KARMA TOKENS – A FRAMEWORK TO SYSTEMATICALLY MEASURE AND OFFSET ESG DEBT AND ENABLE UNBIASED GOVERNANCE FOR RESPONSIBLE & SUSTAINABLE GROWTH

by

Namitha Jeremiah

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Namitha Jeremiah

APPROVED BY: Apostolos Dasilas

Dissertation chair

RECEIVED/APPROVED BY: Renee Goldstein Osmic

Admissions Director

Dedication

This research is dedicated to all those who have lost their lives and loved ones due to the devastating effects of climate change. Your pain and sacrifice remind us of the urgent need to protect our planet for future generations. May your stories inspire lasting change and a more resilient world.

Acknowledgements

It is with immense gratitude and deep appreciation that I present this research, a culmination of hard work, perseverance, and unwavering support from those who stood by me throughout this journey.

First and foremost, I extend my heartfelt gratitude to God, whose divine guidance, wisdom, and grace have been the cornerstone of my academic journey. The strength to overcome obstacles, the clarity to navigate complex ideas, and the resilience to persist through challenges have all been blessings that I humbly acknowledge.

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Additionally, I express my sincere appreciation to my friends, peers, and all those who have contributed—directly or indirectly—to this research. Their support, insights, and kindness have played an integral role in shaping the final outcome of this work. This research stands not just as an academic achievement but as a testament to the collective efforts, sacrifices, and encouragement of those who have walked alongside me. To each and every one who has been part of this journey, I offer my deepest gratitude.

ABSTRACT

KARMA TOKENS – A FRAMEWORK TO SYSTEMATICALLY MEASURE AND OFFSET ESG DEBT AND ENABLE UNBIASED GOVERNANCE FOR RESPONSIBLE & SUSTAINABLE GROWTH

Context

One of the primary drivers of climate change is trapped CO2 that is released into the atmosphere by conventional energy sources like coal and petroleum. India still uses a lot of fossil fuels; despite the fact that "clean" and "renewable" energy technology have advanced significantly. In order to ascertain why the G20 nations—particularly India—are not meeting the objectives of the Paris Agreement, the worldwide strategy to mitigate climate change, this study has embarked on a journey of data collection, analysis, and hypothesis testing based on Business Responsibility and Sustainability Reporting (BRSR) published by the Government of India. The phrase "ESG debt" was coined as part of this study to describe an entity's adverse environmental effects and to provide guidance on how to mitigate them. Furthermore, the key objective of this research is a novel implementation framework termed "Karma tokens". Karma Token formulates a set of guidelines to incentivize companies and individuals to become more conscious of their actions and behaviors in relation to their carbon footprint. The research on "ESG Debt & Karma Tokens" investigates the social cost of emissions, the time-value of carbon, and carbon pricing schemes. Through the use of Karma Tokens, this framework seeks to increase public awareness and encourage sustainable growth in order to enhance both the planet's and people's quality of life.

Research Methods

The study recommends using positivism and pragmatism as its research philosophies in conjunction with the Theory of Inventive Problem Solving (TRIZ theory) to find answers for the research questions, taking into account the necessity of empirical data analysis based on emissions data, and maintaining a practical point of view while drawing inferences from the analysis. This study used a mixed-method approach, combining the advantages of qualitative and quantitative analysis. The data sources include a combination of primary and secondary data analysis, case studies, and survey research. To meet the research's objective, Julius, an AI-powered tool for statistical data processing, linear regressions, correlation analysis, descriptive statistics, and projections for data analytics and corroboration, is employed. In order to do an empirical investigation and create a strategy to arrive at an effective carbon price, this study investigated data samples of emissions and the social cost of carbon to compute ESG debt.

Results

This research examines India's path to net-zero emissions by 2070, emphasizing the critical role of industry-level emissions and the potential of ESG frameworks in accelerating climate action. Analysis of BRSR data from India's top 100 companies reveals that heavy engineering sectors—responsible for 88% of emissions among high-turnover firms—have shown slow progress, with only 34% achieving notable reductions in FY24 and renewable energy usage remaining at just 1%. In contrast, non-engineering sectors demonstrate higher renewable integration (73%) and lower emissions intensity, indicating faster decarbonization potential. Strong correlations between GDP, energy supply, and emissions (>0.98) confirm that India's economic growth remains tightly coupled with carbon output.

The study proposes an ESG debt model leveraging BRSR disclosures to quantify environmental, social, and governance liabilities. This model, supported by technologies like AI, blockchain, and IoT, can dynamically track emissions and financial impacts. It integrates carbon pricing mechanisms using the Social Cost of Carbon (SCC) and recommends offsets through CSR initiatives. Financial instruments such as green bonds and sustainability-linked loans further reinforce the economic case for emissions reduction. The findings highlight that widespread ESG adoption, sector-specific policy reforms, carbon markets, and targeted incentives are essential to align industrial growth with India's climate goals.

Discussion and Conclusions

This research highlights the pressing misalignment between India's current industrial emissions trajectory and its 2070 net-zero ambitions. The heavy engineering sector, with its high emissions intensity and minimal renewable energy integration, remains a critical challenge. In contrast, non-engineering sectors show promising signs of transition, demonstrating the feasibility of decarbonization when accountability, incentives, and policy alignment converge. The ESG debt framework introduced here offers a novel, quantifiable mechanism to measure sustainability performance. By integrating ESG liabilities with carbon pricing metrics like the Social Cost of Carbon (SCC), the model creates financial motivation for companies to internalize environmental costs and adopt cleaner technologies. Supported by real-time tracking technologies and predictive analytics, ESG debt can serve as both a corporate performance metric and a policy planning tool. While green finance instruments and carbon markets present enabling mechanisms, their limited adoption underscores the need for regulatory reinforcement and broader ESG literacy. Sector-specific mandates, especially stricter decarbonization targets for heavy industries and earlier net-zero pathways for others, will be essential. In conclusion, ESG debt transforms sustainability into a strategic imperative. If scaled effectively, it can realign India's industrial growth with climate responsibility—turning net-zero from a distant aspiration into a structured, accountable, and achievable goal.

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CHAPTER I: INTRODUCTION

1.1 Introduction

As the world is rapidly adopting ESG compliance to slowdown the alarming pace of climate change, Indian corporates have recognized that meeting ESG compliance may no longer be a regulatory demand, but non-compliance can ultimately lead to business crisis. In 2016, as part of the Paris Agreement, 196 countries committed to cooperating to reduce greenhouse gas emissions and decelerate climate change. The treaty aimed at reducing global warming to pre-industry levels ideally well below 2°C. The foundation of the Paris Agreement, widely known as a Nationally Determined Contribution (NDC), is a five-year cycle in which nations undertake ever-more-aggressive climate action. India's first pledge towards Paris Agreement in 2015 had three primary objectives (Khureja, 2022): (1) reduce emissions intensity by 33–35% below 2005 levels (2) ensure 40% of installed electric power from non-fossil-based energy resources by 2030. (3) increase afforestation by 2030 to produce a cumulative carbon sink equivalent of 2.5–3 giga tonnes of carbon dioxide. To propel the expansion of renewable energy, India made significant strides in developing favorable regulations supporting both wind and solar energy, however India still depends heavily on coal as the major source of energy. In FY23, the energy generated from coal in India accounted for about 77.01% of the total generation of energy followed by electricity from Hydroelectric, Nuclear and other Renewable energy sources (7.58%) and Natural Gas (6.83%) (Energy Statistics India. (2024)). As per the industry analysts, global emissions must peak before 2025 in order to have a chance of fulfilling the targets of the Paris Agreement, but India's emissions have been rising steadily as per the projections published by IESS (Indian Energy Security

Scenarios tool published by NITI Aayog, the apex public policy think tank of the Government of India).

According to SEBI's (Securities Exchange Board of India) most recent Business Responsibility and Sustainability Reporting, released in 2021, the top 1,000 listed Indian companies by market capitalization are required to submit sustainability disclosures on their ESG policies and practices. The timeline mandated to listed entities to undertake reasonable assurance of BRSR core is as per the following table:

Table 1 - Applicability of BRSR reporting by listed entities

Financial Year	Applicability of BRSR core to top listed entities by market capitalization
2023-24	150
2024-25	250
2025-26	500
2026-27	1000

The objective of BRSR reporting is to evaluate and publish a company's commitment to sustainable and responsible business practices based on the nine principles laid out in the framework referred as principle-wise performance disclosures. The framework correlates company's financial achievements and ESG performance and simplifies assessment of company's stability, performance, and sustainability.

In 2021, the Indian Prime Minister Narendra Modi announced the following new five-point set of targets at the United Nations Climate Change Conference in Glasgow:

(1) increase non-fossil fuel energy capacity to 500 gigawatts by 2030. (2) meet 50% of its energy requirements from renewable sources by 2030. (3) Reduce total projected carbon emissions by 1 billion tonnes from now through 2030. (4) Decrease carbon intensity to less than 45%. (5) achieve target of net zero by 2070. According to

point 3, Indian Industries must have reduced emissions significantly each year, yet the BRSR data evaluated reveals marginal reduction in emissions. In accordance with BRSR reporting Principle 6 (companies should respect and make efforts to protect and restore the environment), this research article aims to thoroughly examine five aspects (1) Company turnover, (2) Energy intensity per rupee of turnover (3) GHG emissions reduction (Scope 1 and Scope 2 emissions & its intensity (4) Rate of adoption of renewable energy in India, and (5) GDP growth of India. The conclusions drawn will be applied to determine ESG Debt, compute optimal carbon price based on the social cost of carbon, company's financial performance, energy intensity, and emissions intensity to propose a framework (karma tokens) to effectively offset ESG Debt.

1.2 Research Problem

Carbon pricing has been applauded by specialists in the domains of business, economics, and science as one of the most cost-effective strategies to decarbonizing economies. The two most prevalent types of direct carbon pricing are carbon taxes and cap-and trade-scheme, alternately referred as emissions trading systems (ETS). The third type is a credit process that grants "credits" to eligible projects that demonstrate real, sustained reductions in greenhouse gas emissions. The ETS determines the total amount of emissions that can be released by an entity. For every ton of emissions that the emitter releases into the atmosphere, an emission permit is needed. The government issues a limited number of emissions permits through an auction or offer free emission allowances to certain sectors.

The Government of India announced Carbon Credit Trading Scheme (CCTS) in June, 2023 to reduce greenhouse gas emissions from various sectors by pricing the emissions through a cap-and-trade system (Bureau of Energy Efficiency. 2024). Furthermore, government is expected to permit businesses to voluntarily offset their emissions by purchasing carbon credits from initiatives that reduce or eliminate greenhouse gas (GHG) emissions. Even though cap-and-trade schemes can accelerate pollution reductions and cut emissions, past researches have argued that they frequently result in higher prices for natural gas, coal, and oil as a means of compelling industries to switch to alternative energy sources causing an adverse impact on the economy.

The main goal of this research is to thoroughly examine the following issues:

(1) Inability to determine the right carbon price for the economy - The inability of governments to impose an appropriate cap on emissions is a potential roadblock to the implementation of a cap-and-trade scheme. A cap that is too low is perceived to heavily burden the business, potentially passing the cost on to consumers. On the contrary companies may not have an incentive to lower their emissions if governments place unreasonably high cap on emissions. Critics argue that Carbon tax, which charges corporations for every ton of emissions produced, is considered more punitive compared to cap-and-trade scheme.

(2) Lack of standardized frameworks for monitoring, reporting, and verification of GHG emissions - The foundation of carbon pricing and management systems is the monitoring, reporting, and verification of GHG emissions. Air pollution emissions are measured and reported in real time using Continuous Emission Monitoring Systems (CEMS). In 2014, the Central Pollution Control Board (CPCB) of India mandated the adoption of CEMS, a tool to track pollution in India's industries. Key policy & implementation gaps identified by CPCB are lack of a standardized framework for implementing CEMS across various industries, inadequate real-time data, audit information and verification procedures to guarantee the integrity of data and absence of

a clear and consistent enforcement plan to penalize non-compliance (Srivastava et al. 2024).

(3) Lack of effective tools to link social cost of carbon to emissions - The social cost of carbon, or SCC, is a commonly used indicator of the expected economic losses from CO2 emissions. SCC demonstrates how current CO2 emissions affect future economic outcomes by changing the climate. SCC can become a benchmarking tool to gauge the overall societal benefits of policies aimed at lowering greenhouse gas emissions. As a result, SCC is a crucial variable that guides research on many climate policy models across the globe.

1.3 Purpose of Research

Recent studies, including a comprehensive meta-analysis, have demonstrated that carbon pricing can lead to significant reductions in emissions. For instance, a study published in Nature Communications (Döbbeling-Hildebrandt et al. 2023) found that carbon pricing schemes resulted in statistically significant emissions reductions ranging from 5% to 21%. The researcher observed that the carbon pricing saw annual CO2 emissions growth rates of about 2% points lower than those without such pricing. These findings imply that, despite the modest carbon prices in many instances, the introduction of these schemes made significant impact on lowering emissions. This is consistent with the economic theory that by making carbon-intensive processes more expensive, industries are compelled to switch to cleaner alternatives – the key is determining the ideal carbon price.

The objective of this study is to ascertain the relationships between variables that impact emissions, such as the social cost of carbon, ESG Debit, and carbon pricing in the context of India, and variables that affect emissions, such as the adoption of renewable energy and increased production leading to increase in GDP.

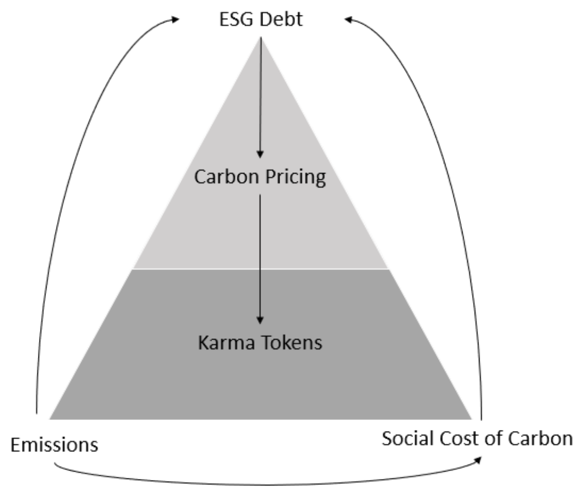

Figure 1 - Triangulation of variables impacting carbon price

Additionally, it attempts to analyze how these variables are influenced based on the energy sources, monitoring frameworks and technologies to ensure data integrity and immutability.

1.4 Significance of the Study

Through gazette notification, the Energy Conservation Amendment Bill, 2022 was approved by the Indian parliament in July 2023. This amendment empowered the central government to launch carbon trading scheme following consultation with the Bureau of Energy Efficiency. The Bureau of Energy Efficiency proposed a phase-wise inclusion of the following sectors under carbon credit trading scheme. Phase I is expected to cover energy, industries, agriculture, waste handling & disposal, forestry and transport sectors. Other areas like construction, solvent use, fugitive emissions, carbon capture, CO2 storage, and other abatement processes are expected to be covered in Phase II (Bureau of Energy Efficiency. 2021).

India has less than 45 years to achieve net-zero and the Indian Carbon Market is still under discussion while its predecessor PAT (Perform Achieve and Trade) scheme had several implementation fiascos failing to meet its objectives. A few of the key challenges faced by PAT, significant for this research, are excess availability of carbon credit certificates, lack of revenue generation opportunities such as auctioning or trading of carbon certificates to fund green projects, data quality, data transparency, and non-imposition of penalties to defaulters (CSE India. 2019).

As per the GDP statistics (World Bank. 2024) India is poised to increase the GDP by another 7% in the fiscal year FY25. Since emissions maintain a linear relationship with GDP, emissions are expected to scale up unless there is significant negative structural or technology effect to nullify the energy intensity effect curbing emissions created due to burgeoning demand and proportionate production.

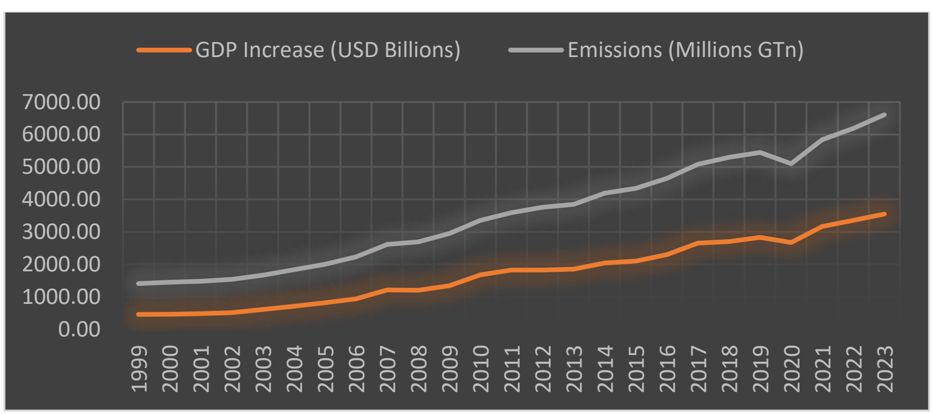

Figure 2 - World Bank Open Data – GDP & annual CO_2 emissions

Based on the facts published in BRSR reporting, the energy consumption (from renewable and non-renewable sources) and emissions is not commensurate and India must rapidly transition into renewable fuels for fulfilling its staggering energy demands.

As per **Error! Reference source not found.** renewable energy production in I ndia grew by 230% from 2010 to 2013, however the emissions did not show any dip as per Figure 2.

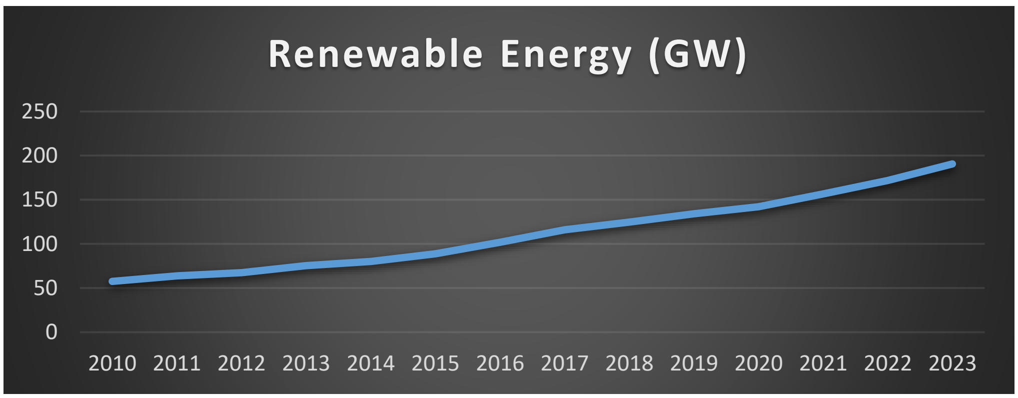

Figure 3 - Renewable energy production

At this juncture, to my knowledge, this is the first study examining the impact of renewable energy consumption, energy intensity, emissions and social cost of carbon to arrive at an optimal carbon pricing. Second, this study intends to compute ESG debt of a firms based on the data disclosed or reported by entities recognized by Government of India. Third, the research goes beyond demonstrating linear impacts and delves into understanding the mediation effects of renewable energy consumption and carbon pricing and proposes to introduce karma tokens to create public awareness highlighting indirect ways in which these factors influence LiFE (Lifestyle for environment). LiFE a public movement in India to mobilize individuals to become 'Pro-Planet' and adopt environment-friendly actions in their daily lives. Finally, by addressing these points, this study aims at getting closer to SDGs 7 (affordable and clean energies) and 13 (climate actions) targets.

1.5 Research Purpose and Questions

While the companies are grappling with the new BRSR reporting and numerous datapoints, the correlation of these datapoints to measure company's ESG debt has not been arrived at. The term "ESG debt" is a term coined as part of this research to describe an entity's detrimental effects on the environment and to explain how to effectively mitigate those effects by leveraging "Karma tokens," which can be a unique implementation tool developed based on my research proposal, to ensure adherence to sustainable growth through ethical business practices. The following research questions are developed based on the study of reporting, the inability of the present systems to measure ESG debt, and the lack of an effective tool to lessen the effects of unsustainable business practices.

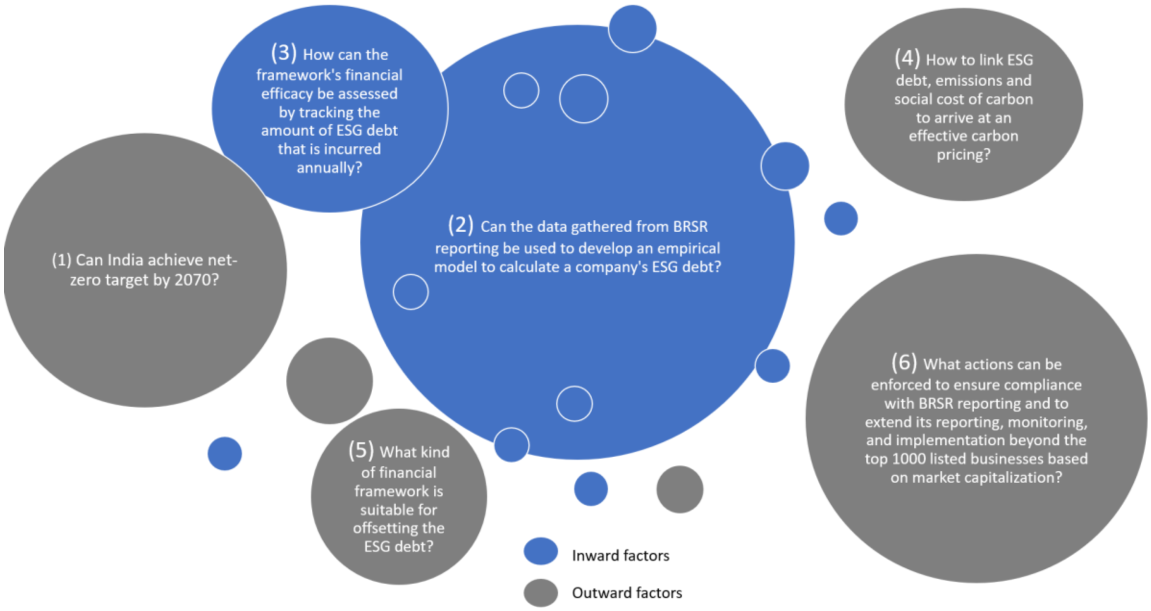

Figure 4 - Research questions

For defining the purpose of this research both inward and outward looking factors are considered. The questions marked in blue bubbles are the inward-looking factors (impacting company operations) and the ones marked in grey bubbles are outward looking factors. Aspects that are internal to the entity or business under study, such as internal procedures, performance indicators, social standing, or strategies, are referred to as inward-looking factors. Examples of inward-looking criteria include data on energy consumption, emissions, employee satisfaction, and financial performance. External influences including market trends, competitor strategies, the legal system, or social standards are referred to as "outward-looking factors." Examples of outward-looking influences include industry benchmarking for carbon pricing, sustainability policies, and the public's opinion of the organization. These research question considers inward factors like a company's emissions alongside outward factors like climate regulations, carbon pricing, social cost of carbon and societal expectations. Additionally, an organization's internal product innovation can be evaluated in relation to external competition products and consumer trends.

Key advantages in considering both inward and outward looking factors in this research are (1) A thorough understanding of how internal characteristics interact with external influences can be obtained by taking into account both inward-looking and outward-looking aspects. (2) Organizations may discover areas for internal improvement while effectively responding to external changes by striking a balance between inward and outward-looking variables. (3) Recognizing trends and foreseeing potential obstacles or opportunities in the future require an awareness of external circumstances. In the meanwhile, assessing present skills and preparedness requires consideration of inward-looking elements.

CHAPTER II: REVIEW OF LITERATURE

The concept of Environmental, Social, and Governance (ESG) originated in the early 1990s, aligning with the rise of socially responsible investing. This evolution was accompanied by the development of formal standards and guidelines for ESG disclosure. Over the years, ESG integration has gained prominence, significantly influencing both investment strategies and regulatory policies. Today, ESG is widely recognized as a comprehensive framework for assessing the sustainability and ethical conduct of corporate practices. One of the main causes of global warming worldwide is trapped CO2, which is released into the atmosphere by conventional power sources like coal and petroleum. Even with notable advancements in "clean" and "renewable" energy technologies, India still depends mostly on fossil fuels. Together with a case study, this literature review sought to offer a thorough understanding of the basics of the carbon market and its main obstacles, effects, and advantages. According to the literature review, stakeholders and regulators increasingly require corporations to report on the governance, social, and environmental aspects of their business activities.; Traditional financial measurements are no longer thought to be helpful in establishing a relationship between an organization's value creation and ESG debt.

2.1 Theoretical Frameworks

This section broadly explores the theoretical frameworks such as Global standards for Carbon Emissions and its significance in combating emissions, Continuous Emission Monitoring Systems (CEMS) to accurately monitor and measure emissions, Time-value of carbon concept that acknowledges the value of saving carbon today than in future, carbon pricing and instruments that can effectively determine the price of carbon, the role of caron markets and its impact on international trading and price discovery, social cost of carbon to estimate the monetary cost of damage resulting from each additional ton of carbon emissions, ESG scores and its implications on cost of capital, and the relationship between ESG score and systemic risk of a company. Additionally, this literature review also examines Carbon Credit Trading Scheme of India that is expected to enable companies to trade carbon credits followed by a case study based on the BRSR data published by a prominent Indian conglomerate.

2.2 Global Standards for Carbon Emissions

Organizations such as the International Organization for Standardization (ISO), Greenhouse Gas Protocol (GHG Protocol) and the Global Reporting Initiatives (GRI) are mostly responsible for setting global standards for carbon emissions. Other noteworthy standards are the Science Based Targets initiative (SBTi), the Task Force on Climate-Related Financial Disclosures (TCFD), the Carbon Disclosure Project (CDP), and BRSR Reporting, which was established by Securities Exchange Board of India.

GHG Protocol Corporate Standard: Launched in 1998, the greenhouse gas (GHG) Protocol is a Corporate Standard that requires business organizations to measure, quantify, and disclose their emissions in order to control global emissions systematically. Key frameworks of the GHG Protocol for companies are Corporate Standard for monitoring company-level GHG emissions inventory, Corporate Value Chain (Scope 3) Standard for evaluating emissions throughout a company's value chain, Mitigation Goal

Standard for defining and reporting national and subnational mitigation goals, and Policy and Action Standard for estimating the greenhouse gas impact of policies. As per the GHG protocol, Direct emissions from owned or controlled sources are referred to as scope 1 emissions. Indirect emissions from the production of purchased energy are referred to as scope 2 emission (GHG Protocol. 2025). Scope 3 emissions encompass all indirect emissions not included in Scope 2 that arise throughout a company's value chain, including upstream and downstream, as delineated by the Corporate Value Chain Standard. The noteworthy effects of the GHG Standard include improved emissions measurement, enhanced reporting, setting realistic reduction targets, regulatory compliance, corporate value chain management, and market differentiation. Understanding a product's emissions over its entire lifecycle and concentrating efforts on the biggest mitigation opportunities are enabled by the GHG Product Standard. Scope 1, 2, and 3 emissions forms the essential components of carbon pricing model since they serve as the basis for calculating the social cost of carbon and ESG debt.

International Organization for Standardization (ISO. 2018): ISO promotes 3 key standards for carbon emissions such as (1) ISO 14000 standards, established in 1996, enables organizations to define targets and accomplish environmental performance goals linked to lowering carbon emissions. (2) ISO 14064, established in 2006 and revised in 2018 and 2019, offer guidelines to standardize emission measurement by quantifying and reporting GHG emissions from a company's various operations. (3) ISO 50001 standard, founded in 2011, for energy management systems is designed to help organizations in multiple sectors to achieve energy efficiency providing a practical approach to optimizing energy use through the development of an energy management system. These ISO standards support efforts to mitigate and adapt to climate change, promote regulatory compliance, open global markets for clean energy and energy-efficient technologies, and encourage international collaboration to address carbon emissions across various sectors and regions (Isocerts. 2025).

The Global Reporting Initiative (GRI): The entity was founded in 1997, as an independent, non-profit, international standards organization that assists governments, corporations, and other entities in recognizing and reporting the impact of their business operations on governance, corruption, human rights, labor practices, responsible business conduct and climate change. Similar to GHG protocol, GRI provides guidelines for organizations to report on their emissions-related impacts such as Scope 1 (Direct GHG Emissions), Scope 2 (Indirect GHG Emissions) and Scope 3 (Other Indirect GHG Emissions). GHG Protocol standards are specific to greenhouse gas emissions accounting and reporting, whereas GRI standards provide a more comprehensive framework for sustainability reporting. When combined, they offer a thorough understanding of an organization's sustainability performance (GRI. 2022).

Task Force on Climate-Related Financial Disclosures (TCFD): In 2015, the Task Force on Climate-related Financial Disclosures (TCFD) developed an internationally recognized framework for disclosing climate-related risks, with a focus on governance, strategy, risk management, measurements, and targets. In July 2023, the Financial Stability Board (FSB) announced that the Task Force on Climate-related Financial Disclosures (TCFD) has completed its work with the release of International Sustainability Standards Board (ISSB). In October of 2023, TCFD dissolved after fulfilling its objective (Task Force on Climate-related Financial Disclosures. 2017).

Science Based Targets initiative (SBTi): Science-Based Targets (SBTs) and the Science-Based Target Initiative (SBTi) are rapidly becoming the industry standard for companies committed to addressing climate change with backing from prominent institutions such as the UN Global Compact, CDP (Carbon Disclosure Project) and WWF (World wide Fund for Nature). SBTi offer a well-defined pathway to lower emissions and provides businesses with an open and credible means to set realistic and attainable emissions reduction goals in accordance with the objectives of the Paris Agreement. Founded in 1995, SBTi has over 5,000 companies engaging with it globally (Science Based Targets Initiative. 2023).

Sustainability Accounting Standards Board: Established in 2011, SASB standards help businesses disclose relevant sustainability-related risks and opportunities that could impact their financial performance. In 2022, SASB was integrated into the International Sustainability Standards Board (ISSB) under the IFRS Foundation, which continues to maintain and evolve its standards. More than 3,200 organizations across well over 80 jurisdictions adopt the SASB Standards considering industry-based sustainability disclosures are cost-effective for enterprises and aid investors in their decision-making.

Carbon Disclosure Project: CDP is a global non-profit organization with offices globally and CDP assists public authorities, businesses, cities, states, and regions in disclosing their environmental impact. In order to govern market behavior, CDP collaborates with investors, regulators, and businesses to reveal their environmental impact and provide data to decision-makers thereby gaining a competitive edge over non-responders, recognizing environmental concerns and opportunities, and increasing investor trust. For the Indian companies, CDP and BRSR has several commonalities particularly Principle 2 and Principle 6 of BRSR reporting which are primarily concerned with the environment.

Business Responsibility and Sustainability Reporting: In India, SEBI established BRSR in response to the growing national and international focus of stakeholders and investors who want companies to be sustainable and responsible to the environment and society. The BRSR requests information from listed companies regarding how well they are performing in relation to the nine tenets of the "National Guidelines for Responsible Business Conduct" (NGRBC). SEBI mandated top 1000 listed businesses to submit BRSR data for the fiscal year 2026–2027. Mapped to five Global Reporting Frameworks -such as GRI, SDG, TCFD, CDP and SASB- the BRSR framework combines the financial success of Indian companies with their ESG performance, facilitating the comprehensive evaluation of a company's stability, performance, and sustainability for regulators, investors, and both upstream and downstream stakeholders. The objective of BRSR reporting is to evaluate and publish a company's commitment to sustainable and responsible business practices based on the nine principles laid out in the framework referred as principle wise performance disclosure. The BSBR report (SEBI. 2023) recommends to provide emission intensity per rupee of turnover, emission intensity in terms of physical output and break-up of the greenhouse gases into CO2, CH4, N2O, HFCs, PFCs, SF6, and NF3 if available. According to BRSR, businesses are required to report on the substantial direct and indirect effects they have on biodiversity, as well as any preventative and remediation measures, they have taken, including specific initiatives, cutting-edge technology, or inventive techniques to lessen the impact of emissions. This research paper intends to deep-dive into Principle 6 of BRSR reporting, which states that businesses should respect and make efforts to protect and restore the environment mandating companies to disclose greenhouse gas emissions. The table below is a summary of standards in the emissions space:

Table 2 – Summary of emissions standards

Aspect	SBTi	ISO	GRI	GHG Protocol	CDP	SASB	BRSR
Founded in	1995	1996	1997	1998	2000	2011	2018
Focus	Climate	General sustainability and net-zero guidelines	Sustainability reporting and emissions management	GHG accounting and reporting	Emissions disclosure and management	ESG & Financial Materiality	ESG & Compliance

Aspect	SBTi	ISO	GRI	GHG Protocol	CDP	SASB	BRSR
Scope	Scope 1, 2, and 3 emissions	Direct and indirect emissions	Scope 1, 2, and 3 emissions	Scope 1, 2, and 3 emissions	Scope 1, 2, and 3 emissions	Scope 1, 2, and 3 emissions	Scope 1, 2, and 3 emissions, energy consumption, value chain assessment
Reporting Standards	SBTi Criteria	ISO 14064 series	GRI Standards	Corporate Accounting and Reporting Standard	CDP Questionnaire	Industry specific guidelines	SEBI guidelines, aligned to global frameworks
Verification	Voluntary, but widely adopted by organizations						Voluntary, but mandatory for top listed Indian companies
Key Metrics	GHG emissions, science-based targets	GHG emissions, net-zero targets	GHG emissions, energy consumption, emissions reduction targets	GHG emissions and reduction targets	GHG emissions and reduction targets	Financially material ESG metrics	Emissions, energy consumption, investments in sustainable products
Global Reach	Global, widely used by organizations						Primarily in India, but aligned and mapped to

Aspect	SBTi	ISO	GRI	GHG Protocol	CDP	SASB	BRSR
							global ESG standards
Regulatory Framework	Developed by SBTi	Developed by ISO	Developed by GRI	Developed by WRI and WBCSD	Developed by CDP	Developed by IFRS	SEBI regulations in India

2.3 Continuous Emission Monitoring Systems

Industrial emissions are a primary contributor to air pollution in India, discharging various pollutants into the atmosphere, notably carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen oxides (NOx), and particulate matter (PM). These pollutants severely damage the ecosystem, and mitigating them through clean energy, environmentally conscious farming, and advanced garbage disposal is essential for safeguarding the planet. (MoHFW India. 2021).

Table 3 - Emissions, source and impact

Types of emissions	Source	Impact
Carbon Dioxide (CO_2)	Fossil fuel combustion (transportation, electricity generation, industry), deforestation.	Major greenhouse gas contributing to global warming and climate change.
Methane (CH_4)	Agriculture (livestock digestion), landfill decomposition, and fossil fuel extraction.	Has a shorter atmospheric lifespan than CO_2 but is over 25 times more effective at trapping heat.

Types of emissions	Source	Impact
Nitrous Oxide (N_2O)	Agricultural practices (use of synthetic fertilizers), industrial activities, and burning of fossil fuels.	Potent greenhouse gas that also contributes to ozone layer depletion.
Sulphur Dioxide (SO_2)	Burning of coal and oil, smelting of mineral ores.	Causes acid rain damaging ecosystems and aquatic organisms, and exacerbating respiratory issues in humans.
Chlorofluorocarbons (CFCs) and Hydrofluorocarbons (HFCs)	Refrigerants, aerosol propellants, and solvents.	Deplete the ozone layer and act as powerful greenhouse gases.
Particulate Matter (PM2.5 and PM10)	Industrial emissions, vehicle exhaust, and open burning.	Harmful to human health (causes respiratory and cardiovascular problems) and contributes to air pollution.

CEMS systems are essential for tracking and measuring the levels of pollutants released by industrial processes in order to guarantee both environmental protection and legal compliance. CEMS comprises measurement and monitoring techniques, sampling of emissions data, assessment of monitoring technologies, site assessment, preparation and installation of CEMS devices, calibration, performance evaluation and Audit of CEMS, data acquisition systems and management reporting (Bhawan et al. 2018). Adoption of CEMS is gaining traction as India struggles with serious air pollution problems. To efficiently regulate pollution from different businesses, the Central

Pollution Control Board (CPCB) in India has issued a regulation for continuous emissions monitoring. According to the Directorate of Environment's analysis, roughly 500 industries in Uttar Pradesh have installed CEMS to measure and report their emissions in real-time, tracking emissions through real-time data monitoring systems. However, only 60% of these industries have shared their data with the CPCB, suggesting that obtaining real-time data from all of the industries remains a significant challenge (Srivastava et al. 2024).

As per the research by Bhuiyan, (2024), although there are challenges and issues associated with carbon footprint measurement as the corporates need to disclose scope 1, scope 2 and scope 3 emissions as per the GHG protocol, AI technologies, including machine learning algorithms, Internet of Things (IoT) devices, and blockchain, empower precise and real-time measurement of carbon footprints. In summary, CEMS underscores the critical role of advanced technologies in tackling India's air pollution and enhancing emission reporting accuracy. Despite challenges in obtaining real-time data from all industries, the proactive measures taken by regulatory authorities and the adoption of advanced technologies signal a promising shift towards more effective environmental management and sustainability in India.

2.4 Time-value of Carbon

Moura Costa et al. (2024) calculated the carbon equivalency time, which is approximately 55 years, during which sequestered carbon should be retained to counteract the radiative impact of carbon emissions. This estimate was based on the residence duration, decay pattern, and global warming potential of atmospheric CO_2. The effect of storing 1 tCO_2 (ton CO_2) for a year was calculated using this equivalency period, and it was discovered to be comparable to avoiding the effect of emitting 0.0182 tCO_2. The implementation of equivalence parameters was expected to address a number of issues related to land-based sequestration programs. (1) By using a "pay-as-you-go" basis approach, it eliminates any doubt over the forests' long-term sustainability. (2) Comparability between projects is enabled by equivalency parameters. The main flaw with the equivalency method is the uncertainty about the residence time and decay profile of atmospheric CO_2 and, consequently, the credibility of the equivalency parameter values.

The recent studies recommend a widespread adoption of negative emissions technology to limit global warming to 1.5 degrees Celsius. The "time value of carbon" theory (Marshall, 2010) states that cutting emissions of greenhouse gases, such as carbon dioxide, now will benefit society more than cutting emissions later. According to a number of studies, strict implementation of forest conservation, better forest management, afforestation and reforestation, soil carbon storage, and other land-based techniques are the only ways to achieve carbon neutrality by 2030.

Parisa et al. (2022) offers a typical model of the global carbon cycle to illustrate how many tons of short-term carbon storage in the ecosystem reserves have the same economic value as one ton of permanently trapped carbon. The landowners who intend to store their carbon reserves can utilize the resulting carbon credits to participate in a carbon trading market. The strategy might boost market participation and reduce trade costs between emission sources and specific land parcels that can produce offset credits. The author anticipates that the value of a ton of carbon sequestered from the atmosphere increases with storage time. While the early research on carbon offsets acknowledged the benefits of short-term sequestration, but failed to reach a consensus on how to create a meaningful benchmark. A ton of carbon stored permanently is valued at the current social cost of carbon, but a ton stored for a single year has an annual rental value based on the carbon price. Currently, investors are deterred from participating in an offset market by the requirement for long-term carbon storage. Consequently, it is believed that shorter carbon storage periods will boost wider market participation and raise the net quantity of carbon stored in the environment.

While the "time value of carbon" theory emphasizes the immediate benefits of cutting greenhouse gas emissions and the necessity for widespread adoption of negative emissions technologies to limit global warming to 1.5 degrees Celsius, however uncertainties in CO2 residence time and decay profiles undermine the credibility of sequestration efforts. Additionally, the lack of consensus on meaningful benchmarks for short-term sequestration and the deterrent effect of long-term storage requirements on investor participation further complicate the situation. Despite theoretical benefits, the practical implementation of these strategies remains troubled with difficulties, limiting their effectiveness in addressing climate change although there are a multitude of green projects claiming to reduce emissions.

The recent research from Pan et al. (2024) covers three decades of data from 1990 to 2020 and estimates that 46% of fossil-fuel emissions has been sequestered from the atmosphere by global forests since 1990 with 95% confidence level. The quantity of carbon exchanged between the oceans, atmosphere, land, and living organisms on earth is defined as a carbon flux, and it is commonly expressed in gigatonnes (Gt) of carbon annually. The study underlines that the global forest sequestration rate of around 13 Gt of CO2-equivalent per year provides a conclusion that agriculture, forestry and other land-use sectors have a combined potential to mitigate an additional 8–14 Gt CO2-equivalent per year in 2020–2050. The study from Harris et al. (2021), integrates ground and earth observation data to map annual forest-related greenhouse gas emissions and abatement globally. The study suggests that forests are a carbon sink that absorb 1.5 times as much carbon dioxide as the United States emits each year, with a net annual absorption of 7.6 billion metric tons. The study explains that the carbon flux can be reliably measured throughout any region by combining the data from satellite observations with ground measurements. The recent studies imply that the time-value of carbon can be measured with some degree of accuracy using information gathered from different regions and continents, and as a result, they suggest that governments should support any project that improves a region's carbon flux through strict implementation of forest conservation, better forest management, afforestation and reforestation, soil carbon storage, and other land-based techniques.

In summary, carbon equivalency models and the “time value of carbon” underscore the urgent need for immediate emissions reductions and land-based sequestration. While carbon sequestration’s effectiveness depends on storage duration and atmospheric CO_2 dynamics, the “time value of carbon” theory emphasizes early emission cuts for maximum impact. While long-term storage yields high-value, but faces credibility and investment barriers, short-term approaches can boost carbon trading participation. Forests remain vital carbon sinks, with recent data supporting targeted conservation to boost global carbon flux and climate mitigation.

2.5 Social Cost of Carbon

The social cost of carbon (SCC) is a commonly used indicator of the expected economic losses from CO2 emissions. SCC explains how current CO2 emissions affect future economic outcomes by changing the climate. According to the research from Aon. (2023), the fifth most expensive year with 421 major natural disaster incidents that claimed over 31,000 lives and cost the global economy $313 billion was year 2022. Year 2024 was the warmest year on record, averaging 1.60°C above pre-industrial levels and surpassing 1.5°C for the first full calendar year with eleven months exceeding the 1.5°C threshold. Record highs were observed globally with multiple seasons and months setting new temperature records. In 2024, global sea surface temperatures hit a record 20.87°C marking the end of El Niño and a shift toward neutral or La Niña conditions triggering a series of catastrophic weather events. (Copernicus Climate Change Service 2025).

Policies aimed at lowering greenhouse gas emissions frequently get assessed as a function of their net benefits to society. This makes SCC an incredibly significant variable guiding researches globally on a wide range of climate policy models. The SCC serves as a benchmark for evaluating the societal benefits of policies aimed at reducing greenhouse gas emissions. For instance, it allows policymakers to compare the cost-effectiveness of different emission reduction strategies by providing a consistent measure of the economic benefits of avoided damages. SCC is a crucial variable in many climate policy models guiding the development of carbon pricing mechanisms, regulatory standards, and investment decisions, but when it comes to actual carbon pricing, policymakers are not really aided much because SCC estimates differ greatly. Based on a study conducted on social cost of Carbon Figure 5 - Country-level Social Cost of Carbon , India tops the chart with \$160.025/ tCO2. The social cost borne by India is significantly high although India ranks only fourth in the world with roughly 6.65% of global carbon emissions, behind China (26.83%), the USA (14.36%), and the EU (9.66%).

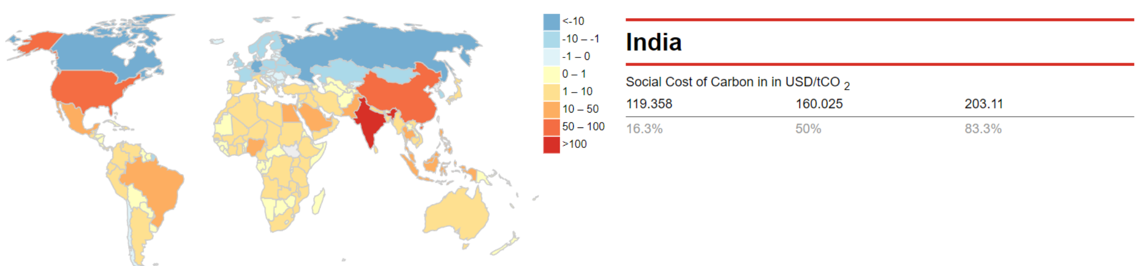

Figure 5 - Country-level Social Cost of Carbon

Discount Rates play a significant role in determining the present value of future damages due to carbon emissions. The discounting principle enables the comparison of immediate costs of cutting emissions with the long-term benefits of preventing climate change. The choice of discount rate significantly affects the SCC. At lower discount rates, future benefits are valued higher, leading to higher SCC estimates; at higher discount rates, future benefits are valued lower, leading to lower SCC estimates. A simplified illustration using different discount rates – Present Value (PV) of future climate damages in 100 years is computed for a future Value (FV) of \$1,000 at different discount rates such as 2%, 3%, 5% and 7%:

$P\ V = F\ V\ (1 + r)\ t$ Where: $F\ V =$ \$ 1,000 r = 0.02/ 0.03/ 0.05/ 0.07 and t ranges from 10 to 100 years. The present value of future climate damages (\$1,000) for various discount rates is as per the graph below. This demonstrates that a lower discount rate results in a higher present value of future damages, leading to a higher SCC estimate. Research from Guo et al. (2006) indicates that declining discount rates increase estimates of the SCC in a more variable manner than the earlier literature.

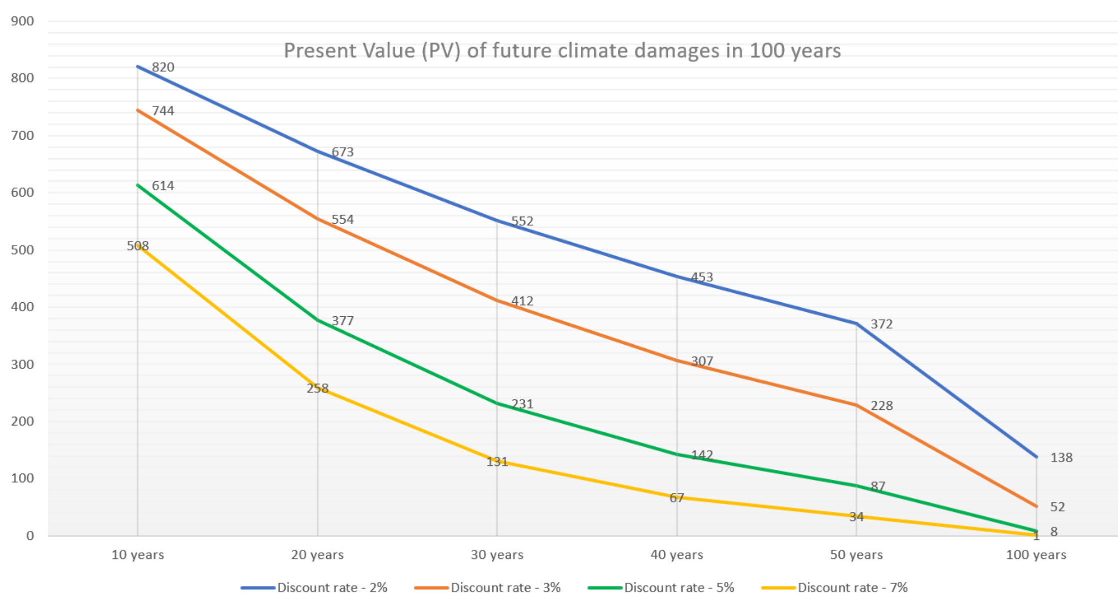

Figure 6 - Present value (PV) of future climate damages in 100 years

Socially Optimal Marginal Abatement Cost (SMAC), an alternative to SCC, represents the cost of reducing carbon emissions by one extra unit (one ton of CO2) while optimizing social welfare. Essentially, it helps determine the extent of emission reductions that will mitigate climate change at the most economical level.

Table 4 – Comparison of SCC and SMAC

Aspect	Social Cost of Carbon (SCC)	Socially Optimal Marginal Abatement Cost (SMAC)
Definition	The economic cost of the impacts of emitting one additional ton of CO2	The cost of reducing one additional unit of emissions to maximize social welfare
Scope	Focuses on the broader economic and social damages	Focuses on the cost of achieving emission reductions
Purpose	To quantify the economic damage caused by CO2 emissions	To determine the most efficient level of emission reductions
Calculation Basis	Based on the impacts of emissions on health, environment, and economy	Based on the cost-benefit analysis of reducing emissions
Policy Application	Used to set carbon pricing, taxes, and evaluate policy impacts	Used to inform optimal emission reduction strategies and policies
Impact on Decision-Making	Helps policymakers assess the economic implications of emissions	Guides policymakers on cost-effective emission reduction measures

Although they target different facets of the emissions reduction challenge, SCC and SMAC are both crucial instruments for guiding climate policy. While SMAC determines the most economical ways to cut emissions, SCC assigns a monetary value to the harm that emissions cause. The table above highlights the key objectives and differences between SCC and SMAC Khabarov et al. (2020). Despite the widespread use of SCC, Khabarov et al. (2020) highlights issues with the current calculation methods as it does not accurately reflect the intricate linkages between the climate and economic systems. The author strongly recommends to replace the SCC with the socially optimal marginal abatement cost (SMAC), which would better account for technological possibilities at the optimal level of emissions reductions.

2.6 Theories for Computing Social Cost of Carbon

Noteworthy theories utilized in calculating SCC include Integrated Assessment Models, which integrate information from multiple fields, including economics, politics, and climate science, to evaluate the effects of SCC and climate change. The examples of Integrated Assessment Models are The Dynamic Integrated Climate-Economy model (DICE), Policy Analysis of the Greenhouse Effect (PAGE) and Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) (Calel et al. 2017).

These models estimate the Social Cost of Carbon (SCC), an indication of economic damage caused by carbon emissions enabling policymakers to formulate laws that can slow down climate change. Value functions are essential indicators that determine the Social Cost of Carbon (SCC) in integrated assessment models (IAMs). Value functions rank a number of possible world conditions viz. agriculture, forestry, water resources, energy consumption, temperature & sea level rise, ecosystems, biodiversity, species, landscape, human health etc. from better to worse. These indicators are vital to determine how society values present well-being above future well-being and are crucial in determining the SCC.

The Dynamic Integrated Climate-Economy model (DICE) predicts economic growth, the corresponding CO2 emissions, the climatic response (including the temperature impact of these CO2 emissions), and the damage caused by rising global temperatures on economic consumption (DICE/RICE Models. 2020). According to Khabarov et al. (2020), DICE model uses two marginal values related to the consumption equation (cc.m (t)) and the emissions equation (eeq.m (t)) to determine the social cost of carbon (SCC). The formula eeq.m (t) + x * cc.m (t) = 0 is used to determine the SCC, where x represents the SCC value. Specifically, eeq.m (t) measures the impact of adding one ton of CO2, and cc.m (t) measures the impact of a one-dollar increase in consumption. Based on this equation, x determines the social cost of carbon, providing an exchange rate between rising emissions and consumption. The author claims that SCC is useful to estimate monetary damage when unforeseen events disrupt the emission equation. However, the SCC does not provide guidance on how to reallocate investment and consumption after a catastrophe.

Rebonato et al. (2023) modified the DICE model to identify two primary strategies for mitigating global temperature increase due to climate change: (1) abatement, which focuses on decreasing dependence on carbon-intensive energy sources, and (2) removal, which involves the implementation of negative emission technologies (NETs) to extract CO_2 from the atmosphere. The analysis of marginal costs for both approaches indicates that, although abatement is essential, the simultaneous and vigorous adoption of carbon removal strategies offer a more feasible pathway to meet the 1.5–2°C temperature objectives established in the Paris Agreement. Furthermore, the amalgamation of both strategies enables a more progressive transformation toward decarbonization, thereby fostering a smoother and more sustainable transformation in energy systems and economic frameworks.

The PAGE model (Policy Analysis of Greenhouse Effect), developed at the University of Cambridge by Chris Hope, is an Integrated Assessment Model (IAM) to predict the economic impacts of climate change and evaluate the costs and benefits of adaptation and mitigation strategies. While PAGE09 is an improved version of the PAGE2002 integrated assessment model, PAGE2002 was used to quantify the impacts and determine the societal cost of carbon. PAGE09 derives results from advanced scientific and economic models while accounting for the significant uncertainty surrounding climate change. Assessment cover eight world regions, ten time periods up to 2200, including four impact sectors such as rising sea level (linearly related to global mean temperature), economic & non-economic factors (a function of difference between regional temperature and the tolerable temperature level) and discontinuities (large-scale changes such as arctic ice melt due to rising temperature) (Hope, 2011).

Climate Framework for Uncertainty, Negotiation and Distribution (FUND) Model, developed by Richard Tol in 2002, is widely used in climate policy analysis. The model defines 16 major world regions and operates in one-year time-steps from 1950 to 2300. With detailed calculations Tol et al. (2006) argues that nations with high energy consumption and a heavy reliance on fossil fuels, emission reduction is inexpensive; in contrast, other nations with lower energy consumption and fossil fuel dependence are closer to the technological threshold of pollution abatement. By modeling how greenhouse gas emissions affect global temperatures and, in turn, sea levels, the FUND model creates a link between sea level rise and emissions. According to the model, greenhouse gas emissions increase atmospheric CO2 concentrations raising global mean temperatures leading to rising sea levels. It is assumed that the income density ($/km2) of dryland is linear, with an average value of $4 million per square kilometer. The amount of land lost and the average population density in the area determine how many people are compelled to migrate costing three times the regional per capita income. The cost in the receiving nation is approximately 40% of per capita per migrant. The FUND model has several disadvantages as it relies on simplifications and assumptions about complex systems, which can lead to inaccuracies. The model's conclusions are significantly influenced by the discount rate selection, which can have a significant impact on the expected costs and benefits of climate policy. The model may not sufficiently account for non-linear impacts and future uncertainty because its damage functions for evaluating economic implications are based on historical data. The model obscures important regional variances by aggregating impacts at the regional level, which could lead to incorrect policy recommendations.

In order to establish the official social cost of carbon, President Obama formed an Interagency Working Group in 2017. Three well-known Integrated Assessment Models—Hope's proprietary PAGE model, Anthoff and Tol's FUND model, and Nordhaus' DICE model (D. Nordhaus, 2023) —were used to distribute the social cost of carbon across time and scenarios. This table presents the SCC estimates for different years and discount rates, including a high-impact scenario for 2020 at a 3% discount rate (Zycher, 2018). The average of 50,000 simulations for each model is the frequently referenced estimate of the societal cost of carbon. The table represents the fluctuations in SCC based on various discount rates which indicates that if the discount rates are inaccurate, the resulting SCC can be largely misleading to policy makers due to significant deviations in discount rates considered for computation.

Table 5 – Sample calculation for Social Cost of Carbon

Year	Discount Rate	SCC / ton of CO2 (2007 Dollars)
2020	3%	$42
	5%	$12
	2.5%	$62
2030	3%	$50
2050	3%	$69

Additionally, the Interagency Working Group conducted a high-impact scenario, which calculates SCC as $123 and represents the 95th percentile number at a 3 percent discount rate. As of 2024, the discount rate applied in the US for computing the SCC is 4.65%. (The Federal Reserve. 2019). According to Auffhammer. (2018), the current computation approach is unable to capture the connections between the economy and climate, two important IAM components representing intricately intertwined systems and both impacting emissions reduction measures.

2.7 Carbon Instruments

Carbon pricing instruments are economic tools aimed at reducing greenhouse gas emissions by assigning a cost to carbon emissions, thereby incentivizing emitters to lower their carbon output. These mechanisms create financial motivation for sustainable practices. The two main types of carbon pricing instruments are carbon taxes and emissions trading systems (ETS), each employing different strategies to achieve emissions reduction goals.

(1) Carbon Tax places a direct price on carbon emissions. This is a direct tax imposed on the carbon content of fossil fuels or on greenhouse gas emissions and the tax rate is typically set per ton of CO2 emitted. By increasing the cost of emitting carbon, it encourages individuals and businesses to reduce their emissions and invest in cleaner alternatives.

(2) Emission Trading Systems (ETS), also known as cap-and-trade systems, establish an overall cap on greenhouse gas emissions and allocate or auction emission allowances to companies. Firms can trade these allowances, enabling cost-effective compliance. Over time, the emissions cap is gradually reduced to drive long-term reductions in overall carbon emissions. Emission allowances are distributed or auctioned to entities, who can then trade (buy or sell) allowances based on their needs. The overall emissions cap is gradually lowered over time to help meet long-term reduction goals, promoting flexibility and cost-effectiveness in achieving environmental targets.

According to Green (2021), Carbon taxes and Emission Trading Systems (ETSs) exhibit several key differences. (1) Carbon taxes ensure cost certainty as the government sets the price, but they do not limit emissions if regulated entities can pay the tax. In contrast, ETS ensure certainty by setting a government-imposed emissions cap. The cost of allowances in ETS vary based on scarcity, oversupply, and design features. By making it profitable, both strategies seek to encourage companies and individuals to lessen their carbon footprint. (2) Compared to Emission Trading Systems (ETSs), carbon taxes are simpler to design and administer due to governments' extensive experience in tax collection. ETSs are more complex as they involve setting a cap based on scientific and cost considerations, distributing or auctioning allowances, and establishing a platform for tracking, trading, and retiring allowances. Simultaneous auctioning of allowances from multiple years can influence future prices.

Key findings of Green (2021) are (1) There is limited evidence on the actual performance of carbon pricing policies using ex-post data, despite the consensus on their necessity for addressing climate change. (2) Overall reduction effect of both carbon taxes and Emission Trading Systems (ETSs) is insignificant, ranging between 0% and 2% per annum while carbon taxes show slightly better results than ETSs in producing reductions. These conclusions starkly contradict the conclusion from Döbbeling-Hildebrandt et al. (2023) which strongly correlates carbon pricing and emissions reduction.

2.8 Carbon Pricing

Concerns over Earth's changing climate have prompted governments all around the world to begin endorsing carbon-pricing schemes to promote the funding of sustainable development projects, although opinions on these laws' efficacy are still being argued. Proponents of carbon pricing have argued that it would eliminate the need for special regulatory policies on individual emission sources, making it a crucial tool for encouraging the reduction of GHG emissions. However, detractors contend that carbon pricing cannot effectively cut emissions as long as infrastructure and institutions remain the same and question its capacity to attract the capital needed for the advancement and implementation of low-carbon technology. The general public is directly impacted by the costs of carbon emissions since they are annually exposed to unfavorable weather conditions. These expenses include agricultural losses due to changed rainfall patterns, loss of property from extreme weather, and—above all—loss of all life forms. The objective of carbon pricing is to largely transfer the burden of these expenses, to the companies who generated these emissions. Failing to elevate our standards and engage in this essential aspect of life will leave policymakers and society uninformed regarding the most effective strategies to address the climate crisis.

Döbbeling-Hildebrandt et al. (2023) performed a comprehensive review and meta-assessment of empirical studies evaluating the effectiveness of carbon pricing mechanisms. By examining twenty-one globally implemented carbon tax and cap-and-trade programs, their research ascertained the average emissions reductions resulting from carbon pricing. Unlike earlier reviews, which considered up to thirty-five studies, their machine learning–assisted methodology identified eighty quantitative ex-post evaluations, offering a significantly broader evidence base on the impacts of these policy instruments. A review of seventeen carbon pricing schemes revealed that such policies led to immediate and long-term emission reductions ranging from 5% to 21%, averaging 10.4%. The effectiveness of these schemes varied widely, influenced by their design and scope rather than solely by carbon price levels. Notably, China's pilot emission trading schemes, despite having lower carbon prices, achieved greater emissions reductions (13.1%) than both the EU ETS (7.3%) and British Columbia's carbon tax (5.4%). This suggests that higher carbon prices do not automatically lead to greater emission reductions, highlighting the importance of policy design and national context in determining effectiveness. These differences were potentially attributed to other policies and schemes such as lower abatement costs, indirect carbon prices and alternate energy sources. Such instances, despite of the lower carbon tax, countries have witnessed significant reduction in emissions.

The study reinforced the idea that fuel usage is price elastic, meaning that rising carbon prices result in lower emissions and fuel use. Furthermore, research data analysis indicates that the effectiveness of carbon pricing policies increases over time; that is, studies conducted over longer time periods following the implementation of the carbon price report greater effects on emissions reduction than assessments conducted over shorter time periods. The counter argument is that emissions may have decreased as a result of a gradual transformation process over time, supported by innovation and investments. According to the research, the effectiveness of the policy increases with the increasing stringency in implementation.

The author highlights some research gaps that need to be filled by further primary research (1) Even though some of the more than 50 carbon pricing programs have been in place for more than a decade, their effectiveness in reducing emissions has not yet been assessed. (2) Studies assessing emissions reductions in systems with mean carbon prices exceeding $30 are limited. As the objectives of emissions regulation become increasingly stringent over time, there is a chance to support primary research in this field. (3) Only around 50% of the studies have rigorous designs with low risk of bias. The absence of high-quality primary research, partly due to poor data availability, limits the knowledge of climate policy effectiveness.

2.9 Carbon Markets

Carbon markets are trading platforms that allow enterprises and consumers to offset their greenhouse gas emissions by purchasing and selling carbon credits. A single carbon credit signifies the reduction, sequestration, or avoidance of one metric ton of carbon dioxide or other greenhouse gases similar in nature through diverse mitigation efforts. According to Piris-Cabezas et al. (2023), carbon markets can help achieve ambitious emissions targets more cost-effectively and enable global carbon markets to nearly double climate ambition compared to current Paris pledges (NDCs) without increasing total costs. Research from Green (2021) cautions that while Article 6 of the Paris Agreement and the ICAO agreement on aviation emissions have raised demand for an expanded international carbon market, the implementation of Article 6 has been controversial with unresolved rules on market mechanisms. Given the limited effects of carbon pricing, policymakers ought to weigh carefully while expanding worldwide markets and exercise discretion while connecting various markets considering the challenges in regulatory undertaking that may have unforeseen implications and tougher resolutions. These initiatives are viable only if they led to considerable reductions in carbon emissions, although there is limited data available to justify this theory.

2.10 Carbon Credit Trading Scheme

The Government of India announced the Carbon Credit Trading Scheme (CCTS) in June, 2023 to reduce GHG emissions from various sectors of Indian economy by pricing the emissions through a carbon credit certificate trading mechanism (Bureau of Energy Efficiency. 2024). The scheme's objective is to establish the country's first-ever domestic carbon market. Carbon Credit Trading Scheme (CCTS) promotes two primary categories of carbon trading: (1) A cap-and-trade system often termed as Emissions Trading Systems (ETS) determines the total amount of emissions that can be released by an entity. The government issues a limited number of emissions permits through an auction or by giving them away to companies at no cost. For every ton of emissions that the emitter releases into the atmosphere, an emission permit is needed. Those who are unable to profitably cut their emissions must buy more permits from those who can, as permits can be swapped. The supply and demand for permits then determines the final carbon price. (2) Voluntary methods allow businesses to voluntarily offset their emissions by purchasing carbon credits from initiatives that reduce or eliminate greenhouse gas emissions. According to Article 17 of the Kyoto Protocol, countries who have spare emission units, or emissions that are permitted but not "used," can use the emissions trading mechanism to sell their excess capacity to other nations that have not met their commitments. With the launch of CCTS, India is anticipating a rapid reduction in emissions to achieve its national targets by lowering 30% of its carbon emissions by

2050 and obtaining 40% of its energy from non-fossil fuel sources by 2030. Enhancing the share of non-fossil fuel generation will lower emissions from power generation and expedite the drive to achieve the Net Zero target by 2070. The table below illustrates the percentage of built capacity and generation from non-fossil fuels annually, according to the National Electricity Plan (NEP) for 2022–2027 and its prospective plan for 2027–2032. (*Energy Portal India. 2023)*:

Table 6 - India's renewable energy adoption plan

Year	**% of non-fossil fuel installed Capacity**	**% of non-fossil fuel**
2021-22	41%	25%
2026-27	57%	39%
2031-32	68%	49%

2.11 ESG Score, Cost of Capital and Systematic Risk

An unbiased assessment of a business's performance using Environmental, Social, and Governance (ESG) factors is referred as ESG score. It gauges how effectively a business handles opportunities and risks associated with social responsibility, governance, and environmental impact. Investors and other stakeholders can evaluate a company's sustainability and ethical policies using ESG scores, which can have an impact on its long-term financial performance. Numerous studies have looked at how ESG ratings affect a range of financial outcomes in recent years, including corporate financials, cost of capital, systematic risk, portfolio liquidity, company value, and stock market performance. Adopting ESG can help with risk/opportunity management (Park et al. 2021), while firms with a higher ESG disclosure witnessed lower default risk (Atif et al. 2021). The relationship between ESG and loan costs and default risk has not received much attention, but some researchers have shown a negative link, suggesting that lenders consider borrowers with better ESG performance to be less susceptible to default. According to Agnese et al. (2023), banks with higher ESG scores have lower costs of issuance, and ESG considerations have an impact on bank bond prices in the primary market. Owolabi et al. (2024) looked at the relationship between carbon risk and cost of debt for companies in G7 countries between 2011 and 2022. The findings demonstrate a significant positive correlation between debt costs and carbon risk and bolster the idea that lenders consider carbon hazards more seriously when borrowers seek for credit or loans.

Francisco Alves et al. (2024) suggest that reliable ESG score provide valuable insights into a firm's sustainability, which conventional financial risk measures may overlook. High debt and leverage indicate higher risk levels, but these metrics might not fully capture sustainability. Therefore, heavily indebted companies may struggle with cash flow for debt servicing. Creditors need information on long-term sustainability beyond traditional risk indicators, making ESG scores more significant for highly indebted firms. The study concludes that since lenders are more inclined to lend to businesses with a solid reputation and strong stakeholder relationships, organizations with higher ESG scores are more likely to have better stakeholder relationships and have access to affordable funding. In situations where banks and businesses have a long-standing relationship, this can result in better credit availability and better loan terms.

In summary, while better stakeholder relationships and lower financing are two benefits that organizations with higher ESG scores may experience, this viewpoint may oversimplify the intricacies involved. Higher ESG scores are assumed to inevitably result in better credit availability and advantageous loan terms, however this assumption ignores a number of important aspects. (1) The relationship between financial performance and ESG scores can be ambiguous. Businesses with high ESG ratings can still have financial difficulties due to various operational, market, or sector-specific issues. (2) Depending on their unique priorities and legal frameworks, financial institutions and geographical areas may substantially impact ESG scores. (3) Companies may pretend to improve their ESG scores by using "greenwashing" strategies without genuinely changing their sustainability standards. misleading investors and stakeholders about the true environmental and social impact of the business. In conclusion, a company's reputation and stakeholder relationships can be improved by having high ESG scores, but their effects on loan terms and funding are intricate and multidimensional. To ensure that ESG scores are more than just a surface-level indicator, these must be critically examined to ensure accurate representation of a company's sustainability performance.

2.12 Emissions Landscape of India

India has committed to reducing its carbon emissions by 30% by 2050 and sourcing 40% of its energy from non-fossil fuel sources by 2030, indicating that it is aware of the importance of taking environmental sustainability issues into account. India, a signatory to the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC), filed its first Nationally Determined Contribution (NDC) in

2015, which included the two measurable goals among other things. (1) to attain roughly 40% of installed capacity for electric power from non-fossil fuel-based energy sources by 2030, and (2) to lower the GDP's emissions intensity by 33 - 35% from 2005 levels by that time. The overall installed capacity of electric power derived from non-fossil fuel-based energy sources as of October 2023 is 186.46 MW, or 43.81% of the total installed capacity. According to India's third national statement to the UNFCCC, which was sent in December 2023, the country's GDP's emission intensity decreased by 33% between 2005 and 2019 (*Energy Portal India. 2023)*.

Although a few major Indian corporations have been disclosing their ESG performance for a while, most companies are not transparent on their commitment to the sustainability objective. India's rapid economic growth is driving up energy demand and pushing the nation to shift away from fossil fuels. However, the energy consumption is still dominated by fossil fuels, which drives up greenhouse gas emissions. The energy transformation necessitates large investments: according to McKinsey, climate control initiatives require $9.2 trillion in average annual spending on clean energy assets. As per the report submitted by CEA (Central Electricity Authority), India will need to invest ₹2.44 trillion to triple its solar and wind power capacity, to achieve 500 GW in renewable power capacity by 2030, in order to close the emissions gap and meet the Paris agreement. The Ministry of New and Renewable Energy (MNRE) is an Indian government ministry primarily tasked with developing and implementing new and renewable energy sources to augment the country's energy needs. According to the research findings of Kumar, C.R. et al. (2020), MNRE's efforts to advance the renewable energy sector have been successful, however it identified a number of obstacles in implementation.

Sharma et al. (2020) investigated the relationship between financial performance and ESG disclosure among Indian companies using the Ordinary Least Squares method. The study found a significant positive association between ESG disclosure levels and both financial and market performance. Conversely, foreign institutional investor (FII) stake and leverage were negatively associated with ESG disclosure. The analysis, which accounted for company size and industry sector, highlights the importance of transparent ESG reporting. The findings suggest that while strong financial performance encourages higher ESG disclosure, external ownership and debt levels may discourage it, emphasizing the need for consistent ESG presentation in annual and sustainability reports. The publication titled "ESG Reporting in India: Practices and Challenges" (Asokan, 2023) examines the enhancement of ESG reporting to better address stakeholder requirements and possible obstacles to implementing policy changes in this area.

The research on ESG Reporting, Environmental Dimension Disclosures by Large Energy Sector Companies in India (Motwani et al. 2023), applauds BRSR reporting to be in the right direction persuading companies to report. However, they highlighted that at the time of their research the reporting was not made mandatory making it difficult for the researchers to compile reliable data. The researchers proposed that some of the optional questions (found under leadership indicators) should be made mandatory for environmentally sensitive companies, like those in the coal and oil industries, if not for all companies in accordance with GRI reporting, in order to improve transparency and accountability, as the current BRSR reporting may still have shortcomings despite regulatory efforts.

The prior literature highlights India's commitment to reducing carbon emissions and increasing renewable energy sources, demonstrating awareness of environmental sustainability. It commends efforts by some Indian corporations to disclose ESG performance and notes the significant role of the Ministry of New and Renewable Energy (MNRE) in advancing renewable energy. While the inclusion of specific research findings adds credibility, showing that financial and market performance positively correlate with ESG disclosure, it also suggests regulatory improvements to ESG reporting, advocating for mandatory disclosure to improve data reliability and transparency. India's commitment to reducing carbon emissions and increasing reliance on non-fossil fuel sources appears ambitious but lacks transparency and comprehensive implementation. While some corporations disclose their ESG performance, most do not, leading to doubts about their commitment to sustainability. Despite efforts by the Ministry of New and Renewable Energy (MNRE), significant obstacles in implementation hinder progress. The reliance on fossil fuels continues to dominate energy consumption, contradicting the goal of reducing greenhouse gas emissions. The enormous investment required for clean energy transformation, as highlighted by McKinsey, poses a significant financial challenge. Additionally, the lack of mandatory ESG reporting hampers reliable data collection and transparency, making it difficult to gauge actual progress.

2.13 Case Study

The Securities Exchange Board of India (SEBI), the regulatory body in charge of India's markets, developed the Business Responsibility and Sustainability Report (BRSR), a national framework for environmental, social, and governance (ESG) reporting. The objective of BRSR reporting is to evaluate and publish a company's commitment to sustainable and responsible business practices based on the nine principles laid out in the framework referred as principle wise performance disclosure. This case study intends to deep-dive into the BRSR report published by Reliance Industries Limited (RIL), a Fortune 500 company and the largest private sector corporation in India. The study will make use of data made available in compliance with BRSR reporting Principle 6, which requires businesses to respect the environment and take action to protect and restore it. Under principle 6, there are 9 areas listed as Mandatory disclosures/ Essential Indicators of which three areas pertinent to carbon emissions will be undertaken for the detailed assessment (SEBI. 2023):

Table 7 – BRSR Principle 6 - Essential indicators

S No	Instruction/ guidance on assessment
1	Details of total energy consumption (in Joules or multiples) and energy intensity per rupee of turnover – This includes source as renewable and non-renewable energy sources.
2	Disclosure of air emissions to understand how the data has been compiled, such as any standards, methodologies, assumptions and/or calculation tools have been used.
3	Details of GHG emissions (Scope 1 and Scope 2 emissions) & its intensity. The term greenhouse gases cover Carbon dioxide (CO_2), Methane (CH_4),

S No	Instruction/ guidance on assessment
	Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6), and Nitrogen trifluoride (NF_3).

The energy expenditure and energy intensity per rupee of turnover that Reliance Industries Limited submitted to SEBI in the BRSR report for FY 2022–2023 and FY 2023–2024 are illustrated in the table below:

Table 8 - Energy consumption and Energy intensity

Parameters	FY 2021-22	FY 2022-23	FY 2023-24
Renewable energy (Million GJ)	3.121	6.705	6.826
Non-renewable energy (Million GJ)	482.680	466.885	457.374
Total energy consumed (Million GJ)	485.801	473.590	464.200
Turnover (₹ in billions)	4650.593	5780.880	5749.560
Energy intensity per rupee of turnover *	0.00010446	0.0000819	0.0000807

* Energy intensity is a measure of the energy inefficiency of a company. Energy intensity per rupee of turnover = (Total energy consumption/ turnover in rupees). In FY23, there was a 20% decrease in energy intensity while the use of renewable energy climbed by 115% and turnover rose by 24%. On the contrary, in FY24, there was a modest rise in the use of renewable energy at 1.8%, and the percentage fall in energy intensity was just 4% while the turnover shrank by 1%.

Emissions analysis – Greenhouse gases released by an organization from sources under its direct ownership or control are referred to as scope 1 emissions. This pertains to the emissions generated by Reliance Industries from the production of lubricating oils, illuminating oils, gaseous and liquid fuels, and other products derived from crude petroleum. Indirect emissions fall under scope 2 and are caused by an organization's purchases of energy sources viz. heat, steam, power, or coolants. These include greenhouse gases that are emitted off-site for which the Reliance Industries is still solely responsible. The GHG emissions that RIL reported in the BRSR submitted for the fiscal years 2022–2023 and 2023–2024 are listed below.

Table 9 - Scope 1 and Scope 2 emissions

Parameter	FY 2021-22	FY 2022-23	FY 2023-24
CO2 (Metric tonnes)	36,989,370	36,857,083	36,680,367
NH2 (Metric tonnes)	36,508	30,682	33,571
N2O (Metric tonnes)	197,699	189,226	205,004
Total Scope 1 emissions (Metric tonnes)	37,223,578	37,095,658	36,900,275
Total Scope 2 emissions (Metric tonnes)	867,610	850,070	781,764
Turnover (₹ in billions)	4650.593	5780.880	5749.560
Emissions intensity / rupee of turnover	0.00000819	0.00000656	0.00000655

According to the table above the decline of scope 1 emission intensity in FY23 vs. FY22 was negligible while the scope 2 emissions dropped by 2%. Conversely, FY24 witnessed a moderate drop in the scope 1 emission intensity by 1%, and the fall in scope 2 emission intensity was roughly 8%.

As per the following table, the energy consumption (from renewable and non-renewable sources) vs. emissions is not commensurate and Reliance Industries need to rapidly transition into renewable fuels for fulfilling its staggering energy demands.

Table 10 - Percentage change in emissions and energy intensity

Energy Source/ Emission Parameter	FY 2021-22	FY 2022-23	FY 2023-24	% change in FY23	% change in FY24
Renewable energy (Million GJ)	3.121	6.705	6.826	115%	2%
Non-renewable energy (Million GJ)	482.68	466.885	457.374	-3%	-2%
Total Scope 1 emissions (Metric tonnes)	37,223,578	37,095,658	36,900,275	-0.3%	-0.5%
Total Scope 2 emissions (Metric tonnes)	8,67,610	8,50,070	7,81,764	-2%	-8%
Turnover (₹ in billions)	4650.593	5780.88	5749.56	24%	-1%
Energy intensity per rupee of turnover	0.00010446	0.00008377	0.0000807	-20%	-4%
Emissions intensity per rupee of turnover	0.00000819	0.00000656	0.00000655	-20%	-0.2%

In FY24, RIL modestly boosted the usage of renewable energy by 2% while decreasing the use of non-renewable energy by 2%. In contrast, CO2 emissions reduced by less than 1%, but other features like energy intensity and emissions intensity dropped by just 4% and 0.2%, respectively. These figures signify that, although there is a downward trend, it's not significant enough to meet the net zero target unless the spend on renewable energy and its impact on climate needs are closely monitored and addressed in a timely manner.

According to BBC News (2022), the world is expected to spend approximately $10 trillion year-on-year until 2050 to combat climate change, this paper suggests that top 100 global companies must spend an equivalent percentage of its annual sales towards climate control initiatives based on the facts above. Considering the adverse effects of its greenhouse gas emissions and rising global temperatures have caused to the environment, Reliance Industries Limited must contribute significantly towards reaching the $10 trillion annual spend target for supporting climate control initiatives.

The 26th UN climate change conference, COP26, was held in Glasgow, Scotland. India's new five-point set of targets announced at COP26 states that the country will reduce its total anticipated carbon emissions by 1 billion tons in ten years, i.e. from 2021 to 2030, approximately 10% annually. According to COP26, RIL must have reduced emissions by 10% in FY23 and FY24, yet the data in BRSR only demonstrates reductions of 0.4% and 0.7%, respectively. Based on the evidence presented, this article claims that India may not accomplish the 2030 emissions target, unless there is a considerable effort and investment towards transitioning to renewable energy and stringent policy/ penalty enforcement by the government and regulators in case of non-compliance.

Reliance Industries Limited secured a meritorious 49th rank in Forbes global 2000 companies, and its sales, profit and market cap attributes to 0.7% of overall sales, profit and market cap of top 100 global companies. As per the Companies Act of 2013, a company having net worth of rupees five hundred crore or more must invest 2% of its average net income from the three fiscal years prior in corporate social responsibility (CSR). The integrated annual report of reliance industries limited (Reliance Industries Limited. 2024), disclosed consolidated revenue as ₹ 10,000 billion in FY24 and the same report mentioned the CSR Contribution of RIL as ₹ 1,592 crores. As per the companies act, RIL should have invested ₹ 200 billion for CSR activities and a fair bit of that must have been spent on emissions reduction activities.

2.14 Key Regulatory Bodies in India Driving Net-Zero Efforts

a. Bureau of Indian Standards (BIS) - BIS develops sustainability standards for industries, including energy efficiency, biofuels, and green building materials. It ensures compliance with low-carbon technologies and promotes eco-friendly manufacturing.

b. The Ministry of Environment, Forest and Climate Change (MoEFCC) oversees India's climate policies, including emissions reduction strategies and environmental regulations. They implement the National Action Plan on Climate Change (NAPCC), which includes missions on renewable energy, energy efficiency, and sustainable agriculture.

c. Central Pollution Control Board - CPCB regulates industrial emissions and monitors air quality and enforces carbon reduction policies and ensures industries comply with environmental norms.

d. Ministry of Power - MoP develops energy conservation policies and promotes renewable energy adoption and oversees the Carbon Credit and Trading Scheme (CCTS), which helps industries transition to low-carbon operations.

e. Bureau of Energy Efficiency - BEE implements energy efficiency programs across industries and households and manages the Perform, Achieve, and Trade (PAT) scheme, which incentivizes industries to reduce energy consumption.

f. National Green Tribunal - NGT enforces environmental laws and penalizes industries that violate emissions regulations and ensures compliance with net-zero targets through legal interventions.

2.15 Indian Standards Supporting Net-Zero Goals

a. Energy Efficiency Standards such as Energy Conservation Building Code (ECBC) sets guidelines for energy-efficient buildings and Star Rating Program labels appliances based on energy efficiency to reduce electricity consumption.

b. Renewable Energy Standards such as IS 17082: Solar Photovoltaic Systems defines quality standards for solar panels and IS 15652: Wind Turbines ensures reliability and efficiency in wind energy generation.

c. Carbon Market Regulations - Carbon Credit and Trading Scheme (CCTS) is promoting a national carbon market to incentivize emissions reduction and Perform, Achieve, and Trade (PAT) Scheme encourages industries to improve energy efficiency and trade carbon credits.

d. Sustainable Transportation Standards such as BS-VI Emission Norms regulates vehicle emissions to reduce air pollution whereas National Electric Mobility Mission Plan (NEMMP) promotes electric vehicles to lower fossil fuel dependency.

2.16 Key Challenges

According to the research findings of Kumar, C.R. et al. (2020), MNRE's efforts to advance the renewable energy sector have been successful, however it identified a number of obstacles in implementation. The following are some of the most significant findings:

Policy and regulatory obstacles:

• Lack of Comprehensive Policy: There is no unified regulatory framework for renewable energy, leading to mismatched policies and development plans across states increasing investment risks.

• Poor maintenance: Older projects are poorly maintained as they were primarily built for tax benefits. The policy does not mandate maintenance post-tax benefits.

• Lack of Penalty Mechanisms: The majority of states lack penalty mechanisms for non-compliance.

Institutional obstacles:

• Ineffective Approval System: The single window project approval and clearance system is unstable and causes delays, resulting in penalties for project developers.

• Deficient Reports: Pre-feasibility reports prepared by states have deficiencies, affecting small and medium scale developers.

• Insufficient/ unskilled Workforce: Lack of skilled workforce in institutes, agencies, and ministries causing project delays and quality issues.

• Limited Research Centers: Insufficient facilities for the research and development of renewable infrastructure. Current manufacturing facilities are mostly replicating existing technologies rather than innovating.

Financial and fiscal obstacles:

• Budgetary Constraints: Delays in fund allocation and budget releases hinder the development of renewable energy projects.

• High Initial Costs: Renewable projects have higher initial capital costs compared to fossil fuels, leading to financing challenges.

• Lack of Expertise in Financial Institutions: Government and private banks often lack understanding or expertise in renewable energy projects, creating financial barriers.

• Payment Delays: Delays in payments by State Electricity Regulatory Commissions (SERCs) impose debt burdens on small and local developers.

• Perceived Investment Risks: Investors view the renewable sector as risky due to lower gross returns, despite these returns being relatively high and within the market standards.

Market obstacles:

• Unfair Subsidy Structure: Subsidies are more adequately provided to conventional fossil fuels, creating a perception that conventional power is prioritized over renewables.

• Cost Calculation Methods: Renewable power costs are calculated using cost-plus methods, which do not account for environmental costs, thus undervaluing the ecological benefits of clean energy.

• Land Supply Issues: There is an inadequate supply of land for wind, solar, and solar thermal power plants, leading to poor capacity addition in many states.

Technological obstacles

• Policy Standardization: The standards are still at a basic level compared to international practices.

• Quality Assurance: The quality assurance processes for renewable energy projects are still in their early stages. Success in this sector relies on concrete action plans for standards, testing, and certification of performance.

• Dependence on International Suppliers: India relies heavily on international suppliers for equipment and technology and spare parts are not manufactured locally, leading to scarcity.

• Concerns exist over MNRE's ability to get beyond political obstacles and drive up the price of carbon, to a level where faster emission reductions are achieved, is a critical success factor for the swift adoption of renewable energy in India.

2.17 Impact and Benefits

The following are a few key benefits and impact of carbon pricing:

Economic efficiency: By placing a price on carbon emissions, emitters are financially motivated to lessen their carbon impact. Carbon emissions are priced, which incentivizes companies to adopt cleaner technologies contributing to a substantial decrease in emissions from power plants and industrial facilities.

Technological innovation: By increasing the competitiveness of low-carbon technologies, Ministry of New & Renewable Energy (MNRE) can stimulate innovation. Businesses are encouraged to create and fund innovative ways to cut pollution.

Revenue Generation: Government of India can make a sizable profit from the carbon price. These funds can be allocated to renewable energy initiatives, infrastructure upgrades, or assistance for low-income people hit by rising energy prices or aftermath of severe weather conditions.

Ecological balance and quality of life: Carbon pricing helps to prevent climate change by cutting emissions, which results in fewer extreme weather occurrences, better air quality, and generally better public health.

Increases market flexibility: Carbon Price Discovery at Indian Carbon Market (ICM) can potentially increase market flexibility by letting the Market choose the most economical methods of reducing emissions instead of depending on laws that prescribe how they must be done.

New job opportunities: Millions of additional employment possibilities can be generated as a result of the research work on energy-saving techniques, deployment, construction and maintenance of renewable energy sources, and the production of equipment necessary for renewable energy production propelling the GDP up.

Environmentally conscious decision making based on increased awareness: This can drive manufacturers and consumers to adopt an environment-friendly mindset. For example, businesses may choose to invest in greener production methods to reduce the carbon footprint, and consumers may choose to purchase energy-efficient products embracing the LiFE (Lifestyle for Environment) movement launched by Prime Minister Narendra Modi.

2.18 Emerging technologies shaping the future

Globally there are several technological advancements in the production of renewable energy. Hussain, et al. (2017) narrates five emerging renewable technologies covering marine energy, concentrated solar photovoltaics (CSP), enhanced geothermal energy (EGE), cellulosic ethanol, and artificial photosynthesis, which are advanced forms of the mainstream energy sources such solar, wind, geothermal, biofuels, biomass, and hydropower. India's reliance on traditional methods for producing renewable energy needs to be updated, and cooperation with international research facilities is necessary to quickly adopt cutting-edge technologies to increase the output and cut prices.

The Internet of Things (IoT) is another technological advancement that has the potential to revolutionize the deployment of renewable energy by enabling real-time monitoring of multiple variables. (Kanchan et al. 2023). In 2020, Sembcorp Industries Ltd (Sembcorp. 2020) launched the first platform in Singapore for managing various sources of renewable energy certificates (RECs) which leveraged the power of IoT devices. IoT devices integrated into the renewable energy sources such as solar and wind farms offer quality data and establishes provenance of renewable energy. Real-time data from multiple renewable energy sources generates RECs (renewable energy certificates) and publishes these RECs on a marketplace for primary and secondary market trading. The marketplace leverages Blockchain technology to enhance transaction security, transparency, and integrity. The platform offers real-time tracking and control over every transaction, from REC generation and registration through transfer and final retirement. The immutability of blockchain technology creates transparency and trust in operations amongst various market participants. The data from blockchain platforms combined with AI/ ML technologies can significantly ease the burden on regulators to continuously implement, monitor, measure, and fine-tune policies pertaining to renewable energy deployment. The research paper published by Zhang. (2022) reveals that Big Data and AI models can be used to create long-term solar radiation prediction models by combining weather forecast data with solar radiation and wind speed prediction. Furthermore, the research indicates that a variety of optimization methods and deep learning algorithms can be blended to provide long-term wind speed forecasts achieving better prediction of energy production in colder regions.

2.19 Summary of Literature Review

Since the Industrial Revolution, fossil fuels have dominated the energy composition in most countries. 75 percent of the greenhouse gas emissions in the world are caused by the burning of fossil fuels for energy purposes. Because of their accessibility and affordability in conjunction with the existing infrastructure and well-established policies, fossil fuels are anticipated to supply most of the world's energy needs, which are predicted to quadruple by 2030. The current atmospheric concentration of CO_2 is responsible for 26% of the global warming. For emissions to reach the Paris

Agreement's target by 2050, emissions must be lowered by 50–80% from 1990 levels (Dey, S. et al. (2022)).

India is a substantial contributor to the growing worldwide energy demand, which is met in part by fossil fuels (69%), of which 44% come from coal (International Energy Agency. et al. (2021)). This seems possible considering that India has the third-largest coal reserve in the world. In addition, around 80% of India's oil is imported to fulfil the nation's growing energy requirements. The heavy dependence on fossil fuels intensifies climate change by increasing carbon emissions and an excessive dependence on imported fossil fuels could jeopardize national energy security and ignite global turmoil. (Shaw, R. et al. (2022))

Large firms have been heavily involved in environmental pollution since the beginning of the Industrial Revolution, which has exacerbated climate change and other environmental issues. Electricity and heat production are the largest contributors to global emissions followed by transport, manufacturing, construction, and agriculture. According to an International Energy Agency assessment (Spencer, T. et al. 2024), 135 million tonnes of methane were released into the atmosphere by the worldwide energy sector in 2022. According to the International Energy Agency, India's economy grew by 6.7% in 2023, accompanied by a 7% rise in carbon dioxide emissions—approximately 190 megatons—bringing total emissions to 2.8 gigatons. This increase positioned India as the third-largest CO_2 emitter globally. However, the country's per capita emissions remain low at around 2 tonnes, which is less than half the global average of 4.6 tonnes, highlighting its relatively modest individual carbon footprint.

According to the preliminary literature review, stakeholders and regulators increasingly require corporations to report on the governance, social, and environmental aspects of their business activities.; Traditional financial measurements are no longer thought to be helpful in establishing a relationship between an organization's value creation and ESG debt. India has committed to reducing its carbon emissions by 30% by 2050 and sourcing 40% of its energy from non-fossil fuel sources by 2030, indicating that it is aware of the importance of taking environmental sustainability issues into account. Although a few major Indian corporations have been disclosing their ESG performance for a while, most companies are not transparent on their commitment to the sustainability objective.

The research on ESG Reporting, Environmental Dimension Disclosures by Large Energy Sector Companies in India (Motwani et al. 2023), applauds BRSR reporting to be in the right direction persuading companies to report. However, they highlighted that at the time of their research the reporting was not made mandatory making it difficult for the researchers to compile reliable data. The researchers proposed that some of the optional questions (found under leadership indicators) should be made mandatory for environmentally sensitive companies, like those in the coal and oil industries, if not for all companies in accordance with GRI reporting, in order to improve transparency and accountability, as the current BRSR reporting may still have shortcomings despite regulatory efforts.

The study conducted on Indian market (Sharma et al. 2020), examined the relationship between financial performances and the extent of environmental, social and corporate governance (ESG) disclosure of Indian companies. The Ordinary Least Square approach was employed in the study to evaluate the association between the ESG disclosure index and the independent variables, which included market and financial performance, FII stake, and statistics controlling the company size and industrial sector. The results showed that financial and market performance have a positive and significant association with the level of ESG disclosure, whereas FIIs stake and leverage have a negative and significant association with the level of ESG disclosure. The study reveals the extent of the disclosure of ESGs and how it needs to be presented in a company's annual and sustainability reports. The book published on ESG Reporting in India: Practices and Challenges (Asokan, 2023) discusses how ESG reporting may be enhanced to better serve the needs of the relevant stakeholders and the potential challenges in bringing regulatory reforms on this front. The previous studies on the subject matter lacks holistic assessment of social cost of carbon, renewable energy consumption, energy intensity, industrial productivity, ESG debt and its impact on carbon pricing. This study proposes to compute the ESG debt statistically and offset the short falls using a tokenization strategy, such as the proposed "Karma Tokens", can strike a healthy balance between growth and sustainability.

2.20 Conclusion

The evidence gathered in this study reflects the urgent and compounding challenge posed by human-induced greenhouse gas (GHG) emissions and the inadequacy of current strategies to reverse their impact. As CO_2, CH_4, and N_2O levels continue their upward trajectory (Stein, 2024), there is increasing consensus that conventional approaches to climate mitigation—though well-intentioned—are not fully sufficient. Reporting frameworks such as BRSR (SEBI. 2023) represent a critical step in holding corporations accountable for their environmental footprints by encouraging greater transparency and biodiversity disclosures. However, despite the progress in data collection, the challenge remains in interpreting these datasets into actionable insights, especially for quantifying a company's environmental liabilities—termed here as ESG debt.

This study introduces ESG debt as a conceptual and practical tool to quantify the environmental liabilities accrued by businesses. Much like financial debt, ESG debt signifies the accumulation of negative environmental externalities, which, if left unaddressed, could compound and destabilize ecological and economic systems alike. The introduction of "Karma Tokens" as an offset mechanism offers a novel approach to bridging the gap between sustainability and business performance. These tokens function within a market framework, enabling businesses to internalize environmental costs and incentivize ethical operations through a measurable and tradeable credit system. In this sense, Karma Tokens are not merely symbolic but represent an enforceable and economically meaningful method to reduce ESG debt and promote responsible business conduct.

Drawing from global targets, especially India's commitment under the Paris Agreement, the need for drastic energy transformation is evident. With an estimated demand of 2,518 billion units of electricity by 2030 and an expected per capita CO_2 emission of 2.98 tons (Bhatti et al. 2022), India surpasses the IPCC's per capita threshold of 2.14 tons for limiting global warming to 1.5°C. Although the country has laid ambitious renewable energy targets, increasing the capacity from 500 GW to 700 GW, the over-reliance on coal, oil, and solid biomass (which still account for 80% of its energy mix per IEA) remains a major obstacle. Additionally, the industrial sectors—cement, iron and steel, non-ferrous minerals, and petrochemicals—continue to be emission-intensive with limited access to sustainable finance.

The research also highlights the need for systemic changes, including greater social acceptability and awareness of renewable technologies, especially in urban India. Financial incentives and legislative support must be reinforced to enable more widespread adoption. Merely producing surplus emission reduction units is not enough; these efforts must align with broader developmental goals and ensure inclusive, long-term socio-economic gains.

A major contribution of this research lies in its comprehensive framework to compute ESG debt using the existing GST system and in presenting a real-world solution through tokenization. By associating carbon pricing with Karma Tokens, it not only proposes an internal market for emissions accountability but also ensures that sustainability is not just aspirational but operationalized at scale. This model addresses some key implementation issues cited in literature: lack of uniform ESG valuation methods, delayed regulation enforcement, opacity in corporate reporting, and insufficient project financing—all of which delay effective climate action.

This study also reflects on the broader philosophical and ethical dimensions of environmental sustainability. The concept of Karma Tokens draws from indigenous philosophies of balance and reparation, thereby resonating with culturally rooted notions of environmental justice. As the world transitions towards net zero, incorporating such frameworks ensures that the shift is not just technical or financial but also moral and inclusive.

In conclusion, the findings of this research advocate for an integrated, data-driven, and ethically grounded approach to sustainability. The ESG debt and Karma Token framework provide both a diagnostic and prescriptive tool to confront environmental degradation. As climate change intensifies and global targets tighten, such innovative, scalable, and culturally relevant tools are essential to close the implementation gap. Only through concerted efforts across governance, industry, and civil society can we hope to steer towards a more equitable and sustainable planetary future.

CHAPTER III: METHODOLOGY

A research methodology is a blueprint or plan that outlines the overarching approach that guides the research activity. A concise and well-defined research question, a plan for data collection, analytical tools and methods leveraged for data analysis and interpretation procedure are the fundamental elements of a well-designed research process. In order to solve the stated research questions, this research will employ a quantitative research approach combined with empirical data analysis. The methodical examination and assessment of data and evidence in order to derive significant findings and arrive at well-informed decisions is known as empirical analysis.

The methodologies leveraged from empirical analysis for this research are (1) Regression Analysis, (2) Correlation Analysis, (3) Inferential Analysis, and (4) Time Series Analysis. Regression analysis ascertains the relationship between a dependent variable and one or more independent variables which helps in predicting outcomes, identifying repeating patterns, and determining the influence of certain variables. Correlation analysis investigates the relationship between two or more variables determining the direction and degree of the relationship between the variables establishing probable correlations. inferential analysis examines a sample for hypothesis testing, probability percentage (confidence intervals), and regression analysis to generate inferences about a larger population by extrapolating conclusions and forecasts from observable data. Time series analysis explores for patterns and anomalies, forecasts future trends, and assesses seasonality by measuring, recording, or collecting data at regular intervals. It comprises methods that assist businesses in forecasting, identifying cyclicality, and comprehending the temporal behavior of variables (Empirical Analysis. (2024)).

In the 1980s, Russian engineer Genrich Altshuler created the Teorya Resheniya Izobreatatelskikh Zadatch, or TRIZ theory. "Theory of inventive problem solving" is the literal translation. Although TRIZ was designed to give inventors a systematic approach to problem-solving, Mulder, P. (2024) lists five TRIZ fundamentals that will serve as the basis for my research. The TRIZ technique employs 5 fundamental principles and 40 innovative principles and compels the researcher to adopt a new perspective on challenges to arrive at solution. The TRIZ Method of Problem Solving (1) promotes being open to even greater ideas and discourages from accepting solutions to problems too early (2) fosters creativity in leveraging data or materials available to solve apparently tangential problems (3) assists in problem definition by framing issues in terms of widely used generic concepts, enabling to look for answers outside of the primary area of expertise (4) encourages the pursuit to unearth fundamental contradictions, which often yields innovative solutions (5) Systems do not change arbitrarily, instead the predictable nature of change can be attributed to established patterns learnt from historic data and processes. While adhering to positivism and pragmatism as its research philosophies, this study intends to use historical data, empirical data analysis, and a fresh viewpoint to arrive at an optimal carbon pricing through a careful analysis of emissions statistics, energy intensity, output intensity, and the social cost of carbon.

3.1 Overview of the Research Problem

The Government of India's Carbon Credit Trading Scheme (CCTS) aims to reduce greenhouse gas emissions through a cap-and-trade system. Overall, cap-and-trade schemes aim to reduce greenhouse gas emissions by creating a financial cost for emitting carbon. The cap-and-trade system creates a financial incentive for companies to reduce their emissions. To avoid the cost of purchasing allowances, companies may invest in cleaner technologies or switch to alternative energy sources driving innovation and adoption of cleaner technologies. However, companies that incur higher costs due to the need to purchase emission allowances may pass these costs on to consumers leading to increased prices for products and services that rely on fossil fuels, including electricity, transportation, and heating.

Key challenges in carbon trading scheme are in determining appropriate carbon pricing and establishing an effective cap. A low cap burdens businesses, potentially passing costs to consumers, while a high cap disincentivizes emission reduction. The Social Cost of Carbon (SCC) serves as an indicator of economic losses from CO2 emissions and guides climate policy research but lacks effective tools to link SCC directly to emissions and ESG debt of organizations. A significant challenge in the application of SCC lies in the absence of effective tools that directly link SCC to real-time emissions data. This limitation hinders the practical implementation of SCC in policy and decision-making. The current tools and methodologies do not adequately capture the dynamic and complex interactions between emissions, climate impacts, and economic outcomes. In summary, while the SCC is a vital tool for assessing the economic impacts of CO2 emissions and guiding climate policy, its practical application is limited by the absence of effective tools linking SCC to emissions. Addressing these limitations requires advancements in modeling techniques, improved integration of real-time data, and a more comprehensive understanding of the interactions between climate, economy, and emissions.

3.2 Operationalization of Theoretical Constructs

In research, a theoretical construct is an abstract concept identified or developed especially to describe a specific phenomenon. Theories that describe the relationships between variables are frequently developed using constructs. Although they cannot be directly observed, they can be quantified using a variety of characteristics or indicators. For example, theoretical constructs such as social cost of carbon, ESG debt, and karma tokens are abstract in nature as not directly observable or measurable. Operationalization is the process that defines how a construct will be measured enabling researchers to build theories that explain how different variables relate to each other. Constructs are often measured using various indicators or variables that can be observed and quantified.

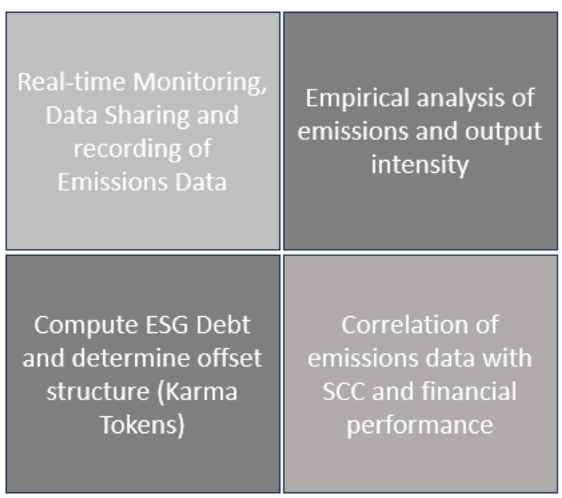

Figure 7 - Theoretical constructs

Social cost of carbon (SCC) is a theoretical construct that indicates the monetary estimate of the economic damages associated with an incremental increase in carbon dioxide (CO_2) emissions. This concept encapsulates the expected economic losses resulting from the adverse impacts of climate change, including health, agricultural productivity loss, damage from extreme weather events, loss of lives and other ecological imbalances. This construct is critical in climate economics and policy modeling, offering insights into the long-term economic implications of current emissions and the importance of mitigating climate change. Observation of SCC involves estimating the economic damages from climate change, projecting future climate impacts, and converting these impacts into current monetary values. In order to offer a thorough evaluation of the economic costs of CO_2 emissions, integrated assessment models that incorporate policy analysis, economic values, and climatic projections are used to measure the SCC.

ESG debt is the accumulation of debt and commitments incurred by a business as a result of its environmental, social, and governance (ESG) policies. This concept includes the risks and adverse effects of a company's ESG performance that may have an influence on its long-term viability, reputation, and financial stability. Data platforms such as Bloomberg, Refinitiv, and other ESG data providers collect and analyze ESG data. Measuring ESG debt involves a combination of ESG ratings, Reporting frameworks (BRSR), quality of Sustainability-Linked bonds, KPIs (energy consumption, emissions & energy intensity), third-party audits, and data analysis, assessment, reporting and implementing corrective measures periodically to achieve annual reduction targets while working towards net-zero ambitions. These tools and methods provide a comprehensive assessment of a company's ESG performance and its impact on financial obligations.

3.3 Research Purpose and Questions

The objective of this study is to ascertain the relationships between variables that impact emissions, such as the social cost of carbon, ESG Debit, and carbon pricing in the context of India, and variables that affect emissions, such as the adoption of renewable energy and increased production. The factors impacting the carbon pricing such as ESG debt and social cost of carbon are listed in the Figure 8 – Factors impacting Emissions, Social Cost of Carbon and ESG Debt. This study attempts to analyze how these factors/ variables are monitored, calculated and stored using latest technologies to ensure data integrity and immutability. This study further explores emissions, social cost of carbon, and the effectiveness of carbon markets in determining the optimal carbon pricing for developing a sustainable business strategy. The outcomes are expected to be enablers that will assist businesses in strategizing product conceptualization, planning, sourcing, execution adhering to emissions standards while lowering the impact on society and keeping the social cost of carbon minimal.

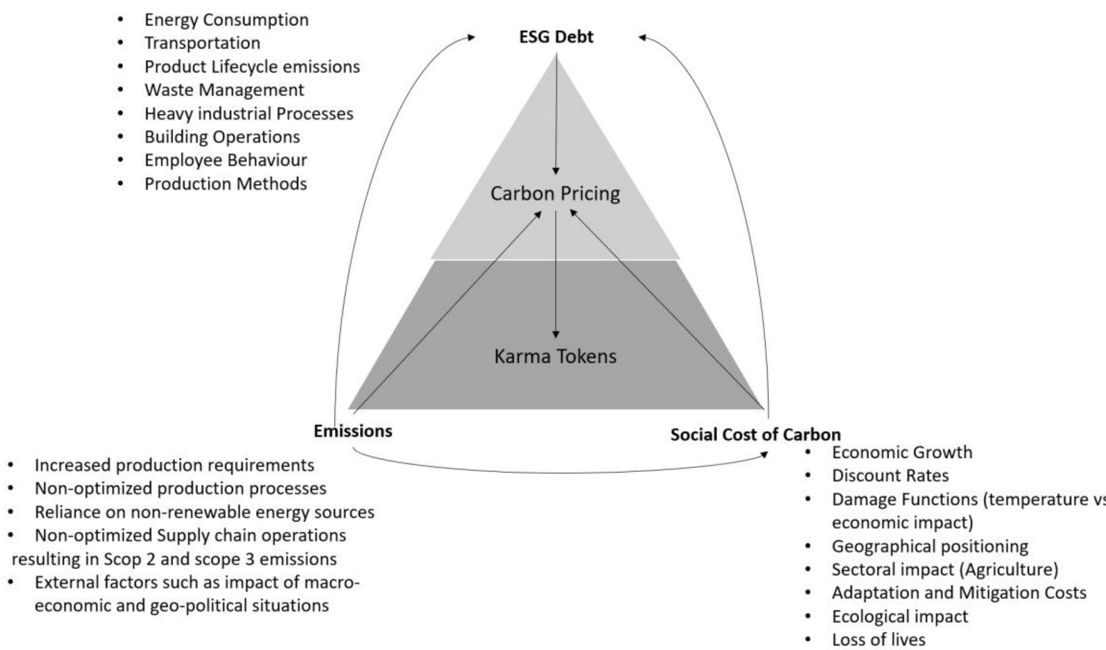

Figure 8 – Factors impacting Emissions, Social Cost of Carbon and ESG Debt

The study on BRSR reporting, the shortcomings of current systems to quantify ESG debt, and a lack of a useful instrument to mitigate the consequences of unsustainable operations serve as the foundation for the following research questions.

1. Can India achieve net-zero target by 2070?
2. How can the data gathered from BRSR reporting be used to develop an empirical model to calculate a company's ESG debt?
3. How can the framework's financial efficacy be assessed by tracking the amount of ESG debt that is incurred annually?
4. How to link ESG debit, emissions and social cost of carbon to arrive at effective carbon pricing?
5. What kind of structure is suitable for offsetting the ESG debt of a company?

6. What actions need to be taken to ensure BRSR compliance and for extending the implementation beyond top 1000 listed businesses based on market capitalization?

3.4 Research Strategy and Design

According to Taherdoost, H. (2022), a research strategy is a comprehensive plan that directs a researcher through the design, execution, and monitoring of a research work and research method is a strategy used to implement that plan. Although distinct, the methods and designs of research are tightly related – A well-designed study guarantees that the information gathered will address the research issue. The two most widely used research approaches are qualitative and quantitative research. A mixed-method study incorporates the benefits of both approaches. This study will adopt mixed-method encompassing primary data (BRSR reports published by companies) and secondary data (market data published by data providers) analysis, survey research, and case studies.

According to Saunder's Onion model, the more general methods of induction, abduction, and deduction are crucial for drawing inferences from data collection and processing (Saunders, M. N. et al. 2009). Inductive approaches include developing hypotheses from research rather than starting a project with a theory as its foundation. Conversely, deductive methods start with a theory and work to refine it through investigation. The research from Hassan, M. (2024) articulates the key differences between these research approaches.

Table 11 - Inductive vs. Deductive research

Terms of Comparison	**Inductive Research**	**Deductive Research**
Definition	Inductive research is based on specific observations or real-world data based on which researchers identify patterns to develop more thorough generalizations or theories.	Deductive study begins with a well-established theory or hypothesis and then formulates a strategy to evaluate specific hypothesis.
Process	Observation, Pattern Recognition, Theory Formation and Conclusion	Starts with existing theory, Hypothesis formulation, Data collection and analysis to verify the claims of hypothesis and Conclusion
Direction of Reasoning	Specific observations to broader generalizations (bottom-up approach).	Starts with a general theory to specific observations or experiments (top-down approach).
Theory Development	Theories are developed based on observed patterns	Theories are tested through empirical observation
Usefulness	Explores new phenomena or generates new theories	Effectively evaluates existing theories or hypotheses

This study will examine data samples of emissions and social cost of carbon to create an empirical study and formulate a strategy to arrive at an effective carbon pricing by computing ESG debt and Karma tokens principles. Therefore, the study will leverage both inductive and deductive research principles.

3.5 Population and Sample

In a research study, the research population entails the entire group or subject being studied, while the sample is a subset to represent the data practically (Ahmad, N. et al. (2023). For the primary data analysis, a sample of 100 listed companies that submitted BRSR reports are considered while the target population will encompass all Indian firms. For the ease of analysis, these companies are classified as heavy-engineering and non-engineering companies. Secondary data sources are used to calculate other metrics such as GDP, total emissions, and ESG debt data computed based on audits, rating data from data providers or non-profit organizations. While the quantitative analysis was executed based on the collected data points, surveys were employed to gather information for qualitative research.

3.6 Participant Selection

In order to operationalize India's carbon trading plan, the Indian government announced emissions intensity objectives for nine industrial sectors by February 2025. Iron and steel, aluminum, chlor-alkali, cement, fertilizers, pulp and paper, petrochemicals, petroleum refineries, and textiles are the nine industries in India that are required to meet emission intensity objectives. Within a year these companies will be put under stringent enforcement measures to reduce emissions as Indian Carbon Market for carbon credit trading is anticipated to start by October 2026. For this research, BRSR reports of top companies in these sectors were considered for analysis in addition to non-engineering sectors.

3.7 Instrumentation

This research primarily uses BRSR reports submitted by Indian companies as the primary data source. BRSR report for top companies listed in 9 industrial areas were downloaded for a period of 2-3 years for assessing the energy and emissions intensity along with other financial parameters like turnover, revenue and profits. Secondary data sources include ESG data from data providers. Furthermore, world bank data was analyzed as a secondary data source to collate GDP and SCC data. Datapoints published by Our world data has been used for emissions projections and analysis.

3.8 Data Collection Procedures

The data for this research project was gathered from the real world based on Corporate BRSR reporting, GDP data, and India's renewable and non-renewable energy forecasting published by reliable government sources. This study utilized mixed-method (both quantitative and qualitative) for data analysis. The BRSR reporting submissions of India's leading listed firms furnished primary data for the quantitative analysis, while secondary data was obtained from other research papers and publicly available data from reputable government websites.

Table 12 - Research data source

Organization	Website Link
SEBI	https://www.nseindia.com/companies-listing/corporate-filings-bussiness-sustainabilitiy-reports
ESG assessment data	https://www.esganalytics.io/
MSCI	https://www.msci.com/web/msci/esg-ratings
Our World in Data	https://ourworldindata.org/co2-emissions
World Bank Group	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
India climate and energy dashboard	https://iced.niti.gov.in/
Statista	https://www.statista.com/topics/8881/emissions-in-india/
A Digital India Initiative	https://www.data.gov.in/keywords/emission
BSE India (Bombay Stock Exchange)	https://www.bseindia.com/markets/equity/eqreports/topmarketcapitalization.aspx

The data collated for the assessment include emissions and energy utilization data of top 100 Indian companies by market capitalization. The company list considered for this research are listed below:

Sl. No	Company Name	Industry	Activity	# BRSR reports	Data Assurance Provider
1	Reliance	Petrochemicals	Manufacturing	2	Deloitte Haskins & Sells LLP
2	TCS	IT	ITeS	3	KPMG
3	HDFC Bank	Bank	Banking Services	3	Price Waterhouse LLP
4	Bharti Airtel	Telecommunications	Communication services	1	TUV
5	ICICI Bank	Bank	Banking Services	2	Grant Thornton Bharat LLP
6	Infosys	IT	ITeS	3	Deloitte Haskins & Sells LLP
7	SBI	Bank	Banking Services	3	Talati and Talati LLP
8	Bajaj Finance	NBFC	Financial services	3	DNV Business Assurance India Private Limited
9	HUL	FMCG	Manufacturing	2	B S R & Co. LLP
10	ITC	FMCG	Manufacturing	3	KPMG Assurance and Consulting Services LLP
11	LIC India	Insurance	Life Insurance	3	Batliboi & Purohit
12	Larsen	Construction	Engineering and construction	3	Deloitte Haskins & Sells LLP
13	HCL Tech	IT	ITeS	3	DNV Business Assurance India Private Limited
14	Sun Pharma	Pharma	Pharma	3	DNV Business Assurance India Private Limited
15	Kotak Mahindra	Bank	Bank	2	Price Waterhouse Chartered Accountants LLP
16	Maruti Suzuki	Automobile	Manufacturing	2	DNV Business Assurance India Private Limited
17	M&M	Automobile	Manufacturing	0	
18	Axis Bank	Bank	Bank	2	DNV Business Assurance India Private Limited
19	NTPC	Energy	Power Generation	2	BUREAU VERITAS.
20	UltraTech Cement	Cement	Manufacturing	3	BDO India LLP

21	Wipro	IT	ITeS	3	Deloitte Haskins & Sells LLP
22	Bajaj Finserv	NBFC	NBFC	3	DNV Business Assurance India Private Limited
23	ONGC	Petroleum Refineries	Petroleum Refineries	2	Bureau Veritas
24	Titan Company	Fashion	Jewellery	2	KPMG Assurance and Consulting Services LLP
25	Adani Enterprises	Mining	Integrated Resources Management	3	Intertek India Pvt. Lt
26	JSW Steel	Metal and metal products	Manufacturing	2	Bureau Veritas (India) Pvt Ltd
27	Adani Ports	Shipping	Transport and storage	3	TUV India Pvt Ltd
28	Power Grid Corp	Energy	Transmission of power	2	Grant Thornton Bharat LLP
29	Tata Motors	Automobile	Manufacturing	2	KPMG Assurance and Consulting Services LLP
30	Coal India	Mining	Production of coal	3	Not audited
31	Avenue Supermarts	FMCG	Retail chain	2	Grant Thornton Bharat LLP
32	Hindustan Aeronautical	Aerospace	Manufacturing	3	Sustainability Actions Pvt Ltd
33	Asian Paints	Paints	Manufacturing	3	Price Waterhouse Chartered Accountants LLP
34	Nestle	FMCG	Manufacturing	1	Grant Thornton Bharat LLP
35	Bajaj Auto	Automobile	Manufacturing	2	DNV Business Assurance India Private Limited
36	Zomato	Information Service	Restaurant aggregator	2	Deloitte Haskins & Sells LLP
37	Bharat Electronics	Electronics	Manufacturing	2	Not audited

38	Adani Power	Energy	Power Generation	3	DNV Business Assurance India Private Limited
39	Tata Steel	Metal and metal products	Manufacturing	2	Price Waterhouse & Co Chartered Accountants LLP
40	Siemens	Electrical equipment	Manufacturing	2	Price Waterhouse Chartered Accountants LLP
41	Hind Zinc	Metal and metal products	Manufacturing	3	Mazars Advisory LLP
42	Interglobe Aviation	Aviation	Passenger services - Air transport	2	TUV India
43	Trent	Retail chain	Retail Sales	3	BDO India LLP
44	IOC	Petroleum Refineries	Petroleum Refineries	3	TUV India Private Limited
45	Vedanta	Metal and metal products	Manufacturing	3	Mazars Advisory LLP.
46	Varun Beverages	Beverages	Manufacturing	2	Deutsch Quality Systems India Private Limited
47	DLF	Constructio n	Real estate	2	SGS India Private Limited
48	IRFC	Finance	Financial services	2	JointValues ESG Services Private Limited
49	Grasim	Textiles	Manufacturing	3	BDO India LLP
50	Hindalco	Mining	Mining - Aluminium, Copper	3	Bureau Veritas India Pvt.
51	Divis Labs	Pharma	Manufacturing	2	Bureau Veritas (India) Private Limited
52	Tech Mahindra	IT	IT Services	3	DNV
53	SBI Life Insurance	Insurance	Life insurance	2	S K Patodia & Associates LLP
54	Jio Financial	NBFC	Financial and Insurance	1	KPB & Associates
55	LTIMindtr ee	IT	IT Services	2	DNV Business Assurance India Private Limited

56	Pidilite India	Consumer, Business and bazar products	Manufacturing	2	M/s B S R & Co. LLP
57	Eicher Motors	Automobile	Manufacturing	3	BSI group India Pvt Ltd
58	Hyundai Motor	Automobile	Manufacturing	0	
59	HDFC Life	Insurance	Life Insurance	2	Sustainalytics
60	Adani Green Ene	Energy	Generation of power	3	Intertek India Private Limited
61	Power Finance	NBFC	Financial and Credit leasing activities	2	Not audited
62	Bajaj Holdings	NBFC	Investment company	2	DNV Business Assurance India Private Limited
63	Ambuja Cements	Cement, Clinke	Manufacturing	2	Intertek India Pvt. Ltd.
64	Chola Invest.	NBFC	Lending	2	Sundaram & Srinivasan, Chartered Accountants
65	Shriram Finance	NBFC	Financial services	2	M/s. Pijush Gupta & Co.
66	Cipla	Pharma	Manufacturing	3	DNV Business Assurance India Private Limited
67	Britannia	FMCG	Manufacturing	2	Earthood Services Pvt. Ltd
68	BPCL	Petroleum Refineries	Manufacturing - Coke and refined petroleum products	2	Intertek India Private Limited
69	ABB India	Electrical equipment	Manufacturing	2	ISO 14001 audit
70	Tata Power	Energy	Power Generation	3	TUV India Private Limited
71	Macro tech Dev	Constructio n	Real Estate	2	DNV Business Assurance India Private Limited
72	TVS Motor	Automobile	Manufacturing	2	Bureau Veritas India (Private) Limited

73	REC	Financial services	Financial and Credit leasing activities	3	M/s Corporate Professionals
74	Godrej Consumer	Home care and personal care products	Manufacturing	2	KPMG Assurance and Consulting Services LLP
75	Bank of Baroda	Bank	Corporate Banking	2	S. Venkatram & Co LLP
76	Indian Hotels	Hospitality	Hospitality services	0	
77	PNB	Bank	Retail banking	2	M/s Ummed Jain & Co., Mumbai
78	GAIL	Petroleum Refineries	Natural gas	2	M/s SR Asia, Ghaziabad, Uttar Pradesh
79	Torrent Pharma	Pharma	Manufacturing	3	ISO 50001 by ISOQAR
80	Shree Cements	Cement	Manufacturing	2	M/S SGS India Private Limited
81	Bajaj Housing	Constructio n	Real Estate	0	
82	United Spirits	Beverages	Manufacturing	1	Price Waterhouse & Co Chartered Accountants LLP
83	CG Power	Electrical equipment	Manufacturing	2	Not audited
84	Mankind Pharma	Pharma	Trading and manufacturing	2	TUV India Pvt. Ltd.
85	Max Healthcare	Healthcare	Healthcare services	2	BDO India LLP
86	TATA Cons. Prod	FMCG	Manufacturing	2	British Standards Institution (BSI)
87	Dr Reddys Labs	Pharma	Manufacturing	3	DNV Business Assurance India Private Limited
88	Mazagon Dock	Submarine & Ship	Manufacturing	2	Not audited
89	Jindal Steel	Steel	Manufacturing	2	Bureau Veritas (India) Pvt Ltd.
90	Lupin	Pharma	Manufacturing	3	Not audited

91	Havells India	Electrical equipment	Manufacturing	2	Price Waterhouse & Co Chartered Accountants LLP
92	Zydus Life	Pharma	Manufacturing	2	Intertek India Private Limited
93	MOTHER SON	Automotive parts	Manufacturing	3	Thakur, Vaidyanath Aiyar & Co
94	Union Bank	Bank	Retail banking	3	TUV India Pvt Ltd
95	Adani Energy	Energy	Generation & transmissions of power	1	TUV India Pvt Ltd
96	Apollo Hospital	Healthcare	Healthcare services	2	Deloitte Haskins & Sells LLP
97	Info Edge	Internet business	Operation of web portals	2	SGS India Private Limited.
98	Dabur India	FMCG	Manufacturing	2	TUV India Pvt Ltd
99	Muthoot Finance	NBFC	Financial services	2	Tibu & Niyas Chartered accountants
100	SRF	Chemicals, textiles	Manufacturing	2	BDO India LLP

In the financial year 2024, a total of 7,547 companies were listed in the National Stock Exchange (NSE) and the Bombay Stock Exchange (BSE) across India out of which a minimal sample population of companies have been considered for this study. About 25% of the top listed companies are banks, NBFCs, insurance providers, and IT services, while 45% are manufacturing firms. Other high-impact industries like Petrochemicals, refineries, mining operations, cement, paints and textiles production form roughly 15% of the top listed 100 companies.

In addition to the data collated from BRSR reports, a qualitative analysis is conducted to collect data from employees of major IT organizations in India to get feedback on the following questionnaire:

Sl. No	Questions
General Policy Framework	
1	What is the company's overarching policy on energy efficiency and emissions reduction?
2	How does the organization align its emissions policies with regulatory requirements and global standards?
3	Are there dedicated teams or roles responsible for implementing and monitoring energy and emissions policies?
Energy Utilization Policies	
4	How is energy consumption tracked across your company's operations (e.g., data centers, offices)?
5	Does the company have specific goals for reducing energy use? If yes, what are they and how are they set?
6	What renewable energy sources, if any, are integrated into your energy mix?
7	How often are energy utilization audits conducted, and how are the findings implemented?
8	Are employees given training or awareness programs on energy-saving measures?
9	Has the company invested in energy-efficient technologies (e.g., low-power servers, LED lighting)?
Emissions Policies	
10	Does the company have an official greenhouse gas inventory? If yes, what scopes (1, 2, 3) are covered?

11	How are emissions from the supply chain (Scope 3) calculated and addressed?
12	What strategies are in place to reduce direct emissions (e.g., fuel use in company-owned vehicles)?
13	How is the company working to offset emissions that cannot be reduced?
Implementation Strategies	
14	How are emissions and energy reduction targets communicated within the organization?
15	What metrics or KPIs are used to evaluate the success of your energy and emissions policies?
16	Are there any challenges faced in policy implementation, and how are they addressed?
17	What role does technology, such as IoT or AI, play in supporting the implementation of these policies?
Net-Zero Target	
18	Does your company have a net-zero target? If yes, by when is it expected to be achieved?
19	What steps have been taken to create a roadmap toward achieving net-zero?
20	How does the company engage with stakeholders (e.g., suppliers, customers) to align with its net-zero goals?
21	Are there any interim milestones set before reaching the net-zero target?
Reporting and Verification	
22	How is data on energy usage and emissions verified for accuracy and reliability?

23	What frameworks or standards (e.g., GHG Protocol, CDP) are used for reporting emissions data?
24	Are the company's policies and progress externally audited? If yes, how often?
25	How does the company maintain transparency with investors and the public regarding its energy and emissions performance?
Energy Utilization	
26	What percentage of your company's energy consumption comes from renewable sources?
27	Are energy audits conducted across operations? If so, what key findings have led to measurable improvements?
28	How are energy consumption trends analyzed, and how does this influence operational decisions?
29	Have you implemented energy-efficient technologies? Can you share examples and their impact on usage patterns?
30	Are there programs to encourage employees to adopt energy-efficient practices at the workplace (e.g., remote work energy savings)?
Emissions Tracking and Reduction	
31	How are Scope 1, Scope 2, and Scope 3 emissions tracked in your company? What challenges do you face in measuring each?
32	Are emissions-reduction targets broken down into short-term and long-term goals? How do they align with operational growth?
33	What strategies are employed to reduce emissions related to IT infrastructure, such as data centers?

34	Does the company engage suppliers or partners to reduce their emissions as part of the overall strategy?
Future Plans	
35	What future innovations or initiatives is the company exploring to further reduce its environmental footprint?

3.9 Data Analysis

This research leverages BRSR data to build an empirical ESG debt model providing an indicative view of sustainability gaps while driving accountability and improvements. This approach aligns financial incentives, environmental responsibility, and regulatory compliance, equipping companies to better navigate sustainability challenges. This blueprint integrates quantitative data (e.g., emissions metrics) and qualitative tools (e.g., interview insights) to calculate ESG debt comprehensively. By leveraging statistical methods and benchmarks, the model ensures reliability and offers actionable insights for improving sustainability performance.

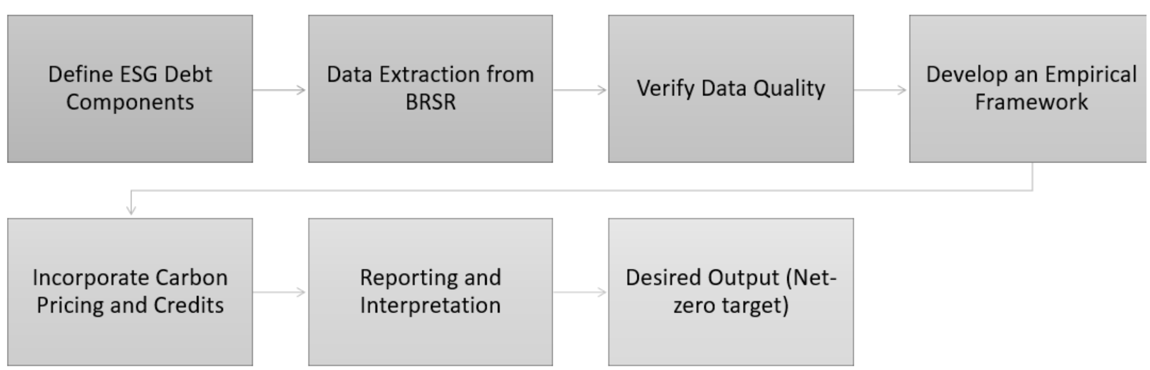

Figure 9 - Blueprint for ESG Debt computation

Define ESG Debt Components

To calculate ESG debt, this research starts with identifying quantifiable factors that contribute towards ESG debt

- Environmental Debt covers excess emissions against industry standards, inefficient energy usage, lack of renewable energy adoption. Emissions and energy usage significantly contribute to environmental debt, resulting in long-term ecological damage.
- Social Debt define numerical scores for social indicators such as community engagement in addressing social responsibility causes. The company workforce can play a pivotal role in reducing or mitigating emissions by taking collective action and driving sustainability within their organizations and beyond. By working together, workforce communities can amplify their collective impact and inspire broader cultural shifts toward sustainability.
- Governance debt refers to the gap between a company's actual governance performance and the benchmarked standards for ethical and transparent practices. Weak board oversight, lack of transparency in disclosures, non-ethical decision-making, and non-compliance with governance standards are major factors contributing towards governance debt.

Data Extraction from BRSR

This research leverages the following structured and standardized data disclosed in the BRSR reports for developing an empirical formula for ESG debt. While the quantitative metrics will cover data published by top 100 companies, qualitative insights will be based on the interview questionnaire focusing on IT industry.

Table 13 - Key data points from BRSR

Quantitative Metrics	1. Scope 1, and Scope 2 emissions monitoring 2. Energy consumption, and energy intensity 3. Renewable energy vs. non-renewable energy usage
Qualitative insights	1. Understand company targets (long-term and short-term) 2. Challenges in implementing incremental process optimization and adoption of latest technologies for process transformation 3. Sustainability strategies
Performance Indicators	1. Achievements against goals 2. Penalties for non-compliance 3. Initiatives for improvement

Data quality verification

The research recommends the usage of CEMS data published on distributed systems to automate data capture and ensure the reliability and integrity of data inputs by addressing the following:

- Standardization: Cross-reference data points with global standards like GHG Protocol enabling comparison against global standards to operate emissions offset in global markets.
- Third-Party Assurance: Incorporate independently verified data for assessment to ensure data reliability.
- Consistency Checks: Resolve any reporting inconsistencies or gaps in historical data.

Develop an Empirical Framework

The empirical formula is derived based on variable value, weightage assigned and the industry benchmarking data. Variable Selection covers the key independent variables identified from BRSR data for this research are listed in the table below. Weightage assignment is used for assigning weights to each variable based on its impact on sustainability performance and its relevance to ESG debt. Benchmarking defines the industry standards or thresholds (e.g., permissible emission levels) to compare actual performance against ideal benchmarks. Industry standards (e.g., permissible CO_2 emissions per unit of output), National or global sustainability guidelines and top-performing peer companies are a few benchmarking standards that can be considered for the computation. A tougher benchmark will motivate companies to improve their processes and avoid penalties.

Table 14 - Variable selection

Variables	**Description**
Company Financials	
Turnover (in Rs crore)	Company turnover in the given financial year
Net worth (in Rs crore)	Company net worth in the given financial year
From renewable sources	
Electricity consumption (A)	Energy consumption from renewable sources
Fuel consumption (B)	
Other sources (C)	
Total Energy consumption (A+B+C)	
From non-renewable sources	
Electricity consumption (D)	Energy consumption from non-renewable sources
Fuel consumption (E)	
Other sources (F)	
Total Energy consumption (D+E+F)	
Total energy consumption (A+B+C+D+E+F)	Total energy consumption across renewable and non-renewable sources
Energy intensity per rupee of turnover (optional)	Total energy consumed / Revenue from operations
Energy intensity per physical output (optional)	Energy intensity in terms of physical output
Emissions	
Scope 1 emissions (Million Metric tonnes)	Break-up of the GHG into CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3, if available
Scope 2 emissions (Million Metric tonnes)	Break-up of the GHG into CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3, if available
Scope 1 and Scope 2 emissions per rupee of turnover (Tonnes/Rs)	Total Scope 1 and Scope 2 GHG emissions / Revenue from operations

3.10 Research Design Limitations

In 2021, SEBI made the top 1,000 listed firms in India subject to obligatory reporting requirements under the Business Responsibility and Sustainability Reporting (BRSR) framework. At the time of this research, BRSR reporting is limited to top 250 companies by market capitalization. This may not include all high-impact industrial companies contributing to major emissions. Implementing BRSR reporting can be financially and technologically burdensome for companies, especially smaller ones due to which data may not be available for the entire population. Companies often struggle with gathering the required data across their entire operations in the absence of advanced continuous emissions monitoring systems especially when it comes to scop 2 and scop 3 emissions. ESG-related metrics like energy consumption, and emissions data often exist in silos and require sophisticated data management systems to centralize and report effectively. Reporting on value chain data, including upstream and downstream partners, is complex and the authenticity of data reported is questionable.

Inconsistency in reporting is another key challenge noticed while analyzing the data across different financial years. From FY24 onwards, BRSR enforced the disclosure of total energy consumption and fuel consumption for the current fiscal year and previous year. The data analysis of BRSR revealed that the data for consecutive reports are not matching – For example, FY23 data mentioned in FY23 and FY24 reports are inconsistent (e.g. BRSR reports for Bharti Airtel, HDFC Bank limited).

While BRSR reporting is mandatory for the top 1,000 listed companies, the voluntary nature of certain disclosures results in inconsistencies and gaps in data. For example, energy intensity per rupee of turnover, energy output adjusted for purchasing power parity, energy intensity per output produced, scope 3 emissions reporting are optional and several companies have opted not to disclose these parameters while many others in the industry have disclosed these parameters voluntarily. Many institutions including petrochemicals are not reporting scope 3 emissions data due to lack of technology to capture this information (for example, Reliance Industries Ltd., Infosys etc.). Given a choice, environmental conscious/ friendly investors will choose to switch to a greener alternative while purchasing products from environmentally conscious companies or investing in greener businesses in contrast to businesses with a greater ecological impact.

Lack of standardization is yet another issue that needs to be addressed on priority. Currently the unit of reporting is loosely defined, due to which companies report energy consumptions in Mega Joules, Giga Joules, Tera Joules, and Kilowatt-hours. Likewise, energy intensity is being reported as Giga Joules/Crore of Rupees or Giga Joules/ Rupees making the comparison really challenging. An industry-wise definition of energy intensity per turnover, and energy intensity per production output is very much needed to create data parity. Similarly, emissions intensity is recorded using various measures such as metric tonnes of CO2/ million rupees, metric tonnes of CO2/ crore rupees, metric tonnes of CO2/ rupees, billion joule/ crore rupees, metric tonnes of CO2/ lakh rupees and so on. Non-standardization of data collected for energy usage and emissions poses several challenges:

(1) Inconsistent Metrics: Different organizations may use varying methodologies to measure energy usage and emissions, making it difficult to compare data across industries or regions. (2) Data Fragmentation: Without standardized formats, data often exists in silos, preventing integration and comprehensive analysis. (3) Accuracy Issues:

Non-standardized data can lead to inaccuracies, as methodologies may not account for all variables or may rely on incomplete information. (4) Regulatory Compliance: Companies may struggle to meet reporting requirements if standards differ across jurisdictions. (5) Decision-Making Challenges: Policymakers and businesses rely on consistent data to make informed decisions about energy efficiency and emissions reduction – non-standardization hampers this process. (6) Resource Inefficiency: Organizations spend additional time and resources reconciling disparate data sources, which could be streamlined with standardized practices.

Lack of enforcement in reporting is very evident as a few companies in the top 100 list by market capitalization has still not started reporting BRSR data. For example, Mahindra and Mahindra Ltd operating in the Auto sector with a market cap of Rs 3,31,499.92 Crores falls within the top 20 companies in India. The company has not started disclosing the BRSR data although the disclosure was made mandatory by the regulator since FY22. Other top companies who have not complied to mandatory data disclosure are Hyundai Motors (Automobiles manufacturing), Indian Hotels (Hospitality) and Bajaj Housing (Construction). The Indian Hotels Company Limited (IHCL) operates a diverse hospitality portfolio, including hotels, resorts, palaces, safaris, spas, and in-flight catering services. Not having a carbon emissions target is detrimental for a company that operates a wide range of high-end chain of hotels. Apart from this, a few companies still continue to include unstructured BRSR data in their integrated annual report and they do not have an independent BRSR report making it challenging to collate data. Stringent penalties for non-compliance and incentives for accurate reporting are factors that can influence and improve the reporting accuracy.

Veracity of data reported is questionable in the absence of Continuous Emissions Monitoring Systems. Continuous Emissions Monitoring Systems enables real-time data collection to measure emissions from industrial processes by providing reliable data on pollutants like CO_2, NOx, and SO_2. This ensures timely and accurate reporting. These systems help industries comply with environmental regulations by tracking emissions against permissible limits. By automating data collection, CEMS reduce human error and manipulation, ensuring the integrity of emissions data. Furthermore, CEMS can be tailored to monitor specific pollutants relevant to different industries, making them versatile and effective. By combining CEMS for precise data collection and decentralized reporting on blockchain for secure and transparent data sharing, governments and industries can create a robust framework for emissions accountability. Decentralized systems, such as blockchain, create tamper-proof records of emissions data. This ensures transparency and builds trust among stakeholders. Decentralized reporting allows multiple entities (e.g., suppliers, logistics partners and dealers regulators) to contribute and verify data, reducing the risk of inaccuracies. Decentralized platforms make emissions data accessible to the public, encouraging companies to improve their environmental performance. These systems can integrate data from various sources, including CEMS, across global supply chains, providing a comprehensive view of emissions.

Inconsistency in data reported across multiple BRSR reports – Emissions data in BRSR prescribes reporting of emissions in the current and previous financial years. There are instances where emission intensity is significantly revised for the previous financial year. For the purpose of this research latest year’s data has been considered for statistical analysis considering the fact that company may have corrected omissions made in the earlier reports.

Lack of 3rd party verification - Independent audits of emissions data through third-party audits must be mandated to assure data accuracy and prevent manipulation. Based on the data collected, it was found that 10% of the firms had not audited BRSR data including emissions data which is crucial for calculating the Social Cost of Carbon (SCC) because it directly influences the accuracy and reliability of the estimate. Emissions data feeds into climate models to predict future temperature changes, sea level rise, and extreme weather events. These projections are essential for estimating the long-term impacts of carbon emissions. Furthermore, emissions data allows for consistent comparisons across countries and industries, ensuring that SCC calculations are equitable and globally applicable. The absence of reliable CEMS and third-party assurance obstructs regulators and policy makers from making well-informed decisions about regulations, carbon pricing, and mitigation strategies.

The primary focus of this research being emissions, energy consumption and related ESG debt computation, other parameters disclosed under principle 6 of BRSR report (water usage, liquid discharge, waste processing, impact to national parks, wildlife sanctuaries, biosphere reserves, wetlands, biodiversity hotspots, forests, coastal regulation zones etc. and environmental related projects) are not in scope of this study. Therefore, the empirical formula derived will only consider emissions and energy consumptions data.

3.11 Conclusion

This study utilizes a mixed-methods approach to analyze energy utilization and emissions data from Indian IT companies. The quantitative analysis leverages Business Responsibility and Sustainability Reporting (BRSR) data to derive measurable insights on energy consumption, greenhouse gas (GHG) emissions, and progress toward sustainability targets. Complementing this, qualitative data is collected through structured interviews with middle and senior managers to capture nuanced perspectives on policy implementation, challenges, and strategic goals. The findings establish critical interconnections between key components of corporate sustainability:

Emissions and Social Cost of Carbon (SCC): The interconnections between emissions and SCC are profound, as SCC directly quantifies the economic impact of each ton of carbon dioxide (CO_2) released into the atmosphere. Accurate emissions data allows for reliable calculation of SCC, quantifying the economic damages caused by carbon emissions. This, in turn, enables companies to evaluate the financial burden of their environmental impact and prioritize emission-reduction initiatives.

Emissions and ESG Debt: The relationship between emissions and a company's Environmental, Social, and Governance (ESG) debt is critical for evaluating its sustainability practices, financial health, and reputation. Excess emissions contribute to a company's environmental, social, and governance (ESG) debt, reflecting deficiencies in sustainability practices. ESG debt poses reputational and financial risks, impacting access to investments and partnerships.

Carbon Pricing: Carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems, use emissions data to assign monetary value to carbon pollution. This incentivizes companies to adopt cleaner technologies and lower their carbon footprint.

Carbon Credit Tokens: To offset emissions imbalances, companies participate in carbon markets by purchasing carbon credits. These credits represent investments in projects that reduce or absorb GHG emissions. Carbon credit tokens play a vital role in achieving net-zero goals by compensating for emissions that cannot be eliminated.

By linking these aspects, the research highlights how comprehensive emissions data, coupled with targeted policies and financial instruments, can drive corporate accountability and accelerate progress toward sustainability. This integrated approach aligns with global climate commitments and positions companies to thrive in a decarbonized economy. Furthermore, this study uncovered several systemic issues that hinder the effectiveness of energy utilization and emissions reporting, and these are critical for addressing sustainability challenges. The research underscores the urgent need for:

- Standardization of Reporting Standards: Creating industry-wise standards will enable better data reporting.
- Regulatory Enforcement: Governments should mandate emissions reporting and ensure compliance through penalties and incentives.
- Third-Party Assurance: Independent audits must be integrated to verify the accuracy of emissions and energy data.
- Capacity Building: Providing tools and resources for companies, especially smaller ones, to improve reporting quality.

Addressing these issues will enable more reliable data collection and analysis, fostering actionable insights into emissions management and helping industries align with global sustainability goals.

CHAPTER IV: RESULTS AND DISCUSSION

4.1 India's Pathway to Net-zero by 2070

Question 1 – Can India achieve net-zero target by 2070?

4.1.1 Assessment of Emissions and Energy intensity based on BRSR data

BRSR data for top 100 Indian companies by market capitalization have been sliced and diced to get an understanding of how these companies are planning to embrace carbon tax which is going to be implemented in less than a year from now. For the purpose of this analysis, the data has been sliced to identity all companies involved in heavy industrial engineering activities across different industries. There are 64 companies involved in heavy industrial engineering operations and their company profiles are as below:

Table 15 - Classification of heavy engineering industries

Group	Industry	No. of companies	Data assessment and observations
1	Aerospace, Automobile, Automotive parts, Submarine & Ship	10	Within the dataset considered, this group generated maximum turnover for India; 48% of turnover is generated by these ten companies from sixty-four heavy engineering companies while two out of top ten companies by market cap are from these industries.

Group	Industry	No. of companies	Data assessment and observations
			Six companies out of ten have achieved more than 10% average reduction in FY24. Two companies did not report emissions data in FY24 or previous years. One company reported reduction of less than 10% while another company reported increase in emissions.
2	Pharma	8	This is the only sector where emissions reduction is observed across all companies although the reduction varied approximately between 1% - 60% and the average emissions reduction was around 21%.
3	FMCG Home care and personal care products, Consumer, Business and bazar products	8	Two companies have made significant strides in lowering the emissions by more than 20%, however significant efforts are required from others to lower the emissions. Two companies have reported increase in emissions by 25 – 275 % with 10-20% increase in turnover. Such companies may need to strengthen leadership indicators to improve the efficacy of production processes. Emissions from one company in this group is above the mean and median of emissions

Group	Industry	No. of companies	Data assessment and observations
			calculated for the heavy engineering companies.
4	Electrical equipment, Electronics	5	40% of the companies in this industry showed significant reduction (more than 10%) while two companies reported 30% - 40% increase in emissions with about 10% increase in turnover.
5	Petrochemicals Petroleum Refineries	5	These companies are the second largest revenue contributors and second largest emissions contributors within the dataset considered for this research. These companies reported emissions ranging between 6 – 60 times above the mean emissions calculated for the heavy engineering companies. The emissions considerably increased compared to the previous financial year with the increase in production with an average increase of 26%. Carbon capture and storage (CCS), energy efficiency improvements, use of renewable energy, process innovations and circular

Group	Industry	No. of companies	Data assessment and observations
			economy practices are a few techniques that can be adopted by these companies to reduce emissions. As per Nath et al. (2024) Carbon capture, utilization, and storage (CCUS) is the most efficient way to reduce CO2 emissions. This technology helps in decarbonizing fossil-based petrochemical industry processes by injecting CO2 into geological formations, preventing it from entering the atmosphere.
6	Metal and metal products	5	All companies in this sector reported increase in emissions in FY24 ranging between 2% – 33%. Recommend the formation of Center of Excellence governed by the government for steel production to improve the operational processes by transitioning into electric furnaces. Implementing CCUS, recycling raw materials, reducing reliance on non-renewable energy and adopting latest technologies (Ncube et al. 2025) for extracting iron ore are a few other measures that can be considered to lower emissions. These measures require collaboration

Group	Industry	No. of companies	Data assessment and observations
			between governments, industries, and researchers to ensure successful implementation.
7	Cement, Clinke	3	These companies are the third largest emissions contributors within the dataset considered for this research. These companies reported the maximum emission intensity which is more than 50 times the median (Median=20) of the emissions intensity calculated for the manufacturing companies. In absolute terms, emissions reported is between 15 – 73 million metric tonnes of carbon. One company reported emission intensity reduction of 31% while the others reported increase in emissions by 2%. Reducing emissions in the cement industry is crucial, as it accounts for about 7-8% of global CO_2 emissions. (Sunsure. 2025). Usage of renewable energy, clinker substitution by incorporating materials like

Group	Industry	No. of companies	Data assessment and observations
			fly ash, slag, or limestone, implementation of carbon capture and storage (CCS), optimizing kiln operations, waste heat recovery, and AI-powered cement production can improve efficiency and reduce emissions. Further, circular economy practices such as recycling concrete and reusing materials can minimize waste and emissions.
8	Paints Textiles Chemicals	3	Two companies have reported increase in emissions while the third company reported marginal decrease in emissions although the emissions of most of the companies are above the median (348,941 metric tonnes) calculated for the heavy engineering industries while their turnover is below the median (25,847 Crores) for the manufacturing industries. These industries can significantly lower their carbon footprint by adopting sustainable practices and innovative technologies by developing paints with lower volatile organic compounds (VOCs) to reduce air pollution,

Group	Industry	No. of companies	Data assessment and observations
			optimizing production processes to minimize energy consumption, usage of renewable fuels and implementation of energy-efficient machinery.
9	Mining	3	These companies are the third largest revenue generators within the dataset considered for this research. Mining companies have reported reduction in emissions; however, the absolute scope 1 and scope 2 emission is 21 million metric tonnes. Transitioning to renewable energy, Carbon capture and storage (CCS), energy efficiency improvements, adoption of precision mining methods to reduce material waste and energy use are a few sustainable practices for reducing emissions in the mining industry.
10	Generation & transmissions of power	6	These are the largest emissions contributors where their average emissions intensity exceeds 1000 metric tonnes/ crore of turnover. These companies have on an average reduced the emissions by 13% while the percentage reduction vary from 3% -

Group	Industry	No. of companies	Data assessment and observations
			25%. Although the data exemplified an increase in emissions in a few companies between 6% - 23%. On absolute value, these companies witnessed 200 – 1000 times emissions compared to the median calculated for the heavy engineering industry. Some of these businesses are heavily dependent on fossil fuels and may see a steady decline as the government urges companies to adopt cleaner energies. Grid modernization, upgrading power plants with high-efficiency turbines and boilers and implementing smart grid technologies to optimize electricity distribution, and promotion of distributed energy resources like rooftop solar and microgrids are a few practices that can significantly reduce emissions in addition to Carbon Capture and Storage (CCS), transitioning to renewable energy. (Barth et al. 2025)

Group	Industry	No. of companies	Data assessment and observations
11	Engineering and construction	4	While the turnover from these companies is only 2% of the overall turnover of the top 100 companies, emissions from these companies was 1.3 million tonnes of CO_2 in FY24. Carbon tax can have a heavy hit on these industries considering the amount of taxes and penalties that need to be collected based on the emissions. (Refer tables 16 and 17 for more details)
12	Transportation - Passenger services Cargo and storage	2	While the turnover from these companies is only 1% of the overall turnover of the top 100 companies, emissions from these companies was 8.8 million tonnes of CO_2 in FY24. Carbon tax can have a heavy hit on these industries considering the amount of taxes and penalties that need to be collected based on the emissions. (Refer tables 16 and 17 for more details)
13	Beverages	2	One company has reported more than 20% reduction in emissions while the other company reported 30% increase in emissions.

Group	Industry	No. of companies	Data assessment and observations
			The beverage industry emitted 1.5 billion tons of CO_2 in 2021, accounting for 3.8% of global emissions. Based on the current trajectory of 0.7 percent reduction per year, the industry will miss both its 2030 and 2050 targets. To reach these targets, the beverage industry needs to improve its current reduction rate 11-fold to meet climate targets, and companies need to accelerate their reduction efforts. (Rocha et al. 2023)

The table below indicates the turnover of heavy engineering companies found in the dataset considered for this research. The data is sorted in the descending order of turnover.

Table 16 - Total turnover from heavy engineering industries

Group No	Company Profiles	Sum of Turnover (Crore Rs)
1	Aerospace, Automobile Automotive parts, Submarine & Ship	4,400,472
6	Metal and metal products	2,215,463
9	Mining	506,290
5	Petrochemicals Petroleum Refineries	498,862

Group No	Company Profiles	Sum of Turnover (Crore Rs)
10	Generation & transmissions of power	345,330
2	Pharma	290,562
3	FMCG Home care and personal care products, Consumer, Business and bazar products	209,055
11	Engineering and construction	138,939
7	Cement, Clinke	107,314
12	Transportation - Passenger services, Cargo and storage	97,113
4	Electrical equipment, Electronics	76,921
8	Paints Textiles Chemicals	73,746
13	Beverages	38,021
Grand Total		8,998,087

Companies listed under group numbers 1, 5, 6, 9, and 10 constitute 88% of the turnover from top listed heavy engineering companies in India. These companies generate a combined turnover of Rs 79,664 billion. Interestingly, the same companies generate maximum emissions (5, 6, 7, 9, and 10) barring group 1 companies i.e. automobile, aerospace and ship manufacturing.

The table below details the emissions from heavy engineering companies found in the dataset considered for this research. The data is sorted in the descending order of total scope 1+ scope 2 emissions.

Table 17 Total emissions from heavy engineering industries

Group No	Company Profiles	Total scope 1 + scope 2 emissions (Metric tonnes of CO2)	Emissions Intensity (Tonnes/Crore Rs)
10	Generation & transmissions of power	470,526,248	6,061
5	Petrochemicals Petroleum Refineries	225,551,942	1,993
7	Cement, Clinke	89,038,623	3,072
6	Metal and metal products	84,189,335	210
9	Mining	65,715,849	329
12	Transportation - Passenger services, Cargo and storage	8,896,510	139
8	Paints. Textiles, Chemicals	7,979,038	381
2	Pharma	3,028,579	221
1	Aerospace, Automobile Automotive parts, Submarine & Ship	1,537,967	184
11	Engineering and construction	1,352,294	119
3	FMCG	1,043,913	57

Group No	Company Profiles	Total scope 1 + scope 2 emissions (Metric tonnes of CO2)	Emissions Intensity (Tonnes/Crore Rs)
	Home care and personal care products, Consumer, Business and bazar products		
13	Beverages	26,7608	21
4	Electrical equipment, Electronics	25,2317	16
Grand Total		959,380,223	12,802

Out of these sixty-four heavy engineering companies analyzed, three companies did not report their emissions data while four companies showed zero reduction in emissions in FY24. Twenty-one companies out of sixty-four (34%) showed significant reduction in emissions which is considered as more than 10% for the purpose of this research. These companies demonstrated an average reduction of 25%. Fifteen companies out of sixty-four (23%) showed moderate reduction (below 10%) with an average reduction of 5% in FY24. Twenty-four companies out of sixty-four (37.5%) increased their emissions or did not reduce emissions with an average increase of 27%. Lack of awareness, monitoring., enforcement, penalties and taxes are found to be the key factors contributing to higher emissions. Emissions intensity is highest for the generation & transmissions of power followed by cement production and petrochemicals and petroleum refineries.

The table below details the minimum, maximum and average emissions reductions for the company profiles mentioned in the table below.

Table 18 - Emissions reduction from heavy engineering industries

Group No	**Company Profiles**	**Number of companies under group**	**Average % emissions reduction in FY24***	**Minimum % reduction in FY24***	**Maximum % reduction in FY24***
1	Auto	10	19%	0%	50%
2	Pharma	8	21%	1%	61%
3	FMCG	8	-28%	-279%	29%
4	E&E	5	-3%	-42%	36%
5	PetroChem	5	-26%	-90%	0%
6	Metal	5	-15%	-33%	-2%
7	Cement	3	10%	-2%	31%
8	PTC	3	-3%	-9%	5%
9	Mining	3	8%	-7%	26%
10	Power	6	2%	-23%	24%
11	Construction	4	6%	0%	10%
12	Transportation	2	1%	0%	3%
13	Beverages	2	-7%	-37%	23%

* Positive values indicate emissions reductions whereas negative values indicate increase in emissions.

The table below describes the energy utilization profiling of heavy engineering industries in India by market cap within the dataset considered for this research.

Table 19 - Energy utilization of heavy engineering industries

Group No	**Company Profiles**	**Total Renewable Energy (RN) consumption (GJ)**	**Total Non-renewable Energy consumption (GJ)**	**% of RN/ Total Energy**	**Average % emissions reduction in FY24***
1	Auto	51,738,649	689,167,830	7%	19%
2	Pharma	6,582,426	16,160,147	29%	21%
3	FMCG	7,194,813	7,153,768	50%	-28%
4	E&E	300,443	1,064,482	22%	-3%
5	PetroChem	7,645,852	1,087,474,108	1%	-26%
6	Metal	14,141,884	2,870,566,382	0%	-15%
7	Cement	19,184,121	480,303,692	4%	10%
8	PTC	6,054,794	76,207,751	7%	-3%
9	Mining	2,703,850	339,808,049	1%	8%
10	Power	3,988,989	5,297,193,336	0%	2%
11	Construction	670,074	12,228,562	5%	6%
12	Transportation	228,068	122,952,377	0%	1%
13	Beverages	898,613	1,341,273	40%	-7%
Grand Total		121,332,577	11,001,621,757	1%	1%

As per the table above, in FY24, the average percentage of renewable energy usage over total energy consumption is 1% whereas the emissions are reduced by 1% compared to FY23. While this finding does not reflect a linear relationship between emissions and the usage of renewable energy, India will not be able to achieve net-zero target by 2050 or 2070 based on the current pace at which the emissions are getting reduced. Moreover, it is observed that the emissions increase significantly in certain industries based on the increase in turnover. Based on these facts, Indian government must enforce the following measures on engineering companies:

1. Ensure upward trend in adoption of renewable energy year-on-year – Recommend this to be 15-20% increase in adoption annually.
2. Showcase a downward trend in emissions year-on-year – Recommend this to be 10% decrease in emissions annually.
3. Enforce process improvements/ operations to avoid exponential increase in emissions based on increased output/ production.

Analysis of companies operating in the non-engineering sectors

The table below lists the companies that do not employ heavy engineering which accounts to 33% of the overall turnover.

Table 20 - Classification of non-Engineering Industries

Group	**Industry**	**Number of companies**	**Characteristics**
1	Banking & Financial Services	18	These companies generated more than 50% of total turnover of non-engineering companies while their emissions stood at 54%. One company did not report emissions data stating that their operations do not involve heavy engineering processes.

Group	Industry	Number of companies	Characteristics
			In terms of turnover, six out of top ten companies are from banking sector. Likewise, the same companies contributed to the maximum emissions showing a linear relationship between emissions and turnover. This sector has seen an average reduction of 22% in FY24 although some companies reported increase in emissions. Energy-efficient offices, paperless operations, green data centers, sustainable financing and investments, digitalization and smart banking, eco-friendly procurement, carbon-neutral logistics, transparent ESG reporting and carbon pricing, and climate-conscious employee initiatives are a few initiatives to reduce emissions in the banking and financial industries.
2	IT Services	7	IT services contributed around 19% towards the total turnover of non-engineering companies while their emissions stood at 9%. In terms of turnover, two out of top ten companies are from IT sector while one out of the top ten companies is from IT in terms of emissions.

Group	Industry	Number of companies	Characteristics
			Around 40% of these companies reported emissions reduction ranging between 15%-51% while 3 companies reported increase in emissions ranging between 16% - 112%. IT industries can follow similar recommendations given for banking services in order to reduce emissions.
3	Retail chain	3	Retail chain contributed around 3% towards the total turnover of non-engineering companies while their emissions stood at 6% and one out of top ten companies is from retail in terms of emissions. Retail chains reported an average reduction of 11% in FY24.
4	Insurance	3	One of the insurance companies secured the top position in terms of turnover in FY24, while their emissions reported is around 2% of the overall emissions for non-engineering companies. Insurance companies demonstrated non-linear relationship between turnover and emissions which is a model that can be adopted by other companies in the non-engineering sector. However, a few insurance

Group	Industry	Number of companies	Characteristics
			companies reported increase in emissions or zero reduction showing lack of awareness of the government initiatives to reduce targets. This sector can easily achieve net-zero since their branch operations are limited compared to banking and financial services.
5	Healthcare services	2	Healthcare services reported less than 1% of turnover while their emissions stood at 17% which is much higher than the 2nd and 3rd top income generators in the non-engineering segment. Healthcare services can significantly reduce their emissions by implementing local procurement, low-carbon transportation, low-carbon patient care strategies, sustainable transportation for healthcare workers, green procurement policies, climate-resilient building designs, disaster preparedness with low-carbon emergency response.
6	Restaurant aggregator	1	While these companies reported less than 1% turnover and lower emissions, their service models depend heavily on transportation. Their scope 3

Group	Industry	Number of companies	Characteristics
			emissions stood at 120,000 metric tonnes while turnover was about Rs 6000 crores.
7	Communication services	1	This company is at the fourth position in India in terms of market cap, while its emissions is about 10% of the non-engineering companies.
8	Hospitality services	1	BRSR report was not published in FY24 or previous years showing lack of compliance to regulatory measures.

The table below details the turnover analysis of top thirty-six non-engineering companies in India by market cap.

Table 21 - Turnover analysis of non-engineering companies

Group No	Company Profiles	Total Turnover (in Rs crore)
1	Banking & Financial Services	1,579,308
4	Insurance	620,259
2	IT Services	559,813
3	Retail chain	108,573
7	Communication services	94,119
5	Healthcare services	24,465
6	Restaurant aggregator	6,622
8	Hospitality services	BRSR is not published

Group No	Company Profiles	Total Turnover (in Rs crore)
Grand Total		2993159

The table below details the emissions analysis of top thirty-six non-engineering companies in India by market cap.

Table 22 - Emissions Analysis of non-engineering companies

Group No	Company Profiles	Total scope 1 + scope 2 emissions	Emissions Intensity (Metric tonnes/ Crore Rs)
1	Banking & Financial Services	2,769,801	56
5	Healthcare services	882,020	53
7	Communication services	492,496	5
2	IT Services	476,992	11
3	Retail chain	340,132	15
4	Insurance	109,284	1
6	Restaurant aggregator	89	0
8	Hospitality services	-	-
Grand Total		5070813	141

As per the table above, emissions and emissions intensity are much lower compared to heavy engineering industries. With relatively lower investments these companies can achieve net-zero. Based on this study, it is recommended that Government of India must enforce net-zero targets for each sector based on the ease of achieving the targets. For example, all non-engineering companies must be forced to achieve net-zero within the next 10 years while heavy engineering can be given additional time as it involves significant investments in terms of process optimization and adoption of new engineering practices to reduce emissions. Transitioning into renewable energy must be heavily incentivized for businesses to drive adoption.

The table below details the minimum, maximum and average emissions reduction for the non-engineering industries.

Table 23 - Emissions reduction from non-engineering industries

Group No	Company Profiles	Number of companies under group	Average % emissions reduction in FY24*	Maximum % reduction in FY24*	Minimum % reduction in FY24*
1	Bank	18	22%	67%	-18%
2	ITeS	7	-2%	51%	-112%
3	Retail	3	11%	23%	-3%
4	Insurance	3	-98%	0%	-197%
5	Health care	2	-182%	0%	-363%
6	Aggregator	1	16%	16%	16%
7	Communication services	1	7%	7%	7%

* Positive values indicate emissions reductions whereas negative values indicate increased emissions.

The table below describes the energy utilization profiling of non-engineering industries in India by market cap within the dataset considered for this research.

Table 24 - Energy utilization from non-engineering industries

Group No	Company Profiles	Total Renewable Energy (RN) consumption (GJ)	Total Non-renewable Energy consumption (GJ)	% of RN/ Total Energy	Average % emissions reduction in FY24*
1	Bank	658,079	12,577,599	5%	22%
2	ITeS	1,267,687,285	444,743,923	74%	-2%
3	Retail	209,931	1,745,746	11%	11%
4	Insurance	32,295	857,800	4%	-98%
5	Health care	209,664	13,667,015	2%	-182%
6	Aggregator	0	516	0%	16%
7	Communication services	5,963	2,595,360	0.23%	7%
Grand Total		1,268,803,217	476,187,445	73%	-6%

For the non-engineering companies although the average percentage increase in renewable energy usage is 73%, the overall emissions did not show a declining trend. The industry's receptivity to change is not reflected in the lack of progress in reducing the emissions; rather, it shows how difficult it is to address this issue.

4.1.2 Emissions analysis based on historic data from Our World Data

The graph below depicts key historical periods, growth rates and major events that affected emissions in India from 1850 to 2022 (Ritchie et al. 2020). The pre-Independence period (1858-1947) witnessed steady industrialization under British rule.

Railway expansion and early industrial development were major factors contributing towards emissions. The industrialization driven by the Indian government post-Independence to economic liberalization in further increased emissions on account of Green Revolution, agricultural mechanization, expansion of power generation and heavy industry.

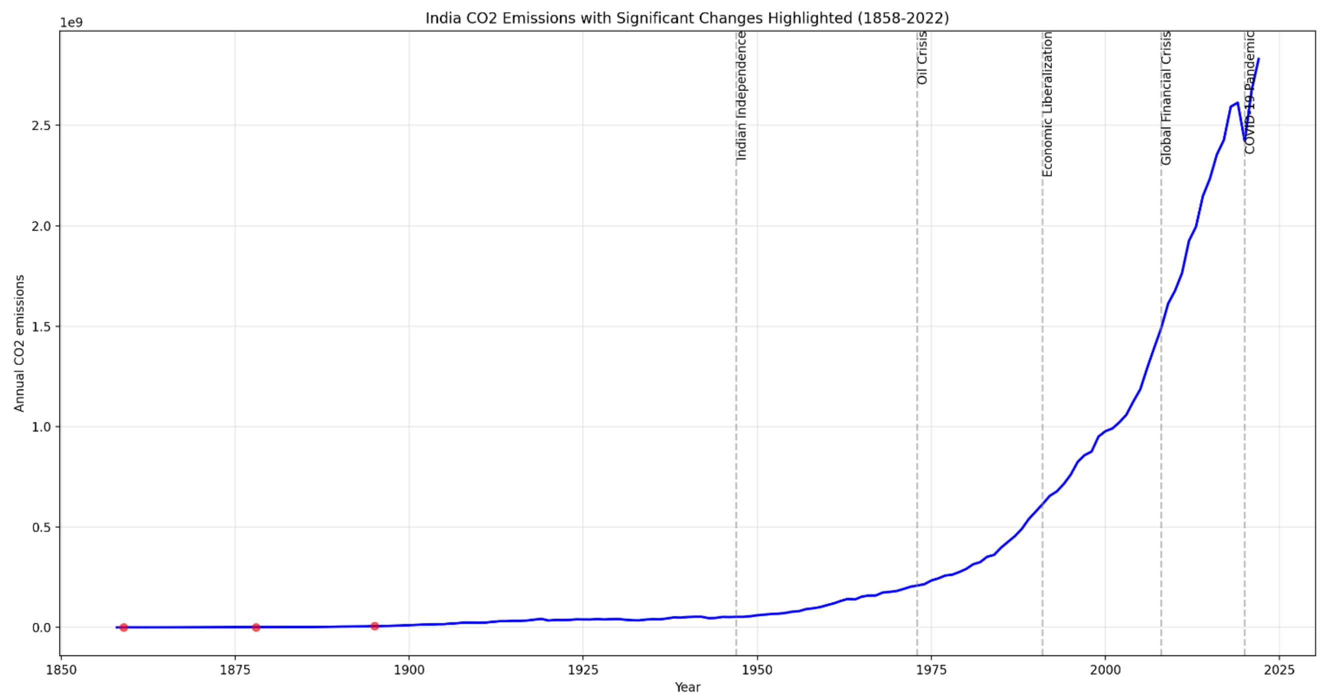

Figure 10 - India historic CO2 emissions

The period from post-Liberalization to pre-COVID (1991-2020) recorded accelerated industrial growth, increased energy consumption, and exponential growth in automotive sector and infrastructure development due to rapid urbanization. Post-COVID (2020-2025), Indian economy made a rapid recovery in growth rebounding emissions due to accelerated industrial activity post-pandemic. Major events that affected emissions marked on graph are Indian Independence in 1947 resulting a shift in industrial policy, oil crisis in 1973 temporarily impacting on growth, economic liberalization in 1991 accelerating industrial growth, global financial crisis in 1991 causing a temporary slowdown and COVID-19 pandemic in 2020 resulting in sharp drop followed by a quick recovery. These important transition points are represented by vertical lines in the image, and times when emissions changed significantly from year to year are indicated by red dots. Emissions have been increasing exponentially overall, especially since economic deregulation in 1991.

Table 25 - India emissions statistics from 2011 - 2022

Year	**Emissions in million tonnes**
2013	1995.098
2014	2148.343
2015	2234.219
2016	2354.658
2017	2426.606
2018	2593.057
2019	2612.888
2020	2421.552
2021	2674.221
2022	2829.644

As per the table above, emissions increased by 60% between 2011 and 2022. Below is the forecast of India's future CO_2 emissions in million metric tonnes for selected years based on several modeling approaches using linear, polynomial, and exponential growth models and calculated forecasts through 2050 based on the historic data from 1850 to 2022.

Table 26 - India emissions forecast (Based on 2001-2022 data)

Year	Linear Forecast*	Polynomial Forecast*	Exponential Forecast*
2025	1256	2146.4	3269.7
2030	1310.1	2362.5	4171.0
2040	1418.4	2823.5	6787.4
2050	1526.8	3322.8	11045.0

* In million metric tonnes

The forecasts above are revised based on the recent 20 years of data, to provide a more realistic projection. The table below illustrates the emissions forecast based on historic data from 2011 to 2022.

Table 27 - India emissions forecast (Based on 2011-2022 data)

Year	Linear Forecast*	Polynomial Forecast*	Exponential Forecast*
2025	3120.16	3064.29	3579.31
2030	3590.62	3469.32	4658.1
2040	4531.54	4216.04	7889.09
2050	5472.46	4878.32	13361.18

* In million metric tonnes

The emissions forecast plot shown below based on the restricted dataset from 2002 onwards depicts a better representation of the recent trends, as the historical data prior to that might not reflect the current market dynamics. The polynomial and exponential models provide slightly different trajectories, but overall, all forecasts are now more consistent with the recent observed data.

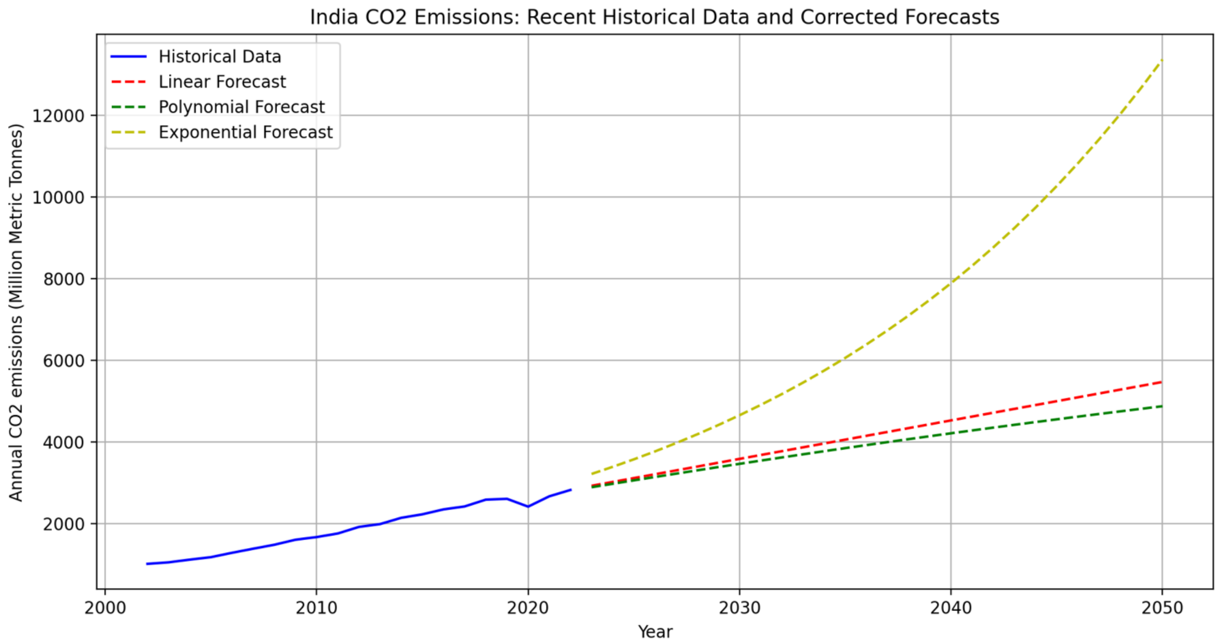

Figure 11 - Emissions forecast from 2023 till 2050

Considering 2022 emissions as 2829.64 million metric tonnes, to achieve net-zero emissions by 2070 will require annual reduction rate of 30.06%. To achieve net-zero by 2070, India would need to reduce emissions by approximately 30.06% each year which is an extremely aggressive reduction rate that would require dramatic changes in energy infrastructure, industrial processes, transportation systems, carbon capture and storage capabilities. The trajectory shows that most emissions would need to be eliminated by 2040 under this reduction rate. However, this analysis suggests that a more realistic approach might involve (1) a slower initial reduction rate while building green infrastructure (2) accelerated reductions in later years as technology improves (3) significant investment in carbon capture and storage technologies (4) international cooperation and support for technology transfer.

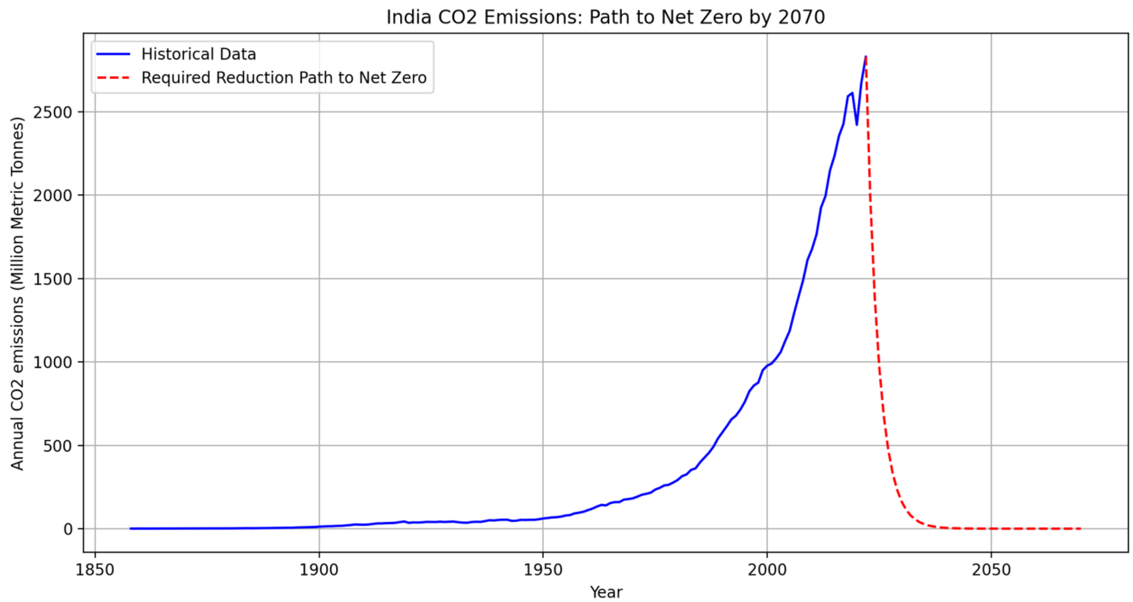

Figure 12 - India's trajectory to net-zero (Based on the data from 1850)

A few of the alternative net-zero pathways for India from 2022 to 2070 are listed below:

- Linear Reduction Pathway: This approach reduces emissions evenly year by year.
- Delayed Action Pathway: This scenario assumes a slower reduction initially (until 2040) followed by a rapid reduction afterward.
- Early Action Pathway: This scenario implies rapid reductions in the early years (until 2040) and then a gentler pace later.
- S-Curve Transition: This pathway follows a sigmoid (S-curve) pattern, reflecting a gradual transition accelerating in the mid-period.

Table 28 - Emissions milestones by pathway & average annual reduction rates

Year	Linear	Delayed	Early	S-Curve
2030	2358.04	1877.24	1949.31	2778.75
2040	1768.53	1123.98	848.89	2313.44
2050	1179.02	138.35	104.49	761.01
2060	589.51	0.08	0.06	82.94
2070	0	0	0	7

Year	Linear	Delayed	Early	S-Curve
2022-2030	2%	4%	4%	0%
2030-2040	3%	4%	6%	2%
2040-2050	3%	9%	9%	7%
2050-2060	5%	10%	10%	9%
2060-2070	10%	10%	10%	9%

The chart below exemplifies the milestone emissions (in million metric tonnes) outputs for selected years.

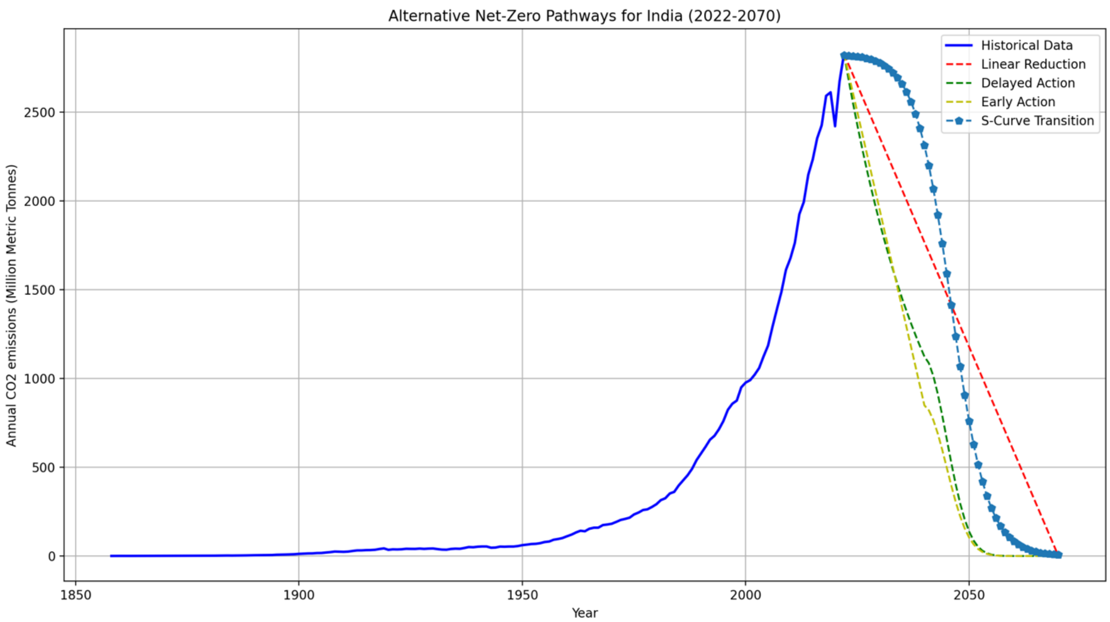

Figure 103 - Alternate net-zero pathways for India

With linear reduction, emissions fall steadily, requiring increasingly higher annual percentage reductions as the starting number decreases. For example, the pathway reaches net-zero by 2070 with a 10% annual reduction between 2060 and 2070. In Delayed Action, due to a slower initial reduction, this scenario has higher emissions in the early stages (e.g., 1877.24 million metric tonnes by 2030) but then accelerates to achieve net-zero by 2070 where as in Early Action reducing emissions faster early on leads to much lower emissions by mid-century (e.g., 104.49 million metric tonnes by 2050) and then maintains net-zero. S-Curve Transition pathway gradually starts, then accelerates during the middle period. Even so, the final decade (2060–2070) still see a steep decrease (approximately 9.16% per year) to reach net zero.

4.1.3 Statistical checkpoint - Augmented Dickey-Fuller (ADF) vs. KPSS

An augmented Dicky Fuller (ADF and KPSS (Kwiatkowski-Phillips-Schmidt-Shin) tests were executed on the emissions data to check if the time-series has a unit root, i.e. to determine if the series is stationary. Stationary series have constant mean and variance over time, which is a key assumption in most time-series models like ARIMA or linear regression on time variables as a non-stationary series can lead to misleading regressions.

Iteration 1 used emissions data from 1960 to 2023 to run ADF and KPSS tests. Results are as below:

Test	Statistic	p-value
ADF	2.593692941334692	0.9990739619420482
KPSS	1.0575390003750686	0.01

ADF's very high p-value (≈ 1) fails to reject a unit root, signaling a non-stationary series. KPSS's low p-value (< 0.01) rejects stationarity, reinforcing the same theory.

Iteration 2: After removing the anomalous 2020 observation (the sharp pandemic-dip) and then taking a first difference still leaves the annual-change series non-stationary—the ADF p-value is ≈ 0.94, well above conventional rejection thresholds.

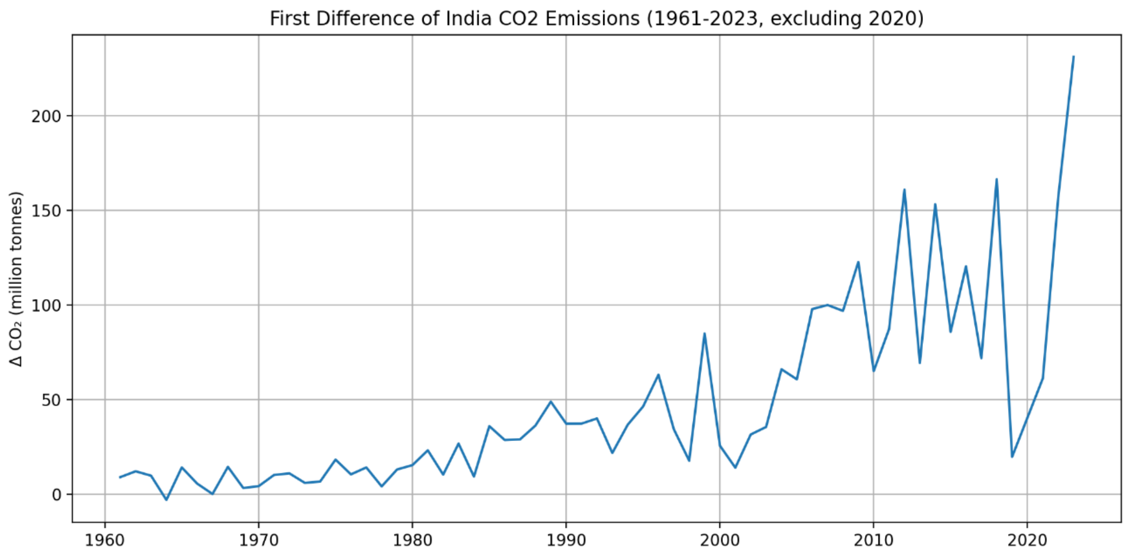

Figure 114 - First difference computation

The chart visualizes year-to-year swings: spikes around the oil shocks of the 1970s, a strong growth phase in the 2000s, and the 2021 rebound after the pandemic dip was removed. Despite eliminating the long-run trend, the differenced series retains enough persistence that the unit-root null is not rejected.

Iteration-3: The test was re-executed after switching to log-differences (without considering 2020 data). This approach took the natural log of emissions (adding 1 tonne to avoid log 0), then differenced that log series with which the ADF p-value dropped to 5.9 times10−14, well below any significance cut-off. That means the null of a unit root is rejected and the log-differenced series is now stationary.

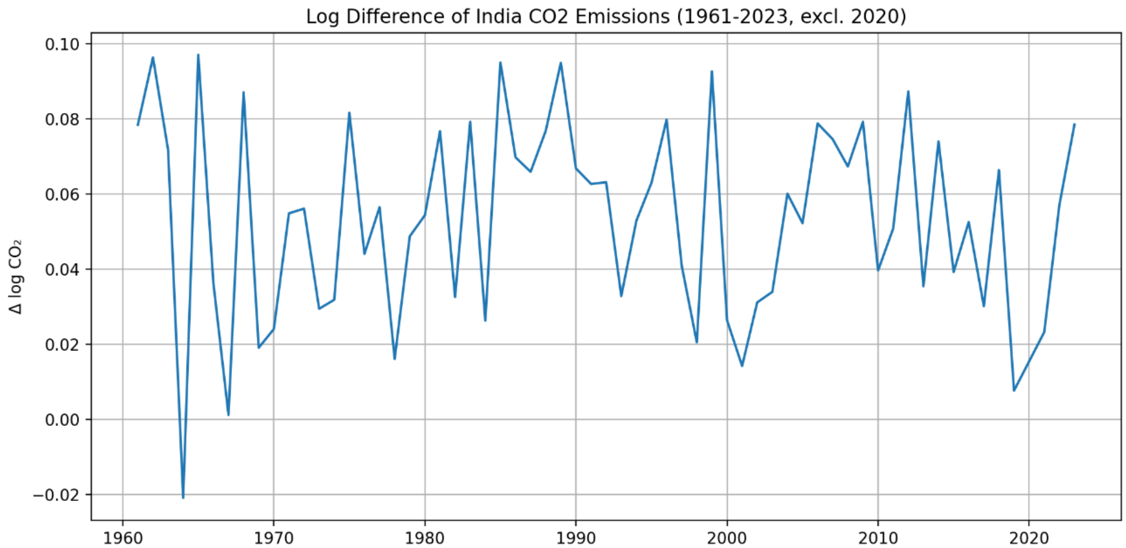

Figure 125 - Log difference computation

Now that the time series is stationary with log difference, ARIMA model, Kaya Pathway (Collins, 2021) and Linear line trajectories are projected.

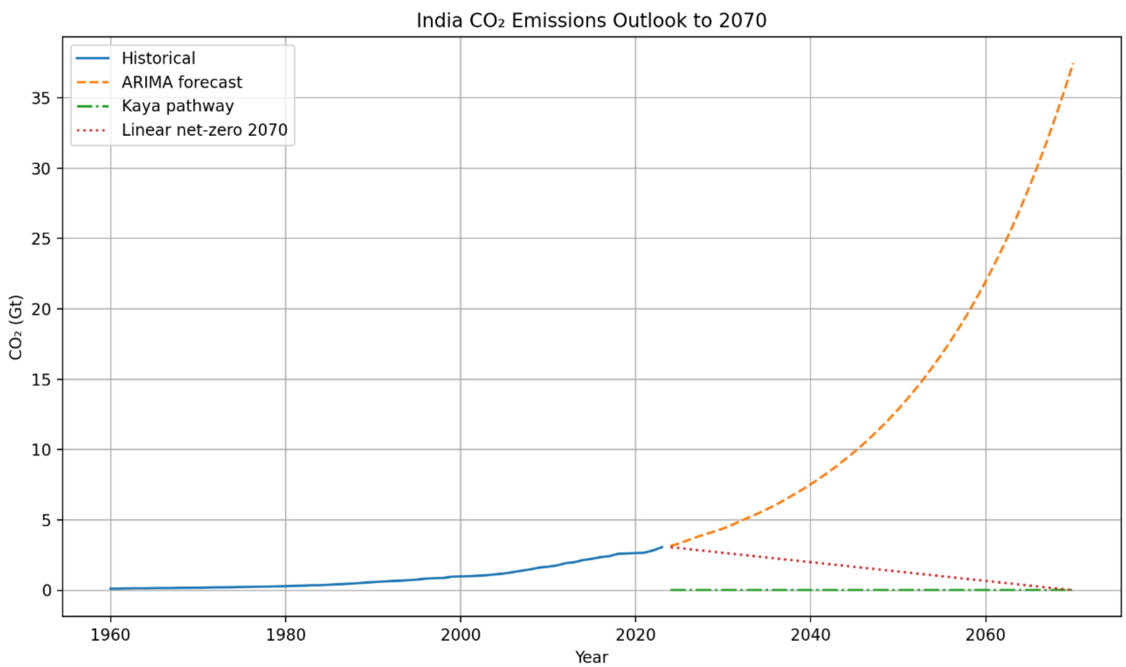

Figure 13 - Net-zero pathway

The chart overlays four trajectories:

(1) Historical: India's reported emissions through 2019. (2) ARIMA forecast: a purely statistical extrapolation of past growth-rate patterns kept emissions rising for decades.
(3) Kaya pathway: an illustrative "net-zero-compatible" scenario assuming 6.4% annual GDP growth, 1% annual efficiency gains (lower energy intensity), and 2% annual decarbonization of the energy mix. This combination bends emissions downward fast enough to cross zero in 2070. (4) Linear line: a simple straight-line decline from 2019 to zero in 2070, shown for visual reference.

The emissions trajectory was further explored to identify annual reduction rates required to achieve net-zero target by 2070 using Linear and Exponential models. The following considerations are made to arrive at the net-zero pathway:
India's latest reported emissions in 2019 ≈ 2.6 Gt CO_2.
Finish level: 0 Gt CO_2 in 2070.
Time horizon: 51 years (2019 → 2070)
As per the Linear method, required cut per year is approximately 1.96 % (100 % ÷ 51) of the 2019 level each year. For the Exponential method, consider $(1 - r)^{51} = \varepsilon$, where ε is the small non-zero level left in 2070. If we consider $\varepsilon = 1$ % of the 2019 value (effectively "net-zero"), reduction will be computed as 8.6% as per the equation below:
$r = 1 - \varepsilon^{1/51} \approx 1 - 0.01^{1/51} \approx 8.6\%$ / yr.

Typically, models that build multiplicative growth/decline scenarios such as IAMs, ARIMA, etc. use the exponential framing which is about an 8½ % compound decline each year. However, policymakers and most national roadmaps use the linear framing of about 2 % of today's emissions removed every year.

As per Ritchie et al. (2023), 41 billion tons of CO2 were released into the atmosphere in 2022 whereas the maximum emissions permitted as per the calculation was only 250 billion tonnes to have a 50% chance of keeping the temperature below 1.5°C. With a rate of 41 billion tons of emissions/ year, 250 billion tons accounts only for six years' worth of our present emissions. In order to bring down the emissions to zero, world emissions must reduce by 10% year-on-year to achieve net zero by 2050. Global greenhouse gas (GHG) emissions reached an all-time high of 53 billion metric tons of CO_2 equivalent in 2023, despite numerous climate commitments (Greenhouse Gas Emissions Worldwide, 2025). China was the leading emitter, contributing nearly 16 billion metric tons—almost equal to the combined emissions of the U.S., India, the EU, and Russia. These five economies together accounted for about 60% of global emissions. With emissions rising from 41 billion tonnes in 2022 to 53 billion tonnes in 2023, the data underscores the urgent need for a minimum annual global emission reduction of 10% in order to stay on track for net-zero emissions by 2070.

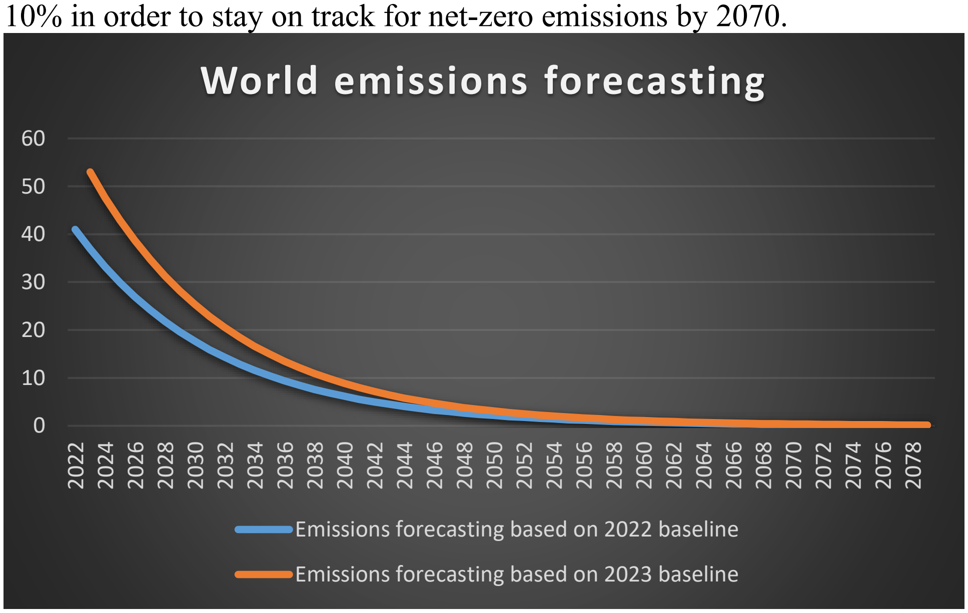

Figure 14 - World emissions forecasting

The chart above indicates that global emissions must be reduced by more than 10%; otherwise, within six years, temperature rise will surpass 1.5°C, leading to severe and potentially catastrophic events.

4.1.4 Evaluation of energy utilization based on data published by NITI Aayog[1]

As per Ministry of New and Renewable Energy. (2025), India's total renewable energy capacity reached 209 GW in 2024 with an annual growth rate of 15.86% while the GDP rose to INR 173.82 trillion with a CAGR of 6.4% (Ministry of Statistics & Programme Implementation. 2024). India's installed capacity for producing power from renewable sources has significantly increased, as seen in the table below (NITI Aayog. 2023). As on April, 2025 the energy mix of India is as below (NITI Aayog. 2023).

Table 29 – India - Energy mix in 2025

Source	Daily Generation (Million Units)	Percentage of energy generation	Capacity (in GW)
Coal	3739.02	74%	221.81
Wind	299.43	6%	82.86
Solar	483.86	10%	105.65
Nuclear	161.22	3%	8.18
Oil & Gas	95.02	2%	50.04
Hydro	280.65	6%	47.73
Other Resources	26.71	1%	11.58

[1] The NITI Aayog serves as the apex public policy think tank of the Government of the Republic of India.

The table below depicts the break-up of renewable energy generated based on various sources (NITI Aayog. 2023).

Table 30 - Renewable energy - Installed capacity in FY24

Year	**Source**	**Installed Capacity (in GW)**
2024-25	Solar: Ground Mounted	83.89
2024-25	Solar: Rooftop	17.02
2024-25	Solar: Off-grid	4.74
2024-25	Hydro	47.73
2024-25	Wind	50.04
2024-25	Small Hydro	5.10
2024-25	Bio Power	11.58
Total		**220.10**

According to the data, India still depends heavily on coal as its main energy source, but the push for renewable energy is growing steadily, which is encouraging for closing the colossal emissions gap of India. With a 129 GW capacity in pipeline, India is poised to meet 500 GW target by 2030. The data obtained from NITI Aayog. (2023) depicted in the table below is used for creating a correlation analysis between energy usage, GDP and CO2 emissions

Table 31 - Renewable energy, GDP, emissions data from NITI Aayog

Year	Total renewable energy	Annual CO2 emissions (Million metric tonnes)	GDP (in Rs Trillion)	Energy Supply (Nuclear, Coal, Oil, Renewable, Hydro, Gas) (MToE)
2010-11	57.55	1677	83	522
2011-12	63.91	1765	87	554
2012-13	67.56	1926	92	584
2013-14	75.51	1995	98	595
2014-15	80.21	2148	105	650
2015-16	88.7	2234	114	677
2016-17	101.73	2355	123	693
2017-18	115.94	2427	131	714
2018-19	124.82	2593	140	761
2019-20	133.95	2613	145	773
2020-21	142.02	2422	137	718
2021-22	156.61	2674	150	752
2022-23	172	2830	161	846
2023-24	190.58	-	174	915
2024-25	220.1	-	-	-

Based on the correlation analysis between GDP, CO_2 emissions, and total energy supply, the key findings are list as below:

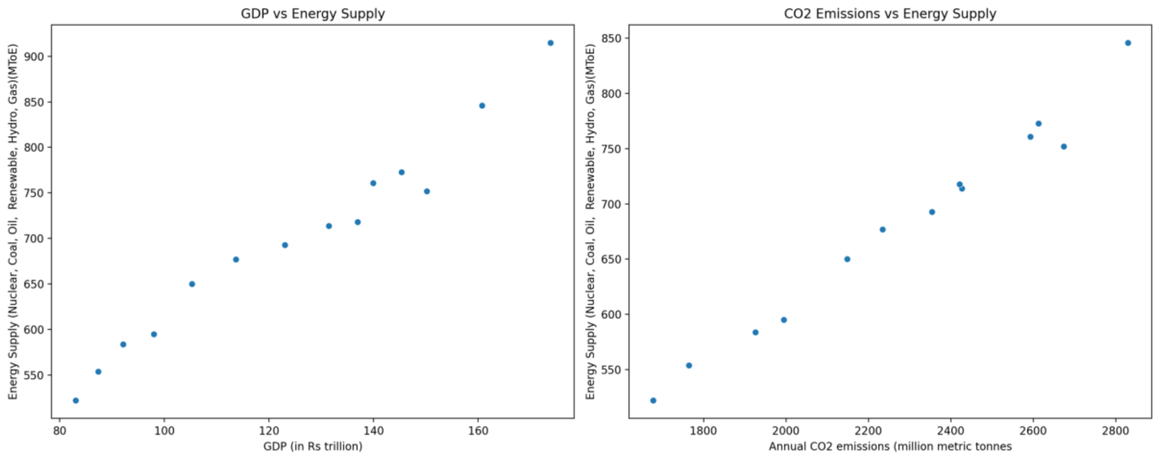

Figure 15 - Correlation analysis of GDP, Emissions and Energy Supply

GDP and energy supply correlation is 0.984 indicating an extremely strong positive correlation. As India's GDP grows, there's a proportional increase in energy supply. This relationship suggests that economic growth is closely tied to energy consumption. CO_2 Emissions and energy supply correlation of 0.991 demonstrates the strongest correlation among all pairs indicating that increase in energy supply is very closely associated with increases in CO_2 emissions. Despite the faster adoption of renewable energy, fossil fuels still play a dominant role in the energy mix of India. GDP and CO_2 emissions correlation of 0.990 indicates a very strong positive correlation between economic growth and emissions reflecting the carbon-intensive nature of India's economic development. The extremely high correlations (all above 0.98) indicate that these three factors are very tightly interconnected in India's development and the relationship suggests that India's economic growth is currently dependent on increasing energy supply, which is leading to proportional increases in CO_2 emissions. The strong correlation between energy supply and emissions suggests that despite renewable energy initiatives, the overall energy mix is still heavily dependent on fossil fuels. This data highlights the challenge of decoupling economic growth from both energy consumption and carbon emissions. These relationships demonstrate the complex challenge India faces in balancing economic growth with environmental sustainability and energy security. The strong correlations suggest that significant structural changes would be needed to break the link between economic growth and emissions.

Considering the latest emissions data for year 2022 with emissions of 2829.6443 million metric tonnes, latest renewable energy capacity for year 2024 as 220.1 GW and latest total energy supply data for year 2023 of 915.0 MToE (Million Tonnes of Oil Equivalent), the predicted annual percentage changes to meet net-zero target by 2070 is 9.53% with an annual renewable energy growth rate of 5.21%. The mathematical formulas used for these calculations are:

For Emissions Reduction

$E(t) = E_{current} * (1 - r_{emissions})^{t}$

Where $E(t)$ is the emissions at time t

$E_{current}$ is current emissions

$r_{emissions}$ is the required annual reduction rate

t is years from present setting target emissions to effectively zero

$0.01 = (1 - r_{emissions})^{t}$

$r_{emissions} = 1-(0.01)^{1/T}$

For Renewable Energy Growth:

$R(t) = R_{current} \times (1 + r_{renewable})\, t$

$R(t)=R_{current} \times (1+r_{renewable})\, t$

Where: $R(t)$ is renewable capacity at time t

$R_{current}$ is current renewable capacity

$r_{renewable}$ is the required annual growth rate

The target renewable capacity must meet total energy demand in 2070:

$R(T)= E_{total} \times (1.02)^{T}$

Where E_{total} is current total energy supply assuming 2% annual growth in total energy demand.

$r_{renewable} = ((R_{current} / E_{total}) \times (1.02)^{T}))^{1/T} - 1$

The projected net-zero pathways based on the equations are depicted in the following graphs:

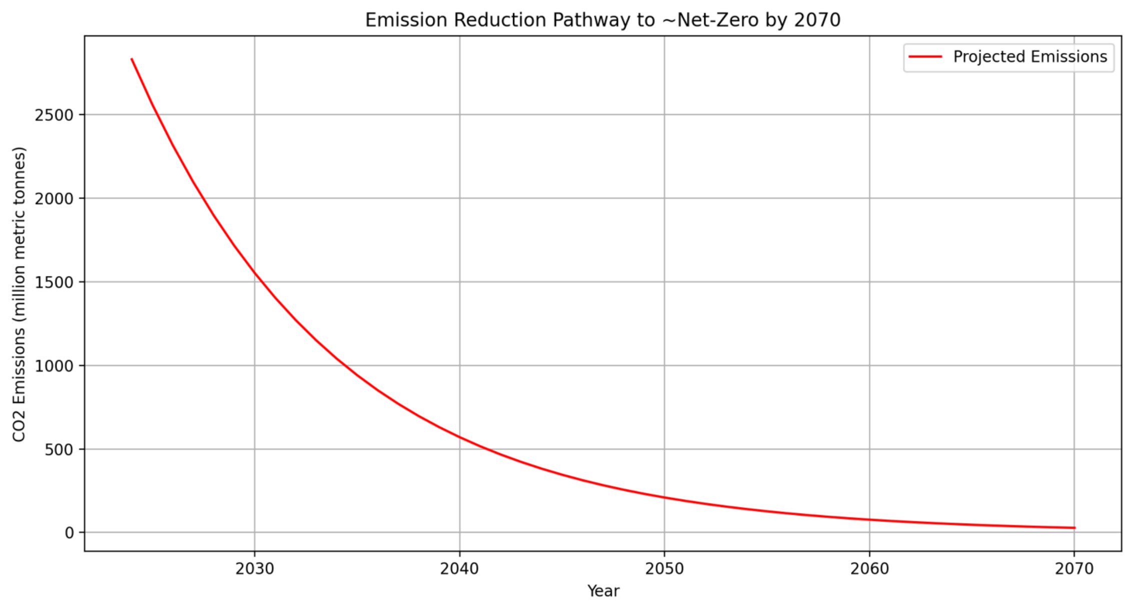

Figure 19 - Emissions pathway to net-zero by 2070 (Based on the data from 2022)

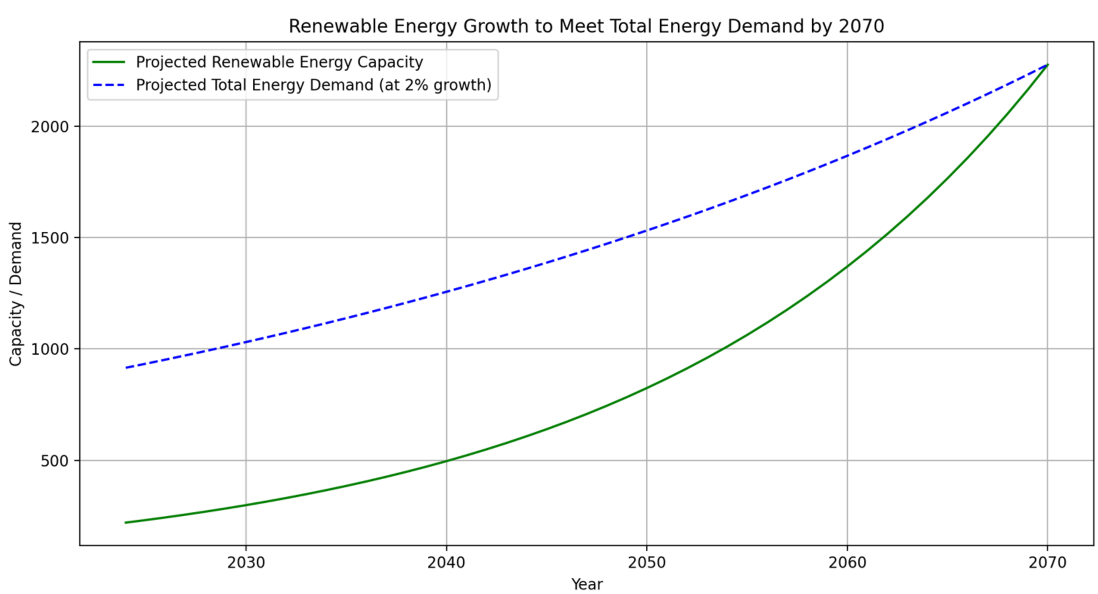

Figure 2016 - Expected renewable energy growth to meet energy demand by 2070

These graphs depict the exponential decline in emissions needed to reach net-zero by 2070 and the growth required in renewable energy capacity (green line) to meet projected total energy demand (blue dashed line). The analysis suggests India needs to reduce emissions by approximately 9.53% annually while increasing renewable energy capacity by 5.21% annually to achieve net-zero by 2070, assuming 2% annual growth in total energy demand. India has set a goal to achieve net-zero by 2070, but the facts Ritchie et al. (2023) presented are concerning, and world leaders, including India, should take a sober look at the situation and adopt the fastest pathway to net-zero before the tipping point—a crucial threshold that, when crossed, causes significant, rapid and irreversible changes in the climate system.

4.2 Empirical model to calculate ESG debt

Question 2 – Can the data gathered from BRSR reporting be used to develop an empirical model to calculate a company's ESG debt?

The data analysis indicates that the details available in BRSR can be utilized for arriving at an empirical formula for ESG debt computation once some of the key limitations mentioned in section 3.10 are addressed. Integrated ESG Debt combines the environmental, social, and governance debts into a single ESG Debt score calculated as below:

$$\text{Total ESG Debt} = w_1 * (\text{Environmental Debt}) + w_2 * (\text{Social Debt}) + w_3 * (\text{Governance Debt}) - w_4 * (\text{Emissions Abatement Credit})$$

Note: Appropriate weights (w_1, w_2, w_3, w_4) must be assigned based on the relative importance of each category in the industry context.

Equation 1 – Total ESG Debt computation

Environmental debt calculation can potentially use two equations depending on the context. (1) Equation for annual carbon tax that can be applied in case of regular computation wherein there are no catastrophic events reported in the given financial year. (2) Equation for cess payment towards social cost of carbon will apply when there is a serious natural catastrophe in the country or a region in the given financial year and the cess collected will cover the expenses towards redevelopment of infrastructure, rehabilitation of affected community and compensation of business and personal losses. In Equation (1), excess CO2 emissions are computed based on the industry cap set by the government and carbon price discovery will be determined based on the trades in Indian Carbon Market which will become operational in 2026.

Equation for annual carbon tax payment

Environmental Debt = National Calamity Contingent Duty + Current FY Carbon tax + Surcharge on fossil fuel usage in the current FY

Whereas,

National Calamity Contingent Duty = ∑ No. of years in operations * Emissions intensity for current FY * Average revenue over the years in operations * diminishing balance interest rate

Current FY Carbon tax = (Actual CO_2 emissions - Benchmark) * (Carbon Price in India) if global benchmark emissions is available.

OR

Current FY Carbon tax = Actual CO_2 emissions * Carbon Price in India (if the company has already defined a pathway towards net-zero and the current emissions is below the benchmark emissions)

Surcharge on fossil fuel usage in the current FY = X% * Amount of non-renewable energy used for operations in the current FY

Equation 2 - Equation for annual carbon tax payment

In the equation for cess payment towards social cost of carbon, global benchmark emissions and social cost of carbon determined by Annual CO_2 Emissions. (2023) and Country-level Social Cost of Carbon (Ricke et al. 2018) are considered for computation. The social cost of carbon (SCC) for India, as per the GitHub repository on country-level

SCC, is estimated to be \$86 per ton of CO_2 (Country-Level-Scc. 2018). This value reflects the economic damages caused by emitting one additional ton of carbon dioxide.

Equation for cess payment towards social cost of carbon

Environmental Debt = Excess CO_2 emissions * {Social Cost of Carbon)

Note: Cess, is a specific type of tax, which is collected by the government to raise funds for a particular purpose, such as education or infrastructure, and is distinct from general revenue.

Equation 4 - Equation for cess payment towards social cost of carbon

<u>Social debt computation</u>

Social debt can be computed based on verifiable outcome reported against various employee led initiatives yielding emissions reduction such as implementation of greener policies, sustainable work habits, energy-saving behaviors, energy-efficient process ideas, and tree-planting drives. By default, the social debt is zero, by doing activities that positively impact the environment, companies can reduce their environmental impact as social debt which is negative in value can offset the environmental impact.

Social Debt = ∑ (No. of emissions reducing social initiatives * (-1 * Cost of each initiative)

Equation 3 - Social Debt computation

Equation 5 - Governance Debt computation

Governance debt computation

In the BRSR framework, leadership indicators are voluntary disclosures that go beyond the essential indicators. While essential indicators are mandatory for all entities required to file the BRSR report, leadership indicators are meant for organizations that aspire to demonstrate higher levels of social, environmental, and ethical responsibility. The table below shows the indicative list of leadership indicators mentioned in BRSR that can be considered for the computation of governance score with regard to emissions reduction and usage of renewable energy sources based on the company policies and strategic decisions.

Table 32 - Governance score based on BRSR's leadership indicators

Sl. No	Leadership indicators
1	Discussion and implementation of long-term and short-term strategy or plan to manage scope 1 & 2 emissions, emissions reduction targets, and an analysis of performance against those targets.
2	Discussion and implementation of strategy or plans to address air emissions-related risks, opportunities, and impacts.
3	Report how the goals and targets for GHG emissions are set, specify whether they are informed by scientific consensus, and list any authoritative intergovernmental instruments or mandatory legislation the goals and targets are aligned with.
4	Entity must disclose whether the emissions by the entity were within limits as prescribed by CPCB/SPCB & whether any show cause notices in relation to emissions were issued by CPCB/SPCB & if any of them are pending with the entity

Sl. No	Leadership indicators
5	Describe actions taken to improve product quality to reduce air emissions.
6	Indicate if any independent assessment/ evaluation/assurance has been carried out by an external agency to assess emissions? (Y/N) If yes, the name of the external agency
7	Entity must disclose any targets for increase in renewable energy (short term targets (up to 3 years) & long-term targets (more than 3 years) set by the entity
8	Indicate if any independent assessment/ evaluation/assurance has been carried out by an external agency to assess usage of energy sources? (Y/N) If yes, name of the external agency.

The governance score can be positive or negative depending on the implementation status. If implemented, the score can be marked as negative to indicate overall reduction in ESG debt, conversely, the score will be positive if not implemented. The leadership indicators can strongly influence the overall ESG debt and will reflect the impact of management vision, decision making, and financial expenditures towards adopting cleaner, emissions free production. Governance Debt assesses governance lapses using qualitative responses in BRSR, assigning scores for compliance. For example, using categorical variables (e.g., "Yes" or "No" for third-party audits) can be used to quantify their impact.

$$\text{Governance Debt} = \sum (\text{Governance Score} * \text{Governance Adjustment Factor} * \text{cost of implementation})$$

Equation 6 - Governance Debt computation

Other potential leadership indicators are (1) adoption of CEMS systems to automate the monitoring efficiency of scope 1, scope 2 and scope 3 emissions (2) Adoption of latest technologies such as IoT devices, and blockchain algorithms ensuring transparency and accuracy in emission reporting. (3) Leveraging AI/ML models for predicting emissions for the financial year and proactively finding ways for offsetting the emissions or improving production processes to cut emissions.

Based on the literature review it is established that the emissions removal can be calculated with fair degree of accuracy and therefore any such initiatives potentially help companies to lower ESG debt. Therefore, Emissions Removal Credit negates the ESG debt because of the initiatives undertaken by the company for the removal of emissions from the atmosphere by creating emissions reservoir utilizing the fund allocated for CSR initiatives.

Emissions Abatement Credit = ∑ (No. of emissions reducing social initiatives * (Cost of each initiative)

OR

Emissions Abatement Credit = ∑ (Emissions removed from atmosphere in the current FY * Carbon Price in India)

Equation 7 - Equation for computing credits for emissions abatement

ESG debt can become a fundamental financial parameter that reflects a company's commitments towards environmentally conscious operations – lower the debt, better the brand value as it indicates company's commitment towards a greener future. ESG debt can be offset using karma tokens which is another important financial parameter reflecting how much a company is investing towards balancing its ESG debt. Karma Token represents a system of credits that flow between organizations and individuals, mirroring the concept of karma from Indian religions. The tokens cannot be exchanged for money or other assets; they are earned through positive actions and contributions within a community or system. In the context of this research, karma tokens are used as a mechanism for resource allocation, where organizations & individuals earn and spend tokens based on their actions and contributions. Overall, the theoretical construct of a karma token provides a framework for understanding how these credits can be used to achieve efficient and fair resource allocation, incentivize fair policies, and enhance economic welfare. ESG debt and Karma tokens collectively offer a comprehensive perspective on corporate practices on environmental responsibilities similar to Enterprise multiple (EVEBIDTA) – a ratio used to determine the value of a company. ED-to-KT (ESG Debt to Karma Tokens) can be used to determine the environmental friendliness of the company; lower ratios can indicate a company's strong commitment to reduce its carbon footprint. Higher value of ESG debt can be reduced by investing in green initiatives enabling companies to accumulate karma tokens which in turn can reduce the ED-to-KT ratio. Investor community can compare the financial performance of a company along with ED-to-KT ratio to determine its brand value for being environmentally responsible. By requiring companies to invest in carbon reduction programs, the Indian government might increase corporate involvement in emissions removal initiatives and increase their karma token balance. Companies having excess karma tokens over a period of time may allow transfer of underlying initiatives which can be maintained by companies that are short of karma tokens to balance their debt.

This strategy aligns with market-based emissions trading systems and worldwide trends in carbon pricing. Businesses that reach net-zero emissions may be able to sell carbon credits to companies with significant ESG debt, effectively creating a financial incentive for sustainability. India's Carbon Credit Trading Scheme (CCTS) may incorporate such a structure to guarantee adherence to the Paris Agreement's global climate commitments. Additionally, Industries might be encouraged to adopt low-carbon technologies through the systematic application of cap-and-trade schemes and corporate responsibility initiatives. The success of this initiative depends on robust policy enforcement, clear carbon accounting methodologies, and transparent reporting mechanisms to prevent green washing and misuse of credit trading. India's evolving ESG regulations and corporate sustainability goals make this model a viable strategy for accelerating decarbonization.

4.3 ESG debt-based evaluation of businesses' financial performance

Question 3 – How can the company's financial efficacy be assessed by tracking the amount of ESG debt that is incurred annually?

An ESG framework's financial efficacy is evaluated by looking at how well it assists businesses in striking a balance between their financial performance and sustainability objectives. In particular, monitoring ESG debt linked to energy use and emissions provide quantifiable information about how it affects a business's environmental and financial responsibility.

1. Defining Financial Efficacy: In the context of this research, financial effectiveness denotes the ESG framework's ability to enhance cost efficiency while reducing environmental liabilities through the adoption of sustainable practices and

maximizing economic advantages. It evaluates whether the framework helps companies to reduce costs, avoid penalties, and improve revenue streams without compromising sustainability goals whereas ESG debt is a measurable indicator of how much a business has fallen short of its sustainability goals, particularly with regard to energy and carbon. Financial efficacy is assessed through several dimensions. (a) Cost reduction: By streamlining operations, ESG frameworks seek to lessen financial pressures. For instance, switching to renewable energy reduces reliance on pricey and unstable fossil fuels. Emissions reduction helps prevent carbon taxes and other fines. (b) Risk mitigation: Businesses can reduce financial vulnerabilities that may result in lawsuits, penalties, or harm to their reputation by proactively addressing ESG risks. (c) Revenue generation: By implementing sustainable practices, businesses can draw in socially conscious partners, investors, and clients, possibly creating new sources of income. Businesses that sell environmentally friendly goods frequently see a rise in demand and larger profit margins. Further, by investing in creating reservoirs of carbon flux can help generate more income as well as improve brand value of the company. (d) Creation of long-term value: The long-term advantages of ESG alignment are also taken into account by financial efficacy. Enhanced ability to withstand market upheavals, such as changes in energy costs, increased brand loyalty as a result of eco-friendly operations, and increased market value as a result of excellent ESG performance.

2. Computing and Tracking ESG Debt: The core concept of ESG debt revolves around monetizing the environmental costs associated with a company's operations. Tracking this debt annually provides clarity on the following aspects. (a) Emissions Tracking - Scope 1 covers direct emissions from owned assets (e.g., machinery, manufacturing processes). Scope 2 includes indirect emissions from purchased energy (e.g., coal-powered electricity usage). Scope 3 encompasses indirect emissions from

supply chains and product use. Tracking emissions debt annually allows companies to identify areas where they are lagging behind their sustainability goals and quantify the financial impact. (b) Non- renewable vs renewable energy usage - Companies need to assess the proportion of energy derived from fossil fuels versus renewable sources like solar, wind, and hydropower. Financial impact due to the choice of energy usage is: (a) Fossil fuel dependency leads to higher costs due to fluctuating oil prices in the global markets and potential carbon taxes (b) Transitioning to renewable energy may involve initial investments but reduces long-term operational costs and ESG debt. (c) Periodic (monthly, quarterly, half yearly and annual) tracking of energy debt can indicate progress toward energy efficient processes and adoption of renewable energy sources for operations.

3. Assessing Financial Efficacy - The following techniques are used in annual tracking to assess the ESG framework's financial effectiveness: (a) ESG debt reduction: Examine ESG debt reductions from year to year. A decline indicates reduced environmental expenses and better adherence to sustainability standards. For instance, a business that cuts emissions by 20% a year pays less in carbon taxes, illustrating the framework's economic advantages. (b) Cost savings: Examine the operational savings resulting from the use of renewable energy. Lowering the use of fossil fuels reduces costs and lessens the chance of price volatility. The economic usefulness of the ESG framework is demonstrated, for instance, if renewable energy lowers energy prices by 15%. (c) Improved Market Value and Reputation: Good ESG practices draw in socially conscious investors and consumers, which in turn raises a company's brand value and profitability.

4. Innovative adjustments to operational process refer to strategic changes made within a company to improve efficiency, sustainability, and financial performance. These

adjustments involve rethinking traditional methods and incorporating new technologies, practices, or frameworks to enhance operational effectiveness. (a) Adopting Automation and Technology: Smart Manufacturing: Use technology such as the Internet of Things (IoT) to enhance production line monitoring and efficiency. IoT-enabled sensors are able to identify energy-use inefficiencies and automatically modify processes to cut waste. (b) Artificial Intelligence (AI): Forecast demand, cut down on overproduction, and expedite decision-making processes with AI-driven analytics. For instance, supply chain data can be analysed using AI algorithms to reduce delays and enhance resource use. (c) Adoption of sustainable practices such as energy optimization: Use renewable energy sources like solar panels, wind turbines, or geothermal systems in place of fossil fuel-based ones by retrofitting buildings with energy-efficient features, like improved HVAC systems or LED lighting. (d) Sustainable supply chains & carbon neutrality: To lessen the environmental impact, source raw materials from suppliers who follow ethical and sustainable standards and implement circular economy ideas, such as designing products for durability, repairability, and recyclability, to modify operational procedures to reduce carbon footprints. (e) Workforce and cultural transformation - To increase productivity and flexibility, educate associates on sustainable practices and cutting-edge technologies. Encouraging staff members to find and apply process improvements by creating an innovative culture through processes like crowdsourcing ideas within teams to increase productivity or cut expenses. (f) Periodic monitoring. of ESG debt enables businesses to make dynamic strategy adjustments. For example, if the energy debt is significant, companies can increase their investment in renewable energy or reduce scope 3 emissions by streamlining supply chains or enhance regulatory compliance to safeguard against penalty charges.

5. Benchmarking Financial Efficacy: Benchmarking involves comparing a company’s performance with industry peers, regulatory standards, or global best practices to assess how effectively it is managing and mitigating ESG-related financial liabilities. Benchmarking highlights areas where a company is underperforming compared to peers or industry standards. Transparent benchmarking allows companies to show investors, regulators, and customers that they are making tangible progress toward sustainability goals. Companies can use benchmarking data to prioritize investments in high-impact areas, such as transitioning to renewables or implementing energy-efficient technologies. ESG performance benchmarking reassures investors that the company is proactive in managing environmental risks, potentially leading to better access to sustainable financing. Effective benchmarking requires robust tools and techniques to analyse ESG data such as (a) Comparison Against Industry Standards - Industry standards set baselines for emissions and renewable energy usage, such as average emissions per unit of output or the proportion of energy derived from renewable sources. By comparing a company’s ESG debt trends (e.g., emissions reduction, energy efficiency improvements) with these standards, stakeholders can evaluate the effectiveness of the company's ESG strategy. For example, in the manufacturing sector, the industry might set a benchmark for scope 1 emissions at 1.5 tons of CO_2 per ton of product manufactured. Companies can compare their emissions data annually to assess alignment with these benchmarks. (b) Peer-to-Peer Comparisons - Companies within the same sector often face similar environmental and financial challenges. Comparing ESG debt across peers helps to identify leaders, laggards, and opportunities for improvement. For example, a company may find that its fossil fuel dependency is 40%, while peers average 30% indicating opportunities for greater adoption of renewable energy sources. (c) Alignment with global commitments - A lot of businesses align their ESG objectives

with international programs such as the Sustainable Development Goals (SDGs) of the UN or the Paris Agreement, which aims to keep global warming to 1.5°C requiring minimum 10% reduction in emissions annually. Company's commitment to ESG debt reduction can be compared to these goals to acquire a better understanding of how well the business is carrying out its worldwide obligations. As an example, a business may compare its annual emissions reductions to the Paris Agreement's common goal of lowering carbon intensity by 40% over five years. By benchmarking financial efficacy annually, companies can monitor the trajectory of their ESG debt, refine their ESG frameworks to address specific gaps and stay aligned with industry and global sustainability goals.

6. Transformational changes: By systematically tracking ESG debt related to emissions and energy usage annually, companies can quantitatively assess the financial efficacy of their ESG frameworks, however transformational changes requires significant investments but can offer a leap in terms of reducing emissions. This process not only reveals gaps in sustainability but also demonstrates how proactive strategies translate into financial benefits. Over time, such tracking drives long-term cost reductions, compliance improvements, and enhanced profitability, proving the value of the ESG framework. A few proven methodologies to arrest emissions are listed based on the previous research.

1. Adopting circular economy: As per G20 Secretariat, India et al. (2024), India's transition to a circular economy could reduce greenhouse gas emissions by 44% while generating economic benefits. Encouraging recycling and reuse of materials reduces the need for new resource extraction, cutting emissions from mining and manufacturing. Initiative like Extended Producer Responsibility (EPR) policies ensure companies take responsibility for post-consumer waste. Usage of recycled materials in industries like

construction, textiles, and electronics lowers emissions from raw material processing and eco-friendly packaging reduces plastic waste and carbon footprint. Circular economy principles promote energy recovery from waste, such as converting organic waste into biogas. For example, encouraging solar panel recycling can reduce dependence on mining for critical minerals. Efficient resource utilization is another way forward in reducing emissions. For example, water recycling in industries minimizes freshwater consumption and energy-intensive purification processes battery recycling lowers raw material procurement costs and reduces dependence on critical minerals. Scope 3 emissions often account for the majority of an organization's total greenhouse gas emissions, typically exceeding 70% of the carbon footprint for many industries. In contrast, Scope 1 and Scope 2 emissions are generally smaller in scale, as they cover direct emissions from owned or controlled sources and indirect emissions from purchased energy, respectively. Encouraging companies to design products with end-of-life recyclability in mind will systematically reduce scope 3 emissions.

2. Invest in tools and methodologies – ESG benchmarking through agencies like CDP and MSCI, along with sector-specific tools and KPIs, enables businesses to measure sustainability performance against peers. Integrating predictive analytics and big data enhances decision-making, reduces emissions and operational costs, and aligns financial performance with long-term ESG goals.

ESG rating agencies: Organizations such as CDP, MSCI, and Sustainalytics offer ESG rankings and ratings, which act as external standards for sustainability and financial performance. Businesses can evaluate their ESG debt against industry averages and those of their peers to alter both near-term and long-term strategic decision making and fund allocation for implementation.

Sector-specific benchmarking tools: Industry associations frequently provide sustainability reports or offer sector-specific benchmarks. For instance, sector-specific tools for benchmarking emissions and energy efficiency are available from the World Resources Institute (WRI) or in India, NITI Ayog may consider publishing sector wise data for comparison and benchmarking.

Quantitative metrics: To monitor performance over time, utilize Key Performance Indicators (KPIs) such as energy intensity (energy used per unit of revenue) and carbon intensity (CO_2 emissions per unit of output). Other financial indicators that can be benchmarked include lower ESG debt, cost savings from energy efficiency upgrades, and cost incurred in offsetting ESG debt.

Predictive analytics: Make use of data analytics to foresee possible inefficiencies or disruptions. For instance, AI-powered predictive maintenance can forecast equipment faults. Improved processes powered by AI can lower operational costs, reduce liabilities (e.g., carbon taxes), and enhance profitability.

Data-driven decision making: Use insights from big data to inform choices about customer service, logistics, and production reducing downtime, optimizing resource usage, and eliminating waste.

Monitoring of emissions and establishing the accuracy of emissions data shared is pivotal in computing the emissions and ESG debt of a company. Lack of integrated continuous monitoring tool is an impediment while adopting green transition in India. India employs various technologies and frameworks to track emissions. Continuous Emission Monitoring Systems (CEMS) mandated by CPCB real-time tracking of emissions from industrial chimneys. The Online Emission Monitoring Systems (OCEMS) automates data collection from industries, transmitted to State Pollution Control Boards (SPCBs) and CPCB to improve transparency and accountability in emissions. Satellite-Based Monitoring from ISRO and NASA collaborations help track large-scale emissions using satellite imagery. Government of India also promotes technology solutions such as AI and Blockchain for Data Accuracy. AI-driven analytics to predict emissions trends and recommend reduction strategies, Blockchain technology to ensure tamper-proof emissions records, improving ESG disclosures, and IoT-enabled sensors and cloud-based monitoring tools to prevent manual data errors.

4.4 Carbon pricing based on ESG debt, SCC, and emissions

Question 4 – How to link ESG debt, emissions and social cost of carbon to arrive at an effective carbon pricing?

As per the Annual Climate Summary 2024 published by IMD [2](IMD. 2024), India's annual mean land surface air temperature in 2024 was +0.65°C higher than the long-term average (1991–2020). Overtaking the previous maximum temperature recorded in 2016 (with an anomaly of +0.54°C), 2024 was the warmest year since national records began in 1901. Heatwave conditions affected most of the east coast in April, most of northwest India in May, and most of northern and central India in June. Four cyclonic storms developed across the Indian Ocean in 2024. Of these, two were cyclonic storms and two were severe cyclonic storms. Extreme meteorological phenomena, including lightning, thunderstorms, droughts, floods, landslides, and exceptionally high rains, were also experienced in different parts of the country in addition to these cyclones. Extreme weather phenomena resulted in over 2400 fatalities, of which over 1280 were attributable to lightning and thunderstorms. To compensate loss of lives, damages caused and disruption to small and medium scale businesses

[2] IMD is the Indian agency for meteorological observations, weather forecasting and seismology.

To establish an effective carbon price, a comprehensive framework must be developed to connect ESG debt, emissions, and the social cost of carbon (SCC) by measuring the environmental impact of emissions, monetizing that impact, and integrating it into a practical pricing strategy.

ESG Debt (Due to emissions) = Excess Emissions * Carbon Pricing (CP)

Whereas Excess Emissions=Actual Emissions−Benchmark Emissions

In case of a catastrophic event,

ESG Debt (Due to emissions) = (Actual Emissions - Benchmark Emissions) * Social Cost of Carbon (SCC)

$$\text{Carbon Pricing (CP)} = \frac{\text{(Actual Emissions} - \text{Benchmark Emissions)} * \text{Social Cost of Carbon (SCC)}}{\text{(Actual Emissions} - \text{Benchmark Emissions)}}$$

This simplifies to:

Carbon Pricing (CP)=Social Cost of Carbon (SCC)

Equation 8 - Ideal Carbon Pricing

The effective carbon price accounts for both emissions penalties and societal impacts, guiding companies toward sustainable practices. ESG Debt emissions represents the financial liability a company incurs due to exceeding acceptable emission thresholds.

The Social Cost of Carbon reflects the monetary value of societal damage caused by each ton of CO_2 emitted. It includes factors like health impacts, environmental damage, and economic losses. Excess Emissions is the difference between a company's actual emissions and the permissible benchmark level. The equation above reveals that carbon pricing should align with the SCC, as the SCC represents the appropriate cost to internalize the societal harm caused by emissions. By setting carbon pricing equal to or higher than the SCC, companies are incentivized to reduce emissions and align with sustainability goals. The effective carbon price accounts for both emissions penalties and societal impacts, guiding companies toward sustainable practices. Setting the carbon price equal to the Social Cost of Carbon (SCC) is both practical and impactful, as it aligns the financial cost of emissions with their societal and environmental damage. However, there are challenges and considerations in implementing this approach effectively. Key challenges in SCC computation are (1) SCC values can vary significantly depending on assumptions about future climate impacts, discount rates, and socioeconomic projections, (2) High SCC values may face resistance from industries and governments due to concerns about economic competitiveness and affordability. (3) Carbon pricing based on SCC requires international cooperation to avoid disparities and carbon leakage (where emissions shift to regions with lower prices).

Based on the literature review, it is evident that SCC is calculated using Integrated Assessment Models (IAMs), which combines climate science, economics, and social factors, however it has not established an effective social cost of carbon. Karma token recommends to utilize the ESG score of a company (especially attributed to emissions, related temperature increase leading to catastrophes and losses on account of those events) to arrive at the percentage damage the company might have caused to the environment based on the calculations illustrated in section 4.2 Empirical model to calculate ESG debt. Although the Companies Act of 2013 mandates companies to set aside 2% of its annual revenue for CSR initiatives, most of these companies do not spend those funds effectively. This research recommends to enforce a policy to enforce transferring the CSR funds to a mutually agreed escrow account which will be monitored by the government of India and an International agency in charge of climate control. Transparency, cooperation and willingness to change are the only way forward to address a challenge that is of global scale.

Karma tokens represent the difference between good and bad that a company brings upon this planet and people based on its sustainability measures, ecological footprint, technology advancements, regulatory compliance and social obligations that a company undertakes for the well-being of the planet and its people. A token may represent the cost of carbon in the international market and allows countries to trade based on the emissions generated. This is a task easier said than done, however establishing carbon markets in each country is a good step towards disciplining each country to achieve its national targets and arrive at a global market. Unless carbon is traded like a commodity like gold or silver in the international markets, it's challenging to arrive at the uniform price. The tokens represent how much each company and country have to off-set based on their carbon footprint. Consumerism driven cost of carbon is another aspect to consider – a deeper look at the spending habits of people will reveal the facts about how people have shifted to consumerism fueled by global trade liberalization. In the long run, if a carbon metering system is created for measuring the carbon footprint of individual, a carbon tax can be applied to curtail over-consumption. Household consumption as well as individual decisions and actions are closely related to carbon emissions. A variety of potential levers, such as technology innovation, regulation, investment, financial incentives, organizational and behavioral change must be used in order to move towards a low or zero carbon economy. LiFE (Lifestyle for environment is an initiative of Hon'ble Prime Minister of India Shri Narendra Modi) aims to replace the current "use-and-dispose" economy, which is characterized by careless and destructive consumption, with a circular economy, which is characterized by thoughtful and intentional use. The Mission aims to encourage people to take little actions in their daily lives that, when adopted globally, can have a big impact on climate change.

4.5 Financial structure to offset ESG debt

Question 5 – What kind of financial re-structuring is suitable for offsetting the ESG debt?

In India, ESG debt is becoming a critical factor in corporate financial planning, especially with increasing regulatory pressure and investor demand for sustainable business practices. Financial restructuring is essential to offset ESG debt, ensuring long-term sustainability while maintaining profitability. Financial restructuring to offset ESG debt in India involves several strategic measures:

(1) Green Financing and ESG-Linked Loans

Green Bonds: A Green Bond is a fixed-income instrument issued by corporations, municipalities, or governments to fund specific environmental projects, such as clean energy initiatives, sustainable infrastructure, or climate adaptation efforts. Companies can issue green bonds to raise capital specifically for sustainable projects, such as renewable energy, and carbon reduction initiatives. This is a framework ensuring that funds raised through green bonds are used for climate-friendly projects. Further, empower municipalities in issuing green bonds for climate-friendly projects to contain the emissions within their territory.

Renewable Energy ETFs: A Renewable Energy ETF is a fund that tracks a group of companies involved in renewable energy sectors, such as solar, wind, hydro, and battery technology. Investors buy shares of the ETF, gaining exposure to a diversified portfolio of clean energy stocks. Clean energy exchange-traded funds (ETFs) are seeing strong investor interest, particularly in China, South Korea, and Taiwan.

Table 33 - Green bonds vs renewable energy ETFs

Aspect	Renewable Energy ETFs	Green Bonds
Investment Type	Equity (stocks)	Fixed-income (bonds)
Purpose	Invest in clean energy companies	Fund sustainable projects
Risk	Market-driven	Interest rate-sensitive
Liquidity	High (traded daily)	Lower (fixed maturity period)
Direct Climate Impact	Indirect (profit-driven firms)	Direct (funding green projects)

Both these investment vehicles are essential for financing the transition to a low-carbon economy. ETFs are ideal for investors seeking growth, while Green Bonds suit those looking for stable, impact-focused investments.

Transition bonds are financing instruments aimed at supporting industries that are moving away from high-carbon operations toward more sustainable practices. Unlike green bonds, transition bonds allow funding for projects in carbon-intensive sectors as long as they lead to emissions reductions. These will be ideal for energy-intense industries to raise capital for decarbonization efforts. Energy corporations can use transition bonds to finance carbon capture and hydrogen fuel adoption.

Table 34 - Green bonds vs Transition bonds

Aspect	Green Bonds	Transition Bonds
Purpose	Direct funding for green projects	Supports industries transitioning to sustainability
Allowed Sectors	Renewable energy, waste management, eco-friendly infrastructure	Hard-to-abate sectors like oil, gas, and steel aiming for cleaner operations
Risk Level	Lower (backed by government or large institutions)	Moderate (associated with industries still emitting carbon)
Investor Preference	ESG investors focused on zero-carbon impact	Investors supporting gradual decarbonization efforts

ESG-Linked Loans: Banks and financial institutions can offer loans with interest rates tied to ESG performance. Companies that improve their ESG metrics receive lower interest rates, incentivizing sustainable practices. Sustainability-linked loans tie the applicable interest rate to a firm's achievement of predefined sustainability performance targets, offering reduced rates upon successful compliance. This mechanism serves to motivate corporate entities to pursue and meet sustainability objectives. Prominent Indian banks have adopted various environmentally focused initiatives for industrial power generation. These efforts are complemented by the introduction of green financial products such as eco-friendly housing and automobile loans. These developments reflect a strategic shift in the financial sector toward embedding sustainability into lending practices, thereby aligning economic growth with environmental responsibility.

(2) <u>Carbon Credit and Trading Mechanisms</u>

India's Carbon Credit and Trading Scheme (CCTS) allows companies to trade carbon credits, enabling high-emission industries to offset their carbon footprint by purchasing credits from low-emission firms. Perform, Achieve, and Trade (PAT)

Scheme encourages industries to improve energy efficiency and trade excess energy savings. Import Tariffs strategy imposes tariffs on carbon-intensive imports to promote cleaner production.

(3) Sustainable Investment Strategies

ESG-Focused Private Equity and Venture Capital to attract investors interested in funding businesses with strong ESG commitments, providing financial incentives for companies to restructure their operations. Through impact investing, companies can attract investors who prioritize social and environmental returns alongside financial gains. Climate Tech Investments aim at raising funds for AI-driven emissions tracking, smart grids, and energy-efficient solutions.

Table 35 - Comparison of sustainable investment strategies

Category	ESG-Focused PE/VC	Impact Investing	Climate Tech Investments
Primary Goal	Financial returns with ESG integration	Social/environmental impact with financial returns	Climate-focused technological innovation
Investment Type	Private equity and venture capital	Direct investments in impact-driven businesses	Startups and tech firms tackling climate change
Approach	Private equity (PE) firms and venture capital (VC) funds integrate ESG factors into investment decisions.	Investments are made in businesses, nonprofits, or funds that address global challenges like climate change.	Investments focus on innovations that reduce carbon emissions, improve energy efficiency, or enhance sustainability.
Focus Areas	ESG compliance, ethical governance	Social good, sustainability	Carbon reduction, clean energy, green technology
Challenges	ESG transparency, balancing returns	Measuring impact, scalability	High capital needs, regulatory risks

Category	ESG-Focused PE/VC	Impact Investing	Climate Tech Investments
Examples	PE firms acquiring companies with strong ESG policies; VC funds backing startups with sustainable innovations.	Microfinance institutions, renewable energy projects, and social enterprises.	Startups developing carbon removal technologies, battery storage solutions, and AI-driven climate analytics.

(4) <u>Debt Restructuring and ESG Integration</u>

With refinancing High-Carbon Assets, Companies with significant fossil fuel investments can restructure their debt by refinancing through green finance instruments. ESG-Linked Corporate Bonds enables companies to issue corporate bonds tied to ESG performance ensures accountability and attracts sustainability-focused investors.

Table 36 - Key features of debt restructuring vehicles

Feature	ESG-Linked Corporate Bonds	Refinancing of High-Carbon Assets
Use of Funds	Can be used for any purpose	Transitioning high-carbon assets
Performance Metrics	Based on company-wide ESG goals	Based on transition strategy
Financial Penalties	Higher interest rates if ESG targets are missed	Requires clear sustainability commitments
Reporting Requirements	Must report on ESG performance	Must demonstrate transition progress
Example	A corporation issuing an ESG-linked bond with a commitment to reduce its	A coal-fired power plant refinancing its debt to invest in renewable energy projects.

Feature	ESG-Linked Corporate Bonds	Refinancing of High-Carbon Assets
	carbon footprint by 30% within five years.	

Indian government has introduced several subsidies and incentives to support emissions reduction across industries as per the table below.

Table 37 – Government of India - Emissions schemes and benefits

Scheme	Benefits
Faster Adoption and Manufacturing of Electric Vehicles (FAME) Scheme	Provides subsidies for electric vehicles (EVs) to promote clean transportation
Production-Linked Incentive (PLI) Scheme	Supports domestic battery manufacturing for EVs and renewable energy storage.
Renewable Energy Subsidies	Financial incentives for solar, wind, and hydro projects to accelerate clean energy adoption.
National Bio-Energy Mission	Subsidies for biomass and biogas projects to reduce fossil fuel dependence.
Perform, Achieve, and Trade (PAT) Scheme	Incentives for industries improving energy efficiency and reducing emissions.
Carbon Credit Trading Scheme (CCTS)	Allows industries to trade carbon credits, rewarding emission reductions.
Green Hydrogen Mission	Subsidies for green hydrogen production to decarbonize industries.

Scheme	Benefits
Energy Efficiency Financing	Low-interest loans for businesses investing in energy-efficient technologies.
Solar Rooftop Subsidy	Financial support for residential and commercial solar installations.
Waste-to-Energy Subsidies	Incentives for converting municipal waste into renewable energy.
Sustainable Agriculture Subsidies	Support for organic farming and climate-smart agricultural practices.
Electric Bus Procurement Subsidies	Funding for state governments to purchase electric buses for public transport.
Smart Grid Development Grants	Financial aid for modernizing electricity grids to integrate renewables.
Carbon Capture and Storage (CCS) Incentives	Support for industries adopting CCS technologies to reduce emissions.
Green Building Incentives	Tax benefits for constructing energy-efficient buildings.
Water Conservation Subsidies	Funding for industries implementing water recycling and conservation measures.
Circular Economy Initiatives	Grants for businesses adopting recycling and waste reduction practices.
Sustainable Textile Industry Subsidies	Incentives for eco-friendly textile production and waste management.
Low-Carbon Cement Production Support	Financial aid for cement manufacturers adopting low-carbon technologies.

Scheme	Benefits
Biofuel Production Subsidies	Support for ethanol and biodiesel production to reduce fossil fuel use.
Electric Vehicle Charging Infrastructure Grants	Funding for expanding EV charging networks across India.
Green Logistics and Transportation Incentives	Subsidies for fuel-efficient and electric freight transport.
Sustainable Mining Practices Support	Grants for mining companies implementing emission-reduction technologies.
ESG-Linked Corporate Financing	Financial incentives for companies meeting sustainability targets.
Research and Development Grants for Climate Tech	Funding for startups and research institutions developing low-carbon technologies.

While all these subsidies are in place for encouraging industries towards net-zero, the adoption rate is low due to lack of awareness and enforcement policies.

4.6 Improve BRSR effectiveness beyond top 1000 listed businesses

Question 6 – What actions can be enforced to ensure compliance with BRSR reporting and to extend its reporting, monitoring, and implementation beyond the top 1000 listed businesses based on market capitalization?

To support the conclusions and add the ground truth to the findings, the researcher used a qualitative multiple case study. Twenty associates from major IT enabled Services organizations in India were interviewed for the study in order to gauge their knowledge of workplace policies pertaining to energy use, monitoring, emissions control systems, net-zero targets, and emissions. The time period for these interviews was April–May 2025. The length of the interviews ranged from 18 to 37 minutes, with an average of 26 minutes. Below is the demographics of associates participated in this voluntary research interview.

Table 38 - Demographics of interviewees

Sex	**Age**	**Industry**	**Educational background**	**Job category**	**Working experience**	**Interview time (minutes)**
Male	40-50	ITeS	Bachelors	Middle management	15-20	23
Male	40-50	ITeS	Masters	Middle management	15-20	20
Male	40-50	ITeS	Bachelors	Middle management	15-20	21
Male	40-50	ITeS	Bachelors	Middle management	15-20	19
Male	40-50	ITeS	Masters	Senior Management	20-25	21
Female	40-50	ITeS	Bachelors	Senior Management	20-25	25
Female	30-40	ITeS	Bachelors	Middle management	10-15	22

Sex	Age	Industry	Educational background	Job category	Working experience	Interview time (minutes)
Female	50-60	ITeS	Masters	Senior Management	30-35	35
Female	40-50	ITeS	Masters	Senior Management	20-25	31
Male	50-60	ITeS	Bachelors	Senior Management	30-35	37
Female	30-40	ITeS	Bachelors	Junior cadre	15-20	24
Male	40-50	ITeS	Bachelors	Senior Management	20-25	25
Male	40-50	ITeS	Masters	Senior Management	20-25	35
Female	30-40	ITeS	Bachelors	Junior cadre	15-20	18
Female	30-40	ITeS	Bachelors	Junior cadre	15-20	20
Male	40-50	ITeS	Bachelors	Senior Management	20-25	32
Male	40-50	ITeS	Bachelors	Senior Management	20-25	28
Male	40-50	ITeS	Masters	Senior Management	20-25	32
Male	50-60	ITeS	Bachelors	Senior Management	30-35	30

Sex	Age	Industry	Educational background	Job category	Working experience	Interview time (minutes)
Male	50-60	ITeS	Bachelors	Senior Management	30-35	29

Conducted structured interviews to compile the study's qualitative data. For processing convenience, the interview responses were transcribed into a Microsoft Excel file. Analysis was done on the themes that emerged from the study participants' responses to the research questionnaire. The identified themes are listed below:

- General Policy Framework
- Energy Utilization Policies
- Emissions Inventory
- Emissions Reduction Policies
- Implementation Strategies
- Net-Zero Target
- Reporting and Verification
- Audits

These themes aided in comprehending the mindset and tactics that Indian businesses require in order to raise awareness, make environmentally friendly decisions, influence corporate policies, engage in green initiatives actively, and impact society positively, all of which can enhance a company's brand value and improve the financial performance in the long run.

The interviewees' demographic information

The qualitative research began with a series of questions about the colleagues' personal histories, including age, education, and work status and subsequently covered the scope of qualitative analysis covering various facets of this research such as company policies on emissions, reduction policies, reporting, net-zero targets, and the use of renewable energy. The demographics of the research participants include 35% female and 65% male associates. Participants in the study ranged in age from 32 to 55, with 20% being in their 30s to 40s, 60% being in their 40s to 50s, and 20% being in their 50s to 60s. Of those interviewed, 30% had a master's degree and 70% had a bachelor’s degree. Middle management accounted for 25% of the interviewees, senior management for 60%, and junior cadre for 15%. 5% of the 20 interview candidates had 10 to 15 years of experience, 35% had 15 to 20 years, 50% had 20 to 25 years, and 10% had 30 to 35 years. All interviewees are from IT enabled Services sector.

Most of the associates in the junior cadre were unaware of company’s progress, policies and actions towards general policy framework, emissions inventory, emissions reduction policies, implementation strategies, net-zero target, reporting & verification, and audit procedures however they were aware of energy utilization policies due to its visible impact in the office spaces – These included the use of LED lights, motion detector-based lighting systems, solar panel-based energy generation, and the installation of energy-efficient equipment to optimize energy utilization. Lack of basic training on environmentally friendly practices, failure in communicating company policies on energy saving initiatives and emissions reduction policies, the absence of a taskforce-led green initiatives, and the company's limited vision in reaching net-zero were cited as reasons for the lack of awareness in other areas.

The middle management expressed better awareness about company's green initiatives – This group of interviewees were aware of company policies in place to combat climate change such as optimization of office space, flexible work from home options, commute sharing policies, migration to EV vehicles for office commuting, investment in tier-3 cities to create greener offices and reducing travel time for employees. This group was also well aware of the importance of incentivizing the green initiatives to promote adoption at a large scale, usage of green bonds in raising capital for green initiatives to reduce carbon footprint, carbon taxes to penalize companies for non-compliance, and the need for appointing a special taskforce to engage with people in all centers once a year to create awareness and engage in impactful programs – like large scale tree planation and creating a corpus for maintaining mini forests created by thousands of volunteers, marathons to improve awareness of society at large etc. In contrast to their apparent lack of expertise in the areas of Emissions Inventory, Emissions Reduction Policies, Net-Zero Target, Reporting and Verification, and Audits, middle management looked to be aware of the General Policy Framework, Energy Utilization Policies, and Implementation Strategies. As per NASSCOM (National Association of Software and Service Companies), there are about 5.8 million employees in IT industry – a well-educated crowd that can spread the news on environmental conscious lifestyle, small steps for reducing carbon footprint at individual and household level. The same thought process can be applied for other industries in the non-engineering sectors to reduce emissions. According to the BRSR data analysis, some NBFCs and insurance businesses appeared to be unaware of their emissions footprint and stated in the study that emissions reporting was not relevant considering their business not being associated with the engineering sector.

Associates interviewed from senior management were well aware of company's General Policy Framework, Energy Utilization Policies, Emissions Inventory, Emissions Reduction Policies, Reporting and Verification processes, Audit procedures and Implementation Strategies. However, they lacked clarity on Net-Zero Target set by the company. This group seemed to be fully cognizant of how the energy usage and emissions data is gathered, monitoring processes for energy utilization and across offices, causal for offices having the largest and least energy footprints as well as the policies in place for emissions reduction, and adoption of renewable energy sources like wind turbines, solar panels, company sponsored initiatives like buying land parcels for tree planation to create carbon capture and storage and possibility of grids supplying renewable energy sources and the possibility of creating clusters of companies to share renewable energy storage equipment and energy optimization even outside the periphery of their company. The interviewees expressed a detailed knowledge on scope 1, scope 2 and scope 3 emissions and how that can be targeted for their own organizations as well as customers using technology solutions and how to monetize these solutions generating more revenue for the company. This group expressed reasonable understanding of CSR expenses and allocation of funds for various activities including social and environmental causes. In their personal capacity this group reasoned that expanding Business Responsibility and Sustainability Reporting (BRSR) beyond the top 1000 listed businesses requires a combination of regulatory enforcement, incentives, and industry collaboration. The Indian government can play a pivotal role in helping manufacturing and engineering companies in reducing emissions while maintaining profitability. Some of the strategies detailed by associates from senior management are listed below:

1. Incentivize Green Technologies: Providing subsidies or tax benefits for companies adopting energy-efficient machinery and renewable energy sources, can drive

adoption. Further, offer additional tax benefits or financial incentives for companies that voluntarily adopt BRSR reporting. Offering preferential treatment in government contracts for businesses with strong sustainability disclosures will motivate industries to comply with emissions regulations. Government support for conducting research and development in low-carbon technologies, such as green hydrogen and carbon capture can facilitate smoother transformational journeys for heavy engineering companies. Expanding access to green bonds and sustainability-linked loans helps small and medium scale businesses invest in low-carbon technologies.

2. Access to Green Financing – It can be very demanding when small and medium scale companies transition into green energy while they need to strike a fine balance between emissions and balance sheets. Facilitating loans and grants for companies investing in sustainability projects can be a booster for startup companies who are starting bottom up. Established large companies may not find it so challenging as they can invest in research and development to re-engineer the operations while paying taxes and penalties for the current emissions. The government of India partnering with international organizations to provide funding for large-scale green initiatives can be a real booster to small and medium scale businesses (G20 Secretariat, India et al., 2024).

3. Regulatory Frameworks and stringent enforcement: India has set ambitious net-zero emissions targets, aiming to achieve carbon neutrality by 2070. Several standards and regulatory bodies play a crucial role in guiding industries, businesses, and policymakers towards this goal. Setting achievable emission reduction targets tailored to specific industries is crucial in the net-zero journey of Indian companies and encouraging compliance through rewards for exceeding targets and penalties for non-compliance may

push mid-range companies to their limits, however with careful planning companies can gain investor confidence if they start early with the transformation processes.

4. Skill development and training play a crucial role in reducing emissions in India by equipping the workforce with the knowledge and expertise needed to implement sustainable practices. Initiatives like the Green Skill Development Programme (GSDP), a visionary program of the Hon'ble Prime Minister, train individuals in areas such as pollution monitoring, emission inventory, and waste management. These programs can create a workforce capable of implementing eco-friendly solutions across industries. Training workers in solar, wind, and biofuel technologies helps accelerate India's transition to clean energy as the skilled professionals can improve efficiency in renewable energy projects, reducing reliance on fossil fuels. Training in energy-efficient manufacturing helps industries adopt low-carbon production methods. Educating businesses and workers about recycling, reusing, and waste reduction lowers emissions from landfills and industrial processes. Skill-building in sustainable construction promotes eco-friendly building designs and materials. Encouraging research and development in green technologies fosters innovation in emission reduction and training engineers and technicians in carbon capture and storage (CCS) can help industries cut emissions. Educating businesses on environmental regulations and carbon trading ensures compliance with emission reduction targets. Training government officials and corporate leaders in sustainability strategies strengthens policy implementation. Research by the Skill Council for Green Jobs (SCGJ) and Sattva Consulting, with backing from JP Morgan, indicates that India might generate up to 35 million employments in both established and growing sectors. The research titled “Gearing Up the Workforce for a Green Economy” was derived from engagements with more than 85 industry leaders, specialists from the skills ecosystem, covering over 2,000 participants.

5. Industry Partnerships - Industry leaders frequently possess access to sophisticated technologies and research capabilities that smaller enterprises or nascent sectors may lack, and by disseminating innovations—such as carbon capture technology, energy-efficient manufacturing techniques, or AI-driven sustainability solutions. Leveraging TRIZ theory of innovation, companies across sectors can implement proven strategies without reinventing the wheel. For example, the automotive and energy sectors can collaborate to develop more efficient battery technologies for electric vehicles (EVs). Partnerships to establish centers of excellence that provide specialized training for industry-specific emissions reduction targets and finance pilot projects for cutting-edge emission-reduction technologies. According to TRIZ theory, a systematic approach to innovation, states that when industries work together, they can create a structured way towards innovation, establishing common sustainability benchmarks that make it easier to regulate and measure progress. Companies can set industry-wide carbon neutrality goals, ensuring all players align with best practices rather than taking fragmented approaches. Cross-industry collaboration can help optimize data-driven emissions tracking, improve supply chain sustainability, and develop smart grids for renewable energy usage.

6. Carbon Trading Mechanisms: India's Carbon Credit Trading Scheme (CCTS) allows industries to trade carbon credits, incentivizing emission reductions. Companies that lower emissions can sell credits, creating a financial incentive for sustainability. Establishing a robust carbon credit trading system and improving awareness among companies and providing opportunities to work with Industry experts in re-engineering or transforming the processes to lower emissions through the engineering lifecycle. Additionally, allowing companies to offset emissions while generating revenue from

unused credits can potentially create new revenue streams for companies that promote investments in green technologies.

7. Improving Market Opportunities – The governments can negotiate to support the export of eco-friendly products by reducing tariffs and providing marketing assistance encouraging more business startups to setup cleaner industries. Encouraging adoption of Green Technologies by lowering tariffs for producing solar panels, wind turbines, and energy-efficient appliances are more affordable, accelerating their adoption worldwide. Free trade agreements that eliminate tariffs on environmental products can energize the market, increasing demand and production of low-carbon alternatives reducing the product pricing. When eco-friendly products are more affordable, industries shift toward low-emission production methods, reducing overall emissions. India can integrate carbon tax incentives with tariff reductions to further promote green trade and emissions reduction. Domestic demand for sustainable products needs to be encouraged through awareness campaigns to promote local businesses. Higher demand for eco-friendly products pushes manufacturers to adopt low-emission production methods. Local sourcing of sustainable materials and optimized logistics minimizes scope 3 emissions from transportation. As per Kuriyama et al. (2023), trade policies play a crucial role in reducing emissions by shaping market behavior and incentivizing sustainability. While tariffs on high-emission imports discourage reliance on carbon-heavy supply chains, Indian government can prioritize local production of sustainable materials, reducing scope 3 emissions. Import duties on non-sustainable goods will push manufacturers to adopt low-carbon production methods and to invest in energy-efficient technologies to remain competitive. Higher tariffs on single-use plastics and non-recyclable materials encourage businesses to use recycled and biodegradable alternatives promoting waste reduction and resource efficiency. Indian government can reinvest tariff

revenues into green infrastructure and renewable energy projects and support carbon markets to further drive emissions reduction.

These are a few measures expected to help small and medium scale Indian companies to transition to greener practices without compromising their financial performance and achieve net-zero targets.

4.7 Summary of Findings

Analysis of BRSR data from the top 100 Indian companies reveals that heavy engineering industries, responsible for 88% of emissions among high-turnover firms, are reducing emissions too slowly—only 34% achieved significant reductions in FY24, while 37.5% increased or stagnated. The renewable energy usage in these sectors remains abysmally low at 1%, signaling a pressing need for aggressive policy enforcement, renewable energy adoption (targeted at 15–20% annually), and process optimization. In contrast, non-engineering sectors exhibit lower emissions intensity and higher renewable adoption (73%), making them better positioned to achieve net-zero within a decade. Historical and projected emissions data further highlight India's challenge: emissions rose by 60% between 2011 and 2022, and meeting the 2070 net-zero target demands much lower annual emissions cut and rapid adoption of renewable energy. Strong correlations between GDP, energy supply, and emissions (all above 0.98) underscore that India's economic growth is tightly coupled with carbon output. Therefore, India's net-zero ambitions hinge on decoupling this link through rapid clean energy scaling, policy mandates tailored by sector, technological transformation, and global collaboration.

The BRSR framework in India provides detailed emissions disclosures that enable the quantification of environmental, social, and governance (ESG) debts.

Environmental debt can be calculated using equations based on CO_2 emissions, either via national industry caps and carbon market pricing or global benchmarks and the social cost of carbon in case of catastrophic events. Social debt can be derived from verifiable employee-led sustainability initiatives that reduce environmental impact, while governance debt can be assessed through compliance-based scoring of qualitative disclosures, including voluntary leadership indicators. Advanced technologies such as CEMS, IoT, AI/ML, robotics and blockchain can further enhance emission tracking and transparency. The model can also account for emission removal credits through CSR-funded initiatives, to offset ESG debt. With the support of India's Carbon Credit Trading Scheme and alignment with global climate policies, BRSR data can thus effectively support the creation of a dynamic and reliable empirical ESG debt model.

The financial efficacy of an ESG framework can be effectively assessed by annually tracking the amount of ESG debt incurred, particularly in relation to emissions and energy use. ESG debt serves as a quantifiable indicator of how far a company deviates from its sustainability targets, and its annual reduction signals improved environmental responsibility and financial performance. By monitoring ESG debt, companies can evaluate cost savings from operational efficiencies (e.g., reduced reliance on fossil fuels), identify risk mitigation outcomes (e.g., avoidance of penalties), and assess new revenue opportunities from sustainable practices. Additionally, innovative adjustments—such as automation, AI, and renewable energy adoption—enable dynamic responses to ESG performance data. Benchmarking ESG debt against industry standards, peer performance, and global commitments like the Paris Agreement provides further clarity on financial and environmental alignment. Through tools like ESG rating agencies, predictive analytics, and sector-specific KPIs, companies can make data-driven decisions that validate the ESG framework's role in lowering environmental liabilities and enhancing long-term economic value.

To establish effective carbon pricing, ESG debt, emissions, and the Social Cost of Carbon (SCC) must be linked through a framework that quantifies excess emissions, monetizes environmental damages, and aligns penalties with societal costs. ESG debt reflects a company's environmental liability, while SCC represents the economic harm per ton of CO_2. Setting carbon prices equal to or above SCC incentivizes emission reductions and Karma tokens may help standardize this globally. Policy reforms, including CSR fund allocation and lifestyle changes like India's LiFE initiative, are essential to drive accountability and support a low-carbon, sustainable economy.

To ensure broader compliance with BRSR reporting beyond the top 1000 listed companies, a multi-pronged strategy is essential. This includes regulatory enforcement, tailored emission targets by industry, and financial incentives such as tax benefits, green bonds, and sustainability-linked loans. Expanding awareness through taskforce-led initiatives, training programs, and public-private partnerships can build capacity across management levels. Additionally, integrating carbon trading mechanisms like India's Carbon Credit Trading Scheme (CCTS) and incentivizing voluntary disclosure will drive adoption. Leveraging the IT sector's influence and extending BRSR to non-engineering sectors may ensure a systemic shift toward sustainability expediting India's transition to a net-zero economy.

CHAPTER V: SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

India's journey to achieving net-zero by 2070 is both ambitious and essential, yet it is riddled with challenges stemming from high emissions intensity in industrial sectors and a slow pace of renewable energy adoption. The BRSR data paints a concerning picture, especially among high-turnover heavy engineering industries, where emissions remain largely unabated and renewable energy penetration is a mere 1%. This sectoral inertia threatens to derail national climate goals unless addressed through stringent regulatory interventions, targeted renewable adoption mandates, and accelerated technological upgrades. Conversely, non-engineering sectors present a more hopeful scenario, with significantly higher renewable integration and lower emissions intensity, proving that transformation is viable when incentives and accountability align. Decoupling economic growth from emissions, given the strong correlation between GDP, energy consumption, and carbon output, is no longer optional—it is a strategic imperative. Achieving this will require multi-level coordination across industries, robust policy enforcement, and investment in clean technologies.

The BRSR framework, with its detailed ESG disclosures, offers a crucial pathway to operationalizing sustainability at scale. The concept of ESG debt—quantifying environmental, social, and governance liabilities—introduces a powerful metric to track corporate responsibility, policy alignment, and financial performance. Linking this debt to carbon pricing mechanisms, using the Social Cost of Carbon as a benchmark, can internalize environmental externalities and create market-driven incentives for emission reductions. Advanced technologies like AI, advanced, robotics, blockchain, and real-time monitoring systems can dramatically enhance transparency and accountability in this process. Moreover, integrating emission removal credits through CSR and leveraging the Carbon Credit Trading Scheme (CCTS) can provide flexibility while maintaining rigor in climate action.

To institutionalize sustainable practices beyond the top 1000 companies, a comprehensive, multi-pronged strategy must be adopted. This should combine regulatory enforcement with incentives like tax benefits and sustainability-linked financing to drive compliance and innovation. Capacity building through training programs creating broader awareness, taskforce-led outreach, and public-private partnerships will be critical to expand ESG literacy and reporting capabilities. Extending BRSR's reach into non-engineering sectors and leveraging India's IT expertise can catalyze systemic transformation across the corporate ecosystem. Ultimately, the ESG debt model—supported by robust data, predictive analytics, and global benchmarking—can serve as a cornerstone for India's low-carbon transition. If integrated effectively, it has the potential to align financial interests with environmental goals, positioning India not only to meet its net-zero commitment but also to emerge as a global leader in sustainable industrial growth.

6.2 Implications

From the principle that net-zero emissions require annual emission reductions at a consistent and substantial rate, and observing that India's emissions need to decline by approximately 30.06% annually to meet net-zero by 2070, it logically follows that India's current reduction pace (1% in FY24) is grossly inadequate. This deduction is strengthened by empirical data showing that 37.5% of heavy engineering companies either increased emissions or made no reductions, and that renewable energy usage is at just 1% of total energy consumption in these sectors. Similarly, based on the assumption that emissions are directly tied to energy supply (correlation of 0.991) and energy supply is strongly correlated with GDP growth (0.984), it follows that unless energy decouples from fossil fuel use, economic growth will continue to drive up emissions. Therefore, without a radical shift in energy mix, India cannot achieve the net-zero objective. Further, using deductive reasoning from global precedents and carbon budgeting (as per Ritchie et al. 2023), we can infer that India must accelerate its emissions reduction before 2040 to prevent unsustainable temperature rise. The S-curve or early action trajectory would be more feasible than the linear or delayed pathways, requiring front-loaded policy and technology interventions.

From the observed performance of 64 heavy engineering companies—where only 34% showed significant reductions and 23% moderate—it can be induced that industry-wide compliance is inconsistent and sporadic, primarily due to lack of policy enforcement, weak incentives, and minimal renewable integration. Furthermore, it is observed that emissions tend to rise with turnover, suggesting a pattern of emissions-intensified economic activity, particularly in sectors like power generation, cement, and petroleum. Analyzing non-engineering sectors shows higher adoption of renewables (73%) but no corresponding emissions drop, indicating that renewable adoption alone does not guarantee emissions reduction unless paired with systemic efficiency improvements and carbon accounting transparency. This induces the need for sector-specific pathways—enforcing earlier net-zero deadlines for non-engineering sectors and longer but stricter targets for heavy engineering.

On a national scale, historical trends from 1850–2022 and projections to 2050 suggest a consistent emissions surge, especially post-liberalization, and even post-COVID recovery has intensified emissions. Therefore, past and current patterns inductively imply that India will not achieve net-zero by 2070 without policy overhaul, aggressive renewable targets (15–20% annual growth), carbon pricing, and international cooperation on technology transfer and finance. A combination of deductive projections and inductive trends clearly suggest that India's current trajectory is misaligned with its 2070 net-zero target. Achieving this goal will require structural transformation in industrial energy use, rigorous enforcement, front-loaded climate action, and holistic economic realignment toward sustainability. Based on both inductive and deductive reasoning, it is evident that the data provided through the Business Responsibility and Sustainability Report (BRSR) can be effectively leveraged to construct an empirical model for calculating a company's ESG (Environmental, Social, and Governance) debt.

The Inductive analysis of reported BRSR data across companies shows patterns in environmental disclosures, social initiatives, and governance practices that allow for the quantification of ESG-related liabilities. Patterns such as excess CO_2 emissions relative to government caps, qualitative governance disclosures (e.g., third-party audits), and employee-led sustainability initiatives provide consistent, repeatable indicators that can be translated into measurable variables. Observations from this data support the formulation of ESG debt as a composite score, integrating environmental, social, and governance factors—each with clear indicators and weightages. Deductively, the theoretical framework for ESG debt is constructed using established environmental economics principles, such as the social cost of carbon (SCC), carbon pricing, and emissions trading schemes. For example, Equation for cess payment towards social cost of carbon integrates internationally accepted SCC benchmarks and catastrophe-related compensations, thus aligning the model with macroeconomic and policy-level parameters. Furthermore, governance and social debt estimations are anchored in regulatory compliance and measurable impacts, reinforcing the logical validity of the model structure. Hence, by combining empirical observations (induction) with structured theoretical frameworks (deduction), the study confirms that BRSR data, when standardized and complemented by appropriate carbon market pricing and emissions tracking mechanisms, can indeed form the basis for a robust and scalable empirical model to compute ESG debt. This also lays the groundwork for future ESG-linked financial instruments and policy enforcements.

The annual tracking of ESG debt presents a compelling approach to assess the financial efficacy of ESG frameworks adopted by businesses. The empirical evidence from businesses shows that tracking ESG debt—specifically emissions and energy usage—provides measurable insight into how sustainability strategies affect cost structures, risk exposure, and revenue generation. Observations of companies that have invested in renewable energy, adopted automation, and implemented ESG-aligned practices reveal patterns of reduced operational costs, improved market reputation, and increased investor interest. These recurring outcomes establish the utility of ESG debt as a quantifiable approach for sustainability linked financial performance. The model evaluates financial efficacy by logically linking ESG initiatives to economic outcomes through defined mechanisms: (1) cost avoidance from reduced fossil fuel dependence, (2) penalty mitigation via regulatory compliance, (3) long-term value through enhanced resilience, and (4) revenue growth from alignment with socially conscious markets. The principle that lower emissions result in reduced ESG debt—which in turn translates to improved financial health—is supported by frameworks such as the Paris Agreement and Sustainable Development Goals (SDGs). These provide normative benchmarks to assess ESG alignment and debt performance. Thus, combining observable trends (induction) with normative frameworks (deduction), ESG debt emerges as a dynamic indicator of how effectively a company integrates sustainability into its financial strategy. Benchmarking tools, real-time monitoring systems, and predictive analytics further strengthen the framework, ensuring robust data accuracy and enabling strategic adjustments that enhance financial performance while meeting environmental obligations.

The increasing frequency and severity of climate events in India, as recorded in 2024, correlate with rising emissions, indicating a pattern where excess carbon output directly contributes to environmental and social harm. Empirical evidence, such as fatalities and economic losses due to extreme weather, supports the inference that corporate emissions bear quantifiable societal costs. Observing that ESG debt grows with increased emissions, it becomes rational to convert these environmental liabilities into financial terms. The carbon pricing grounded in SCC ensures companies internalize the full social and environmental costs of their emissions. The principle that higher emissions equate to higher societal costs justifies using SCC to calculate ESG debt. By aligning carbon prices with SCC values, businesses are economically incentivized to mitigate emissions, promoting sustainability. Innovative instruments like Karma tokens and carbon markets offer practical frameworks for carbon trade and offsetting in India. When combined with enforceable CSR contributions and lifestyle shifts advocated by initiatives like LiFE, a holistic, multi-tiered strategy for climate responsibility emerges—

balancing corporate accountability, individual behavior, and regulatory enforcement in achieving a low-carbon economy.

Inductive inference based on the diverse financial instruments emerging globally and in India—such as green bonds, ESG-linked loans, transition bonds, and carbon trading—it is observed that markets increasingly reward sustainable behavior. Empirical patterns show that companies adopting ESG-linked financial strategies attract favorable investor interest and reduced capital costs. The growth in renewable energy ETFs and success of schemes like India's PAT scheme reinforce that financial structuring can effectively drive emissions reduction and sustainability goals. However, low adoption despite available incentives suggests a systemic gap in awareness and enforcement. Deductively, if ESG debt represents the liability incurred due to unsustainable operations, then logically, any financial restructuring aimed at reducing this debt must align capital flow with sustainability performance. Instruments like sustainability-linked loans and transition bonds can raise capital for combating emissions.

6.3 Recommendations for Future Research

The primary goals of this study were to forecast India's emissions trajectory by baselining the current emissions from the country's top 100 listed companies, identify a net-zero pathway for India, evaluate the empirical model for calculating ESG debt, evaluate a company's financial performance based on its ESG debt, determine an effective carbon pricing strategy based on ESG debt, compute karma tokens required to offset ESG debt, and how to apply these research's lessons to all Indian companies. The following research areas are recommended for future research based on the limitations of this study.

1. Expansion to small- and medium-scale engineering companies including unlisted companies: Future studies should examine the ESG debt burden and financial restructuring options specific to small- and medium-scale engineering-based enterprises (SMEs), which form the backbone of India's manufacturing sector. These businesses often lack access to green finance or ESG-linked instruments due to awareness gaps, resource constraints, or limited regulatory push. Research should identify tailored financial models and government-backed incentives to facilitate ESG integration at the SME level.

2. Scope 3 emissions accounting: Future research must incorporate the assessment of Scope 3 emissions—indirect emissions from a company's supply chain and product use. This is crucial for sectors like engineering and manufacturing, where upstream and downstream emissions can surpass direct (Scope 1 and 2) emissions. Methodologies for mapping, quantifying, and integrating Scope 3 emissions into ESG debt calculations must be developed and standardized.

3. Accuracy of emissions monitoring systems: Research is required to evaluate the accuracy, transparency, and interoperability of current emissions monitoring systems in India. The effectiveness of carbon pricing and trading relies heavily on reliable data. Future studies should explore the application of digital technologies like AI, robotics, IoT, and blockchain for real-time, verifiable emissions tracking.

4. Drivers for emissions accountability (Corporate and Individual): Further research should explore behavioral, regulatory, and economic drivers that encourage accountability at both corporate and individual levels. This includes consumer-based carbon taxes, employee engagement in sustainability, and public awareness campaigns under programs like LiFE. Understanding motivation structures can help frame policies that are both enforceable and ethically grounded.

5. Gaps in enforcement policies: Despite policy availability, enforcement of emissions regulations in India remains weak. Research must focus on identifying institutional, administrative, and legal barriers that hinder effective implementation. Comparative studies with successful international enforcement mechanisms can provide guidance for reforms in monitoring, compliance, and penalty frameworks.

6. Effectiveness of the Carbon Credit Trading Scheme (CCTS): At the time of this research, CCTS is not operational in India. Future work should critically assess the efficacy of India's CCTS in terms of emissions reductions, industry participation, and market efficiency. The research should explore whether the CCTS can evolve into a robust market mechanism that supports a socially acceptable carbon tax. The balance between environmental outcomes and economic competitiveness must be quantified to recommend policy thresholds that maintain growth while driving decarbonization.

7. Future research should explore frameworks for channeling Corporate Social Responsibility (CSR) funds into decentralized renewable energy projects, such as solar microgrids and clean cooking solutions in underserved regions (Kritisrivastava. 2024). This would align CSR mandates with national sustainability goals, ensuring measurable climate impact while enhancing energy access and equity. Policy mechanisms for transparent fund allocation and public-private collaboration should also be examined.

6.4 Conclusion

India's pursuit of net-zero emissions by 2070 while maintaining economic growth stands as one of the most critical challenges and opportunities of this century. The analysis presented in this research, grounded in both inductive observations and deductive logic, reveals that the current trajectory—marked by slow emissions reduction, low renewable energy adoption in heavy industries, and inadequate policy enforcement—is misaligned with the nation's long-term climate objectives. High emissions from engineering-intensive sectors, as highlighted through Business Responsibility and Sustainability Report (BRSR) data, present a significant bottleneck to sustainable growth, especially when compared to the more promising trends in non-engineering sectors.

The integration of ESG (Environmental, Social, and Governance) debt as a conceptual and operational tool offers a transformative way to quantify and manage sustainability liabilities. By tying ESG debt to carbon pricing metrics such as the Social Cost of Carbon (SCC), companies are economically incentivized to reduce emissions and invest in green transitions. This approach facilitates transparency and accountability, allowing stakeholders to monitor sustainability performance with greater precision. Empirical patterns—such as improved investor sentiment, operational efficiency, and market positioning for companies with ESG-linked strategies—validate the model's relevance to both financial planning and environmental accountability.

Furthermore, the development of financial instruments like green bonds, ESG-linked loans, and carbon credits creates an enabling ecosystem for aligning capital allocation with sustainability outcomes. While these mechanisms show significant potential, their adoption remains limited due to gaps in awareness, regulatory enforcement, and technical capacity. To bridge these gaps, policy interventions must be paired with widespread ESG literacy programs, capacity-building initiatives for small and medium enterprises, and robust technological frameworks for emissions monitoring.

The research also identifies critical trends through deductive reasoning—such as the urgent need to decouple energy consumption from GDP growth and the infeasibility of meeting climate targets without front-loaded policy interventions. Sector-specific pathways are recommended: heavy engineering sectors must be subjected to stricter, longer-term decarbonization mandates, while non-engineering sectors should adopt early net-zero deadlines paired with efficiency and transparency enhancements.

From a systems perspective, the ESG debt model presents an innovative and scalable tool to institutionalize sustainability across corporate India. It encourages annual tracking of environmental liabilities, fosters accountability through market mechanisms, and supports informed policy-making by offering measurable, comparable data points. This model, supported by technologies like AI, blockchain, and real-time emissions tracking, can evolve into a standardized benchmark for corporate sustainability, influencing financial strategy and regulatory compliance alike.

In conclusion, India's climate journey demands a coordinated transformation across policy, finance, technology, and corporate behavior wherein all emissions related actions are measured, recorded, analyzed and accounted using karma tokens. The path to net-zero is not only about emissions reduction—it is about redefining economic growth through sustainability. By leveraging ESG debt as a financial, operational, and moral metric, India can realign its industrial trajectory with global climate goals, balancing development with responsibility. This integrated framework offers a pragmatic yet visionary approach—one that turns sustainability from a regulatory obligation into a strategic advantage, and climate action from a challenge into an opportunity for inclusive, resilient, and equitable growth.

APPENDIX A: INFORMED CONSENT

You are invited to participate in an interview as part of a research study assessing employees' awareness of energy and emissions policies within the company. The purpose of this study is to understand how corporate sustainability initiatives are communicated and implemented in the workplace. Your participation in this study is **completely voluntary**, and all information shared during the interview will be treated with **strict confidentiality**. Your responses will be **anonymized** in research reports, ensuring that no personally identifiable information is disclosed. All interview recordings, transcripts, and related materials will be securely stored and accessible only to authorized research personnel. You may choose to participate or decline without any consequences. You also have the right to **withdraw your consent** at any point during the interview or after completion, without providing any justification. If you withdraw, all collected data related to your participation will be permanently deleted. With your consent, this interview will be **electronically recorded** for accuracy and research purposes. The recordings will only be used for analysis and will not be shared outside the research team.

For any concerns or questions regarding this study, please contact:

Researcher: Namitha Jeremiah

Organization: Swiss School of Business Management

By signing below, you acknowledge that you have read and understood this consent form and voluntarily agreed to participate in the interview and you understand your right to withdraw at any time.

Participant Name: ____

Signature: ___________________________

Date: ____________

APPENDIX B: INTERVIEW GUIDE

The interview guide used for qualitative assessment in given in the table below:

Sl. No	Questions
General Policy Framework	
1	What is the company's overarching policy on energy efficiency and emissions reduction?
2	How does the organization align its emissions policies with regulatory requirements and global standards?
3	Are there dedicated teams or roles responsible for implementing and monitoring energy and emissions policies?
Energy Utilization Policies	
4	How is energy consumption tracked across your company's operations (e.g., data centers, offices)?
5	Does the company have specific goals for reducing energy use? If yes, what are they and how are they set?
6	What renewable energy sources, if any, are integrated into your energy mix?
7	How often are energy utilization audits conducted, and how are the findings implemented?
8	Are employees given training or awareness programs on energy-saving measures?
9	Has the company invested in energy-efficient technologies (e.g., low-power servers, LED lighting)?
Emissions Inventory	
10	Does the company have an official greenhouse gas inventory? If yes, what scopes (1, 2, 3) are covered?
11	How are emissions from the supply chain (Scope 3) calculated and addressed?
31	How are Scope 1, Scope 2, and Scope 3 emissions tracked in your company? What challenges do you face in measuring each?

Sl. No	Questions
Implementation Strategies	
14	How are emissions and energy reduction targets communicated within the organization?
15	What metrics or KPIs are used to evaluate the success of your energy and emissions policies?
16	Are there any challenges faced in policy implementation, and how are they addressed?
17	What role does technology, such as IoT or AI, play in supporting the implementation of these policies?
Net-Zero Target	
18	Does your company have a net-zero target? If yes, by when is it expected to be achieved?
19	What steps have been taken to create a roadmap toward achieving net-zero?
20	How does the company engage with stakeholders (e.g., suppliers, customers) to align with its net-zero goals?
21	Are there any interim milestones set before reaching the net-zero target?
Reporting and Verification	
22	How is data on energy usage and emissions verified for accuracy and reliability?
23	What frameworks or standards (e.g., GHG Protocol, CDP) are used for reporting emissions data?
24	Are the company's policies and progress externally audited? If yes, how often?
25	How does the company maintain transparency with investors and the public regarding its energy and emissions performance?
Energy Utilization	

Sl. No	Questions
26	What percentage of your company's energy consumption comes from renewable sources?
27	Are energy audits conducted across operations? If so, what key findings have led to measurable improvements?
28	How are energy consumption trends analyzed, and how does this influence operational decisions?
29	Have you implemented energy-efficient technologies? Can you share examples and their impact on usage patterns?
30	Are there programs to encourage employees to adopt energy-efficient practices at the workplace (e.g., remote work energy savings)?
Emissions Reduction Policies	
31	How are Scope 1, Scope 2, and Scope 3 emissions tracked in your company? What challenges do you face in measuring each?
32	Are emissions-reduction targets broken down into short-term and long-term goals? How do they align with operational growth?
12	What strategies are in place to reduce direct emissions (e.g., fuel use in company-owned vehicles)?
13	How is the company working to offset emissions that cannot be reduced?
33	What strategies are employed to reduce emissions related to IT infrastructure, such as data centers?
34	Does the company engage suppliers or partners to reduce their emissions as part of the overall strategy?
Future Plans	
35	What future innovations or initiatives is the company exploring to further reduce its environmental footprint?
36	What in your view can help achieve net-zero for your company

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