the US is building second-life systems and high-efficiency recycling loops (Hawkins, 2025). BYD also reports closed-loop

recycling in its Sustainability Report, including its recycling factories and tracked lifecycle flows (BYD, 2025). The pathway of converting ambition into large-scale implementation remains a challenge for CATL in this competitive market.

Geopolitical Tensions or External Evaluation Risks

Finally, CATL faces geopolitical and other external risks which directly influence its international operations (Bernhart et al., 2025). A prime example is the decision made by US utility Duke Energy. Under pressure from Congress on national safety, it decommissioned CATL batteries at a major Marine Corps base and phased them out of certain civilian projects (Martina, 2024). This action exemplifies how CATL's global partnerships and positions can expose it to geopolitical scrutiny.

Moreover, policies like higher US tariffs have raised CATL's price levels, affecting its competitiveness and market share (Li, 2025). These pressures reveal an urgent need for CATL's continuous ESG reporting, third-party verification, and strategic alignment with international frameworks to mitigate such risks and maintain market access.

Strategic Recommendations

To enhance its sustainability performance, CATL should continue strengthening supply chain governance by adopting digital traceability systems, such as battery passports, and increasing the use of independent third-party audits. It can continue to work with auditors to audit key suppliers from mine to cell production, ensuring compliance with ethical and environmental standards. This would not only improve transparency but also reduce reputational risks in Western markets which view responsible sourcing through a stricter lens.

CATL can also increase renewable energy use in its factories, following similar companies like Panasonic which has committed to 100% renewable energy for its global battery production (Panasonic Group, 2021). Looking at LG's 2025 RE100 goal (LG Energy Solution, 2022), CATL can try to design a more comprehensive roadmap by utilising China's green power gradually, such as installing rooftop solar systems and forming renewable power purchase agreements (PPAs) to reduce Scope 2 emissions.

Expanding closed-loop recycling is another option. As mentioned previously, although CATL already collaborates with customers to create such recycling systems, more opportunities are still waiting to be discovered. For instance, it can partner with international recyclers such as Redwood Materials to improve recovery efficiency and align with emerging circular economy policies in different countries. Coupled with increased R&D investment in sustainable, more easily recyclable materials, CATL can reduce its reliance on critical minerals while improving life-cycle sustainability.

Finally, stakeholder collaboration is crucial. By working with NGOs, governments, and academic institutions to develop standards and ESG benchmarks, CATL can further enhance its data credibility and policy consistency.

Conclusion

In summary, CATL's sustainable development strategy clearly demonstrates how innovation and responsibility can work together to support ESG outcomes. While CATL aims to secure its long-term market position, its investments in advanced battery technologies such as sodium-ion and solid-state systems could support a cleaner and more resilient future for the energy industry, though several risks and challenges remain.

Ultimately, through implementing more effective strategies and building on its position as a market leader, CATL's sustainability progress continues to support global decarbonisation efforts, improving both environmental protection and social well-being through a more circular, equitable, and low-carbon business model.

Discussion Questions

1. How might CATL's integration of ESG principles into its global battery operations create both competitive advantages and reputational vulnerabilities amidst growing scrutiny over supply chain transparency?

2. Given the converging pressures of multiple challenges, what integrated strategy should CATL prioritise to secure its long-term sustainability and leadership in the global battery industry?

3. Can the global push for sustainability be truly inclusive if supply chains still rely on resource extraction from developing regions? Explain your reasons.

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LONGi Green Energy Technology: From Product to System Sustainability

Jiho JEON

OUYANG Ziqi

Amisha SHRIVASTAVA

WANG Zhaozhe

ZHEN Jinhua

Loh, L., & Ang, H. M. (Eds.). (2026). *Cases in sustainability (Vol. 2: System-level and structure-based approaches).* Centre for Governance and Sustainability, NUS Business School.

Upstream / Infrastructure

Environmental & Institutional Impact

Introduction

LONGi Green Energy Technology Co., Ltd. is one of the global leaders in solar technology, focused on shaping the future of clean energy with its innovation-driven ecosystem. The company was founded in 2000 in Xi'an, China, and has grown to become one of the world's largest manufacturers of monocrystalline silicon wafers and solar modules, solidifying its core position in the global renewable energy transition (LONGi, 2025). In 2024, the company's operating revenue was RMB82.6 billion. It has had a stream of periodic technological breakthroughs, vertically integrated manufacturing, and a strong commitment to a circular economy that is supported by sustainable business processes. The company's sustainability report for 2024 highlights science-based net-zero goals and RE100 commitments that play an imperative role in decarbonising the global solar supply chain (LONGi, 2025).

Having presence across 150 countries and regions, LONGi serves as a benchmark for the global photovoltaic (PV) industry. Production bases of the company span across China, Malaysia, Vietnam and the United States, reflecting the company's value of localised manufacturing and low-carbon operations. LONGi's "Solar for Solar" vision aims to produce green energy through its business model: the entire production cycle adds to carbon neutrality and sustained growth. Centred around this philosophy, the firm's ambition is to make renewables globally accessible and economically viable. The aforementioned also greatly reinforces LONGi's ESG framework. In 2024, the proportion of renewable electricity use in production and overall operations increased to 47.5% which resulted in a 37% reduction in Scope 1 and 2 emissions and a 26% reduction in Scope 3 emissions compared to 2023 (LONGi, 2025).

Since its inception, LONGi has been pioneering monocrystalline silicon technology, but since the 2010s, the company has expanded from wafer production into high-efficiency solar cells, modules, and hydrogen solutions. At present, it has five primary sectors of service and delivery: monocrystalline wafers, solar cells, solar modules, hydrogen energy systems and distributed generation solutions (LONGi, 2025).

Another reason of selecting LONGi as a case study is that its Environmental, Social and Governance (ESG) leadership has been recognised internationally. Among many other achievements, LONGi was identified as an "Industry Mover" in the S&P Global Sustainability Yearbook (LONGi, 2025). It has invested in greening its operations through programmes such as the "Green Partner Empowerment Program", invested in social welfare projects and rural revitalisation initiatives, and empowers communities across the world through its partnership with the United Nations High Commissioner for Refugees.

Fostering Systems Change

On a product level, LONGi's efficient wafer and solar cell technologies allow the company to achieve growth. From 2015, it positioned itself as an integrator that has

established full vertical integration in the solar supply chain. During this time, steps were taken towards sustainability and technological innovation to manage the network and comply with regulations. To advance its decarbonisation initiatives, the firm introduced a module recycling programme. It expanded its vision from product-level to system-level sustainability, offering comprehensive green energy solutions to firms rather than just selling products. This makes it a critical player and integrator in the PV supply chain.

In the following pages, we focus on different aspects of sustainability and explore LONGi's initiatives and results in depth.

Understanding the Industry

Understanding the solar photovoltaic (PV) supply chain is essential for LONGi's sustainability and strategies. Each stage has its distinct role demanding specialised technology.

Table 1: Understanding Solar Photovoltaic (PV) Supply Chain

Category	Product	Process	Industry Characteristic
Upstream	Polysilicon, Ingot/Wafer	Polysilicon → Ingot/Wafer	Capital and energy intensive
Midstream	Cell, Module, Array	Cell → Module → Array	Highly competitive market
Downstream	System, Installation	System integration, installation, operations and maintenance (O&M)	Service-oriented, policy-driven

Upstream: Polysilicon and Ingot/Wafer

The upstream process starts with converting silicon dioxide into high-purity polysilicon, an energy-intensive process. This process is mostly operated by specialised producers such as Tongwei and GCL. Thereafter, ingots are formed through melting and crystallising. These ingots will be sliced into thick wafers, which undergo surface treatment to be supplied to cell producers.

Midstream: Cell Supply Chain (Cell - Module - Array)

In the midstream process, wafers are converted into photovoltaic cells, the basic units of the solar panel system, through diffusion, doping, passivation, metallisation, and coating processes. The cells will be multiply connected and turned into a module. Tests are conducted on the module, which then gets packaged and supplied to the downstream stage. At the midstream stage, the low-barrier and highly competitive market prioritises conversion efficiency, production cost, and reliability. Innovation exists in diverse areas, including cell efficiency, smart manufacturing and recycling.

Downstream: Solar PV System and Installation

The downstream stage connects previous manufacturing with consumption through system integration, installation, and maintenance. In this stage, the module is integrated into the energy systems for households, firms, and communities. As a service-oriented stage, it relies on feed-in tariffs (FiTs), renewable portfolio standards (RPS), and green tax credits. Recently, downstream functions have expanded beyond installation and include energy management, grid connection, and module recycling. This implies that the previous linear industry production model is transitioning into a circular and service-based energy ecosystem. As solar capacity grows, the downstream segment is playing a critical role in achieving decarbonisation goals, grid stability, and energy access for local communities.

Core Principles and Resources for Sustainability

As the only Chinese firm (at one point in time) joining all three climate organisation “100” initiatives (i.e. RE100, EP100, EV100) and Science Based Target initiative (SBTi), LONGi has an advanced and comprehensive sustainable strategy.

Core Principles of Sustainability

The overall sustainable vision of LONGi is “to be the most compelling solar technology company by leading the world’s transition to green energy” (LONGi, 2025). It also aims to provide clean energy that is affordable for all. Based on the vision and goal, LONGi developed its sustainable development philosophy “LIGHT” by considering the company’s development strategy, industry characteristics, national development plan, and the United Nations Sustainable Development Goals (UN SDGs). There are five principles included in this philosophy: Lead, Innovative, Green, Harmonious, and Trustworthy (LONGi, n.d.), which reflect the SDGs.

- **Lead**: Promoting better development of the company, the industry, the communities, and the society, which is aligned with LONGi’s vision of leading the world’s transition to green energy.

- **Innovation**: Providing better clean energy solutions through innovation, enhancing product and technology developments.

- **Green**: For environmental protection, Longi has environmental goals including water usage and carbon footprint reduction, as well as fostering a circular economy (SDGs: 6, 7, 12, 13, 15).

- **Harmonious**: Sharing value with all stakeholders, as well as enhancing the development of employees, industry, communities, and the society (SDGs: 1, 3, 4, 5, 8, 10, 11).

- **Trustworthy**: Constructs a trustworthy brand by continuously enhancing collaboration and relationships with stakeholders throughout the value chain to meet social responsibilities (SDGs: 8, 12, 16, 17).

Overall, these principles support LONGi's sustainability and economic development, guiding its objectives and actions.

Resources for Strategy Execution

Governance framework support

LONGi established a comprehensive three-tier ESG governance framework, including corporate governance, management, and execution levels, (LONGi, 2025) for sustainability strategy execution. From the highest-level decision-making to sustainable actions in daily operations, the governance framework provides systemic support in directing, monitoring, and evaluating the execution. Meanwhile, company policies are in place to comply with China's laws and regulations.

Technology Support

LONGi owns advanced technology to support its sustainability development in the supply chain. For example, it improved the battery efficiency for PV Modules with Hybrid Passivated Back Contact (HPBC) technology, allowing better usage of solar energy to produce more electricity. Meanwhile, it achieved a 20% reduction in unit energy consumption in production bases and has constructed a "Lighthouse + Zero Carbon" factory (LONGi, 2025). Its alkaline water electrolysis technology for producing hydrogen also allows clean energy production for the corporation and its consumers. With technology support, LONGi advances sustainability development in its supply chain.

Sustainable Actions and Impact

Environment

Environmental Objectives & Commitments

As a global leader in the photovoltaic manufacturing industry, LONGi emphasises environmental sustainability management throughout its production and operational processes. The following parts of the report demonstrate LONGi's "Green" principle and commitments.

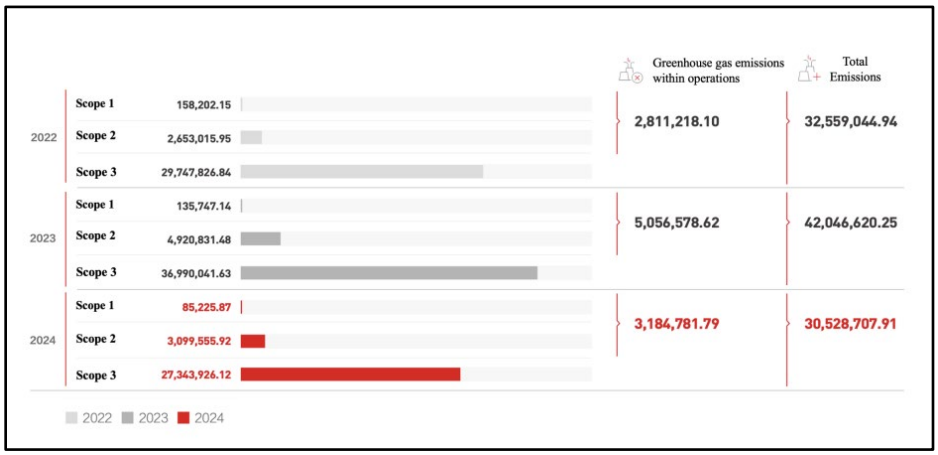
LONGi's early commitment to RE100 and SBTi has evolved into a comprehensive ESG framework (Jonnak, 2025). It has joined international initiatives including SBTi, RE100, EP100, and EV100. Compared to 2020, the company is committed to reducing its Scope 1 and 2 greenhouse gas (GHG) emissions by 60% by 2030, in alignment with the SBTi, and to achieve 100% renewable electricity consumption by 2028 under the RE100 commitment (LONGi, 2025). Its 2024 performance had also exceeded targets set for wastewater reduction and waste recycling.

Key Environmental Initiatives

Strategies for Reducing GHG Emissions

Systematic energy-saving upgrades were implemented across its major manufacturing processes: monocrystalline silicon ingot production, wafer cutting, cell manufacturing, and module assembly. LONGi implemented 477 technical upgrading projects aimed at reducing energy, which was expected to save 426 GWh of electricity a year and significantly lower emissions (LONGi, 2025). To improve internal sustainability awareness and capabilities, LONGi provides management with specific energy efficiency courses and educates all staff about energy conservation.

Figure 1: LONGi's Scope 1, 2 and 3 Emissions from 2022 to 2024



Source: LONGi, 2025

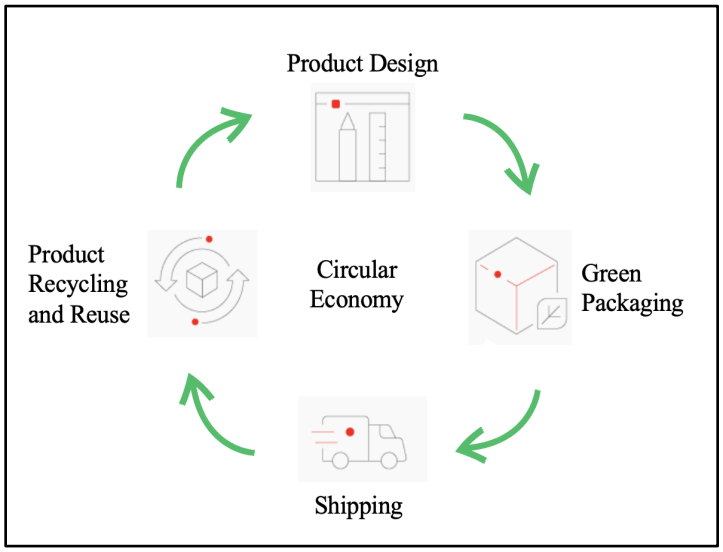
LONGi made major advances in reducing greenhouse gas emissions, improving energy efficiency, and using renewable energy sources between 2022 and 2024. In comparison to 2023, the company's total greenhouse gas emissions decreased by nearly 27%, with Scope 1, 2, and 3 emissions declining by 37.2%, 37.0%, and 26.1%, respectively c. These figures demonstrate how the company has substantially reduced the carbon footprint of its supply chain and operations by improving energy efficiency and optimising energy structures.

Water Resource Utilisation and Wastewater Discharge

LONGi's water resource management initiatives have yielded significant environmental impacts, primarily manifested in three areas: water conservation and efficiency enhancement, recycling, and pollution reduction. The company has established comprehensive water resource management systems across all production processes, setting clear water-saving targets and accountability mechanisms. Consequently, the amount of water used per unit of production has decreased by 24.8% annually (LONGi, 2025). The total wastewater discharge was decreased by 17.7% by implementing source reduction and differential treatment at each stage. This would also lead to lower waste recycling costs for the firm. These achievements illustrate LONGi's industry-leading role in developing sustainable and circular production methods within the solar manufacturing sector.

Circular Economy

Figure 2: How LONGi Fosters a Circular Economy



According to its life cycle assessment (LCA), LONGi solar panels have a significantly lower environmental effect than traditional sources of energy, from manufacturing to disposal (Austra Solar Pty Ltd, 2024). From product design to recycling, LONGi adopts a circular economy approach.

For product design, sustainable optimisation across the entire product lifecycle is driven by process upgrades and innovative technological enhancements. By using Zero-Waste Design principles, the firm reduces its dependency on non-renewable resources while increasing the recyclability of its products and the efficiency of its material usage.

LONGi has reduced carbon emissions by almost 1,300 tonnes by using only recycled packaging for domestic wafer shipments during the green packaging and shipping phases c. These practices not only reduced the carbon emissions but also improved the efficiency of reusing. For establishing a green supply network, LONGi has effectively lowered carbon emissions and energy usage in the logistics process. At the end of its product life cycle, through cooperation with European recycling networks, LONGi has built a systematic photovoltaic module recycling system, which achieved a recycling rate of up to 94%.

To summarise, LONGi's environmental initiatives have already made progress on carbon reduction and protecting the environment. The actions and results align with their "green" commitments, which help the company to make greater contributions to the sustainable development of the photovoltaic industry.

Economic

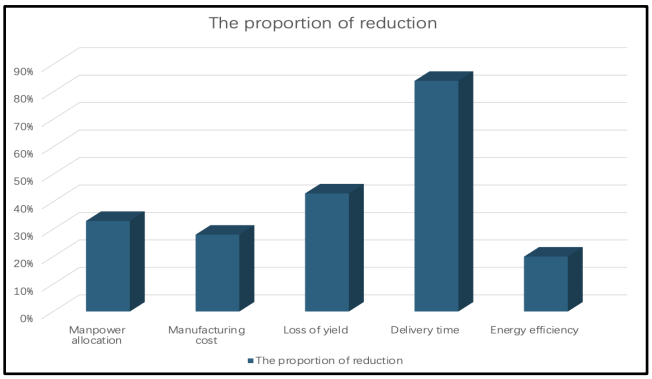
Sustainability in business strategy goes beyond social and environmental responsibilities. The conventional ESG (Environmental, Social, and Governance) framework places a strong emphasis on social responsibility and environmental preservation, but it ignores economic development and shareholder profit, which makes a company's long-term strategy unsustainable. Loh (2024) notes that "EESG is the way forward, but the colour of money must be green too". Achieving a balance in sustainable development within the ESG framework requires consideration of economic variables. LONGi combines sustainability and profitability through green innovation, sustainable manufacturing, and global value chain collaboration. This aligns with the "Innovation" principle of LONGi. This shows the long-term competitive advantage and economic resilience of green energy enterprises. The economic advantages of LONGi's inventions and Research & Development (R&D) will be analysed further in the following paragraphs.

Innovation and R&D

In recent years, LONGi's achievements in R&D have made significant contributions to the company's economic sustainability. LONGi has achieved product innovations in wafers, cells, and modules. This has strengthened its dominant position in the global solar sector, allowing for technical independence. According to the research, LONGi's independently designed HPBC 2.0 module broke the 36-year monopoly held by foreign photovoltaic companies on crystalline silicon module efficiency records and set a new world record for photovoltaic modules with an efficiency of 25.4% (LONGi,

2025). In addition to improving product performance and market competitiveness, LONGi's technological advancements allowed the company to integrate R&D achievements with financial gains. LONGi's pricing power was strengthened by the mass manufacture of high-efficiency modules, which also improved return on investment and decreased manufacturing costs. At the same time, this technical leadership promoted sustainable economic growth, allowing the company to increase profits through green innovation and accomplish a positive cycle within the ESG framework.

Figure 3: Economic Benefits from LONGi's R&D



LONGi's Jiaxing plant, the first worldwide "Lighthouse Factory" in the photovoltaic industry, has made the integration of intelligent and digital production processes. Its innovations have not only improved production flexibility and quality control standards but also gained economic benefits: a 33% reduction in manpower per production line, a 28% decrease in manufacturing costs, a 43% reduction in yield loss, an 84% shortening of production delivery time, and a 20% reduction in energy consumption per unit (LONGi, 2025).

From an economic perspective, this intelligent manufacturing system has successfully increased output and resource utilisation while lowering energy and operating expenses. As a result, LONGi can sustain its commitment to green manufacturing practices while achieving significant profit growth. This illustrates that digital transformation is not just a process of updating technology. It could be a strategic foundation that motivates companies to have sustainable economic growth. It is also crucial to achieving low-carbon and effective development within the Economic, Environmental, Social and Governance (EESG) framework.

Social

LONGi influences the industry and the community through its social sustainability initiatives in human rights, occupational safety and health, human capital development, and community development.

Protect Human Rights

Internally, LONGi designed various policies to prevent child labour, forced labour, discrimination and harassment, launching compliance audits of these aspects annually. Meanwhile, it constructs a diverse, equitable and inclusive (DEI) culture through policy support, recruitment, training, KPI measurement, and bottom-to-top monitoring. Externally, the company conducts human rights due diligence on all the entities in its supply chain (LONGi, 2025).

In 2024, LONGi has no incidents or complaints related to child labour, forced labour, or violations of labour laws. The employee structure is diverse in gender, age, region, and educational background, while 100% of employees received training about DEI principles (LONGi, 2025). This contributes to building an equal and inclusive workplace, while also reducing ethical risks and encouraging human rights protection in its supply chain.

Occupational Safety and Health

LONGi emphasises safety and health in the workplace. It introduced 17 new institutional documents in 2024. Moreover, it has an Environment, Health, and Safety (EHS) system under a three-level management framework (Group Department, Division/Center Department, Subsidiary Department), to achieve “zero harm, zero accidents, zero pollution”. This system offers security guidelines and training, aids in risk detection and emergency management, and promotes a culture of safety.

With the EHS system, LONGi had significant achievements. In 2024, all the operational sites underwent labour health and safety assessments, while no deaths, level 1 or level 2 work-related injuries or fire incidents occurred. 57,490 potential safety hazards were recognised, with a rectification rate of 99.51% (LONGi, 2025).

Human Capital

In supporting employees’ career development, LONGi has a multidimensional remuneration framework (base salary, subsidies, bonuses, profit sharing, etc.), while promotion is based on a comprehensive evaluation of performance (LONGi, 2025). Targeted training (on leadership, new employee onboarding, and professional skill enhancement) is also provided for career development, and employee care programmes in health management, living support and leisure activities are conducted. In addition, bottom-up communication is enhanced through labour unions, workers’ congresses, and diversified communication channels (mailbox, forums, reception days, etc.), promoting employee satisfaction and motivating them to give suggestions for corporate development.

In 2024, the company achieved 100% employee regular formal performance assessment, 100% social insurance coverage rate for employee care, and 100%

collective agreement signing rate (LONGi, 2025). The investment in employee training was RMB25.4 million, with 57.73 training hours per individual, while the employee satisfaction score of the corporate atmosphere was 91.03 (LONGi, 2025). LONGi's human capital development helps employees improve skills and advance their careers, while care programmes boost satisfaction and well-being. The company gains from greater productivity and profitability through motivated, high-performing staff.

Community Engagement

LONGi contributes to the community through multiple supportive campaigns. It invested in clean energy infrastructure construction and improvements, donating Hi-MO to a Polish primary school for the disabled, and building rooftop photovoltaic systems for maternity clinics in Mozambique (LONGi, 2025). Additionally, the firm donated RMB28.89 million in rural revitalisation and provided RMB1.35 million in educational support for the School of Physics in Lanzhou University (LONGi, 2025).

LONGi's total donation amounted to RMB78.47 million in 2024 (LONGi, 2025). Supporting rural areas and education boosts the company's reputation, benefits donation recipients, and promotes social equity and community development.

Overall, LONGi's sustainable actions in the social aspect not only improve its reputation and reduce potential ethical risks, but also protect employees' rights and safety, support their career development, and enhance their well-being. The donations also increase rural energy access and reduce social inequity. The company's efforts make a meaningful impact on society, creating advantages for itself, the industry, and the wider community.

Governance

Governance Structure and Board Oversight

Figure 4: LONGi's Governance Structure

Source: LONGi, 2025

LONGi's governance framework exemplifies the corporate governance perspective, where governance should define the relationship among stakeholders to shape the strategic direction and performance of organisations. In implementation, the company

operates under a “three-tier governance structure” spanning the corporate governance, management and execution levels. This hierarchy establishes order between ownership and management, and ensures strategic decisions are made effectively and stakeholders’ interests remain aligned.

The Board of Directors, which includes independent members with financial, environmental, and technical expertise, bears overall responsibility for ESG oversight. The Strategy and Sustainability Committee, part of the board, integrates sustainability objectives into LONGi’s core business strategy, reviewing progress on climate targets, emissions management, and resource efficiency. This vertical integration illustrates that effective sustainability performance depends on board-level oversight connected to systematic implementation, rather than fragmented or ad-hoc initiatives.

Ethics, Compliance, and Integrity Culture

Ethical governance at LONGi is anchored in its Code of Business Conduct and Compliance Management Policy, which emphasises integrity, anti-bribery, and fair competition. In 2024, the company conducted 4,447 integrity and ethics training sessions, a sevenfold increase from 578 in 2022, reaching 40,681 employees and achieving 100% training coverage for both employees and board members (LONGi, 2025). Over 99% of employees rated integrity practices as above average, and 98% expressed willingness to report violations (LONGi, 2025).

Furthermore, LONGi maintains an independent audit department and a whistleblowing system that allows anonymous reporting and board-level oversight of investigations. These instruments serve as checks and balances, highlighting that effective governance depends on information transparency and control mechanisms to manage agency conflicts.

Transparency and Disclosure

In line with the governance framework, disclosure acts as an accountability mechanism that enables stakeholders to evaluate corporate behaviour. LONGi discloses detailed information on governance performance, ESG targets, and risk management through its annual sustainability reports and board communications.

At the same time, LONGi’s disclosures comply with international frameworks including the GRI Standards, the IFRS S1 and S2 Sustainability Disclosure Standards issued by the ISSB, the TCFD Recommendations, and the CDP Climate Disclosures. These standards enhance the reliability and comparability of data. The company’s adoption of independent third-party assurance further strengthens confidence in its ESG statements.

Risk Management and Oversight

LONGi has established a comprehensive risk management framework to ensure stable and compliant operations across all business units. Guided by domestic and international standards, the company implements the “Three Lines of Defence” model, which defines responsibilities across departments for identifying, assessing, and controlling risks (LONGi, 2025).

The first line of defence consists of business departments responsible for monitoring and managing key operational risks within their functions. The second line of defence, the Risk Management Department, develops company-wide risk management standards, coordinates cross-departmental risk governance, and provides professional guidance on risk control. The third line of defence, the Internal Audit Department, conducts independent audits to evaluate the effectiveness of the overall risk management system and internal controls.

LONGi has also developed a structured Risk Management Process, covering risk identification, assessment, response, and ongoing improvement. Emerging risks such as cybersecurity threats and extreme climate events are monitored through regular evaluations, and corresponding countermeasures include network security enhancement, emergency management plans, and climate response initiatives.

To strengthen organisational preparedness, the company promotes a strong risk management culture through both online and offline training. In 2024, LONGi conducted 29 empowerment sessions with an average satisfaction rate of 93%, complemented by e-learning courses and internal communication platforms (LONGi, 2025). These efforts aim to improve employees’ awareness, response capabilities, and alignment with the company’s risk management principles.

In conclusion, LONGi’s governance architecture demonstrates the integration of accountability, transparency, and stakeholder alignment. Its multi-layer board oversight, strong compliance culture, transparent disclosure systems, and proactive risk controls managed to move governance from a compliance function to a strategic enabler of sustainability.

Performance Evaluation and Benchmarking

LONGi’s ESG Rating

LONGi’s ESG ratings in 2024 reflect significant progress in disclosure and performance but also reveal the structural challenges of its industry. Different rating agencies have also shown different methodologies when evaluating the company’s ESG performance.

Table 2: LONGi's ESG Rating (as of January 2025)

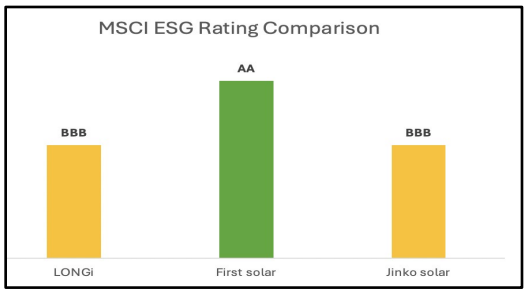
Agencies	Ratings
MSCI	BBB
Sustainalytics	Medium Risk: 24.8
S&P Global	50

According to MSCI's sector framework, companies in the Semiconductors & Solar Equipment industry are primarily evaluated on carbon emissions, labour management, toxic waste, and corporate governance. LONGi's improvements in renewable electricity adoption, water conservation, and transparent supplier audits have bolstered its management score, increasing its MSCI ESG rating to BBB, the highest rating among semiconductor and photovoltaic A+H-share companies globally (LONGi, 2025). However, MSCI ratings are peer-relative, and the BBB grade suggests that while LONGi performs well within China's solar industry, it continues to lag behind global leaders that demonstrate lower life cycle carbon intensity, more comprehensive supply chain traceability, and broader third-party assurance coverage.

By contrast, Sustainalytics applies a risk-based methodology, quantifying how much ESG risk could materially affect enterprise value after existing controls. Its score of 24.8 with a medium risk shows that LONGi's management systems substantially mitigate but cannot eliminate risks such as the exposures linked to energy-intensive production and complex supply chains. Hence, this result captures the tension between strong operational management and unavoidable industrial exposure.

Meanwhile, S&P Global's Corporate Sustainability Assessment (CSA) focuses on disclosure breadth and evidence of implementation. LONGi achieved an S&P Global CSA improvement, being recognised as the "Industry's Most Improved Company" and included in the Sustainability Yearbook (China Edition) 2025. The CSA score of around 50 out of 100 indicates that LONGi's governance and disclosure maturity now exceeds the global median but still lacks the full data.

Figure 5: MSCI ESG Rating Comparison



Source: Figure created by authors, with information from First Solar (2024) and Jinko Solar (2025)

EESG Scoreboard

The rating comparison raises the concern about whether LONGi is indeed a leading company in sustainability. To understand this, our data collection measures the EESG scoreboard of three major companies: LONGi, Jinko Solar and First Solar (two Chinese firms and one American firm). Each EESG sector has five sub-factors to measure the score. Overall, LONGi fared better than Jinko Solar in most aspects but had a lower score than First Solar.

In detail, in the Environmental aspect, LONGi showed a strong ability in “Scope 1+2 emission intensity” and “Waste Recycling rate”, which brings a comparatively high score. However, in Economics, except for “R&D intensity”, LONGi did not show a comparatively strong performance. For the Social sector, most of its data is higher than Jinko, but lower compared to First Solar, implying the need to match global peers. In governance, LONGi only had three independent directors for the board, attaining 33% for board independence, a lower proportion compared to the other two firms.

In conclusion, LONGi showed a similar or better score compared to Jinko and a relatively lower score compared with First Solar. Especially in the fields of economics, social issues, and governance, there is a need to improve to match global standards. Considering LONGi’s integrator position within the PV industry, simply comparing numerical indicators can put LONGi at a relative disadvantage. While other companies mostly focus on a single aspect, LONGi looks at a broad range of the industry and has high complexity in its supply chain and network. Its actual efforts and outcomes are likely higher than what the scores reflected.

Figure 6: EESG Radar Chart

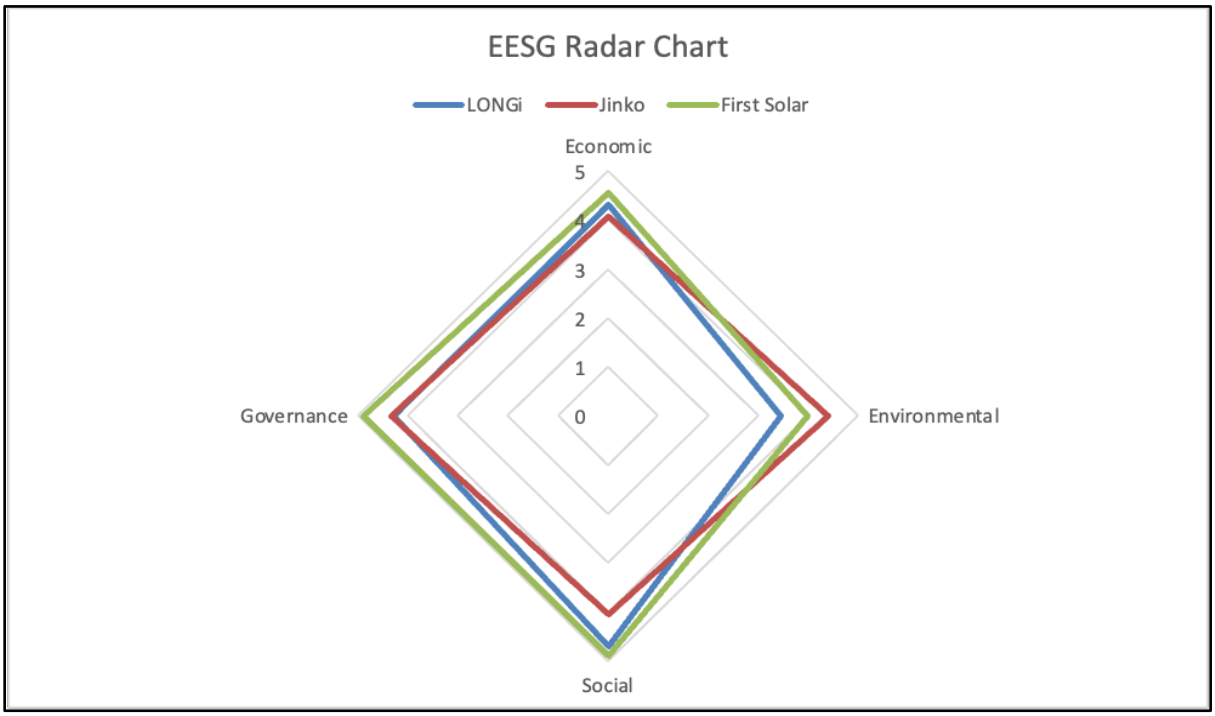


Table 3: EESG Scoreboard

Pillar	Indicator	LONGi	Jinko Solar	First Solar
Economic	R&D Intensity (% revenue)	6.07	5.5	4.9
	Operating Margin (%)	15	14	18
	CapEx/Sales (%)	8.2	7.4	9.8
	Debt-to-Equity	0.55	0.63	0.4
	Gross Margin (%)	21	19	25
Environmental	Renewable Electricity Share (%)	47.5	53.3	Average
	Scope 1+2 Emission Intensity (tCO_2/MWh)	0.35	0.37	0.25
	Scope 3 Disclosure Coverage (%)	85	95	100
	Water Withdrawal Intensity (m^3/MWh)	1.8	0.2658	1.4
	Waste Recycling Rate (%)	82.7	76	98
Social	Employee Safety (ISO 45001, %)	100	85.71	100
	Human Rights & Diversity (1–5)	4.5	4	5
	Training Hours per Employee (h/year)	57.7	50	72
	Community Investment (million RMB/USD)	78.47	60	70
	Supplier ESG Audit Coverage (%)	100	80	100

Pillar	Indicator	LONGi	Jinko Solar	First Solar
Economic	R&D Intensity (% revenue)	6.07	5.5	4.9
	Operating Margin (%)	15	14	18
	CapEx/Sales (%)	8.2	7.4	9.8
	Debt-to-Equity	0.55	0.63	0.4
	Gross Margin (%)	21	19	25
Environmental	Renewable Electricity Share (%)	47.5	53.3	Average
	Scope 1+2 Emission Intensity (tCO_2/MWh)	0.35	0.37	0.25
	Scope 3 Disclosure Coverage (%)	85	95	100
	Water Withdrawal Intensity (m^3/MWh)	1.8	0.2658	1.4
	Waste Recycling Rate (%)	82.7	76	98
Governance	Board Independence (%)	33	Average	80
	Anti-Corruption (1–5)	5	4	5
	ESG Integration in Strategy (1–5)	5	4.5	4.5
	Data Security & Privacy (1–5)	5	4	5
	Transparency & Reporting (1–5)	5	4.5	5

Challenges and Recommendations

Challenge 1: Environmental Gap

LONGi comes across as a sustainability leader in the PV supply chain. It is enhancing the circular economy practices by using energy-efficient technology, module recycling programmes and using hydrogen-powered solutions. However, most efforts that are focused on the environmental aspects are concentrated on downstream and midstream operations, indicating a huge gap in the emissions management upstream. Upstream activities contribute significantly to a PV supply chain's carbon emissions, especially in the refinement of raw materials, an area that is largely outside of LONGi's direct purview. The sector's intrinsic focus on stability and efficiency makes it difficult for any intervention, as price and economic effects restrict direct action (Ng, 2022). Hence, the main challenge is finding a way to leverage market influence to improve upstream decarbonisation across suppliers and industry partners. The focus needs to go beyond improving internal processes.

Recommendation: LONGi should better collaborate with upstream partners for the reduction of supply chain-wide emissions. It should set targets as well as incentive plans for associated parties. It can also enhance transparency through carbon footprint certification and third-party audits.

Challenge 2: Governance Gap

LONGi's Strategy and Sustainability Committee comprises the Board Chairman, Managing Director, Chief Financial Officer, two directors and one independent director (LONGi, 2025). This composition leans towards very limited independence. External ESG experts advise only at the management level and not on the board itself. Such a structure with limited external visibility poses challenges of external oversight, accountability, and protection against conflict of interest. Effective governance should strike a balance between internal and external mechanisms.

Recommendation: LONGi can improve the independence of its Strategy and Sustainability Committee by appointing external ESG advisors who report directly to the board. While the committee may be chaired by the Chairman, a hybrid model where a balance of internal and external control is achieved would maintain feasibility and align international best practices with LONGi's sustainability governance.

Challenge 3: Reporting Gap

LONGi's sustainability reporting claims to align well with international frameworks such as GRI standards, ISSB, SBTi, and other regional regulatory guidelines. There are also third-party assurance checks. However, some gaps persist. For example, LONGi could address dual materiality more clearly, bearing in mind that the GRI focuses on

impact materiality and stakeholder interests and ISSB focuses on financial risk materiality for investors. There could be more transparency in showing its business impacts and financial risks.

Regarding end-of-life and product traceability, the PV sector is now moving towards more stringent rules, with EU standards demanding more granular data, comparable lifecycle analysis and recycling performance measures. External pilots in module recycling are documented in LONGi's current reporting, but it could also include international ecolabel adoption and full product certification, hence matching EU's best practices.

For risk and opportunity disclosure, LONGi considers climate and supply chain risks and opportunities, but offers very limited scenario-based planning, forward-looking analysis or qualified financial risk exposure. Greater clarity is needed on the assumptions and steps behind its risk assessments.

Recommendations: LONGi should consider maintaining transparency in reporting material sustainability points and how they relate to the company's financial performance. In addition, it should inculcate EU standards by adopting international ecolabel certifications and implementing digital product passports for product traceability. Its reporting should also have detailed scenario-based planning and the identification of risks and opportunities, in line with TCFD recommendations and ISSB S2's forward-looking requirements.

Conclusion

LONGi stands as a global leader in solar technology through driving innovation, sustainability and an exemplary circular approach in its vertical supply chain. It has led the industry by being a benchmark in reducing GHG emissions, improving renewable energy usage and investing in social welfare and community empowerment. LONGi's governance framework integrates ESG principles at the board level, inculcating accountability and risk management. However, regardless of strong sustainability efforts, LONGi faces challenges in upstream emissions management, governance independence and full alignment with advanced reporting standards. As LONGi moves forward, a strong focus on collaboration, improved transparency and addition of international best practices will play an imperative role in the company's leadership position in the clean energy transition.

Discussion Questions

1. Heavy upstream emissions by specialised manufacturers may be out of LONGi's direct purview. How should the firm manage this situation? Discuss options such as internally producing those materials and setting strict sustainable supply contracts.

2. If you were a director of LONGi, would you continue to invest heavily in hydrogen despite weakening profitability? Is hydrogen essential for LONGi's long-term renewable ecosystem strategy? (Note: Hydrogen needs long-term investment but is considered a good match with renewable energy.)

3. Can sustainability reporting be LONGi's competitive advantage? How should it balance the benefits of sustainability reporting with reporting costs?

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Sembcorp: Energising Sustainability

LI Jiaan

LUO Shuangziyi

Yolanda SUCIATI

WU Jiaqian

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Upstream / Infrastructure

Environmental & Institutional Impact

Introduction

Sembcorp Industries Ltd. is a Singapore-based company that provides energy and urban development solutions across more than 10 countries in Asia, the Middle East, and the United Kingdom. The company was primarily known for its traditional power and utility operations; however, over the past decade, it has undergone a significant transformation towards sustainability and decarbonisation. This transformation responds to both external and internal needs, such as the global movement towards net-zero economies, growing stakeholder expectations for corporate responsibility, and Singapore's national Green Plan 2030.

At the centre of Sembcorp's strategy is the idea of "Energy and Urban Transformation" which makes sustainability the foundation of its business growth. This approach encompasses the expansion of renewable energy, green finance, and sustainable urban projects, supported by a strong governance system that ensures accountability and reduces risk. The company plans to reach net-zero emissions by 2050 and increase its renewable energy capacity from 13 gigawatts (GW) to 25 GW by 2028 (Sembcorp Industries, 2025). Sembcorp has also established a governance structure that integrates environmental, economic, social, and governance (EESG) factors, reflecting a strategic shift in which sustainability is seen as a key element of competitiveness rather than just a corporate duty.

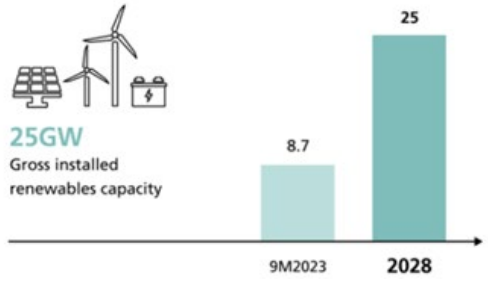
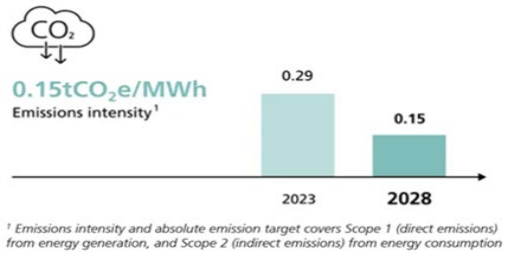
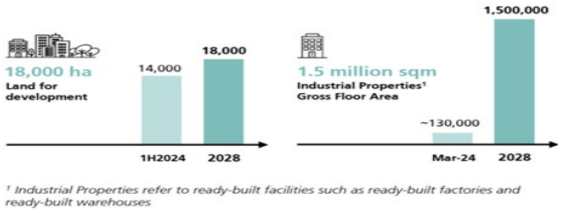
Company Overview

As climate change worsens, Sembcorp is committed to strengthening its presence in energy transitions to have a greater impact on sustainability. By shifting its business from carbon-intensive ("brown") to low-carbon and renewable ("green"), Sembcorp aims to become a leader in the renewables sector and a key provider of industrial and urban solutions in Asia. With an energy and urban portfolio spanning 11 countries, in 2024, Sembcorp achieved 25.1 GW in its energy portfolio, including 17.0 GW of renewable energy and 14,400 hectares (ha) of Gross Development Land. Sembcorp is actively expanding its renewable capacity and strengthening its competitive advantage by lowering its emissions intensity from 0.29 tCO2/MWh in 2023 to 0.27 tCO2/MWh in 2024, and by increasing its industrial properties from 134,000 square metres of gross floor area (GFA) in 2023 to 508,000 square metres of GFA in 2024. As of 2024, the company reported a profit of S$1,011 million, representing a 7% increase from 2023, when the profit amounted to S$942 million (Sembcorp Industries, 2025).

Sembcorp Transformation Journey

In 2023, Sembcorp announced its commitment to its 2024-2028 strategic plan with the following targets.

Table 1: Sembcorp 2024-2028 Strategic Plan

<table>
<tr><th colspan="2">Accelerate Renewables Growth</th></tr>
<tr><td> 
</td><td>Sembcorp focuses on growth in key markets while allocating 75% of its investment plan to renewable energy.</td></tr>
<tr><th colspan="2">Strengthen Commitment to Decarbonisation</th></tr>
<tr><td> 
</td><td>Sembcorp is exploring and expanding its decarbonisation offerings, allocating 10% of its investment plan to support them.</td></tr>
<tr><th colspan="2">Asia’s Leading Low-Carbon Industrial Park Developer</th></tr>
<tr><td> 
</td><td>With its extensive development experience and established track record, Sembcorp is planning to expand its land bank and increase the gross floor area of its industrial properties, supported by 5% of its investment plan.</td></tr>
<tr><th colspan="2">Business as Usual</th></tr>
<tr><td colspan="2">Sembcorp is planning to optimise its existing gas assets to support Asia’s transition towards a cleaner, more responsible energy future, while meeting its carbon commitments. Sembcorp intends to allocate 8% of its investment plan to hydrogen-ready assets and 2% to replacement capital expenditure.</td></tr>
</table>

Source: Sembcorp Industries, n.d.-a

Four Business Focuses

Gas and Related Services

Sembcorp's portfolio comprises 8 GW of primarily gas-fired power generation capacity across countries such as Singapore, Myanmar, China, Bangladesh, Oman, the United Arab Emirates (UAE), and the United Kingdom (UK), with a leadership role in natural gas in Singapore (Sembcorp Industries, 2025). Sembcorp offers comprehensive services ranging from gas sourcing to importation and trading. To secure earnings, support its role as a major importer of natural gas in Singapore, Sembcorp actively secures multiple long-term Power Purchase Agreements (PPAs), typically spanning 8 to 18 years. These contracts are designed to provide reliable power, mitigate the impact of energy price dynamics, and support customers' decarbonisation goals (Sembcorp Industries, 2025). Sembcorp has diversified its gas supply in Singapore from various sources and has divested all its coal-fired power plant interests as part of its commitment to advancing the energy transition.

Renewable Energy

Sembcorp's renewable energy spans wind, solar, hydropower, and energy storage. As of 2024, Sembcorp has established a gross renewable energy capacity of 19.3 GW across Southeast Asia, China, India, the UK and the Middle East. As of January 2025, Sembcorp had secured its long-term PPAs for 50 megawatts (MW) of solar capacity and 14 megawatt-hours (MWh) of battery energy storage system (BESS) projects in Indonesia, alongside 196 MW of wind and solar projects, and the acquisition of a 49 MW hydropower asset in Vietnam. It also deployed up to 729 MW of its solar project portfolio in Singapore and expanded into the Philippines' renewable energy sector with a capacity of 96 MW (Sembcorp Industries, 2025).

Integrated Urban Solutions

The Integrated Urban Solutions segment comprises urban development, water, and waste-to-resource activities, aiming to promote sustainable urban development and to develop innovative solutions. Within the urban segment, Sembcorp has established itself as a leading low-carbon industrial park player, capturing growing demand for green factories and low-carbon industrial properties for lease and integrating renewable energy solutions to reduce carbon footprints. SembEnviro, a subsidiary of Sembcorp, provides integrated waste management services in Singapore, cooperating with TBS Energi to reduce its carbon footprint and promote environmental sustainability through low-carbon growth (Sembcorp Industries, 2025).

Decarbonisation Solutions

Sembcorp helps companies develop practical, scalable, low-carbon solutions to support their decarbonisation journey. The Decarbonisation Solutions segment consists of renewable imports, low-carbon alternatives, and GoNetZero (Carbon Management Solutions) (Sembcorp Industries, 2025).

Market and Competitive Analysis

Conducting a competitor analysis for Sembcorp Industries Ltd. is inherently complex due to the company's diversified business portfolio. Sembcorp operates across multiple sectors, including gas and related services, renewable energy, integrated urban solutions, and decarbonisation services — each characterised by distinct market dynamics and industrial structures. As a result, it is not feasible to identify a single competitor whose operations fully mirror Sembcorp's entire business scope.

To ensure analytical accuracy and relevance, this report adopts a sector-specific benchmarking approach. Competitors are selected based on two key criteria:

Operational similarity: companies engaged in comparable products and services within each of Sembcorp's four business segments.

Regional and scale alignment: firms with substantial operations in Southeast Asia, where Sembcorp's business presence is most significant, and with comparable asset scale or market influence.

This framework enables both horizontal comparability within each sector and contextual understanding of Sembcorp's market position in the Southeast Asian sustainability landscape.

Gas and related services industry

Sembcorp Industries operates gas-fired power generation assets across multiple regions, with a total installed capacity of approximately 8.0 GW (Sembcorp Industries, 2025). Among these markets, Singapore represents the company's primary and most strategically significant market, hosting the 1,219 MW Sembcorp Cogeneration Plant (Sembcorp Industries, n.d.-b). Given this concentration, the competitor analysis in this section focuses on Singapore's gas-fired power generation market.

According to the Energy Market Authority (Energy Market Authority, 2025a), for the first half of the year 2025, the major licensed electricity generation companies and their approximate market shares are: Senoko Energy (18.7%), Tuas Power Generation (18.5%), YTL PowerSeraya (13.9%), with other participants such as Keppel Merlimau Cogeneration and Sembcorp Cogen also active in the market. The market remains

relatively balanced due to regulatory limits, as no single generation licensee is permitted to hold more than 25% of total market share in Singapore's wholesale electricity market (Energy Market Authority, 2025b). This ensures a competitive yet concentrated structure among these companies.

Among these companies, Tuas Power Generation, Senoko Energy, and YTL PowerSeraya primarily focus on electricity generation. In contrast, Sembcorp and Keppel represent a higher level of integration across the sustainable energy value chain, encompassing gas importation, cogeneration, and downstream energy solutions. This structural similarity makes both firms direct competitors in market positioning.

Singapore's power generation market is highly regulated and oligopolistic, with fewer than ten licensed generation companies. Competition in Singapore's electricity generation market is therefore limited, as regulatory restrictions prevent large-scale price competition and market consolidation.

Instead, firms differentiate themselves through technological efficiency, operational reliability, and asset optimisation. The ability to maintain high thermal efficiency and stable generation output amid volatile gas prices is a key determinant of competitiveness. Consequently, technological advancement and consistent operational reliability have replaced price rivalry as the primary sources of competitive advantage in the sector.

Renewable energy

Sembcorp operates as an Independent Power Producer (IPP), focusing on owning and operating renewable assets, such as solar and wind farms and energy storage facilities, rather than manufacturing equipment. The company sells electricity to governments, grid operators, and corporate clients through long-term Power Purchase Agreements (PPAs). By 2024, its total renewable capacity secured was about 16.8 GW across Asia and the UK (Sembcorp Industries, 2025).

Like Sembcorp, several regional multinational energy companies are active in Southeast Asia's renewable energy sector. Notable examples include Vena Energy (headquartered in Singapore) and EDP Renewables (based in Portugal, with a strong presence in China and Vietnam). Vena Energy reported a construction and contracted renewable capacity of 3.9 TWh across the Asia-Pacific region as of the first half of 2023 (Vena Group, 2023). Meanwhile, EDP Renewables has surpassed 1 GW of installed capacity in the Asia-Pacific region, including approximately 510 (megawatts peak) MWp in Vietnam, 335 MWp in Singapore, and smaller projects in China and other APAC markets (EDP Group, 2023). These companies operate across multiple Asian markets under a build-own-operate (BOO) model, leveraging regional hubs such as Singapore or Manila to coordinate development, financing, and asset management activities.

Competition in this market is shaped by its highly regulated nature, large-scale capital requirements, and dependence on government approvals and land concessions. As a result, local state-owned utilities often retain structural advantages in accessing permits, land, and grid connections. To compete effectively, cross-border IPPs like Sembcorp must demonstrate superior technical expertise, cost efficiency, and strong sustainability credentials to win government-backed tenders and private PPAs. Among international operators, competition focuses less on pricing and more on negotiation strength, policy alignment, and partnership with local authorities, which are factors that determine long-term access and expansion capability in emerging renewable energy markets.

Integrated Urban Solution

Sembcorp's Urban business focuses on developing and operating industrial parks and commercial spaces that promote both environmental and economic sustainability. As of 2024, the company has already invested in 21 industrial parks across Vietnam, Indonesia and China. Its key growth markets are Vietnam and Indonesia, while its operations in China focus on optimising existing assets.

Sembcorp faces competition from a wide range of domestic and international developers. In Vietnam, major local players such as Becamex IDC and Kinh Bac City (KBC) dominate the industrial park landscape, leveraging long-standing relationships with provincial governments and deep experience in infrastructure development. Meanwhile, in Indonesia, leading domestic developers include PT Jababeka Tbk (PT MMID), which operates large-scale industrial cities across West and Central Java. In addition to these national developers, Sembcorp also competes with several regional and foreign investors. In Vietnam, Amata Corporation and WHA Vietnam, both based in Thailand, have become critical foreign participants in the market. In Indonesia, Karawang International Industrial City, a joint venture between Japan's Itochu Corporation and Indonesia's Sinar Mas Land, represents a similar model of cross-border industrial development.

The industrial park market in Southeast Asia is fragmented and highly competitive. In Vietnam and Thailand, most developers operate around 20 parks each, generally medium-sized and spread across several provinces. By contrast, Indonesian players tend to manage fewer but significantly larger integrated industrial cities, often spanning thousands of hectares. Overall, no single company dominates the regional market.

Competition unfolds across two distinct phases. The first concerns the bidding for and acquisition of development rights, where local developers often enjoy advantages through established networks and regulatory familiarity. At the same time, regional or multinational entrants must rely on superior technical capabilities, cost efficiency, and environmentally, socially, and governance (ESG)-aligned design to gain a foothold.

The second phase concerns the operational stage, in which sustained profitability depends on tenant acquisition, efficient infrastructure management, and long-term

occupancy. Winning a land tender does not necessarily translate into enduring profits; rather, continuous operation, maintenance, and environmental compliance determine long-term success. Due to the similarity in market share with competitors, the ability to sustain operations and generate profits is more important.

To remain competitive, Sembcorp must excel not only in securing new development opportunities but also in ensuring consistent, long-term returns. Leveraging its sustainability expertise, regional IPP experience, and strategic partnerships with local governments will be essential to maintaining an advantage in Vietnam's and Indonesia's fast-evolving green industrial-park sector.

Decarbonisation

Sembcorp's low-carbon solutions business focuses on providing integrated decarbonisation and energy-efficiency services across Asia. These solutions primarily target industrial and commercial clients, including manufacturing facilities, industrial parks, and data centres in Singapore, Vietnam, Indonesia and India.

Within Southeast Asia, YCP Group and Cenergi SEA Berhad have emerged as notable competitors in the corporate decarbonisation space. YCP Group, headquartered in Singapore and operating across the Association of Southeast Asian Nations (ASEAN), provides decarbonisation consulting and transition planning to enterprises and governments. Its services cover carbon accounting, emission-reduction roadmaps, ESG strategy design, and compliance with emerging regional carbon regulations. Although primarily a consulting-driven business, YCP has expanded its advisory reach across Japan, Singapore, Thailand, and Indonesia, serving multinational clients seeking regional carbon-reduction strategies.

Cenergi SEA Berhad, based in Malaysia, positions itself as a sustainable energy solutions provider focusing on renewable generation, biogas, biomass, and energy-efficiency projects. Compared with Sembcorp's regional-scale integrated model, Cenergi SEA targets mid-sized industrial clients and municipal projects, making it a key regional competitor in Southeast Asia's low-carbon energy market.

Sustainability Strategy and Initiatives

Overview

Sembcorp's sustainability strategy is centred on decarbonising energy and accelerating the energy transition, strengthened by renewable energy growth, sustainable emissions management, and responsible governance. The company has publicly committed to achieving net-zero greenhouse gas emissions for Scope 1 and Scope 2 emissions by 2050, alongside interim goals for emissions intensity and absolute emissions reductions. A core pillar of the strategy involves scaling renewable energy capacity to 25 GW of solar, wind, and battery storage by 2028, and integrating

sustainability performance indicators into its financing and operations (Sembcorp Industries, 2023). Climate governance and risk management are integrated with voluntary commitments and regulatory frameworks such as the Task Force on Climate-related Financial Disclosures (TCFD) and the Science Based Targets initiatives (SBTi), as well as a dedicated Climate Change Working Committee (Sembcorp Industries, 2025). In general, the strategy outlines a realistic route to reducing carbon emissions while maintaining energy reliability and long-term value creation.

Current Sustainability Progress

Sembcorp's progress towards its sustainability commitments is demonstrated in tangible results in renewable capacity growth, emissions reduction, and sustainable finance. The company's most recent disclosures indicate tangible progress in decarbonisation and portfolio transformation, driven by strategic investments and strong governance. The FY2022-FY2024 Key Sustainability Indicator Overview table outlines the key sustainability performance indicators and the company's direction for future targets.

Table 2: FY2022-FY2024 Key Sustainability Indicator Overview

Category	Key Indicator	FY2022	FY2023	FY2024 / Target	Progress / Remarks
Renewable Energy Capacity	Installed or secured renewables	8.3 GW	12.9 GW	16.8 GW (2024) Target: 25 GW by 2028	Rapid expansion driven by solar, wind and battery storage projects in India, China and Singapore.
Energy Storage Capacity	Installed Battery Energy Storage System (BESS) capacity	0.71 GWh	1.01 GWh	1.46 GWh	Growing hybrid solar + BESS developments enhance grid stability.

GHG Emissions Intensity	tCO_2e/MWh	0.50	0.29	0.27 (2024) Target: 0.15 by 2028	Emissions intensity reduction outpaced plan through renewable integration and operational efficiency.
Absolute GHG Emissions	Scope 1+2 (Mt CO_2e)	25.4	10.5	9.3 (2024) Target: 2.7 by 2030	On track with decarbonisation roadmap and fuel efficiency measures.
Renewable Energy Share in Portfolio	% of secured or installed capacity over total capacity	50%	61%	67% (2024)	Transitioning steadily towards low-carbon portfolio dominance.

Source: Information adapted from Sembcorp Industries, 2024; Sembcorp Industries 2025

The figures above indicate a sustained effort to implement Sembcorp's sustainability roadmap. The company doubled its secured renewable energy capacity between FY2022 and FY2024, increasing from 8.3 GW to 16.8 GW, primarily driven by large-scale solar, wind, and energy storage projects in Asia (Sembcorp Industries, 2025). Meanwhile, Sembcorp's greenhouse gas (GHG) emissions intensity, measured in tonnes of carbon dioxide equivalent per megawatt-hour (tCO_2e/MWh), has declined from 0.50 to 0.27 between 2022 and 2024, surpassing interim reduction targets ahead of schedule (Sembcorp Industries, 2025). This improvement is attributable to higher renewable penetration and enhanced operational efficiency. The company's absolute emissions have also trended downward, in line with its 2030 target of 2.7 tCO_2e (Sembcorp Industries, 2025). In addition, secured renewables account for 67% of total generation capacity, reflecting a positive transition towards a low-carbon portfolio. Sembcorp further underscores alignment between its financial strategy and its long-term decarbonisation goals, with around 75% of capital expenditures directed towards green projects (Sembcorp Industries, 2023).

Environmental Dimension

Sembcorp's commitment to the environment is reflected in a robust environmental management system, which also helps build a culture of environmental consciousness that permeates every level of the company. Sembcorp's environmental strategy is built on changing its business and operations to achieve low-carbon, resource-efficient, and climate-resilient growth. This strategy is structured around three pillars: the transition to renewable energy, resource efficiency, and environmental stewardship, each featuring tangible, measurable actions.

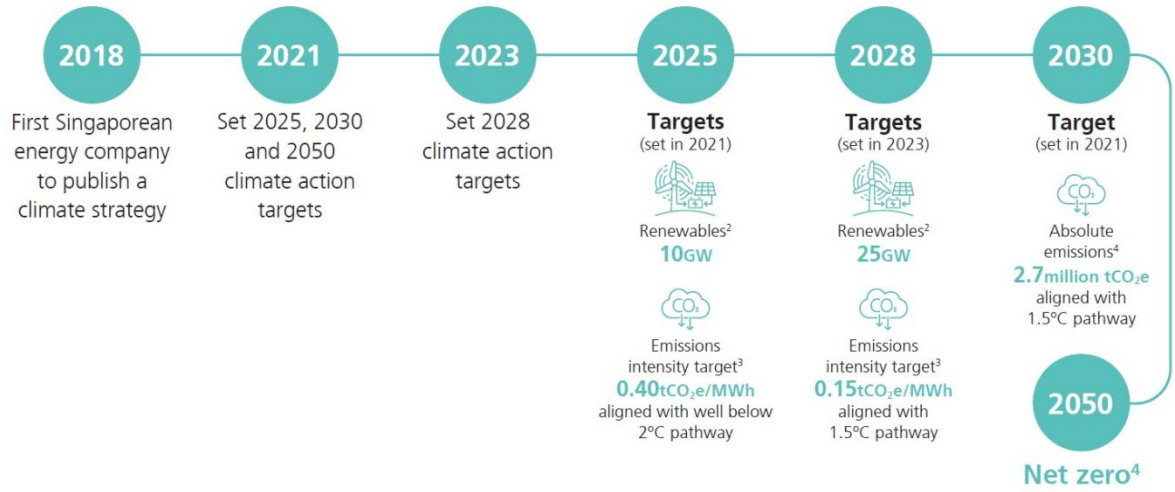
Renewable Energy Transition

Central to Sembcorp's environmental strategy is the shift from traditional to renewable energy sources. The Climate Action Framework outlines the company's plan to reach net-zero Scope 1 and 2 emissions by 2050 (Sembcorp Industries, 2025).

The framework translates climate objectives into concrete activities through the prioritised growth of solar and wind capacity, battery energy storage system (BESS) integration, the use of batteries to store energy for later use, and hybrid solutions that compensate for power volatility while maintaining grid reliability.

A key example is Sembcorp Energy India's solar-plus-storage project, which combines 150 MW of solar capacity with 300 MWh of energy storage (The Economic Times, 2024). This project in India illustrates how technology supports decarbonisation by providing a stable renewable power supply and grid support.

Figure 1: Sembcorp's Climate Roadmap and Energy Transition Pathway

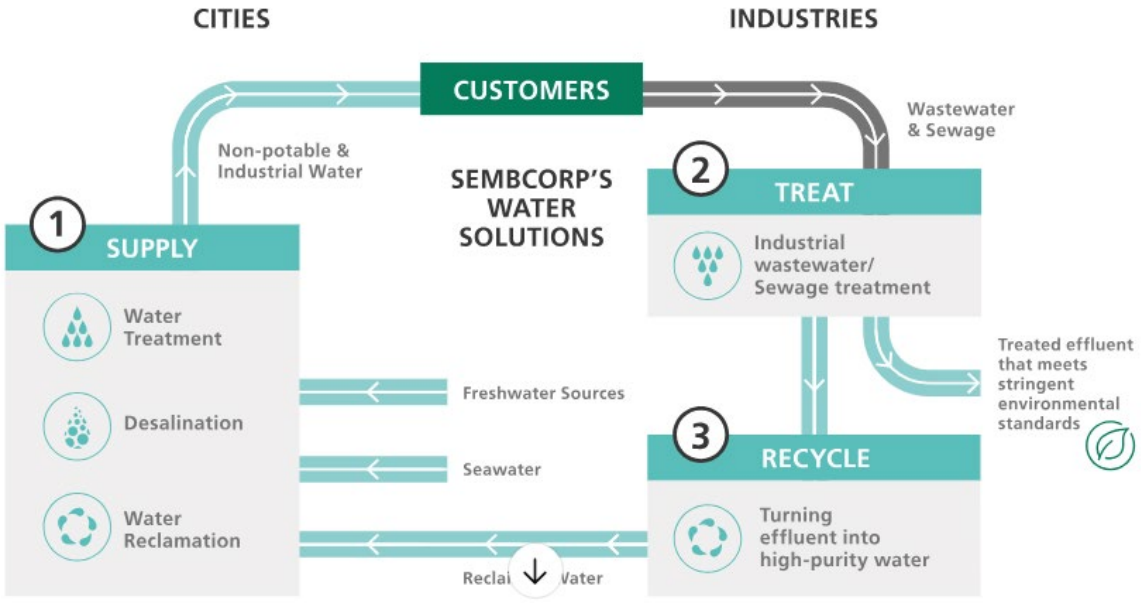


Source: Sembcorp Industries, 2025

Resource Efficiency and Circular Operations

Beyond energy generation, Sembcorp integrates resource efficiency in all aspects of its operations. The company incorporates circular economy concepts, including wastewater recycling, waste-to-energy conversion, and industrial heat recovery. For instance, in Singapore, Sembcorp's Tuas wastewater treatment and resource recovery plant processes industrial effluent for reuse and captures energy from biogas, resulting in lower emissions and less freshwater consumption. These products also reduce resource intensity and highlight how operational efficiency and environmental sustainability can be jointly achieved.

Figure 2: Resource Circularity and Waste-to-Energy Integration at Tuas Facility



Source: Sembcorp Industries, n.d.-c

Environmental Stewardship and Risk Management

Sembcorp acknowledges that the energy transition to low-carbon energy must be accompanied by environmental protection. The company conducts biodiversity and environmental risk analyses for all significant projects, ensuring that land is used responsibly and that natural habitats are not disrupted. Solar farms in Southeast Asia, for example, are being located using ecological mapping to identify sensitive natural areas and avoid locations of high conservation value.

In addition, Sembcorp engages in cross-sector partnerships to co-create nature-based solutions, such as mangrove restoration that supports carbon sequestration and coastal resilience. These measures exemplify the company’s shift from a narrow risk-mitigation approach towards a more expansive approach of ecosystem stewardship.

Social Dimension

Under the “Empowering Lives” pillar, Sembcorp’s social strategy focuses on people, diversity, and community. The company prioritises employee well-being and safety, integrating health, safety, and environmental requirements at all levels. Audits, leadership accountability, and strong training keep its safety culture consistent with zero harm.

Sembcorp has established its own diversity and inclusion policies to create a more equal workplace across gender, ethnicity, and experience. Employees benefit from structured career paths, including upskilling and reskilling training tailored to clean-energy and digital jobs, which support workforce readiness for the energy transition.

Beyond its internal workforce, Sembcorp’s social responsibility extends to the communities in which it operates. Through initiatives in education, infrastructure, and environment, the company not only helps develop local communities but also promotes the concept of sustainability. For instance, it partnered Singapore Polytechnic to launch a solar photovoltaic research lab that will focus on environmental innovation and renewable energy training for students (Sembcorp Industries, 2022).

Governance Dimension

Sembcorp’s governance extends beyond compliance by embedding sustainability considerations into corporate decision-making processes. Two examples illustrate how this commitment is operationalised in practice.

Board and Committee Oversight

Sembcorp’s Board of Directors is responsible for the company’s long-term success and explicitly considers sustainability and climate-related matters among other factors. In this context, the Climate Change Working Committee (CCWC) plays a significantly important role in climate governance. Chaired by the Executive Vice President, the committee meets at least twice annually to formulate and review policies, analyse climate-related risks and opportunities, establish targets, and report to both the Enterprise Risk Committee (ERC) and the Board’s Risk Committee. The CCWC ensures that climate-related considerations are embedded in enterprise risk management (Sembcorp Industries, 2025).

Performance Incentives and Finance Linkage

Another tangible manifestation of governance is Sembcorp’s Sustainable Financing Framework (SFF), which guides capital-raising by considering environmental impact (Sembcorp Industries, 2025). Under the SFF, financing products such as sustainability-linked bonds and loans are tied to specified key performance indicators

(KPIs), for instance, greenhouse gas (GHG) emissions intensity, absolute emissions, and gross installed renewable energy capacity.

Linking these KPIs to financing terms means that the cost of capital, lending terms, and investor expectations are directly influenced by sustainability performance. Meanwhile, the Executive Resource and Compensation Committee (ERCC), which oversees executive remuneration and incentives, approves the overall compensation framework and operating environment-linked goals for senior executives, ensuring leadership incentives are aligned with the ESG agenda.

Together, these governance practices demonstrate a comprehensive approach to sustainability management. Performance is measured, incentivised, and linked to capital. Additionally, climate risks are managed as part of the enterprise risks. This enables Sembcorp to fully integrate ESG into its strategy.

Impact on Sustainability

Economic Dimension

This section evaluates Sembcorp's sustainability performance through an economic lens, examining how its sustainable-oriented strategies create measurable financial value, mitigate risk, and build long-term resilience. The analysis covers seven economic dimensions: sustainable financing, capital allocation, operational efficiency, innovation investment, risk governance, circular economy integration, and inclusive growth.

Sustainable Financing

Sembcorp has embedded sustainability into its financial structure through its Sustainable Financing Framework (SFF). This framework ties capital costs directly to ESG outcomes, potentially lowering costs for strong ESG performance. Under the SFF, green bonds and sustainability-linked loans are tied to predefined performance indicators, such as greenhouse gas (GHG) emission intensity and renewable capacity expansion.

This system encourages management to prioritise decarbonisation and renewable investment, ensuring sustainability is embedded within financial performance metrics. By linking interest rates to sustainability performance, the framework reduces borrowing costs, increases investor confidence, and improves access to green capital markets. Economically, the system lowers financing costs, attracts green investment, and converts sustainability initiatives into a source of competitive financial advantage. This demonstrates the internalisation of environmental responsibility through direct, positive financial impacts.

Capital Allocation and Portfolio Transition

Sembcorp's capital strategy marks a clear shift away from carbon-intensive operations toward low-carbon and renewable assets. From 2024 to 2028, the company plans to invest S$14 billion, with 75% allocated to renewable energy, 10% to hydrogen and low-carbon fuels, and 10% to decarbonisation solutions (Sembcorp Industries, 2024). This shift redirects capital flows to support economic returns and climate goals.

There are two main economic impacts. First, it diversifies the company's income by expanding into high-growth, policy-supported renewable energy sectors, thereby creating new revenue streams. Second, it reduces the likelihood of stranded asset risks in fossil-fuel operations, thereby lowering financial exposure. As a result, Sembcorp strengthens its balance sheet against energy transition shocks and secures a sustainable foundation for long-term profits.

Operational Efficiency and Cost Reduction

Operational excellence remains a key driver of Sembcorp's economic sustainability. With advanced monitoring, predictive analytics, and energy optimisation systems, the company achieved an energy intensity of 1.7 gigajoules per megawatt-hour (GJ/MWh) in 2024 (Sembcorp Industries, 2025).

Initiatives such as waste-to-resource and heat recovery programmes further lower operating costs by reducing waste disposal fees or reusing energy, while also decreasing emissions. Such initiatives generate financial and environmental synergies. These efficiency measures illustrate the "return" dimension of sustainable economics, where resource optimisation increases profit margins, supports revenue growth, and reduces environmental impact.

Innovation and Green Technology Investment

Innovation functions as the core enabler of Sembcorp's sustainable growth. The company invests in green hydrogen, battery storage, and digital energy management technologies to position itself for future competitiveness. For example, Sembcorp's hybrid solar-plus-BESS projects in India combine 150 MW of solar capacity with 300 MWh of energy storage. These projects offer an innovative model for balancing supply volatility in renewables (The Economic Times, 2024). It also builds Sembcorp's regional leadership in green infrastructure. Economically, innovation improves long-term returns by increasing revenue streams and reducing operational costs.

Risk Governance and Financial Resilience

Sembcorp integrates climate-related and transition risks into its Enterprise Risk Management (ERM) framework. The company uses analyses from the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6)

and Network for Greening the Financial System (NGFS) to evaluate the potential economic impacts of carbon pricing, resource scarcity, and market volatility (Sembcorp Industries, 2025).

By quantifying these risks, Sembcorp uses sustainability as a risk-mitigation tool. For example, retaining selected gas-fired plants as transitional assets helps ensure supply reliability during renewable growth, stabilises revenues in volatile energy markets, and avoids costly disruptions. This strategy protects short-term profits and cash flow, supporting economic performance while advancing long-term decarbonisation.

Circular Economy and Resource Productivity

Sembcorp's use of circular-economy principles brings measurable financial and ecological benefits. Through industrial wastewater reuse and by-product recovery systems, the company converts waste into usable resources, reducing annual raw material procurement costs and mitigating environmental compliance expenses. For example, the Tuas Materials Recovery Facility converts municipal waste into energy, reducing landfill management costs and generating additional electricity revenue streams.

Economically, this model follows the "regenerative efficiency" principle, whereby value is maximised from each input while waste leakage is minimised across the production cycle. Circular practices lower costs, create new income streams, and boost brand reputation.

Inclusive and Regenerative Economic Growth

Sembcorp's sustainability work supports regional socio-economic development by generating employment opportunities, funding infrastructure improvements, and increasing energy availability. Across India, China, and Southeast Asia, renewable and urban projects provide thousands of green jobs and enhance local industrial capabilities.

By linking economic growth with social inclusion and environmental integrity, Sembcorp follows a regenerative growth paradigm. This ensures profitability while creating jobs, stimulating local economies, and supporting long-term social welfare, all within planetary boundaries. The approach demonstrates that sustainable economic performance encompasses not only profit, but value for society, the environment, and all stakeholders.

Environmental Dimension

This section provides a systematic assessment of Sembcorp's efforts and impacts in environmental sustainability. The evaluation follows the eight key environmental factors within the ESG framework: renewable fuels, greenhouse gas emissions,

energy efficiency, climate risk, water management, recycling processes, and emergency preparedness.

Renewable Fuels

Sembcorp has channelled financial and technological resources towards renewables, contributing to the decarbonisation of its overall energy mix. As a result, the company's actual installed renewable generation capacity reached 13.1 GW in 2024, representing nearly a 40% year-on-year increase from 2023 (Sembcorp Industries, 2025).

This additional 3.7 GW of renewable generation capacity produces a significant fuel-substitution effect, even as its total generation capacity expands. In addition, replacing coal- and gas-fired units with renewables leads to lower air pollution.

Greenhouse Gas Emissions

The company has implemented an Internal Carbon Pricing (ICP) mechanism and a Sustainable Financing Framework (SFF) that ties borrowing rates to GHG intensity and renewable capacity (Sembcorp Industries, 2025). This approach also supports Sembcorp's progression towards its emissions intensity target of 0.15 tCO_2e/MWh by 2028.

This quantifiable goal demonstrates a structured and measurable approach to decarbonisation. As of 2024, Sembcorp reported total greenhouse gas emissions of approximately 9.3 million tCO_2e, with an average emission intensity of 0.27 tCO_2e/MWh, representing a decline from 0.29 tCO_2e/MWh in 2023 (Sembcorp Industries, 2025).

The intensity-based improvement indicates that, even as total electricity generation grows, each unit of energy produced generates significantly less emissions.

Energy Efficiency

Sembcorp operates under the ISO 50001 (Energy Management System), conducting regular, data-driven audits and performance benchmarking to identify energy losses and efficiency gaps. Process optimisation guided by the 5R principle (Reduce, Reuse, Recycle, Recover, and Replace) further reduces energy waste at the production stage. This systematic auditing enables continuous improvement and allows real-time performance tracking, leading to technological innovation and behavioural change across operational units. As a result, the company achieved an energy intensity of 1.7 GJ/MWh in 2024 (Sembcorp Industries, 2025), indicating a mature and efficient energy management structure.

Climate Risk

Sembcorp integrates climate scenario models based on the IPCC AR6 and the NGFS into its Integrated Assurance Framework (IAF). The company conducts quarterly climate-risk reviews, complemented by the establishment of the CCWC, which monitors global climate trends and formulates adaptive strategies. These strategies and execution enable Sembcorp to assess potential physical and financial risks across varying temperature trajectories. This scientific approach supports pre-emptive adaptation rather than reactive correction, aligning risk governance with global best practices. As a result, Sembcorp has reinforced flood protection, drainage, and roof structures in high-risk regions and insured significant assets against climate-related disasters, significantly improving climate resilience and reducing potential economic losses.

Water Management

Sembcorp provides industrial wastewater treatment and water reclamation service for businesses. These services help to reduce pressure on local water systems and mitigate the risk of water scarcity, especially in resource-stressed regions. Prioritising reuse over discharge also cuts pollutant release into natural waterways, improving aquatic ecosystem health and maintaining a balanced hydrological cycle.

Recycling Processes

By shifting from end-of-pipe treatment to upstream prevention, the company reduces overall waste generation and lowers pollution risks at the source. Converting solid waste into renewable fuel through waste-to-energy projects further decreases landfill use and methane emissions. These practices transform waste from an environmental burden into a resource stream, advancing both carbon reduction and circular-economy goals.

Emergency Preparedness

By reinforcing infrastructure and securing comprehensive disaster insurance, Sembcorp enhances its resilience to extreme weather events and minimises potential environmental damage. Strengthened facilities reduce the risk of chemical leaks, waste overflow, and other secondary pollution during floods or storms. This integrated approach helps stabilise operations under climate stress while safeguarding surrounding ecosystems from disaster-related contamination.

Biodiversity and Ecological Management

The company employs the Integrated Biodiversity Assessment Tool (IBAT) during the early investment phase to evaluate ecological sensitivity at potential project sites

(Sembcorp Industries, 2025). Incorporating biodiversity metrics before project initiation prevents encroachment into ecologically fragile areas and internalises ecosystem costs into project evaluation

A prominent example is Sembcorp's Tengeh Reservoir Floating Solar Farm in Singapore, one of the world's most significant inland floating solar projects, with a capacity of 60 MWp. This project was developed following a comprehensive Environmental Impact Assessment to minimise disruption to aquatic ecosystems. The company implemented measures such as wildlife buffer zones, eco-friendly floating materials, and continuous water-quality monitoring (Sembcorp Industries, 2022a). As a result, local biodiversity remained stable alongside the solar farm.

Social Dimension

As a global company, Sembcorp values its communities and employees, as they are key to the company's success. Advancing its workforce's capabilities and enhancing community engagement become its main social sustainability priorities.

Workforce Transformation

Sembcorp operates within a highly dynamic and competitive energy sector, where continuous learning and the development of technical expertise are essential. Thus, it established Sembcorp Academy, a blended, digital learning platform, to help employees develop their skills and learn at their convenience (Sembcorp Industries, 2025). Sembcorp also fosters its employees' experiences through job rotation, on-the-job training programmes, and special project assignments.

By 2024, the average learning hours per employee increased by 14% from 2023 to 24 hours. A total of 623 employees and partners were upskilled as a commitment to advance the solar industry in Singapore (Sembcorp Industries, 2025).

Sembcorp Solar Singapore SkillsFuture Queen Bee

Sembcorp Solar provides mentorship to small and medium enterprises (SMEs) and non-SMEs. Participants develop proof-of-concept projects aimed at operational transformation. Sembcorp will provide perspective and assistance on the feasibility of proposed ideas, which could focus on one of the following areas: improving safety, reducing capital expenditure, increasing yield, or introducing new solutions.

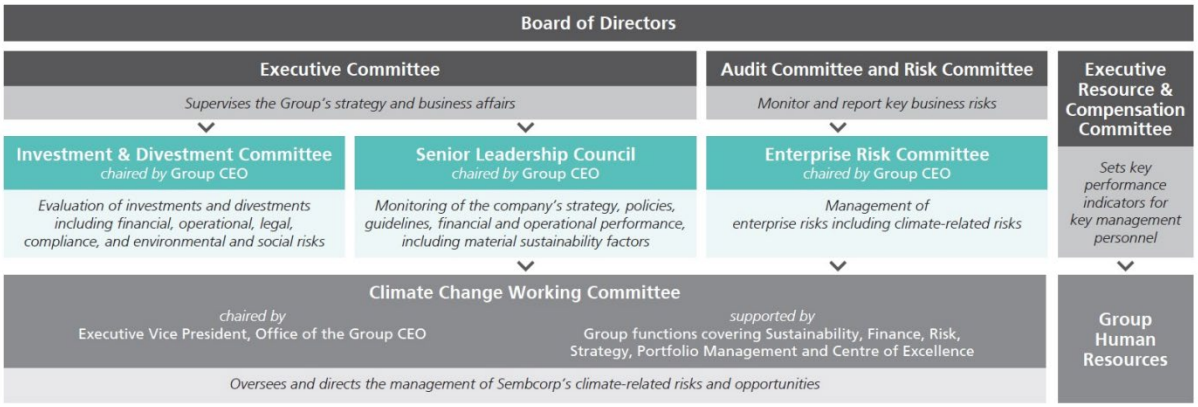
Community Engagement and Investment

Sembcorp's operations are closely intertwined with the communities in which it operates, recognising these stakeholders as integral to the company's long-term growth and sustainability. Sembcorp is committed to ensuring that the energy transition is inclusive and beneficial to the communities within its operational areas.

The company aligns its initiatives with Sustainable Development Goal (SDG) 7 — Affordable and Clean Energy — by facilitating access to sustainable energy solutions. Through targeted community programmes, Sembcorp raises awareness of clean energy and addresses information gaps, enabling residents to adopt and benefit from sustainable practices. Sembcorp has offered 514 kilowatt-peak (kWp) of renewable energy capacity to over 70 community facilities and generated 390,000 kWh of solar energy for its partners. These efforts resulted in the avoidance of 286,000 kg of carbon dioxide equivalent GHG emissions (Sembcorp Industries, 2025).

Governance Dimension

Figure 3: Internal Governance Structure



Source: Sembcorp Industries, 2025

Sembcorp's governance spans the following five pillars.

Pillar 1: Ethical Standards and Corporate Conduct

Sembcorp bases its governance on strong ethical standards. The company's Code of Business Conduct (CoBC) and Anti-Bribery and Corruption (ABC) policy guide the actions of employees, management, and directors. Employees in sensitive roles are required to undergo mandatory ethics and compliance training, while a whistleblowing system enables staff to report misconduct safely.

However, even with these measures, the company faced several regulatory penalties between 2023 and 2024, particularly relating to environmental and contract compliance in Singapore and China. These incidents show a gap between policy design and enforcement. To strengthen ethical governance, Sembcorp should enhance compliance monitoring and create more independent oversight systems to ensure consistent practice across all regions.

Pillar 2: Board Diversity and Strategic Oversight

The Board of Directors is responsible for the company's strategic direction, alignment with sustainability, and risk management. It has four central committees: the Audit Committee, Risk Committee, Executive Committee, and Executive Resource and Compensation Committee, each tasked with specific governance areas (Sembcorp Industries, 2025).

Although this structure follows sound corporate governance practice, there are still challenges. Most directors are independent, but there is limited gender and professional diversity, and few have deep knowledge of ESG or climate governance. This lack of expertise can limit the board's ability to guide Sembcorp's low-carbon transition. Therefore, the company should enhance diversity across demographics and professional backgrounds, adding directors with experience in sustainability, energy transition, or environmental policy.

Pillar 3: Pay-for-Performance and ESG-Linked Incentives

Sembcorp has begun linking executive pay to sustainability goals, a positive step toward performance-based governance. The company's compensation committee oversees how ESG factors, such as greenhouse gas reduction, renewable energy expansion, and workplace safety, influence executive bonuses.

However, Sembcorp has not clearly explained the weight these ESG indicators carry in total compensation, making it hard for stakeholders to assess their impact. To build more trust, Sembcorp should disclose how ESG metrics affect pay outcomes and align them with global best practices, in which 15–30% of variable pay is linked to sustainability performance.

Pillar 4: Stakeholder Engagement and Public Accountability

Sembcorp has established a structured process for stakeholder engagement, underpinned by regular materiality assessments to identify key ESG issues and regularly communicates with investors, employees, communities, and regulators. The company's sustainability reports are aligned with international frameworks, such as the Global Reporting Initiative (GRI), Sustainability Accounting Standards Board (SASB), and TCFD, with data externally verified by DNV Business Assurance Singapore Pte Ltd (Sembcorp Industries, 2025).

While this strengthens transparency, Sembcorp's reports often highlight positive results and rarely discuss the difficulties or trade-offs involved in sustainability decisions. For greater credibility, Sembcorp should share not only achievements but also challenges and lessons learned. Adopting the "double materiality" approach — considering both the impacts of ESG issues on the firm's financial status and the firm's

impacts on society and the environment — would improve its reporting depth and accountability.

Pillar 5: Shareholder Rights and Governance Disclosure

Sembcorp provides regular financial and ESG updates through meetings, quarterly reports, and online portals. It follows the Singapore Code of Corporate Governance and discloses policies on dividends, director independence, and other key areas.

However, shareholder engagement remains mostly one-directional. Investors receive information but have few opportunities to influence ESG strategy or major decisions. Sembcorp should move from simple disclosure to more participatory communication, explaining the reasoning behind significant sustainability investments and how they balance risks and returns.

Sembcorp's governance model is well-structured and aligned with international standards. Still, it must continue improving its governance to make it not only compliant but also transformative. The company needs more ESG expertise at the board level, clearer disclosure of sustainability-linked pay, and more consistent ethical enforcement across its global operations. As Sembcorp works towards its 2050 net-zero goal, strong governance will be essential to achieving both environmental and financial success. Balancing ethical leadership, inclusive decision-making, and transparent communication will determine whether Sembcorp can genuinely become a sustainable leader in the energy sector.

Outlook and Recommendations

Competitiveness Dimension

- Strengthen licensing edge and operational efficiency: Sembcorp operates in a regulated market where government licensing defines both entry and profit sustainability. To stay competitive, the company should refine its technology and solution mix to demonstrate superior efficiency, environmental performance, and reliability, thereby enhancing appeal to regulators in future licensing rounds. The company should also enhance post-licence profitability through digital monitoring, predictive maintenance, and circular-economy practices.

Economic Dimension

- Expand stress testing for policy tightening: Sembcorp should enhance scenario analysis to include earlier and more abrupt policy tightening (e.g., accelerated carbon pricing, fast-tracked coal/gas phaseouts). Disclosing the sensitivity of asset values and earnings to these scenarios would improve investor visibility on downside risks.

Environmental Dimension

- Validate net-zero targets via SBTi: Sembcorp should pursue formal SBTi validation for near-term and net-zero plans. Submitting targets for SBTi approval (or explaining inapplicability) will materially increase credibility with investors and stakeholders.

- Publish transparent gas transition pathways: The company should disclose asset-level decarbonisation routes for each major gas asset, including fuel switch, Carbon Capture and Storage (CCS) or Carbon Capture, Utilisation, and Storage (CCUS) timeline and economics, contractual life, repurposing or retirement. Such transparency would clarify transition and stranded-asset risks.

- Set Scope 3 targets and supplier-linked KPIs: Sembcorp should expand its KPI framework to include Scope 3 emissions (upstream, downstream, embodied). Supplier engagement and procurement design should be linked to measurable reduction milestones.

- Clarify offset and removals policy: Sembcorp should strengthen its disclosure on offsets and removals by publishing a quality policy with specified criteria such as permanence, additionality, and verification.

Social Dimension

- Structured diversity and inclusion: Sembcorp's diversity efforts should focus on providing equal opportunities, supported by a formal programme for disability hiring, cultural inclusion, and gender balance at scale.

- Empowerment of marginalised groups: Sembcorp could target the marginalised population for training, upskilling, entrepreneurship mentoring, and leadership workshops, aligning with Sembcorp's primary focus on community outreach.

Governance Dimension

- Enhance board diversity and ESG expertise: Sembcorp could recruit directors with sustainability expertise and form a dedicated sustainability committee to improve decision-making quality and strengthen strategic oversight.

- Increase transparency of ESG-linked incentives: The company should disclose the weighting of ESG-linked executive incentives, incorporate long-term sustainability metrics (e.g., Scope 3 reduction), and ensure independent verification of performance outcomes.

- Improve sustainability reporting and stakeholder dialogue: Sustainability disclosures should be enhanced by adding a “Challenges and Lessons” section, applying the double materiality principle, and engaging stakeholders through regular dialogue and co-governance mechanisms.

Conclusion

Overall, Sembcorp’s transformation journey represents a strong example of how traditional energy firms can balance profitability with sustainability. Through an integrated strategy that combines energy transition, urban development, and decarbonisation solutions, the company demonstrates that environmental responsibility can coexist with economic competitiveness. Moving forward, Sembcorp should continue to prioritise innovation, human capital development, and collaborative partnerships to strengthen its role as a sustainable energy leader in Asia and beyond.

Discussion Questions

1. How do Sembcorp's environmental management strategies, such as renewable energy expansion, circular economy principles, and biodiversity preservation, specifically contribute to reducing its carbon footprint?

2. What types of government policies, regulatory frameworks, or international partnerships are required to create an enabling environment for decarbonisation transitions?

3. How can financial instruments such as internal carbon pricing, green bonds, or sustainability-linked financing make low-carbon operations economically sustainable?

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An Energy Conundrum and ExxonMobil's Efforts

FANG Zibu

JI Shiyu

Niranjana NARAYAN

ZHONG Shilin

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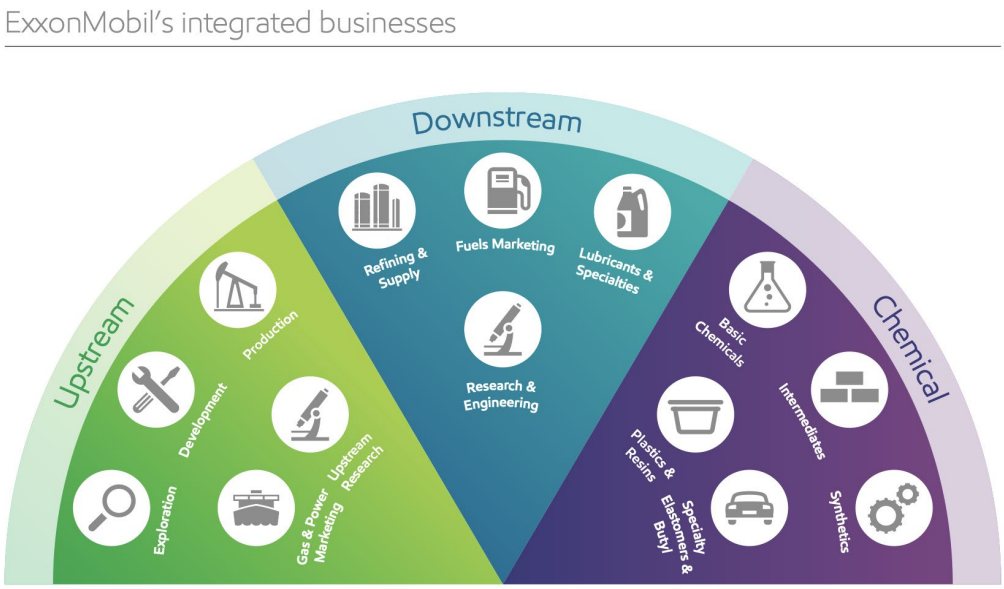
Introduction

Company Background

ExxonMobil is one of the world's largest publicly traded petroleum and petrochemical enterprises (Exxon Mobil Corporation, 2023a). Operating across most regions, it is best known by its brand names: Exxon, Esso, and Mobil. The corporation's primary businesses include upstream, product solutions and low-carbon solutions, making it one of the largest integrated fuels, lubricants, and chemical companies in the world (Exxon Mobil Corporation, n.d.-f). In Asia, ExxonMobil Asia Pacific Pte. Ltd. is one of Singapore's largest foreign manufacturing investors. Its manufacturing facilities include an integrated, world-scale refining and petrochemical complex, as well as a lubricant plant (Exxon Mobil Corporation, n.d.-c). It also provides customers with fuels, lubricants, petrochemicals, and liquefied natural gas.

Figure 1: ExxonMobil's Integrated Business



Source: Exxon Mobil Corporation, 2014

Regional Industry Background

ExxonMobil projects that by 2050, energy demand in most of the developing countries is projected to increase by more than 25%, as population growth and economic development accelerate demand for modern energy services (Exxon Mobil Corporation, 2025a). To meet this rising demand, all energy types will be needed for a more prosperous, lower-emission future (Exxon Mobil Corporation, 2025c).

Renewable energy is projected to grow the fastest, coal will decline the most, while oil and natural gas will still account for more than half of the global energy mix by mid-century.

However, CO_2 emissions are expected to fall by around 25% by 2050, driven by efficiency improvements and an increasing shift towards lower-emission solutions. ExxonMobil is also expanding its lower-emission fuels and low-carbon solutions portfolio to accelerate decarbonisation in the Asia-Pacific region, where many countries are positioning themselves as clean-energy innovation and trading hubs, opening opportunities for low-carbon partnerships (Exxon Mobil Corporation, 2025d).

Issue Overview

As energy consumption continues to increase, reducing emissions has become both a technical and strategic imperative. ExxonMobil faces heightened pressure to reduce emissions from its Asian operations while maintaining energy reliability. Public scrutiny has raised concerns about "greenwashing" as ExxonMobil has limited Scope 3 disclosures and relies heavily on emerging technologies such as carbon capture and storage (CCS) and hydrogen (Webster, 2024).

ExxonMobil must therefore balance economic competitiveness, regional decarbonisation goals, and global net-zero commitments. The transition towards a lower-carbon business is inevitable yet challenging. Key barriers include the high carbon footprint of refining and petrochemical operations (Exxon Mobil Corporation, 2025a), tightening regional environmental regulations, growing investor and NGO criticism of ExxonMobil's intensity-based targets (Bloomberg, 2021), and rising local expectations for multinationals to support Singapore's green growth vision (Lim, 2025).

Nowadays, global awareness of sustainability has grown considerably, and concerns about sustainability in the energy industry are increasingly prominent. The environmental, social, and governance (ESG) framework highlights corporate responsibility for environmental protection, social equity, and transparent governance. This approach emphasises that financial return is not the sole indicator of success. Instead, integrating ESG dimensions can enable firms to achieve long-term, sustainable business. The following section analyses ExxonMobil's strategies and actions through the ESG framework, assessing both their impacts and limitations.

Environmental Dimension

Strategy and Action – A Dual Pathway Towards Decarbonisation

75.6% of global greenhouse gas (GHG) emissions stem from energy consumption (Ruiz, 2024). ExxonMobil, a company historically known for its upstream focus in the oil and energy sector, is a significant contributor to global emissions. Thus, it has implemented decarbonisation operations to reduce its Scope 1 and 2 emissions

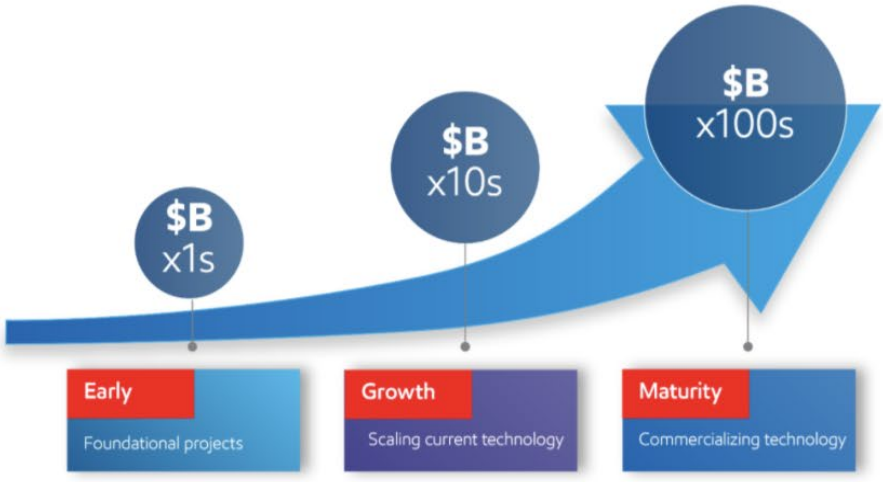
(Exxon Mobil Corporation, 2025a). At the same time, it also expends efforts towards curbing downstream energy consumption, forming a dual pathway towards decarbonisation.

Low-emission Solutions for Downstream Use

In Singapore, although fossil fuel products are still its core product, Esso also provides lower-carbon fuel options for its regional downstream customers, including aviation, marine, and automotive sectors (Civil Aviation Authority of Singapore, 2022; Exxon Mobil Corporation, 2022a; Exxon Mobil Corporation, 2022b; Esso Singapore, n.d.). These fuels are approved by a third-party life-cycle analysis (LCA) for their effectiveness in reducing carbon emissions, indirectly lowering the intensity of ExxonMobil's Scope 3 emissions over time (Exxon Mobil Corporation, 2022a).

Collectively, such low-carbon products position ExxonMobil to meet growing market demand for sustainable energy solutions. As shown in Figure 2, although there is no detailed financial return-on-investment data yet, ExxonMobil regards these products as closely aligned with market trends and corporate responsibility. It anticipates strong returns as its presence in premium segments grows, and is willing to invest US$1 out of every US$5 earned into lower-emission research and development (R&D) (Exxon Mobil Corporation, 2025a).

Figure 2: Low Carbon Solutions Potential Revenue



Source: Exxon Mobil Corporation, 2025e

Decarbonisation Pathway in Operation

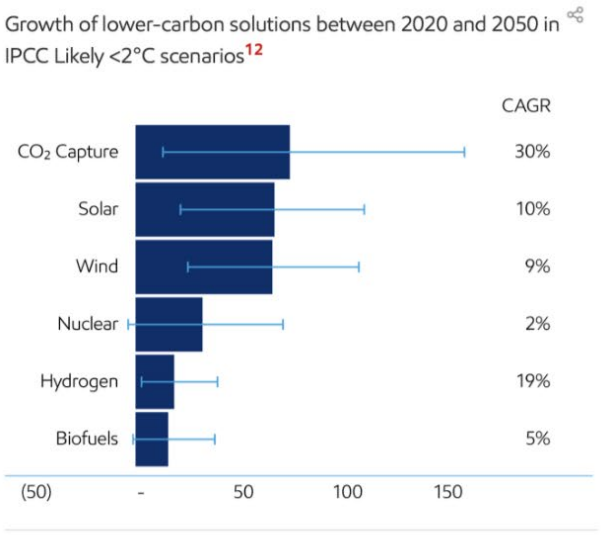
On the operations side, ExxonMobil has adopted site-specific environmental strategies. In Singapore, the company recognised the local environment's scarcity of freshwater through its assessment processes, utilising local assessment tools and the World Resources Institute (WRI) Aqueduct™ Water Risk Atlas (Exxon Mobil

Corporation, 2025h). Then, aligning with its own environmental management framework, ExxonMobil built an on-site membrane bioreactor at its site to treat and reuse wastewater, decreasing reliance on freshwater (Exxon Mobil Corporation, 2025h). This project's value lies not only in sustainability benefits but also in lower daily operating costs and reduced freshwater-related risks, which could affect production output and costs.

Additionally, ExxonMobil began production at a new plant in Jurong Island in 2025 to enhance productivity and energy efficiency across its operations (Subhani, 2025). As a result, greater quantities of "high-quality fuels" reach regional markets, while Singapore's geographical proximity to major customers helps reduce transport-related emissions and logistics costs (Exxon Mobil Corporation, n.d.-c).

Furthermore, ExxonMobil offers carbon-management solutions to external stakeholders through its carbon capture and storage (CCS) initiatives. In general, CCS technologies are recognised by the Intergovernmental Panel on Climate Change (IPCC) as critical for meeting global net-zero goals (IPCC, 2005). In Singapore, the company collaborates with government agencies to study how CCS can lower the country's carbon emissions (Ministry of Trade and Industry, 2025).

Figure 3: Growth of Low-Carbon Solutions Between 2020 and 2050 with <2°C Scenarios



Source: Exxon Mobil Corporation, 2025h

Circular Transformation

ExxonMobil's transition towards sustainability also advances a circular-economy pathway via advanced chemical recycling (Exxon Mobil Corporation, 2025h). Unlike mechanical recycling, this process breaks down plastics into molecular feedstocks that are then re-polymerised into ISCC PLUS-certified circular polymers with performance

comparable to virgin resin, broadening eligible waste streams and market adoption (Exxon Mobil Corporation, n.d.-d).

In the Asia-Pacific market, ExxonMobil has been collaborating with regional companies to promote circular value chains. A notable example is its partnership with Thanh Phu, a Vietnam-based flexible packaging manufacturer that uses ExxonMobil's certified-circular plastic resins to produce recyclable mono-material packaging, advancing sustainable packaging solutions across economies (Exxon Mobil Corporation, 2024a).

Target Setting Aligned with Global Standards

ExxonMobil aligns its GHG performance metrics with the Greenhouse Gas Protocol, ensuring consistency with international frameworks such as the Task Force on Climate-related Financial Disclosures (TCFD) and the International Sustainability Standards Board (ISSB) (Exxon Mobil Corporation, 2025h). For Scope 1 and 2 data, independent verification is provided by Environmental Resources Management Certification & Verification Services (ERM CVS), to ensure the credibility of reported results (ERM CVS, 2024). For Scope 3 data, the company's disclosures are limited to Category 11 (Use of Sold Products), while upstream and downstream categories, such as processing, transport, and end-of-life treatments, remain outside the current reporting boundary (Larin, 2024).

Nonetheless, ExxonMobil's targets align with sectoral initiatives, including the Oil & Gas Decarbonization Charter adopted at COP28 and its participation in the United Nations (UN) Oil & Gas Methane Partnership (OGMP) 2.0, which supports methane detection, measurement, and mitigation (Exxon Mobil Corporation, 2025a). ExxonMobil reports steady progress towards its methane-reduction objectives, having reduced 60% of methane emissions intensity and on track to achieve its targeted reductions of 70-80% by 2030 (Exxon Mobil Corporation, 2025a).

Unlike some peers which have withdrawn or revised their 2050 emission targets (Gabbatiss, 2024), ExxonMobil has not set absolute Scope 3 targets, arguing that applying the Greenhouse Gas (GHG) Protocol to measure and manage these emissions is inaccurate and might hinder effective climate action (Exxon Mobil Corporation, 2025a) Instead, it prioritises biofuel development and life-cycle-based emissions reductions through CCS, low-carbon hydrogen, and ammonia (Exxon Mobil Corporation, 2025a; Exxon Mobil Corporation, 2025e). While stakeholder pressure has driven more extensive Scope 3 disclosures, several datasets still rely on estimates (Reuters, 2021).

Scientific Leadership

Firstly, ExxonMobil had included third-party organisations to certify product features and audit emissions-related metrics, both to reduce the risk of greenwashing and to provide more transparent, quantifiable evidence of its sustainability development (Exxon Mobil Corporation, 2025h).

Secondly, ExxonMobil uses high-technology monitoring systems, including satellite-based detection, aerial surveys and ground-based sensors, to improve the accuracy and geographic coverage of methane-emissions measurement and performance tracking. These data support the setting of emissions-reduction targets and the development of a more detailed roadmap for methane management (Exxon Mobil Corporation, 2025a)

Finally, ExxonMobil works with top international universities to develop lower-carbon solutions. In 2024, it collaborated with Nanyang Technological University (NTU) and the Agency for Science, Technology and Research (A*STAR), launching a S$60 million ExxonMobil-NTU-A*STAR Corporate Lab in Singapore for decarbonisation solutions (Nanyang Technological University, 2024).

Positive Impact

Specific Positive Impact on Low-carbon Solutions

Majid (2023) identifies CCS technology as an essential strategy for mitigating climate change impacts, such as global warming, rising sea levels, and extreme weather events. This technology could reduce greenhouse gas emissions by 14% by 2050. CCS can play a central role in mitigating emissions from hard-to-abate sectors such as cement, steel, and chemicals, which are challenging to decarbonise (Paltsev et al., 2021). As a result, CCS enables substantial near-term emission reductions.

As a leading player in CCS, ExxonMobil has cumulatively captured more than 120 million tonnes of CO_2, accounting for about 40% of all anthropogenic CO_2 ever captured globally (Exxon Mobil Corporation, n.d.-a), and has the potential to reduce third-party emissions by more than 50 million tonnes of CO_2 per year by 2030 (Exxon Mobil Corporation, 2025a). On the other hand, ExxonMobil is expanding its advanced plastic-recycling capacity, targeting the extremely low global rate of 9% for recycled plastic. The effort aims to accelerate and scale up circular-economy solutions. For reference, one ton of plastic waste recycled offsets the need for about one ton of fossil-derived feedstocks (Exxon Mobil Corporation, 2025b).

Last but not least, while competitors such as Shell and BP are reassessing their climate push, ExxonMobil has asserted influence in shaping the global energy transition (Zacks Equity Research, 2025).

General Impact

ExxonMobil's environmental initiatives have generated numerous positive outcomes, solidifying its role in advancing more sustainable energy systems. The company follows a more holistic approach which encompasses environmental management, decarbonisation, low-emission energy, and circular transformation (Exxon Mobil Corporation, 2025h). These elements have helped the company achieve improvements in resource efficiency and environmental quality.

A notable impact is the reduction of greenhouse gas emissions across the operational footprint of the company's facilities worldwide (Exxon Mobil Corporation, 2025h). Through integrating cleaner technologies and better resource allocation, the company has managed to reduce direct emissions, thus improving local air quality and associated environmental outcomes.

ExxonMobil's role in CCS and hydrogen production goes beyond its own operations. It has created technology that helps decarbonise heavy industries and transportation while enabling other sectors to decrease their emissions (Paltsev et al., 2021). This collaborative effort helps build the backbone of a broader transition to a low-carbon economy. It also serves as an example of how industrial innovation can advance business objectives while simultaneously supporting sustainability goals.

Continuous optimisation of chemical processes and refineries, supported by advanced monitoring and predictive technologies, is used to increase output while managing energy use and emissions (Exxon Mobil Corporation, 2025a). Enhanced monitoring and process-safety measures can also help reduce the frequency and severity of incidents such as leaks and spills that might otherwise affect surrounding ecosystems and water bodies (Exxon Mobil Corporation, 2025h).

Overall, ExxonMobil's practices show how large-scale industrial operations can integrate environmental stewardship into business strategies. The progress the company has made in emissions reduction, resource conservation and waste management shows an ongoing commitment to sustainability and the environment.

Social Dimension

Strategy and Action – Governance-Driven Social Responsibility And Labour Management

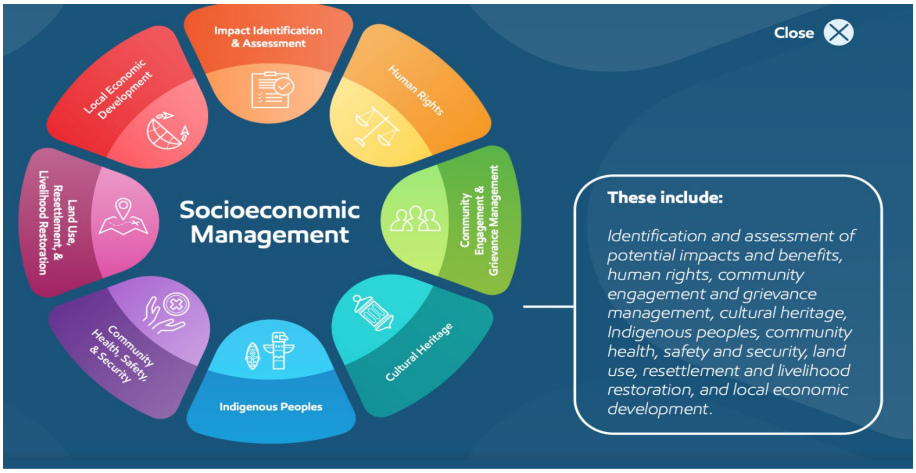
Instead of focusing on voluntary initiatives within corporate operations and stakeholder interests, ExxonMobil's social approach considers how its activities can generate broader benefits for society.

Risk Assessment and Implementation

ExxonMobil implements structured processes and tools to identify socioeconomic risks and opportunities and to guide investments in international socioeconomic management (Exxon Mobil Corporation, 2014). To ensure its commitments are aligned with international standards, such as the UN Sustainable Development Goals (SDGs), ExxonMobil uses an Operations Integrity Management System (OIMS) framework to identify social and economic risks, including impact assessment, stakeholder engagement, community health and safety, and grievance mechanisms (Exxon Mobil Corporation, 2024c). Then, ExxonMobil develops and decides on implementation and monitoring plans, taking into account local environmental conditions and concerns of relevant stakeholders.

In the implementation and reporting step, ExxonMobil ensures that objectives are effectively achieved through screening, audits, and corrective actions. Once performance metrics are collected, these results will be disclosed in its sustainability report. The process then continues cyclically, with new implementation plans designed based on previous insights.

Figure 4: Socioeconomic Management



Source: Exxon Mobil Corporation, 2025h

Employee Welfare

ExxonMobil states that it applies international human rights standards while providing region-specific employee benefits. In Singapore, ExxonMobil provides employee welfare across five key areas: health, security, financial, life, and additional life benefits (Exxon Mobil Corporation, n.d.-g). More specifically, its employee welfare includes comprehensive medical coverage for employees and family members, dental benefits, vacation and parental paid time off, and unpaid leave. Additional initiatives include a permanent disability and survivor benefit plan, an education assistance programme, and a home ownership assistance programme, depending on role and eligibility.

Labour Policies

ExxonMobil enables collective representation of employees in various locations. For example, in Singapore, the ExxonMobil Singapore Employees Union (EMSEU) was established in 1988 and operates under the National Trades Union Congress (NTUC) (National Trades Union Congress, n.d.). ExxonMobil also extends its fair-work commitments to its supply chain by eliminating forced or compulsory labour, including child or prison labour (Imperial Oil Limited, 2024). Internationally, ExxonMobil's Standards of Business Conduct includes an Equal Employment Opportunity Policy to ensure job fairness and prevent discrimination, which aligns with Singapore's Fair Consideration Framework (FCF) requirements for non-discriminatory hiring and transparent job advertising (Exxon Mobil Corporation, 2025h; Ministry of Manpower, 2025). ExxonMobil has demonstrated its labour diversity through operations in more than 56 countries and across more than 160 nationalities in 2025 (Exxon Mobil Corporation, 2025i).

ExxonMobil has published its overall workforce composition in its sustainability report. In 2024, the company employed approximately 61,000 employees worldwide, with women representing 28% of the total workforce and 34% of the professional workforce (Exxon Mobil Corporation, 2025h). In the United States workforce, 23% of executives were reported as minorities, while 40% of new professional hires were minorities. There company has also increased its investment in employee training and community programmes (Exxon Mobil Corporation, 2025h). These disclosures reflect progress in labour diversity, aimed at improving gender and racial representation and supporting equitable recruitment practices.

Supply Chain's Selection and Alignment

Human Rights, Working Conditions and Safety

ExxonMobil's supplier and country selection processes are guided by its membership in the Voluntary Principles Initiative (VPI) (Exxon Mobil Corporation, 2025h). The aim is to ensure that working conditions and security practices align with the 2011 UN Guiding Principles on Business and Human Rights, UN Universal Declaration of Human Rights, and International Labour Organization's 1998 Declaration on Fundamental Principles and Rights at Work (Exxon Mobil Corporation, 2025f). ExxonMobil's approach is complemented by its public policies on security and human rights, as well as expectations for suppliers, vendors, and contractors. In 2023, over 9,500 security personnel were trained on the Voluntary Principles across more than 11 high-risk countries (Exxon Mobil Corporation, 2023c). Its contract agreements include clauses requiring adherence to human rights standards, strengthening accountability within the company's global supply chain.

Audits and Safety Monitoring

Additionally, ExxonMobil's sustainability report discloses safety performance metrics for employees and contractors, including total workforce incident rate, lost-time incident rate, total recordable incident rate, and process safety Tier 1 events (Exxon Mobil Corporation, 2025h). While third-party assurance is not consistently applied across all indicators, ExxonMobil conducts internal oversight through risk-based screening, performance monitoring, and retained audit rights (Exxon Mobil Corporation, 2025h). Supplier, vendor, and contractor compliance is reinforced through flow-down requirements, ensuring the implementation of ExxonMobil's sustainability expectations throughout the supply chain.

Safety, Health and Security Forum or Committee Representative

ExxonMobil actively participates in more than 40 industry committees and forums to advance safety, health, and security practices, including the Construction Users Roundtable, Center for Chemical Process Safety (CCPS), and International Association of Oil and Gas Producers (IOGP) (Exxon Mobil Corporation, 2025h).

Community Investment and Charity

Across its operating countries, ExxonMobil invests in local communities, focusing on education, health, and cultural preservation. In Singapore, ExxonMobil, with its long-term partner FairPrice Group, jointly raised over S$65,000 for the Children's Aid Society through the 10th Charity Car Wash event in 2024 (FairPrice Group, 2024). It also partners with the Singapore Red Cross on blood donation initiatives, contributing over 15,000 blood units since 1999 (Exxon Mobil Corporation, n.d.-e).

Positive Impact

The company's commitment to social responsibility has created numerous positive outcomes. This is achieved through fostering workforce development, supporting education, and enhancing health and safety (Exxon Mobil Corporation, 2025h). ExxonMobil makes its employees undergo extensive training programmes and skills-building classes, offering multiple career development opportunities (Exxon Mobil Corporation, n.d.-g). Such initiatives can strengthen the company's internal talent pool and promote greater economic stability in the local communities where the company operates. The company also runs multiple programmes targeting the youth, enabling the younger generation to participate in higher-value segments of the economy (Exxon Mobil Corporation, 2023b; NUS School of Continuing and Lifelong Education, 2025).

ExxonMobil also has thorough occupational and health measures that have helped reduce workplace accidents (Exxon Mobil Corporation, 2014; Exxon Mobil Corporation, 2025h). The company supports public initiatives such as improving

access to clean water, sanitation, and education, which benefit both employees and local residents. These efforts have enhanced the quality of life and well-being of thousands of people in the regions where the company operates. In addition, ExxonMobil invests in small businesses as part of its community development initiative (Exxon Mobil Corporation, 2025h). This has promoted entrepreneurship and helped many communities to diversify their sources of income. This diversification has strengthened these regions' resilience to economic shocks.

ExxonMobil's commitment to diversity, equity and inclusion is evident in its efforts to promote equitable workplaces and support programmes catered to minorities (Exxon Mobil Corporation, 2014; Exxon Mobil Corporation, 2025j). This approach empowers employees and fosters a better workplace culture. Through its multi-pronged approach encompassing community development, human capital improvement and sustainable development, the company has achieved a good balance between creating social value and maintaining operational excellence (Exxon Mobil Corporation, 2025h).

Governance Dimension

Strategy & Action – Strong Internal Control, Independent Board, Policy Alignment

Governance provides the structure through which ExxonMobil organises, monitors, and executes its sustainability strategy effectively.

Board Diversity and Employees' Sustainable Governance

Board of Directors

ExxonMobil's operations are overseen by a Board of Directors and the Chief Executive Officer (CEO). Independent directors comprise the majority of the Board and collectively bring expertise across relevant areas such as sustainability, finance, and operations (Exxon Mobil Corporation, 2024b). These directors have no material relationships with the company, ensuring impartial oversight and alignment of ExxonMobil's strategy, risk management, and audit practices with public policy expectations (Exxon Mobil Corporation, 2025h).

Management Team

ExxonMobil's OIMS is used by the management committee to translate board direction into short-term plans, budgets and controls (Exxon Mobil Corporation, 2025h). This OIMS aligns with the intent of the International Organization for Standardization (ISO) 14001 and ISO 45001, as assessed by Lloyd's Register Quality Assurance (LRQA). This alignment enables more effective daily operations by establishing rules and standardised processes that support corporate objectives related to security, health,

safety, and environmental performance. Moreover, at the project level, the Environmental and Social Management Plan (ESMP) helps project managers identify potential sustainability risks and plan corresponding solutions and actions (Exxon Mobil Corporation, 2025h).

Figure 5: OIMS Framework

Source: Exxon Mobil Corporation, 2025h

Supplier Selection

ExxonMobil extends its governance expectations to its suppliers and other business partners, including requirements related to human rights, workplace standards, and ethical conduct (Exxon Mobil Corporation, 2025g). Supplier and third-party expectations are incorporated into contracts and supported by risk-based screening, spot checks, and audit rights (Exxon Mobil Corporation, 2025h).

Policy Making Aligning with Ethical Standards

ExxonMobil's published Standards of Business Conduct sets out 18 policies covering areas such as anti-corruption, directorships, alcohol and drug use, and harassment in the workplace, which guide ethical practice and relationships with shareholders, customers, employees, and communities (Exxon Mobil Corporation, 2025g).

Auditing and Internal Control

General Control

For internal control and audit, ExxonMobil maintains an internal audit hotline steering committee to prevent violations, provides quarterly reporting to the audit committee, and operates a Controls Integrity Management System (CIMS) to ensure performance

meets or exceeds Sarbanes-Oxley and NYSE standards (Exxon Mobil Corporation, n.d.-b; Exxon Mobil Corporation, 2022c). Employees complete mandatory ethics training every two years covering the Standards of Business Conduct, implementation guidelines, and policies on antitrust, anti-corruption, and international operations.

According to ExxonMobil's audit committee disclosures, in addition to independent external audits, the company established an audit committee with four independent directors (Exxon Mobil Corporation, 2025i). The committee oversees the integrity of financial reporting, internal controls, regulatory compliance, and internal audit performance, and has the authority to appoint or replace external auditors to safeguard audit independence and risk coverage.

International Control

As an international company, ExxonMobil regularly conducts comprehensive reviews of its own business practices and those of its affiliates, suppliers, and partners (Exxon Mobil Corporation, 2025i; Exxon Mobil Corporation, 2025h). Those with questions or concerns about applying these standards can contact their regional Controls Advisor using the provided regional directory (Exxon Mobil Corporation, 2023d). This approach strengthens internal controls, ensures consistent policy application across markets, and aligns practices with local regulatory and business requirements.

Stakeholder Engagement

ExxonMobil frequently engages with stakeholders and shareholders to balance the interests of all parties concerned. As a publicly traded firm with relatively low individual ownership concentration, its largest shareholder, Vanguard Group Inc., owns approximately 10% of the company's shares as of 2025 (Simply Wall St, 2025). The company employs a structured, phased approach to identify shareholders' interests and rights via continuous communication, meetings, and related events. In 2024, ExxonMobil reported a 47% engagement rate for total outstanding shares and 76% for institutional shareholdings, demonstrating its commitment to balancing business growth with social responsibility (Exxon Mobil Corporation, 2025h). It engaged with various stakeholders, including a religious organisation, an ESG rating firm, and a pension fund. These engagements involve participants ranging from non-employee directors to subject matter experts.

Positive Impact

Ethical practices, transparency, and accountability across ExxonMobil's global operations have generated significant benefits for its stakeholders (Exxon Mobil Corporation, 2025h). The company promotes responsible decision-making and long-term corporate stability, beginning with its comprehensive code of ethics and business conduct guidelines that place integrity at the core of operations (Exxon Mobil

Corporation, n.d.-b). These standards reduce the risk of misconduct, corruption, and fraud, while fostering a more cohesive internal framework that enhances the company's credibility. Moreover, clear disclosure practices enhances governance, strengthening market confidence and public accountability.

Risk management, including systematic assessments of financial, operational, and environmental risks, helps mitigate adverse impacts on ecosystems, communities, and shareholders (Exxon Mobil Corporation, 2025h). These proactive strategies improve market resilience and enable the company to better navigate market fluctuations, global crises, regulatory changes, and supply chain disruptions. Board oversight, internal audits, and independent committees support alignment with ethical, legal, and social expectations. Overall, ExxonMobil's governance practices have generated largely positive outcomes, including stronger stakeholder trust, enhanced corporate credibility, and improved employee benefits.

Challenges and Limitations

Environmental Aspect

On the environmental front, ExxonMobil's ESG initiatives lack complete Scope 3 coverage and rely on intensity-based targets, demonstrate carbon lock-in through reliance on CCS, and exhibit inconsistent data assurance and comparability issues.

Firstly, ExxonMobil discloses only partial and estimated Scope 3 emissions, limiting comparability and transparency in climate accountability (Tracenable, n.d.). Moreover, reliance on intensity-based rather than absolute emissions targets undermines climate credibility, since total emissions may continue to rise alongside production growth (Foerster & Spencer, 2023).

Secondly, ExxonMobil's decarbonisation path relies heavily on large-scale CCS deployment and low-carbon hydrogen. However, CCS remains uncertain, costly, and geographically limited (Rasool & Hashmi, 2025). Over-reliance on this technology risks delaying genuine decarbonisation, locking the company into high-carbon infrastructure, and increasing the risk of stranded assets (Kazlou et al., 2024).

Thirdly, although the company issues third-party assurance statements, these typically have a limited scope, covering only greenhouse gas inventories while excluding key social and environmental performance indicators (Maccarrone et al., 2024). This selective assurance hinders comparability and undermines investor trust, echoing the findings of Sullivan and Gouldson (2016), who observed that incomplete ESG verification is associated with lower capital market credibility.

Additionally, Burger et al. (2024) highlight that CCS supply chains require substantial energy, materials and infrastructure, equivalent to 10-15% of the anticipated emissions reduction. These trade-offs suggest that ExxonMobil should combine CCS efforts with LCA and renewable energy adoption to maximise net environmental benefits.

Social Aspect

On the social front, ExxonMobil's ESG initiatives are activity-oriented rather than outcome-based, display supply-chain blind spots and limited human rights oversight, and have limited leverage in joint ventures and frontier operations.

Firstly, ExxonMobil's social initiatives, such as workforce training and community investment, are often presented as counts of activities rather than measurable outcomes (Exxon Mobil Corporation, 2025h). This form of symbolic CSR suggests that the company prioritises public image over genuine social impact, which may cause employees and other stakeholders to question the authenticity of the company's values and motives (Shahzadi et al., 2024).

Secondly, although ExxonMobil conducts supplier audits and enforces contractual clauses, its oversight is most robust at the Tier 1 level, with limited visibility into subcontracters and labour-broker networks. This gap is increasingly misaligned with evolving due diligence regulations and could weaken the company's ability to demonstrate accountability and compliance with global standards (European Commission, 2022; UK Home Office, 2025).

Thirdly, while ExxonMobil communicates ambitious decarbonisation and equity narratives, Pucker (2021) and Banerjee (2008) caution that overstating ESG ambitions without corresponding capital expenditure and executive incentives will result in a commitment-delivery gap. The absence of direct ESG-linked compensation structures further weakens behavioural alignment.

Governance Aspect

On the governance front, ExxonMobil's ESG initiatives face notable shortcomings, including policy and capital misalignment, as well as conflicts surrounding shareholder rights. Specifically, the company's 2024 lawsuit to block a climate-related shareholder proposal was widely condemned by investors, who view it as violating shareholder democracy (Ambrose, 2024). Meanwhile, LobbyMap (2025), which evaluates corporate engagement with climate policy, gives ExxonMobil a "D" rating for its Performance Band (A+ to F scale). This rating indicates ExxonMobil's obstructive behaviour towards Paris Agreement-aligned climate policies. Such conduct may represent "governance capture", in which corporate influence on policy undermines the credibility of ESG commitments (Liu et al., 2023).

Overall, ExxonMobil's investment portfolio is characterised by partial transparency, technological optimism, and conservative management. Its climate indicators emphasise intensity rather than absolute values, its social projects prioritise activities over measurable impacts, and its management mechanisms often focus on reaction rather than cooperation. Independent analyses, such as those from LobbyMap (2025), corroborate these patterns, suggesting an underlying institutional inertia that constrains genuine transformation. As global ESG regulations continue to strengthen,

ExxonMobil will face increasing pressure to transition from a compliance-oriented approach to one based on performance-based accountability.

Conclusion

The findings indicate that ExxonMobil has made significant efforts towards sustainable development, especially in reducing carbon emission intensity. However, the analysis highlights limitations and challenges in embedding sustainability within the corporation, including an over-reliance on carbon-intensity metrics and carbon-capture technologies. The energy industry is inherently at odds with the concept of sustainability, as its core operations depend heavily on fossil fuel extraction and combustion. Achieving a sustainable transition is especially challenging in the short term for such a heavily energy-invested industry.

ExxonMobil's approach may appear cautious. In addition, it has yet to fully disclose its Scope 3 emissions. This omission reflects its transitional phase towards a lower-carbon model rather than an attempt at greenwashing. In addition, ExxonMobil invests heavily in R&D, focusing on frontier technologies and in-house innovations aimed at sustainable solutions.

Looking ahead, ExxonMobil's primary challenge lies in enhancing its Scope 3 transparency and strengthening its R&D in carbon solutions. While the company has not yet disclosed its complete Scope 3 data, we believe this gap reflects its ongoing transformation rather than deliberate omission. The company's future success will depend on how effectively it can translate R&D breakthroughs into measurable Scope 3 reduction pathways and broader sustainability outcomes.

Discussion Questions

1. Can a fossil fuel company like ExxonMobil ever achieve genuine sustainability, or is “sustainable oil” an inherent contradiction?

2. What does “corporate social responsibility” truly mean for ExxonMobil when global energy demand keeps rising—to provide energy security or to reduce fossil fuel dependency?

3. How should we view the lack of data (e.g. Scope 3 emissions) in firms’ sustainability reports?

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How India's Social Stock Exchange is Redefining Value, Investment and Accountability

GAO Jiaying

LI Zhengyi

Akshay Shridhar PRASAD

WANG Shuyi

Loh, L., & Ang, H. M. (Eds.). (2026). *Cases in sustainability (Vol. 2: System-level and structure-based approaches).* Centre for Governance and Sustainability, NUS Business School.

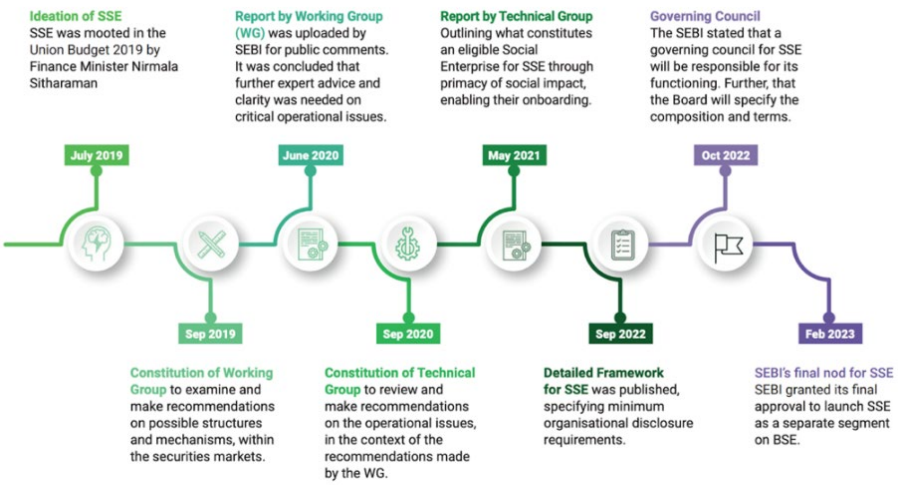
Background of Social Stock Exchange (SSE)

In an era of rapid transformation where social issues such as environmental governance and climate change are increasingly prominent, many social enterprises, development sector organisations, non-government organisations (NGOs), and civil society organisations (CSOs) have engaged in social governance. However, their efforts to convert intent into impact are often constrained by a lack of capital and a lack of sustained access to this capital. A new report by Dasra and Kearney indicates that nearly 75% of India's nonprofits encounter a financing shortfall, with 92% of NGOs identifying core funding as their primary concern (Tripathi et al., 2025). In addition, India faces a funding gap to meet the United Nations Sustainable Development Goals (SDGs) by 2030, which would need the support of the government, the business sector and high-net-worth individuals.

Problem Definition

The social development sector in India is mainly financed through Corporate Social Responsibility (CSR), philanthropy, government funding and retail charity. In order to standardise fund allocation and enhance transparency, the finance minister of India announced the launch of the Social Stock Exchange (SSE) in 2019, operating under the supervision of the Securities and Exchange Board of India (SEBI). The SSE developed a comprehensive framework covering fund administration, utilisation, disclosure, and reporting (Balasubramaniam, 2023). The UN SDGs 17 (Partnerships for the Goals) underscores the necessity of cultivating multi-stakeholder partnerships to mobilise financial resources, disseminate knowledge, and enhance overall sustainable development. SSE represents a profound localisation of this global vision, incorporating the SDG 17 into its national sustainable financial system.

Figure 1: Launch Timeline of SSE



Source: Sattva Knowledge Institute, 2024

The Emergence and Institutional Design

SSE is a platform that enables social entrepreneurs and organisations to seek funds from the public. Similar to stocks, commodities, derivatives and small and medium-sized companies (SMEs), the SSE will constitute a part of the stock exchange. Both the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE) have obtained licenses to operate an SSE. The entities registered on the SSE are generally categorised as For-profit Social Enterprises (FPEs) and Not-for-profit Organisations (NPOs). These two types of social enterprises draw some similarities with commercial entities. Hence, the table below compares the three types of entities.

Table 1: Comparison of NPOs, FPEs and Commercial Entities under India's Social Stock Exchange Framework

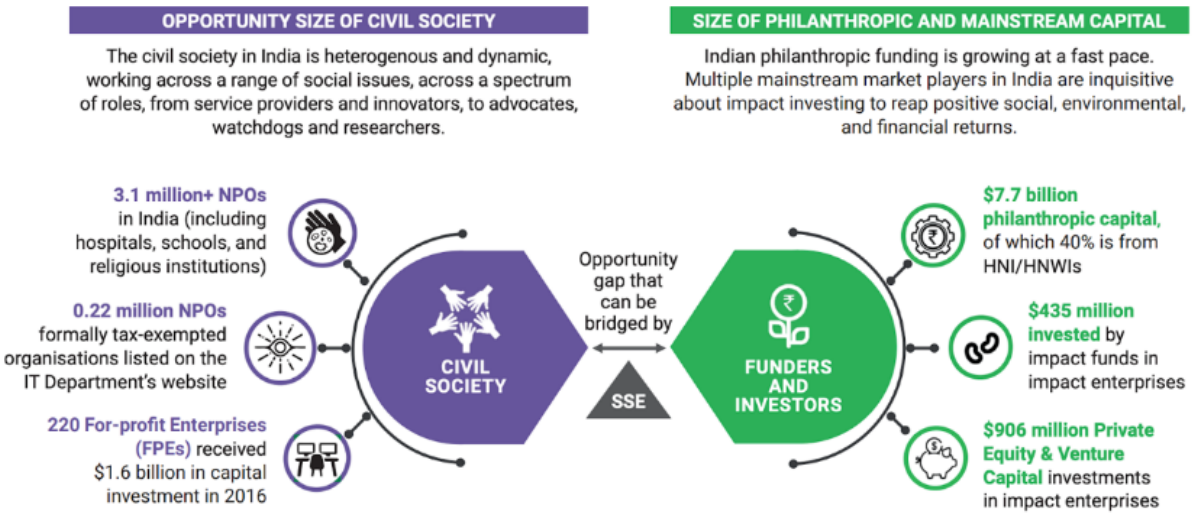
	NPOs	**FPEs**	**Commercial Entities**
Focus	Maximising social impact	Maximising social impact along with growing shareholder wealth	Maximising shareholder wealth
Instruments /modes for raising funds	Equity, Zero Coupon Zero Principal (ZCZP) bonds, development impact bonds, social impact funds, donations from mutual funds	Equity shares through the main board, SME, or innovators growth platform, equity shares through Alternative Investment Funds (AIFs) or Social Impact Funds, or debt	Equity, debt
Social Mandate	At least 67% over the past three years' average revenues / expenses/ customer base should be dedicated to providing eligible social activities.	At least 67% over the past three years' average revenues / expenses / customer base should be dedicated to providing eligible social activities.	A company with at least a net worth of ₹500 Cr / revenues of ₹1000 Cr / net profit of ₹5 Cr shall spend at least 2% of its average over the three years' net

			profits towards CSR activities.
Who can invest?	All entities are allowed. In case of ZCZPs, anyone with a minimum of ₹10,000 can invest	Retail investors, HNIs, institutional investors - all entities allowed in the capital markets	Retail investors, HNIs, institutional investors - all entities allowed in the capital markets
Reporting social impact	Social Impact Scorecard	Social Impact Scorecard	Business Responsibility and Sustainability Report (mandatory for the 1000 largest listed companies)

Source: Zerodha, n.d.

Among them, Zero Coupon Zero Principal (ZCZP) is a new innovative security. In contrast to conventional investments, it enables investors to effectively contribute to NPOs for designated social development initiatives, without interest payments or principal payback upon maturity, functioning just as a symbolic certificate of public welfare involvement. This instrument offers NPOs a novel funding avenue to secure non-financial-return-driven capital while allowing corporations to fulfil their CSR obligations by investing in SSE-listed NPOs, thereby combining regulatory compliance with social impact. As there is no monetary return, the main risk with ZCZPs is that NPOs will not deliver the social impact that they promised to create. The NPO issuing ZCZPs must exhibit the following on its website: Vision, target demographic, strategic plan for achieving the vision, governance issues, information on key management personnel, operational details, financial statements, compliance documentation, registration papers, records of previous social impact, and associated risks. Thus, individuals can now participate in India's social development journey with transparency and accountability.

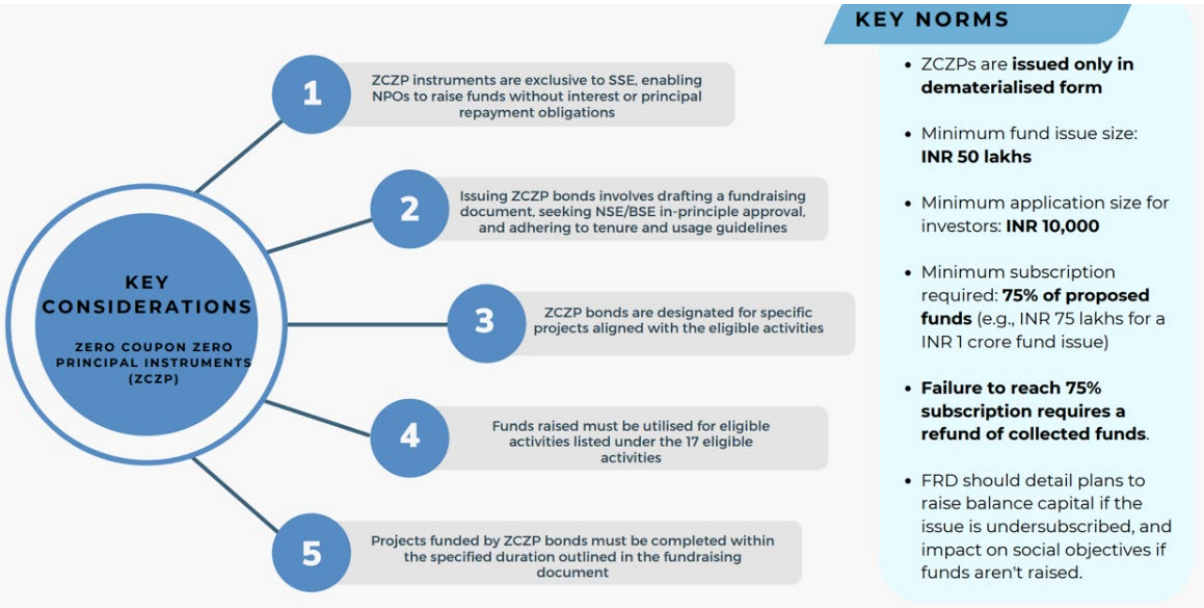
Figure 2: Opportunity Gap Bridged by SSE



Source: Sattva Knowledge Institute, 2024

Socially aware firms and non-profits might utilise SSE as a distinctive and innovative method to secure a dependable funding source that is transparent and open to public examination. In India, an SSE entity might significantly foster professionalism, objectivity, and a culture of tracking, measuring, recording, and reporting the social effect it generates. The transparency and potential to execute large-scale social change represent a distinct advantage for all players within the ecosystem.

Figure 3: Significance of ZCZP



Source: Atma, 2025

Impact Analysis

The SSE serves as a pioneering platform supporting India's sustainable development goals. It provides a structured financing channel for social enterprises and NGOs, helping them attract private investment while advancing priorities across environmental, social and governance (ESG) dimensions. The SSE integrates capital market mechanisms with social development objectives, aligning financial incentives with measurable social outcomes. Its innovations in capital allocation, accountability, and green investment have introduced new models for sustainable finance in India.

Social Dimension

Indian non-profits and social enterprises are unable to realise their full potential due to persistent funding shortages. Traditional charitable donations are largely from individuals and corporations, which are highly unpredictable in both amount and timing. This unpredictability means Indian charities cannot effectively develop or implement budget plans, as there is no guarantee when funds will be available. However, the emergence of SSEs addresses this issue by providing a stable and predictable financing channel and mitigating corruption through transparency and accountability.

As of December 2024, more than 120 non-profit organisations had registered on the SSE operated by the NSE of India and the BSE (Taparia, 2025). This shows that organisations are discovering and are willing to join the SSE as a financing platform and shows the feasibility of its business model. The SGBS Unnati Foundation became the first to raise funds through the SSE at the end of 2023, focusing on expanding youth skills training programmes (Sinha, 2023).

Economic Dimension

The emergence of the SSE demonstrates that India's impact investing ecosystem is maturing. India has an impact investing market of US$10 billion, highlighting a promising and underexplored market for socially oriented investment (Impact Investors Council, 2020).

Traditional impact investing has mainly focused on private equity funds, family offices, and corporate social responsibility. Now, the SSE provides these funds with an open, transparent, and regulated market entry point into the development sector. By the end of 2024, over 10 NPOs had raised approximately ₹220 million through the SSE platform, with the Swades Foundation alone accounting for nearly half that sum (Shekhar, 2024; Taparia, 2025).

While this data is relatively small compared with the overall market size, it signals a positive message, indicating growing investor interest and reducing barriers to entry for social investment. Meanwhile, the data also encourages the combination of public

funds, private capital, and CSR resources to provide stronger support for social projects.

Governance Dimension

One of the key features of the SSE is the governance and disclosure framework. Every individual and organisation that is raising funds on the SSE must follow the SEBI regulations. Annual Social Impact Reports, third-party independent evaluations, and fund usage statements must be submitted to the authority for review and examination (Securities and Exchange Board of India, 2023b).

Differing from traditional donation methods, this mandatory disclosure framework reduces information asymmetry and improves trust among investors and the public. SSE has also progressively established common evaluation standards for social project performance, promoting the professionalisation and standardisation of social organisations.

This mechanism directly supports SDG 16 (Peace, Justice and Strong Institutions), strengthening governance transparency and accountability in social capital operations.

Environmental Dimension

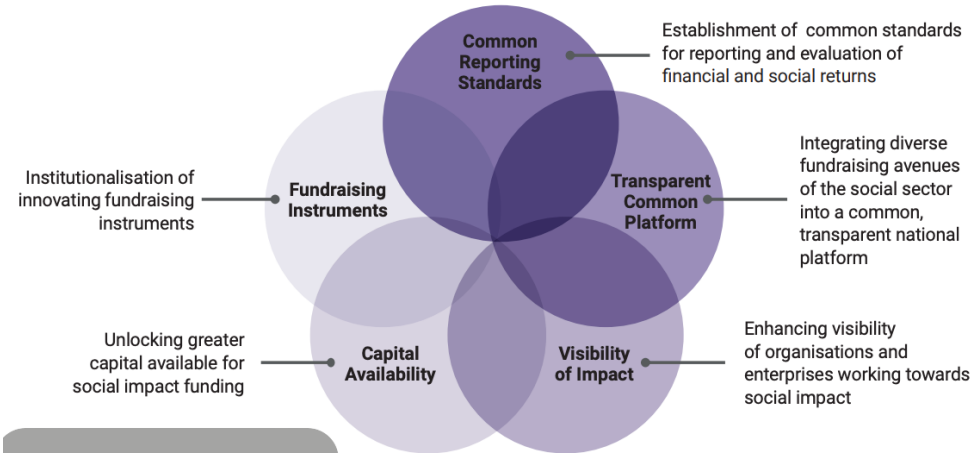
Some of the funds raised through the SSE have already kicked into clean energy, water management, and climate adaptation projects that aim to improve sustainability. Currently, environmental programmes represent a smaller share of SSE activity compared with sectors like education and healthcare. Even so, their progress suggests that capital markets can genuinely support environmental protection and climate action, while remaining financially viable and long-term scalable. These efforts are closely linked to SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action), and they are laying a foundation for broader green finance development.

Strategic Alignment with UN Sustainable Development Goals (SDGs)

The SSE's initiatives align closely with multiple United Nations SDGs, collectively reinforcing India's broader sustainable development agenda, including:

- **SDG 1:** No Poverty (decentralised funding and inclusive finance)
- **SDG 4:** Quality Education (skills enhancement and educational support)
- **SDG 7 and 13:** Affordable and Clean Energy, Climate Action (green energy project financing)
- **SDG 8:** Decent Work and Economic Growth (job creation and livelihood support)
- **SDG 16 and 17:** Strong Institutions and Partnerships (transparent governance and collaborative financing)

Figure 4: Impact of SSE



Source: Sattva Knowledge Institute, 2024

Strategic Significance of SSE

The 3R Model: Rethinking Value Creation

The core innovation of the SSE is the integration of Risk, Return, and Reputation into its design, which redefines the value proposition for both Social Enterprises (SEs) and investors. This model advances beyond the duality of financial return or social impact by establishing a framework in which multiple forms of capital and value are systematically recognised and measured.

Risk: Structured Accountability and Regulatory Oversight

Risk mitigation operates through three regulatory instruments:

- **Initial Disclosure Requirements** mandate detailed information on vision, target segments, strategy, governance, management capabilities, operational infrastructure, three years of financial statements, compliance history, and past social impact.

- **Continuous Reporting Obligations** should cover aspects like organisational goals, beneficiary outreach, scale of operations, governance aspects like board composition, risk management, related party transactions, and financial aspects that include audited statements, programme-wise fund utilisation.

- **Annual Impact Reports (AIR)** should be audited by certified Social Auditors registered with the Institute of Chartered Accountants of India (ICAI) and have qualified through the National Institute of Securities Markets (NISM) certification programmes.

For investors, the SSE's regulatory framework provides structured risk assessment tools. The key social intent criterion targets SDG-aligned activities and underserved populations in regions with lower development performance. This quantitative threshold will be verified through revenue (67% from eligible activities), expenditure (67% for eligible activities), or beneficiary metrics (67% of customer base from target population) (National Stock Exchange of India Ltd., 2023), which creates a measurable standard for social commitment.

Return: Expanding the Definition Beyond Financial Metrics

As mentioned previously, the SSE's innovation lies in formalising social return as an authorised investment outcome through financial instruments, particularly the ZCZP bonds. This will enable tax benefits for investors, exemptions from Securities Transaction Tax and Capital Gains Tax, and allow CSR expenditure directed to SSE-listed entities to count towards the mandatory CSR obligation of 2% for the entities.

For For-profit Social Enterprises (FPEs), the SSE enables equity listings on the Main Board, SME platforms, or the Innovators Growth Platform, as well as debt securities issuance and fundraising through Social Impact Funds (SIF) under the Alternative Investment Fund (AIF) scheme. This creates pathways for blended capital structures where financial returns coexist with social impact, which leads to expanding the investor base beyond traditional philanthropy to include impact investors, family offices, and ESG-focused institutional funds.

Signalling Credibility Through Regulatory Validation

The SSE's registration process functions as a powerful credibility signal in an ecosystem (Atma, 2025). The value of SSE listing extends beyond capital access to consider enhanced visibility, institutional validation, creates accountability and responsive governance, and sector leadership positioning.

The technical mechanism for accountability and reputation enhancement operates through the following multiple channels:

- **Public Listing and Visibility:** SSE-registered NPOs are displayed on the NSE and BSE websites with their registration status, creating national-level visibility for mid-sized and smaller entities.

- **Third-Party Impact Assessment:** The impact reports assessed by independent social auditors or social audit firms provide external validation of outcomes. This creates a differentiated level of "impact verified" organisations within the sector.

- **Governing Council Oversight:** SSE operates under a Social Stock Exchange Governing Council (SGC) with balanced representation from philanthropic

sectors, NPOs, information repositories, social impact investors, social audit professionals, capacity building funds, and stock exchanges (Securities and Exchange Board of India, 2022). This governance structure provides oversight and credibility enhancement for entities and trust among investors.

- **Network Effects of Reputation:** Early adopters gain first-mover advantages in accessing a diversified funding base, while subsequent listings benefit from established frameworks and investor familiarity.

Institutional Significance and Hybrid Governance: Elevating Social Sector Accountability

Extending Corporate Governance Principles to the Non-Profit Sector

The extension of corporate governance, custodian duty and regulatory oversight addresses a fundamental governance gap: while India has approximately 3.3 million registered NGOs, the sector has predominantly operated with limited accountability mechanisms, disintegrated disclosure practices, and minimal standardisation in impact measurement. SSE has focused on creating a Hybrid Governance Model that balances market discipline with social impact objectives.

Regulatory Governance: SEBI's Supervisory Framework

Board members and trustees of SSE-registered NPOs are subject to debarment criteria comparable to corporate directors. This regulatory system creates accountability for the institutions through the following ways:

- **Governing Body Oversight:** NPOs must disclose board composition, roles and responsibilities, qualifications, selection processes, frequency of meetings, attendance records, and performance review methods.

- **Key Managerial Personnel Accountability:** NPOs must designate a Compliance Officer responsible for regulatory compliance, coordinate with statutory auditors on regulatory documentation, and serve as the single point of contact (SPOC) with SSE authorities, which creates professional accountability that was previously uncommon in the social sector.

- **Related Party Transaction Disclosure:** All transactions with related parties (entities or individuals with relationships to the organisation) must be disclosed with rationale, mirroring corporate related party disclosure requirements under Indian Accounting Standard (Ind AS) 24.

- **Remuneration Policy Disclosure:** Policies for governing body and senior executive compensation must be disclosed, which address concerns about NPO resource allocation, overhead expenses and enhance transparency.

Impact Governance: Social Auditor Certification and Annual Impact Reporting

One of the most institutionally significant innovations is the establishment of professional impact governance through mandatory Annual Impact Reports (AIR) audited by certified Social Auditors. This mechanism operates through:

- **Social Auditor Certification:** Individuals registered with ICAI self-regulatory organisations who have qualified for NISM certification programmes can act as Social Auditors.

- **AIR Mandatory Components:** The AIR must cover Strategic Intent and Planning, Approach (baseline status, past performance trends, sustainability measures, alignment with SDGs/national priorities and risk mitigation), and Impact Scorecard.

Global Significance and the "Global South" Model: A Pioneering Approach to Social Finance

Positioning the SSE as a "Global South" Innovation

The approach of SSE is that of the Global South context. It takes into account the massive scalability of social needs, limited public resources, budding institutional infrastructure and varied organisational forms that are operating in the social sector. This is very unlike the social finance mechanism developed in the UK's Social Impact Bonds (Social Finance, 2018), United States outcome-based contracting and Europe's social entrepreneurship.

Table 2: Global South Features of India's SSE Model

Inclusive Organisational Eligibility	**Dual-Track Architecture**	**Regulatory Capacity Building**	**Scale-Appropriate Thresholds**
The SSE accommodates diverse legal forms prevalent in Indian	The SSE simultaneously serves NPOs and FPEs. This	Unlike developed market models that assume mature institutional	Minimum requirements (3-year operational history, INR 50

civil society, such as charitable trusts registered under public trust statutes or the Indian Trusts Act 1882, societies registered under the Societies Registration Act 1860, and Section 8 companies under the Companies Act 2013. This flexibility contrasts with Western models that predominantly focus on specific legal forms.	approach recognises the ecosystem reality in developing countries where social impact is delivered through mixed organisational models.	infrastructure, the SSE incorporates capacity building as a core component through the proposed Capacity Building Fund and SGC oversight. This recognises that many organisations require institutional strengthening to meet disclosure and reporting requirements.	lakhs annual spending, INR 10 lakhs past year funding) are calibrated for mid-sized organisations that have demonstrated operational maturity but may lack access to large-scale philanthropy. This contrasts with Western impact investing that often targets venture-scale social enterprises.

Source: Adapted from Atma, 2025

Additionally, the SDG alignment is at the base of the Global South Model. The eligible activities specified under Regulation 292E can be mapped to SDGs, aligning the SSE with the 2030 Agenda for Sustainable Development.

Linkages to Global Sustainability Frameworks

The SSE's global significance is enhanced by explicit linkages to internationally recognised sustainability frameworks, raising the social impact reporting to standards comparable with financial reporting through the following:

- **Global Reporting Initiative (GRI) Standards:** The SSE's Annual Impact Report framework encompasses principles from GRI Standards, which are the world's most widely used sustainability reporting standards, with 71% global adoption and used by 77% of the world's 250 largest companies (Global Reporting Initiative, 2024).

- **Task Force on Climate-related Financial Disclosures (TCFD):** While the SSE's primary focus is social impact rather than climate, environmental

sustainability and climate change mitigation are among the eligible activities. NPOs and FPEs working on these themes must disclose climate-related risks and opportunities, aligning with TCFD's four pillars (Governance, Strategy, Risk Management, Metrics and Targets).

- **World Economic Forum (WEF) Stakeholder Capitalism Metrics:** The SSE's focus on target segment definition (underserved/less privileged populations), diversity and inclusion metrics, and governance disclosures aligns with WEF's stakeholder capitalism framework. The inclusion dimension in the SSE's Impact Scorecard, which covers income levels, diversity and inclusion, and social equity, directly corresponds to WEF metrics on community investment, dignified work, and inclusive growth.

Challenges and Limitations

Despite its institutional novelty, the SSE remains an emerging experiment in embedding sustainability principles within India's capital markets. While the initiative represents a bold step in the democratisation of social finance, its practical execution exposes a maturity gap between regulatory ambition and institutional capacity. The SSE conceptually aligns with the UN SDGs, but its early adoption demonstrates the difficulty of translating aspirations into functioning domestic systems. Regulatory flexibility introduced by SEBI in 2023 reflects this transitional phase (Securities and Exchange Board of India, 2023a), signalling that the framework remains iterative as implementation challenges exist. Three interrelated limitations stand out as follows:

Fragmented Measurement and Disclosure

A primary constraint is the absence of common metrics to evaluate social outcomes. Although SEBI mandates annual Social Impact Reports, its guidance is rare, principle-based rather than standardised. Participating entities utilise various frameworks, ranging from the GRI to custom SDG mappings, resulting in uneven and non-comparable data (Dinavahi & Bangali, 2025). Such fragmentation undermines impact attribution, limits benchmarking, and erodes investor confidence. SEBI's 2023 circulars and the SSE guide for NPOs acknowledge this gap and call for greater codification of templates and independent assurance (Securities and Exchange Board of India, 2023a; Atma, 2025). Until convergence occurs, the SSE cannot fully generate verifiable and useful evidence of impact, which is an essential precondition for credible and scalable sustainable finance markets (Vig, 2023).

Limited Investor Participation and Market Liquidity

The second challenge concerns the market's behavioural and structural readiness. Investor literacy regarding "social-return" instruments remains low, and many retail

participants continue to view ZCZP bonds as a philanthropic act rather than investable assets with measurable outcomes (Banerjee, 2019). This perception depresses demand, narrows participation, and weakens secondary market liquidity (Paul, 2024). When contrasted with India's US$10 billion impact-investment ecosystem (Impact Investors Council, 2020), the SSE appears symbolic in scale and scope. This gap reflects the classic sustainability tension between ethical intent and economic incentive. Translating social value into investable returns remains challenging (Dinavahi & Bangali, 2025). For the SSE to gain traction, investor education, fiscal incentives, and integration of impact metrics into financial performance reporting will be critical (Securities and Exchange Board of India, 2023b).

Figure 5: Fundraising on SSE as of March 2025

Issuer Name	Issue opening opening date	Issue amount (₹ cr)
SGBS Unnati Foundation	Oct 30, 2023	2.0
Ekalavya Foundation	Feb 8, 2024	1.1
Transforming Rural India Foundation	Feb 21, 2024	2.0
Mukti	Feb 27, 2024	1.7
Swami Vivekananda Youth Movement	Mar 6, 2024	1.55
Foundation to Educate Girls Globally	Mar 12, 2024	1.3
Routes 2 Roots	Mar 12, 2024	1.0
Missing Link Trust	Apr 2, 2024	1.2
Sarthak Educational Trust	Jul 1, 2024	1.0
Swades Foundation	Aug 2, 2024	10.0
SGBS Unnati Foundation	Feb 28, 2025	0.5
Prashanthi Balamandira Trust	Mar 19, 2025	18.0

Source: Coutinho, 2025

Evolving Governance and Assurance Mechanisms

While SEBI has refined the SSE through successive memoranda and circulars, detailed verification protocols and enforcement mechanisms remain underdeveloped (Patel & Patel, 2023; Chaturvedi et al, 2019). Current procedures require issuers to report on fund utilisation and outcomes, but do not define how claims should be audited or validated. This ambiguity creates inconsistencies in fund tracing and impact verification, which leads to exposing the platform to reputational risks of "impact washing" (Dinavahi & Bangali, 2025; Vig, 2023). Establishing clear accountability through board-level oversight, external audits, and cross-entity comparability will be crucial to building institutional trust and market legitimacy. These governance challenges underscore a broader truth: sustainable finance depends as much on transparency and verification as on innovation and intent.

Synthesis and Implications

The fragmentation of metrics hampers transparency. Limited investor readiness constraints and underdeveloped assurance systems erode confidence. Addressing these deficits requires multi-level coordination among regulators, market participants, and assurance professionals. For SEBI and the exchanges, establishing uniform disclosure taxonomies, accredited auditors, and periodic impact reviews would lead to better consistency. For issuers, building quantitative impact-measurement capacity and governance structures can translate intent into measurable outcomes. The SSE's experience thus incorporates a broader lesson of sustainability transitions: institutional innovation must evolve in tandem with market incentives and verification systems to achieve systemic credibility (Patel & Patel, 2023; Vig, 2023). Only through the alignment of governance, measurement and participation can the SSE mature from experimental policy to a durable pillar of India's sustainable finance architecture.

Revelations and Future Prospects

India's SSE offers an instructive lens through which to examine the institutional, behavioural, and governance challenges of embedding sustainability in capital markets. Its design and early implementation reveal both the promise and fragility of aligning finance with social purpose. While operational limitations remain, the SSE's evolution also provides broader insights for the future of sustainable finance systems in emerging economies, organised across institutional, enterprise, and regional perspectives.

Institutional Insights: Integrating ESG and Social Impact

At the policy level, the SSE demonstrates how a regulator can institutionalise sustainability by extending capital market access to social enterprises and non-profits. SEBI's initiative integrates ESG principles with social-impact investing, redefining fiduciary responsibility to include measurable social outcomes. This approach resonates with the hybrid-capital model described by Vig (2023), which blends philanthropic and commercial capital to achieve systemic change. Embedding SDG logic within market infrastructure reframes financial intermediation as a tool for inclusive growth. Yet policy innovation must be matched by administrative depth and enforcement consistency (Patel & Patel, 2023). This institutional trajectory reflects the challenge of operationalising the governance dimension of sustainability.

Enterprise Insights: Building Impact Governance and Reporting Capability

For participating organisations, the SSE represents both opportunity and responsibility. Listing requires transparency, data-driven impact measurement, and board-level governance, where many small-scale and mission-focused entities remain under-resourced. Dinavahi and Bangali (2025) note that Indian non-profits often lack

the institutional systems to translate social outcomes into quantifiable metrics, limiting their ability to attract market-based capital. The SSE functions as a catalyst for professionalisation: it incentivises social enterprises to adopt recognised standards such as GRI or TCDF, articulate outcome baselines, and publish verified impact statements. SSE's participating entities span education, health, and rural development sectors (National Stock Exchange of India Ltd., n.d.), and these fields are those with strong social externalities but weaker financial infrastructures. Over time, such participation may accelerate a shift from grant dependence towards blended-finance models that balance impact and financial sustainability (Chaturvedi et al., 2019).

Figure 6: Suggested Recommendations for Evolving SSE

Source: Sattva Knowledge Institute, 2024

Regional Insights: Replicating the SSE Model in the ASEAN Context

Regionally, India's experience offers a prototype for emerging economies seeking to align capital mobilisation with the SDGs. ASEAN countries face parallel challenges: fragmented social-finance ecosystems, limited assurance infrastructure, and low investor literacy. The SSE suggests that a state-anchored but market-operated platform can crowd in private capital for social priorities without displacing philanthropic flows. As Paul (2024) highlights, transparency and standardisation are prerequisites for building investor trust in any such exchange. Singapore's impact-investment ecosystem, Indonesia's green-finance initiatives, and Malaysia's sukuk-based social-bond market provide fertile ground for adaptation. Policymakers can leverage regional collaboration to harmonise disclosure norms and enable cross-border listing of social instruments, thereby strengthening Southeast Asia's contribution to SDG financing gaps.

Outlook: From Symbolism to Systemic Credibility

Looking ahead, the SSE's next phase will depend on its ability to integrate credibility, scale, and innovation. As data accumulation improves, regulators may introduce more

sophisticated products, such as outcome-based bonds or blended-impact funds that tie financial returns directly to verified social performance (Patel & Patel, 2023). This evolution parallels global trends in sustainability reporting, where impact assurance is becoming integral to corporate governance rather than an ancillary exercise. Technological enablers such as digital ledgers and AI-assisted verification could reduce the cost of auditing social outcomes, enabling scale at lower friction (Vig, 2023).

Ultimately, India's SSE illustrates that sustainability transitions are not achieved through policy design alone but through the incremental construction of institutional capacity, investor trust, and measurement credibility. Its continued refinement will serve as a reference point for other developing economies seeking to reconcile financial logic with social purpose.

Discussion Questions

1. How can capacity building be leveraged to better prepare different stakeholders within the SSE ecosystem for meaningful participation and long-term success?

2. How might collaboration among NPOs, investors, regulators, and other stakeholders evolve to ensure that the SSE's mechanisms remain effective and adaptive as the platform scales?

3. As the SSE grows to include social enterprises from diverse sectors, how can we develop credible and comparable impact measurement frameworks that support investor confidence, without imposing uniformity or limiting local innovation?

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SP Group in Singapore's Green Transition

GAO Chang

LI Xinxin

SHI Jiali

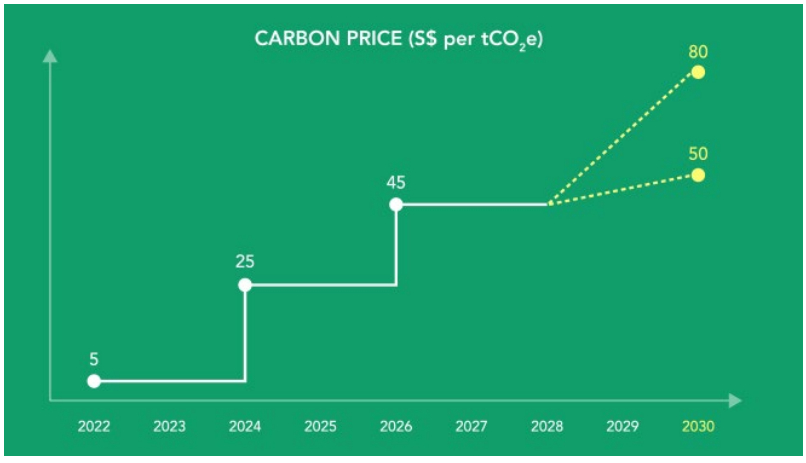
Loh, L., & Ang, H. M. (Eds.). (2026). *Cases in sustainability (Vol. 2: System-level and structure-based approaches).* Centre for Governance and Sustainability, NUS Business School.

Introduction & Macro Context: Singapore's National Sustainability Agenda

Singapore has launched an ambitious national sustainability agenda to combat climate change and move towards green growth. The Singapore Green Plan 2030 serves as the key whole-of-nation roadmap guiding this transition. It outlines measurable targets over the next decade and supports the country's long-term goal of achieving net-zero emissions by 2050, in line with the Paris Agreement (Singapore Green Plan, n.d.). The plan links action to city planning, industry development and daily life.

Yet, the transition presents significant challenges. Around 95% of Singapore's electricity still comes from natural gas, a fossil fuel. The power sector contributes almost 40% of the country's total emissions, so decarbonising it will not be easy (Chin, 2025). The government has introduced carbon pricing to encourage change in both the public and private sectors. A carbon tax, first introduced in 2019, increased to S$25 per tonne of carbon emissions in 2024 and will move up in steps to reach S$50-80 per tonne of emissions by 2030 (National Climate Change Secretariat, n.d.). The policy sends a clear cost signal that reshapes project economics for grid infrastructure, cooling systems, and electric mobility. At the same time, Singapore is diversifying its energy sources. The Energy Market Authority (EMA) plans to import six gigawatts of low-carbon electricity by 2035, which accounts for about one-third of the country's projected energy demand (Energy Market Authority, n.d.). To complement this, the government announced the National Hydrogen Strategy, outlining a pathway to use hydrogen for power generation and industrial applications (Energy Market Authority, 2022).

Figure 1: Projected Carbon Tax Pathway for Singapore (2022–2030)



Source: National Climate Change Secretariat, n.d.

Figure 2: Regional Power Import Strategy Targeting 6 GW of Low-Carbon Electricity by 2035

Source: Energy Market Authority, n.d.

Corporate Background: SP Group Overview and Evolution

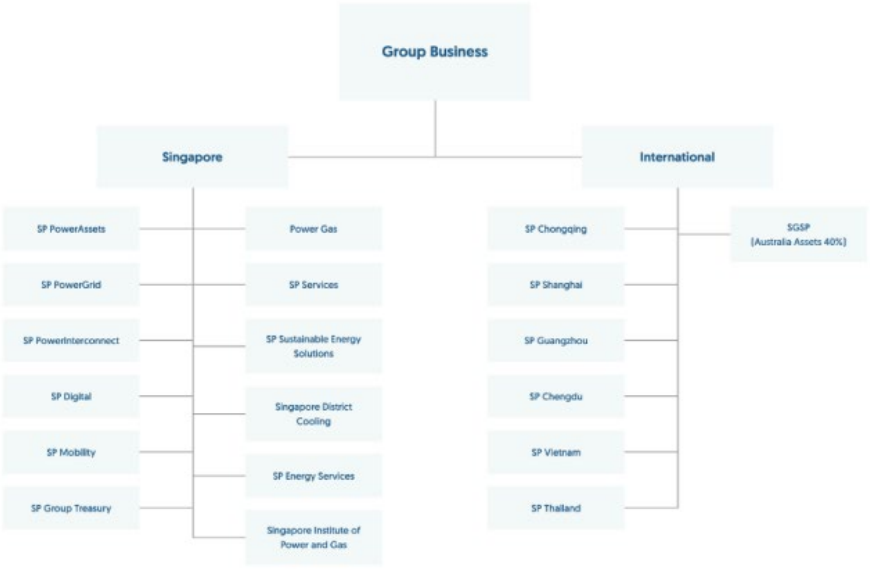
Within this national context, SP Group plays a pivotal role in implementation. SP Group (Singapore Power Group) is a state-owned energy utilities company under Temasek Holdings, with origins in the former Public Utilities Board (PUB). It was formally incorporated in 1995 when Singapore corporatised PUB's electricity and gas operations. Since then, SP Group has evolved from a local electricity provider into one of Asia-Pacific's leading utilities. Today, it owns and operates the national electricity and gas transmission and distribution networks, serving more than 1.7 million customers (SP Group, n.d.-b). In fact, the reliability of Singapore's grid—managed by SP—is among the world's best, with an average interruption duration of only 0.15 minute (SP Group, n.d.-c). This strong performance sets a high bar for integrating renewable energy and digital technologies into the network.

A simple timeline helps frame how SP has evolved from a traditional utility into a broader solutions platform. In the early 2010s, the company's structure consisted of SP PowerAssets, PowerGas, SP PowerGrid, and SP Services (SP Group, 2011). In 2017, it rebranded from "Singapore Power" to "SP Group" and launched the SP Utilities app, which later added energy-usage insights and green features to help users manage consumption more efficiently (SP Group, 2017). The company has also expanded into district cooling, public EV charging, and other digital infrastructure, while strengthening climate disclosures in its annual sustainability reviews (SP Group, 2024).

In parallel, SP's strategy extends beyond Singapore's borders. Through joint ventures and investments, the company operates in China, Vietnam, Thailand, and Australia, through projects such as district cooling and via strategic investments (including a stake in Australia's Jemena utility network)(SP Group, n.d.-d). These ventures

demonstrate how SP Group exports Singapore's energy-efficiency expertise while contributing to decarbonisation in neighbouring economies. As Singapore's primary energy operator, SP Group's mission aligns closely with national sustainability objectives.

Figure 3: SP Group Business Structure, Showing Singapore and International Segments



Source: SP Power, n.d.-b

Figure 4: SP Group's Evolution Timeline

SP's Sustainability Strategy (Four Pillars)

SP Group constructs its net-zero strategy on four pillars: Net Zero Integrator, Transition Enablers, and Sustainable Operations, while People & the Community serves as a cross-cutting commitment and a foundation to strengthen its sustainability strategy (SP Group, 2024).

In a tactical sense, large-scale deployment of renewable energy, smart-grid digitalisation, e-mobility, sustainable financing, and community capacity-building focus on the three pillars.

Net Zero Integrator (Future of Grid)

This pillar aims to reconfigure the power infrastructure of Singapore by assimilating renewables. The primary activities are building climate-resilient infrastructure and digital grid blueprints, including the Distributed Energy Resources Management System (DERMS), as well as the expansion of low-carbon electricity imports. These are to ensure Singapore's energy network stability, as well as being poised for high levels of renewables integration.

Figure 5: SP Group's Actions for Net Zero Integrator

Source: SP Power, 2024

Sustainable Operations

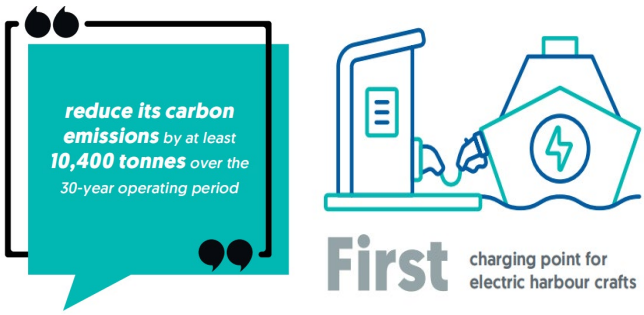
Sustainable Operations advocates for the SP operations to incorporate safety, efficient use of resources, and minimise carbon footprints. These include the green design of buildings, electrification of vehicles, enhancements in digital surveillance, and workplace safety culture bolstering. SP's use of technology and sustainable management principles put the organisation on the path of operational sustainability.

Transition Enablers

Now positioned as a transition facilitator, SP collaborates with partners to deliver great scalable sustainable energy solutions such as district cooling, deployment of

renewables, and electric vehicle charging networks. SP's one-stop-shop service, combined with the Energy-As-A-Service proposition, empowers clients and municipalities to reach carbon neutrality while advancing clean energy infrastructure in the rest of Asia.

Figure 6: Transition Enablers' actions



Source: SP Power, 2024

People and Community

As for the People and Community pillar, SP's efforts include all facets of the organisation, targeted employee welfare, structured professional development, and societal engagement on the principles of inclusivity. These include workplace health promotion, comprehensive training and social support for community members at risk, all of which continue to promote the integration of the energy transition in social equity.

Alignment with the United Nations Sustainable Development Goals (SDGs)

Referring to the UN's 2030 Agenda, SP focuses on SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action) (SP Group, 2024).

SDG 7 – Affordable and Clean Energy: SP meets Target 7.1 (Universal access to electricity) by deploying smart meters in 1.2 million households, allowing consumers to track and control energy expenditure. SP also fulfills Target 7.2 (Increase share of renewable energy) with 1.7 GW of solar capacity secured and regional renewable energy imports to facilitate 7.3 (Improved energy efficiency) with tools like GET™ Control and the GreenUP app. My Green Credits™ enables customers to counterbalance their carbon footprints and meets Target 7.a (Clean energy technology) investment.

SDG 9 – Industry, Innovation and Infrastructure: SP meets Target 9.1 (Sustainable infrastructure) through grid modernisation and underground substation programmes. Predictive maintenance and system optimisation are advanced by AI-enabled asset-health digital twins, complying with Target 9.5 (Foster innovation). Project green-financing, such as the S$650 million Labrador Tower loan, helped to pursue Target 9.4 (Sustainable infrastructure).

SDG 11 – Sustainable Cities and Communities: SP's Marina Bay district cooling network, Tengah smart-energy town, and regional systems in Bangkok contribute to achieving Target 11.6 (Reduce Air Pollution in Cities) set under Goal 11.

SDG 13 – Climate Action: SP contributes towards Target 13.2 with emission management and long-term planning to attain net zero. Since 2020, SP has avoided 1.734 million tonnes of CO_2 emissions, electrified 44% of its service fleet, and constructed SLE-certified buildings (SP Group, 2024). This reflects integrated climate governance within SP. Its climate risk assessments and regular safety training also helps mitigate climate risk.

Figure 7: SDGs of Relevance to SP Group

Source: Authors

Key Initiatives & Impact Analysis

Net Zero Integrator (Future of Grid) Key Initiatives

The SP Group improves Singapore's electricity infrastructure by integrating more advanced technology and net-zero focus innovations. For example, the Underground Substation Development project began the construction of Southeast Asia's first underground 230 kV substation at Labrador to provide Singapore's electricity infrastructure with enhanced climate resilience (SP Group, 2024). The underground facilities address land constraints and also protect against rising sea levels. Another example is the Grid Digital Twin Innovation project which was developed with Nanyang Technological University and uses AI and real-time data for predictive asset management and maintenance (SP Group, 2024).

Figure 6: SP Group's Two Initiatives for Net Zero Integrator

Paya Lebar 230kV substation

SP-NTU Joint Lab

Source: SP Power, 2024

Impact Analysis

These initiatives support Singapore's target of 6 GW of clean energy imports by 2035 and improve the country's world leading System Average Interruption Duration Index (SAIDI) of 0.236 minutes (SP Group, 2025c). This is due to the uninterrupted flow of low-carbon power imports and renewable integration. The Grid Digital Twin also improves the economy by predictive maintenance, thus reducing asset downtime and replacement costs (SP Group, 2024).

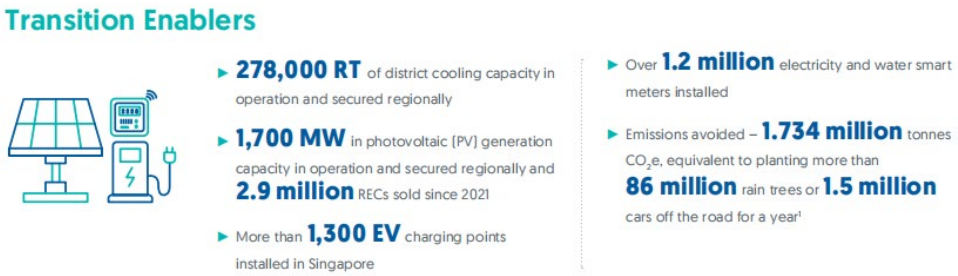
Trade-offs

For SP, the biggest issue concerns the trade-offs among decarbonisation, compliance, and reliability. SP identifies the risks associated with electricity imports and supply diversity, along with geopolitical and technical risks. Hydrogen provides long-term flexibility, but the cost issue still remains. These risks are managed through smart grids, energy storage, and digital twin technology (Siano, 2014; Luo et al., 2015).

Transition Enablers Key Initiatives

SP initiates collaborative decarbonisation within and across sectors by providing scalable energy services. One of the several activities is the expansion of the District Cooling Network, within which SP has added manifolds to achieve a total of 206,000 RT of capacity, which now includes the Marina Bay–Suntec City expansions and the new regional systems being built in Bangkok, Chengdu, and Chongqing (SP Group, 2024). These expansions are critical to the improvement of energy efficiency and urban sustainability. SP has also installed 1.7 GW of local and overseas renewable energy by March 2024, including agrivoltaic and aquavoltaic systems in China and rooftop solar systems in Singapore and Vietnam, as well as collaborating to increase multi-use land applications to enhance renewable energy generation (SP Group, 2024). In addition, SP has enhanced the electric vehicle (EV) charging network by providing over 1,300 charging points and Singapore's largest fast-charging network, as well as the first electric harbour-craft charger to support decarbonisation of the marine sector (SP Group, 2024).

Figure 7: Transition Enablers: Scale of Deployment and Emissions Avoided (Cooling, Solar, EV, Smart Meters)



Source: (SP Group, 2024)

Impact Analysis

Overall, on the environment front, SP's projects avoided the emission of 717,426 tonnes of CO_2e in FY 2023/24, which is equivalent to taking 652,206 Singapore cars off the road or planting close to 35 million rain trees. Numbers have captured SP's positive development in carbon footprint reduction, and climate change mitigation within the region. The aquavoltaic plant in Qingdao, China, can capture 160,000 tCO_2e annually (SP Group, n.d.-e) and, the district cooling projects are estimated to reduce 160,000 tCO_2e annually. Furthermore, the "cooling-as-a-service" model benefits its clients economically by providing them access to clean technologies and eliminating the need for costly capital investments while offering predictable returns and long-term cost savings. Annual savings for Frasers Property, for instance, were estimated at S$200,000 and SP's Bangkok project generates S$1.57 million in electricity savings per year (SP Group, 2024).This goes to show that economic efficiency and competitiveness can be achieved simultaneously, along with the implementation of sustainable technology.

District cooling systems offer huge potential in terms of carbon footprint reduction, however, they are expensive and take a long time to recoup the initial investment and get through the concession period (Dominkovic et al., 2017). SP addresses this through its modular expansion approach and the development of long-term relationships. The infrastructure for electric vehicles induces short-term demand/load variations that require time-of-use pricing and AI-based load balancing (Clement -Nyns et al., 2010).

Sustainable Operations

SP is a leader in the community-oriented industry and puts great emphasis on implementing safe and sound practices and the digitalisation of the company. Internally, for the sake of safety and reducing risk through innovative technologies, it uses SPock robots, AI Buddy, drones and AR technology that does account inspections in hazardous environments, broadly improving employee safety and operational precision. In terms of customer social accountability, SP has helped customers in energy saving through the SP App and GreenUP. It also advances sustainable operations through low-energy buildings, low-carbon oils used in the transformers and EV fleets.

Impact Analysis

Sustainable operations have an impact on two areas. Firstly, in terms of the environmental impacts, SP's internal practices have reduced its Scope 1 and 2 emissions through increased energy efficiency and electric mobility. The reduced carbon intensity and reduced waste production have a positive influence in connection with the national Singapore Green Plan 2030. From the social and economic point of

view, SP reported a Lost Time Injury Frequency Rate of 0.25 per million working hours, indicating an established safety culture (SP Group, 2025b). Overall, digitalisation and automation contribute significantly to operational efficiency. These advancements minimise unavoidable service interruptions by improving organisational effectiveness, thereby strengthening resilience.

Figure 8: SP Group's Reduced Emissions from FY22 to FY25

Emissions, tCO_2e	FY22/23	FY23/24	FY24/25
Scope 1	76,721	70,333	69,513
Scope 2[6]	Location Based		
	360,262	392,531	362,808
	Market Based		
	357,046	389,308	359,586
Scope 1 & 2 Intensity ($kgCO_2e$/MWh)	8.52	8.97	8.00

Source: SP Group, 2025b

Trade-offs

Programmes to reduce emissions, such as green building initiatives and fleet electrification, tend to incur a high initial cost. SP uses green financing instruments, such as the S$650 million green loan, and invites supplier collaboration to incorporate sustainability into the entire value chain.

People and Community

SP focuses on human capital and community support through a range of strategic initiatives. For talent enhancement alone, the company provided training on AI, hydrogen safety, and digital grid management, and dedicated 159,000 training hours to 3,700 employees—five times the national average (SP Group, 2024). For employee wellbeing, SP implemented comprehensive health programmes, which include the LIVE WELL Portal, on-site counselling, and health screenings (SP Group, 2024). SP also supports the community**,** having contributed S$5.3 million to charitable initiatives like KidSTART and SP Heartware Fund, which includes vocational training for over 400 autistic children and the distribution of 10,000 power packs to families (SP Group, 2024).

Figure 11: Training & Development Highlights (FY2023/24)

Source: (SP Group, 2024)

Impact Analysis

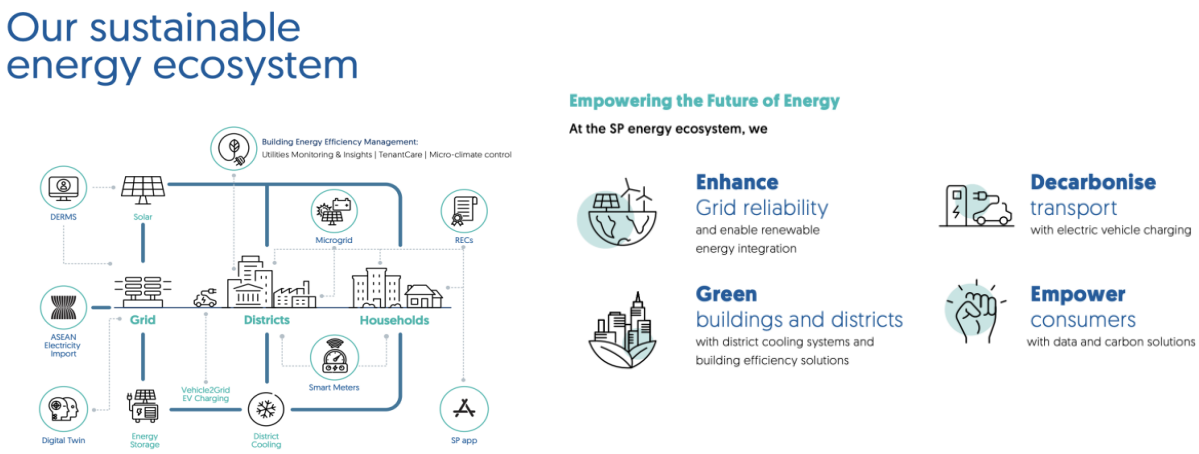
The environmental and economic impacts of SP's measures have been illustrated. SP's training enhances technical skills for managing carbon-light infrastructure, improves DERMS execution, and boosts renewable adoption. It also raises community sustainability awareness, benefiting future generations. Financially, these programmes reduce turnover and operational errors, and foster community support for sustainable initiatives like electric vehicles in HDB estates. Focusing on both social and economic goals drives SP's long-term growth.

Trade-offs

Social programmes and employee training are investments that take time to see the benefits. While these initiatives promote innovation and legitimacy, the trade-offs are time and opportunity costs. Still, these investments for upholding safety and inclusion should be prioritised to enhance the firm's resilience and to align with the social dimensions of the energy transition.

Enablers: District Cooling and EV Charging

Figure 12: SP's Sustainable Energy Ecosystem

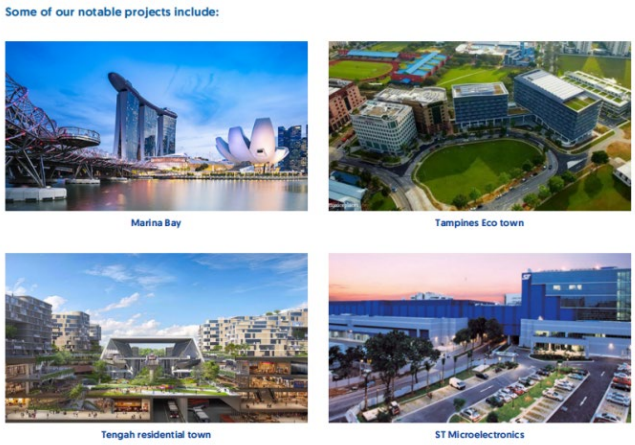


Source: SP Group, 2022

District Cooling (DC) Solutions: Redefining Low-Carbon Cooling

By cooling an entire metropolitan area from a central plant, DC systems sip a tiny fraction of the energy consumed by numerous skewed individual systems. Industry studies showed that centrifugal chillers used in DC systems achieve higher efficiency values year-round (Wajima et al., 2008). DC systems enjoy the scale of economies in industrial processes and modular systems configuration. SP Group achieves such technical benefits for its partners in its DC projects, which consolidate greenfield and brownfield developments, transform and renovate historical pedigree projects, and expand internationally by cross-border plumbing—through a blend of economics and ecology.

Figure 13: SP's Notable DC Projects



Source: (SP Group, 2024)

Greenfield Projects: Scaling Efficiency in New Developments

One of Asia's largest-ever greenfield district cooling projects, the Marina Bay District Cooling Network serves 24 high-density buildings (e.g. Marina Bay Sands and Clifford Centre) as of April 2024 (Leong, 2024). Via a 2 km underground pipeline extension, it is set to reach 75,000 Refrigeration Tons (RT) of installed capacity by 2027 (SP Group, 2023).

As for industrial stakeholders, SP Group's DC system solves the semiconductor industry's cooling challenges (semiconductor fabs require 24/7 precise temperature control). It helps ST Microelectronics to achieve 120,000 tCO_2e annual reduction through 20% lower cooling energy use (SP Group, 2025b). In this way, it helps the semiconductor industry meet its ESG goals: tracking decarbonisation and serving the carbon-heavy industry.

Brownfield Renovation: Retrofitting Existing Urban Areas

SP Group's capability to apply DC technology to retrofitted old cityscapes is illustrated by the Tampines Distributed District Cooling (DDC) Network, making Tampines the first town centre in Singapore to undergo this retrofitting.

Commencing operations in March 2025, this brownfield development integrates seven pre-existing structures and distributes excess cooling capacity from three energy efficient "injection nodes" (Century Square, Our Tampines Hub and Tampines 1) (SP Group, 2025a). It avoids the costs of building a new centralised cooling plant, minimises disruptions to traffic and business, and also reduces the town centre's carbon emissions by 1,000 tonnes and saves 2.3 million kWh of energy annually (SP Group, 2025a).

Overseas Expansion: Exporting Low-Carbon Cooling Expertise

Flagship projects in China and Thailand demonstrate SP Group's capability in extending DC expertise to international businesses.

In Chengdu, China, its DC system will serve the International Sports Park City which hosts important sports events. It is expected to save 2,900 MWh of electricity and reduce 1,700 tonnes of carbon emissions annually (SP Group, 2025b). SP Group is also serving the Chengdu Future Medical City that hosts hospitals and research. SP's more energy-efficient cooling systems for Raffles City Chongqing, in place since 2019, achieved 40% reduction of cooling energy consumed (SP Group, n.d.-a). This also supports China's "Double Carbon" Goals.

In Bangkok, SP's DC network for the Government Complex Center Zone C is expected to achieve energy savings of 20% and reduce emissions by up to 3,000 tonnes annually (SP Group, 2024).

From a societal perspective, shops and city centres benefit from fewer system interruptions, a quieter and cooler environment, and seamless upgrades that avoid the disruption associated with building-by-building equipment replacements. Environmentally, when systems are connected across multiple blocks, they consume less electricity while maintaining comfort levels, help flatten peak demand on the hottest days, and reduce emissions—all without requiring tenants to alter their operations or customers to alter their shopping habits. In dense, tropical cities where real estate is expensive, such cooled districts represent more than an engineering solution; they serve as vital urban infrastructure that lowers costs, enhances comfort, and minimises environmental impact. SP's DC systems approach has the potential to deliver tangible long-term benefits.

Trade-offs

It is foreseeable that centralised cooling will emerge as a significant development in energy transition. From single-floor central cooling to building-wide and district-wide cooling, the overall operational costs and carbon emissions are significantly reduced. However, centralised cooling faces a major challenge: energy loss (Ma & Long, 2019). Friction losses along the piping network and resistance losses in heat exchangers cause chilled water to warm up, with additional power consumption losses being linearly proportional to the cooling supply radius. Thus, determining the appropriate level of centralisation presents a challenge. This will test SP Group's planning capabilities, R&D expertise, and comprehensive operational proficiency.

EV Charging Solutions: Accelerating Transport Electrification

SP Mobility, under SP Group, operates over 2,100 charging points across nearly 550 locations as of early 2025 (SP Group, 2025b). The operational and climate benefits of EVs are tied to the availability of infrastructure, availability of energy, and the level of remote control used to manage the flow of power. In a highly populated urban area, slow or unreliable charging is a major psychological barrier to EV adoption. SP Mobility is making the adoption of EVs for widespread use easier by providing reliable charging and strategically placing charging stations at high-density areas. SP Mobility also uses the Charging Station Management System (CSMS) to integrate different charger brands, monitoring and remote diagnostics (SP Group, 2025b).

The lifespan emissions/km of EVs is declining further due to Singapore's shifting import hydrogen fuel supply mix (SP Group, 2024). This means that constructing EV chargers now means building infrastructure to decouple emissions in the future. In the maritime industry, SP Mobility and its partner Pyxis were appointed to operate Singapore's first charging point for electric harbour crafts (SP Group, 2024). This pilot is strategically important because decarbonising port and near-port operations is expensive and difficult. Supplying chargers in that niche helps to lower the experimentation cost for the rest of the entire maritime ecosystem.

For high-mileage, short-stop fleets—ride-hailing, delivery vans, coaches, and private buses—time is money. A fast charger reduces dwell time, enabling more trips per day or shorter breaks, directly improving TCO for operators while keeping fares or delivery prices competitive (Lee, 2025). Locating the unit at Temasek Polytechnic also matters: it creates a training ground for technicians and students, strengthening the skills pipeline for EV, power electronics, and grid integration roles. On the user side, SP Mobility's app features—real-time availability, transparent pricing, and queue management—lower range anxiety and nudge charging behaviour towards efficient use of bays.

Trade-offs

EVs can greatly promote sustainable development. However, when considering the carbon emissions of a product—especially industrial products—we should not only view its carbon emissions throughout the entire product lifecycle. The U.S Department of Energy (n.d.) pointed out that tailpipe emissions are only one factor in assessing the lifecycle emissions of a vehicle; upstream emissions from fuel pathways (both gasoline and electricity) also need to be considered, including the extraction, refining, production, and transportation of fuels. To estimate cradle-to-grave emissions, fuel cycle emissions must be taken into account simultaneously. In the case of electricity, most power plants generate emissions, and there are additional emissions associated with the extraction, processing, and distribution of primary energy sources used for electricity generation.

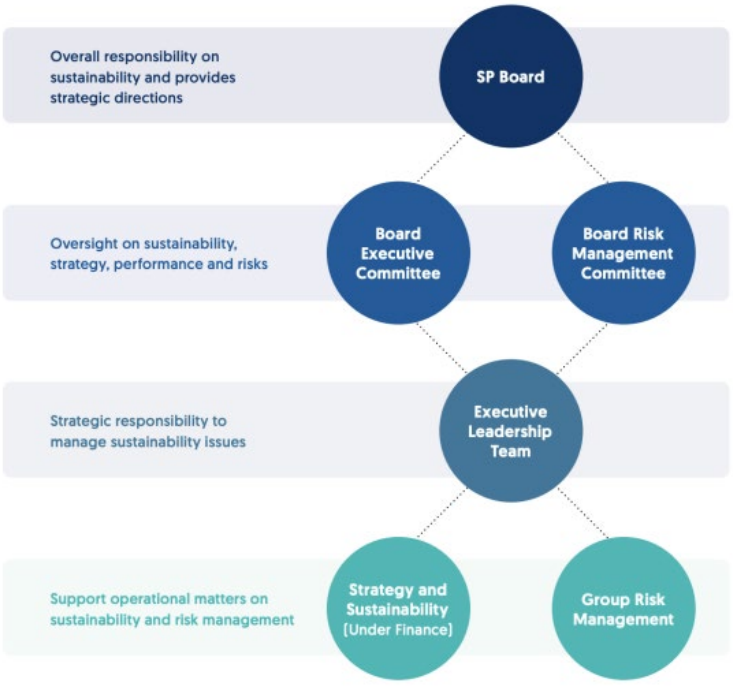
An article in Qianzhan (2025) shows that during the initial manufacturing stage of EVs, their carbon footprint is usually approximately 40% higher than that of internal combustion engine (ICE) vehicles due to battery production, but this gap can be offset after driving about 17,000 km.

Overall, consideration needs to be given to addressing the environmental impact in the manufacturing and recycling of EV batteries.

Governance & Reporting

Disclosures, assurance, finance and compliance feature in SP Group's governance and climate action. It uses recommendations from the Task Force on Climate-related Financial Disclosures (TCFD) to define its risks and targets. It has also sought external assurance for its emissions data (SP Group, 2022). A Green Financing Framework guides its use of green financing instruments for funding green projects. Whistleblowing channels and Supplier Code of Conduct provide further accountability and guardrails.

Figure 15: Internal Controls of Reporting



Source: SP Group, 2022

Sustainability Reporting

SP publishes a yearly sustainability report that describes its governance, strategy, risk, and targets, including GHG emissions by scope and associated methodologies. This corresponds with Singapore's initiative to implement mandatory climate-related disclosures aligned with ISSB frameworks (for listed issuers starting FY2025, recently adjusted timelines) (Accounting and Corporate Regulatory Authority, & SGX First, 2024). In practical terms, this indicates that SP's current reporting structure is already aligned with the expectations of investors and regulators.

Guardrails Against Greenwashing

SP has various guardrails against greenwashing. First, on independent assurance. SP's GHG data has received independent assurance according to ISO 4064-3:2019 (limited assurance), which adds credibility to its self-reported data (SP Group, 2022).

Second, use-of-proceeds control. SP's Green Financing Framework has a publicly available second-party opinion by Sustainalytics which certifies that it complies with international green bond/loan principles and ASEAN standards (Sustainalytics, 2021). SP is required to disclose the expenditures and the associated environmental benefits, which provides a financial control mechanism to sustainability claims and is a requirement for the issuance of green instruments.

Third, on product customer transparency. On the SP app under My Green Credits™ feature, users are allowed to pair their spending with renewable energy certificates. When a user selects the “OneMillionTrees” category, SP Group donates 15% of the purchase towards that national greening initiative (SP Group, n.d.-f).

In addition, SP maintains a public whistleblowing channel and also incorporates whistle-blowing protection. Its Supplier Code of Conduct promotes accountability and ethics in the value chain.

Conclusion

In a city constrained by land and heat, SP Group’s value is “delivering reliable and efficient energy utilities services” to customers and “enabling a low carbon, smart energy future” with sustainable solutions (SP Group, n.d.-b). It does this through a digitised grid that can absorb cleaner supply, plus three demand-side levers—cooling, solar, EVs—that deliver metered savings today and bigger abatement tomorrow as the grid becomes cleaner. Its social and governance efforts encompasses the following aspects: skills, safety, security, and green finance—these are key to ensuring the sustainability of these outcomes.

Discussion Questions

1. If Singapore's carbon tax goes up faster than planned, which of SP Group's three green solutions—district cooling, solar power, or EV charging—can cut the most carbon emissions per dollar spent, and scale up fastest? Why?

2. For brownfield developments, what are the biggest bottlenecks in lowering their emissions, and how would you alleviate the problems?

3. How should SP Group split its capital expenditure between domestic grid resilience and overseas growth to maximise long-term environmental and shareholder value?

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BYD: Driving Sustainability Impact Across the Globe

CHU Yun Li Lynnette

LU Ian Teng

SUN Kaiqi

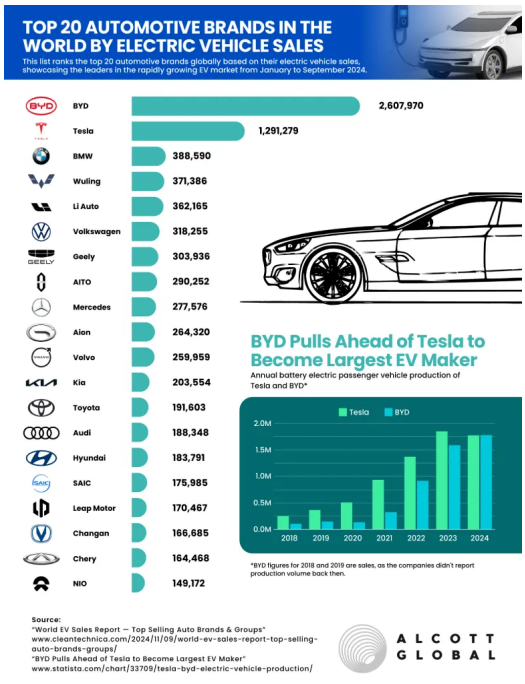
ZHANG Ruobing

Loh, L., & Ang, H. M. (Eds.). (2026). *Cases in sustainability (Vol. 2: System-level and structure-based approaches).* Centre for Governance and Sustainability, NUS Business School.

Introduction

Founded in 1995 by Wang Chuanfu in Shenzhen, China, Build Your Dreams (BYD) began as a rechargeable battery manufacturer supplying to major electronics brands like Motorola and Nokia before entering the automobile industry in 2003 through the acquisition of Qinchuan Auto (BYD, n.d.-a). Leveraging its battery expertise, BYD pioneered electric and hybrid vehicles, launching the world's first mass-produced plug-in hybrid (F3DM) in 2008, the same year Warren Buffett's Berkshire Hathaway became a key investor (BYD, n.d.-a). Over the next decade, BYD expanded into electric buses, solar power and energy storage, developing its signature Blade Battery and becoming the world's largest New Energy Vehicle (NEV) maker (Kharpal & Cheng, 2024). In 2022, it ceased production of conventional gasoline cars to focus entirely on electric vehicles (EVs) and plug-in hybrids, evolving into a global leader in sustainable mobility with operations across more than 70 countries (BYD, 2022). By 2024, BYD had achieved remarkable success as one of the world's top electric vehicle sellers. Its annual revenue reached RMB777.1 billion which was a 29% increase compared to the previous year (BYD, 2024; BYD, 2025). As shown in Figure 1, from January to September 2024, BYD sold over 2.6 million electric vehicles, which was approximately 101% more than Tesla's 1.29 million units during the same period. This financial strength not only underscores BYD's market leadership but also enables the company to invest more decisively in achieving its long-term sustainability objective, aligning with the Economic, Environmental, Social and Governance (EESG) framework.

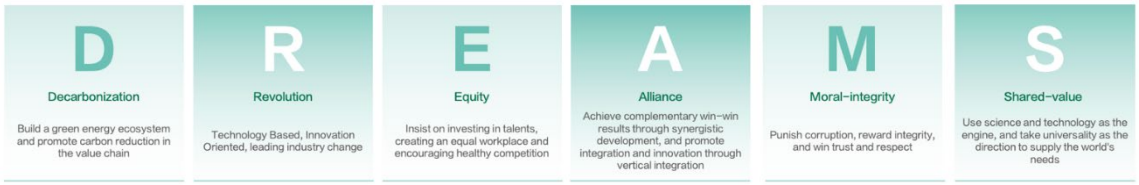
Figure 1: Top 20 Automotive Brands in the World by Electric Vehicles from January to September 2024



Source: Alcott Global, 2025

BYD has set clear long-term sustainability objectives centred on environmental responsibility. The company aims to reduce its operational carbon intensity by 50% by 2030 and achieve carbon neutrality across its entire value chain by 2045, covering manufacturing, supply chain, and product use phases. In addition, BYD is committed to industry best practices and complying with environmental regulations. To reach the goals, BYD introduced the DREAMS philosophy: Decarbonisation, Revolution, Equality, Alliance, Moral Integrity, and Shared Value as guiding pillars for sustainable development (ESG Times, 2025). BYD integrates sustainability into its core business strategy by advancing renewable energy technologies, promoting green manufacturing and establishing circular resource systems such as battery recycling and energy storage. Beyond environmental goals, the company also emphasises social responsibility through inclusive growth, employee well-being and transparent governance, aiming to create long-term shared value for both stakeholders and society.

Figure 2: BYD's DREAMS Framework



Source: BYD, 2025

The Choice of BYD as a Case Study

BYD's evolution from a battery manufacturer to a global leader in sustainable transportation and energy solutions highlights how business innovation, when done righ,t can deliver systemic climate benefits. By scaling NEVs, pioneering safer battery chemistry, electrifying public transport and integrating renewable storage, BYD exemplifies the intersection of profitability and sustainability. While challenges remain, its success confirms that corporations can serve as catalysts in the fight against climate change. BYD's impact extends beyond market share. It represents a symbol of hope that companies can help shape the future of mobility and energy systems.

BYD is an excellent example for analysing the impact of sustainability precisely because it operates at the intersection of multiple critical junctures. First, BYD's dominance in developing economies, particularly China and Southeast Asia, positions it at a critical juncture when transportation infrastructure and consumption patterns remain malleable, allowing sustainability choices to fundamentally shape decades of environmental outcomes rather than merely mitigating existing systems. This contrasts sharply with mature markets where infrastructure is already entrenched and change is incremental. Second, BYD's vertical integration of battery production demonstrates that environmental stewardship and economic efficiency need not be in conflict,

challenging the pervasive corporate narrative that sustainability requires sacrifice. Third, BYD increases access to EVs through affordable pricing, thus distributing environmental and health benefits (from clean air) across income strata. This brings the elephant in the room to the fore: whether firms' actions lead to equitable distribution of environmental gains.

BYD is a catalyst in driving sustainability. In a geopolitically fragmented world where governments struggle to cooperate on climate action, BYD's operations have the potential to shape regions' development pathways and emissions trajectories. This positions it as both a beacon and a mirror of corporate-led transformation in an age of competing interests.

Within the Singapore market, BYD's sales have surged significantly in recent years. In 2020, the brand sold only three cars. In less than five years, BYD has become the top-selling car brand in Singapore, with the number of BYD cars sold skyrocketing to 7,473 cars in the first nine months of 2025, further extending its lead over the second-placed car brand Toyota (Lee, 2025). What led to such a dramatic increase? Before BYD's entry, Singapore's EV market was largely led by Tesla. To boost visibility and accelerate growth, BYD launched "BYD by 1826", a lifestyle dealership concept blending a restaurant and showroom. Located in prime areas like Boat Quay and Suntec City, it merges dining, community and EV showcases. The concept redefines car retail and positions BYD as a modern lifestyle brand that connects with consumers through culture, community and technology (Ong, 2025).

After establishing strong brand awareness, BYD introduced a Singapore-specific EV model designed to better align with and navigate the country's Certificate of Entitlement (COE) system. The COE system in Singapore requires car buyers to bid for the right to own and use a vehicle for 10 years, making affordability a major factor in purchasing decisions (Land Transport Authority, n.d.). Recognising this, BYD strategically developed Singapore-specific models such as the ATTO 3 100 kW and SEAL Category A to fit within the cheaper Category A segment in the COE system (Chong, 2024). This localisation approach demonstrates BYD's deep understanding of local market dynamics and policy constraints. By tailoring its products to reduce total ownership costs, BYD effectively positioned itself as a value-driven EV brand by offering technology, quality and environmental sustainability at accessible prices (Chong, 2025). This focus on affordability and market fit allowed BYD to appeal strongly to low and middle-income consumers as well as first-time EV buyers, giving it a competitive edge over brands like Tesla, whose cars typically fall into the higher-priced Category B.

Initiatives by BYD and the Corresponding Impact

Blade Technology

BYD leveraged its decades of experience in battery production to innovate and produce the in-house Blade Battery, a lithium iron phosphate (LFP) battery in a cell-to-pack architecture. The design eliminates traditional module housings by arranging blade-shaped cells in the battery pack, increasing volumetric space utilisation by approximately 50% and bridging the energy density gap that previously limited LFP batteries to budget vehicle segments (BYD, n.d.-b).

From an integrated EESG perspective, BYD's Blade Battery technology demonstrates how technical innovation can simultaneously address economic, environmental, social, and governance imperatives in the electric vehicle transition. Economically, the technology boosted LFP's market share from 32.5% (2019) to 74.6% (2024) (BYD, 2025). Independence from conventional cobalt and nickel also reduces its exposure to commodity price instability. BYD's warranties and cruising range transform fleet economics and democratise EV access across socioeconomic strata (BYD, 2025). Environmentally, eliminating the use of cobalt and nickel avoids the habitat destruction, water contamination and higher carbon emissions associated with their mining and refining, while superior longevity reduces replacement frequency. On the social aspect, its thermal stability and performance in nail penetration tests are better than traditional batteries, enhancing safety and public confidence (BYD, n.d.-b). On the governance front, BYD's vertical integration enables greater supply chain transparency and quality control, as well as compliance with regulations on life-cycle assessment. Its technology could influence regulatory evolution regarding Chinese safety standards.

This convergence of advantages across all EESG dimensions explains the technology's catalytic effect on industry-wide LFP adoption, with Tesla, Ford and Volkswagen subsequently incorporating LFP batteries into their portfolios, validating that intelligent engineering can deliver sustainability outcomes.

Electrification of Transport

BYD has played a leading role in the global electrification of transport, a process of replacing internal combustion engines with electric propulsion systems. Such an initiative aligns with international sustainability targets such as the Paris Agreement and China's dual carbon goals of reaching carbon-emission peak by 2030 and carbon neutrality by 2060 (BYD, 2025). BYD's comprehensive product range, from passenger EVs, electric buses, and commercial vehicles, reflects its strategic commitment to sustainable mobility.

BYD's electrification initiative has stimulated green and sustainable growth by increasing employment, attracting foreign investment and export growth. The

company supports nearly a million jobs worldwide (BYD, 2025) across R&D, manufacturing and services, while economies of scale have lowered unit cost and positioned China as a hub for electric mobility (International Energy Agency, 2023).

On the environmental aspect, the initiative delivers measurable carbon reduction. For example, the full electrification of Shenzhen's bus fleet has lowered annual CO_2 emissions by approximately 1.35 million tonnes (Autocar Professional Bureau, 2018). These results demonstrate BYD's key contribution to national decarbonisation and urban air quality improvement.

On the social front, BYD's electrification enhances public health and living standards through cleaner, quieter mobility. The shift to e-buses and e-taxis benefits lower-income commuters who are most affected by traffic-related pollution (World Health Organization, n.d.). Governance-wise, BYD's vertically integrated model ensures tighter quality control and supply-chain transparency, though continued improvements in ESG disclosure and lifecycle reporting remain essential (MSCI ESG Research LLC, 2024).

Innovation forms the foundation of this initiative. BYD's integration of vehicle electrification with renewable energy and digital technologies, such as smart charging and AI-based battery management, illustrates the firm's ability to merge technological advancement with sustainability goals.

Sustainability AI

BYD has embedded AI across vehicle software, advanced driver-assist systems, battery and factory operations. These AI applications boost efficiency and competitiveness but create mixed outcomes across EESG dimensions—delivering clear environmental and economic upsides while raising social and governance risks that require active mitigation.

As of 2025, BYD has deployed AI-enabled "Smart Driving" systems in over 1 million of its vehicles, indicating rapid commercialisation. For instance, BYD's DiPilot system integrates onboard sensors, including cameras, radar and ultrasonic modules, supported by a cloud-connected neural network that updates driving models through over-the-air (OTA) upgrades (Suki, 2025). It has also used AI in its quality control of batteries, cutting battery defects by 40% and increasing battery lifespan by 20% (Darley, 2025).

Environmentally and economically, AI-optimised energy management, such as the fifth-generation DM technology in BYD Qin L and Seal 06 models, increases engine thermal efficiency and range efficiency (BYD, 2025). However, the expansion of cloud-computing infrastructure and GPU-based training clusters increases electricity consumption and could partially offset environmental gains.

Socially, AI contributes to safer, more accessible vehicles by enabling advanced driver-assistance systems and real-time diagnostics. Nonetheless, automation reduces

manual employment in manufacturing, and extensive data collection raises privacy concerns. Responsible data use and worker reskilling are therefore essential.

From a governance perspective, AI strengthens quality control, supply-chain traceability, and compliance monitoring. Still, rapid deployment of autonomous functions requires robust testing, algorithmic transparency, and regulatory cooperation to prevent misuse or safety lapses.

Upon analysis, integrating sustainability with AI considerations allows BYD to score in all EESG dimensions. It achieves a positive impact by promoting clean technology and operational excellence. However, sustaining a positive EESG trajectory requires strengthening data governance, balancing automation impacts with workforce retraining, and maintaining transparent testing and oversight as AI-driven autonomous features continue to scale.

Energy Grid

BYD has expanded from vehicle and battery manufacturing into large-scale grid energy solutions—deploying utility battery storage, vehicle-to-grid pilots, and integrated energy systems. This shift materially advances Environmental and Economic goals by enabling renewables and creating new revenue streams, while presenting measurable Social and Governance trade-offs that require active management.

BYD Energy Storage reports hundreds of global projects and large commercial experience: by end-2024 the company claimed over 75 GWh of commercial operation experience across 350 projects in more than 110 countries and regions (BYD, 2025). Notable deployments and contracts include a 12.5 GWh grid-scale project signed with Saudi Electricity Company (China Energy Storage Alliance, 2025) and the Bollingstedt Energy Storage Station (238 MWh) in Germany (Liu, 2025).

Environmentally, AI-optimised energy storage and smart-grid systems allow BYD to play a key role in accelerating renewable energy adoption. Its utility-scale storage facilities help stabilise power grids by absorbing excess solar and wind energy and releasing it during peak demand. These reduce reliance on fossil-fuel plants and enable lower carbon emissions system-wide.

Economically, BYD’s grid business diversifies its revenue base and strengthens its resilience beyond the vehicle market. By providing grid-balancing services, capacity trading, and backup power solutions, BYD gains access to fast-growing global energy storage markets. The company’s vertical integration—from battery cells to entire energy systems—gives it a significant cost advantage, allowing it to scale projects quickly and maintain profitability even in competitive international tenders.

At the same time, these capital-intensive projects require careful financial management and governance. A misalignment between rapid expansion and market regulation, or a slowdown in government incentives for renewable infrastructure, could

expose BYD to financial risks. Thus, sustained transparency in project financing and clear reporting of financial outcomes are crucial to maintaining investor confidence.

BYD's grid solutions also have meaningful social benefits. By enhancing grid stability and energy access, the company supports economic development in emerging regions and helps reduce power outages in rural communities. Projects that integrate battery storage with renewable microgrids can supply reliable electricity to hospitals, schools, and transportation systems, directly improving quality of life.

Overall, BYD's integration of energy-grid technologies generates strong environmental and economic value by enabling renewable energy storage, improving grid reliability, and creating new business opportunities. While the company's rapid growth presents challenges related to social equity, data responsibility, and project governance, these risks can be mitigated through transparent reporting, circular supply-chain management, and investment in human capital.

Education Charity Fund

In December 2024, BYD established a RMB3 billion Education Charity Fund at its headquarters in Shenzhen, aiming to promote social sustainability through education and scientific literacy. The initiative operates through two main channels: first, by setting up scholarship programmes at more than 100 partner universities to support outstanding students in their academic and research pursuits; and second, by funding the development of exhibition zones and educational installations in science and technology museums across China (BYD, 2025). The actions underscore BYD's long-term commitment to education, innovation, and talent development in alignment with national priorities.

Although the fund does not directly reduce emissions or control pollution, it creates significant indirect environmental benefits. By advancing public education on new energy and sustainability, the initiative helps enhance societal understanding and acceptance of clean energy, green mobility, and low-carbon innovation. Over time, this knowledge diffusion encourages behavioural change towards "green consumption" and low-carbon lifestyles, amplifying public participation in environmental sustainability (White et al., 2019).

From a social perspective, the Education Charity Fund plays a vital role in promoting equity, inclusion, and knowledge dissemination. The scholarship programmes help reduce financial barriers for students—especially those from underprivileged regions—thereby narrowing educational disparities and supporting upward social mobility. At the same time, the science museum partnerships improve public access to knowledge on clean technology and innovation, inspiring future generations to engage with sustainable industries. Through these efforts, BYD reinvests its social capital into education and public welfare, fostering a new generation of professionals with sustainability awareness and innovative thinking.

Beyond social benefits, the initiative significantly enhances BYD's corporate reputation and ESG performance. Leading ESG rating agencies and indexes, such as MSCI and the Hang Seng Index ESG Index, emphasise social indicators including education investment, employee development, community engagement, and social inclusion (Hang Seng Indexes, 2021; MSCI ESG Research LLC, 2024). Through this large-scale, long-term social investment initiative, BYD demonstrates a strong and credible commitment to social value creation and inclusive growth. The fund serves as tangible evidence of the company's corporate citizenship and helps strengthen its credibility among international investors.

Moreover, the initiative represents an innovative public–private collaboration model that embodies the spirit of the United Nations Sustainable Development Goal 17 (Partnerships for the Goals). By partnering with governments, universities, and science institutions, BYD mobilises private-sector resources to advance public education and sustainable development. This cross-sector cooperation enhances the effectiveness and reach of social programmes, contributing to both local community development and global sustainability agendas. Ultimately, the Education Charity Fund not only reinforces BYD's brand as a socially responsible and forward-looking enterprise but also positions it as a key contributor to international sustainability partnerships and collective progress towards a low-carbon future.

Impact Analysis

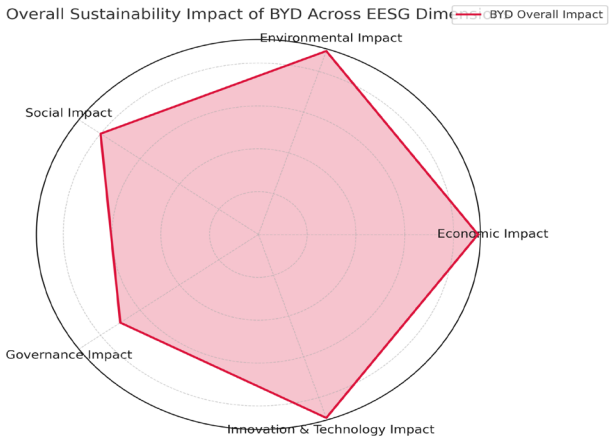
The sustainability impacts of BYD's five core initiatives—Blade Battery Technology, Electrification of Transport, Sustainability AI, Energy Grid and Storage Solutions and the Education Charity Fund—are comprehensively assessed. Each initiative contributes distinctively to BYD's sustainability strategy by advancing economic growth, improving environmental performance, promoting social inclusion, strengthening governance practices, and fostering technological innovation. To visualise their relative influence, two radar charts are included: Figure 3 illustrates BYD's overall sustainability performance across the EESG dimensions, while Figure 4 compares the impact levels of each initiative. Radar charts are employed to provide a clear and intuitive comparison of impact intensity across these dimensions.

Overall Sustainability Performance

Across initiatives, BYD demonstrates strong alignment between environmental innovation and economic growth. The Electrification of Transport programme has delivered large-scale decarbonisation, employment in green jobs, and new clean-energy industrial clusters. The Blade Battery, using cobalt-free LFP chemistry, reduces toxic mining, enhances safety, and improves recyclability. Sustainability AI increases efficiency and product quality but raises social and governance concerns, such as automation-related job losses and data privacy. Energy Grid and Storage Solutions expand BYD's environmental influence by integrating renewables and stabilising grids

in more than 110 countries and regions, strengthening both resilience and revenue diversity. Finally, the Education Charity Fund advances social inclusion through scholarships and science literacy programmes, building long-term human capital and public awareness of sustainability.

Figure 3: Overall Sustainability Impact of BYD Across EESG Dimensions

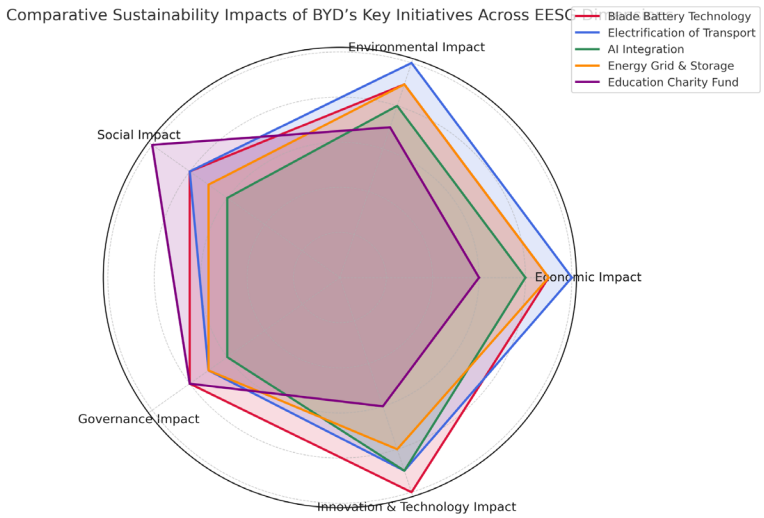


Source: Figure created by the authors, based on the sustainability reports.

As shown in Figure 3, BYD achieves outstanding results in economic, environmental, and innovation dimensions (scores 9-10). Its vertical integration and clean-tech leadership lower lifecycle emissions and drive competitiveness. Social and governance impacts remain moderate (around 7-8), reflecting progress in domestic education programmes but limited global outreach and partial ESG disclosure.

Comparative Sustainability Impacts

Figure 4: Comparative Sustainability Impacts of BYD's Key Initiatives



Source: Figure created by the authors, based on the sustainability reports.

Figure 4 reveals the distribution of these impacts across initiatives. As shown above, BYD performs particularly well in Economic and Environmental, where its initiatives in Electrification of Transport and Blade Battery Technology stand out through large-scale EV deployment, job creation, and improved air quality in urban areas. Blade Battery scores highest in innovation and environmental responsibility as it advances cobalt-free technology that enhances safety and reduces supply chain risks while driving wider LFP adoption across the EV industry. Energy Grid and Storage perform well environmentally and economically by supporting renewable integration and grid stability, but could strengthen governance disclosure and consistency in sustainability reporting. Sustainability AI (or AI Integration) demonstrates strong technological efficiency, improving production and vehicle performance, though data ethics and transparency require further attention.

The chart also highlights the areas of improvement for BYD, specifically governance and social aspects. Education Charity Fund delivers its most notable social contribution by promoting equitable education and sustainability awareness despite limited direct economic returns.

Overall, the radar chart highlights BYD's leadership in economic and environmental progress, while governance transparency and ethical oversight remain key areas for improvement. These initiatives show that BYD's sustainability success stems from innovation-driven decarbonisation complemented by social investment. Referencing Figure 4, it is evident that Electrification of Transport has produced the greatest overall sustainability impact, particularly in economic and environmental dimensions. This aligns with how it greatly lowers the carbon emissions by 1.35 million tonnes and attracts direct foreign investment, positioning China as an electric mobility hub. Such a strategy transforms global mobility and creates scalable green employment. The company's challenge now lies in enhancing transparency and ensuring that rapid technological expansion remains socially inclusive and ethically governed.

Limitations, Challenges and Mitigating Solutions

Governance

According to Amnesty International's (2024) report "Recharge for Rights: Ranking the Human Rights Due Diligence Reporting of Leading Electric Vehicle Makers", 13 major EV manufacturers—including BYD, Tesla, and Mercedes-Benz—were assessed on how effectively they report human rights due diligence (HRDD) across their battery supply chains involving key minerals such as cobalt, lithium, copper, and nickel. Despite being the world's largest electric vehicle producer, BYD ranked last among all companies evaluated, scoring only 11 out of 90 points.

BYD's weak performance stems largely from governance shortcomings. The company released its first Human Rights Policy Statement only in July 2024, making it the last major EV manufacturer to do so. However, the document remains highly declarative

filled with broad commitments rather than concrete operational measures. It lacks detailed provisions on risk mitigation, remediation mechanisms, and transparency procedures, and fails to explicitly recognise Indigenous Peoples' rights or commit to the principle of free, prior, and informed consent (FPIC).

Additionally, BYD's current governance disclosures remain only partially aligned with leading global frameworks such as the Global Reporting Initiative (GRI), International Sustainability Standards Board (ISSB), and Task Force on Climate-related Financial Disclosures (TCFD). While its current sustainability reports provide information on executive ESG-linked incentives, anti-corruption systems, and supplier audits, more details could increase investor confidence and access to green finance.

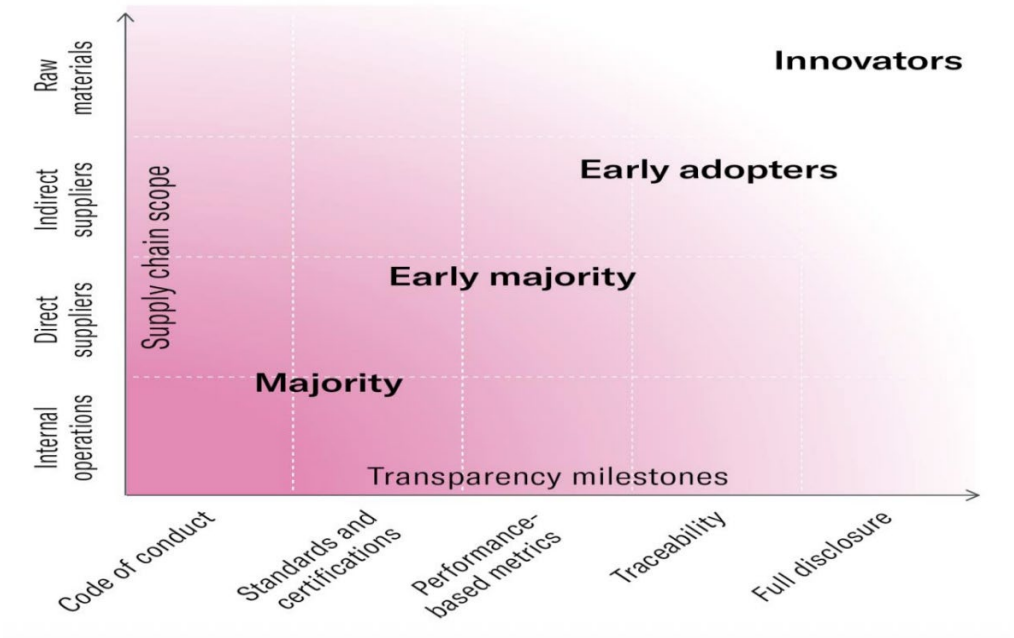
To address these issues, BYD has taken some preliminary steps, such as appointing a Chief Sustainability Officer (CSO) and linking 10% executive compensation to sustainability performance (BYD, 2025)—moves that signal growing governance accountability. Thus, it is commendable that BYD is shifting towards governance-driven sustainability management.

Supply Chain Transparency and Traceability

Beyond governance, BYD continues to face significant challenges in managing its complex upstream supply chain for raw materials such as lithium and graphite. This dependence exposes the company to ethical, environmental and social risks, particularly where supplier supervision and third-party audits remain insufficient. In contrast, several long-established brands, such as BMW and Tesla, have already taken steps towards greater supply chain transparency. For instance, BMW commits to regularly disclosing the list of cobalt smelters and countries of origin for its raw materials, emphasising responsible sourcing practices that protect workers and ensure traceability (BMW Group, 2020). Hence, BYD must make further progress in this area.

Although BYD is highly advanced in manufacturing and AI automation, its application of blockchain, Internet of Things (IoT), and Cyber-Physical Systems (CPS) in upstream raw material management remains limited. According to Ada et al. (2021), the adoption of blockchain in the automotive industry enhances transparency, reduces waiting times, and improves overall supply chain efficiency through secure and real-time data exchange. Similarly, IoT and CPS can increase visibility across procurement, warehousing and distribution, making smart and interactive supply chains far more efficient than traditional systems (Patel, 2025). For complex and multi-tiered automotive supply chains, such end-to-end visibility significantly improves decision-making efficiency and cost control.

Figure 5: BYD Positioned as the Early Majority in the Supply Chain Transparency Framework



Source: Figure created by the authors

Positioning BYD within the Early Majority segment reflects its current stage of progress—where sustainability commitments exist, but complete transparency across the supply chain has not been achieved. The company demonstrates awareness and partial implementation of responsible sourcing frameworks but remains focused on compliance and incremental improvement rather than system-level innovation. Its gradual movement towards digital traceability tools signals an intent to evolve but also reveals caution typical of early majority firms which tend to adopt proven technologies only after they have been validated by industry leaders. Thus, BYD stands at a pragmatic midpoint—neither lagging nor leading—in the global transition towards transparent and technology-enabled supply chains.

To help BYD advance from the Early Majority towards the Early Adopters or even Innovators stage, the company could expand both the scope and depth of its supply chain transparency. On the vertical dimension, BYD should extend oversight beyond direct suppliers to include indirect and raw material suppliers, ensuring end-to-end visibility across every production tier. On the horizontal dimension, it can progress from basic codes of conduct and certifications towards advanced milestones such as traceability and full disclosure. This can be achieved by establishing a unified supplier sustainability standard aligned with international frameworks like the OECD Due Diligence Guidance and UN Guiding Principles on Business and Human Rights (UNGPs), while integrating blockchain-based traceability systems (e.g., VeChain or IBM Food Trust) to secure and verify data flows. By combining broader supply chain coverage with deeper transparency, BYD would move closer to the frontier of

innovation, enhancing governance, stakeholder trust, and its reputation as a transparent and responsible global manufacturer.

Future Outlook for BYD

Looking to the future, BYD's trajectory points towards even greater influence in the global transition to clean energy. What began as a battery manufacturer has evolved into a company that now connects electric vehicles, renewable energy, and intelligent grid systems under one ecosystem. As countries race to meet net-zero targets, demand for affordable EVs and large-scale energy storage will continue to rise—trends that play directly to BYD's strengths in vertical integration and technological innovation.

BYD's push into smart energy grids and vehicle-to-grid technology could redefine how electricity is produced and used, turning its cars and buses into active participants in power networks rather than passive consumers. This integration of transport and energy gives BYD a strategic edge that few competitors can match. At the same time, its growing global footprint—expanding factories in Thailand, Hungary, and Brazil—shows that BYD is not only exporting products but also building a global manufacturing network.

Still, challenges remain. Competition from Tesla, CATL, and emerging EV makers is intensifying, and geopolitical uncertainty could disrupt supply chains. BYD will also face increasing pressure to improve transparency, recycling systems, and governance as it scales. Yet, with its combination of innovation, cost control, and strategic vision, BYD appears poised to move from being a dominant EV maker to becoming a cornerstone of the global clean energy economy—bridging the gap between transportation, electricity, and sustainability in a way few others can.

Conclusion

BYD's trajectory from a battery manufacturer to a comprehensive clean technology enterprise exemplifies a critical paradox of our era: the very industries that once drove environmental degradation can become architects of ecological restoration. Yet, this potential remains contingent on the choices embedded within corporate strategy, supply chain governance, and technological innovation.

BYD's environmental significance transcends the tangible metrics of displaced emissions and stored renewable energy. Its true impact lies in demonstrating that sustainability and profitability need not be antagonistic forces but rather can be structurally aligned through vertical integration and competitive advantage. This is a critical reframing that dismantles the persistent corporate narrative that environmental responsibility demands sacrifice. BYD's influence is fundamentally temporal and geographic, operating at a critical juncture where developing economies remain malleable and transportation infrastructure is still being determined. By establishing

electric vehicle adoption at scale in China and Southeast Asia, BYD is not merely reducing emissions today; it is locking in low-carbon development pathways that will enable options for generations.

However, a contradiction remains. While BYD has democratised EV access through affordable pricing, distributing environmental and health improvements across income strata, this achievement rings hollow if unexamined labour practices and opaque supply chains compromise human dignity and perpetuate resource extraction inequities. True sustainability cannot be merely compartmentalised where environmental gains are celebrated while systemic injustices are relegated elsewhere. The legitimacy of BYD's sustainability claims hinges not on its technological prowess or market dominance, but on whether it can integrate ethical accountability into its competitive model or whether it merely represents a more sophisticated iteration of profit prioritised over planetary and human boundaries.

Looking forward, BYD's case illuminates both the possibilities and limitations of corporate-led sustainability. No single company, regardless of scale, can address systemic challenges rooted in consumption patterns, infrastructure design and policy frameworks. Yet BYD offers a good model where sustainability outcomes multiply when they become intertwined with its competitive advantage. The question facing regulators, investors and consumers is whether BYD represents an anomaly in corporate behaviour or an early indication of a necessary realignment between profit and planetary boundaries. The answer will shape not merely automotive markets, but the viability of sustainability as a genuine organising principle rather than a marketing category.

BYD is leading the change in reshaping the sustainability paradigm and offers a beacon of hope at this critical juncture marked by geopolitical tensions. In a world fragmented by geopolitical conflict, BYD emerges as a counter-narrative, proving that sustainability can be forged through corporate courage and strategic vision.

Discussion Questions

1. How has BYD prioritised economic, environmental and social gains? What role does governance play in this process?

2. Asia is progressing to become the next global leader in sustainability, and BYD plays a key role. What can other companies learn from BYD in leading the sustainability momentum in Asia?

3. Moving forward, what should BYD focus on to maximise its impact on sustainability?

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Kia: Sustainable Movement for an Inspiring Future

FU Bin

LIU Yixuan

Shreyaa SARAVANAN

YU Sheng

Loh, L., & Ang, H. M. (Eds.). (2026). *Cases in sustainability (Vol. 2: System-level and structure-based approaches).* Centre for Governance and Sustainability, NUS Business School.

Introduction

Kia Corporation, established in 1944, is a maker of quality vehicles for the young-at-heart. Moving beyond its role as a traditional car manufacturer, Kia aims to be a “sustainable mobility solutions provider” through “Sustainable Mobility”, “Sustainable Planet” and “Sustainable Energy” (Kia Corporation, 2021b). This approach is characterised by care for the environment, stakeholder welfare, and transparent management. Fuelled by its “Plan S” strategy, Kia aims to achieve carbon neutrality by 2045, establish circular-based systems, and expand ESG investments in its operations worldwide (Kia Corporation, 2021b). These efforts, such as partnering with Ocean Cleanup and creating end-to-end sustainability standards for production sites, are indicative of a business strategy that supports social and environmental responsibility alongside growth. Yet, Kia’s metamorphosis is not without its obstacles, with electric cars still a costly business, the building of sustainable supply chains proving fiendishly difficult, and localised regulatory expectations differing across regions. This case study examines Kia’s Economics, Environmental, Social and Governance (EESG) management and the implications of how its sustainable mobility efforts intersect with, and at times conflict with, broader corporate and global objectives.

Economic Dimension

Strategic Transformation and Innovation

Kia Corporation’s economic transformation is driven by its goal to embed sustainability within its long-term profitability model. Building on a broad product base, including sedans, SUVs, and hybrids, the company is pivoting from a manufacturing-centred approach to a sustainable mobility solutions provider. This shift is implemented through Plan S, which combines electrification, digitalisation, and green finance to ensure revenue expansion aligns with environmental progress. Hyundai Motor Group, the parent company of Kia, is advancing its strategic focus on sustainable mobility and future expansion through research and development (R&D). It completed its test centre extension at Nürburgring, Germany, incorporating eco-friendly materials, photovoltaic panels, and heat pump systems (Kia Global Media Center, 2025). Kia ranked fifth among Korean companies in 2023 for R&D investment, with an expenditure of KRW2.2 trillion (The Korea Times, 2024). Additionally, under Plan S, Kia has pledged a total of KRW38 trillion over the next 5 years to advance electrification, establish new business models, and expand Electric Vehicle (EV) capacity (Kia Corporation, 2024). Kia’s strategic re-positioning and substantial investment in R&D align with the economic dimension of EESG, as they enhance economic resilience while maintaining environmental sustainability. Viewed from a 3R sustainability framework of Responsibility-Risk-Return, Kia’s sustainability journey can be said to evolve from responsibility (EV transition) to risk mitigation (regulatory and

supply-chain risks) and ultimately to return through profit margins and capital efficiency.

Financial Mechanisms

Building on these R&D investments, Kia has introduced its Green Finance Framework to integrate sustainability with capital efficiency (Kia Corporation, 2021a). To support its sustainability transition, Kia issued its first offshore green bond totalling US$700 million in April 2021, divided into a three-year US$300 million (1.00% coupon, UST + 75 bp) tranche and a five-and-a-half-year US $400 million (1.75% coupon, UST + 90 bp) tranche. The transaction attracted orders exceeding US$4.9 billion from more than 280 institutional investors, signalling widespread market confidence in Kia's Plan S sustainability roadmap (Santiago, 2021). The proceeds are allocated to zero-emission vehicle R&D and production, EV-charging networks, and energy-efficient facilities. The Kia Green Finance Framework requires annual allocation and impact reporting to ensure transparency and accountability. By linking capital access to clear sustainability results, Kia effectively lowers its financing costs while attracting ESG-focused investors. This Green Bond programme diversifies Kia's funding sources, enhances investors' confidence, and shows how Kia has transformed this "sustainability" responsibility into tangible economic returns.

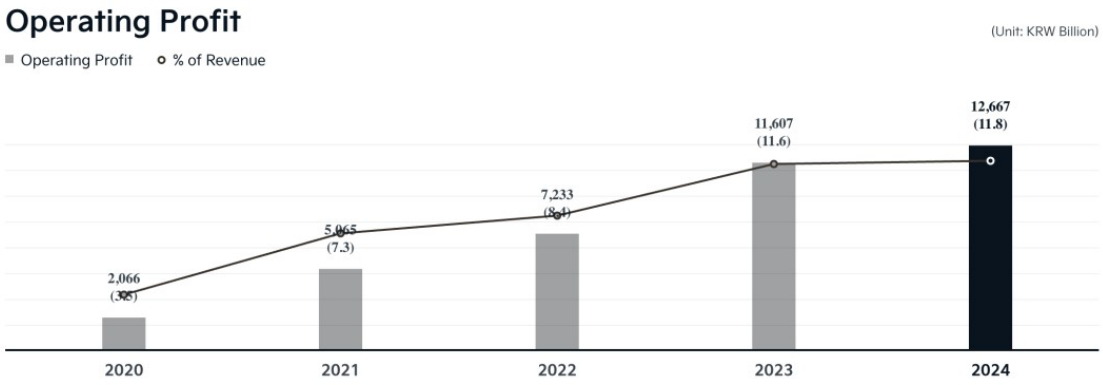
Cost Management

Kia's transformation strategy, Plan S, also helps improve cost optimisation and productivity gains across its manufacturing network. It is predicted that the profitability of electric vehicles will improve. Initially, the Plan S strategy required significant investment in new technologies, thereby increasing costs. However, over time, the cost of EVs will decline through economies of scale from expanding EV sales and reduced material costs through innovative technology applications.

Profitability Enhancement

Kia's transformation has produced tangible economic results. As shown in Figure 1, operating profits present a positive trend after the introduction of Plan S in 2020, increasing from KRW 2.1 trillion in 2020 to KRW 12.7 trillion in 2024, while the operating margin improved from 3.8% to 11.8% (Kia Corporation, 2024).

Figure 1: Kia's Operating Profit from 2020 to 2024



Source: Kia Corporation, n.d.-a

Stakeholder-Driven Economic Value

Kia's approach to sustainability extends not only to internal transformation but also to a broader ecosystem of stakeholder engagements that reinforces the brand's economic value and long-term growth. As shown in Figure 2, Kia identifies seven key stakeholder groups (Kia Corporation, 2025). Kia's stakeholder model functions not only as Corporate Social Responsibility (CSR) messaging but also as an economic collaboration system.

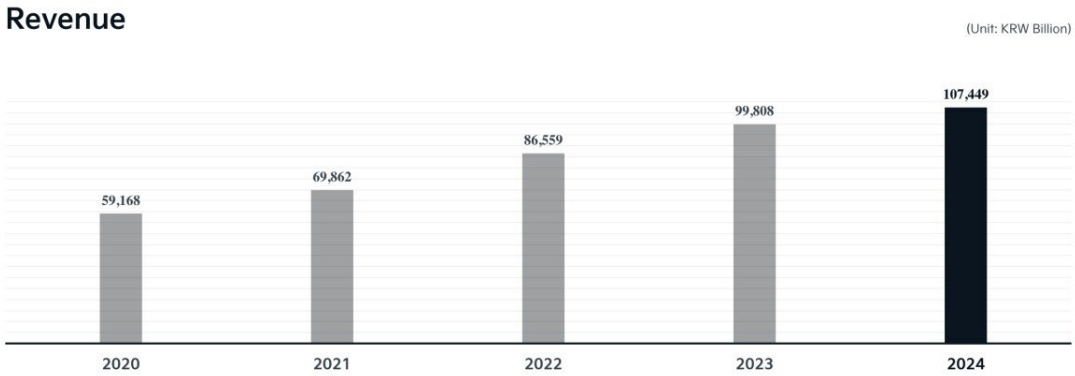
Figure 2: Kia's Stakeholder Groups

Stakeholder	Shareholders and Investors	Customers	Dealers	Employees	Suppliers	Local Communities	Government and NGOs
Definition	Stakeholders that provide capital for Kia's sustainable growth, for whom we fulfill shareholder/investor expectations through transparent and reliable management	Stakeholders who purchase and experience Kia's products and services, for whom we provide the best quality and service for customer satisfaction and convenient purchasing experience	Important partners that deliver Kia's products directly to customers, promoting brand value together	Members who participate in the development, production, and sales of Kia's products and are the driving force behind realizing Kia's vision	Partners who supply parts and materials for Kia's vehicle production, contributing to our growth through a shared commitment to quality and sustainability	Local residents and communities where Kia's operations are located, with whom we seek to strengthen communication and contribute to the sustainable development of local communities	Influence Kia's business operations by enacting automotive industry-related legislation or calling for social responsibility

Source: Kia Corporation, 2025

In the market and customer dimension, Kia's shift towards eco-friendly technology aligns with market trends, and its focus on sustainable mobility has effectively enhanced its brand image and generated noticeable revenue growth, as shown in Figure 3. Through strong partnerships with its dealers, Kia has promoted its electric and hybrid lineups as premium and sustainable products. Kia's models, such as the EV6, have boosted its brand image as an industry innovator and sustainability leader, strengthening its market differentiation and aligning environmental leadership with consumer loyalty. As sustainability becomes increasingly influential in consumers' purchasing decisions, Kia's focus on engaging customers not only boosts sales but also helps build lasting brand equity in a competitive global landscape.

Figure 3: Kia's Revenue from 2020 to 2024



Source: Kia Corporation, n.d.-a

From the perspective of shareholders and investors, Kia's transparent ESG governance reinforces market confidence and facilitates access to sustainable finance. As mentioned in the last section, the issuance of the offshore green bond, which links financing directly to measurable sustainability outcomes, such as EV production and renewable energy use, transforms capital relations into a driver of economic growth and stability.

Kia's economic dimension of sustainability evidences a coherent shift of the 3R model, from responsibility to risk mitigation and ultimately to profit return. Under its sustainability strategy, Plan S, the firm integrates priorities of resource efficiency, investment in sustainable industries, and transition to renewable energy within its profit model. The concrete data of profit margin lift demonstrates that strategic sustainability remains a consistent source of business profit.

Environmental Dimension

Core Vision and Strategy

Kia frames its ambition as a transformation from a traditional automaker to a "Sustainable Mobility Solutions Provider", organising its environmental policies around Sustainable Mobility, Sustainable Planet, Sustainable Energy and based on standards such as ISO 14001. It adopts a life cycle orientation that extends beyond vehicles to services, materials and energy sourcing. This means that it considers the environmental impact of the vehicles as well as how they are powered, their service duration, and what happens to the materials eventually. This is a necessary conceptual shift for managing vehicle life cycle emissions. A specific sustainability management committee at the Board level helps to oversee and facilitate the implementation of the environment-related strategies.

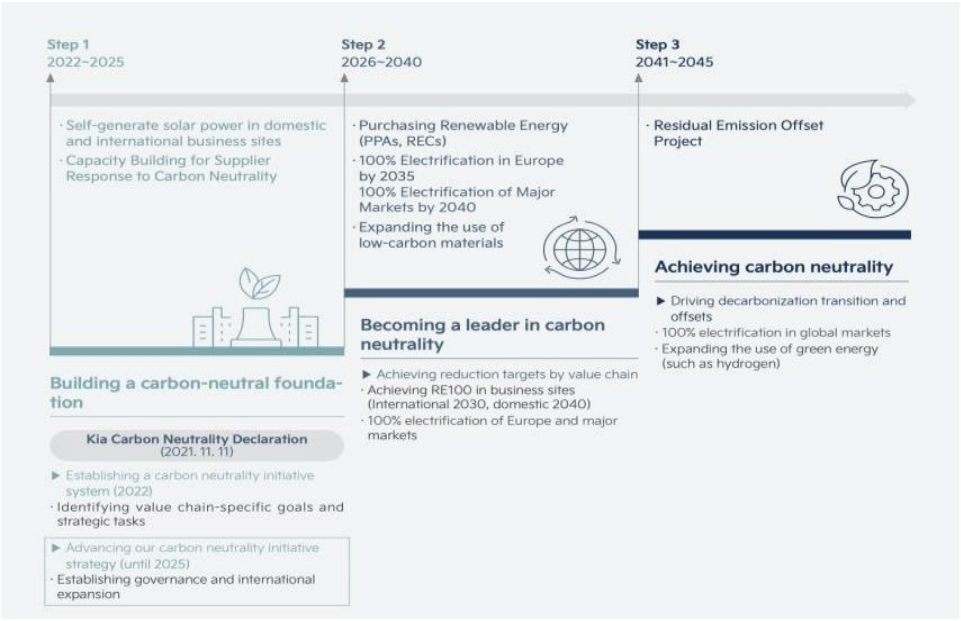
Figure 4: Organisational Chart Showcasing Kia's Sustainability Management Committee

Source: Kia Corporation, 2025

Environmental Sustainability Roadmap and Targets

Kia commits to achieving carbon neutrality by reducing its carbon emissions by 97% compared to 2019 levels by 2045 (Kia Corporation, n.d.-b). The figure below shows its design for three phases to achieve its carbon neutrality commitment.

Figure 5: Kia's Three Stages in Achieving Carbon Neutrality by 2045



Source: Kia Corporation, 2024

There are three clear and distinct key pillars to achieving this goal, which are Sustainable Mobility, Sustainable Energy, and Sustainable Planet.

Sustainable Mobility

This pillar focuses on transforming its vehicle and related products to achieve carbon neutrality. Specifically, it involves transitioning the vehicle line-up to eco-friendly models to reduce on-the-road emissions, which account for the largest proportion of a vehicle's total emissions. The key targets include upgrading new models and fully electrifying Kia's line-up in Europe by 2035, and in key global markets by 2040 (Kia Corporation, 2021b). Meanwhile, Kia is committed to improving its fuel and battery efficiencies through innovative technologies and process designs, such as the third-generation Smartstream powertrain that can optimise fuel injection (Kia Corporation, 2025).

Sustainable Energy

This pillar refers to Kia's vision of achieving zero emissions at business and operation sites. The company targets to achieve the RE100 goal, which is transitioning to 100% renewable energy use in its business sites by 2030 overseas, and by 2040 in Korea (Kia Corporation, n.d.-b). For Kia, solar power is set to be the major source of renewable energy that will facilitate this transition. Kia has invested in building solar power facilities in Korea and in creating solar energy Power Purchase Agreements (PPAs) with countries such as the United States, China, and India (Kia Corporation, 2024). In the near term, Kia plans to self-generate 86 GWh of solar renewable energy annually and generate 62 MW across its global business sites (Kia Corporation, 2024).

Sustainable Planet

This pillar focuses on implementing circular economy principles and actively contributing to environmental preservation, recognising sustainability as a holistic system, and exploring synergies across multiple functions.

Kia's embrace of the circular economy is strategic, aiming to fundamentally redefine its relationship with materials by creating new supply chains and recycling loops. The core commitment here is quantitative: Kia explicitly plans to achieve more than 20% recycled plastic usage in its vehicles by 2030 (Kia Corporation, 2024). This requires active development of specialised material supply chains capable of delivering high-quality recycled content. One example is Kia's partnership with The Ocean Cleanup, which transforms marine waste into useable materials, accessories, and parts, effectively integrating a major external waste stream into Kia's manufacturing ecosystem. In 2023, this project resulted in approximately 55 tons of ocean plastic recovered for future EV model interior use (ESG News, 2023). This holistic approach signifies that Kia views the circular economy not just as a waste-reduction programme,

but also as a crucial pillar for achieving both its carbon-neutrality goal and its vision as a sustainable mobility provider.

Kia is also integrating second-life battery energy storage systems into its material loop for EVs to achieve a circular economy. This initiative transforms the used EV batteries into a valuable resource for the energy sector. The company's major pilot project, launched in 2022, involves a strategic partnership with "encore", a corporate start-up of Deutsche Bahn (DB) (Batteries News, 2022). Through this collaboration, used Kia Soul EV battery modules are collected, diagnosed, and repurposed into modular energy storage systems. This process effectively extends the battery's economic lifespan beyond automotive use, directly supporting both Kia's "cradle-to-cradle" design philosophy and the broader transition to renewable energy storage.

Meanwhile, Kia's Blue Carbon Project reflects a broader vision of carbon neutrality, extending beyond its direct operations to generate benefits for the planet. The initiative focuses on enhancing marine ecosystems, particularly seaweed forests and tidal mudflats, which naturally absorb and store carbon. Through partnerships with external organisations, Kia is actively engaged in restoring and protecting Korea's coastal wetlands. Kia signed a Memorandum of Understanding in 2022 with Korea's Ministry of Oceans and Fisheries to extend the reach of this project (Kia Corporation, 2024).

Apart from this, Kia also introduced the Design Sustainability Strategy, which includes policies on eliminating leather in car interior designs, starting with the EV9 model launched in 2023 (Kia Corporation, n.d.-c). Beyond leather, Kia has identified 10 innovative material solutions that reduce environmental impact, including bio-based polyurethane for seat cushions, recycled PET fabrics for interior trims, and bio-based paints to lower VOC emissions during production. Additionally, Kia is repurposing fishing nets into carpet materials, diverting marine waste from oceans into automotive interiors. Collectively, these initiatives reflect a life cycle-oriented approach, reducing the carbon footprint of materials and integrating into a circular economy.

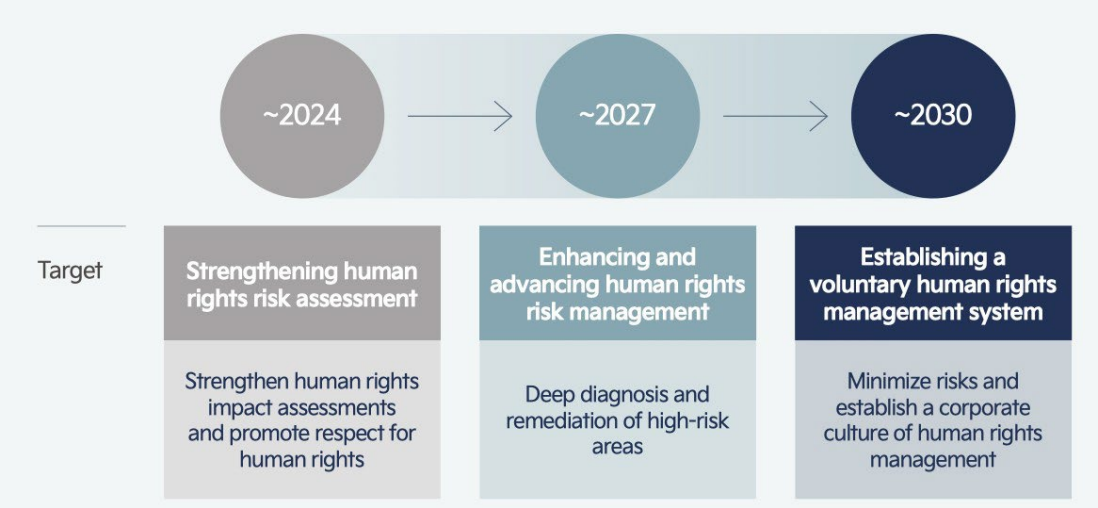
Social Dimension

Human Rights Management

Kia embeds human rights protection as a fundamental principle across its global operations and supply chains. The company proactively identifies risks, mitigates potential violations, and ensures that its partners comply with ethical labour and sourcing standards. Kia implements a comprehensive supplier risk management system to ensure ethical and responsible operations throughout its supply chain. The company conducts desk-based assessments and on-site audits for all Tier 1 and high-risk suppliers, focusing on critical issues such as forced labour, child labour, unsafe working conditions, and ethical sourcing practices. Screening results are systematically integrated for suppliers by risk level, guiding management systems and enabling the categorisation of suppliers by risk level to inform management and

monitoring efforts. For suppliers identified as high risk, they mandate either immediate corrective actions or the development of structured remediation plans, with continuous oversight to ensure compliance, including penalties for violations. The company also adheres to Free, Prior, and Informed Consent (FPIC) principles, ensuring that the indigenous communities are properly informed and provide voluntary consent regarding land and resource use. To strengthen supplier capabilities, Kia offers an ESG consulting and training programme, particularly targeting Tier 1 and Tier 2 small and medium-sized suppliers, supporting 188 suppliers in 2024 through guidance on environmental risks and human rights (Kia Corporation, 2025).

Figure 6: Kia's Mid- to Long-Term Roadmap for Human Rights Management



Source: Kia Corporation, 2025

Human Resources (Employee Welfare and Development)

Kia aims to foster an organisational culture where employees can freely express their ideas and embrace new challenges. This cultural orientation is defined as a "Customer-centric and People-focused Culture", embodied by "Kia Values and Behaviours" (Kia Corporation, 2025). Five core values are each accompanied by three "behaviours" that represent the methods and attitudes employees adopt.

Figure 7: Kia's Values and Behaviours

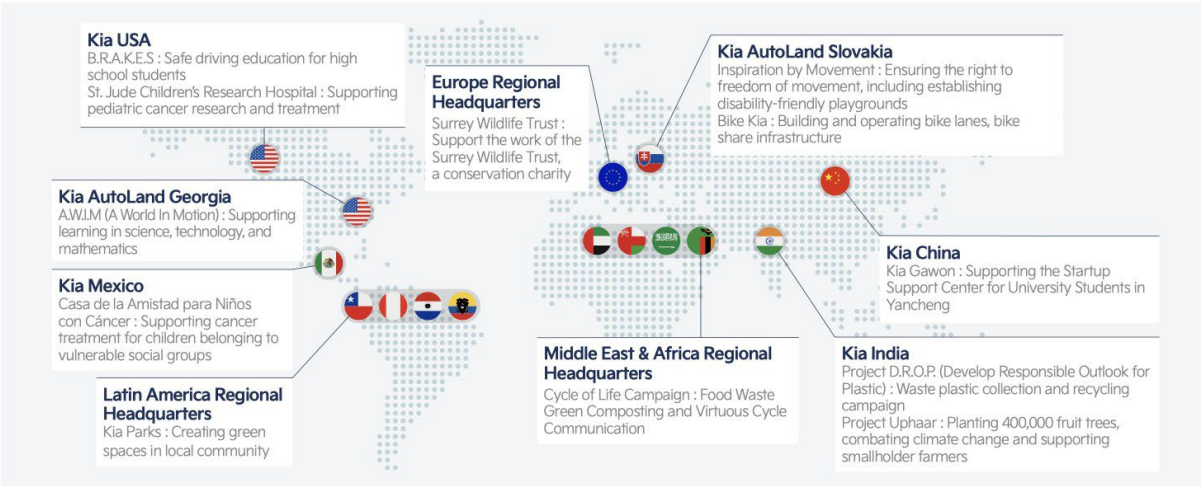
Source: Kia Corporation, 2025

The company's human resources strategy is designed to foster a fair, inclusive, and supportive work environment, emphasising employee welfare, skill development, and safety. Compensation and benefits are competitive, encompassing healthcare, retirement plans, and mental health support, ensuring employees are well protected and motivated. Diversity and inclusion are integral to the Human Resources (HR) strategy, with policies that promote equal opportunities across gender, ethnicity, and regional representation, creating a workplace where all employees can thrive. Overall, Kia's HR framework fosters a holistic culture of development, inclusivity, and safety, driving employee satisfaction, performance, and sustained contribution to the company's broader ESG objectives.

Social Contribution

Kia's social contribution programmes are designed to strengthen the communities in which it operates, with a focus on education, environmental stewardship, and sustainable development. Locally, the company invests in infrastructure, vocational training, and small business development to foster inclusive growth. Globally, Kia drives initiatives such as EV awareness campaigns, environmental education programmes, and carbon-neutrality efforts through supplier life-cycle assessment (LCA) programmes. Employee volunteerism is actively encouraged, allowing staff to participate in community projects and ESG-focused events. At the same time, strategic partnerships with NGOs enable collaboration on disaster relief, education, and sustainable livelihood programmes.

Figure 8: Kia's Social Contribution in Different Countries



Source: Kia Corporation, 2025

Globally, Kia tailors its community engagement initiatives. In the US, it supports safe-driving education and paediatric cancer research and fosters STEM learning in Georgia. In Latin America, Kia aids children with cancer and develops green community spaces. European programmes focus on accessibility, sustainable mobility,

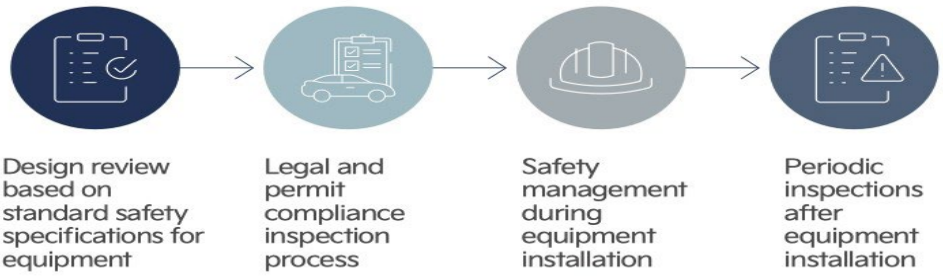
and wildlife conservation. In the Middle East and Africa, Kia promotes food waste reduction and sustainable practices. In Asia, it supports entrepreneurship, education, plastic recycling, tree planting, and smallholder farmers.

Safety and Health

Kia highly prioritises the safety and health of employees, suppliers, and customers, implementing comprehensive systems, audits, and preventive strategies. In the workplace, Kia conducts regular safety audits, ensures compliance with occupational standards, and maintains robust emergency preparedness programmes. Product safety is maintained through proactive measures, including vehicle recalls, defect tracking, EV battery inspections, anti-theft systems, and voluntary corrective actions to mitigate potential risks. Customer safety is further supported through the Customer Safety Quality Hotline, integrated vehicle and EV safety inspections over 8 -10 years, and a refurbished battery programme that reduces repair costs while ensuring safety.

Kia emphasises employee health and well-being with regular medical check-ups, vaccination drives, and mental health support initiatives. Continuous monitoring, incident tracking, and root-cause analysis allow the company to prevent recurrence of safety incidents and maintain a culture of proactive risk management.

Figure 9: Facility Safety Management Process



Source: Kia Corporation, 2025

Sustainable Supply Chain

Kia is committed to building a responsible and sustainable supply chain by ensuring ESG compliance, continuous monitoring, and proactive risk management across all supplier tiers. Through tiered risk assessments, suppliers are mapped from Tier 1 to Tier N and categorised based on ESG performance, product type, country-specific risks, and industry-specific challenges. They emphasise sustainable sourcing of materials, avoid conflict minerals and commodities linked to deforestation, comply with regulations such as the European Union Deforestation Regulation (EUDR), and pursue carbon-neutrality goals. Carbon footprint reduction is supported through life-cycle assessment (LCA) programmes at the part level and through third-party

certification of supplier emissions (Kia Corporation, 2025). Water stewardship is also integrated, with supplier policies and improvement plans to monitor and optimise water use.

Information Security & Customer Satisfaction Enhancement

Kia integrates information security, customer trust, and service excellence into its operations, reinforcing social responsibility across all touchpoints. The company ensures compliance with EU's General Data Protection Regulation and local privacy regulations, supported by encryption, access control, and continuous cybersecurity monitoring to safeguard customer data. Customer feedback is actively captured through surveys, complaint channels, and Voice of Customer (VoC) programmes, enabling real-time responses and resolution of concerns (Kia Corporation, 2025).

Proactive safety measures, including voluntary recalls, EV battery inspections, immobilisers, and anti-theft programmes, further enhance customer protection. Kia's customer-centric services, such as free safety inspections, emergency roadside assistance, towing services, and over-servicing compensation, demonstrate a commitment to exceeding expectations. Employees receive continuous training on quality verification, safety, and ESG standards, while internal audits and guidelines prevent greenwashing and ensure transparency in environmental claims. All these initiatives foster trust, satisfaction, and long-term loyalty, aligning Kia's operations with its ESG and social responsibility goals.

Governance Dimension

Governance Structure

Governance functions as the backbone of sustainability by ensuring strategic direction, accountability, and transparency. Kia reinforces ESG integration into decision-making, overseen by the Sustainability Management Committee, while closely monitoring ESG issues.

Figure 10: Kia's ESG Governance Structure

Source: Kia Corporation, 2025

While Kia's official report does not explicitly label its ESG governance structure into decision-making, planning, and execution layers, its framework inherently embodies multilevel governance logic.

Decision-making Layer

Within Kia's ESG governance structure, the Board of Directors (BOD) and its Sustainability Management Committee represent the core decision-making layer. The Committee meets quarterly to review key ESG issues, approve sustainability strategies, and evaluate progress. It embodies the "who governs and sets accountability" aspect of internal governance mechanisms.

Planning Layer

Beneath the BOD, the CEO leads the ESG Council and the Strategic Business Planning Division, which function as the planning layer. These bodies translate high-level ESG goals into measurable KPIs and coordinate cross-functional initiatives across business units. By integrating ESG indicators into management evaluations and investment planning, Kia turns governance principles into actionable business strategies, reflecting the "how governance is implemented" dimension.

Execution Layer

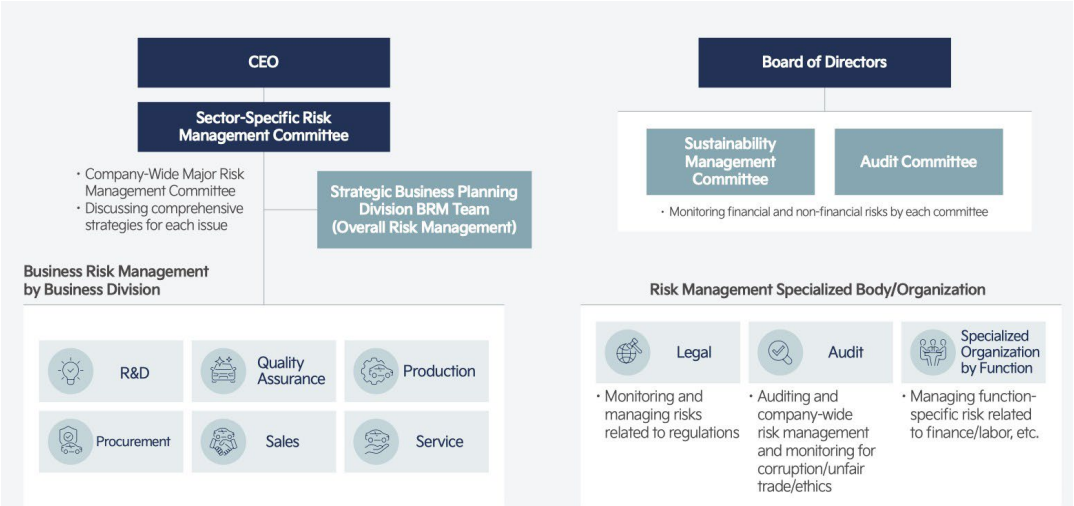
At the operational level, the Sustainability Management Division, together with domestic and international ESG Councils and employees, drives the execution of sustainability initiatives.

This layer monitors key ESG metrics and promotes employee awareness through the "Sustainability Issue Focus" programme. It ensures that decisions made at the board and planning levels are effectively integrated into daily operations, embodying the "how governance drives behaviour and accountability" stage of the governance process.

Risk Management

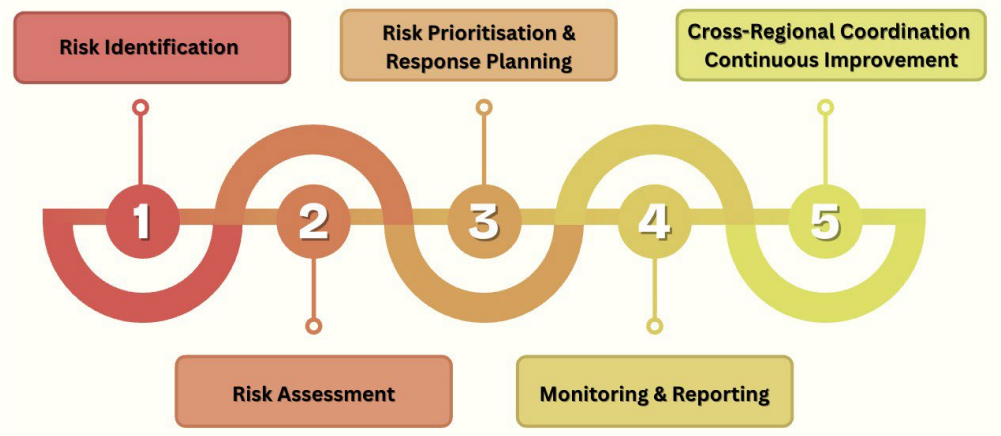
Kia operates an integrated risk management system, as shown in Figure 11, that addresses both financial and non-financial risks in line with enterprise risk management principles. Risk areas spread across environmental, financial, business, and operational fields. Kia's risk management process is generally divided into five stages, as shown in Figure 12.

Figure 11: Kia's Risk Management System



Source: Kia Corporation, 2025

Figure 12: Kia's Risk Management Process



To ensure effective risk management, responsibilities are allocated across three levels, in line with the three lines of the defence model. At the operational level, managers in each business unit continuously monitor and manage potential risks throughout daily activities. The Strategic Business Planning Division then functions as the second line, overseeing risk response status by implementing company-wide risk sensing and response mechanisms. The Sustainability Management Committee acts as the final oversight body, reviewing material ESG risks and determining policies on ethics and social contribution, as well as the internal audit.

Kia integrates its risk management system into a broader ESG governance and disclosure framework that ensures accountability, transparency, and continuous improvement. Kia does its sustainability report following the Global Reporting Initiatives (GRI) Standards 2021. To ensure disclosures are aligned with Kia's business activities and industry characteristics, its report complies with the requirements of the Sustainability Accounting Standards Board (SASB) and incorporates the

recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) (Kia Corporation, 2025).

Risks and Challenges

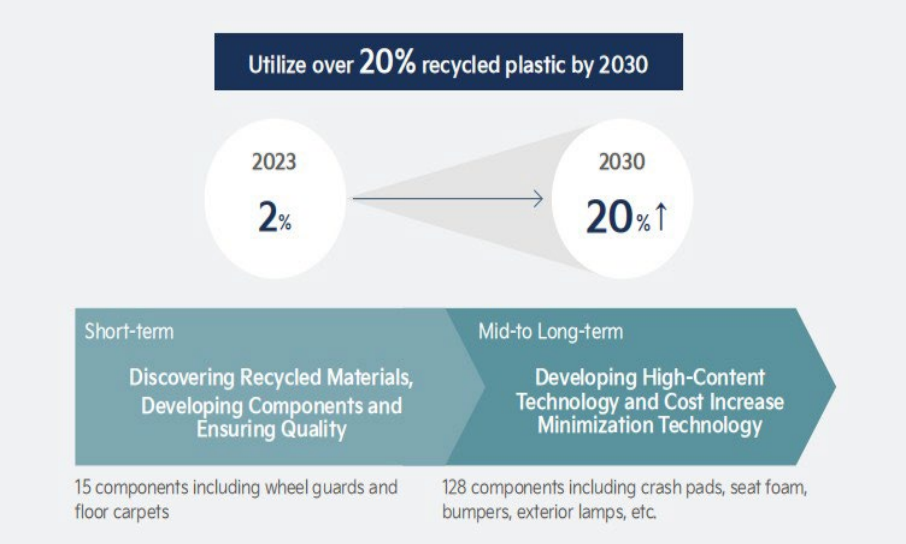
Carbon Neutrality and Energy Transition Risks

Kia has a target to achieve carbon neutrality by 2045 while transitioning to RE100 (100% renewable energy) on its own behalf by 2040. But this goal is fraught with implementation difficulties and cost pressures. Kia's renewable energy conversion rate in 2023 was reported to be just around 9% (Kia Corporation, 2024). The energy transition depends not only on its own power generation facilities (such as Autoland Hwaseong's solar plant), but also on its integration into global supply chains. This is challenging in an uncertain geopolitical environment and volatile energy prices.

Resource Circulation and Material Risks

Kia has vowed to raise the percentage of recycled plastics used in vehicles to over 20% by 2030 and has established a "Plastic Circulation Governance Structure."

Figure 13: Recycled Plastic Utilisation Targets



Source: Kia Corporation, 2024

The supply chain for automotive-recyclable materials is underdeveloped. The low worldwide recycling rate, as well as cost challenges in raw material sourcing and technical bottlenecks, can delay related targets. In addition, the upcoming End-of-Life Vehicles Regulation (ELVR) is expected to increase compliance costs and regulatory exposure.

Occupational Safety and Cultural Gaps

Corporate management has legal responsibility for occupational deaths and serious injuries under South Korea's Serious Accident Punishment Act (Enhesa, 2025). KIA has introduced the KIA Safety & Environment Management System (SEMS) (Kia Corporation, 2024). However, safety cultures and protocol implementation vary across regional operations. The working relationships between the head office and affiliates are among the critical issues that Kia needs to manage.

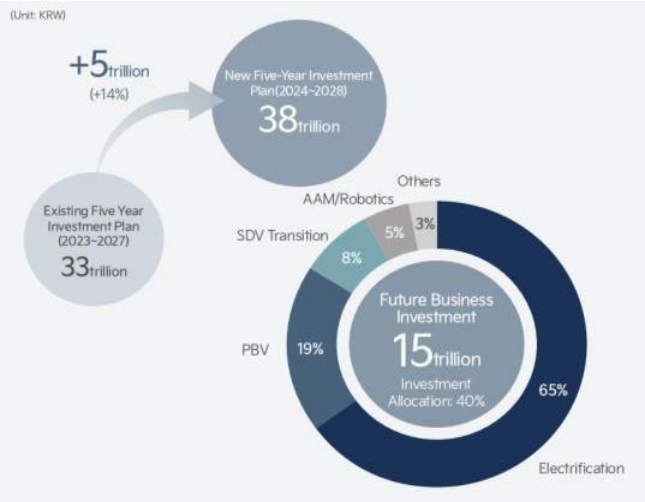
Institutionalisation Risks

Kia may encounter challenges when quantifying ESG indicators and consistently implementing them. The finalisation of the EU's Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS) has also led to Kia being held to a higher ESG reporting standard in the European markets. Where the systems of data collection, verification, and external audit are not appropriate, there may be belated or incorrect disclosures.

Strategy and Systemic Risks

The company aims to spend an enormous sum of money (around KRW38 trillion) over the next five years on emerging areas, including electrification, Platform Beyond Vehicle (PBV), and robotics (Kia Corporation, 2024). However, this is a systemic risk. If global demand for electric vehicles is lower than expected, or government subsidies are tightened, it may put significant pressure on investment returns and cash flow. Also, much of its sustainability work is still in the pilot phase. This execution lag means that global integration of its ESG strategy will take longer and more validation.

Figure 14: Allocation of Investments for Future Growth



Source: Kia Corporation, 2024

Recommendations

Develop Replicable Green Business Models

Kia could set specific targets, for example, the percentage of recycled plastics used or the reduction of energy consumption at factories for each new car model and tie them to operating income and share. While creating dedicated lines of green products or eco-preferred models, they could distinguish price spreads, customer premiums and market positioning. Furthermore, establishing an “environmental payback” tool helps associate the environmental benefits of each green material or process innovation (e.g., CO_2 savings, reduction in raw materials) with profitability (e.g., cost savings, increased brand value).

Strengthen Cross-Departmental Capacity Building

Carry out ecological awareness training at the board of directors, senior management levels, and core business department levels to ensure that all responsible units grasp the commercial logic behind ecosystem services, raw material risks, and recycling. Create cross-functional, cross-departmental ecological task forces that bring environmental and sustainability teams together with departments such as procurement, production, or finance to ensure ecological performance targets are embedded in business metrics. Integrate ecological and social indicators such as material circularity rates into performance evaluation schemes, linking them to executive bonuses and departmental KPIs to underpin a cultural shift.

Disclosure Transparency and Amplify the Impact of Ecological Issues

Furthermore, Kia’s reporting on ecological matters (e.g., natural capital dependence) is at a lower level of maturity than its climate reporting. Therefore, it is recommended to:

Include more coverage in the sustainability report for natural capital and biodiversity (Geographical ecological sensitivity, supply chain ecological risks, ecological restoration projects, mitigation of their impact on ecology) (Aladağ, 2023).

Adopt disclosure frameworks harmonised across countries, such as the TNFD’s LEAP model, to articulate ecological risks and opportunities, governance practices, metrics, and targets. Kia could also work with independent environmental performance rating organisations to verify and increase the credibility of their disclosures.

Conclusion

Across the dimensions of Economics, Environmental, Social and Governance (EESG), Kia has integrated policies and processes into its operations and strategy to realise its sustainability ambitions. For instance, Kia's board-level oversight of ESG, risk management mechanisms, and transparent reporting ensures alignment with evolving regulations and stakeholder expectations. On the environmental front, Kia advances the circular economy and carbon minimisation through initiatives such as increasing the use of recycled materials, establishing "green factory" certifications, and sourcing renewable energy for production sites. On the social dimension, Kia promotes workforce development, diversity, and community well-being while reinforcing ethical practices and human rights standards across its global supply chain. Economically, Kia invests in future mobility technologies, EV platforms, and sustainable business models to support growth while sustaining its ESG commitment. As Kia expands globally into diverse markets with varying regulatory frameworks and cultural norms, the company faces challenges in maintaining consistent ESG standards—these include aligning regional compliance requirements, ensuring uniform labour standards, and adapting the sustainability ecosystem to local market conditions. For Kia to succeed in embedding its sustainability principles across its global operations, it must continue to strengthen transparency, foster collaboration with local stakeholders, and accelerate technological innovation. These actions will underpin Kia's global ambition of leading the mobility sector through a sustainable and responsible transformation.

Discussion Questions

1. Discuss how Kia integrates economic considerations into its sustainability strategy.

2. How does Kia's long-term environmental sustainability roadmap compare with other automakers?

3. How can Kia collaborate with other organisations to accelerate the achievement of mutual sustainability goals?

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Technology, Safety, and the Road to a Sustainable Toyota

FENG Xianglun

SHENG Yifan

YU Jinna

ZHU Yanyu

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Downstream / Delivery

Environmental & Institutional Impact

Introduction

This report analyses the sustainability strategies of Toyota Motor Corporation (hereinafter referred to as “Toyota”) and their impact across environmental, social, and governance (ESG) dimensions. As one of the world’s leading automotive manufacturers, Toyota has long been recognised not only for its operational excellence and lean production, but also for its commitment to sustainability and innovation (Renascence, 2024). In response to global challenges such as climate change, resource constraints, and social inequality, the company has progressively integrated ESG principles into its corporate strategy and governance structure.

This report examines how Toyota pursues its long-term goal of carbon neutrality by 2050 through diversified electrification, resource efficiency, and circular production systems. It also explores Toyota’s social impact, including workplace safety, employee well-being, diversity and inclusion, and human rights due diligence across its global value chain, alongside reforms towards greater transparency, accountability, and stakeholder engagement.

Company & Industry Background

Corporate History

Toyota was established in 1937 by Kiichiro Toyoda, building on the textile machinery business founded by his father, Sakichi Toyoda (Clifford, 2012). The company was initially focused on manufacturing military trucks, and then launched its first passenger car, the Model SA, in 1947. The introduction of the Corolla in 1966 marked a significant milestone and laid the foundation for its subsequent development. In 1997, Toyota introduced the Prius, the world’s first mass-produced hybrid electric vehicle (HEV), which pioneered the electrification of the automotive industry (Toyota Singapore, 2022).

Since entering the 21st century, Toyota strengthened its presence in the high-end market by developing Lexus (Lexus of Albuquerque, n.d.), and gradually evolving into a comprehensive mobility enterprise spanning multiple vehicle segments. In 2020, it proposed a long-term vision of carbon neutrality and incorporated sustainable development objectives into its core strategy (Toyota Motor Corporation, n.d.-c).

Toyota’s development has been consistently guided by its vision of “Creating Mobility for All”, emphasising the creation of an inclusive and enhanced mobility society through technological innovation (Toyota Motor Corporation, 2025). Beyond automotive manufacturing, Toyota has expanded into robotics, smart city development, and hydrogen energy solutions, reflecting its strategic transition from an automobile manufacturer to a diversified mobility-service company.

Core Business and Market Position

Toyota's core business encompasses automotive design, manufacturing and sales, covering a comprehensive product range from economy sedans to luxury vehicles and commercial vehicles. It also engages in financial services, robotics and intelligent transportation systems. In 2024, Toyota achieved global sales of 10.16 million vehicles (Toyota Motor Corporation, n.d.-d).

In terms of technology strategy, Toyota adopts a multi-pathway strategy, offering different electrification options such as battery electric vehicles (BEV), plug-in hybrid vehicles (PHEV), HEV, fuel cell electric vehicles (FCEV), and hydrogen vehicles (Toyota Motor Corporation, 2025). By 2024, 77% of its models in the North American market had offered different electrified options, differentiating its approach from manufacturers focused solely on one type (Toyota Motor North America, 2024).

In terms of market performance, in the fiscal year 2025 (FY2025), Toyota delivered financial results that were modest but remained resilient. For FY2025, Toyota reported consolidated vehicle sales of approximately 9.362 million units. Net revenues for the period reached ¥48.036 trillion, with operating income of ¥4.795 trillion and net income of ¥4.765 trillion (Toyota Newsroom, 2025).

Company Strategies

"Respect for the Planet" is one of Toyota's core values (Toyota USA, n.d.-a). Toyota demonstrates this value by striving to achieve its environmental sustainability targets and looking for new ways to make a positive impact on the planet and society.

Drivers of Action

Toyota's sustainability efforts are shaped by a combination of external pressures and internal strategic choices.

Tightening regulations are a major driver. The European Union (EU) mandates a ban on the sale of new petrol and diesel cars starting from 2035 (European Parliament, 2022), while major markets such as China and the United States (US) have also imposed increasingly stringent annual carbon emission limits (Lindstrom, 2015). These measures are forcing automakers to accelerate their transition towards electrification.

Resource pressures linked to battery production are another important factor. Supply shortages for critical materials like lithium and nickel could reach 10%-30% by 2035 (McKinsey & Company, 2025). Additionally, supply chains remain highly concentrated, leading to rising geopolitical risks and costs associated with ESG compliance.

Internally, Toyota's actions are guided by the Toyota Environmental Challenge 2050 and its public commitment to leave "a better planet for the next generation" (Toyota

Times, 2021). Toyota views sustainability as an opportunity for technological innovation and cost optimisation, such as by adopting renewable energy to reduce manufacturing emissions.

Social scrutiny also influences corporate behaviour. Consumers and investors are paying closer attention to carbon-emissions transparency, labour rights, and supply chain ethics. At the same time, controversies over “greenwashing” and ESG ratings have emerged as critical factors influencing corporate reputation.

Environmental Strategy

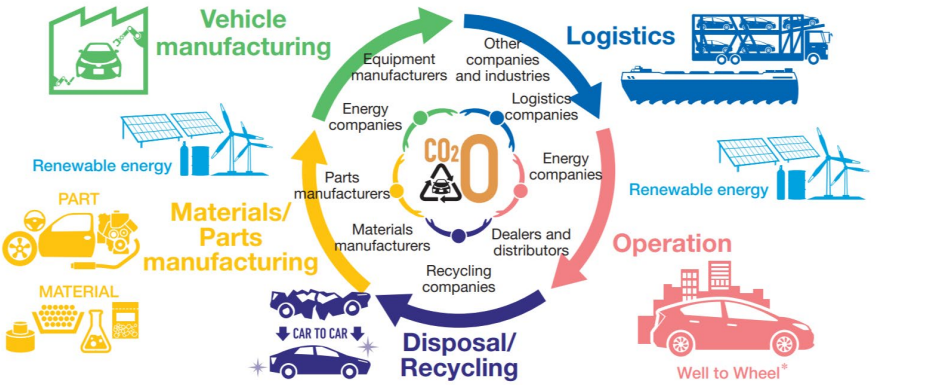
Toyota establishes its environmental strategies, policies, and approaches under the leadership of the Environmental Product Design Assessment Committee, the Consolidated Environmental Committee, and the Resource Recycling Committee (Toyota Motor Corporation, 2025). These committees report to the Carbon Neutral Strategy Subcommittee, which is supervised by the Board of Directors. Toyota has also set up environmental affairs offices in regions such as Asia, Europe, North America, South America and South Africa—to promote environmental efforts tailored to local conditions.

Toyota’s approach is anchored by its Toyota Environmental Challenge 2050 and a set of global mid-term milestones to guide its environmental actions.

Toyota Environmental Challenge 2050

Toyota Environmental Challenge 2050 comprises six long-term, global challenges that seek to minimise negative environmental impacts and create positive value for the planet and society (Toyota Motor Corporation, 2025). Toyota announced these six challenges in 2015 after extensive research and consultation with internal and external stakeholders.

Figure 1: Toyota’s Aims to Achieve Carbon Neutrality



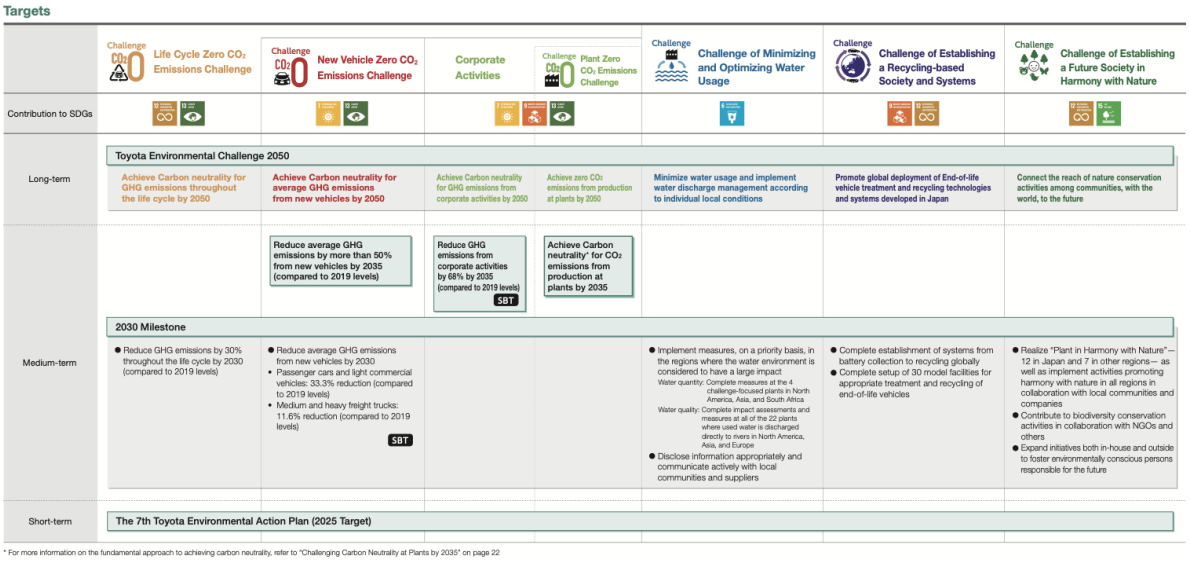
* In addition to greenhouse gas (GHG) emissions during vehicle operation, GHG emissions from fuel and electricity production are also included. (The emissions of battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) vary depending on the power source mix and hydrogen production methods)

Source: Toyota Motor Corporation, 2025

Global mid-term milestones

Toyota has established several global mid-term milestones which act as intermediate checkpoints between current performance and its 2050 goals (Toyota Motor Corporation, 2024).

Figure 2: Mid-term Milestones of Toyota



Source: Toyota Motor Corporation, 2024

Social Strategy

Toyota's social strategy covers areas including human rights, wages, appropriate working hours, management practices, and flexible work styles.

These strategies are guided by a few principles (Toyota Motor Corporation, 2025). Firstly, Toyota aims to be the best company in the region, wanting to be both loved and trusted by people in the regions where it operates. Secondly, it respects and honours the human rights of its employees, customers, and all other people related to its business activities. Thirdly, each employee contributes to creating a safe and healthy work environment that values personal dignity and is free from any human-rights abuse, including discrimination, harassment, child labour, and forced labour.

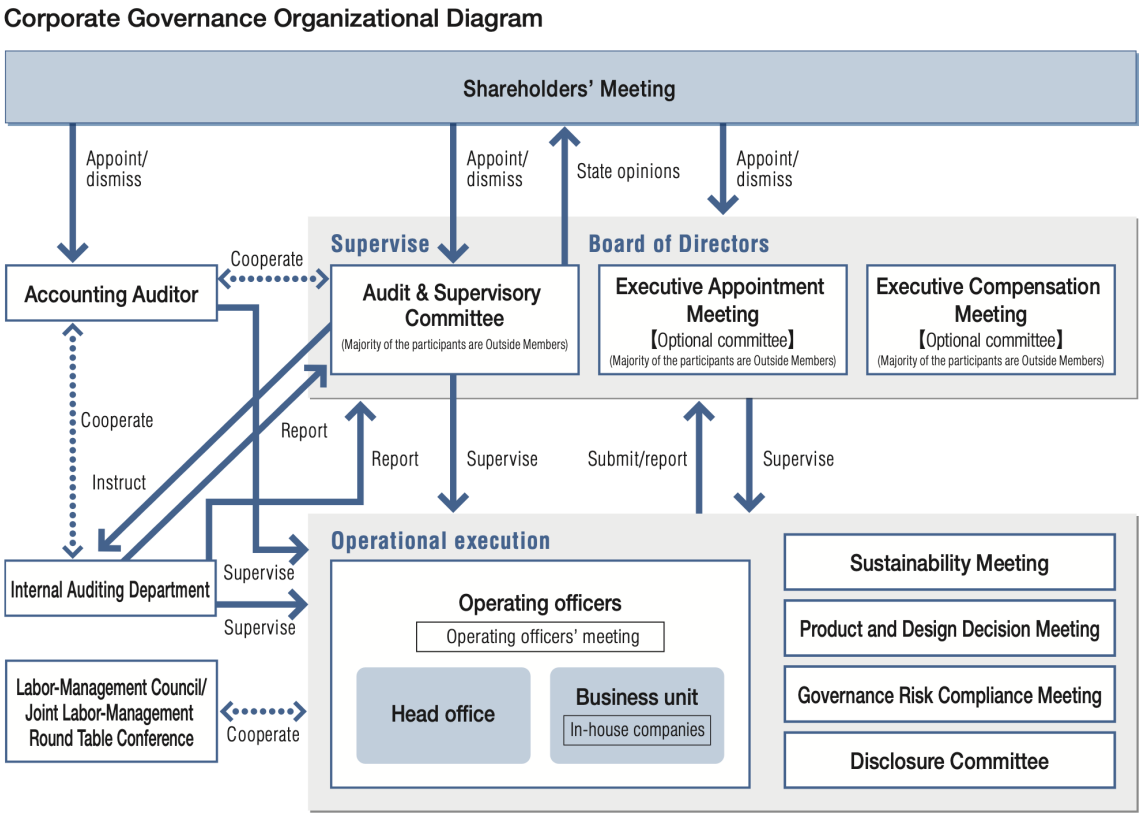
Governance Strategy

Toyota's aim for governance strategy is to establish a corporate governance structure that supports sustainable growth and the stable, long-term enhancement of corporate value. It focuses on enhancing corporate governance to build good relationships with shareholders, customers, suppliers, local communities, and employees, while consistently delivering products that satisfy customer expectations.

In line with these objectives, Toyota has built a structure which enables customer feedback and on-site information to be swiftly communicated to management, with the objective of enabling timely and well-informed decisions, and to review whether such decisions are accepted by the customers and society.

Toyota also formed a Risk Management System to identify, assess, and handle significant risks (Toyota Motor Corporation, 2025).

Figure 3: Organisation Structure of Toyota



Source: Toyota Motor Corporation, 2025

Alignment with International Frameworks

Toyota's sustainability practices are closely aligned with several international standards, demonstrating its environmental and social responsibility.

Task Force on Climate-related Financial Disclosures (TCFD): Since April 2019, Toyota has supported the recommendations of the TCFD (Toyota Motor Corporation, 2024). The company has established a climate risk governance structure overseen by the Board of Directors and employs scenario analysis, including "1.5°C" and "4°C" pathways, to assess costs and supply chain risks (Toyota Motor Corporation, 2025).

United Nations Sustainable Development Goals (SDGs): Toyota's initiatives contribute to multiple SDGs, including SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and

Production), and SDG 13 (Climate Action) (Toyota Motor Corporation, 2025). For example, the development of hydrogen fuel cell technologies advances SDG 7, while the company's waste recycling programmes contribute to SDG 12 (Toyota Motor Corporation, n.d.-a).

Global Reporting Initiative (GRI) Standards: The company's sustainability reporting follows the GRI standards and discloses key performance indicators such as water usage and carbon emission intensity. For example, greenhouse gas emissions from its North American operations decreased by 14% in 2024 compared with 2019 levels (Toyota Motor Corporation, 2024), with quantified outcomes following GRI 305 (Emissions) and GRI 303 (Water and Effluents) standards (Toyota Motor Corporation, 2025).

Impact Analysis – Environmental Impact

Carbon Neutrality Goal and Multi-Technology Strategy

Toyota regards achieving carbon neutrality as its core mission and has formulated a plan to achieve this goal by 2050. Recognising differences in market conditions, the company has adopted a multi-pronged technology strategy encompassing diverse vehicle types (Toyota Motor Corporation, 2025). These strategies will be continuously adjusted and optimised based on local needs and infrastructure conditions. Toyota will carefully consider customer acceptance when promoting electric vehicles in each market and adopt a flexible rollout strategy.

Since 2019, Toyota has implemented various measures to successfully reduce greenhouse gas (GHG) emissions. The company's new vehicle fleet in the US has achieved a 21% reduction in GHG emissions per mile, while in Canada, emissions have decreased by 31% for new cars and 32% for new trucks (Toyota USA, n.d.-b). This comprehensive emissions reduction strategy facilitates a smooth transition to a low-carbon economy in multiple markets, while managing the decline in demand for traditional fuel vehicles worldwide and emphasising the role of diverse technologies in achieving its business and environmental goals.

Lifecycle Carbon Reduction Results

Toyota has focused its emissions reduction efforts on vehicle production, setting a goal of reducing carbon emissions from its global factories by 30% by 2030 compared with 2013 levels (Toyota Motor Corporation, 2025). To achieve this goal, the company is expanding its use of solar energy and piloting hydrogen-based equipment in its factories. Carbon emissions from Toyota's factories have decreased by 19% relative to 2013 (Toyota Motor Corporation, 2025), indicating the company's commitment to reducing emissions.

Efficient Resource Utilisation and Circular Economy Practices

Toyota has consistently demonstrated its commitment to minimising waste and enhancing efficiency while upholding high standards (Renascence, 2024), and applies this to resource utilisation. The company believes recycling and reuse systems are key to achieving its environmental goals. It continuously optimises resource management mechanisms globally to reduce the consumption of natural resources and extend the useful life of product materials. Toyota reported that 93% of all waste generated in 2023 was recycled, reused, or repurposed (Toyota Motor North America, 2024), demonstrating the company's commitment to promoting a circular economy.

Toyota considers battery recycling and reuse as key elements of its circular strategy. In response to the rapid growth of hybrid and electric vehicles, the company has established a multi-tiered battery recycling network in Japan and North America. In the Japanese market, Toyota collaborates with partners such as the University of Tokyo and Panasonic Energy to disassemble, remanufacture, and recover materials from lithium-ion and nickel-metal hydride batteries (Toyota Tsusho Corporation, 2022). A portion of these recycled materials is reused in new battery production, significantly reducing the need for rare metal mining. In North America, Toyota partners with organisations like Redwood Materials and Cirba Solutions to advance battery recovery and recycling (Toyota Motor Corporation, 2024). Through its collaboration with Cirba Solutions, Toyota aims to cut logistics costs by up to 70%, reduce emissions, and recover up to 95% of critical minerals from end-of-life batteries (Toyota Motor Corporation, 2023b).

Water Management and Production Efficiency

Water management is one of the key components of Toyota's sustainability strategy. Given the high reliance on water resources in its production processes, the company is leveraging innovative technologies and optimised processes to reduce water consumption. The average water consumption per vehicle produced decreased from 983 gallons in FY2020 to 886 gallons in FY2024 (Toyota Motor North America, 2024). This improvement results from various enhancements, including the introduction of water-recycling cooling systems and reclaimed water reuse equipment.

In addition, Toyota is pursuing a closed-loop battery ecosystem as part of its broader mission to achieve carbon neutrality and strengthen its resource recycling system (Toyota Motor Corporation, 2023b). The company continuously improves its supply chain and expands its business through parts refurbishment, metal recycling, and plastic reuse. For example, Toyota sorts and collects plastic front bumpers from retired vehicles, then uses these collected bumpers in the production of interior trim components for new models (Toyota Motor Corporation, 2017). This reduces waste emissions and lowers raw material procurement costs.

Ecosystem Conservation Projects

Toyota's ecological conservation projects in overseas markets demonstrate regional and collaborative approaches. In Brazil, Toyota collaborates with local environmental organisations to support wetland and marine conservation through programmes such as the Toyota APA Costa dos Corais Project to protect coral reefs and marine manatee ecosystems (Toyota Motor Corporation, 2014). In Thailand, Toyota is advancing a large-scale mangrove reforestation effort, marking its 18th consecutive year of action in 2025 by planting 50,000 mangrove trees in Samut Prakan Province as part of its drive towards sustainable carbon neutrality (Toyota Motor Asia, 2025).

Summary and Limitations

Toyota's environmental strategy, with the vision of carbon neutrality by 2050, combines technological innovation, life-cycle resource management, and ecosystem protection. This strategy spans production, supply chain operations, and end-of-life product recycling, extending its environmental impact from factories to ecosystems. Its ecological conservation projects illustrate how ecological preservation forms part of Toyota's corporate culture.

However, Toyota's sustainability strategy still faces several challenges. First, the company's relatively cautious pace of electrification may be seen as conservative within an industry accelerating towards electric mobility. Some observers have noted that Toyota's adoption of pure electric vehicles has been slower than that of some competitors (Wayland, 2022). However, Toyota is committed to achieving its emissions reduction targets through a variety of technologies, believing that this approach is more aligned with diverse market demands than a single-technology pathway.

Second, greater transparency and third-party verification of environmental data are needed to enhance external trust. Third, Toyota faces ongoing trade-offs between the scalability of recycling systems and the carbon emissions associated with logistics. Finally, consistent global implementation of sustainability policies remains an area for further integration and improvement.

Impact Analysis – Social Impact

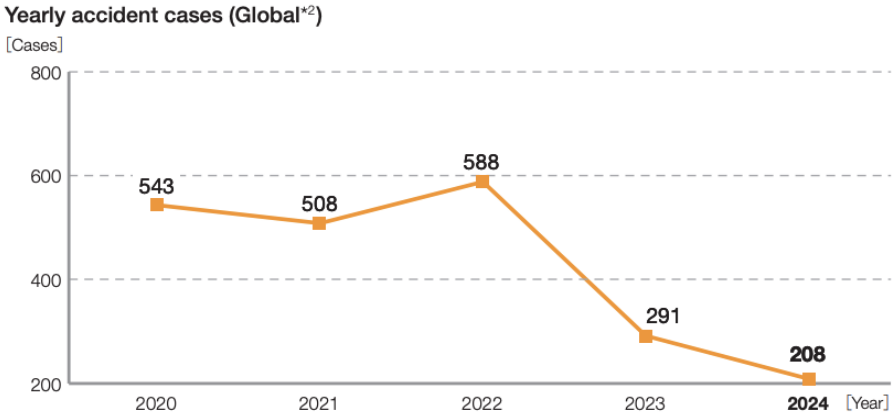
This section assesses Toyota's social impact across five domains: workplace safety, employee well-being and work-life balance, diversity, equity, and inclusion (DE&I), human-rights due diligence within the value chain, and community and consumer safety. The analysis focuses on how Toyota's stated missions translate into operational practices and measurable outcomes, as well as identifying gaps that affect credibility, comparability, and scalability across markets.

Occupational Health and Safety

Toyota treats “zero accidents” as a goal, supported by a system that combines human-centred training, redesign of work methods, and engineered controls on production floors (Toyota Motor Corporation, 2025). Facilities feature physical segregation of pedestrian and forklift routes, and ergonomic aids like power-assist devices that reduce arm fatigue.

As a result, there is a steady reduction in severe workplace incidents. Toyota recorded a low global lost time incident rate of 0.18 in FY2025 (Toyota Motor Corporation, 2025). The company also continues to scale its safety education programmes. In 2024, it ran 280 on-site health literacy and accident simulation seminars, while its online health-related course was accessed 107,399 times. These indicate that Toyota’s behavioural and environmental safety frameworks are institutionalised processes rather than temporary campaigns (Toyota Motor Corporation, 2025).

Figure 4: Toyota’s Yearly Accident Cases



Source: Toyota Motor Corporation, 2025

Figure 5: A Power Assist Device to Reduce Arm Fatigue (North America)

Source: Toyota Motor Corporation, 2025

Employee Well-Being and Work-Life Balance

Toyota's work-life measures are institutionalised rather than symbolic, forming part of its broader approach that addresses fair wages, appropriate working hours, and flexible arrangements that promote a safe and dignified workplace for all employees. Policies include expanded childcare leave, shortened or flexible working hours, telework for caregivers, and supervisor check-ins designed to align career goals with caregiving responsibilities (Toyota Motor Corporation, 2025).

Statistics show that in FY2025, male childcare-leave uptake reached 67.4%, with 78.4% of new fathers taking at least a half-day leave within two months of their child's birth. Return-to-work rates following childcare leave were 100% for males and 99.5% for females, paid-leave utilisation was 88.4%, average overtime was 21.1 hours per month, and stress-check implementation was 94.2% (Toyota Motor Corporation, 2025). These patterns are associated with Toyota's success in reducing burnout, sustaining post-leave retention, and maintaining productivity levels.

Diversity, Equity and Inclusion

Toyota sets long-term targets and develops structured pathways to diversify representation. The company's action plan aims to increase the number of women in managerial positions to five times the 2014 baseline by 2030 and to raise average paternity-leave participation to 85% or higher. Supporting measures include leadership conferences for women, mentoring programmes, divisional roundtable discussions, and career development opportunities for female engineers (Toyota Motor Corporation, 2025).

Progress is measurable but remains uneven. At Toyota, women hold 4% of managerial positions (432 managers) and hold 865 assistant-manager positions (Toyota Motor Corporation, 2025). Although structured sponsorship and selection mechanisms are widening internal pipelines, gender balance within Japan-based operations continues to be a primary area for improvement.

Human Rights and Supply-Chain Due Diligence

Toyota's board-approved Human Rights Policy guides risk identification, mitigation, and remedy. The company has grievance channels for employees and supply-chain partners, including the Global Speak Up Line, All Toyota Speak Up, and the Toyota Consolidated Helpline (Toyota Motor Corporation, 2025). In FY2025, the company received 522 consultations via the Global Speak Up Line and 221 cases through the All Toyota Speak Up and Toyota Consolidated Helpline. Reported issues included potential rule or regulatory infractions, potential harassment, and financial matters, indicating active and monitored use of these reporting mechanisms (Toyota Motor Corporation, 2025).

Growing social scrutiny from consumers and investors has also pushed Toyota to strengthen disclosure on human rights, wages, and labour standards. The company recognises that factors such as carbon disclosure and supply-chain ethics increasingly shape brand reputation and ESG evaluations. Toyota monitors migrant-worker demographics by region (e.g., 1,021 in Japan; 3,089 in Europe), creating the foundation needed for targeted remediation and risk management (Toyota Motor Corporation, 2025). However, independent watchdogs continue to highlight transparency gaps within the aluminium supply chain. Multiple automakers, including Toyota, were identified for insufficient traceability down to the smelter level in China (Human Rights Watch, 2024). Strengthening third-party assurance and traceability would materially strengthen Toyota's social impact credibility.

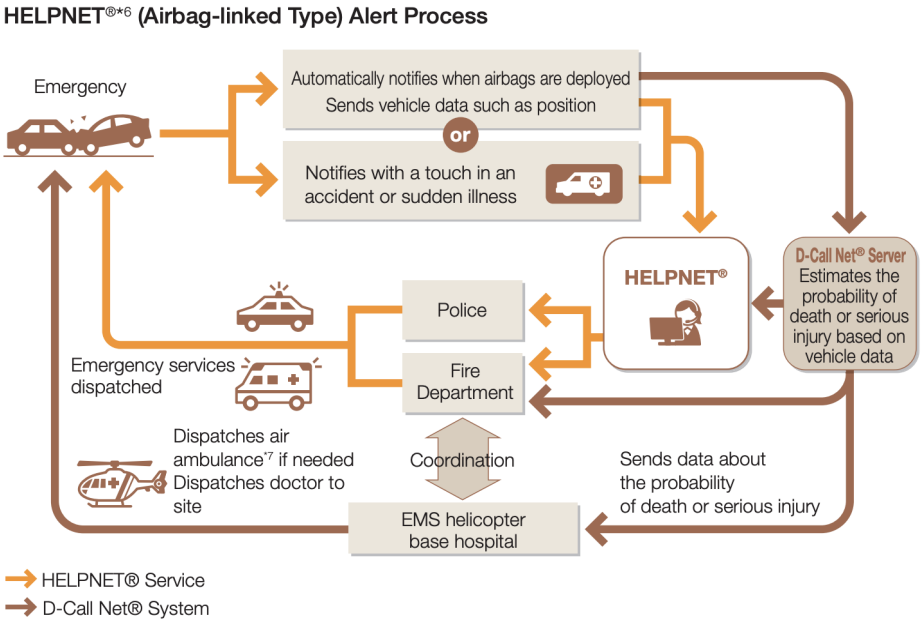
Community Investment & Consumer Safety

Toyota channels community investments into human capital development, traffic safety, environmental conservation initiatives, and cultural projects. In FY2025, community spending across the company was about ¥33.5 billion, governed through the Sustainability Subcommittee and overseen by the Board of Directors (Toyota Motor Corporation, 2025). Many of these initiatives directly contribute to the UN Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 13 (Climate Action), reflecting Toyota's intent to link social contribution with global sustainability frameworks (Toyota Motor Corporation, 2025).

On the consumer-safety side, Toyota's Integrated Safety Management Concept integrates active safety, passive safety, and emergency response into a unified framework (Toyota Motor Corporation, n.d.-b; Toyota Motor Corporation, 2025). It pursues real-world safety by analysing actual accidents to guide the development of vehicles and technologies for accident prevention, collision mitigation, and rescue measures. Toyota also delivers traffic safety education to raise awareness among drivers and pedestrians (Toyota Motor Corporation, 2025).

In Japan, the HELPNET® service, an airbag-linked emergency reporting system, automatically connects the vehicle to a dedicated operator upon airbag deployment, transmitting precise location and collision data before escalating to police, fire, or ambulance services (Toyota Motor Corporation, 2025). Through D-Call Net®, the system can trigger doctor-helicopter dispatch based on estimated injury severity, compressing time based on estimated injury severity, significantly reducing time from crash to definitive care. Customer feedback systems, including the Customer Assistance Centre and Salesperson Support Desk, feed insights back into product development and service improvement, demonstrating Toyota's commitment to continuous safety enhancement and customer-oriented innovation (Toyota Motor Corporation, 2025).

Figure 6: HELPNET® Service Process



Source: Toyota Motor Corporation, 2025

Summary and Limitations

Toyota's most tangible social contributions lie in workplace safety and employee well-being, where established systems and high participation have led to stable outcomes. DE&I initiatives, human rights governance, and community investments further broaden its social impact, while integrated safety measures like HELPNET® and D-Call Net® enhance consumer trust. Nonetheless, progress in leadership diversity remains slow, upstream supply-chain assurance continues to face credibility challenges, and evidence of outcomes for social programmes is still limited. Addressing these areas would strengthen the consistency and comparability of Toyota's social-impact profile.

Impact Analysis – Governance Impact

Governance is a key factor in how Toyota deals with problems related to sustainability (Toyota Motor Corporation, 2025). The company's ongoing governance reforms influence not only its internal decision-making processes but also signal broader shifts in Japan's traditional corporate governance landscape (Inoue & MacManus, 2025).

Reforms of the Structure

One of the most important changes for Toyota is the transition from an Audit and Supervisory Board system to an Audit and Supervisory Committee system (Toyota Motor Corporation, 2025). This reform makes the board more independent and speeds

up the decision-making process, enabling faster approval and integration of ESG goals.

Toyota has also sold ¥325.9 billion of shares, reducing the number of such holdings from 141 to 124 in FY2023/24 (Reuters, 2024). This change marks a departure from Japan's traditional keiretsu structure, improving strategic flexibility and allowing the company to direct resources more effectively towards its sustainability goals.

Transparency

Since April 2019, Toyota has adopted TCFD recommendations to establish a climate risk governance structure led by the Board of Directors. The company uses scenario analyses, including "1.5°C" for transition risk and "4°C" for physical risk, to assess potential supply chain impacts (Toyota Motor Corporation, 2024). Toyota is also ensuring that its reporting is done according to GRI standards to support comparability, accountability, and transparency. These disclosures allow investors, regulators, and the general public to monitor the company's progress, thereby exerting external pressure and reinforcing internal accountability.

Stakeholder Feedback

This governance approach allows Toyota to adapt more quickly to changes in market demand, concerns related to safety, and unexpected disruptions in the supply chain. Improved stakeholder engagement enhances management agility, awareness, and accountability. In the long run, this approach fosters trust among consumers, suppliers, and communities, while reducing decision-making lag and exposure to risk (Toyota Motor Corporation, 2025).

Risk Management

At the same time, Toyota's governance system encompasses a structured risk management system to identify, evaluate, and manage major risks before they escalate (Toyota Motor Corporation, 2025). This strengthens organisational resilience and boosts stakeholder confidence. A company that demonstrates credible risk governance is better positioned to enhance its reputation and access to capital, enabling greater focus on sustainable growth and innovation.

Compliance Breakdown

Governance, on the other hand, remains partly reactive. In 2023, problems with vehicle certification were found in Daihatsu Motor Co., Ltd., a subsidiary of Toyota (Toyota Motor Corporation, 2023a). These problems were discovered by external investigators rather than Toyota's internal systems, highlighting weaknesses in early-warning and compliance systems.

Effects on the Market and Systemic Spillover

Toyota's corporate governance reforms extend beyond the company itself. By reducing its cross-shareholdings and shifting away from the traditional Japanese business model (Reuters, 2024), Toyota sets a precedent for other Japanese companies to pursue more transparent, competitive governance structures. This contributes to wider capital market reforms, reinforcing governance accountability at a systemic level.

Summary and Limitations

Toyota's governance reforms form a foundation for achieving sustainability goals. Structural reforms help strengthen board independence, capital flexibility, and market discipline. Enhanced transparency through TCFD and GRI frameworks has led to greater pressure and accountability. The company will still need to improve its early-warning systems, engage a wider range of stakeholders, and further integrate ESG measures into board-level decision-making. These steps would enhance the speed, transparency, and credibility of governance oversight. Looking ahead, Toyota can continue evolving from reactive to proactive governance by advancing Scope 3 emission disclosure and employing digital tools, such as artificial intelligence (AI) to monitor suppliers and certification processes, to turn ESG commitments into faster and more credible action.

Discussion Questions

1. Discuss the feasibility of Toyota's Environmental Challenge 2050 goals. Provide supporting reasons and potential barriers to achieving these goals.

2. How can Toyota strike a balance between maintaining its traditional business strengths and accelerating its sustainable transformation?

3. The success of Toyota's sustainability efforts would depend not only on itself but also on its global supply chain and partners. How should Toyota encourage its suppliers to adopt higher ESG standards? What strategies should it use if some suppliers cannot fully comply?

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Asian Agri and the Circular Economy

ALHARTHI Faisal

CHEN Runlin

PU Jiayi

Jeslyn Lim SUHARJA

ZHONG Qiwei

Loh, L., & Ang, H. M. (Eds.). (2026). *Cases in sustainability (Vol. 2: System-level and structure-based approaches).* Centre for Governance and Sustainability, NUS Business School.

Introduction

Asian Agri was founded in 1979 and has become one of Indonesia's top private firms. It uses sustainably managed plants to produce crude palm oil. As one of the biggest oil palm firms in Asia, it operates 30 estates, 23 mills and 11 biogas facilities in North Sumatra, Riau, and Jambi with around 22,000 workers. They cultivate, grow, and process oil palms to create sustainable crude palm oil and crude palm kernel oil and sell their products to Asia and Europe (Asian Agri, n.d.).

Current Situation

Currently, Asian agriculture has achieved tangible results in sustainable development. In the 2024 Sustainability Report, the company highlighted zero fire incidents, 11 biogas plants capturing over 90% of methane emissions, and generating 139,122 MWh of renewable electricity. Additionally, 1,373 independent smallholder farmers obtained Roundtable on Sustainable Palm Oil (RSPO) certification, and a 31% reduction in pesticide use (Asian Agri, 2025). These metrics demonstrate the company's success in environmental management and operational execution, providing investors with quantifiable evidence of its sustainability actions. The company's transition to a circular economy model is not only about reducing harm but also actively creating value. The action of capturing methane emissions and generating renewable electricity enables the company to reduce production costs and significantly enhance profitability while combating climate change. Moreover, the company is systematically raising sustainability standards across its entire supply chain, helping independent smallholder farmers obtain international certifications. This initiative meets the sustainable supply chain requirements in markets like the European Union (EU), enabling the company to build a transparent and standardised business model that gains regulatory trust and consumer recognition. In addition, replacing traditional chemical agriculture with technology-driven and innovative farming helps to protect the environment and worker health. This strengthens the competitive advantages of Asian Agri.

Overview of the Industry

In 2024, global palm oil production reached approximately 78 million metric tons. USDA data tables show Indonesia produced 46 million tons (59%) and Malaysia produced 19 million tons (24%), making them the world's largest palm oil producers, accounting for 83% of global production (US Department of Agriculture, n.d.). Within the palm oil sector, the Asia-Pacific region holds a core position as the world's largest producer. The global palm oil market is currently valued at approximately US$72.8 billion in 2024 and is projected to reach approximately US$98.9 billion by 2030 (Grand View Research, n.d). The market continues to grow, driven by palm oil's role as a primary raw material for numerous products. Palm oil is a versatile oil with multiple

characteristics and functions that make it both economically valuable and widely used. It's found in almost everything, contributing to about half of all packaged products in supermarkets, including pizza, doughnuts, and chocolate, as well as deodorant, shampoo, toothpaste, and lipstick. It is also utilised as animal feed and biofuel in many parts of the world (World Wide Fund, n.d). Food and beverages, driven by a growing population and food demands, represent the largest segment of the palm oil market at 65.98% (Grand View Research, n.d). Furthermore, growing demand from the biofuel, energy, personal care, and cosmetics industries has made versatile and low-cost palm oil one of the world's most consumed vegetable oils. Its diverse applications make palm oil good with market elasticity, maintaining stable demand even during price increases. However, the industry's rapid expansion has also brought environmental concerns, with deforestation, greenhouse gas emissions, and biodiversity loss posing significant challenges to the development of the whole industry (World Wide Fund, n.d.). Companies must invest in sustainable development plans and environmental regulators must develop globally recognised sustainability standards and strictly monitor companies for the industry to continue to develop.

The Economic Dimension of Sustainability in Asian Agri

How Asian Agri put the first 'E' in EESG

It is a common misconception that a company must sacrifice its bottom line to do well. The traditional Environmental, Social, and Governance (ESG) framework, while incredibly important, can sometimes create a perceived tension between a company's profit and its purpose (Loh, 2024). This has led some people to believe that sustainability is just another money spender. A more integrated approach, the EESG (Economics, Environmental, Social and Governance) framework, argues that economics is not the opposite of sustainability; it can even be a core part of it. Asian Agri demonstrates this principle by building a business model where doing the right thing for the planet and people is part of its revenue cycle.

Case of Circular Economy: From Waste Stream to Revenue Stream

When people think of a palm oil mill, "waste" often comes to mind. However, for Asian Agri, a better word is probably "opportunities". Instead of production waste as an environmental problem to be managed, it views the waste as an undervalued asset. This is the EESG model at its most practical. Asian Agri had used a liquid residue from palm oil production in its biogas power plants (Yolanda, 2019). The electricity generated is used by Asian Agri and also sold to the electricity supply company Perusahaan Listrik Negara (PLN), so people residing near the palm oil plantations can access the energy. Asian Agri has invested over US$60 million into this programme, with a clear financial return from both cost savings and energy sales. This is both effective resource management and good for the environment.

The “3R” approach in Asian Agri

The “3R” framework (Responsibility, Risk and Return) offers a structure of how we can understand the economic dimension of sustainability (Loh, 2025). It moves beyond abstract concepts to evaluate how a company’s commitments, mitigation strategies and value creation are interlinked. From our research, we found that Asian Agri’s sustainability strategy aligns closely with this framework, demonstrating how deeply embedded ethical commitments and proactive risk management can drive real economic benefits.

R1: Responsibility for Sustainability

The foundation of Asian Agri’s sustainability model is its profound sense of responsibility, which lies in its core policies and long-standing community engagement and support. A primary showcase of this responsibility is the company’s No Deforestation, No Peat, No Exploitation (NDPE) policy (Asian Agri, n.d.). Enacted formally in 2014 but reflecting earlier commitments like the 1994 zero-burning policy, this commitment extends across their entire supply chain. It explicitly prohibits clearing High Carbon Stock (HCS) forests and High Conservation Value (HCV) areas and mandates the protection of peatlands. Since 2003, Asian Agri has stopped expanding its plantation land, focusing instead on intensifying yields on existing land. Apart from this, Asian Agri’s partnership with smallholder farmers has also been considered a great demonstration of responsibility for sustainability. Smallholders are crucial to Asian Agri, supplying over 50% of its total crude palm oil (CPO) production (Asian Agri, 2025). The company partners with over 35,000 scheme and independent smallholders, specifically 27,075 scheme smallholders managing 52,885 hectares and 7,555 independent smallholders under its Corporate Shared Value programme managing 34,843 hectares. This commitment and responsibility go far beyond simply sourcing the farmers; it involves providing training and support for sustainable practices and certification.

R2: Risk for Sustainability

By proactively fulfilling its responsibilities, Asian Agri strategically mitigates its business risks in the palm oil sector, particularly concerning climate and supply chain stability.

- **Climate and Operational Risks:** Asian Agri faces challenges from extreme impacts of climate change, slow certification of smallholder farmers, stringent regulatory policies, and unstable labour forces. First, extreme weather has become a destabilising factor for business operations. Indonesia’s unpredictable rainfall patterns in 2024 resulted in a decline in production, which demonstrates the connection between productivity and climate (Asian Agri,

2025). Specifically, fires are a major threat in Indonesia, which has had devastating effects on both the environment and local people (Borneo Nature Foundation, 2019). Asian Agri's zero-burning policy, implemented since 1994, is a critical preventative measure. Asian Agri reported zero fire incidents within its own estates and smallholder areas in 2024, demonstrating the effectiveness of these fire prevention strategies in protecting assets and ensuring operational continuity. Moreover, the company's No Deforestation, No Peat, No Exploitation (NDPE) development policy for existing peatlands (covering 27,409 ha, or about 25% of their total plantation area) mitigates risks associated with peat subsidence and high flammability (Asian Agri, 2025).

- **Certification and Employee Risks:** Asian Agri's palm oil supply chain is heavily dependent on smallholder farmers, which can introduce volatility. The slow pace of certification among smallholder farmers directly impacts Asian Agri's export qualifications and international reputation, slowing the globalisation of the company. Although the company's Sustainability Report 2024 mentioned that around 27% farmers have achieved RSPO certification (Asian Agri, 2025), the number is not enough. This challenge requires significant financial and time investments from smallholders to manage their farms. Also, data suggests that temporary workers constituted approximately 53% of the total workforce (Asian Agri, 2025). The high proportion of temporary workers implies high labour turnover and potentially weaker worker commitment. Also, the temporary workers may lack proficiency, which leads to low production efficiency and high training and management costs. By providing training (1400 smallholders were trained in 2024), facilitating access to funding for replanting (18,900 ha replanted since 2016), and ensuring access to superior seeds, the company fosters a more productive and stable supply base.

R3: Return for Sustainability

The culmination of the "3R" framework lies in the "Return", where responsible practices and risk mitigation transfer into measurable economic value. Asian Agri's unique model demonstrates that sustainability initiatives can be a significant profit generator and driver of long-term financial stability.

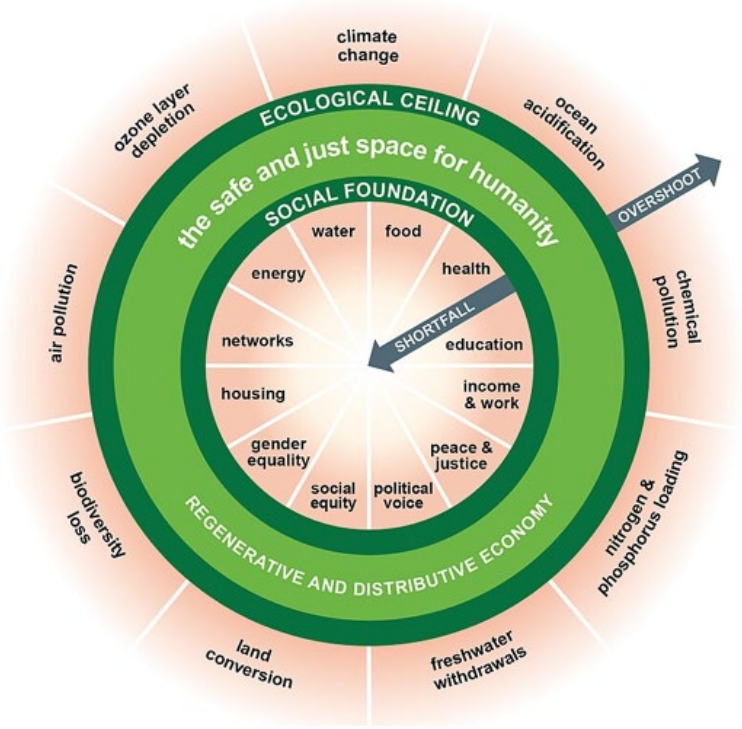
- **Case of Circular Economy:** In 2024, 139,122 MWh was generated from renewable fuels, constituting 96.15% of the company's energy consumption (Asian Agri, 2025). Currently, Asian Agri has 11 biogas plants that are turning waste into value. These biogas plants achieve over 90% reduction in methane emissions from the effluent. The captured biogas is then used to generate electricity.

- **Enhanced Productivity:** Investments in smallholders yield direct economic returns. The target of the replanting programme is to double smallholder yields

from a baseline of 15 tons Fresh Fruit Bunch (FFB)/ha to 30 tons FFB/ha. While the average productivity for all replanted areas was 1.01x the baseline in 2024 due to young and lower-yielding palms, some mills have already achieved 1.87x the baseline yield (Asian Agri, 2025). This increased productivity results in higher incomes for smallholders. In 2024, scheme smallholders' wages were 1.8 times the provincial minimum wage in Riau and 1.7 times in Jambi (Asian Agri, 2025).

The Doughnut Economy in Asian Agri

Figure 1: The Doughnut Economy



Source: Doughnut Economics Action Lab, n.d.

The concept of the Doughnut Economy offers a way to assess the economy's performance by the extent to which people's needs are met without overshooting the ecological ceiling (Doughnut Economics Action Lab, n.d.). The goal is to build a regenerative and distributive economy that meets the needs of all within the means of the living planet. Asian Agri's strategy, particularly its Asian Agri 2030 (AA2030) framework, demonstrates a significant effort to balance socio-economic development with environmental consciousness, which aligns closely with the concept of the Doughnut economy.

Upholding the Social Foundation

Apart from developing a close and intensive partnership with over 35,000 smallholder farmers, Asian Agri has initiated a premium sharing programme, which allocated IDR

5.37 billion (about US$340,000) for community development in 2024 (Asian Agri, 2025). This commitment extends to providing education and health support for both employees and the surrounding communities. Its Sayap Garuda Foundation provides 120 scholarships to employees' children in 2024 (Asian Agri, 2025). Other initiatives include renovating schools and providing educational facilities. The AA2030 target includes providing 5000 sets of school essentials by 2030, and they have already achieved 27.1% of this by 2024. Furthermore, they also explicitly commit to strengthening local food security. This includes supporting community livestock (distributing over 80 goats, 370 chickens, and 39000 fish seeds in 2024) and providing alternative income sources during the non-productive replanting period (Asian Agri, 2025).

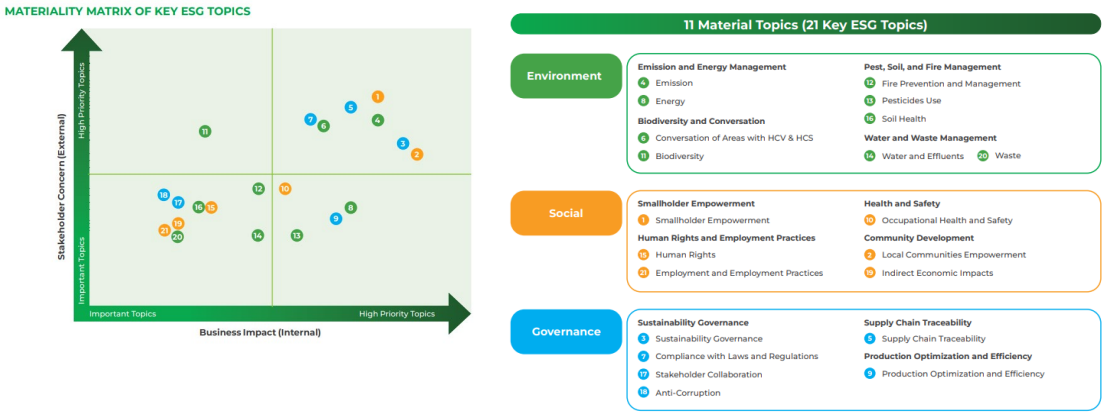
Respecting the Ecological Ceiling

Other than using 11 biogas plants to reduce methane emissions, Asian Agri directly addresses land conversion and biodiversity loss through a moratorium on new plantation expansion since 2003 and an NDPE policy. Moreover, to reduce chemical pollution, Asian Agri is actively reducing its reliance on synthetic inputs, achieving a 31% reduction in pesticide use in 2024 against its 2030 goal of 50%.

Our research suggests that Asian Agri's model demonstrates a strong and tangible effort to operate within the Doughnut Economy concept. The company shows that it is possible for a major agricultural enterprise to pursue economic goals while actively working to uphold social foundations and respect ecological limits.

Environmental and Social Dimensions of Sustainability

Figure 2: Materiality Matrix of Key ESG Topics of Asian Agri



Source: Asian Agri, 2025

Evident in Figure 2, Asian Agri's top sustainability priorities are emission control, biodiversity preservation, and smallholder empowerment. This prioritisation shows the

firm's understanding that social welfare and environmental preservation are interdependent pillars of long-term corporate success rather than distinct agendas. By incorporating these priorities into its main strategy, Asian Agri demonstrates its conviction that sustainable corporate resilience and ecosystem health are the cornerstones of ethical palm oil production.

Social

Community Empowerment, Socio-Economic Impact, and Externalities

Asian Agri's social sustainability strategy serves as an example of how traditional CSR, which prioritised philanthropy and compliance, is giving way to emerging strategic sustainability, which places an emphasis on shared value, systemic collaboration, and empowerment. The company corrects market failures through inclusive programmes that yield both social and economic returns, integrating social development directly into its business model in place of temporary donations.

This strategy is demonstrated by the Smallholder Inclusion for Better Livelihood and Empowerment (SMILE) Programme, which was created in collaboration with Apical and Kao. By 2024, SMILE had provided technical training, RSPO certification, and replanting support to over 3,400 independent smallholders in North Sumatra, Jambi, and Riau (Asian Agri, 2025). Participating farmers gained access to premium pricing and earned a total of IDR 5.37 billion in premiums through microfinance and sustainability-linked incentives, encouraging sustainable farming methods and long-term financial stability (Asian Agri, 2025). In all, participating farmers receive important benefits such as better financial literacy, increased resilience to unstable market conditions, and access to premium pricing for certified sustainable palm oil. This project exemplifies the circular economy concept, which holds that social capital, knowledge and resources continuously build regenerative community systems, as opposed to one-time assistance.

Furthermore, by using community incentives and training to prevent emissions related to fire and haze, the Fire-Free Village Program (FFVP) also internalises negative externalities. Asian Agri rewarded villages for their effective fire prevention efforts in 2024 by achieving zero fire incidents (Asian Agri, 2025). This illustrates how incentives motivated by sustainability can turn possible social costs into benefits for all. SMILE and FFVP are in line with externality theory, which contends that companies can internalise social and environmental costs by using incentive-based and cooperative governance models (Mehrabi & Giagnocavo, 2024).

Human Capital and Well-Being

Asian Agri demonstrates its social responsibility by focusing on internal workforce well-being through robust development and health initiatives. This commitment is quantified by an average of over 33 training hours per employee in 2024 (Asian Agri, 2025),

maintaining a zero-fatality record via its ISO 45001 Occupational Health and Safety (OHS) system, and providing free healthcare to employees and their families. Furthermore, Asian Agri ensures employees and their families have access to comprehensive, free healthcare, delivered through dedicated estate clinics, mobile health posts, and established partnerships with major national providers like BPJS and the National Family Planning Agency.

These programmes generate positive social benefits like improved productivity and lower absenteeism, which aligns with the theory of CSR as market correction by integrating social costs into business practice. Furthermore, the company champions gender equality and labour rights under its No Exploitation clause, thereby operationalising the Protect, Respect, Remedy framework from the UN Guiding Principles on Business and Human Rights (United Nations, 2011). Ultimately, by making human dignity and labour welfare central to its strategy, Asian Agri affirms that internal social sustainability is a prerequisite for both organisational performance and long-term corporate resilience.

Environmental

Mitigation Strategies

Asian Agri has proactively adopted a variety of mitigation strategies aimed at lowering its environmental footprint, particularly its contribution to climate change. A cornerstone of this effort is the Asian Agri 2030 (AA2030) Carbon Roadmap, which plots the company's path toward achieving carbon neutrality by 2030. This roadmap clearly establishes measurable targets and initiatives designed to significantly cut greenhouse gas (GHG) emissions across all operational domains. For instance, the company's investment in methane capture facilities has already yielded a 90% reduction in methane emissions, with plans for further expansion of its biogas plants. Simultaneously, Asian Agri is actively transitioning to use 100% renewable energy in all milling and processing activities, powerfully reinforcing its commitment to a cleaner energy future (Asian Agri, 2025).

Asian Agri's long-standing No Deforestation, No Peat, No Exploitation (NDPE) policy, in effect since 2014, represents another key mitigation strategy for reducing environmental impact. The company rigorously enforces a zero-burning policy for land clearing, a critical measure that prevents uncontrolled fires and the subsequent release of significant carbon dioxide, aligning with sustainable land management practices (Asian Agri, 2025). Furthermore, Asian Agri prohibits new development on peatlands and actively manages existing peat to minimise associated emissions. To reduce agrochemical emissions, the firm substitutes chemical fertilisers with organic waste, such as empty fruit bunches, and uses biological methods for pest control. While these operational efforts are commendable, the company's ambitious goal of achieving net-zero emissions from land use still has some way to go. Adopting standards like Science Based Targets could provide valuable improvement.

Nonetheless, the combination of these strategies demonstrates meaningful progress in climate action.

Adaptation Strategies

Climate adaptation has become an increasingly vital focus for Asian Agri as Indonesia continues to grapple with rising temperatures and extreme weather. In 2024, for example, the country experienced severe flooding that directly impacted the company's operations in Riau and South Sumatra (Asian Agri, 2025). To proactively address these escalating risks, the company planned to conduct a formal Climate Change Risk Assessment (CCRA) in 2025. This assessment will guide strategies to enhance resilience, including improving drainage systems, adjusting planting calendars, and investing in more robust infrastructure.

Asian Agri also contributes to resilience by distributing high-yield TOPAZ seedlings, a strategic move that enhances land productivity without requiring the conversion of new forest areas (Asian Agri, 2025). At the community level, its partnership in conserving the Biang Sari Customary Forest promotes ecosystem-based adaptation by actively maintaining critical watersheds and protecting against erosion and landslides. This entire approach is especially relevant in sectors like palm oil, given the premise of the Environmental Kuznets Curve (EKC), which suggests that environmental performance often improves once a firm or country achieves a critical level of economic development and institutional maturity. Asian Agri's decision to conduct the CCRA represents an intentional move towards this 'turning point' where sustainable, long-term planning takes precedence over short-term cost minimisation.

Environmental Outcomes and Ecological Significance

When combined, Asian Agri's adaptation and mitigation plans show a move away from discrete operational enhancements and towards landscape-based sustainability. The company contributes to the preservation of carbon stocks and reduces the demand for new land conversion by stabilising peat ecosystems, lowering methane emissions, and increasing land productivity. Ecosystem resilience against climate variability is increased, and biodiversity is supported through the preservation of soil health and watershed functions. These environmental performance results demonstrate a strategic approach that aligns the firm's growth trajectory with regional climate and conservation goals.

The Governance Dimension of Sustainability

In the governance dimension, we evaluate how the interests of diverse stakeholders are balanced, as well as how oversight shapes corporate behaviour. These will be discussed in terms of its Board of Directors, Policies and Regulations.

Board of Directors

Asian Agri is a privately held company, and information about its Board of Directors is limited. Its Sustainability Report 2024 indicated that in terms of diversity, 100% of its board and 94% of its senior managers are male, signalling low gender diversity. A breakdown was also given for age—50% of its board in 2024 were aged 51 and above, while the other 50% were in the 31-50 range.

A study on diversity in boards and senior management in Singapore-listed companies found that gender, age, and education diversity positively influence financial performance (Loh et al., 2022). Hence, Asian Agri could do more to have more diverse leaders to better balance diverse stakeholder interests.

Policies

Another mechanism of governance is policies, as they direct the operations. Asian Agri's policies for sustainability include the zero-burning policy, which prohibits burning to clear land, and the No Deforestation, No Peat, No Exploitation (NDPE) policy (Asian Agri, 2025). However, the NDPE policy faced doubts regarding its implementation. The Rainforest Action Network (2024) pointed out that deforestation has persisted in Royal Golden Eagle (RGE) Group's palm oil operations, with over 1,475 ha cleared inside the concessions of its palm oil producer Asian Agri. A satellite analysis of natural forest loss concluded that the company has failed to implement its NDPE policy. This event damages Asian Agri's reputation and also casts doubts on RGE's sustainability-linked loans.

However, Asian Agri has made progress in other policies such as the Fresh Fruit Bunch (FFB) traceability. They have reached and maintained 100% traceability on the plantations and mills (Asian Agri, 2025).

Regulations

Government regulations serve as a mechanism to resolve tensions between a company's pursuit of economic gains and society's social and environmental priorities. The enforcement of regulations assists in balancing these competing interests. For example, the Indonesian government aims to reduce greenhouse gas (GHG) emissions and has introduced related carbon regulations. These create a need for companies to reconsider their current operations, ideally leading to operational innovation while maintaining economic gains. In the case of Asian Agri, these regulatory requirements created opportunities to explore biogas technology. It has built 11 biogas plants designed to capture methane, which can potentially reduce GHG emissions from mill operations by 90% (The Jakarta Post, 2025). These plants also provide electricity for the firm's operations. Thus, the biogas plants surface as a sustainable solution while maintaining a balance among compliance, profitability, and environmental responsibility.

Critical Analysis and Evaluation

Strengths and Successes

Asian Agri's advantage lies in its transparent and inclusive palm oil supply chain. The company utilises its Fresh Fruit Bunch (FFB) digital traceability system to track FFB from the plantations and mills to the processing point. It also strives to balance environmental responsibility with economic benefits. Its biogas projects embody the principles of the circular economy and the 3R model (Responsibility, Risk and Return). At the same time, the company helps smallholder farmers achieve RSPO certifications and long-term buyback contracts. By doing so, the income and living conditions of the farmers, as well as the economic inclusion and environmental protection in rural areas, have been improved.

Weaknesses and Challenges

While Asian Agri has built an inclusive and transparent palm oil supply chain, its sustainability strategy still suffers from several structural flaws.

First, an obvious flaw is the traceability gap for independent smallholders. The company has achieved traceability transparency for its own and affiliated plantations through its Plasma scheme. However, many smallholders still sell their fresh fruit bunches (FFBs) through middlemen. As a result, companies often struggle to identify the source of their raw materials, increasing the risk of non-certified or illegal fruits entering the supply chain (Roundtable on Sustainable Palm Oil (RSPO), 2023).

Furthermore, smallholders have limited financial resources and struggle to afford the costs and training required for RSPO or ISPO certification, resulting in slow implementation of sustainability standards at the grassroots level (World Bank Group, n.d.). This reflects the institutional constraints to inclusive sustainability within decentralised agricultural value chains: while the company has implemented digital traceability at the core, ensuring compliance with digital traceability and transparency across all other supply chains requires long-term capacity building and policy implementation. Therefore, the challenge is bridging the traceability gap for smallholder farmers while ensuring commercial efficiency, sustainability and social legitimacy throughout the value chain.

Another major challenge lies in reputation management and land disputes. Although Asian Agri has been promoting its NDPE policy in recent years and improving land use compliance through third-party certification, certification may still be a weak tool to address deforestation (Greenpeace International, 2021). Separately, unclear land allocation and community tenure disputes during the early stages of palm oil plantation expansion also highlight the importance of ongoing communication and transparent grievance mechanisms.

Furthermore, public perception of the palm oil industry remains negative, with it widely viewed as a “high-risk industry”. Even companies that have significantly improved their environmental performance may still be affected by the overall image of the industry (Kolinjivadi et al., 2019). If companies lack consistent mechanisms for information disclosure, third-party verification, and community engagement, their reputational vulnerability will be further amplified, impacting brand trust and long-term social license to operate in international markets. Therefore, establishing more transparent and open data systems and a multi-stakeholder collaboration platform is crucial for Asian Agri.

Finally, Asian agriculture also faces limitations in external auditing, independent assurance, and corporate accountability. Although annual sustainability reports are audited by third-party organisations, most certifications focus solely on milling and processing, not the entire supply chain. This is particularly true in the areas of carbon accounting, biodiversity monitoring, and social impact analysis. If companies could implement more detailed independent audits and cross-sector verification mechanisms, this would significantly enhance their environmental and social accountability (Eccles et al., 2014).

At the same time, companies also face the 4C challenges in decarbonising operations, such as increased costs associated with green technology upgrades, consumer skepticism about paying a sustainability premium, internal resistance to change, and the challenge of maintaining long-term commitments in a volatile environment (Loh, 2021). These four pressures reflect a widespread structural tension within the palm oil industry: the need to maintain sustainable performance to achieve profitability.

In summary, while the company’s sustainable development strategy has achieved some success, it still faces challenges from multi-dimensional structural constraints. These constraints indicate that the company’s sustainable transformation depends not only on technological and institutional innovation, but also on its ability to integrate and coordinate within its multi-level governance structure.

Overall Impact Assessment

Overall, Asian Agri’s sustainability efforts have generated significant co-benefits across economic, environmental, social and cross-cutting dimensions. Meanwhile, the company is also situated at an intersection of seemingly conflicting objectives: preserving forests, peatlands, and rural livelihoods while boosting palm oil productivity to aid in the country’s economic development. Important sustainability trade-offs result from these conflicting goals, which are not always amenable in the short term. These trade-offs are highlighted in the table below, analysed through different dimensions.

Table 1: Outcomes and Trade-offs

Dimension	Positive Outcome	Trade-off/Tension
Economic	TOPAZ seeds and the commercialisation of biogas increase long-term income and productivity.	Farmers need strong temporary support because replanting results in a short-term loss of income.
Environmental	NDPE stops deforestation and peatland conversion, while biogas lowers emissions.	Productivity must rise on existing land due to limited land expansion, leading to more emissions.
Social	Training, access to credit, and more secure employment for smallholder farmers are provided by the Plasma scheme.	Community discontent and non-compliance may result from uneven assistance or delays.
Cross-cutting	Sustainability programmes improve supply chain transparency and energy efficiency.	Smallholders are strained by the costs of certification and compliance, which can also raise issues of equity and exclusion.

Economic: Long-term financial gains can be obtained from the commercialisation of biogas plants and the introduction of Topaz high-yielding seeds. However, smallholders lose money during the multi-year maturity period needed for replanting. In the absence of strong temporary compensation and support networks, this leads to financial strain and might deter full participation. It illustrates a typical trade-off in development: short-term financial sacrifices are frequently necessary for long-term productivity gains.

Environment: The company's biogas projects capture methane and reduce greenhouse gas emissions. This value chain reduces the company's carbon footprint and reliance on fossil fuels. At the same time, its NDPE policy protects peatlands and forests, advancing climate goals and demonstrating how large-scale agriculture can move towards a low-carbon model. However, it also limits the possibility of growing the business through land expansion. The business must therefore increase productivity on its current land, which calls for additional funding, better technology,

and sustainable agronomy. This transition can be expensive and technically complex, particularly for smallholders with little access to resources.

Social: Asian Agri's Plasma scheme for independent farmers helps them access training, loans, and stable incomes, improving rural livelihoods and fostering social inclusion. However, stakeholder engagement and consistent delivery are essential to these programmes' success. Community discontent, labour disputes, or the abandonment of sustainable practices may result from perceived inequalities or delays in support. Social cohesion thus becomes a governance priority as well as a risk.

Cross-cutting: The company's sustainability strategy has evolved from a compliance requirement to a competitive advantage. Its biogas projects meet international ESG standards by producing energy and lowering emissions. The company's use of transparent digital systems improves supply chain efficiency, reduces business risks, and addresses increasingly stringent global regulations. By prioritising renewable energy and waste, Asian Agri has increased energy self-sufficiency and reduced costs. However, supply chain partners are under financial and administrative strain to ensure compliance with RSPO, Indonesia Sustainable Palm Oil (ISPO) certification scheme, and the future EU Deforestation Regulation (EUDR). Without institutional support, independent smallholders may be burdened by certification fees and audit complexity. Equity issues may arise from this friction if it results in these farmers' exclusion from certified supply chains.

Recommendations and Conclusion

To enhance its sustainability impact and consolidate its leadership position, Asian Agri should prioritise the following strategic recommendations.

- Strengthen supply chain transparency and stability, expand digital applications, and apply necessary support systems to address traceability gaps. The company needs to ensure that the technological support can reach all independent smallholder farmers. Additionally, dedicated funds can also be established for smallholders to provide them with certification and technical support through low-interest loans. This collaborative approach not only reduces waiting time for getting certification for smallholders but also empowers enterprises to enhance bargaining power and resource integration, thereby scaling operations and contributing to broader agricultural development. Partnering fintech companies and the government can reduce certification costs and improve data transparency, as well as comply with global standards and regulations.

- Regarding internal governance, management and audit processes should be improved, and allegations should be addressed proactively. Enterprises should promote gender and age diversity by increasing the number of women and

young leaders on their boards and management teams. Diverse management enables enterprises to identify issues from a more comprehensive perspective and develop innovative strategic approaches. Enterprises can also engage independent third-party audit firms for more rigorous, full-chain audits of carbon roadmap, biodiversity, and social impacts. Publicly addressing NGOs' greenwashing allegations is another practice to maintain its brand reputation. Establishing transparent dispute resolution and communication mechanisms can help companies gain the trust of regulators and consumers while strengthening its brand image.

- Continuously advance the circular economy and green energy development. Expand the coverage of biogas plants to convert waste into biogas or biofertiliser to achieve energy self-sufficiency and external sales. Also, develop biochar or organic fertilisers, using waste products such as empty fruit bunches as an alternative to chemical fertilisers. These actions can reduce costs while increasing new revenue streams. In addition, companies should enhance climate resilience to stabilise production conditions and mitigate the impact caused by natural environmental events. Complete a Climate Change Risk Assessment (CCRA) and implement specific adaptation measures, such as improving drainage systems and adjusting planting calendars. Asian Agri should also continuously invest in ecological restoration projects, including protecting and restoring soil health. Although these initiatives represent long-term projects that require significant upfront financial and time investments, they are crucial for achieving sustainable profitability in the future.

- Asian Agri can maintain competitiveness by pursuing international expansion. Understanding the culture, consumer values, and laws and regulations of different countries helps shape development strategies, thereby enhancing trust among international investors and consumers. Obtaining international certification standards can enhance a company's global influence and branding.

Asian Agri has demonstrated that profitable palm oil production and robust sustainability credentials are not mutually exclusive. While challenges persist, the company now positions sustainability as a core corporate direction. By addressing its weaknesses and enhancing its strengths, Asian Agri can not only navigate the evolving regulatory landscape but also continue to play a leading role in the transition to a truly sustainable palm oil industry.

Discussion Questions

1. How can Asian Agri ensure that farming practices on the ground comply with its sustainability policies?

2. What will enable Asian Agri to create a sustainability ecosystem? Discuss the opportunities and barriers.

3. How will global regulations and geopolitical developments shape the firm’s sustainability direction?

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Greening the Skyline: CDL's Journey Towards Net-Zero and Regenerative Cities

DONG Yanjing

GUAN Jian

Jayni Jasmin PATEL

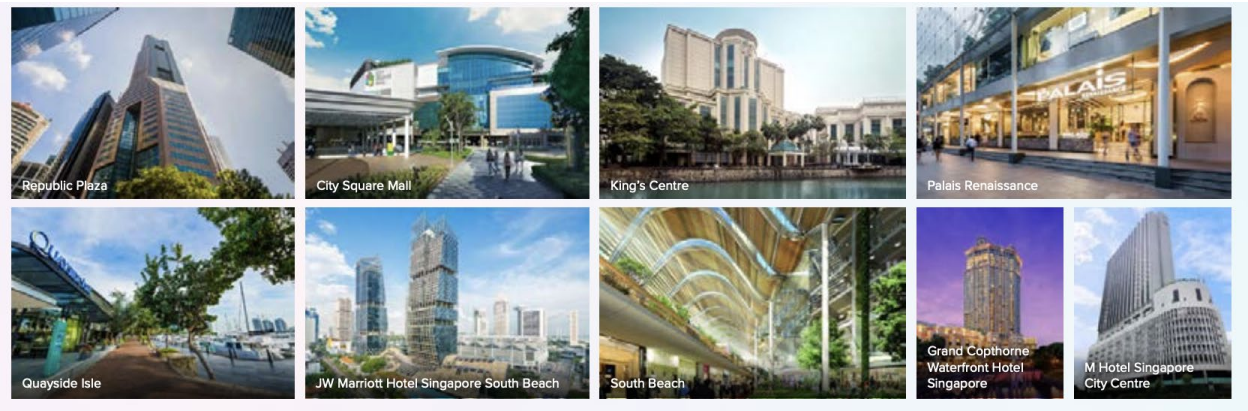
QI Xuanlin

Loh, L., & Ang, H. M. (Eds.). (2026). *Cases in sustainability (Vol. 2: System-level and structure-based approaches).* Centre for Governance and Sustainability, NUS Business School.

Company Overview

City Developments Limited (CDL) is one of the largest real estate groups in Singapore and a benchmark in the industry. This enterprise operates across four core areas: real estate development, hotel investment and operations, hotel hospitality trust and real estate investment trust, as well as asset and property management. Among these, real estate development remains CDL's core segment, covering more than 20 countries and over 100 regions, including high-end residences, commercial complexes and industrial projects. In the hotel investment and operations sector, CDL has established a global hospitality network through its wholly owned subsidiary, Millennium Hotels and Resorts. As of 2024, the portfolio comprises over 160 hotels, with a strategic focus on key markets such as London, New York and Singapore. Moreover, CDL established CDL Hospitality Trusts, which mainly invest in global hotel and accommodation assets. These trusts provide CDL with stable rental income and also offer a platform for CDL's capital circulation and light-asset development. CDL's asset and property management activities include managing private real estate funds and providing professional facility management services for existing properties, ensuring that the properties can operate well and maintain their value over the long term.

Figure 1: CDL's Projects over the Years



Source: City Developments Limited, 2024c

As a global leader in sustainable development, CDL is best known for its commitment to environmental protection and social responsibility. In the 1990s, CDL formally incorporated environmental considerations into its corporate strategy, marking an early foundation for its environmental, social, and governance (ESG) practices. The company released its first sustainability report in 2008, which was also the first Global Reporting Initiative (GRI)-checked sustainability report published by a Singapore-listed company.

The development of CDL is tied to the development of Singapore. As Singapore transforms from a small island into a modern city, CDL turns to developing buildings with the environment and resource conservation in mind. The aim is for these buildings

to be energy-saving, healthy for occupants and operate with low costs. This becomes part of the answer to climate change concerns and part of real estate firms' social responsibility.

In CDL's sustainable development concept, green development has become a comprehensive guiding principle across the entire value chain, from design to supply chain and operations. This is reflected in mandatory compliance with internationally and nationally recognised green building certifications, including but not limited to Leadership in Energy and Environmental Design (LEED) and the Building and Construction Authority (BCA) Green Mark Scheme. In addition, CDL has implemented green procurement policies, requiring suppliers and contractors to comply with defined environmental protection standards, and has undertaken systematic green retrofitting of existing buildings to enhance energy efficiency. Sustainable development within CDL has moved beyond a system requirement to an "enterprise gene", driving the voluntary actions of employees and stakeholders.

The subsequent sections of this paper analyse the impact of sustainable development on enterprise operations, evaluate sustainable development performance using the CDL case study, and identify prevailing challenges that enterprises face in pursuing sustainable development. Critical insights and conclusions will be presented.

Sustainability Journey (1995–2025)

City Developments Limited (CDL) began its sustainability journey in 1995 with the core philosophy "Conserving as We Construct", which emphasises responsible development alongside environmental protection (City Developments Limited, 2025). It became the foundation of CDL's corporate culture and strategy, making CDL one of Singapore's earliest real estate companies to include sustainability in its long-term business plan.

In 2003, CDL formalised its environmental practices through the introduction of an Environmental, Health, and Safety (EHS) policy and the attainment of ISO 14001 environmental management system certification, strengthening internal management and establishing measurable environmental standards for future projects (City Developments Limited, 2025).

In 2008, CDL published its first Sustainability Report based on the GRI framework and started disclosing carbon data to the Carbon Disclosure Project (CDP). This marked CDL as an early adopter of international sustainability reporting standards within Singapore's property sector.

In 2009, CDL launched 11 Tampines Concourse, described as Asia-Pacific's first carbon-neutral development, and opened City Square Mall, widely recognised as Singapore's first eco-mall. These projects reinforced CDL's reputation for green building innovation.

From 2010 onwards, CDL has been consistently listed on the Global 100 Most Sustainable Corporations in the world, often emerging as the highest-ranked Singapore-based company. This recognition strengthened its international reputation as a sustainability leader.

In 2015, CDL became the first real estate company in Singapore to adopt the Integrated Reporting framework, combining financial and non-financial information to show how sustainability contributes to long-term value (City Developments Limited, 2017).

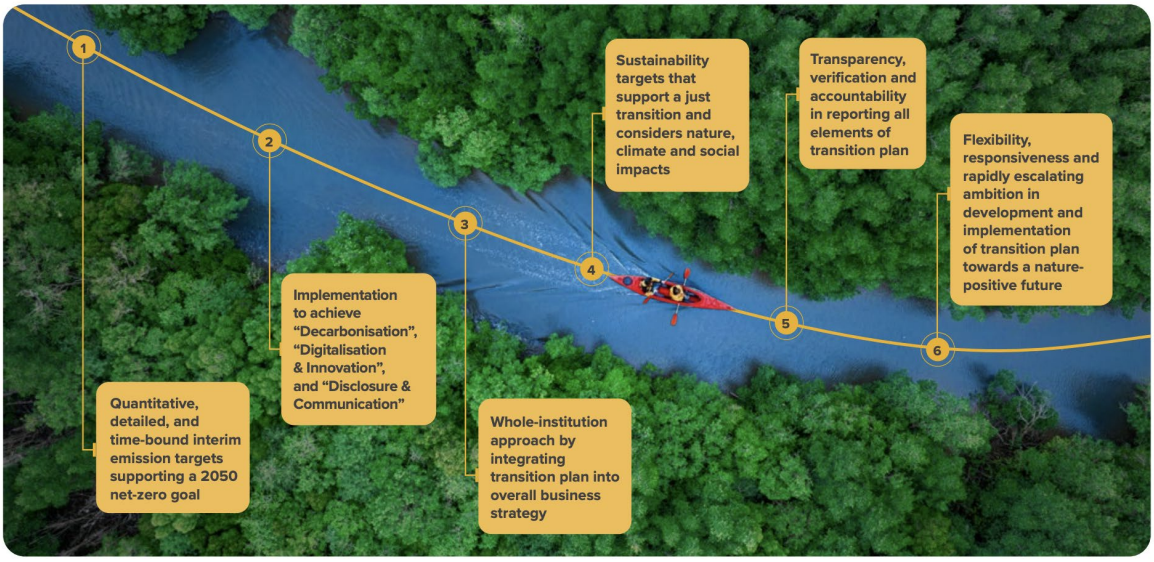
Between 2016 and 2017, CDL partnered with the Sustainable Energy Association of Singapore (SEAS) to establish the Singapore Sustainability Academy (SSA), positioned as the country's first zero-energy training and education platform promoting climate action and community learning (City Developments Limited, 2016). During the same period, CDL launched its Future Value 2030 Blueprint, setting clear targets such as a 38% reduction in carbon emissions intensity by 2030 relative to the 2007 baseline, expanded green building adoption, and increased female representation on the board (City Developments Limited, 2018).

In 2018, CDL further aligned its strategy with global frameworks, including the United Nations Sustainable Development Goals (SDGs) and the Task Force on Climate-related Financial Disclosures (TCFD), becoming one of the earliest Asian real estate firms to do so (3BL Media, 2018).

In the 2020s, CDL continued to enhance transparency and deepen its climate strategy. It strengthened its commitment to the Science-Based Targets initiative (SBTi) and, in 2024, adopted the Task Force on Nature-related Financial Disclosures (TNFD) to address biodiversity and natural capital risks and opportunities. CDL also launched a S$400 million sustainability-linked loan incorporating nature-related performance indicators, showing its innovative approach to sustainable finance (City Developments Limited, 2025).

In 2025, CDL released its 18th Integrated Sustainability Report, titled "Zero in on Action: Fast-Forwarding Towards Sustainable Ecosystems". The report marked 30 years of sustainability progress, showing how CDL evolved from a "green building pioneer" to an ecosystem-driven creator of sustainable value, supported by strong governance, transparent reporting, and nature-positive strategies aligned with its 2030 goals (City Developments Limited, 2025).

Figure 2: CDL's Sustainability Implementation Journey



(Source: City Developments Limited, 2024b)

Board Governance and Leadership

CDL has a strong governance framework that ensures accountability, transparency, and sustainable leadership. The Board of Directors takes collective responsibility for setting the company's strategy, ensuring sufficient resources, and overseeing risk management and internal control systems (City Developments Limited, 2024a). Its main goal is to create long-term value for shareholders through sustainable growth while protecting the interests of a broader set of stakeholders.

The Board comprises executive, non-executive, and independent directors, balancing management expertise with independent oversight. Executive Chairman Mr Kwek Leng Beng and Group Chief Executive Officer (CEO) Mr Sherman Kwek Eik Tse lead the management team, while independent directors such as Mr Philip Lee Jee Cheng help ensure accountability and alignment with the Singapore Code of Corporate Governance (City Developments Limited, 2024a).

To strengthen oversight, CDL has four main committees. The Audit and Risk Committee (ARC) monitors financial integrity and enterprise risk; the Nominating Committee (NC) manages board composition and succession; the Remuneration Committee (RC) links executive pay to long-term company performance; and the Board Sustainability Committee (BSC) oversees environmental, social, and governance (ESG) strategies, including climate risk and workplace safety (City Developments Limited, 2024a). The creation of the BSC underscores CDL's commitment to placing sustainability at the highest level of corporate leadership.

CDL also maintains active communication with investors, employees, customers, communities, and regulators, integrating their views into business strategy and

sustainability reporting. One example is the Singapore Sustainability Academy, a public-private partnership promoting low-carbon education and community engagement (City Developments Limited, 2016). Through this inclusive approach, the Board ensures that stakeholder perspectives on climate, safety, and diversity are reflected in company decision-making.

Key Initiatives and Net-Zero Targets

CDL has long considered green buildings at the core of its sustainability strategy. The company was an early signatory of the World Green Building Council's Net Zero Carbon Buildings Commitment, showing its ambition to achieve net-zero emissions across its operations. According to CDL's 2025 report, the company has reduced its Scope 1 and 2 carbon emissions by 25% from the 2016 baseline, and has achieved a 38% reduction in Scope 3 embodied carbon in new developments compared to 2016 levels (City Developments Limited, 2025). This progress shows that CDL not only focuses on energy-efficient design but also integrates green thinking throughout the entire development and asset management process.

In terms of nature-positive projects, CDL launched two innovative projects in 2025 – the CDL EcoTrain and the CDL MicroForest. The CDL EcoTrain repurposes a decommissioned Mass Rapid Transit (MRT) train carriage into a zero-energy sustainability education space, promoting circular reuse and climate learning. The CDL MicroForest, created in partnership with Singapore's National Parks Board (NParks) and National University of Singapore (NUS), is a 2,800-square-foot regenerative microforest located in the city centre. It aims to improve biodiversity and reduce the urban heat island effect (3BL Media, 2025). These projects reflect how CDL combines "built environment" with "natural capital" to promote urban ecology and community awareness.

In addition, CDL has set its "Operational Net Zero 2030" target and is advancing decarbonisation through internal carbon pricing, green financing, and climate scenario analysis. In 2024, CDL became the first real estate company in Singapore to publish disclosures aligned with the TNFD framework and secured a S$400 million sustainability-linked loan tied to nature performance. This milestone marks CDL's shift from a focus on carbon neutrality towards a broader nature-positive orientation, symbolising a transition from emission reduction to ecosystem restoration.

Strategic ESG Integration

CDL's Value Creation Model

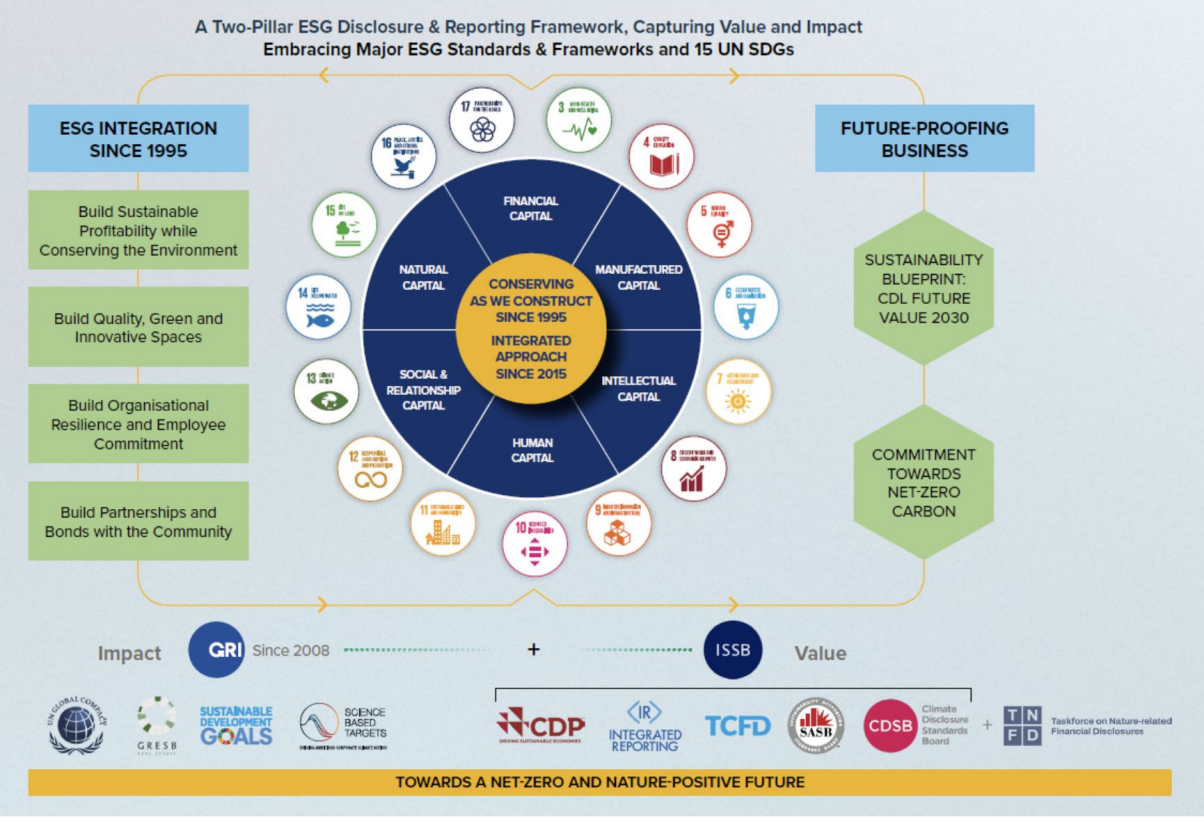
CDL developed its Value Creation Model to demonstrate how sustainability drives long-term business success. This framework integrates environmental, social, and governance (ESG) performance with financial value creation, showing that profitability

and sustainability can be mutually reinforcing rather than competing objectives. Rooted in the principle “Conserving as We Construct”, the model reflects CDL’s belief that responsible development requires a balance between economic growth, environmental protection and community well-being.

The model highlights six interlinked forms of capital—financial, manufactured, intellectual, human, social, and natural—through which CDL creates and sustains value across all dimensions of its business. Rather than treating ESG separately from operations, CDL embeds sustainability considerations into decision-making, design, and investment processes. Each form of capital contributes to sustainable outcomes: financial strength supports green innovation, human and social capital drive inclusivity and resilience, while natural capital underpins CDL’s efforts in decarbonisation and biodiversity protection (City Developments Limited, 2025).

By aligning its operations with major international sustainability and reporting frameworks, such as GRI, International Sustainability Standards Board (ISSB), SBTi, TCFD, and TNFD, CDL ensures transparent, comparable, and credible reporting. This integration supports its *Future Value 2030 Blueprint* and commitment to a net-zero and nature-positive future. Overall, CDL’s Value Creation Model embodies a modern understanding of corporate sustainability, in which ESG principles function as essential drivers of long-term innovation, trust, and value creation.

Figure 3: CDL’s Value Creation Model



Source: City Developments Limited, 2025

Sustainability Impact Assessment

CDL has long positioned sustainability as a central pillar of its business strategy. With quantifiable objectives in line with ambitious international benchmarks, including SBTi, CDP, Global Real Estate Sustainability Benchmark (GRESB), and BCA Green Mark scheme, CDL's sustainability journey has progressed substantially over the past decade.

Emissions and Energy Performance

Aggressive carbon emissions reduction remains a key component of CDL's sustainability plan. CDL has publicly committed to reducing the intensity of Scope 1 and Scope 2 carbon emissions by 63% per square meter of gross floor area by 2030, a target that has been validated by the SBTi, demonstrating adherence to the objectives of the Paris Agreement.

According to CDL's Q1 2024 sustainability disclosures, the company has achieved a 26.5% reduction in operational carbon emissions intensity, demonstrating strong progress towards its interim climate milestones (City Developments Limited, 2024d). This improvement has been driven primarily by investments in energy-efficient technology and operational savings, including asset upgrades, deployment of intelligent energy management systems, and the increased use of renewable energy where feasible. As a result, measurable energy savings have been realised across CDL's diverse portfolio. For example, the company's office and industrial assets reportedly recorded a 24.7% decrease in energy consumption intensity, while its retail properties achieved an 18.6% decrease (City Developments Limited, 2024d). These outcomes have been enabled by the proactive implementation of green building techniques, improved insulation, retrofits of LED lighting, sophisticated advanced heating, ventilation, and air-conditioning (HVAC) controls, and the incorporation of Building Management Systems (BMS) for real-time energy monitoring.

CDL has also concentrated on more comprehensive resource-efficiency initiatives to supplement energy and carbon targets. Supported by the installation of water-efficient fixtures, rainwater harvesting systems, and intelligent irrigation systems, office buildings have reportedly achieved a 28% reduction in water consumption intensity, exceeding interim targets. Improved recycling programmes and circular economy pilots, particularly those aiming at reusing waste from construction and demolition, have contributed to a 16.7% decrease in waste intensity for office assets and a 7% decrease for retail properties (City Developments Limited, 2024d). These initiatives highlight CDL's integrated and multi-dimensional approach to sustainability, addressing all major environmental impacts, from waste and water to energy and emissions.

Biodiversity Initiatives and Nature-Positive Leadership

Beyond resource consumption and emissions reduction, CDL's sustainability approach embraces a nature-positive mindset, recognising the vital role of ecosystem services and biodiversity in enhancing urban resilience and well-being.

The urban "MicroForest" initiative, a pocket forest planted within Singapore's urban landscape to increase local biodiversity, improve air quality, and foster community participation, was one of the innovative biodiversity projects highlighted in CDL's 2024 Integrated Sustainability Report. This project exemplifies CDL's commitment to nature-based solutions by integrating ecological restoration into urban development.

Additionally, CDL became one of the first real estate companies in Singapore to align its corporate disclosures with the TNFD framework, systematically identifying nature-related risks and opportunities across its operations. This action reflects CDL's industry leadership and progressive openness in handling ecosystems and biodiversity matters. In addition to CDL's climate disclosures, TNFD-aligned reporting demonstrates a more integrated approach to environmental stewardship that prioritises ecosystem preservation and carbon reduction.

CDL's creative funding models are also based on biodiversity objectives. The company has obtained significant sustainability-related loans with performance indicators linked to nature-positive outcomes, signalling growing financial recognition and monetisation of ecosystem services within urban development contexts.

Certifications and External Validation

A number of reputable third-party certifications and index rankings provide external validation of CDL's sustainability performance, benchmarking the company against international best practices in the real estate sector.

Figure 4: Sustainability Best Practices: Accolades & Awards

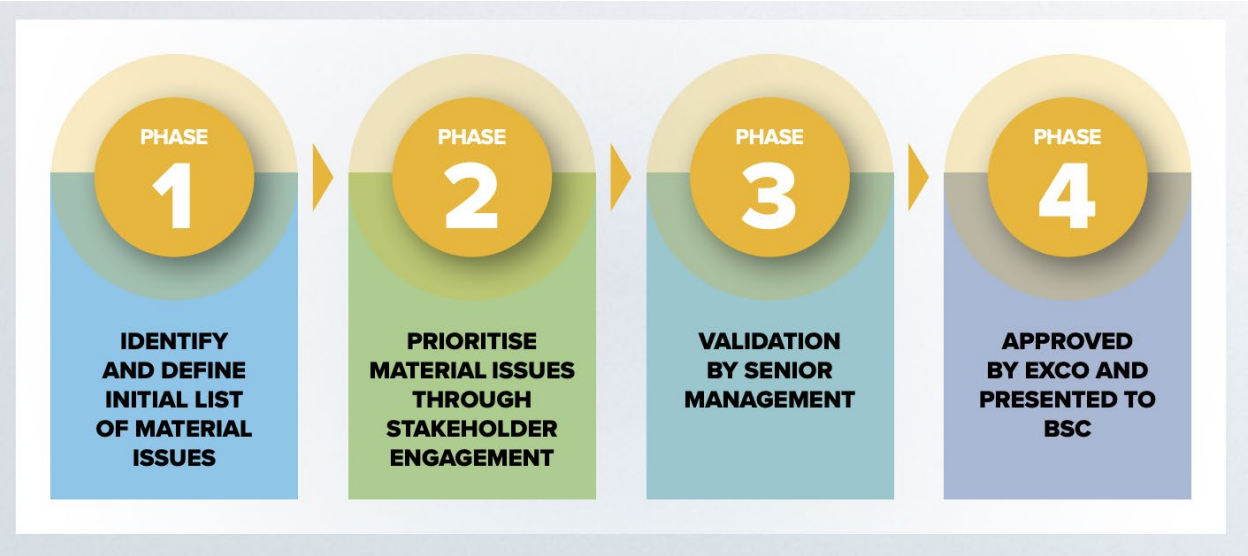
Source: City Developments Limited, 2024b

According to its report, CDL has attained 129 certifications across its development and real estate portfolio under the BCA's Green Mark Scheme, demonstrating strong and consistent performance in green building standards. Numerous buildings are awarded BCA's highest designations, including Green Mark Platinum and Super Low Energy certifications, reflecting CDL's dedication to creating and managing buildings that maximise resource efficiency and reduce carbon footprints beyond minimum regulatory standards.

Materiality Assessment

The foundation of CDL's 2024 materiality evaluation is a double materiality approach, which considers both "outside-in" impacts (how ESG concerns affect CDL's financial performance and resilience) and "inside-out" impacts (how CDL's operations impact the environment and society). This process is conducted annually with the facilitation of an independent third party and involves a wide range of stakeholders, including management, staff, investors, regulators, tenants, suppliers, and sustainability specialists.

Figure 5: Phases of the Double Materiality Assessment



Source: City Developments Limited, 2025

In 2024, CDL revised its materiality evaluation to conform to the International Financial Reporting Standards (IFRS) Sustainability Disclosure Standards S1 and S2 criteria by the International Sustainability Standards Board (ISSB), which place higher priority on financial materiality. Stakeholders ranked 17 ESG issues based on both their impact materiality and financial materiality, using surveys and interviews. To ensure governance oversight and strategic relevance, the outcomes were reviewed and validated by CDL's Executive Committee and Board Sustainability Committee,

ensuring that highly material issues, such as energy efficiency, occupational health and safety, green buildings and governance are prioritised.

Transition from TCFD to IFRS Sustainability Disclosure Standards

As one of the first Singapore companies to obtain external assurance for its TCFD disclosures since 2017, CDL has been at the forefront of climate-related financial transparency. The new IFRS Sustainability Disclosure Standards (specifically IFRS S1 and IFRS S2), which are emerging global standards for sustainability and climate-related financial reporting, were adopted by CDL in 2024.

Task Force on Climate-related Financial Disclosures (TCFD)

CDL's TCFD-aligned disclosures cover governance, strategy, risk management, metrics, and targets related to climate-related risks and opportunities. These disclosures are included in CDL's annual reporting and subject to external assurance.

IFRS Sustainability Disclosure Standards S1 and S2

Building on the TCFD framework, the ISSB guidelines introduce more specific requirements for climate-related disclosures under IFRS S2 and broaden the focus to include all sustainability-related risks and opportunities under IFRS S1. In its 2024 reporting, CDL applies the ISSB's financial materiality lens to prioritise and disclose sustainability-related risks with the potential to affect enterprise value.

Major Issues and Challenges

Despite its industry-leading advancements, CDL's sustainability path is beset by several complex and multifaceted problems that are comparable to those facing the global real estate market.

Deep decarbonisation presents a significant technical and financial obstacle. Since many of CDL's assets are historic structures, it might be challenging to integrate the newest energy-efficient or renewable energy technologies while preserving business continuity. The capital intensity and long payback durations of these technologies necessitate careful financial balancing, even as very low-energy standards increasingly guide new construction.

The transition from conventional carbon reduction to more sophisticated nature-positive solutions also faces capability and spatial limitations. Large-scale ecosystem restoration is hampered by Singapore's dense urban setting, and integrating biodiversity features necessitates creative design and constant observation, aided by emerging frameworks such as TNFD. However, widespread adoption of such approaches remains at an early stage.

From an economic perspective, CDL must manage the expectations of diverse stakeholders, including suppliers required to improve their sustainability performance, investors seeking measurable returns on ESG investments, and tenants concerned about possible interruptions or cost increases. Lifecycle management and circular economy implementation provide further difficulties. Despite CDL's implementation of circular material-use pilots and zero-waste construction initiatives, the availability of high-quality recycled materials and consistent industry-wide standards remains uneven and evolving. Beyond operational boundaries, measuring embodied carbon and Scope 3 emissions necessitates intricate data gathering and close cooperation across disjointed supply chains.

Finally, sustainability reporting and regulatory frameworks are evolving rapidly. To maintain compliance while maximising reporting clarity and minimising administrative burden, CDL's sustainability team needs to stay up to date on global ESG market trends, the Singapore Exchange's (SGX) progressively enhanced climate reporting requirements, and Singapore's transition towards ISSB-aligned disclosures.

Insights and Conclusion

Synthesis of Findings

CDL demonstrates how sustainability can evolve from a compliance obligation into a strategic enabler of long-term value creation. As one of Singapore's leading real estate companies, CDL has consistently integrated sustainability into its business model, governance, and capital management. Over the past decade, the firm has moved beyond a primary focus on "green buildings" towards "nature-positive development", aligning its strategy with global frameworks such as the ISSB and the TNFD.

CDL's Future Value 2030 sustainability blueprint embeds clearly defined environmental and social performance targets into business operations. The company has also pioneered the adoption of sustainability-linked loans and green bonds, such as the S$400 million green finance facility tied to biodiversity outcomes. Leadership oversight through the Sustainability Committee has ensured that sustainability considerations are embedded across decision-making processes, rather than treated as peripheral initiatives.

Strategic Insights

Integration over Isolation

CDL's approach underscores that sustainability is most effective when embedded within corporate strategy. Its sustainability reporting, which has progressively aligned with ISSB S1 and S2 principles, enhances transparency and comparability, thereby

supporting investor confidence. The integration of ESG targets into executive remuneration further strengthens accountability within CDL's governance structures.

Nature as Capital

CDL has increasingly reframed nature from a passive backdrop into an active form of capital. Initiatives such as the *Future Value 2030* roadmap, *My Tree House* children's library, and *EcoTrain* demonstrate the company's philosophy that urban development can coexist with ecological regeneration. This approach resonates with the growing global movement toward nature-based solutions, which seek to balance economic growth with biodiversity conservation.

Data and Disclosure as Trust Drivers

CDL's adoption of digital platforms for real-time energy monitoring and artificial intelligence (AI)-assisted carbon data analytics represents a shift towards more data-driven sustainability. Such transparent disclosure supports regulatory compliance while also strengthening stakeholder trust, particularly among institutional investors who increasingly expect climate reporting grounded in recognised scientific frameworks.

Partnerships for Systems Change

CDL's partnerships with organisations such as the NUS Centre for Governance and Sustainability (CGS), the Singapore Green Building Council, and the United Nations Environment Programme (UNEP) indicate an understanding that sustainability transitions are systemic. These collaborations extend the company's influence beyond property development, positioning it as a regional leader in sustainable finance and environmental innovation.

Challenges and Future Directions

Despite its progress, CDL faces significant challenges. Retrofitting older buildings to meet new energy standards remains costly and often involves long payback periods. Capturing Scope 3 emissions across an extended supply chain is complex due to limited supplier data. Furthermore, balancing biodiversity restoration with Singapore's land scarcity poses strategic trade-offs between environmental ambition and commercial feasibility.

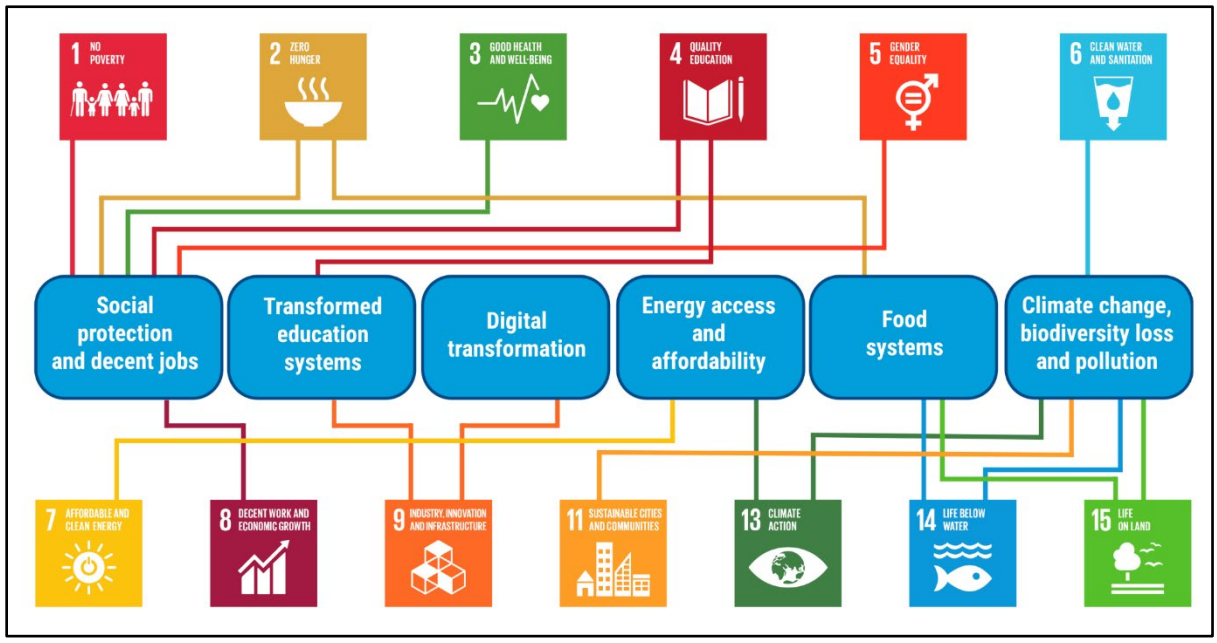
Looking forward, CDL has opportunities to further strengthen its sustainability leadership, particularly in the following three areas:

- **Digital Decarbonisation:** Expand the use of AI and digital twin technologies to support more predictive carbon management and lifecycle optimisation.

- **Green Finance Expansion:** Broaden sustainability-linked financial instruments, including biodiversity credit mechanisms and transition bonds, to support ecosystem restoration.

- **Regional Replication:** Scale its sustainable development model to other Asian cities through joint ventures, positioning CDL as a regional leader in urban decarbonisation and environmentally friendly real estate development.

Figure 7: United Nations Conference on Trade and Development's (UNCTAD) Six Transformative Pathways to Accelerate Progress towards the SDGs



Source: UN Trade and Development, n.d.

Conclusion

CDL's journey offers valuable lessons in strategic sustainability. The company's experience demonstrates that environmental, social, and governance dimensions are mutually reinforcing rather than competing goals. By embedding sustainability across every layer of its value chain, from board-level strategy to community engagement, CDL shows how profitability and responsibility can align.

Ultimately, CDL exemplifies how Asian companies can progress from incremental compliance towards more transformative sustainability leadership. Grounded in strong governance, measurable impacts, and collaborative innovation, its approach illustrates that sustainability, when strategically managed, functions not as a cost burden but as a catalyst for long-term resilience and growth.

Discussion Questions

1. How can CDL further integrate AI and data analytics to enhance sustainability performance and disclosure quality?

2. What role can CDL play in shaping Singapore's transition towards a more "nature-positive" economy?

3. How might sustainability-linked finance continue to evolve to support biodiversity restoration in dense urban contexts?

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Racing Towards Net Zero: F1 Singapore Grand Prix's Sustainability Impact

Joshua CHANG

Azna Ajeng NURFAIZA

QU Jing (Sabrina)

YAN Jiayi

ZOU Wenxuan

Loh, L., & Ang, H. M. (Eds.). (2026). *Cases in sustainability (Vol. 2: System-level and structure-based approaches).* Centre for Governance and Sustainability, NUS Business School.

Introduction

Company Overview

Formula One (commonly known as F1) is a global racing championship that represents the highest tier of international single-seater motorsport (Fédération Internationale de l'Automobile [FIA], 2025). It forms part of the international racing and entertainment industry, combining advanced automotive engineering, global media communications, and luxury brand marketing. Under the supervision of the FIA, F1 has evolved from a small event in post-war Europe to one of the world's most commercially valuable and technologically advanced sports since its inception in 1950 (Goldmeier, 2024).

Within this global setting, the Singapore Grand Prix (SGP) holds a particularly symbolic position. Introduced in 2008, it was the world's first F1 night race, held at the Marina Bay Street Circuit (Formula One, 2023). Over the years, the SGP has become one of the most iconic races on the F1 calendar. It not only showcases elite performance and cutting-edge engineering but also reinforces Singapore's reputation as a global hub for innovation, tourism, and sustainable event management.

Rationale for Selection and Relevance to Sustainability

F1 was selected because it operates at the intersection of technological innovation and environmental controversy. As a high-performance sport, F1 involves extensive logistics, fuel consumption, and carbon emissions, making it one of the most energy-intensive forms of entertainment in the world. In 2022, the overall F1 ecosystem, including teams, mobility, and race transportation, generated approximately 223,031 tonnes of carbon dioxide emissions, showing its significant environmental footprint (FIA, 2024).

Despite its global popularity, F1 has faced increasing criticism regarding the authenticity of its sustainability claims. Recent analyses suggest that F1's sustainability rhetoric often functions as a form of corporate greenwashing, masking the sport's continued dependence on carbon-intensive practices (IrishEVs, n.d.). Although F1 publicly pledges to achieve net zero by 2030, its extensive global logistics, frequent air travel, and ongoing partnerships with fossil fuel companies appear incompatible with this goal.

In addition, F1's "sustainable initiatives", such as using biofuels, reducing single-use plastics, and investing in alternative energies, often lack transparency and quantifiable results, or shift environmental responsibility to spectators, suppliers, and participating teams (IrishEVs, n.d.). Some experts have even pointed out that such "sustainable fuels" could exacerbate deforestation and food security problems. As a result, F1 has become a prime example of the sports industry oscillating between image management and true environmental accountability.

Nevertheless, this paradox makes the SGP a valuable case study for exploring sustainability transformation in large-scale international events. As one of the world's most widely broadcast races, the SGP demonstrates how an energy-intensive sporting event can integrate sustainability into its core business strategy, balancing profitability with environmental and social responsibility (Formula One, 2023).

This report aims to systematically analyse the sustainability strategies and initiatives of the SGP**,** focusing on how its environmental and social programmes align with F1's global sustainability agenda.

Key Sustainability Issues

Why the SGP was Selected

The SGP was selected as the central case for this report because it highlights the contradictions and opportunities within global motorsport regarding sustainable development. The broader F1 system has long been questioned for its environmental externalities, including high-intensity fuel consumption, global freight transportation, and high carbon emissions linked to the construction of temporary circuits (Kulisch, 2022). The SGP exemplifies these issues, as the nature of urban street racing, night-time lighting requirements, and Singapore's tropical climate pose operational challenges and sustainability risks (Pirelli, 2025).

Moreover, as a "City in Nature" and a recognised sustainability leader in Asia, Singapore faces its own test of policy credibility when hosting large-scale international events (Singapore Tourism Board, n.d.). The SGP thus becomes a microcosm of the broader sustainability dilemma: how to balance entertainment value, economic gain, and environmental responsibility amidst increasing public and media scrutiny (Devaraj, 2025).

At the same time, F1's global governing body has proposed a "Net Zero by 2030" strategy, prompting local organisers, including the SGP, to develop innovative and localised environmental initiatives (Formula One, 2023). This interaction between external doubts and internal reforms makes the SGP a compelling case for both strategic evaluation and academic research on the sustainable transformation of global sports.

Sustainability Issues in the Motorsport Industry

The motorsport industry, by nature, involves high energy intensity, material waste, and large-scale logistics, making sustainability one of its defining contemporary challenges. Race operations require the transportation of parts, personnel and broadcasting equipment across continents, and air freight is one of the most carbon-intensive modes of transport (Kulisch, 2022).

F1 produced approximately 223,031 tonnes of carbon dioxide in 2022, with about 71% of emissions originating from logistics and air transport (Formula One, 2024b). Despite the introduction of hybrid engines, advanced fuel research and development (R&D), and renewable energy initiatives, overall operations remain far from carbon neutrality, indicating that sustainable transformation will require systematic restructuring rather than piecemeal adjustments.

Night races such as the SGP further magnify these problems: artificial lighting systems, cooling-related electricity, and large-scale sound systems significantly increase energy consumption and associated emissions (Edmondson, 2025; ProAVLAsia, n.d.). Moreover, F1 has long relied on fossil fuel corporate sponsorship, including companies such as PETRONAS and Aramco, which contrasts with its sustainability-oriented branding (PETRONAS, n.d.; Formula One, 2020). These structural contradictions make F1 a useful indicator of how traditional industries attempt to reinvent themselves under global climate pressures.

Case Analysis: Core Sustainability Issues of the SGP

The SGP epitomises the complexities of contemporary motorsport in terms of sustainability. As a night-time event held in a high-density urban centre, SGP faces unique sustainability challenges at environmental, logistical, and infrastructure levels. Based on its own reports and related media analysis, three core sustainability issues can be identified.

Energy Consumption and Carbon Intensity of Night Race Operations

Energy consumption is one of the most significant sources of SGP's carbon emissions. It is reported that lighting the street circuit and powering associated facilities account for about 96% of the event's total carbon emissions (Shah & Baker, 2023). To reduce emissions, the SGP has introduced a new LED lighting system that consumes 30% less energy, and has piloted a renewable fuel derived from treated vegetable oil to run its generators (Shah & Baker, 2023). However, as night races are a core element of the event's brand and tourism appeal, the SGP still has significantly higher operational emissions than comparable daytime events.

Logistics and Emission Boundary Management

Another major structural challenge lies in the scope and accountability of emissions management. Although logistics and air transport account for 71% of F1's total carbon footprint (Formula One, 2024b), the SGP's carbon inventory covers Scope 1, Scope 2, and minor Scope 3 emissions within the Circuit Park. It excludes major Scope 3 sources such as international travel of F1 teams and spectator transportation (Singapore Grand Prix, 2025). This fragmented accounting results in a carbon

responsibility gap, highlighting the need to integrate global and local emissions data within the event's sustainability governance framework.

Urban Infrastructure and Resource Intensity

As a temporary urban street track, the SGP requires the annual construction and dismantling of grandstands, fences, and lighting projectors every year, which is a resource- and energy-intensive process (Lim, 2023). Despite the installation of approximately 1,500 solar panels, which can power the Pit Building for one month, and the implementation of a recycled-water toilet system that saves more than 129,000 litres of water per year (Shah & Baker, 2023), the material, transportation, and energy consumption associated with temporary facilities still pose a long-term environmental burden.

In summary, these issues collectively highlight the tension between entertainment value and environmental responsibility, making the SGP both a testing ground and a symbolic case for the global motorsport industry's transition towards sustainable innovation.

Key Sustainability Pillars

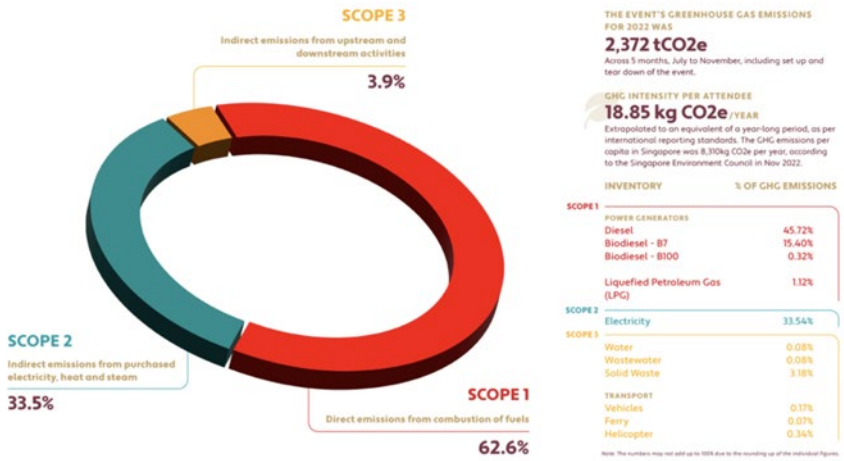
Overview on the SGP's Sustainability Strategy and Approach

The SGP began its transformation journey regarding sustainability in 2022 (Singapore Grand Prix, n.d.). The overall intention of this transformation is to build a legacy of positive change through a more sustainable race experience (Singapore Grand Prix, 2025).

The SGP uses a data-based approach to measure and guide its sustainability performance. The event's greenhouse gas emissions in 2022 was 2,372 tonnes of carbon dioxide equivalent, of which 96.1% were attributed to energy use (Singapore Grand Prix, 2023). On the basis of these findings, a roadmap was created with the vision of reducing total carbon dioxide emissions by half by 2028.

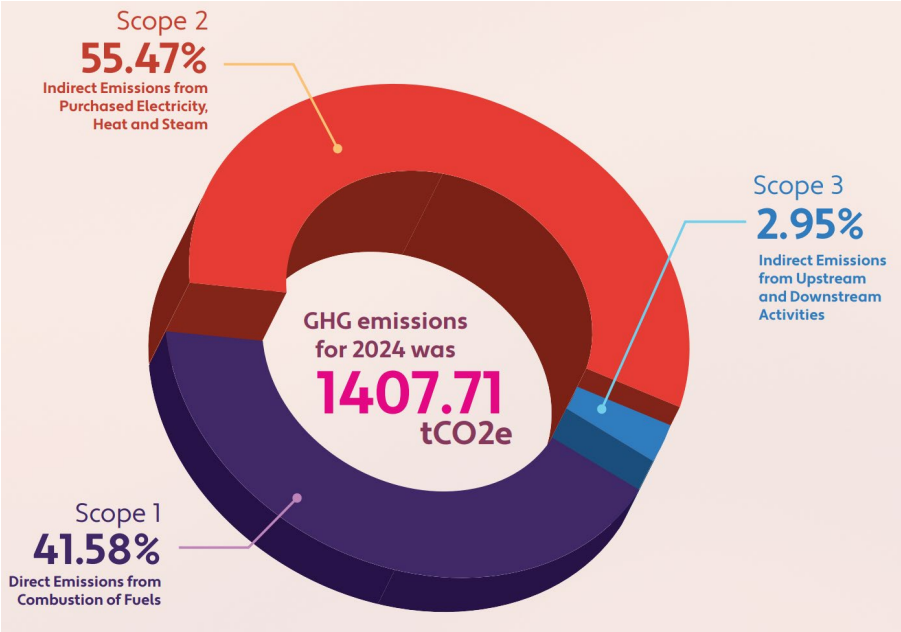
The implementation of these measures has yielded positive outcomes. In 2024, the total greenhouse gas emissions from the Circuit Park was reportedly 1,407.71 tonnes of carbon dioxide equivalent (Singapore Grand Prix, 2025). There was a 40.6% decrease in emissions compared with the 2022 baseline and a 25.2% decrease compared with 2023. Scope 1 and 2 emissions decreased by 40.1% relative to 2022, surpassing the 26% reduction target originally set for 2025 (Singapore Grand Prix, 2025).

Figure 1: Greenhouse Gas Emissions Breakdown of the 2022 SGP



Source: Singapore Grand Prix, 2023

Figure 2: Greenhouse Gas Emissions Breakdown of the 2024 SGP



Source: Singapore Grand Prix, 2025

Figure 2 illustrates that Scope 2 emissions from purchased electricity contributed 55.47% of overall emissions in 2024. Scope 1 emissions from the combustion of fuels contribute 41.58%, while Scope 3 emissions from both upstream and downstream sources contribute 2.95% (Singapore Grand Prix, 2025). These emissions dynamics show that the SGP relies less on diesel fuel and more on renewable fuels such as hydrotreated vegetable oil (HVO), a sustainable biodiesel derived from used cooking oil. It also uses more of its renewable energy credits, which cover 85% of its grid electricity consumption since 2022 (Singapore Grand Prix, 2023).

The SGP also values cooperation with institutional and industry partners. The organisers work closely with the Singapore Tourism Board and other agencies to align event operations with national sustainability policies and global standards such as the FIA Environmental Accreditation Programme. This partnership ensures that sustainability efforts remain transparent, accountable, and measurable (Singapore Grand Prix, 2023).

The SGP has a well-structured framework consisting of three sustainability pillars (Singapore Grand Prix, n.d.).

Pillar 1: Reducing Carbon Footprint

The first key pillar of the SGP sustainability framework focuses on reducing its carbon footprint. Recognising that Scope 1 has been its biggest source of carbon emissions, given the nature of the motorsport industry, it focuses on reducing carbon emissions where possible while leveraging other mechanisms to achieve its goal of halving carbon emissions by 2028. Specifically, the SGP intends to increasingly rely on sustainable energy sources to minimise emissions, while offsetting unavoidable emissions through instruments such as Renewable Energy Certificates (RECs) (Singapore Grand Prix, n.d.). Moreover, it has also stated its intent to phase out diesel over time in favour of lower-carbon alternative fuels, in order to further curb emissions.

The SGP focuses on sustainability with the support of the local government. As Singapore does not have a dedicated F1 race track, the government converts public roads into a temporary race track known as the Marina Bay Street Circuit (Formula One, 2024a). To curb the environmental impact associated with diesel generators needed to power the event, the SGP has decided to utilise HVO, in addition to energy-efficient LED lighting to light up the night race (DHL Express, 2025).

These measures have significantly improved the overall sustainability performance of F1 races. The total carbon emissions from F1 operations decreased by 26% in 2024 compared with its 2018 baseline, even as race attendance increased from 4 million to 6.5 million spectators over the same period (Formula One, 2025). This reduction in carbon emissions indicates that F1 is maintaining its commitment to sustainability and its Net Zero by 2030 strategy while continuing to deliver a strong value proposition to its global fanbase.

Furthermore, the SGP's commitment to sustainability is a sustained effort over many years. In 2022, the race transitioned from physical tickets to digital e-tickets for race attendees, ensured 85% of the electricity consumed was carbon neutral by leveraging RECs, and utilised B7 biodiesel to power 48% of the generators in Zone 4 of the race track (Singapore Grand Prix, 2023). The 2023 race built on these efforts by leveraging sustainable infrastructure alongside RECs (Singapore Grand Prix, 2025). These infrastructure additions include the installation of solar panels at the F1 Pit Building, which generated enough electricity to power the building for the entire race month, and

the track-wide adoption of energy-efficient LED bulbs tested in 2022, which are estimated to contribute at least 30% energy savings (Singapore Grand Prix, 2023).

The 2024 race maintained these measures while scaling them across the race track and diversifying its energy sources. For example, in collaboration with the Singapore Tourism Board, more than 1,300 installed solar panels generated 830,585 kWh in 2024, providing carbon-neutral electricity to many areas in Zone, 1 while R100 HVO was utilised to power Zone 1 generators, contributing to significant emission reductions compared with 2022 levels (Singapore Grand Prix, 2025). The most recent 2025 race reportedly saw a further increase in the utilisation of HVO, with reports indicating that 50% of generators would run on this renewable biodiesel alternative fuel resource (DHL Express, 2025). Overall, this historical perspective on the SGP shows that its continued commitment to sustainability goes beyond one-off greenwashing efforts, and reflects a concrete focus on measurable impacts across Scope 1, 2 and 3 emissions, in support of achieving its Net Zero by 2030 goal.

Vitally, its emissions performance, as reflected in Scope 1, 2 and 3 metrics, provides tangible proof of directional change for the SGP as a whole. Scope 1 usually focuses on direct emissions from owned and controlled company infrastructure and activities, Scope 2 on indirect emissions from the generation and utilisation of purchased energy, and Scope 3 on other indirect emissions across a company's value chain outside its direct ownership and control (McClymont, 2021). The SGP's reported emissions reductions primarily focus on Scope 1 and 2 emissions. In 2024, the SGP achieved a combined reduction of 40.1% in Scope 1 and 2 emissions compared with its 2022 level, alongside a 60.5% reduction in Scope 1 emissions alone over the same period (Singapore Grand Prix, 2025). In addition, the SGP managed to significantly reduce Scope 3 emissions from solid waste in 2024, even though overall Scope 3 emissions increased due to vehicular transport such as shuttle vehicles and helicopters. Taken together, the total reported emissions across all three scopes in 2024 were 40.6% lower than in 2022, positioning the SGP on an accelerated track towards its goal of halving emissions by 2028 (Singapore Grand Prix, 2025).

In addition to these tangible reductions in its Scope 1 and 2 emissions, these sustainability commitments contribute to wider environmental protection, social benefits and economic value for the event and its stakeholders. These broader impacts are addressed through the second and third pillars of the SGP's sustainability framework.

Pillar 2: Holistic Approach to Sustainability

Defining Holistic Sustainability

The second key pillar of the SGP's sustainability framework is its holistic approach to sustainability. Through this pillar, the SGP emphasises that sustainability extends beyond simply reducing carbon emissions to embedding responsible and circular

practices across every part of event operations (Singapore Grand Prix, n.d.). This approach is grounded in circular economy principles, shifting from a linear model of “take, make, dispose” to a circular model of “reduce, reuse, recycle”, in which growth is driven by circulating resources and maximising their value, rather than relying on continuous extraction or simple impact offsetting (Satam, n.d.).

The SGP integrates sustainability into its planning, procurement, and post-race processes, with a focus on extending the lifespan of materials by reusing infrastructure and equipment, sourcing materials responsibly, and improving waste management so as to minimise environmental impact (Singapore Grand Prix, 2025). It works closely with partners, vendors, and government agencies such as the Singapore Tourism Board to ensure responsible procurement and efficient resource use at every phase of event operations (Singapore Grand Prix, n.d). This framework aligns with F1’s Net Zero by 2030 strategy and reflects the SGP’s long-term commitment to building a more sustainable race experience (Singapore Grand Prix, 2025).

Core Programmes and Actions: Sustainability in its Operations

Throughout all stages of the event, the SGP implements several programmes that support its holistic sustainability framework. In the planning phase, the SGP conducts baseline waste assessments before each event to identify key waste streams and set reduction targets (Singapore Grand Prix, n.d.). It also maximises the use of existing facilities across multiple events. For example, barriers and fencing that were initially deployed for Singapore’s National Day celebrations have been reused as race infrastructure, reducing the need for new materials and lowering greenhouse gas emissions (Singapore Grand Prix, 2025). Moreover, all sustainability plans and roadmaps are developed to ensure alignment with F1’s Net Zero by 2030 strategy and the Singapore Green Plan 2030, which outlines the country’s long-term strategy under the United Nations 2030 Sustainable Development Agenda and the Paris Agreement (Singapore Grand Prix, 2025; Singapore Green Plan 2030, n.d.). Some of these initiatives are implemented in collaboration with the Singapore Tourism Board to ensure coherence with national environmental policies and sustainable tourism objectives.

During the procurement phase, the SGP places particular emphasis on sourcing and material use that reflect circular economy principles. It created a sustainable procurement policy that requires suppliers to use recyclable, biodegradable, or responsibly sourced materials (Singapore Grand Prix, 2025). Since 2022, this policy has been implemented across many aspects of the event. For instance, 100% of biodegradable disposable cups and cutlery are used in its workplaces and cafeterias, staff uniforms now contain 56% recycled polyester, and 72% of meals are packed using biodegradable containers (Singapore Grand Prix, 2025). The shift towards digital systems has also reduced material waste significantly. An e-ticketing system introduced in 2022 has eliminated around 250,000 plastic cards and lanyards and approximately 31,000 bubble mailers annually as of 2024 (Singapore Grand Prix,

2025). Similarly, replacing printed staff meal vouchers with a digital system eliminated more than 35,000 paper vouchers annually (Singapore Grand Prix, 2025). The SGP estimates that around 160,000 single-use plastic bottles have been eliminated annually since 2022, supported by the provision of free water refill points throughout the Circuit Park (Singapore Grand Prix, 2025). In addition, the use of water-efficient solar powered-container toilets is reported to save around 129,600 litres of water each race weekend(Singapore Grand Prix, 2025).

In the post-race phase, the SGP continues its sustainability efforts through waste recovery and recycling initiatives. In 2024, more than 5,000 glass bottles were collected to produce approximately 2,700 kg of crushed glass for recycling, while about 2,320 kg of used cooking oil from in-circuit food and beverage operators was recycled into biofuel (Singapore Grand Prix, 2025). The SGP also partnered with Plastify, a local start-up that converts plastic waste into functional products. This collaboration has included plastic collection drives during community engagement events where visitors could make their own keychains from recycled plastic. Through these activities, a total of 144 kg of HDPE plastic was recycled into keychains and another 48 kg was transformed into coasters as part of the 2024 SGP merchandise collection (Singapore Grand Prix, 2025).

Impact and Outcomes to Stakeholders

The SGP's approach to sustainability has created real benefits for both the environment and society. Its foundation lies in adopting circular economy practices, which are implemented by reusing resources, reducing waste, and lowering reliance on new materials throughout all phases of the event, from planning to post-race activities. Examples include reusing infrastructure from earlier Singapore events, switching to digital systems to reduce paper use, and applying sustainable procurement methods to reduce water use and make use of food waste.

For the environment, these initiatives contribute to lowering the overall carbon footprint by minimising energy consumption and demand for new materials. Reusing existing infrastructure and converting waste streams such as cooking oil and glass to new resources illustrate the circular economy principle, whereby materials are kept in use for as long as possible. These measures will help to slow down resource depletion and reduce landfill waste, both of which are major causes of environmental degradation (Bentley, 2022).

On the social side, Singapore's position as a regional sustainability leader is also strengthened. The SGP demonstrates that a large-scale entertainment event can integrate environmental goals into its operations without sacrificing quality or performance (Singapore Tourism Board, n.d.). Moreover, its efforts align with the Singapore Green Plan 2030 and F1's Net Zero by 2030 goal, demonstrating that the SGP supports both national and global climate objectives, while encouraging its attendees and partners to engage with its policies (Singapore Grand Prix, 2025). In

this way, its impact goes beyond emissions reduction, promoting long-term environmental awareness and a sense of shared responsibility among stakeholders.

Pillar 3: Social & Community Impact

The third and final pillar of the SGP's sustainability efforts is its social and community impact. The SGP aims to position community and social development as a core element of its overall sustainability strategy (Singapore Grand Prix, 2025). This pillar reflects the SGP's intention to use the unifying power of sport to generate social and economic value for society beyond the race weekend, and to show how major sporting and entertainment events can act as catalysts for inclusive socio-economic development and education.

The pillar seeks to extend the benefits of the SGP beyond its immediate entertainment value through strengthening local community participation (Singapore Grand Prix, 2025). It is structured around four interconnected objectives. First, the SGP promotes local economic participation by prioritising local sourcing and creating employment opportunities throughout its supply chain. In 2024, more than 700 Singapore-based companies were engaged or sub-contracted as vendors and contractors (Singapore Grand Prix, 2025). Second, the SGP supports education and youth development through partnerships with Institutes of Higher Learning (IHL), providing technical training, experiential learning, and work experience opportunities for more than 900 students annually since 2009, thereby contributing to Singapore's talent development (Singapore Grand Prix, 2025).

Third, the SGP facilitates community engagement and inclusivity through outreach programmes and activations designed to broaden public access to the F1 experience. In 2024, more than 45,000 local residents participated in F1-related community activities such as the #RevUpSGP campaign, behind-the-scenes tours, and a Pit Lane Walk (Singapore Grand Prix, 2025). Lastly, the SGP supports diversity and empowerment within its own organisation. In 2024, women make up 54% of the core team and 26.95% of race officials, placing Singapore among the leading F1 hosts in terms of female race official representation (Singapore Grand Prix, 2025). This diverse workforce, including strong female representation in an industry traditionally dominated by men, underlines the SGP's commitment to gender balance and inclusion. Ultimately, these initiatives work together to promote diversity, inclusion, and local talent development in Singapore in the long run.

The success of these initiatives depends on a broad and extensive network of stakeholders and meaningful collaborative partnerships. SGP has positioned itself as a key community player and not merely an event organiser. This has enabled it to engage a diverse range of internal and external stakeholders, including local companies, schools, residents, and the general community.

Overall, the social and economic impacts are substantial. Thousands of employment opportunities are created for local companies annually, including both temporary and

permanent jobs (Singapore Grand Prix, 2025). Educational programmes also enhance the employability of young Singaporeans by providing practical experience in a complex, real-world operational environment. Other community-focused initiatives help the event reach diverse social groups, fostering social cohesion and widening access to a usually high-profile and expensive global event. Economically, by contracting over 700 local companies, the SGP helps to keep a significant proportion of event-related expenditure within Singapore, strengthening local entrepreneurship and supply chain resilience (Singapore Grand Prix, 2025). Moreover, the race attracts more than 260,000 spectators, supporting the tourism and hospitality sectors while reinforcing Singapore's position as a top location for sustainable mega events (Singapore Grand Prix, 2025).

These initiatives illustrate how the SGP can serve as an example of integrated sustainability, employing a comprehensive approach that treats economic, environmental, and social dimensions as interconnected parts of a single system. They also show how abstract sustainability principles can be translated into tangible and measurable community and economic outcomes. By adopting a stakeholder-oriented and shared-value approach, the SGP can align its efforts with the United Nations Sustainable Development Goals (SDGs), while supporting long-term community development through its focus on local education, inclusion, and empowerment (Singapore Grand Prix, 2025). In this context, sustainability functions as a key source of strategic differentiation and resilience for the SGP, instead of just another buzzword.

Conclusion

The SGP illustrates how an international event can pursue sporting excellence while advancing sustainability goals. The race continues to showcase innovation and high performance, while increasingly aligning these strengths with environmental and social responsibility.

The first pillar of the SGP's sustainability framework focuses on cutting carbon emissions, with measurable progress achieved through measures such as renewable fuels, energy-efficient lighting, and RECs. The second pillar builds a circular economy approach that connects event planning, procurement, operations, and post-race recovery, shifting priorities from resource depletion towards resource sustainability. The third pillar centres on community impact, emphasising education, employment, and inclusion.

Overall, these three pillars form an integrated sustainability system in which each dimension reinforces the others, creating a pathway that positions the SGP as a benchmark for sustainable innovation in global motorsport. The case of the SGP illustrates how consistent leadership, transparent measurement, and cross-sector collaboration can build a more authentic and resilient model for future global events, while also reinforcing Singapore's position as a global leader in sustainability.

Discussion Questions

1. Is the utilisation of Renewable Energy Certificates (RECs) a sustainable alternative for a carbon-intensive industry, or does it act as a license to pollute by depending on third parties to compensate for emissions?

2. The event's circular economy initiatives (such as digital ticketing, reusable infrastructure, and partnerships with local recycling start-ups) reflect a shift from linear to regenerative systems. How effective are these efforts in addressing Scope 3 emissions, which come from indirect sources such as the production and disposal of materials, logistics, and audience travel, given that these are usually the hardest to manage in global events?

3. To what extent can mega-events like the SGP create lasting social and community impact, rather than temporary economic gains?

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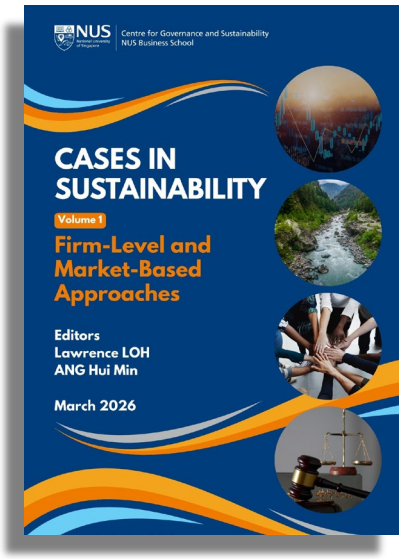

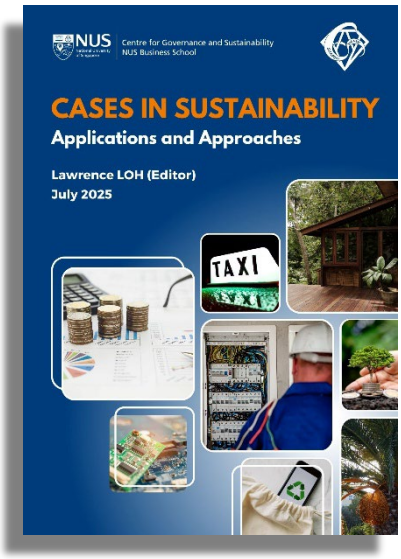

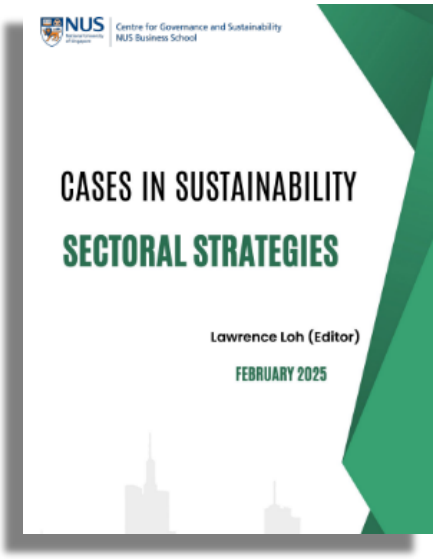

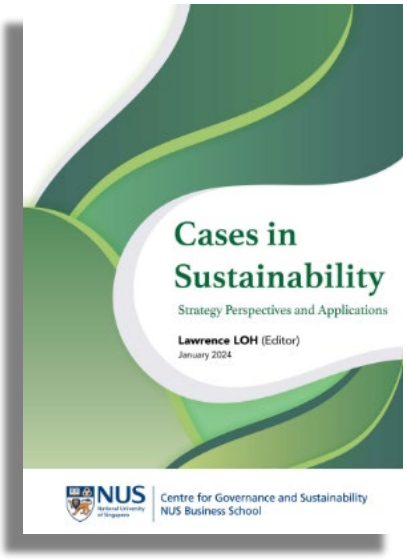

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