International Journal of
Supply Chain and Logistics
(IJSCL)

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CARI
Journals

International Journal of Supply Chain and Logistics

ISSN 2520-3983 (Online)

Vol. 9, Issue No.3, pp 1 - 15, 2025

www.carijournals.org

Assessment of Supply Chain Sustainability Strategy on Sustainable Performance Indicators: Evidence from Siemens DEGREE Framework (2019-2023)

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Accepted: 27th Dec 2025 Received in Revised Form: 27th Feb 2025 Published: 27th Feb 2025

Abstract

Purpose: Since the incessant supply chain disruptions, the need for supply chain sustainability strategy becomes a veritable tool for a competitive advantage in all disciplines, sectors and governance. This study is motivated to empirically investigate the effects of supply chain sustainability strategy on sustainable performance indicators in the manufacturing technology sector.

Methodology: The study employs a purposive sampling technique and selected Siemens Company to analyses the Siemens DEGREE sustainability strategy framework. Secondary data from Siemens sustainability reports and annual reports from 2019 to 2023 were analyzed using descriptive analysis.

Findings: Findings reveals that decarbonization of the DEGREE Key Performance indicators has consistently achieve all decarbonization key performance indicators by Siemens targets and also met the SDGs GHG emissions targets by 2030.

Unique Contribution to Theory, Practice and Policy: Stakeholder theory was preferred over the Triple Bottom Line in this study because the stakeholder theory represents the DEGREE sustainability strategy framework implemented by Siemens to assess the key sustainable performance indicators (KPI). Recommendations to Siemens include use of biodiversity partnership, eco-design technology, tree-planting volunteering campaign, to reduce waste-to-landfill as well as intensive equitable access to career opportunities and offer a higher pay to encourage more digital learning hours per employee for career growth that will meet all DEGREE sustainability performance before 2025 as well as the SDGs by 2030.

Keywords: *Supply Chain Sustainability Strategy, Performance Indicators, Siemens, DEGREE Sustainability Strategy Framework*

1. INTRODUCTION

Since the Brundtland Report published by the United Nations' World Commission on Environment and Development (WCED) in 1987, sustainability has been widely adopted across disciplines, sectors, businesses, and governments. Generally, sustainability refers to meeting present needs without compromising the ability of future generations to meet their own needs (Saeed, Waseek, & Kersten, 2017; Tronnebati & Jawab, 2023).

In supply chain management (SCM), sustainability has become a critical issue that significantly influence decision-making and operational strategies. Traditionally, SCM focuses on managing value chain operations with an economic objective, encompassing raw material sourcing, production, distribution, and coordination of information flows to ensure efficiency and customer satisfaction (Menesha & Mirananumo, 2023; Tronnebati & Jawab, 2023). In contrast, sustainable supply chain management (SSCM) integrates environmental and social standards across all value chain operations, extending beyond product distribution to include reverse logistics and responsible resource utilization (Turrisi, Bruccoteri, & Cannella, 2012; Wetsandorn Phong, 2024). While both SCM and SSCM emphasize operational efficiency, stakeholder engagement, and information flow, SSCM is regarded as superior due to its alignment with the triple bottom line—people, planet, and profit (Correia, 2019)—as well as its contribution to environmental, social, and governance (ESG) objectives (Martiny, Taglianlantela, Testa, & Iraido, 2024).

Beyond its advantages in mitigating social and environmental impacts, supply chain sustainability enhances product quality, brand reputation, and customer loyalty. Additionally, supply chain sustainability minimizes supply chain disruptions arising from social and environmental risks while reducing carbon emissions and resource wastage (Mugoni, Kanyepe, & Tukuta, 2024; Tronnebati & Jawab, 2023). Today, sustainable supply chain practices have emerged as a source of competitive advantage and improved organizational performance in the 21st century (Shebeshe & Sharma, 2024).

Despite the numerous benefits of supply chain sustainability, recent global disruptions including the COVID-19 pandemic, climate change, economic recessions, shifting consumer behaviours, and the ongoing Russia-Ukraine war, all have continued to challenge its implementation. These disruptions have underscored the need for resilient and adaptive supply chain strategies. According to Gartner (2023), over 62% of leading supply chain firms have invested in sustainable supply chain strategies to mitigate emerging disruptions that threaten both the triple bottom line and ESG performance.

In response to these challenges, this study aims to assess supply chain sustainability strategy on sustainable performance indicators, using Siemens' supply chain sustainable strategy to assess the sustainability performance. Furthermore, this study develops practical and innovative strategies to enhance Siemens' sustainable performance. The study is structured as follows: Section 2 presents a literature review, Section 3 evaluates and analyzes Siemens' sustainable supply chain strategies, and Sections 4 and 5 provide recommendations and reflections on the study's findings.

2. LITERATURE REVIEW

This section reviews key theories on sustainable supply chain strategies and examines the key performance indicators (KPIs) used to assess sustainability in supply chain management.

2.1 Sustainable Supply Chain Strategy

Since the advent of globalization and the increasing frequency of global supply chain disruptions, such as the COVID-19 pandemic, economic recessions, and climate change, many organizations have experienced a significant decline in market competitiveness. To increase market competitiveness, there is a wide crusade for integration of sustainable practices into supply chain operations (Sun, Sarfraz, Khawaja, & Abdullah, 2022). For instance, these past leading firms such as Digital Equipment Corporation (DEC), Nokia, Lehman Brothers, and British Leyland have lost their competitive positions despite incorporating sustainability measures into their supply chains. This underscores the need for a more comprehensive and strategic approach to sustainable supply chain management.

To mitigate the loss of competitive advantage, the adoption of sustainable supply chain strategies has become essential for firms aiming to secure long-term market positions through sustainability-driven practices. Consequently, sustainable supply chain strategy has gained increasing attention in both academic literature and business practice, as well as among policymakers, due to its potential to achieve the three core sustainability objectives: environmental, social, and economic sustainability (Komarova & Ustyuzhanin, 2017; Sun et al., 2022).

Today, organizations employ diverse sustainable supply chain strategies not only to meet sustainability goals but also to enhance operational efficiency and overall business performance. These strategies are particularly relevant in the context of Environmental, Social, and Governance (ESG) reporting, which has become a critical component of financial disclosures for publicly listed companies. Several studies (Sun et al., 2022; Komarova & Ustyuzhanin, 2017) have found that sustainability inhibitors, such as globalization, economic downturns, and shifting consumer behaviors, all have driven the adoption of more robust sustainable supply chain strategies. This suggests that external pressures have reinforced organizations' commitment to sustainability, leading to long-term economic, environmental, and social benefits. In another study, Ning and Yao (2023) found that digital transformation and technological advancements have significantly contributed to the evolution of sustainable supply chain strategies, making them key drivers of sustainable competitive advantage. Their study highlights that emerging digital technologies, such as big data analytics, cloud computing, artificial intelligence, and block chain, all have enabled companies to implement more effective sustainability initiatives, including waste reduction, optimized packaging, and carbon footprint minimization.

In summary, sustainable supply chain strategies are essential for maintaining long-term competitive advantage, as evidenced by companies such as Ford, Toyota, IBM, and Pfizer, which have successfully integrated sustainability into their supply chain operations over the past two decades. Therefore, organizations should not merely adapt and implement sustainable practices

but should actively invest in strategic sustainability initiatives to achieve economic, environmental, and social sustainability while securing a lasting competitive edge.

2.2 Theories on Sustainable Supply Chain Strategies and Sustainability Key Performances Indicators (KPIs)

The two prominent theories, Triple Bottom Line (TBL) and Stakeholder theories that align with sustainable supply chain strategies are discussed with their relevant sustainable key performance indicators.

2.2.1 Triple Bottom Line (TBL)

The triple bottom line (TBL) is one of the foremost sustainability strategies that emanated after the environment development agenda by UN in1987. The TBL is an extension of the environment development agenda in the sustainability theory (Alhaddi, 2015). The term triple bottom line (TBL) was developed and coined by Elkington in 1997 to achieve the 3Ps- People, Planet and Profit (Correia, 2019). Furthermore, the seven Millennium Development Goals (MDGs), developed on September 15, 2000 and attainable by end of 2015, by the United Nations (UN) (Oluyomi, Obasa, & Daisi, 2023) is drawn from the 3Ps.

According to Elikington (1997), triple bottom line refers to balance of the three sustainable development lines, environmental, social and economic lines, indicating a sustainability strategy. (Alhaddi, 2015; Correia, 2019). Despite of the importance and wide implementation of TBL sustainability strategy in many organizations, TBL sustainability strategy theory lacks hierarchy level of the three sustainability dimensions (Getzer, 1999; Correia, 2019). Table 1 shows the three TBL sustainability dimensions, strategic objectives and the key performance indicators (KPIs).

Table 1. Triple Bottom Line Sustainability Strategy and Key Performance Indicator

Sustainability Strategy	Strategic Objectives	Key Performance Indicator (KPIs)
Environmental	Reduce negative environmental impact	1. Air emission per unit of Production. 2. Waste Water per unit of Production. 3. Emissions into surface waters per unit of Production. 4. Waste for recycling and disposal per unit of Production.
Social	• Increase employee satisfaction • Increase community satisfaction • Increase satisfaction of Central and Local governments • Corporate Social Responsibility	1. Community Satisfaction Survey 2. Number of Complaints from Neighbors on social pollution and discomforts such as noise, odor, dust, among others 3. Job satisfaction survey 4. Reduction in the number of penalties for non-compliance with Social and environmental legislation standards.
Economic	• Increase profitability • Increase revenues • Reduce costs	1. Net earnings 2. Operating profit 3. Net sales 4. Total operating cost

Source: Adapted from Cordova-Aquirre & Ramon-Jeronimo, 2024.

2.2.2 Stakeholders Theory

Stakeholder Theory, developed by F.E. Freeman in his book *Strategic Management* (1984), is recognized as a key framework for sustainability strategies. According to this theory, a stakeholder is any individual or group whose actions affect or are affected by the achievement of an organization's objectives (Cordora-Aguirre & Ramon-Jeronimo, 2024; Siemens, Securing, & Schilling, 2023).

In the context of supply chain sustainability, the stakeholder sustainability strategy identifies and engages all relevant stakeholders essential for achieving supply chain sustainability within an organization. Unlike the Triple Bottom Line (TBL) sustainability strategy, which relies primarily on management decisions without external consultation, the stakeholder sustainability strategy incorporates multiple perspectives—ranging from internal stakeholders (such as employees and management) to external stakeholders (including customers, governments, and regulatory bodies). This inclusive approach enhances supply chain sustainability and contributes to a long-term

competitive advantage (Siemens, Securing, & Schilling, 2023). However, while the stakeholder approach is more dynamic and effective due to broader consultations, it is also resource-intensive and time-consuming, which can lead to delays in sustainability strategy decision-making.

A major challenge organizations face in maintaining long-term competitive advantage is managing the diverse interests of stakeholders, including shareholders, employees, customers, governments, regulators, and communities. To address these challenges, many organizations have heavily invested in stakeholder sustainability strategies through initiatives such as corporate social responsibility (CSR), promotional discounts, customer engagement programs, business symposiums, and other stakeholder networking activities.

For example, Coca-Cola, a global leader in the beverage industry, recently experienced a significant revenue decline despite its continuous investment in product innovation. The decline was largely attributed to increasing consumer awareness of the health risks associated with high sugar consumption. While Coca-Cola has traditionally maintained strong relationships with its customers, this shift in consumer preferences led to a sharp drop in sales. However, through a stakeholder engagement strategy focused on addressing consumer concerns the company reduced the sugar content in its products. This sustainability-driven adaptation not only helped restore Coca-Cola's competitive position over the past decade but also reinforced the importance of stakeholder sustainability strategies in maintaining long-term market leadership.

Despite its effectiveness, the stakeholder sustainability strategy like the TBL strategy has been criticized for failing to establish a clear hierarchy between different types of stakeholders (internal vs. external). Nevertheless, given its widespread application in corporate sustainability efforts, Table 2 presents key stakeholder sustainability performance metrics used by organizations to evaluate the key performance indicators (KPIs) associated with stakeholder engagement.

Table 2. Stakeholders Sustainability Strategic and Key Performance Indicators

Stakeholder	Strategic Objectives	Key Performances Indicators (KPIs)
Customer	• Improve market share. • Increase Sales volume. • Maximize customer satisfaction.	1. Revenue Percentage of market share. 2. Volume of products sold. 3. % of Customer Loyalty.
Government	• Compliance with Current Regulation.	1. Number of Penalties for non-Compliance with social and environmental legislation.
Community	• Contribution to the economic development • Corporate social responsibility.	1. No. of community developed Programme. 2. Amount of donations to local community. 3. No. of new clients/employees hired.
Employee	• Recruit valuable people • Train and motivate personnel.	1. No. of professionals and technicians hired 2. Investment on employee training.

Source: Adapted from Cordova-Aquirre & Ramon-Jeronimo, 2024.

The review of the Triple Bottom Line (TBL) and Stakeholder theories of sustainability strategies highlights the critical role of sustainability strategies in supply chain management as a source of competitive advantage in the literature. However, the stakeholder sustainability strategy is considered superior to the TBL strategy due to its broader stakeholder engagement and dynamic adaptability. Consequently, this study evaluates the impact of the stakeholder sustainability strategy on Siemens' sustainable supply chain performance over the last five years (2019–2023).

3. METHODOLOGY

This study employs secondary data to evaluate supply chain sustainability strategy on key sustainable performance indicators. The secondary data that ranges from 2019 to 2023 were sourced from annual sustainability report and annual financial report. Siemens Company was selected as a sample study due to its remarkable achievements as the second largest manufacturing technology company in Germany and its strong global reputation for sustainability compliance (Britannica, 2024; Siemens, 2023). Descriptive statistics analysis consisting of percentage, average and bar chart were used to evaluate the Siemens supply chain sustainability strategy in this study.

4. OVERVIEW OF SIEMENS SUSTAINABLE SUPPLY CHAIN STRATEGIES

This section provides an overview of Siemens and an evaluation of the sustainability strategies implemented by the company between 2019 and 2023.

4.1 Siemens Overview

Siemens is a multinational industrial technological company, founded by Werner von Siemens and Johann Georg Halske on October 1, 1847. With over 177 years of business operations, Siemens company has expanded into a multiple chain of businesses. As of 2023, Siemens specializes in five principal business divisions- digital industries, smart infrastructure, Siemens mobility, Siemens healthineers, and financial services. Siemens is headquartered in Munich and Berlin and employed over 320,000 people globally as of September 30, 2022 (Siemens Annual Report, 2023). Siemens is ranked as one of the top 100 most valuable companies globally (Britannica, 2024; Siemens, 2023). Nonetheless, Siemens faces multifaceted challenges relating to incessant supply chain disruptions due to COVID-19 pandemic, and the recent geopolitical conflicts such as, the Russia-Ukraine war and the Egypt-Palestine crisis and the increasing shortage of skilled workers in the technology sector (Tilt, 2023). To mitigate these arising challenges, Siemens develops DEGREE Sustainability framework in 2001 as a sustainable strategy that aligns with the United Nations' Sustainable Development Goals (SDGs). Importantly, this study evaluates the effectiveness of the Siemens DEGREE Sustainability Strategy in achieving sustainable competitive advantage within the manufacturing technology industry.

4.2 Overview of SIEMENS DEGREE SUSTAINABILITY STRATEGY

Siemens launched the DEGREE Sustainability Strategy in 2001 as a comprehensive framework to address sustainability from the perspectives of the Triple Bottom Line (TBL)**,** Stakeholder Theory**,** and Sustainable Development Goals (SDGs)**.** The DEGREE framework aims to ensure Siemens' sustainability practices contribute to long-term competitive advantage in the manufacturing technology sector. The Siemens DEGREE acronym represents six key sustainability pillars:

D – Decarbonization

E – Ethics

G – Governance

R – Resource efficiency

E – Equity, and

E – Employability.

Table 3 presents DEGREE sustainability strategy and the key performance indicators from the Siemens sustainability report 2023.

Table 3. Siemens DEGREE Sustainability Strategy and KPIs

Sustainability Strategy	Key Performance Indicator (KPIs)
D – Decarbonization	1. Net Zero operations by 2030 2. 55% emission reduction by 2025 3. 90% emission reduction by 2030 4. Net zero supply chain by 2050 5. 20% emissions reduction by 2030
E – Ethics	1. Striving to train 100% of our people on Siemens business conduct Guidelines every three year by 2025
G – Governance	1. 100% compliance to government sustainability Legislation in supply chain by 2030 2. Social and ecological standards
R – Resource efficiency	1. Robust Eco Design for 100% by 2030 2. Waste – to – landfill reduction in 2025 by 50% 3. Zero landfill waste by 2030 4. Profitability 5. Recycling
E – Equity, and	1. 30% female share in top management by 2025 2. Access to employee share plans up to 100%
E – Employability.	1. Increase digital learning hours to 25 2. 30% improvement in Siemens lost tie injury frequency rate 3. Employee health and safety

Source: Siemens Sustainability Report, 2024

5. RESULTS AND DISCUSSIONS

5.1 Trend and Assessment of Siemens DEGREE Sustainability Strategy Framework

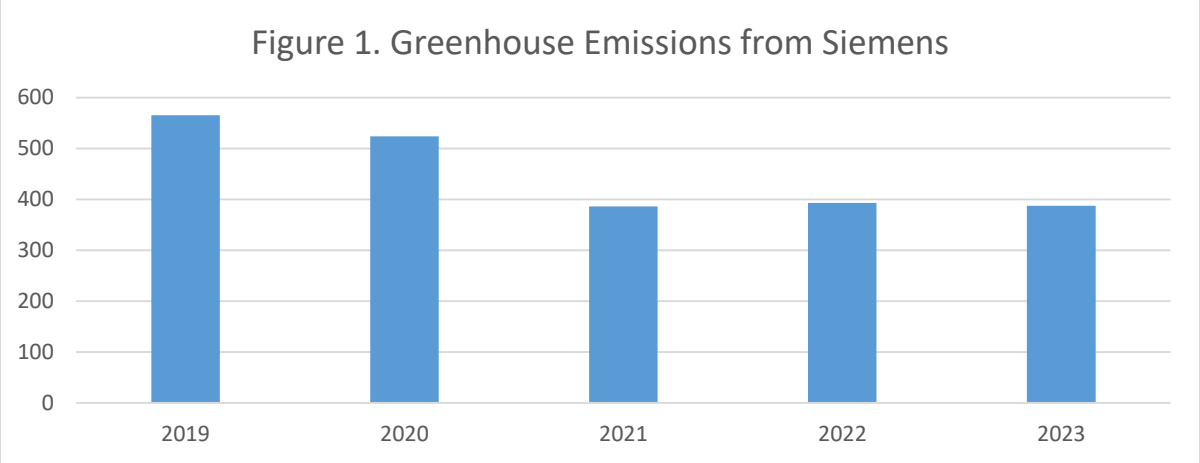
Table 4. Trend of Siemens DEGREE Sustainability Strategy Performance, 1999-2023

Sustainability	KPIs	KPI Targets	2023	2022	2021	2020	2019	2019-2023
Decarbonization	1. Greenhouse Gas Emission from Siemens Operations	55%	-2%	2%	26%	-7%		31.5%
		Zero (0)	387	393	386	524	565	451
	2. Greenhouse Gas Emission from Electricity consumption	15%	-13.8%	-9.1%	17.5%	-50.8%		-54.17%
		Zero (0)	163	189	208	177	360	219.4
	3. Greenhouse Gas Emission from Supply Chain in upstream operations	15%	-4.06%	14.1%	-1.09%	-11.3%		-3.98%
		Zero (0)	11, 048	11,515	10,091	10,202	11,506	
	4. Greenhouse Gas Emission from Supply Chain in downstream operations	55%	5.84%	-5.4%	N/A	N/A	N/A	0.22%
		Zero (0)	472,140	446,090				459,115
Ethics	1. Compliance Trainings		461000	409000	374000			414.667
	2. Spending on employee education and training (In Million €)		416.3	374.6	322.2	N/A 321	N/A 391	365.02
	3. Average training hours per employee		11.1% 30	16.3% 26	-0.57% 22	-17.9% 17	21	1.79% 23.2
Governance % of total employees	1. Corporate responsibility self-assessments		5096	4912				
	2. Retiring expected within next 5 years		10.3%	10.3%				
Resource efficiency	1. Quota of product f with robust eco design	100%	50%	35%	26%			
	2. Waste to landfill							
	3. No. of hazardous waste		14%	18.0%	15.0%			
	4. Recycling & Recovery (non-Hazardous waste)		12.7	`15.0	11.8	18	19	19
	5. Recycling & Recovery (Hazardous waste)		203.8 7.2	213.5 10.0	222.3 6.1	257	265	265
Equity	1. Female share in top management	30%	30.8%	27.7%	27.5%	18.4%	18.5%	18.5%
	2. Employees' access to Siemens share plans	100%	43.5%	44.5%	-	-	-	-
Employability	1. Digital learning hours per employees	25	23	21	17	17	21	21
		100%	99%	89%				
	2. Access to medical care	100%	99.6%	90%	-			
	3. Access to digital learning							

Source: Researcher's computation, 2024

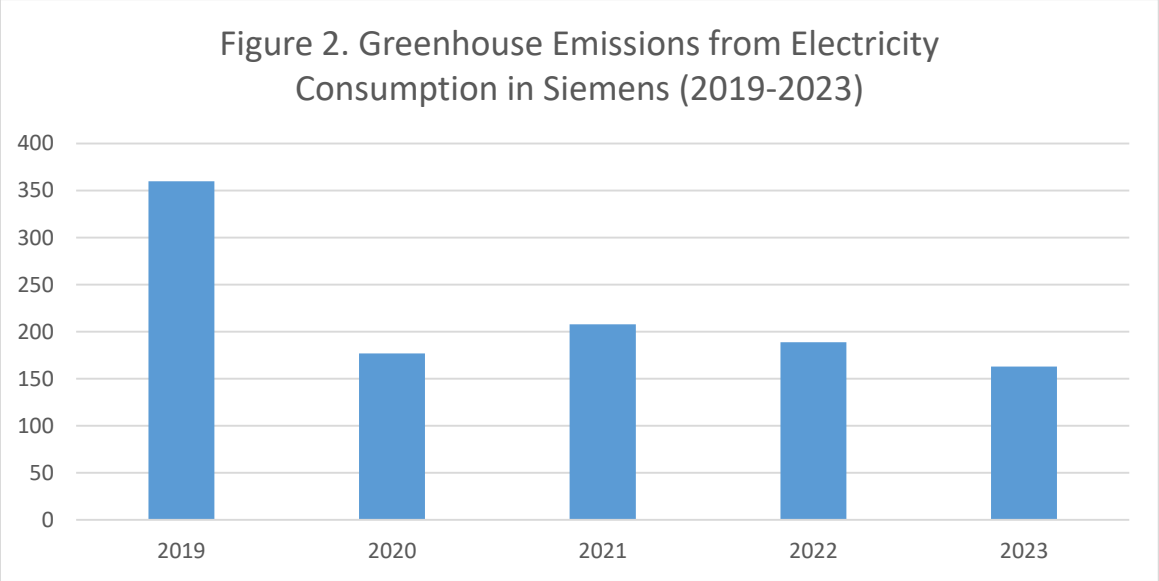
Results in Table 4 shows the trend of Siemens DEGREE sustainability strategy performance in the last five years. Regarding decarbonization sustainability, Table 4 and Figure 1 show that the

Greenhouse gas emission from Siemens operation has consistently decrease from 565 thousand metric tons in 2019 to 387 thousand metric tons in 2023, accounting for -31.5% GHG emissions reduction as of 2023. When compared to Siemens' internal target of a 55% reduction in GHG emissions by 2025, the recorded 31.5% reduction as of 2023 demonstrates significant progress toward this goal. Furthermore, this trend aligns with Siemens' long-term net-zero emissions commitment under the UN Sustainable Development Goals (SDGs) by 2030**.** This suggests that Siemens' decarbonization sustainability strategy is both effective and on track to meet its sustainability targets.



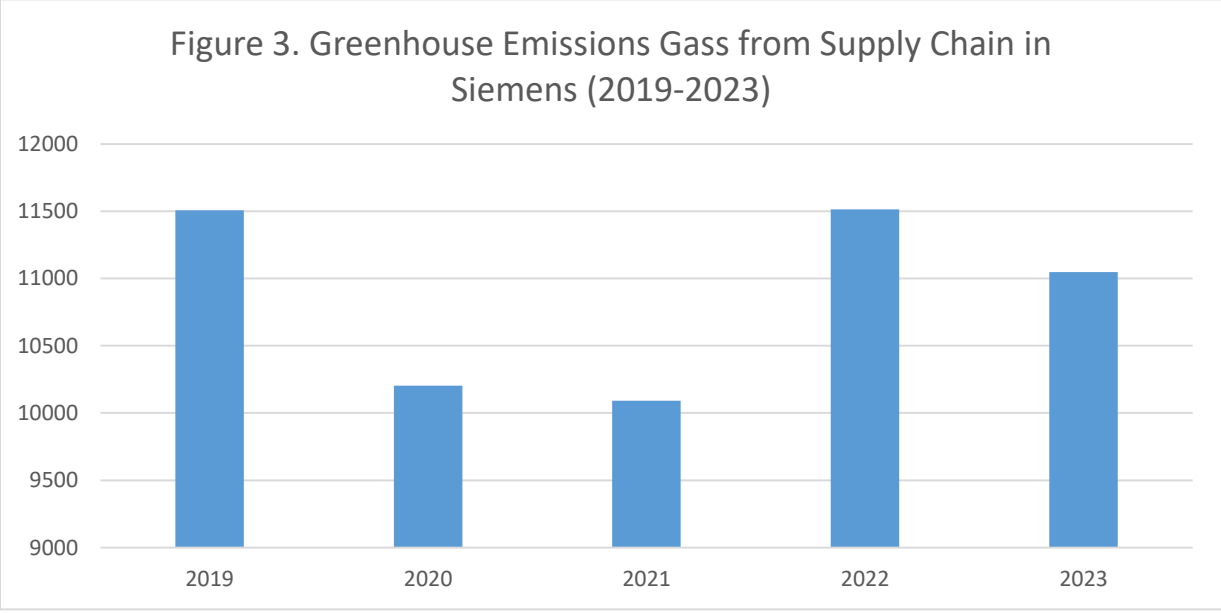
Source: Authors' Chat, 2024

Similarly, Table 4 indicates a consistent decline in GHG emissions from electricity consumption**,** decreasing from 260 thousand metric tons in 2019 to 163 thousand metric tons in 2023**,** representing a 56.7% reduction in emissions as of 2023. This significant reduction surpasses Siemens' target of a 15% reduction in GHG emissions from electricity consumption by 2030 (Siemens Sustainability Information, 2023). The achievement of this target ahead of schedule underscores the effectiveness of Siemens' energy efficiency and renewable energy initiatives**.** Figure 2 further exhibits this downward trend in emissions from electricity consumption.



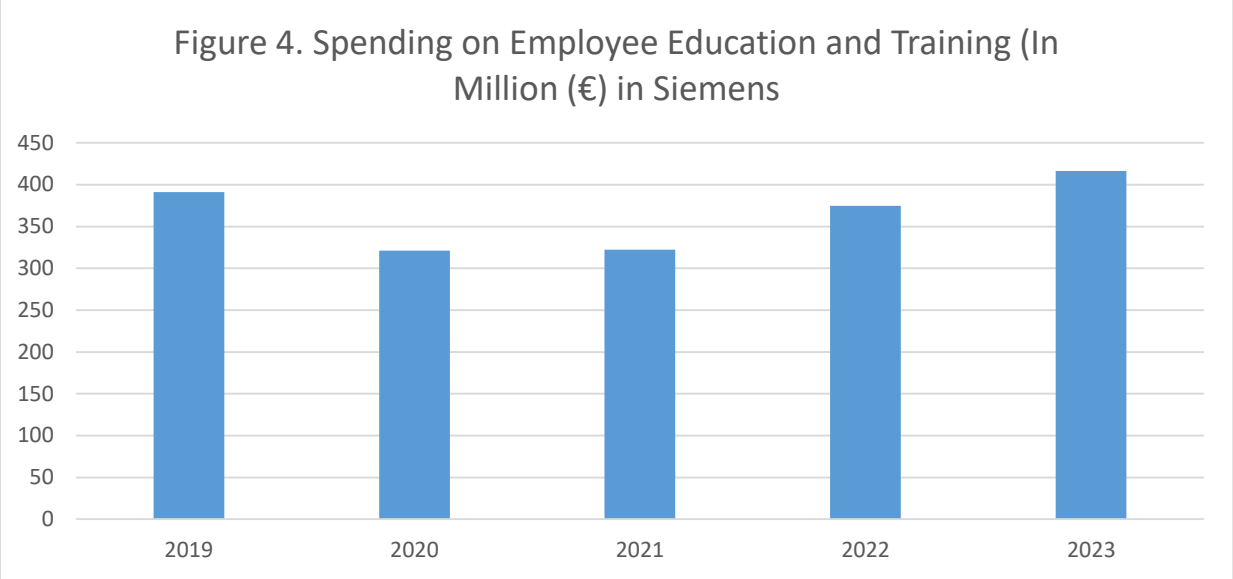
Source: Authors' Chat, 2024

Furthermore, Table 4 indicates that Siemens successfully achieved its 15% GHG emissions reduction target in the supply chain between 2019 and 2023. This study concludes that Siemens' decarbonization sustainability strategy has been highly effective, not only in meeting the company's internal decarbonization targets but also in aligning with global net-zero emissions goals for the supply chain by 2030 and 2050**.** However, as shown in Figure 3**,** while a consistent decline is evident in GHG emissions from Siemens' operations and equipment, emissions from the **supply** chain exhibit fluctuations, highlighting potential challenges in achieving full emissions stability.



Source: Authors' Chat, 2024

The Ethics results in Table 4 indicate that Siemens' spending on education and training has shown **a** consistent increase from €321 million in 2020 to €416.3 million in 2023. However, there was a sharp decline from €391 million in 2019 to €321 million in 2020, likely due to external disruptions such as the COVID-19 pandemic.



Source: Authors' Chat, 2024

As exhibited in Figure 4**,** Siemens' ethical compliance with employee education and training has shown progressive improvement**.** However, the company has yet to achieve 100% compliance training and meet its other ethical targets in this study. On the resource efficiency result, the recycling and recovery of non-hazardous waste have steadily declined from 265 thousand metric tons in 2019 to 203 thousand metric tons in 2023**,** reflecting **a** 23.1% reduction**.** Although this reduction is noteworthy, it remains below Siemens' 50% waste reduction target. This suggests that Siemens' resource efficiency strategy is effective but requires further enhancement to align with its long-term sustainability objectives**.** The equity results as shown in Table 4 reveals that female representation in top management reached 30.8% in 2023**,** meeting the company's 30% target**.** However, employee access to share plans stands at **43.5%**, significantly below the 100% target **by** 2025. This indicates that Siemens' equity sustainability strategy requires further improvement to meet all equity-related Sustainable Development Goals (SDGs) before 2030. Lastly, the employment sustainability strategy results in Table 4 evaluates digital learning hours per employee and access to medical care. The findings show that digital learning hours per employee have fluctuated**,** failing to meet the target of 25 hours as of 2023**.** Meanwhile, access to medical care has reached 99%**,** which **is** close to Siemens' 100% target by 2025. This suggests that while Siemens is making progress in employee well-being**,** further investment in quality education, decent work, and healthcare is necessary to fully achieve both the company's internal targets and global SDG objectives.

6. CONCLUSION AND RECOMMENDATIONS

Based on the assessments of DEGREE Sustainability Strategy framework implemented at Siemens company, this study concludes that Siemens Decarbonization strategy out of the DEGREE Key Performance indicators has consistently achieved all key performance indicators set by the company Siemens targets and aligns with the SDGs Greenhouse gas (GHG) emissions reduction targets by 2030. Within the study period of 2019–2023, Siemens demonstrated significant progress in reducing emissions across its operations, electricity consumption, and supply chain.

However, the evaluation highlights that other components of the DEGREE strategy require further improvements to achieve Siemens' long-term sustainability objectives. The following actionable recommendations are proposed for enhancing the remaining DEGREE key performance indicators:

First, the resource efficiency of Siemens should embrace stakeholder engagement strategy that includes local communities, customer's suppliers, and others to mitigate environmental impact. In addition, Siemens should explore biodiversity partnership and enroll staff to eco-design technology learning programme, that encourages the use of vegetation, tree-planting volunteering campaign, among to reduce waste-to-landfill, leading to overall resource efficiency improvement. Secondly, the study recommends equitable career opportunities and a higher pay offer to encourage more digital learning hours per employee for career growth programme for all Siemens staff. Thirdly, Siemens should develop a Gender equity programme Siemens should develop a comprehensive Gender Equity Program, including policies to increase female representation beyond 30% in top management to achieve 100% employee access to share plans by expanding its equity-based programs. Lastly, Siemens should a develop core learning workshop skills, leveraging on technology for total government legislation and ethical practices compliance in meeting all SDGs targets by 2030.

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