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Fossil Taxes Funding India's Decarbonisation

An Impact Analysis

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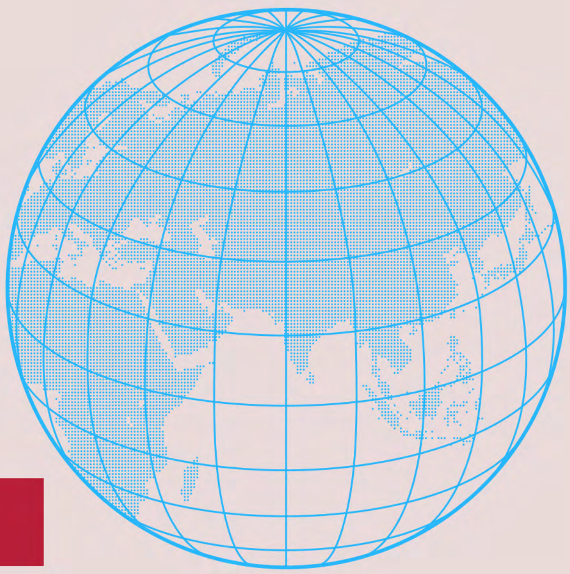

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Abbreviations

AIDF	Agriculture Infrastructure and Development Fund
AS	Appendix Scenario
BAU	Business-as-usual
BATs	Best Available Technologies
BF-BOF	Blast furnace–basic oxygen furnace
Capex	Capital Expenditure
CCS	Carbon Capture and Storage
CCTS	Carbon Credit Trading Scheme
CCU	Carbon Capture and Utilisation
CEA	Central Electricity Authority
CEC	Clean Environment Cess
CIL	Coal India Limited
CO_2	Carbon Dioxide
Coal DRI-EAF	Coal-based direct reduction of iron-electric arc furnace
Coal DRI-IF	Coal-based direct reduction of iron-induction furnace
COP	Conference of the Parties
CPP	Captive Power Plant
CRIF	Central Road and Infrastructure Fund
DMF	District Mineral Foundation
EE	Energy Efficiency
ESAM	Environmentally-extended Social Accounting Matrix
FY	Financial Year
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GST	Goods and Services Tax
GVA	Gross Value Added
GW	Gigawatt
HH	Households
HSD	High-speed diesel
HTA	Hard-to-abate
I-O Model	Input–Output Model
IPPU	Industrial processes and product use
ISTS	Inter-State Transmission System
MoEFCC	Ministry of Environment, Forest and Climate Change
MoS	Ministry of Steel
NDCs	Nationally Determined Contributions
NMET	National Mineral Exploration Trust
ONG	Oil and Natural gas
Opex	Operating Expenditure
PPAC	Petroleum Planning & Analysis Cell
RE	Renewable Energy
S1	Scenario 1
S2	Scenario 2
S3	Scenario 3
SAED	Special Additional Excise Duty
TPD	Tonnes Per Day
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value-added tax

Executive Summary

Context and Objectives

India faces a dual challenge: sustaining economic growth while meeting ambitious climate goals. With **updated Nationally Determined Contributions (NDCs)** and a **2070 Net-Zero pledge**, the country must mobilise significant **domestic climate finance**. Fossil fuel taxation may emerge as an important policy tool.

The fossil taxes contribute approximately one-third to the indirect tax revenue collections in India. Given the significant amount of revenues generated by taxes/duties on fossil fuels, and India's massive need for climate finance, some of these revenues may emerge as an important source of domestic climate finance.

This study asks: What if India redirected some part of fossil fuel taxes back into decarbonisation investments? Specifically, it examines funding energy-efficiency technologies in **hard-to-abate (HTA) sectors**, i.e., cement, iron and steel, aluminium, and building **renewable energy (RE) transmission systems** to meet the 500 gigawatt (GW) non-fossil-fuel-based energy target by 2030.

Objectives of the study:

1. Estimate the investment requirements for industrial decarbonisation and renewable power infrastructure.
2. Assess economic, environmental, and social impacts of redirecting fossil fuel-based tax revenues into green uses.

Methodology

The study uses an **Environmentally-extended Social Accounting Matrix (ESAM)** for 2019–2020, covering **45 economic sectors** (including HTA industries, thermal power, and renewables) and **318 labour categories**. This model captures how investments in one area ripple through the economy, affecting production, emissions, and household incomes.

Three scenarios are modelled:

- **Scenario 1 (S1)—Energy Efficiency (EE):** All funds invested in EE technologies in HTA sectors.
- **Scenario 2 (S2)—RE:** All funds invested in RE transmission systems.
- **Scenario 3 (S3)—Combined:** Funds split between EE and RE transmission.

Impacts on Gross Value Added (GVA), Gross Domestic Product (GDP), emissions intensity, and household income distribution are compared with baseline outcomes.

Revenues and Investment Requirements

Revenue Availability:

- To finance both EE technologies in the HTA sectors and the RE transmission system, around ₹75,166 crore annually is required.
- In light of the recent Goods and Services Tax (GST) 2.0 reforms (September 2025), which discontinued the Compensation Cess, the excess revenue collection from the increased GST rate on coal is estimated at ₹16,949 crore (based on Financial Year (FY) 2023–2024 figures).
- Finance from oil and gas taxes: approximately ₹58,217 crore (8.7% of collections).

Investment Needs:

- **EE in HTA sectors:** As per existing studies, approximately **₹1.32 lakh crore** of cumulative capital expenditure (Capex) is required (Iron and steel: ₹76,479 crore; Aluminium: ₹32,499 crore; Cement: ₹22,650 crore).[1]
- **Renewable transmission system:** As per Central Electricity Authority (CEA) (2022) Capex of around **₹2.44 lakh crore**[2] by 2030.

Observation: The redirected funds could finance a substantial portion of HTA efficiency upgrades or accelerate renewable grid expansion, but fall short of total requirements.

[1] Equivalent to 0.49% of India's FY 2022–2023 GDP (approximately US$ 16.35 billion). The sector-wise breakdown is: iron and steel (0.28%), aluminium (0.12%), and cement (0.08%). Calculations are based on a nominal GDP of ₹269.5 lakh crore, and an average exchange rate of ₹80.51/US$.

[2] Equivalent to 0.91% of India's FY 2022–2023 GDP (approximately US$ 30.33 billion).

Results

Economic Impacts

- All scenarios **boost GDP, GVA, and output** by stimulating demand for machinery, construction, and services.
- **S2 (RE investments)** delivers the **highest GDP growth**, followed by S3 and then S1.
- This is driven by the high spillover effects in S2, followed by S3 and S1 in sectors like **construction, machinery, agriculture, food and beverages, and services** (accounting for around 60% of production activity).
- Using existing taxes (rather than new levies or debt) makes this a fiscally neutral green growth strategy.

Environmental Impacts

- **S2** yields the **largest decline in emissions intensity**, which is largely because almost 40% of emissions in the country are from electricity production and redirecting funds could **reduce the grid's emissions factor.**
- **S1** reduces emissions in the HTA sectors through lower energy use, but with narrower system-wide benefits.
- **S3** balances both approaches, with a decline in emission intensity lower than S2, but higher than in S1.

Social and Distributional Impacts

- Household incomes **rise in all scenarios** due to job creation and higher factor demand.
- **S2** is the most equitable for:
  - **Rural households:** Lower-income quintiles gain relatively more, showing a **progressive impact**.
  - **Urban households:** Only S2 shows progressive results; S1 and S3 display mild regressivity (benefits tilt toward higher-income groups).
- In summary, **S2 achieves a "triple dividend": growth, emissions reduction, and social equity.**

Conclusion

Redirecting some fossil fuel taxes represents a **strategic opportunity** for India, as these funds could:

- **Finance green investments** in HTA sectors and RE infrastructure.
- **Boost GDP and employment**, creating a green growth trajectory.
- **Cut emissions intensity**, advancing India toward its NDC and Net-Zero targets.
- **Improve social equity**, particularly in rural households, when invested in RE systems.

The study demonstrates that this reallocation can generate a **triple dividend**, i.e., economic, environmental, and social, aligning fiscal policy with the nation's climate commitments and sustainable development goals.

Policy Recommendations

- **Leverage fossil fuel tax revenues:**
  - Allocate additional GST collected from replacing the GST compensation cess on coal with an increased GST rate toward financing the decarbonisation measures
  - Allocate part of **Special Additional Excise Duty (SAED)** and **Road & Infrastructure Cess** (on petrol and diesel) toward climate finance.
  - These levies already generate large revenues; earmarking a small share avoids introducing new taxes.
- **Prioritise RE infrastructure:**
  - Evidence from S2 shows **grid investment yields the highest economic, environmental, and social returns**.
  - Building RE transmission enables scaling up to 500 GW of non-fossil energy capacity by 2030.
- **Ensure transparency and accountability:**
  - Revive or establish a **dedicated Clean Energy Fund** with strict reporting on collections, disbursements, and project outcomes.
  - Prevent underutilisation of funds, which plagued the original Clean Environment Cess (CEC), where over 60% of collections remained unused.

Qualification and Future Research

- **Static Analysis:** ESAM framework provides a comparative static analysis, capturing immediate structural dependencies and not dynamic adjustment paths.
- **Future Research:** Incorporate dynamic modelling and expand beyond fossil fuel tax revenue reallocation to explore broader fiscal mechanisms for decarbonisation.

1. Introduction

Successive Conference of the Parties (COP) meetings to the United Nations Framework Convention on Climate Change (UNFCCC) have highlighted the need for generating finances, especially for developing countries, to fight the challenges faced by climate change. The developed countries have set the funding requirements at US$100 billion per year at the 15th COP (COP 15) to UNFCCC held in Copenhagen in 2009. This funding was promised for six years, beginning in 2020 and ending in 2025. But the developed world has so far fallen short of its commitment. This commitment has been tripled in the COP 29 to US$300 billion per year, which is considered abysmally low by several developing countries. Further, developing countries such as India have been investing in moving away from fossil fuels as a source of energy. A recent assessment of India's climate finance requirements underscores the need to scale up investment across key sectors to decarbonise the Indian economy (Raj & Mohan, 2025). Consequently, meeting the NDCs and Net-Zero targets by India will require generating its domestic climate finance resources and channelling them toward meeting these goals. Since carbon pricing is an important mechanism through which this can be done, it is imperative to explore the distributional consequences of such instruments. While this mobilisation can be supported partially[3] by emerging mechanisms like the Carbon Credit Trading Scheme (CCTS) or the rationalisation of fossil fuel subsidies, taxes on fossil fuels like coal, oil, and natural gas offer a viable immediate strategy to generate such resources while incentivising emissions reduction, thereby aligning with the polluter pays principle. In India's context, the distributional consequences become imperative because of its vast population, 40% of which is the youth, and the existing diversity within its masses could lead to varying implications.

India's emissions profile underscores the urgency of decarbonising some of the major carbon-emitting sectors. As per the Ministry of Environment, Forest and Climate Change (MoEFCC), electricity and HTA sectors, such as iron and steel, aluminium, and cement, accounted for more than half of the country's greenhouse gas (GHG) emissions in 2020, with electricity alone contributing nearly 40% (MoEFCC, 2024). Decarbonising these HTA sectors requires the adoption of EE technologies, RE integration, and carbon management measures, whereas decarbonising the electricity sector requires transitioning from fossil fuel-based electricity to RE sources. These measures, however, require significant investments. Given the nature of the fossil fuel taxes, which place a price on polluting energy sources and contribute significantly to India's tax revenues, proceeds from these may be utilised to adopt these decarbonisation measures. However, doing so would have its own implications. The socio-economic implications of utilising fossil fuel taxes for these purposes remain underexplored. This study investigates how redirecting these revenues can support technological advancements in HTA sectors and RE infrastructure, impacting the economy. The objectives of this study are twofold: first, to identify technological improvements for HTA sectors; and second, to simulate the economic, environmental, and social impacts of investing these funds in promoting EE technologies and RE.

With the GST Compensation Cess discontinued in 2026, redirecting fossil fuel tax revenues, including the GST on coal, offers a strategic opportunity to fund India's NDCs. Revenues collected from taxes on oil and natural gas (ONG) are substantially high, as they alone account for approximately one-third of India's indirect tax revenues, and with the increased GST rate on coal, tax revenues from coal are also expected to increase. Since these revenues are shared between the Centre and States, redirecting these revenues would ensure participation of both the Central and State governments in these decarbonisation measures. The public sector's support in decarbonisation is important as the three industry sectors considered in this study are hard-to-abate and thus need significant investments for decarbonisation. Micro, Small and Medium Enterprises (MSMEs) in particular are more emission-intensive and often lack resources to adopt cleaner technologies on their own. Public investment can help these businesses reduce emissions. Additionally, GHG emissions represent a classic negative externality, efficient correction of which requires government intervention through fiscal and regulatory measures, making such revenue reallocation both economically and environmentally justified.

[3] CCTS will take time to mature and mobilise resources from the auctioning of the permits, as there are associated with political economy concerns.

The paper is structured as follows: Section 2 reviews major environmentally related taxes on fossil fuels in India. Section 3 details the costs of financing some of the decarbonisation measures for the HTA sectors and electricity. Section 4 discusses the data and methods employed, followed by the three scenarios focused on in this study. The results and analysis are presented in Section 5, with the conclusion and policy recommendations in Section 6.

2. Environmentally Related Taxes on Fossils in India

Fossil fuels, including coal, oil, and natural gas, are primary sources of GHG emissions in India. In 2020, emissions associated with fossil fuel combustion by the energy sector[4] and fugitive emissions accounted for around 75% of total emissions in the country (MoEFCC, 2024). Countries often levy taxes on fossil fuels, which serve a dual purpose: generating substantial government revenue and incentivising emissions reductions by increasing the cost of carbon-intensive activities. As per the OECD (2001), taxes on energy products, such as fossil fuels, can yield environmental benefits similar to those designed to combat carbon dioxide (CO_2) emissions, provided they induce comparable price changes. Hence, India's fossil fuel taxes can be classified as environmentally related taxes, which are often defined as "any compulsory, unrequited payment to general government levied on tax bases deemed to be of particular environmental relevance." India's taxation framework for fossil fuels comprises a mix of Union and State levies. Some of these key taxes are GST, excise duties, value-added tax (VAT), customs duties, royalties, and various cesses, contributing significantly to the government's revenues. In this section, we will explore the CEC on coal and taxes on ONG to comprehend the possible issues with these taxes/cesses.

2.1 Taxes on Coal

Levies on coal in India include GST, royalties, National Mineral Exploration Trust (NMET), District Mineral Foundation (DMF), GST compensation cess, sales tax, and others. Of these, the GST compensation cess is the largest contributor. As of 2023–2024, it accounted for half of the total revenues collected from taxes and royalties on coal alone (as in Table 1). However, with the latest GST reforms, GST 2.0, in September 2025, GST Compensation Cess on coal has been discontinued, and GST is expected to emerge as the largest contributor to coal-related tax revenues, with its rate on coal increased from 5% to 18% as part of a broader GST rate rationalisation. Column A of Table 1 presents the total taxes and duties paid by Coal India Limited (CIL) and its subsidiaries in 2024–2025, while Column C shows the amounts that would have been paid if GST 2.0 had been in effect that year. Based on these estimates, the share of GST in total tax and duty revenues would have risen from 8% to 39% in 2024–2025. Thus, under GST 2.0, even though the GST Compensation Cess on coal would yield zero revenue, a substantial share of revenue would instead be generated through GST. Here, CIL and its subsidiaries are taken as representatives of the coal industry, as they account for around three-fourths of national coal off-take, defined as the total quantity leaving the mines for consumption over a given period.

[4] Comprises of energy industries, manufacturing industries and construction, transport, and other sectors.

Table 1: Taxes and Duties Paid by CIL and Subsidiaries vis-à-vis Estimated Payments Under GST 2.0 for the Year 2024–2025

Tax/Duties Paid by CIL and Subsidiaries in 2024–2025	Actual Collection		Estimated Collection Under GST 2.0	
	₹ crore	Share (%)	₹ crore	Share (%)
	A	B	C	D
Royalty	15359.2	25.2	15359.2	36.2
DMF	4623.4	7.6	4623.4	10.9
NMET	308.3	0.5	308.3	0.7
Central Goods and Services Tax (CGST)	2113.4	3.5	7608.2	17.9
State Goods and Services Tax (SGST)	2107.7	3.5	7587.7	17.9
Integrated Goods and Services Tax (IGST)	331.6	0.5	1193.8	2.8
GST Compensation Cess	30409.9	49.8	0.0	0.0
Cess on coal	2107.2	3.5	2107.2	5.0
Central Sales Tax	0.3	0.0	0.3	0.0
State Sales Tax/ VAT	0.5	0.0	0.5	0.0
Others	3652.7	6.0	3652.7	8.6
Total	**61014.2**	**100.0**	**42441.3**	**100.0**

Note: Cess on Coal is the State-level cess that is levied by the Government of West Bengal. Since this is not part of the GST compensation cess, it would prevail even under GST 2.0.

Source: CIL (2025) and authors' computations.

In India, different grades of coal are used for different purposes, with coal grade (or quality) determined primarily by its carbon content. The higher the carbon content, the better the grade, and the higher the grade, the higher the price of coal. High-grade coal is mainly used in steelmaking, while lower-grade coal is typically consumed in thermal power plants. An arithmetic comparison shows that if we consider the price of coal to be ₹3,100 per tonne or above, the tax burden under GST 2.0 would be higher than under the earlier GST regime. For example, when the price of coal is ₹3,100 per tonne, the total tax under the earlier GST structure (5% GST plus a compensation cess of ₹400/tonne) amounts to ₹555/tonne (₹155 + ₹400). Under GST 2.0, with the GST rate of 18%, the tax increases to ₹558/tonne, which is slightly higher than the tax under the earlier regime. This suggests that for coal grades priced above ₹3,100 per tonne, GST 2.0 provides the government with an opportunity to generate relatively higher tax revenue compared to the previous system, while resulting in lower revenue otherwise.

2.2 Taxes on Oil and Natural Gas

Levies on ONG in India comprise central excise duties, customs duties, sales tax/ VAT, GST on certain products, octroi, cess on crude oil, royalty, entry tax, and others. These instruments collectively form a significant part of fiscal revenue, with petroleum products remaining largely outside the GST framework to preserve State autonomy over key income sources. Among these, central excise duty and state-imposed VAT emerge as the major contributors, accounting for around 85% of total revenues generated from such levies on ONG (PPAC, 2025).

Union excise duty on petroleum products is structured into four components, including basic excise duty, SAED, agriculture infrastructure and development cess, and additional excise duty, also known as road and infrastructure cess (Table 2). The basic excise duty forms part of the divisible pool of central taxes, enabling sharing between the Union and States under the devolution framework. The other three components are levied on petrol and high-speed diesel (HSD) only. The SAED was introduced as a surcharge on petrol and HSD and constitutes the largest share of excise revenues. These revenues, however, are not earmarked for specific purposes but are directed to the Consolidated Fund of India for general budgetary allocation. The proceeds from agriculture infrastructure and development cess are earmarked to finance agricultural infrastructure and development expenditures, with revenues channelled to the dedicated Agriculture Infrastructure and Development Fund (AIDF). Similarly, the additional excise duty (road and infrastructure cess) intends to support infrastructure projects, with proceeds credited to the Central Road and Infrastructure Fund (CRIF).

Table 2: Excise Duty on Oil and Natural Gas

Excise Duty	2022–2023 (₹ crore)	2023–2024 (₹ crore)
Basic Excise Duty	32,327.2	33,786.9
Special Additional Excise Duty	1,47,163.8	1,46,619.6
Agriculture infrastructure and development cess	51,009.2	53,778.1
Additional excise duty (road and infrastructure cess)	59,232.4	44,549.5

Source: Receipt Budget, Ministry of Finance (2024, 2025).

The utilisation of some of these excise components offers scope for targeted environmental interventions. As stipulated in Article 206 of the Finance Act, 2018 (amendment of Act 54 of 2000), the additional duties of customs and excise on petrol and HSD are to be transferred to the CRIF, which is mandated for the development and maintenance of national highways, railway projects, safety enhancements in railways, state and rural roads, and broader infrastructure initiatives. Eligible infrastructure categories under CRIF include transport, energy, water and sanitation, communication, and social and commercial sectors, thereby permitting allocations to energy-related projects. Given that energy infrastructure falls within CRIF's purview, a part of these resources may be utilised to support RE initiatives. However, in the recent past, the budgetary allocations made to the CRIF are mainly for road infrastructure projects and not for energy-related infrastructure projects (Table 3), underscoring the need to prioritise investments for energy infrastructure as well. Similarly, the SAED revenues are not earmarked and comprise the bulk of excise collections, which may also present an opportunity to allocate some funds toward environmental measures, without necessitating any new levies.

Table 3: Budgetary Allocations Made to the Central Road and Infrastructure Fund in 2023–2024

Budgetary Allocations to CRIF	Actuals in 2023–2024 (₹ crore)
National Highways Authority of India	2,400
Road Works	20,129
Pradhan Mantri Gram Sadak Yojna	13,969
Research, Training, Studies and Other Road Safety Schemes—Road Transport and Safety	279
Central Sector Schemes/ Projects	11,000

Source: Expenditure Budget for year 2025–2026, Ministry of Finance (2025).

On the State side, VAT or sales tax on petroleum products remains an important source of States' revenue. It is levied autonomously by the States, with rates varying across jurisdictions, and sometimes they are supplemented by state-specific cesses or surcharges for purposes like road development or social security. Except for the specific cesses, these revenues are not earmarked and are transferred to State budgets. In a nutshell, some portion of SAED and CRIF could be used for financing the energy transition in India. Another possible way of mobilising revenues for decarbonisation can be by reclassifying a portion of fossil fuel taxes as a carbon tax, as has been approved by the Thai Cabinet in January 2025 (Reuters, 2025), (refer to Box A for more information) and mandating these revenues for environmental purposes, ensuring a dedicated funding stream. In the following section, we will comprehend the estimates available for decarbonising the HTA sectors and the electricity sectors in India.

Box A: The Thai Cabinet Approved to Levy a Carbon Tax on Oil

In July 2024, the Excise Department of Thailand proposed to levy a carbon tax on oil to boost industries and all other relevant sectors to pay more attention towards environmental concerns. This proposal ensured that the proposed carbon tax would not have any additional impact on the public and would be inserted into the oil excise tax (MNRE Thailand, 2024). In January 2025, the Thai cabinet approved a carbon tax of 200 baht (US$ 5.88) per tonne of carbon emissions, which is not a new levy but embedded within existing oil taxes. While it will change the internal structure of the excise tax on oil, it will not affect the retail prices (Reuters, 2025).

3. Cost of Financing Decarbonisation

The electricity generation, industrial, and construction sectors in India play a significant role in the nation's GHG emissions. In 2020, electricity generation alone generated around 40% of the total emissions, of which around 21.3% of emissions were generated by manufacturing industries and the construction sector. This includes the emissions from their industrial processes and product use (IPPU) (MoEFCC, 2024). Of these manufacturing industries, three HTA sectors, i.e., iron and steel, aluminium, and cement, are particularly emission-intensive, accounting for roughly 12% of total national emissions. Given that electricity generation and these HTA sectors accounted for more than half of the emissions, this underscores the urgent need for decarbonisation in these sectors. Decarbonising HTA sectors requires the adoption of energy-efficient technologies, RE, alternative fuels, and carbon management strategies such as carbon capture and storage (CCS) and carbon capture and utilisation (CCU). Decarbonisation of the electricity sector involves transitioning from fossil fuels to RE technologies. However, implementing these measures requires substantial investments, potentially increasing production expenses and necessitating investments in both capex and operating expenditure (Opex), which are given in Table 4.

3.1 Capex vs Opex

Decarbonisation measures for HTA sectors vary in scope and cost. The EE measures include the adoption of technologies that reduce energy consumption and emissions. These are generally more cost-effective compared to measures like CCS and CCU, which require significant investments. In the iron and steel sector, EE technologies require a capex of approximately ₹76,479 crore, covering various production routes such as blast furnace–basic oxygen furnace (BF-BOF), coal-based direct reduction of iron-induction furnace (coal DRI-IF) route, coal-based direct reduction of iron-electric arc furnace (coal DRI-EAF) route, and gas-based direct reduction of iron-electric arc furnace (gas DRI-EAF) route (Elango et al., 2023). In 2021–2022, 48% of steel in India was produced using the BF-BOF route, 29% by coal DRI-IF route, 12% by coal DRI-EAF route and 11% by gas DRI-EAF route. For the aluminium sector, EE measures in refining and smelting processes require a total capex of ₹32,499 crore (Sripathy et al., 2024). The cement sector requires a capex of estimated ₹22,650 crore (Nitturu et al., 2023). Collectively, these three sectors in total demand a capex of approximately ₹1,31,628 crore for EE

Table 4: Investment Requirements for Decarbonisation Measures

Decarbonisation Measures	HTA Sectors	Capex (₹ crore)	Annual Opex (₹ crore)	Source
Energy Efficiency Technologies	Iron and Steel	76,479	N/A	Elango et al. (2023)
	Aluminium	32,499	N/A	Sripathy et al. (2024)
	Cement	22,650	N/A	Nitturu et al. (2023)
Adoption of RE (Captive)	Iron and Steel	1,21,000	21,049	Elango et al. (2023)
	Aluminium	1,18,253	12,413	Sripathy et al. (2024)
	Cement	19,000	N/A	Nitturu et al. (2023)
Transmission System for Renewable Energy	Electricity	2,44,200	N/A	CEA (2022)

Source: As mentioned in the table.

measures, highlighting the substantial financial commitment needed for decarbonisation. However, detailed opex estimates for these technologies are not available. Some estimates, however, show that due to reduced demand for energy, adoption of EE technologies might help to reduce the operating costs. For instance, increasing the pulverised coal injection rate in the iron and steel sector, by reducing the production or purchasing cost of coke, can lead to an overall reduction in the operation costs (IETD, n.d.-a). Similarly, in the aluminium sector, retrofitting with inert anodes may also lead to a reduction in operating costs and improve return on investments in the case of greenfield installation (CTCN, 2016). In the case of the cement sector, however, installation of high-efficiency clinker coolers might require capex as well as opex. The installation and annual operational costs for a high-efficiency grate cooler in a 5,000 tonnes per day (TPD) plant might be around ¥20 million and ¥5 million, indicating significant capex requirements as compared to the opex (IETD, n.d.-b).

A significant source of emissions in HTA sectors is the consumption of fossil-based electricity, predominantly sourced from captive power plants (CPPs), which generate over 95% of their electricity from fossil fuels rather than renewable sources (CEA, 2024). Transitioning these CPPs to renewable-based systems, such as captive solar or wind plants, is critical for decarbonisation but requires substantial investments. The cement sector demands a cumulative capex of approximately ₹19,000 crore (Nitturu et al., 2023), the aluminium sector around ₹1,18,253 crore (Sripathy et al., 2024), and the iron and steel sector approximately ₹1,21,000 crore (Elango et al., 2023) to adopt RE measures. Beyond high capex, RE integration also entails significant opex. The iron and steel sector, for instance, would require an annual opex of around ₹21,049 crore, and aluminium ₹12,413 crore. In the case of iron and steel, the annual opex requirement for RE integration is as high as the capex requirement if annualised over a period of five years. These costs underscore the financial challenges of transitioning from fossil-based to RE sources, necessitating strategic financing mechanisms to support this shift. In HTA sectors, the investment requirements (both capex and opex) of technologies like CCS and CCU are the highest (presented in Table B1, Appendix B). Since these measures are not currently commercially viable in the country, they are not discussed in this study.

One of the five Panchamrit goals of India announced in 2022 is to increase the renewable-based installed electricity generation capacity to 500 GW by 2030. With electricity generation being the single largest emissions source in the country, its decarbonisation is of utmost importance. An achievement of the planned RE capacity by 2030 would require a transmission system for transferring power generated from the RE sources to the load centres. The investment requirement for installing such a transmission system would cost around ₹2,44,200 crore (CEA, 2022). The high capex requirements underscore the need for financing mechanisms, such as redirecting some revenues, say from taxes on fossil fuels, to support these investments and mitigate the economic burden on electricity generation or HTA sectors while advancing India's decarbonisation goals.

This study largely focuses on decarbonisation measures like EE technologies in HTA sectors, and the transmission system for the integration of RE. As far as the RE is concerned, instead of focusing on RE adoption in just three HTA sectors, this study focuses on possible implications of utilising the revenues for greening the grid, as the national grid supplies electricity to the vast majority of the sectors, including industrial as well as residential sectors. The investment requirements in this study are thus limited to capex for EE and the transmission systems for the RE. In the next section, we will discuss the data and methods that are used in this study to estimate the investment requirements and the potential implications of redirecting fossil fuel taxes toward these decarbonisation measures.

4. Data and Method

4.1 Investment Requirements for Decarbonisation

Investment requirements for installing energy-efficient technologies in the three HTA sectors are sourced from secondary literature. Elango et al. (2023), Nitturu et al. (2023), and Sripathy et al. (2024) provide detailed estimates of investment requirements for these measures in the iron and steel, cement, and aluminium sectors, respectively. For the iron and steel sector, while the Ministry of Steel (MoS, 2024) lists best available technologies (BATs), it lacks data on associated emissions and energy reductions; therefore, we rely on Elango et al. (2023). Additionally, the CEA (2022) provides data on the finances required for the transmission system to support 537 GW of RE capacity,[5] to achieve India's NDC target of 500 GW of non-fossil-fuel-based capacity by 2030.

EE measures are estimated to reduce energy consumption and thus the emissions intensity. Sripathy et al. (2024) indicate the potential reductions in coal and thermal electricity use, and the emissions intensity in aluminium refining and smelting. Similar reductions in cement and iron and steel sectors are sourced from Nitturu et al. (2023) and Elango et al. (2023), respectively. While the investment requirements in the reviewed literature are given for the implementation of all the energy-efficient measures, in this study, we are assessing the potential implications of the capex required for financing some of the most emission-mitigating technologies by using the revenues generated from the fossil fuel taxes. Moreover, the investment required for the RE transmission system over the years, as the target is set to be achieved by 2030, and thus, not all of the investment is to be met instantly. Given that the investment made using fossil fuel revenues in the given year is less than the cumulative investment, the environmental benefits corresponding to the invested amount are estimated using the unitary method, total investment requirements, and corresponding energy and emission reductions from the literature. It is challenging to identify the non-linear relationship between investments for a given technology and the potential reduction in energy consumption and emissions. Therefore, the estimated reductions in emissions and energy consumption are considered within a ±10% range.

4.2 Simulating the Implications of Investing in HTA and Renewable Energy Sectors

To evaluate the socio-economic and environmental impacts of redirecting fossil fuel taxes toward decarbonisation, this study utilises the ESAM framework. The CSEP-ESAM for the year 2019–2020 is used in this study. It includes 45 production sectors, comprising the HTA sectors (aluminium, cement, iron and steel), thermal electricity, and renewable electricity (Chadha et al., 2023). To assess the socio-economic implications, 318 labour categories are aggregated on the basis of region and social group. The 80 household categories are aggregated on the basis of region, social group, and income level. Sectoral emissions data provided within the ESAM help estimate the potential impacts on environmental indicators (air emissions).

The macroeconomic impacts of increased investments in RE and technological advancements in HTA sectors on the economy have been assessed using the Social Accounting Matrix (SAM) framework (Miller & Blair, 2009). The equation below illustrates the effect of an exogenous shock in final demand:

$$\Delta \boldsymbol{Y} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\, \Delta \boldsymbol{X} \qquad (2)$$

where Y is the total output vector, $(I\text{-}A)^{-1}$ is the Leontief inverse matrix, I is the identity matrix, A is the technological coefficient matrix, and X is the final demand vector.

In the Indian context, since the adoption of decarbonisation technologies has not matured yet, the increased investments for technological improvements and RE generation in this study are expected to impact the technical coefficients. Since the conventional input–output (I-O) model assumes fixed technical coefficients, alterations have been made in the inter-industry transactions in the ESAM to reflect the expected changes in energy consumption of HTA sectors. These alterations are based on the EE estimates obtained from Elango et al. (2023), Sripathy et al. (2024) and Nitturu et al. (2023). Additionally, the reallocation of some part of fossil fuel taxes to decarbonisation investments is incorporated by altering the government account receipts. The RAS technique is applied to correct any imbalances in row and column totals resulting from these adjustments. It is a bi-proportional scaling method which adjusts the matrix entries until they converge to the target marginal totals, ensuring consistency while preserving the original structure of the data (Holý & Šafr, 2022).

Investments in green technologies and the transmission system for RE are expected to boost demand for various upstream sectors, fostering economic activity while advancing decarbonisation goals. When investments target EE technologies in HTA sectors, the entire allocation is directed to the machinery sector, which includes a wide range of machinery and equipment, such as industrial machinery, electrical industrial machinery, batteries, and related components. In contrast, investments in RE generation capacity (covering solar, hydro, offshore wind, and hydro) are distributed across multiple upstream sec-

[5] It includes 166 GW of RE already commissioned in the country.

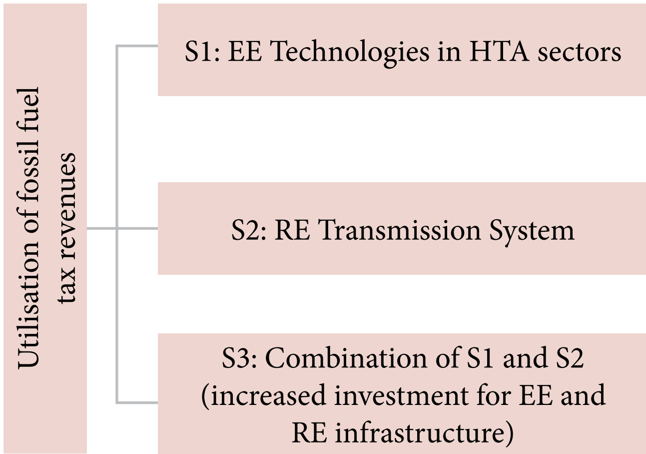
tors. The sectoral distribution of these investments is based on the shares used by Markaki et al. (2013) for the respective energy type.[6]

The utilisation of fossil fuel taxes for environmental purposes is expected to mitigate the emissions generated. The investment in EE technologies, for instance, by reducing the consumption of energy (coal and electricity), will reduce the sector's emissions and emission coefficient, as coal and electricity are amongst the most polluting energy sources. Similarly, an investment in the RE transmission system will lead to an increase in the share of RE in the energy mix, which will reduce the grid's emissions factor.[7] Additionally, emissions of a sector are directly related to the quantity of output produced. The resultant new emissions coefficients of directly targeted sectors (estimated in Section 5.2), and new output (estimated using equation 2) are used to estimate the new emissions in the economy using equation (3) mentioned below. Using the new emissions, the potential impact on the emissions intensity of GDP is estimated as well.

$$\boldsymbol{Emissions_{new}} = \sum_{i} \boldsymbol{Emission\ Coefficient_i * Output_{new_i}} \quad \textbf{(3)}$$

To evaluate the implications of redirecting revenues from the fossil fuel taxes toward India's decarbonisation measures, this study examines three scenarios. S1 analyses the impacts of allocating revenues exclusively to EE technologies in HTA sectors,[8] since the identified decarbonisation measures focus on EE technologies in HTA sectors and expanding the transmission system to support India's target of at least 500 GW of non-fossil fuel-based capacity by 2030. S2 assesses the effects of investing these revenues in RE transmission systems, and S combines investments in both EE technologies and RE transmission systems, as illustrated in Figure 1.

Figure 1: Simulation Scenarios



Note: In this study, for the three scenarios presented, an investment of ₹75,166 crore is considered as the exogenous shock. In Appendix C, four additional scenarios (referred to as Appendix Scenarios (AS)) are also simulated, where an investment of ₹1,08,628[9] crore is considered.

Source: Authors' representation.

While the ESAM framework utilised in this study provides a robust approach to assess the broader economic impacts of an exogenous shock like redirecting fossil fuel tax revenues toward decarbonisation, it is subject to certain assumptions[10] and limitations.

First, the ESAM framework employed here represents a comparative static analysis. It compares two equilibrium states—the baseline economy versus the economy after the investment shock, without modelling the dynamic adjustment path or the specific time duration required for these effects to materialise. While the results indicate the potential economic outcome, this would take time to materialise. Thus, the resultant impacts should be interpreted as immediate or short-run impacts, and not the long-term dynamics.

Second, the estimation of environmental benefits corresponding to the invested amount assumes a linear relationship between investments and reductions in energy consumption and emissions, which might

[6] Detailed information on planned investments for different RE types and their distribution across upstream sectors is provided in Appendix A.

[7] The emissions factor, emissions coefficient, and emissions intensity of the sector are used interchangeably here.

[8] Since electricity used in the three HTA sectors is largely generated from CPPs, greening their electricity consumption would require them to shift from fossil-based captive electricity to RE-based captive electricity. Therefore, in Appendix C, results are also presented for an additional scenario, AS2, where investments are made in HTA sectors to help them transition to RE-based captive electricity, and the AS1 scenario discusses the possible implications of making investments in energy-efficient technologies within the HTA sectors.

[9] When Scenario A2, i.e. investments in HTA sectors for shifting to RE-based captive electricity, is considered in Appendix C, the investment amount considered is ₹1,08,628 crore. This is because, adoption of RE in these HTA sectors would require an annual opex of around ₹33,462 crore (as discussed in Appendix B).

[10] Appendix D summarises the key assumptions made in the study.

not be the case in real-world complexities. However, to address potential non-linearities, the study incorporates a ±10% range for estimated reductions in emissions and energy consumption. Moreover, these estimated environmental benefits are subject to the entire sector and are not firm-specific, as this framework does not capture the firms' heterogeneity in terms of their emissions intensity.

Third, in S1, where investments target EE technologies in HTA sectors, the entire allocation is directed to the machinery sector, which may limit the granularity of sector-specific impacts. However, given that the machinery sector encompasses a wide range of machinery and equipment, including industrial machinery, batteries, and related components, it might be reasonable to assume that for the implementation of EE technologies, HTA sectors would need to make investments in machinery and equipment.

Fourth, the investment requirements used in this study are sourced from the secondary literature and are presented as total (gross) investments. These sources do not provide any information on incremental needs relative to a business-as-usual (BAU) baseline.

Fifth, the allocation of investments to upstream sectors (e.g., rubber and plastic for wind energy) is intended to capture the requisite production activity needed to build the RE infrastructure. While the physical commissioning of these inputs involves supply chain dynamics and takes time, the ESAM framework captures the structural dependencies of the economy, providing a comparative static analysis. Considering these limitations of the model, the results and analyses are discussed in the next section.

5. Results and Analyses

5.1 Investment Requirements

This subsection discusses the investment requirements for the implementation of EE technologies in the HTA sectors, i.e. cement, iron and steel, and aluminium, and RE transmission systems and their corresponding environmental impacts, utilising revenues from the taxes on coal, oil, and natural gas. The analysis builds on the method discussed in Section 4, focusing on the allocation of ₹75,166 crore for these initiatives, with ₹16,949 crore sourced from the GST (estimated excess revenue that would have been generated in FY 2023–2024 from increased GST rate)[11] and ₹58,217 crore (around 8.7% of the total tax revenues) from ONG taxes. An annual investment of ₹75,166 crore is considered in this study, as it represents the annual investment required if both EE technologies and RE transmission systems are to be financed over five years from 2026 to 2030 (as in S3). The period 2026–2030 is considered reasonable because the utilisation of the coal cess for compensating states' revenue losses has been replaced with the increased GST on those products, after which the additional revenues from the higher GST would become available for other purposes, such as decarbonising the economy. Moreover, 2030 is a significant milestone, as some of India's NDCs are expected to be achieved by then. Referring to estimates from Elango et al. (2023), Nitturu et al. (2023), and Sripathy et al. (2024), the capex requirements for EE measures and their corresponding reductions in energy consumption and emissions intensity for Scenarios 1 and 3 are assessed and presented in Tables 5 and 6, respectively. Additionally, investments in RE transmission systems are expected to reduce the grid's emissions factor. In 2019–2020, 79% of electricity was generated from fossil sources, with an emissions factor of 0.80 for thermal electricity. This coefficient gets reduced to 0.72 after including 21% renewable sources. Assuming RE generation increases to 35% by 2030, the grid's emission factor would decline to 0.59, a 17.7% reduction over five years (approximately 3.54% annually), with new thermal electricity emissions adjusted accordingly. Given that the allocated revenues are insufficient to meet the cumulative capex needs, the environmental benefits are estimated using the unitary method, assuming a linear relationship between investments and reductions, and within a ±10% range to account for potential non-linearities.

[11] This assumes that the coal production remains at the 2023–2024 levels in the forthcoming years also. This could be an underestimation of the GST collections from coal. The calculations for the estimated GST have been undertaken for the year 2023–2024 because this is the latest year for which the total GST paid by all the coal companies in India is available. Moreover, the data on total coal produced in the country gives the quantum of coal produced and not the value of coal, hence the increase in GST because of a higher rate has been estimated based on the actual GST paid by coal companies in 2023–2024 at the prevailing rate of 5%.

Table 5: Investment Requirements for Energy Efficiency and Environmental Benefits in S1

HTA Sectors	Total Investment Require-ment (₹ crore)	Potential Reduction in Energy Con-sumption Against Required Invest-ment (%)		Weights for Invest-ing Fossil Fuel Tax Revenues (%)	Invest-ment made from Fossil Fuel Tax Revenues (₹ crore)	Potential Reduction in Energy Consumption Against the Invested Amount (%)		Potential Reduc-tion in Emission Intensity Against Required Invest-ment (%)	Potential Reduc-tion in Emission Intensity Against the Invested Amount (%)	Potential Reduction for Invested Amount—Lower Range (-10%)			Potential Reduction for Invested Amount—Upper Range (+10%)		
		Thermal Electric-ity	Coal and Lignite			Thermal Electricity	Coal and Lignite			Thermal Electric-ity	Coal and Lignite	Emissions	Thermal Electricity	Coal and Lignite	Emissions
	A	B	C	D	E=D*A	F=B*(E/A)	G=C*(E/A)	H	I=H*(E/A)	J=(1-10%)*F	K=(1-10%)*G	L=(1-10%)*I	M=(1+10%)*F	N=(1+10%)*G	O=(1+10%)*I
Cement	22,650	22.3	6.5	17.2	12,934	12.8	3.7	9	5.1	11	3	5	14	4	6
Aluminium	32,499	5.3	36.1	24.7	18,559	3.0	20.6	23	13.1	3	19	12	3	23	14
Iron and Steel	76,479	17.3	11.8	58.1	43,673	9.9	6.7	9	5.1	9	6	5	11	7	6
Total	1,31,628			100	75,166										

Source: Columns A, B, C, and H are sourced or estimated from Nitturu et al. (2023), Elango et al. (2023), and Sripathy et al. (2024). Columns D, E, F, G, I, J, K, L, M, N, and O are the authors' computations.

Table 6: Investment Requirements for Energy Efficiency and Environmental Benefits in S3

HTA Sectors	Total Investment Made (₹ crore)	Potential Reduction in Energy Consumption Against the Invested Amount (%)			Potential Reduction (in %) for Invested Amount—Lower Range (-10%)			Potential Reduction (in %) for Invested Amount—Upper Range (+10%)		
		Thermal Electricity	Coal and Lignite	Emissions	Thermal Electricity	Coal and Lignite	Emissions	Thermal Electricity	Coal and Lignite	Emissions
Cement	4,52,699	4.47	0.74	1.80	4.02	0.67	1.62	4.91	0.81	1.98
Aluminium	6,49,548	1.06	4.13	4.60	0.95	3.71	4.14	1.17	4.54	5.06
Iron and Steel	5,28,563	3.45	1.35	1.80	3.11	1.21	1.62	3.80	1.48	1.98
Renewable Electricity	48,85,790	–	–	–	–	–	–	–	–	–

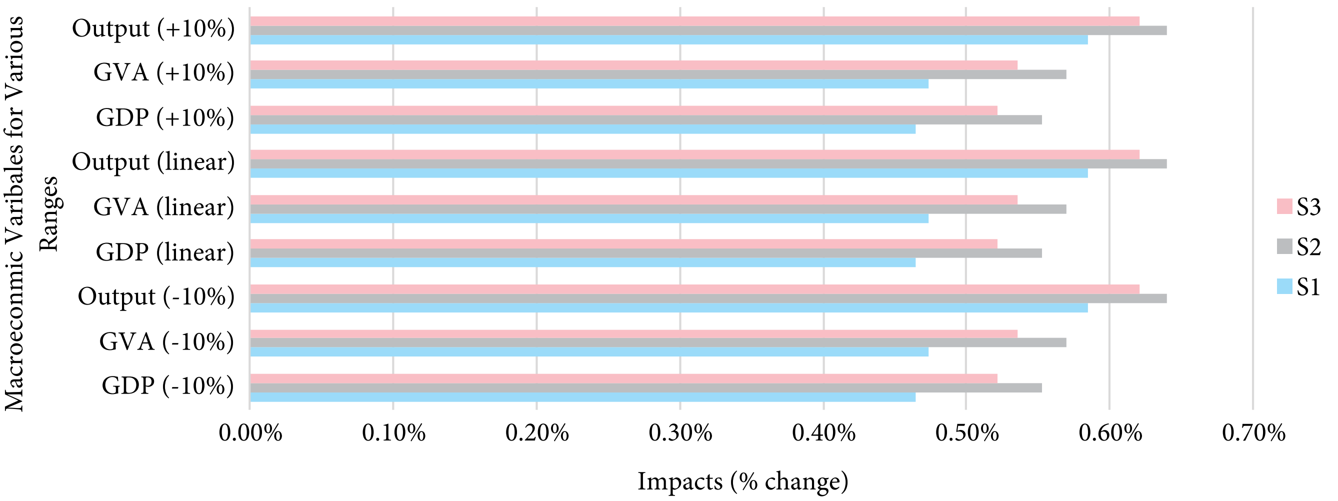
Source: Columns A, D, and F are sourced or estimated from Nitturu et al. (2023), Elango et al. (2023), and Sripathy et al. (2024). Columns B, C, E, G, H, I, J, and K are the authors' computations.

5.2 Simulation Results

Impact on Economy

The utilisation of fossil fuel tax revenues for investments in technologies and RE has the potential for positive economic impacts. This investment creates a multiplier effect, as increased demand for the technologies and transmission system spurs activity in upstream sectors, which in turn depend on various other upstream industries. It results in an expansionary impact on the economy, which is driven by an increase in total output and value added in the economy. The simulation results, presented in Figure 2, show that the increase in total output, GVA and GDP is the highest when investments are made in the RE transmission system, i.e., in S2, followed by S3 (investment for both EE technologies and RE transmission system), and S1 (investment for EE technologies). The results also show that the impact on the economy remains unchanged (with only minor variations at the 4th or 5th decimal place) when a ±10% range is considered to account for potential non-linearities, providing evidence for the fact that the non-linearities do not impact the results. Figure C2 in Appendix C also shows a similar trend of results when the impact on the HTA sectors' RE adoption is considered. However, the extent of impact is higher in C2 because of an increased amount of investment considered in Appendix C. Thus, one can conclude that the pattern of impact here is independent of the quantum of exogenous impact or whether non-linearity is considered or not in the model.

Figure 2: Impact on Output, GVA, and GDP



Source: Authors' computations.

Table 7: Impacts on Five Sectors Contributing most to Production Activity

ESAM Sectors	% Change in Output (Lower Range)			% Change in Output (Linear Computation)			% Change in Output (Upper Range)		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Commerce and Public Services	0.41	0.51	0.47	0.41	0.51	0.47	0.41	0.51	0.47
Construction	0.1	0.57	0.4	0.1	0.57	0.4	0.1	0.57	0.4
Machinery	3.56	2.56	2.91	3.56	2.56	2.91	3.56	2.56	2.91
Agriculture	0.41	0.5	0.47	0.41	0.5	0.47	0.41	0.5	0.47
Food and Beverages	0.39	0.48	0.45	0.39	0.48	0.45	0.39	0.48	0.45

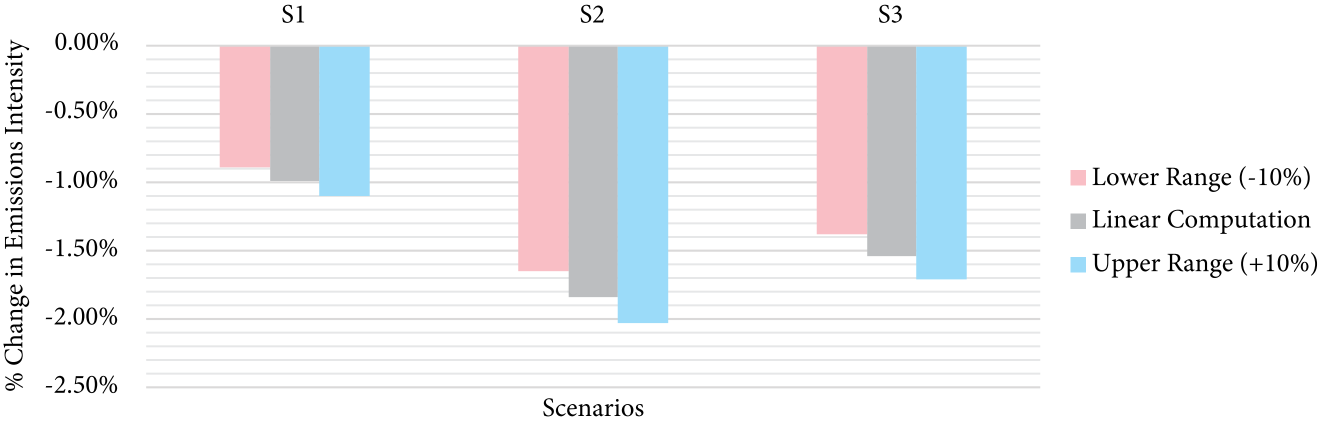
Note: In 2019–2020, these five sectors accounted for around 60% of the total production activity in the country.
Source: Authors' computations.

This variation between the three scenarios can be attributed to the differential effects on five key sectors, i.e., commerce and public services, construction, machinery, agriculture, and food and beverages, which collectively accounted for approximately 60% of India's total production activity in 2019–2020, as per the ESAM. Table 7 shows that, except for the machinery sector, the increase in output for these four sectors is highest in S2, followed by S3 and S1, explaining the relative magnitude of impacts on total output, GVA, and GDP across the three scenarios. The highest economic impact in S2 is driven not only by the size of these sectors but their strong inter-sectoral linkages and multiplier effect, allowing the stimulus to propagate more effectively through the economy. Given their substantial contribution to national production, changes in these sectors significantly drive broader economic outcomes.

Impacts on Emissions Intensity

Investments in EE technologies and RE transmission systems can play a crucial role in advancing decarbonisation targets. EE technologies can reduce the consumption of emission-intensive energy sources, such as coal, electricity, oil, and natural gas, which are primary contributors to India's GHG emissions. The lower energy demand in HTA sectors, i.e. cement, iron and steel, and aluminium, will potentially reduce their emissions intensity, as substantiated by studies such as Elango et al. (2023), Nitturu et al. (2023), and Sripathy et al. (2024). Similarly, the expansion of RE generation, particularly through solar, wind, and hydro systems, reduces the emissions factor of the national grid. The environmental impact of these investments is assessed by estimating changes in the emissions coefficients of targeted sectors and evaluating their effects on total emissions and emissions intensity of GDP. The results (Figure 3) depict that the reduction in emissions intensity is most significant in S2, followed by S3 and S1. The results in Figure C3 in Appendix C also depict a similar trend. The highest reduction in emissions intensity in S2 suggests that greening the grid through RE investments yields the most substantial emission reductions, underscoring its critical role in mitigating the environmental impact of electricity production, which is responsible for almost 40% of emissions in the country (MoEFCC, 2024).

Figure 3: Impact on Emissions Intensity

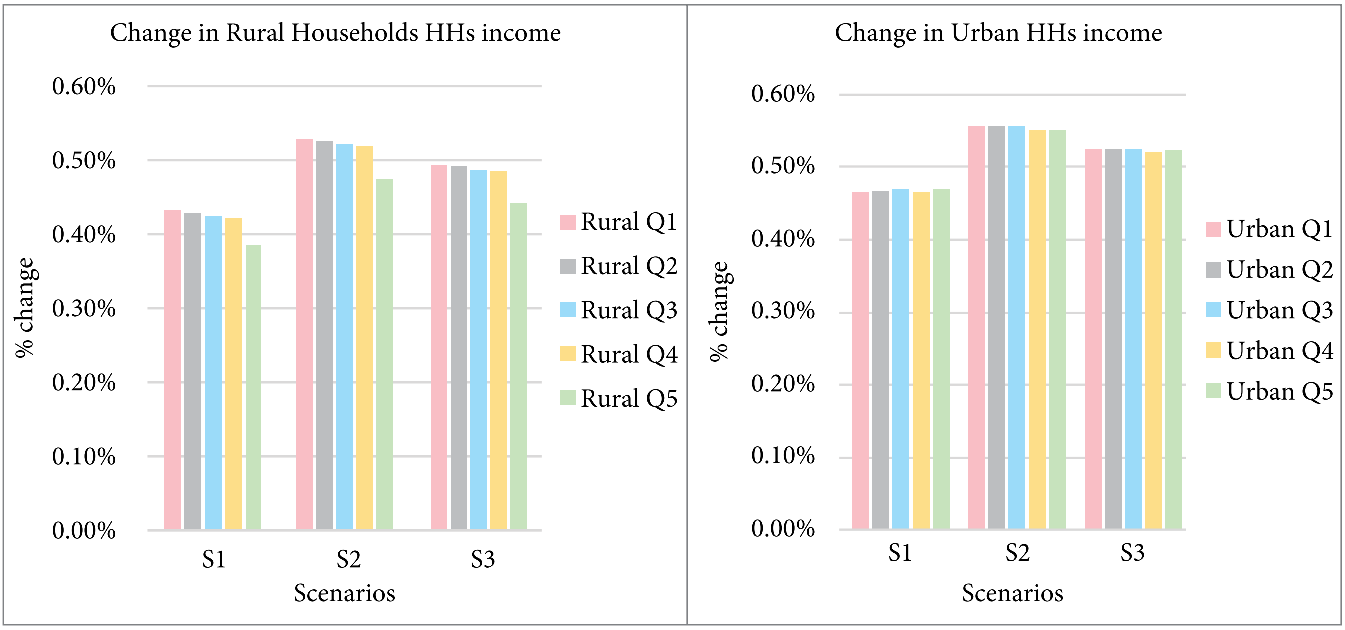


Source: Authors' computations.

Impacts on Households

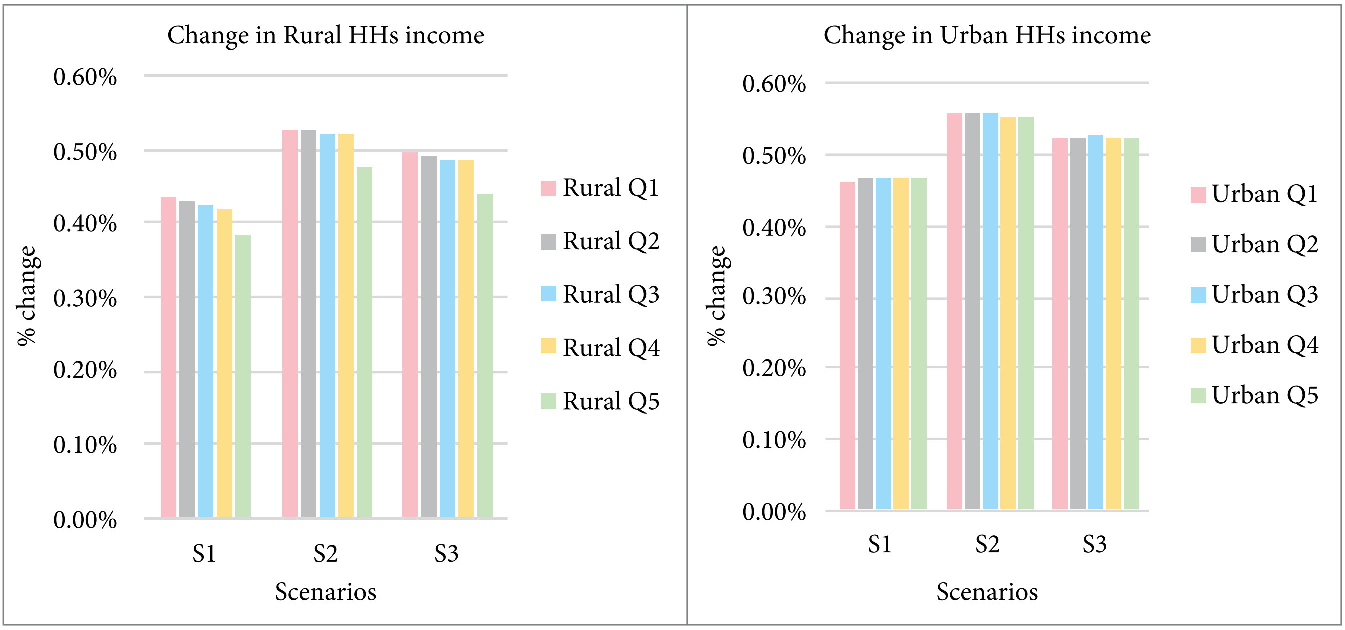
The utilisation of fossil fuel tax revenues for investing in EE technologies and RE generates a positive economic impact, as evidenced by increases in total output, GVA, and GDP, as shown in Figure 2. These investments stimulate demand for factors of production, such as labour and capital, due to increased economic activity and constant factor productivity. As households are the owners of these factors of production, the increased demand will translate into higher household incomes, which in turn enhances household welfare. The simulation results, presented in Figures 4, 5, and 6 (and also in Figures C4 and C5 in Appendix C), indicate that the potential increase in households' income is found to be highest in S2, followed by S3 and S1. Additionally, in rural regions, the income increase is progressive, with lower-income quintiles experiencing relatively higher gains compared to higher-income quintiles, reflecting a distributional benefit. In urban regions, however, only S2 exhibits a progressive income impact, while S3 and S1 show slight regressive patterns, where higher-income quintiles benefit disproportionately. These findings underscore that S2 not only delivers the highest increase in household income but also promotes a more equitable income distribution.

Figure 4: Impact on Households' Income (Computed Linearly)



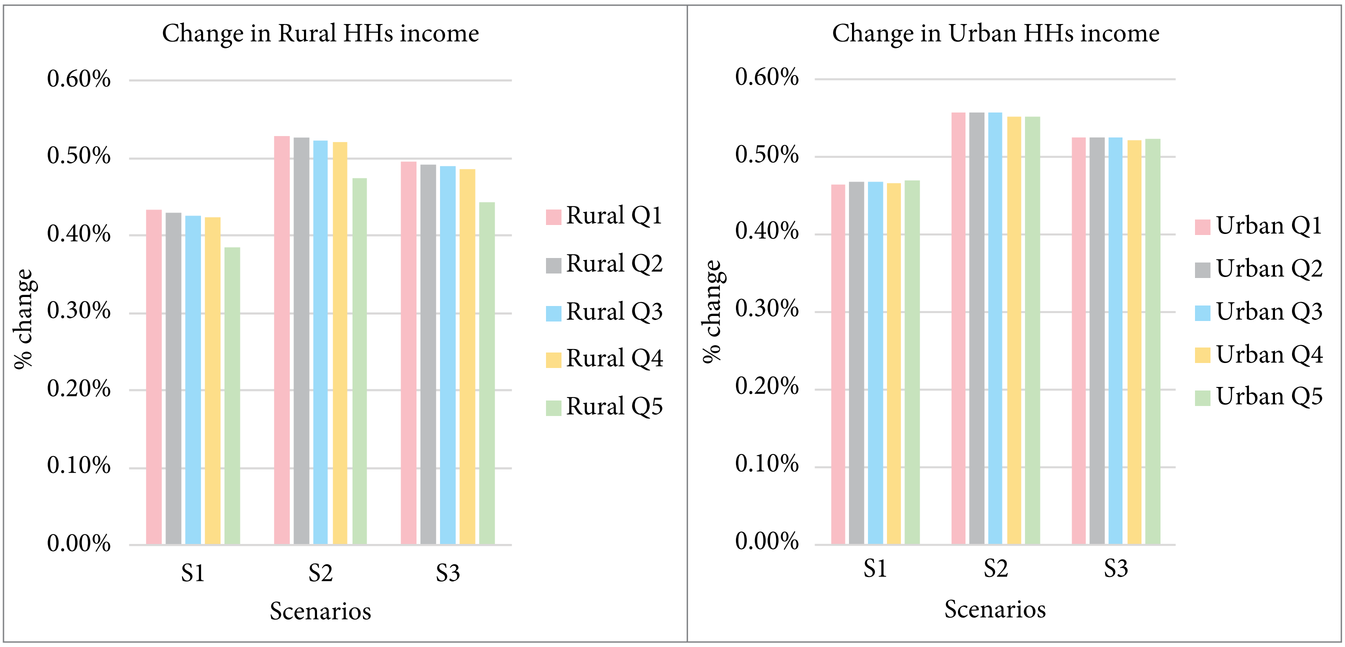
Source: Authors' computations.

Figure 5: Impact on Households' Income (Lower Range)



Source: Authors' computations.

Figure 6: Impact on Households' Income (Upper Range)



Source: Authors' computations.

In summary, the results suggest that redirecting revenues generated from fossil fuel taxes for decarbonisation of HTA sectors and RE generation capacity may yield significant socio-economic benefits. These investments have the potential to reduce the emissions intensity of the GDP, and at the same time boost the economic activities by increasing the output and GDP. It would also lead to welfare gains for the households with households from lower quintiles experiencing the highest increase in their income.

6. Conclusions and Policy Implications

This study examines the critical role of mobilising domestic resources to address climate action in India, particularly through the optimum utilisation of fossil fuel tax revenues. The analysis reveals that with the increased GST on coal, the additional revenue collected may be utilised for funding decarbonisation initiatives. These revenues, combined with a small share (about 8.7%) of fossil fuel taxes on ONG, can help finance critical investments in energy-efficient technologies for HTA sectors and the transmission systems for RE. By reducing energy consumption and greening the grid, these investments not only mitigate adverse environmental impacts but also lower the cost of production for industries, fostering both economic and environmental sustainability. The simulation results suggest that these investments may potentially lead to positive impacts on the economy, environment, and households. S2, in particular, may have the highest positive impacts on economic output, GVA, and GDP, alongside significant reductions in emissions intensity and progressive improvements in household welfare.

Given that GST compensation cess has been discontinued, a critical policy window emerges to realign the additional revenues collected from an increased GST on coal, along with a portion of the SAED and Road and Infrastructure Cess on petrol and diesel, toward supporting clean energy and environment initiatives, as was intended in the case of coal cess. Since these levies already generate substantial revenue, earmarking a small share for decarbonising the economy allows the government to fund the transition without introducing new taxes. The Government of India should prioritise redirecting these additional revenues toward decarbonisation efforts, such as financing the transmission infrastructure required to integrate 500 GW of RE capacity by 2030. Investments in RE, as evidenced in S2, may deliver the most substantial environmental benefits by reducing the grid's emissions factor, given that electricity production solely accounts for nearly 40% of India's emissions. However, to ensure transparency and accountability, the government should consider reviving or establishing a dedicated Clean Energy Fund with strict reporting on collections and disbursements. This institutional mechanism is critical to prevent the underutilisation of funds, a challenge that plagued the original CEC, where over 60% of collections remained unused.

To further incentivise decarbonisation of certain manufacturing sectors, the government of India is already moving ahead with its promise of carbon pricing by implementing the CCTS from 2026. However, CCTS will have to graduate from being a carbon market that can meet its energy emissions targets to a mechanism that can generate resources for the government. Thus, CCTS should be seen as a promising tool for meeting its objective of emissions intensity targets, which could also mean that the absolute emissions could remain the same or increase in proportion to the output increases. Future studies should explore the impacts of such a mechanism. Moreover, while the current study focuses on utilising revenues generated from the fossil fuel taxes, additional revenues could also be saved by reducing existing fossil subsidies and utilised for decarbonising the economy, the implications of which may be assessed in future works.

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Appendix A: Sectoral Distribution of Investment for the RE Transmission System (S2)

Table A1: Planned Transmission System for Additional RE Capacity by 2030

Category	Total (GW)
To be integrated into Inter-State Transmission System (ISTS)	57.64
Additional RE capacity to be integrated into ISTS	236.58
Margin already available in ISTS sub-stations, which can be used for the integration of RE capacity	33.66
Balance RE capacity to be integrated into the intra-state system under Green Energy Corridor I	7
RE capacity to be integrated into the intra-state system under Green Energy Corridor II	19.43
Additional Hydro Capacity likely by 2030	16.67
Total	**370.98**

Source: CEA (2022).

Table A2: RE Type Energy Within Each Transmission Category

Category	Type of Renewable Energy			
	Wind	Offshore Wind	Solar	Hydro
To be integrated into ISTS	13	N/A	48.6	N/A
Additional RE capacity to be integrated into ISTS	52	10	174.58	N/A
Margin already available in ISTS sub-stations, which can be used for the integration of RE capacity	N/A	N/A	N/A	N/A
Balance RE capacity to be integrated into the intra-state system under Green Energy Corridor I	N/A	N/A	N/A	N/A
RE capacity to be integrated into the intra-state system under Green Energy Corridor II	N/A	N/A	N/A	N/A
Additional Hydro Capacity likely by 2030	N/A	N/A	N/A	17

Source: CEA (2022).

Table A3: Share of RE Type and Amount Invested From Fossil Fuel Tax (₹75,16,600 lakh)

RE type	GW	Share (%)	Investment to be made (₹ lakh)
Wind	65	21	15,51,783
Off-shore Wind	10	3	2,38,736
Solar	223.18	71	53,28,108
Hydro	16.67	5	3,97,973
Total	**314.85**	**100**	**75,16,600**

Note: Of the total 370.98 GW, RE type disaggregation is available for 314.85 GW, based on which investments for each RE type are computed.
Source: Authors' computations based on RE capacity sourced from CEA (2022).

Table A4: Distribution of Spending for the RE Transmission System (in %)

Upstream Sectors	Wind	Off-shore Wind	Solar	Hydro
Rubber and plastic	12	9.8	–	–
Fabricated metal products	12	9.8	14	2
Electrical equipment	6	4.9	14	5
Machinery and equipment n.e.c.	37	34.3	49	23
Constructions	26	34.3	20	60
Land transport services	1	0.5	0.5	–
Accommodation and restaurants	0.5	1	–	–
Financial services	0.5	4.9	0.5	1
Real estate services	5	–	2	1.5
Public administration	–	–	–	7.5
Retail trade services	–	0.5	–	–
Total	**100**	**100**	**100**	**100**

Note: n.e.c. refers to not elsewhere classified.
Source: Markaki et al. (2013).

Table A5: Concordance of Upstream Sectors Between Markaki et al. (2013) and ESAM Sectors

Upstream Sectors	ESAM Sectors
Rubber and plastic	Rubber and plastic
Fabricated metal products	Machinery and equipment
Electrical equipment	
Machinery and equipment n.e.c.	
Constructions	Construction
Land transport services	Land Transport
Accommodation and restaurants	Commerce and Public Services
Financial services	
Real estate services	
Public administration	
Retail trade services	

Source: Authors' compilation.

Table A6: Investments to be Made in Upstream Sectors (₹ lakh)

Sectors	Wind	Off-shore Wind	Solar	Hydro	Total Investment
Rubber and plastic	1,86,214	23,396	–	–	2,09,610
Machinery and equipment	8,53,481	1,16,981	41,02,643	1,19,392	51,92,496
Construction	4,03,464	81,886	10,65,622	2,38,784	17,89,755
Land Transport	15,518	1,194	26,641	–	43,352
Commerce and Public Services	93,107	15,279	1,33,203	39,797	2,81,386

Source: Authors' computations.

Appendix B: Annual Opex Requirements

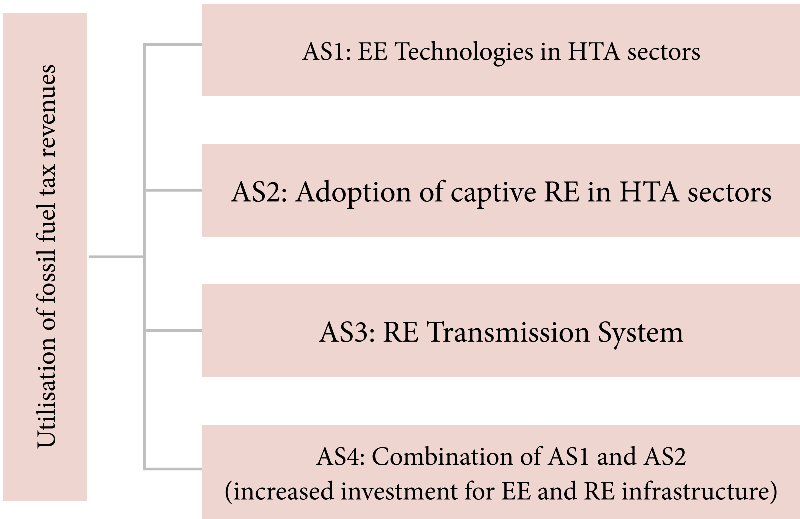
Table B1: Annual Opex to Decarbonise the Three HTA Sectors

Sector	Decarbonisation Measures			
	RE	Alternative Fuel	CCS	CCU
Cement	N/A	5,406	9,992	14,182
Aluminium	12,413	9,271	2,346	2,019
Iron and Steel	21,049	2,522	35,377	7,767

Source: Elango et al. (2023); Nitturu et al. (2023); and Sripathy et al. (2024).

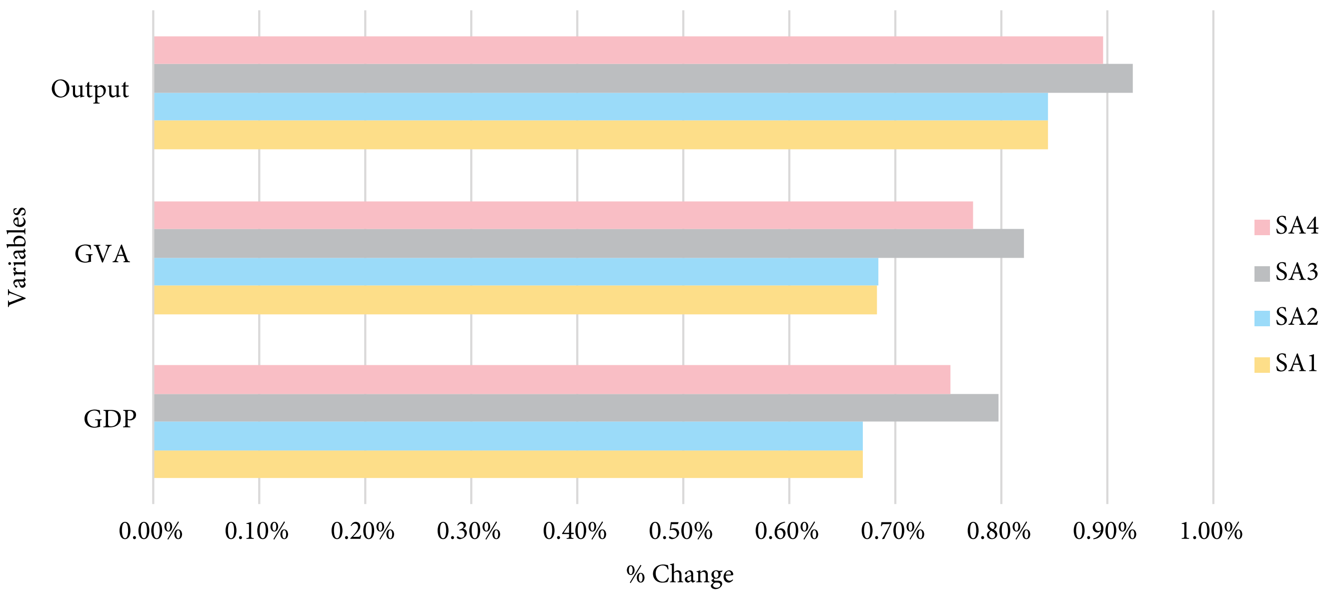
Appendix C: Implications for Investments in Captive RE

Figure C1: Appendix Scenarios (AS)



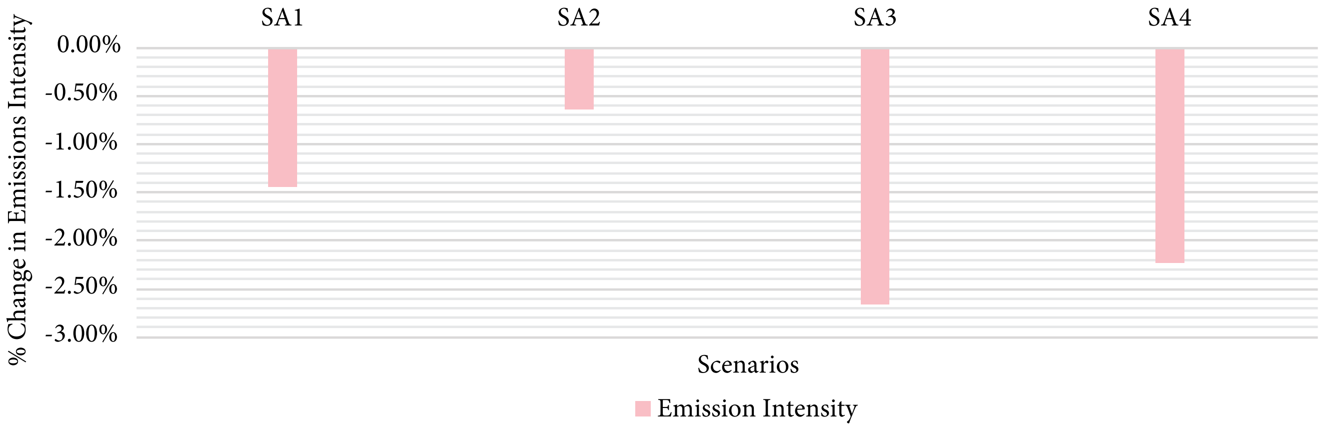
Source: Authors' representation.

Figure C2: Impact on Output, GVA, and GDP



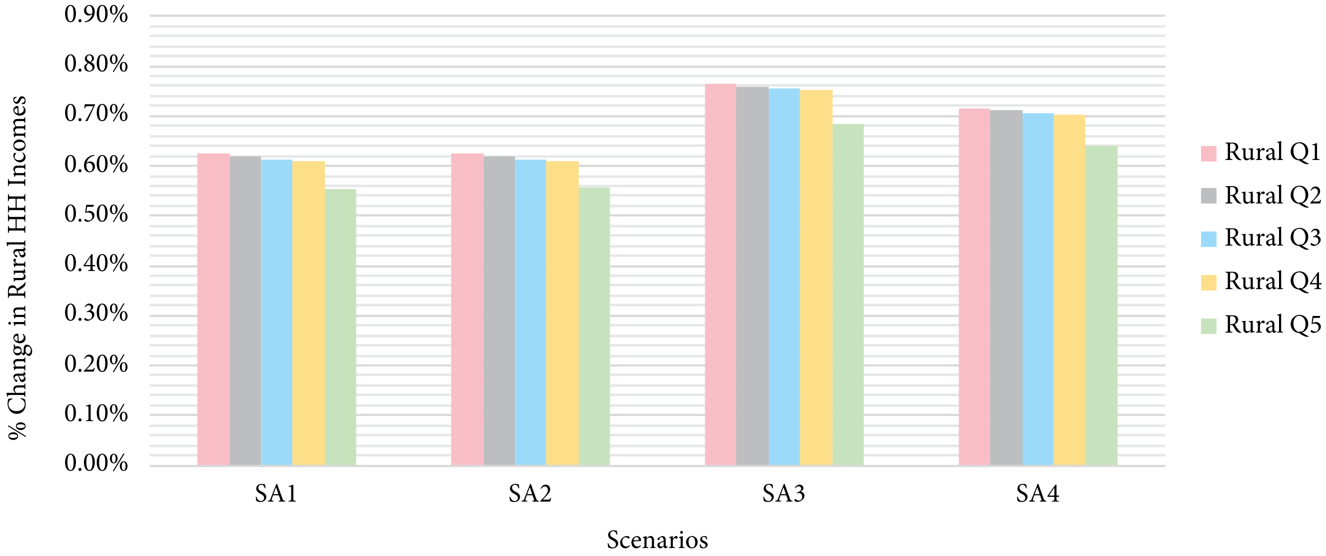
Source: Authors' computations.

Figure C3: Impact on Emissions Intensity



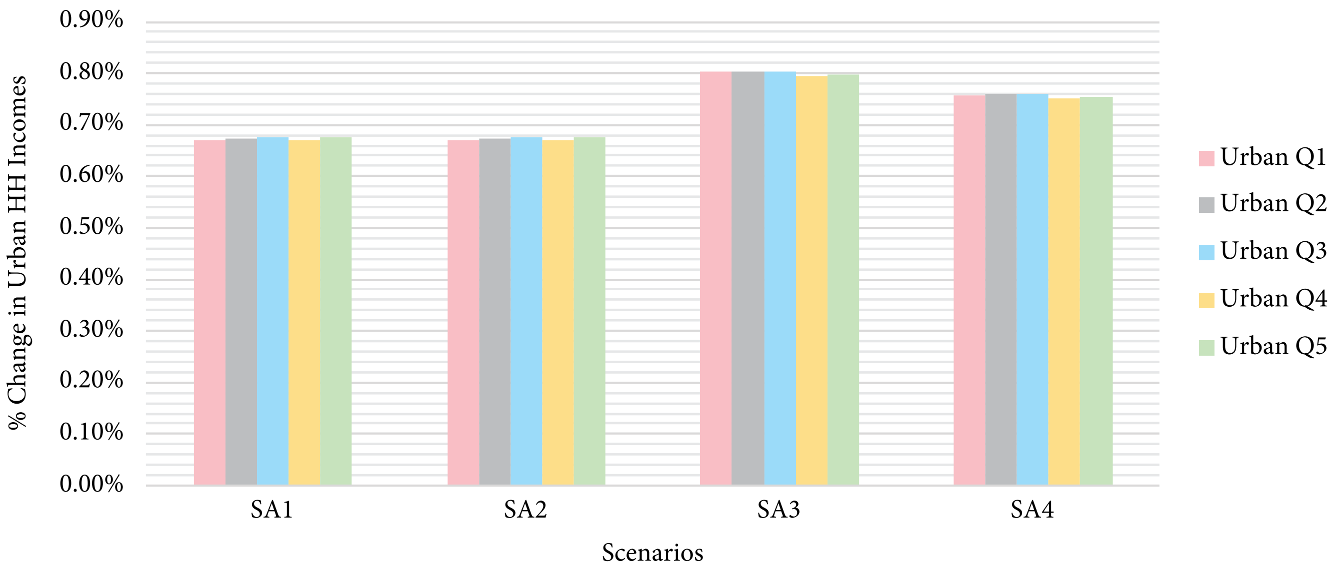
Source: Authors' computations.

Figure C4: Impact on Rural Households' Income



Source: Authors' computations.

Figure C5: Impact on Urban Households' Income



Source: Authors' computations.

The results presented in Appendix C align with the findings from scenarios S1, S2, and S3, showing that potential increases in economic activity, improvements in household welfare, and reductions in emissions intensity are highest when investments are directed toward the RE transmission system, followed by combined investments in the RE transmission system and HTA sectors, and are lowest when focusing solely on HTA sector decarbonisation.

These appendix results also offer an additional insight: the reduction in emissions intensity is higher in AS1 than in AS2. This difference arises because in AS2, a considerable share of investments is allocated to meeting annual opex, whereas in AS1, the equivalent amount is instead channelled toward the implementation of additional EE technologies, thereby achieving greater emissions reductions.

Appendix D: Summary of Key Assumptions

Category	Assumption	Reasoning/Justification
Modelling Framework	The results represent a comparison between two equilibrium states (baseline vsw post-investment) rather than a dynamic time-path. The results are thus short-run impacts and not long-term outcomes.	The study uses an ESAM framework, which by design captures short-term effects of exogenous demand shocks. This analysis is thus called a "What-If" analysis.
	Unlike standard I-O models that assume fixed coefficients, this study assumes technical coefficients for HTA sectors change due to decarbonisation investments.	The adoption of EE technologies and RE alters the input structure (energy mix) of industries.
	A linear relationship is assumed between the quantum of investment and the resulting reduction in energy consumption/emissions.	While real-world relationships may be non-linear, to address this limitation, a sensitivity analysis using a ±10% range was conducted to ensure robustness.
Investment	The simulation assumes the investment and revenue reallocation occurs over a five-year period starting in 2026.	The GST Compensation Cess was replaced with a higher GST on coal in late 2025, freeing up the excess revenue from the increased coal GST for new purposes. 2030 serves as the target year for India's NDCs.
	The investment figures used are total (gross) requirements rather than incremental needs relative to a BAU baseline.	Secondary literature sources such as Elango et al. (2023), CEA (2022), etc., provide total investment costs. Incremental cost data is not available in the current literature.
Sectoral Allocations	For S1 (EE in HTA), the entire investment allocation is directed toward the Machinery sector.	The machinery sector in the ESAM is broadly defined, encompassing industrial machinery, electrical equipment, and batteries. It is the most reasonable proxy for the diverse equipment required for EE upgrades in HTA sectors.
	The spending pattern for RE infrastructure (S2) is distributed across upstream sectors based on shares from Markaki et al. (2013).	In the absence of an India-specific detailed expenditure breakdown for RE transmission construction, these established coefficients serve as the best available proxy.
	All firms within a sector (e.g., all Cement firms) are assumed to have identical emission intensities and production structures.	The ESAM framework operates at the sectoral level and does not capture firm-level heterogeneity.

Source: Authors' compilations.

About the authors

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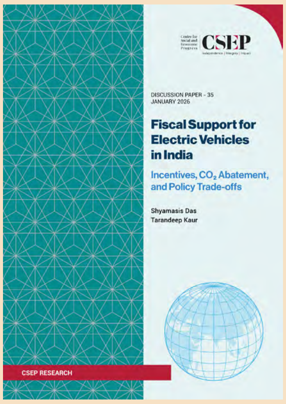
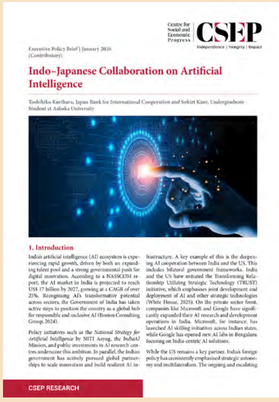
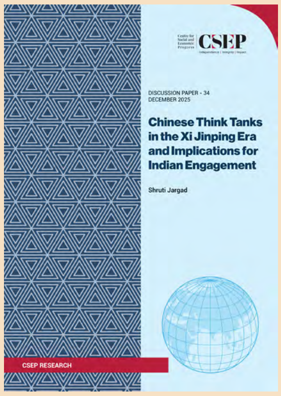
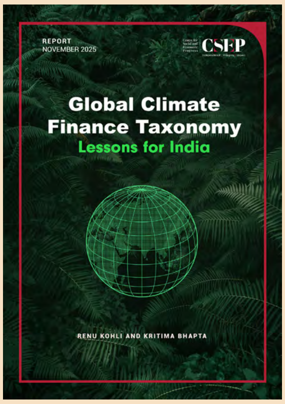
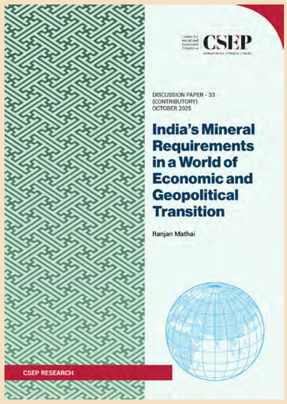
Other publications

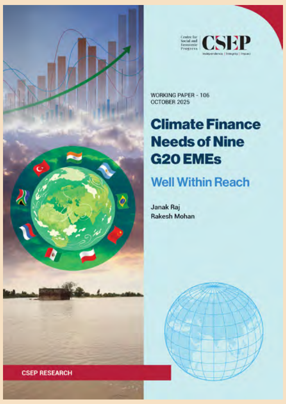


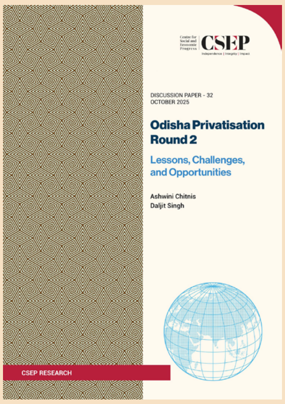


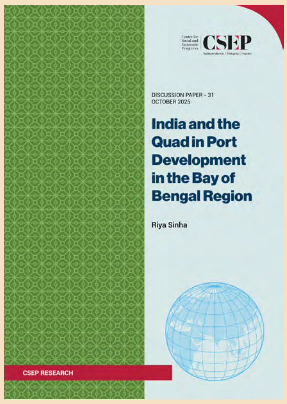


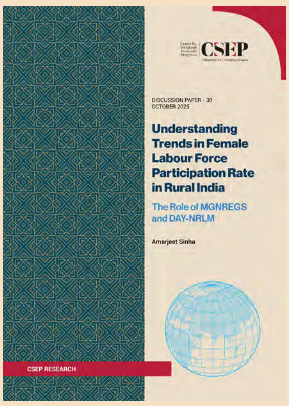


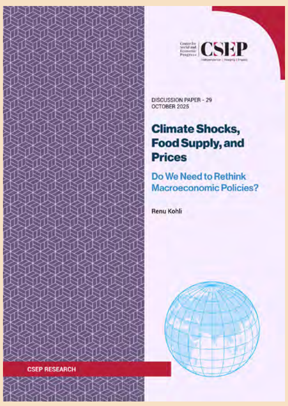


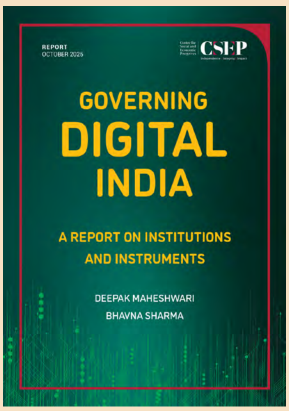


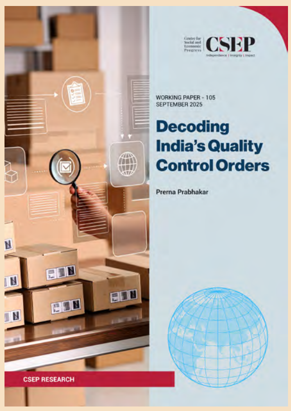












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