SAVi Sustainable Asset Valuation

Exploring the Economic, Social, and Environmental Outcomes of Subsidy Schemes for Electric Vehicles in India

Insights from the Sustainable Asset Valuation assessment of the FAME II policy

TECHNICAL REPORT

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This report is part of a series of Sustainable Asset Valuation assessments on sustainable transport and mobility projects to raise awareness and inform decision-makers on the use of systemic approaches and simulation to support the transformation toward sustainable mobility.

More about the project can be found here: https://www.iisd.org/savi/using-systemic-approaches-and-simulation-to-support-transformation-toward-sustainable-mobility/

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Executive Summary

Purpose of This Assessment and the Sustainable Asset Valuation Methodology

Sustainable Asset Valuation (SAVi) is an assessment methodology that provides policy-makers and investors with a comprehensive and customized analysis of how much their infrastructure projects and portfolios will cost throughout their life cycles. The approach purposefully considers risks and externalities that are overlooked in a traditional valuation. A SAVi assessment is built on a foundation that includes the following elements:

- **modelling:** Assessments involve a combination of systems thinking and different modelling methodologies, spatial modelling, economic multiplier/multicriteria assessments, system dynamics, and financial models.
- **customization:** Assessments are customized to each individual infrastructure project, portfolio, or policy.
- **collaboration:** Assessments are co-created with decision-makers and stakeholders. This multistakeholder approach allows stakeholders to identify material risks and opportunities that are unique to the projects or alternatives. Through this process, the capacity of decision-makers and stakeholders is strengthened, which allows them to take a systemic approach to investments and increases the likelihood of the uptake and use of the results of the analysis, as well as the likelihood that they will have an impact.
- **data driven:** Assessments are based on project-level data (where available), the SAVi database (based on literature reviews and data from previous SAVi applications), and best-in-class climate data from the EU Copernicus Climate Date Store (built into all SAVi models).

This assessment applies the SAVi methodology to the second phase of the Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles in India (FAME II) policy. The results aim to raise awareness of the economic, social, and environmental outcomes of infrastructure and policy interventions in the area of sustainable transport and mobility. It also aims to inform decision-makers on the use of systemic approaches in supporting the transformation toward sustainable mobility.

The assessment is part of a series of SAVi assessments of sustainable transport projects in Albania, Colombia, India, Indonesia, and Senegal.

The FAME II Policy in India

Cities in India face numerous urban mobility and transport challenges, such as long commuting times, safety concerns, air pollution, and many other economic inefficiencies. India's transport sector is expected to meet the transport needs of almost 1.4 billion people, half a billion of which live in urban areas. At the same time, the global automotive industry is experiencing significant disruptions due to developments in digitalization and automation. The electrification of transport vehicles is of particular importance in India, as it can have considerable positive impacts in terms of vehicle pollution and greenhouse gas emissions, especially in the country's large metropolises.

As a strategy to address some of those transport challenges, the Indian National Automotive Board developed a funding scheme for electric vehicles (EVs) in order to create demand for those technologies. FAME II aims to support the electrification of public and shared transportation and is implemented via the use of subsidies directly provided by the National Government of India (the Ministry of Heavy Industries) to urban authorities in Indian cities over a 5-year period, including a recent extension. FAME II aims to support electric buses, cars, three-wheelers, and motorcycles, as well as to establish electric chargers, with a total budget of INR 100 billion or USD 1.2 billion. So far, 70% of the funds have yet to be utilized under the FAME II policy.

This report discusses the results of a systemic valuation of the FAME II policy in India, using the SAVi methodology to illustrate the value of the economic, social, and environmental outcomes of the scheme under different scenarios.

The SAVi assessment uses a variety of models to estimate not only the investment costs (i.e., capital and operation and maintenance [O&M] costs) but also the added environmental, social, and economic benefits and avoided costs. The assessment includes four scenarios with a mix of the following components:

- **subsidy:** the total budget allocated by the government for the promotion of EVs (INR 100 billion) across 3 years (2023, 2024, and 2025).
- **contribution:** the share of the cost of the EV that will be covered by the government subsidy as opposed to the share that will be covered by the consumer.

The four FAME II scenarios modelled for this assessment are as follows:

- scenario 1: 50% subsidy and 40% contribution
- scenario 2: 100% subsidy and 40% contribution
- scenario 3: 100% subsidy and 35% contribution
- scenario 4: 100% subsidy and 25% contribution

For each scenario, the analysis presents the following:

- a valuation of six investment and O&M costs and a valuation of nine added benefits and avoided costs related to the FAME II policy;
- an integrated cost-benefit analysis (CBA) of the FAME II policy, including the added benefits and avoided costs; and
- a valuation of three benefit-cost ratios (BCRs) for the FAME II policy: the conventional BCR; the BCR from the perspective of the government; and the BCR from the perspective of households and the private sector perspective.

Findings

According to the analysis, the FAME II policy in India has a wide range of economic, social, and environmental benefits that are typically overlooked in traditional transport infrastructure assessments.

The results from the SAVi assessment demonstrate that the FAME II policy in India will stimulate economic growth and deliver considerable social and environmental benefits, such as avoided costs of internal combustion engine (ICE) vehicles and fuel use, avoided costs of air pollution and carbon dioxide (CO_2) emissions, and employment creation.

Table ES1. Integrated CBA (discounted at 3.5% over 28 years)

Integrated CBA	FAME II scenario 1 (Subsidy 50%, contribution 40%)	FAME II scenario 2 (Subsidy 100%, contribution 40%)	FAME II scenario 3 (Subsidy 100%, contribution 35%)	FAME II scenario 4 (Subsidy 100%, contribution 25%)
Investment and costs (INR billion)	**539.07**	**1,078.34**	**1,408.59**	**2,761.30**
Subsidies for EVs	39.63	79.26	79.26	79.26
Investment cost of EVs after subsidies	453.14	906.27	1,207.96	2,443.70
Investment cost of EV chargers	8.54	17.08	22.30	43.71
O&M costs of EVs	30.91	61.82	80.74	158.26
Investment cost of power generation	5.17	10.55	13.92	27.75
O&M costs of power generation	1.69	3.37	4.40	8.63
Added benefits (INR billion)	**3.55**	**7.09**	**9.27**	**18.17**

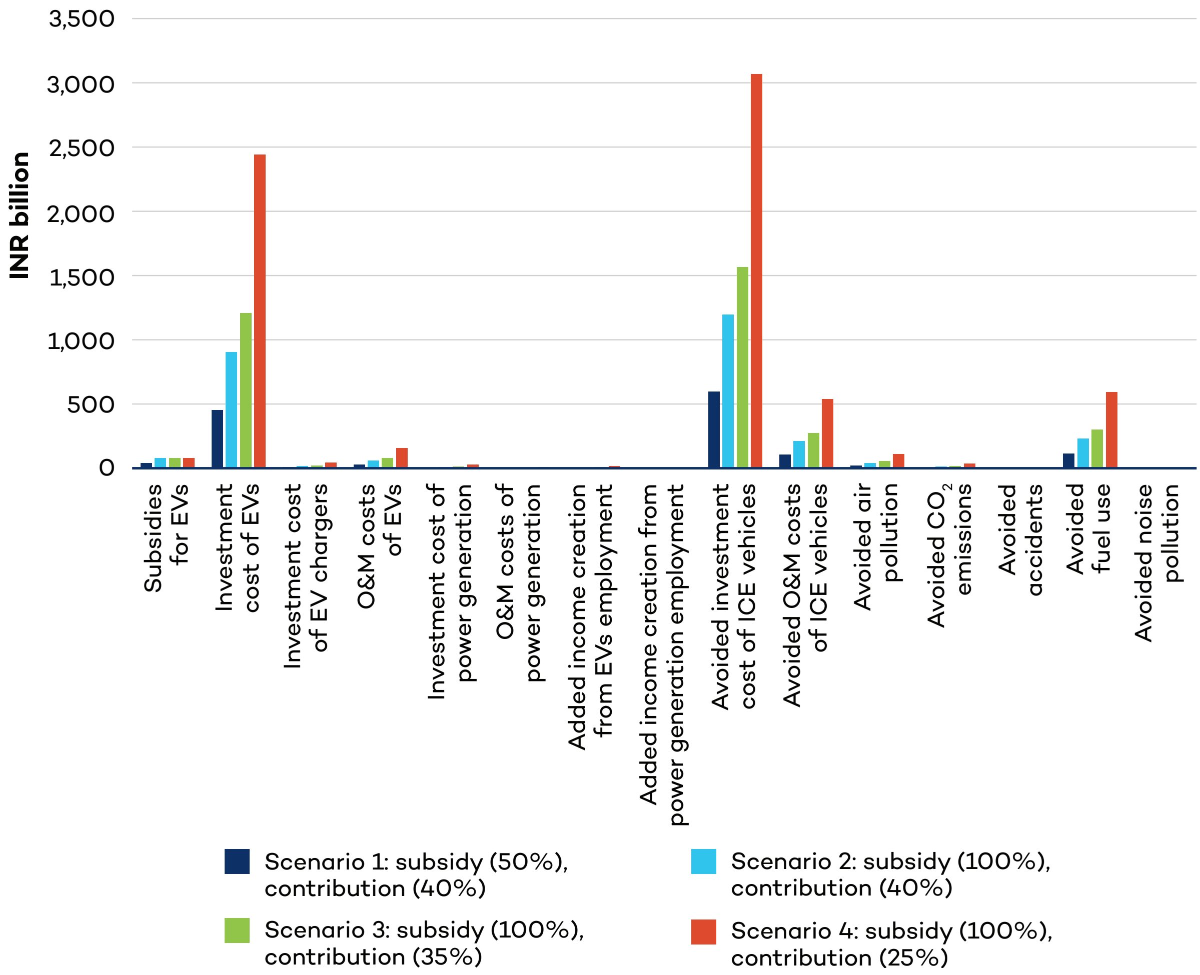
Integrated CBA	FAME II scenario 1 (Subsidy 50%, contribution 40%)	FAME II scenario 2 (Subsidy 100%, contribution 40%)	FAME II scenario 3 (Subsidy 100%, contribution 35%)	FAME II scenario 4 (Subsidy 100%, contribution 25%)
Income generation from EV-related employment	3.43	6.85	8.95	17.54
Income generation from power generation-related employment	0.12	0.24	0.32	0.63
Avoided costs (INR billion)	**849.66**	**1,699.25**	**2,219.45**	**4,350.03**
Investment cost of ICE vehicles	599.11	1,198.23	1,565.03	3,067.46
O&M costs of ICE vehicles	105.37	210.75	275.26	539.51
Air pollution	21.29	42.57	55.60	108.96
CO_2 emissions	7.35	14.70	19.20	37.62
Accidents	0.01	0.03	0.03	0.07
Fuel use	115.97	231.87	302.87	593.56
Noise pollution	0.56	1.11	1.45	2.85
Cumulative net benefits	**314.14**	**628.00**	**820.12**	**1,606.90**
BCR	1.58	1.58	1.58	1.58
BCR – government	0.83	0.83	1.08	1.45
BCR – households and private sector	1.67	1.67	1.63	1.59

Source: Authors' modelling.

As Table ES1 demonstrates, FAME II scenario 4 yields the highest cumulative benefits (INR 1,606.90 billion) from the perspective of the government because the government's contribution is lower, at 25%. This means that the share of the cost of the EV that will be covered by the consumer/user will be highest in FAME II scenario 4. Similarly, FAME II scenario 3 yields the second-highest cumulative benefits (INR 820.12 billion) because the government's contribution is 35%. FAME II scenarios 1 and 2 include a 40% contribution from the government. Naturally, FAME II scenario 2 has double the cumulative net benefits (INR 628 billion) of FAME II scenario 1 (INR 314.14 billion) because in the former, 100% of the subsidy money for the promotion of EVs (INR 100 billion) is used whereas in the latter case, only 50% of the subsidy money is used.

The SAVi assessment of the FAME II policy in India also calculates monetary values for a range of added benefits and avoided costs for the FAME II policy scenarios. The avoided investment costs of ICE vehicles show the highest values across all four FAME II scenarios, followed by the avoided costs of fuel use as a result of the replacement of ICE vehicles with EVs and, to a lesser extent, the avoided O&M costs of ICE vehicles. All of the above costs are borne by consumers/users and not by the government. All of the above investment costs, added benefits, and avoided costs of the FAME II policy across all four FAME II scenarios are shown in Figure ES1.

Figure ES1. Investment costs, added benefits, and avoided costs of the FAME II policy in India



Source: Authors' calculations.

In addition, three BCRs have been calculated: the conventional BCR, the BCR from the perspective of the government, and the BCR from the perspective of households and the private sector. The conventional BCR considers all investments and costs and the full range of economic, social, and environmental added benefits and avoided costs. The BCR from the perspective of the government considers only the impacts that are borne by the government and excludes the ones that are borne by consumers/users, such as investment in EVs, EV chargers, and the O&M costs of EVs, as well as the avoided investment and O&M costs of ICE vehicles and fuel use. The BCR from the perspective of households and the private sector considers only the impacts that are borne by the consumers/users of EVs and excludes the ones that are mostly borne by the government, such as the subsidy itself, income creation from EVs, power generation-related employment, and avoided costs of air and noise pollution, CO_2 emissions, and traffic accidents.

The conventional BCR is the same across all four FAME II scenarios (1.58) because regardless of the investment, the benefits per EV sold are the same. The benefits are accrued per EV, and, therefore, the more EVs that are sold, the more absolute benefits accrue. If we consider both the government and, together, households and the private sector or consumers/users, the BCR does not change, whereas if we consider the government and households separately, the BCR changes. Table ES2 shows the two BCRs across the four FAME II scenarios.

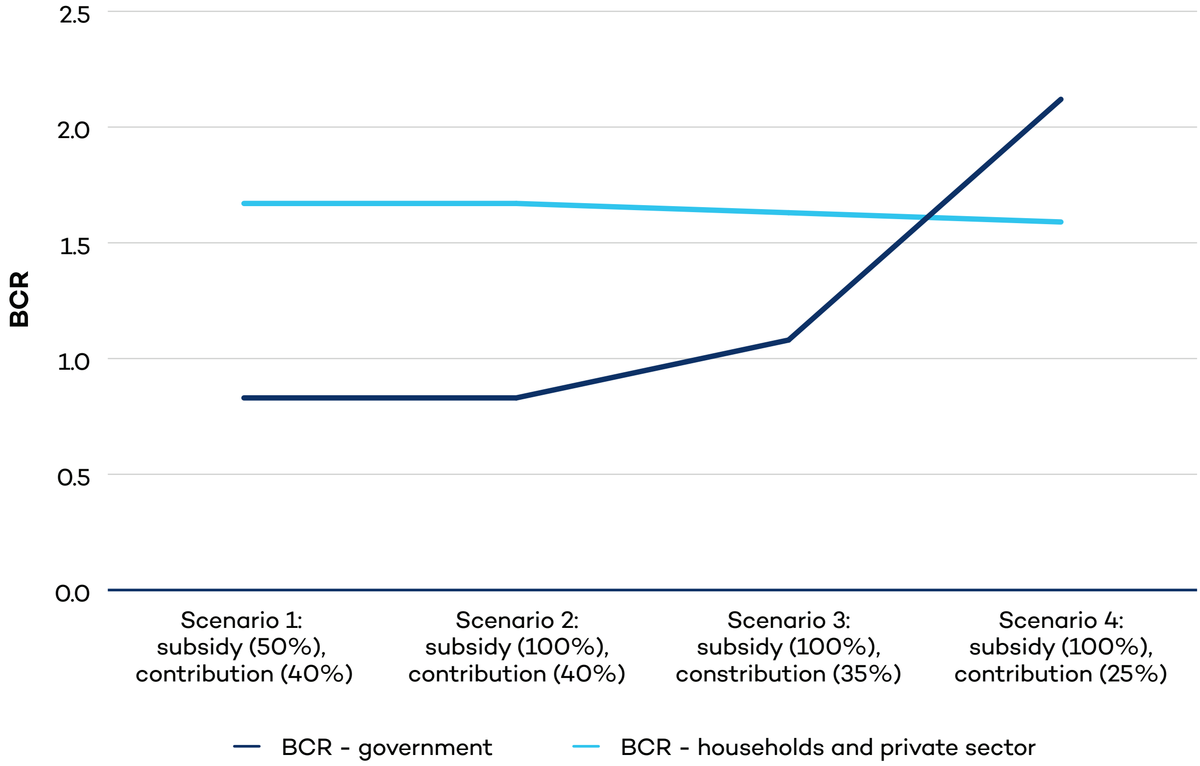
Table ES2. BCRs across FAME II scenarios (discounted 3.5%)

	Scenarios			
BCRs (based on discounted values)	**FAME II scenario 1**	**FAME II scenario 2**	**FAME II scenario 3**	**FAME II scenario 4**
BCR	1.58	1.58	1.58	1.58
BCR – government	0.83	0.83	1.08	2.12
BCR – households and the private sector	1.67	1.67	1.63	1.59

Source: Authors' modelling.

According to Table ES2, the lower the government's subsidy contribution to the total cost of an EV, the lower the BCR from the perspective of households and the private sector and the higher the BCR from the perspective of the government. This is shown clearly in Figure ES2.

Figure ES2. BCRs from the perspectives of the government and of households and the private sector across all four FAME II scenarios



Source: Authors' modelling

These findings are intuitive because the BCR from the perspective of the government becomes greater as its subsidy contribution is reduced, whereas the BCR from the perspective of households and the private sector decreases as a higher share of the cost of an EV is borne by the latter group. It is important to find the right balance between reducing the government's subsidy contribution in order for a higher number of EVs to be subsidized and providing the right incentives for households and the private sector to buy EVs.

Lastly, this SAVi assessment assumes that private investment in EVs will cover the government's gap in the event that the subsidy is not provided. Similar assumptions are based on a combination of factors that are difficult to quantify, including the speed of the global uptake of EVs, the EV market maturity in India, technological advances, future policies, and so on. The EV market in India has currently reached a certain level of maturity for some types of EVs, such as two-wheelers. In this context, it is assumed that reducing the subsidy will not have an enormous impact on the advancement of EVs in the long term.

The SAVi assessment provides benchmark values for policy-makers and public infrastructure planners when it comes to valuing the societal benefits and costs of the FAME II policy. Table ES3 indicates how different stakeholders and decision-makers can use the results of this assessment to make more informed decisions.

Table ES3. How different stakeholders and decision-makers can use the results of the SAVi assessment of the FAME II policy in India

Stakeholder	Role in the project	How the stakeholder can use the results of the assessment
Government	Design, implementation, and finance of the FAME II policy in India	Regional and national governments can use the assessment results to raise awareness and justify investments and support for sustainable transport projects and policies, as well as making these assessments a standard and a requirement for investment decisions.
Private sector/ Industry	Project developers	Businesses and private sector entities can use the assessment results for additional advocacy for sustainable transport projects and policies, as well as for identifying new opportunities.
Donors and funders	Funding of sustainable transport projects and policies	Donors can include the assessment results in their reporting processes to show the impacts of their investments. The assessment results can also be used for awareness raising of the benefits of sustainable transport policies, with the ultimate aim of making these assessments a formal requirement.
Civil society organizations	Consultation with government on sustainable transport projects and policies	Civil society organizations can use the assessment results to conduct more targeted advocacy for sustainable transport projects and policies, to raise awareness of their value to society.

Source: Authors' modelling.

Integrated assessments such as this one conducted using the SAVi methodology can help to make a stronger case for sustainable transport policies.

Abbreviations

BCR	benefit-cost ratio
BAU	business as usual
CBA	cost-benefit analysis
CLD	causal loop diagram
CO_2	carbon dioxide
EV	electric vehicle
FAME	Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles in India
FY	financial year
GDP	gross domestic product
ICE	internal combustion engine
O&M	operation and maintenance
PV	photovoltaic (solar power)
SAVi	Sustainable Asset Valuation
v-km	vehicle-km

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Glossary

Causal loop diagram: A schematic representation of key indicators and variables of the system under evaluation that shows the causal connections between them and contributes to the identification of feedback loops and policy entry points.

Discounting: A financial process to determine the present value of a future cash value.

Indicator: Parameters of interest to one or several stakeholders that provide information about the development of key variables in the system over time and trends that unfold under specific conditions (United Nations Environment Program [UNEP], 2014).

Methodology: The theoretical approach(es) used for the development of different types of analysis tools and simulation models. This body of knowledge describes both the underlying assumptions used and qualitative and quantitative instruments for data collection and parameter estimation (UNEP, 2014).

Model validation: The process of assessing the degree to which model behaviour (i.e., numerical results) is consistent with behaviour observed in reality (i.e., national statistics, established databases) and the evaluation of whether the developed model structure (i.e., equations) is acceptable for capturing the mechanisms underlying the system under study (UNEP, 2014).

Net benefits: The cumulative amount of monetary benefits accrued across all sectors and actors over the lifetime of investments compared to the baseline, reported by the intervention scenario.

Scenarios: Expectations about possible future events used to analyze potential responses to these new and upcoming developments. Consequently, scenario analysis is a speculative exercise in which several future development alternatives are identified, explained, and analyzed for discussion on what may cause them and the consequences these future paths may have on our system (e.g., a country or a business).

Simulation model: Models can be regarded as systemic maps in that they are simplifications of reality that help to reduce complexity and describe, at their core, how the system works. Simulation models are quantitative by nature and can be built using one or several methodologies (UNEP, 2014).

System dynamics: A methodology developed by J. Forrester in the late 1950s (Forrester, 1961) to create descriptive models that represent the causal interconnections between key indicators and show their contribution to the dynamics exhibited by the system as well as to the issues being investigated. The core pillars of the system dynamics method are feedback loops, delays, and non-linearity emerging from the explicit capturing of stocks and flows (UNEP, 2014).

1.0 Introduction

1.1 Mobility Challenges and Transport Strategies in India

Cities in India face numerous urban mobility and transport challenges, such as long commuting times, safety concerns, air pollution, and economic inefficiencies. These problems are projected to worsen with climate change and continued urban development. India's transport sector is expected to meet the transport needs of almost 1.4 billion people, half a billion of which live in urban areas. At the same time, the global automotive industry is experiencing a significant disruption due to developments in digitalization, automation, and new business models. Part of this disruption is the transition to electric vehicles (EVs). Electrification is of particular importance in India, as it can have considerable positive impacts in terms of lowering vehicle pollution and greenhouse gas emissions, especially in the country's large metropolises (Dhawan et al., 2017).

As a strategy to address some of those transport challenges and take advantage of new global trends in vehicle electrification, the Indian National Automotive Board developed a funding scheme for electric buses and other electric commercial vehicles in order to create demand for those technologies. The second phase (II) of the scheme, titled Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles in India (FAME), aims to support the electrification of public and shared transportation and is implemented via the use of subsidies directly provided by the Government of India (the Ministry of Heavy Industries) to urban authorities in Indian cities over a 5-year period, including a recent extension (financial year [FY] 2019/2020 to 2023/2024). In addition to subsidies, various state-level and city-level subsidies and tax exemptions exist to make EVs cost effective. FAME II will support 7,090 electric and hybrid buses; 500,000 electric three-wheelers; 55,000 electric four-wheeler passenger cars (including full or strong hybrids); and 1 million electric two-wheelers. In addition, the Ministry of Heavy Industries in India financed infrastructure for 520 charging stations that were installed under phase I of the scheme. The total budget for FAME II amounts to INR 100 billion, or USD 1.2 billion (Ministry of Heavy Industries, 2023).

As part of the FAME II scheme, the Ministry of Heavy Industries has sanctioned 2,877 EV charging stations in 68 cities across 25 states, as well as 1,576 charging stations across expressways and highways. In parallel, the Government of India has created various incentives to increase awareness about EVs in numerous colleges and universities across the country (Ministry of Heavy Industries, 2023).

So far, 100% of the budget allocated under FAME II has been utilized by the Ministry of Heavy Industries for FY 2019/2020 to 2021/2022. However, for FY 2022/2023, the halfway mark has not even been reached: The number of EVs sold under FAME II as of December 31, 2022, has reached 811,725 or 51.96% of the target that the program aimed to support by the end of December. Overall, 70% of funds remain to be utilized under the FAME II policy (JMK Research & Analytics, 2023).

1.2 Purpose of a Sustainable Asset Valuation of the FAME II Policy in India

Transforming the transport sector in India is imperative for reducing air pollution and greenhouse gas emissions and for contributing to energy efficiency in order to meet economic and environmental targets. The second phase of the FAME scheme aims to start this transformation by subsidizing the electrification of public and shared transportation.

To fully understand the extensive economic, social, and environmental benefits and costs of the FAME II policy in India, a comprehensive quantitative analysis is required. This analysis should not only consider the investment costs (capital and operation and maintenance [O&M] costs) typically assessed in transport infrastructure evaluations but also incorporate the additional benefits and avoided costs resulting from such a policy. Sustainable Asset Valuation (SAVi) assessments aim to clearly demonstrate these added benefits and avoided costs of transport policies and interventions and to what extent such interventions can yield mobility improvements or emission and energy consumption reductions. In other words, it encourages public authorities to understand the impacts of policy intervention across economic, social, and environmental parameters.

The German Federal Ministry for Economic Cooperation and Development recently invited the International Institute for Sustainable Development to customize the SAVi methodology to assess the suggested FAME II policy in India. The SAVi assessment of the FAME II policy in India will assess the economic viability of EVs, considering social, economic, and environmental indicators, to demonstrate the value for money for public support.

This SAVi assessment of the FAME II policy in India is part of a series of nine SAVi assessments on sustainable transport and mobility projects and policies that aim to raise awareness of sustainable transport infrastructure and inform decision-makers on the use of systemic approaches in supporting the transition to sustainable mobility.

1.3 Structure

Section 2 of the report presents the methodology, including an overview of system dynamics and the causal loop diagram (CLD) (system dynamics model) that was created for this assessment, as well as a summary of the valued investment and costs, added benefits, and avoided costs of this assessment. The scenarios and assumptions used in the assessment are indicated in Section 3. The section also summarizes the valuation methodologies and data sources of the added benefits and avoided costs used. Section 4 of the report presents the results starting with the integrated cost-benefit analysis (CBA) table that demonstrates the total cumulative monetary values generated by the FAME II policy scenarios. Section 5 concludes by summarizing the main lessons and results from the assessment of the FAME II policy scenarios.

2.0 Methodology

This section introduces the system dynamics methodology used for this SAVi assessment. It provides an overview of the CLD as well as a summary of the impacts of the FAME II policy, from a system dynamics perspective. The second part of this section summarizes the investments and costs, added benefits, and avoided costs used in the assessment. A more elaborate description and valuation process of the investments and costs, added benefits, and avoided costs is included in Section 3.

2.1 System Mapping

2.1.1 SYSTEMS THINKING AND SYSTEM DYNAMICS

The underlying dynamics of the FAME II policy in India, including driving forces and key indicators, are summarized in the CLD displayed in Figure 2. The CLD includes the main indicators analyzed during this SAVi assessment, their interconnections with other relevant variables, and the feedback loops they form. The CLD illustrates the interconnections of the economy, with a wide range of social and environmental parameters while highlighting key dynamics and potential trade-offs emerging from different development strategies envisaged for the FAME II policy. The CLD is the starting point for the development of the mathematical stock-and-flow model.

2.1.2 READING A CLD

CLDs aim to accurately capture causal relationships within a system in order to increase the effectiveness of relevant solutions and interventions. Therefore, CLDs establish causal links between variables. CLDs include variables and arrows, with the latter linking the variables together with a sign (either + or −) on each link, indicating a positive or negative causal relation (see Table 1):

- A causal link from variable A to variable B is positive if a change in A produces a change in B in the same direction.
- A causal link from variable A to variable B is negative if a change in A produces a change in B in the opposite direction.

Table 1. Causal relations and causality

Variable A	Variable B	Sign
⬇	⬇	+
⬆	⬆	+
⬆	⬆	−
⬇	⬇	−

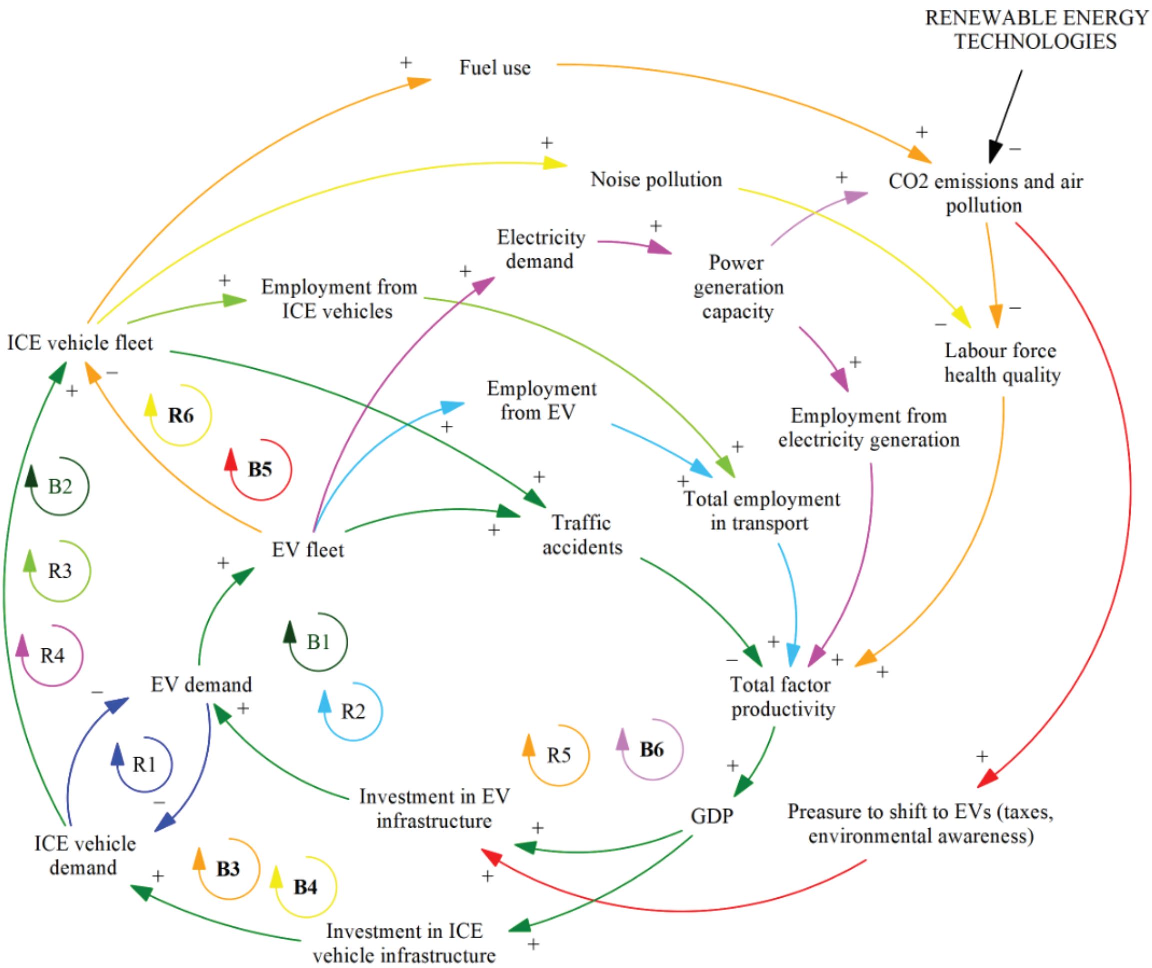
Source: Authors.

Circular causal relations between variables form causal, or feedback, loops. These can be positive or negative. **A negative feedback loop tends toward a goal or equilibrium, balancing the forces in the system (Forrester, 1961). A positive feedback loop can be found when an intervention triggers other changes that amplify the effect of that initial intervention, thus reinforcing it** (Forrester, 1961). CLDs also capture delays and non-linearity. In addition, reinforcing loops tend to increase and amplify everything happening in the system (i.e., action–reaction), whereas balancing loops represent a self-limiting process that aims to find balance and equilibrium. A detailed description of all the reinforcing and balancing loops for the FAME II policy in Coimbatore, India, is included in Appendix A.

2.1.3 CLD FOR THE FAME II POLICY IN INDIA

The impacts of the FAME II policy in India are manifold and diverse. These impacts are presented in a CLD or, more simply, a system map, shown in Figure 1. A more detailed description of the CLD is included in Appendix A.

Figure 1. CLD of the FAME II policy in India



Source: Authors' modelling

Note: ICE = internal combustion engine

2.2 Summary of Actions/Interventions Valued by the SAVi Assessment

The SAVi assessment provides the monetary valuation of the investments and costs, added benefits, and avoided costs of the FAME II policy in India. Table 2 lists all of the interventions considered in this assessment as well as stakeholders and indicators of relevance.

Table 2. Investment and cost, added benefits, and avoided costs considered in the SAVi assessment

Investment and costs, added benefit, or avoided cost	Stakeholders of relevance (government, households, private sector)	Social, environmental, economic
Subsidies for EVs	Households, private sector	Economic
Investment cost of EVs after subsidies	Government	Economic
Investment cost of EV chargers	Government	Economic
O&M costs of EVs	Households	Economic
Investment cost of power generation	Government	Economic
O&M costs of power generation	Government	Economic
Income creation from EV-related employment	Private sector, households	Economic
Income creation from power generation-related employment	Government, households	Economic
Avoided investment cost of ICE vehicles	Households	Economic
Avoided O&M costs of ICE vehicles	Households	Economic
Avoided air pollution	Households	Environmental
Avoided carbon dioxide (CO_2) emissions	Households	Environmental
Avoided accidents	Households	Social
Avoided fuel use	Households	Economics
Avoided noise pollution	Households	Social

3.0 Scenarios and Assumptions

This section primarily introduces the scenarios simulated for the SAVi assessment of the FAME II policy in India. Subsequently, it examines the underlying valuation methodologies of the SAVi assessment for the FAME II policy scenario, which also includes assumptions and data sources used in the FAME II policy model.

3.1 Scenarios in the FAME II Policy SAVi Assessment

This SAVi assessment includes four scenarios that are created using the following two components:

- **subsidy:** the total budget allocated by the government to the promotion of EVs (INR 100 billion) across three years (2023, 2024, 2025).
- **contribution:** the share of the cost of the EV that will be covered by the government subsidy as opposed to the share that will be covered by the consumer.

Table 3 provides an overview of the scenarios simulated for the SAVi assessment of the FAME II policy in India.

Table 3. Description of scenarios simulated in the SAVi assessment of the FAME II policy

	Assumptions	
Scenario	**Subsidy**	**Contribution**
Status quo	This is a “no action” scenario, in which the subsidy for EVs is not provided by the Indian government	
FAME II scenario 1	50% of the initial budget is used	40% of the cost of the EV is covered by the government
FAME II scenario 2	100% of the initial budget is used	40% of the cost of the EV is covered by the government
FAME II scenario 3	100% of the initial budget is used	35% of the cost of the EV is covered by the government
FAME II scenario 4	100% of the initial budget is used	25% of the cost of the EV is covered by the government

Source: Authors’ modelling.

This SAVi assessment considers a project period of 28 years, from 2022 to 2050. FAME II scenario 1 assumes that 50% of the initial budget is used by the Indian government across the 3 years planned and covers 40% of the cost of the EV. The consumer provides the remaining 60% of the cost. FAME II scenario 2 assumes that 100% of the initial subsidy amount is used by the Indian government. The contribution stays the same at 40% of the cost of the EV. FAME II scenario 3 assumes that 100% of the initial subsidy amount is used but the contribution is reduced to 35% of the cost of the EV. Similarly, FAME II scenario 4 assumes that 100% of the initial subsidy amount is used but the contribution is further reduced to 25% of the cost of the EV. The latter two scenarios were modelled to show what would happen if the consumer/user carries a bigger burden when buying an EV. A discount rate of 3.5% is used for the evaluation of all four scenarios, as per the Green Book guidance (UK Government, 2022).

3.2 Valuation Methodologies of the Investment and Costs, Added Benefits, and Avoided Costs

Table 4. Overview of key assumptions and sources used in the SAVi assessment of the FAME II policy in India

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
Investment and costs				
Subsidies for EVs	The total budget for phase II of the FAME scheme is one of the main inputs of the model, defining the number of EVs that are going to be purchased. The values are yearly and apply for 3 years only (2023, 2024, and 2025).	Total subsidies for electrified fleet	FAME II scenario 1: USD 200 million/ year or USD 600 in total, FAME II scenarios 2, 3, and 4: USD 400 million/year	Ministry of Heavy Industries, 2022

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
Investment cost of EVs after subsidies	Calculated by the model as the average cost per EV minus the subsidy per vehicle that corresponds to each scenario. The result is multiplied by the total number of EVs purchased.	Average cost per EV	By 2022: USD 60,000 per EV By 2040: USD 50,000 per EV	Ewing, 2023.
		Subsidy per EV	FAME II scenarios 1 and 2: USD 24,000 per EV (40% of the 2022 cost) FAME II scenario 3: USD 21,000 (35% of the 2022 cost) FAME II scenario 4: USD 15,000 (25% of the 2022 cost)	Model scenario assumption
	Calculated by the model based on the total budget for the subsidies and subsidies per EV	Total EVs purchased	FAME II scenario 1: 61,343 EVs FAME II scenario 2: 122,685 EVs FAME II scenario 3: 160,242 EVs FAME II scenario 4: 314,074 EVs	Model output
Investment cost for EV chargers	The total investment cost for EV chargers is calculated by multiplying the average cost per changer, the average number of chargers per EV, and the EV rate of change.	Average cost per charger	By 2020: USD 1,500/charger By 2030: USD 750/charger	European Association of Electrical Contractors–AIE, 2018
		Average number of chargers per EV	1 charger per EV	Assumption
	The 2023 rates repeat every 10 years, aligned with the EVs' lifetime.	EV rate of change	By 2024: FAME II scenario 1: 43,100 EVs/year FAME II scenario 2: 22,460 EVs/year FAME II scenario 3: 55,730 EVs/year FAME II scenario 4: 106,500 EVs/year	Model output

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
O&M costs of EVs	The total O&M costs of EVs result from the average O&M costs per EV multiplied by the number of vehicles in the electrified vehicle fleet.	Average O&M cost per EV	USD 440/EV/year	Assumption
	Stock variable that represents the cumulative number of EVs obtained under the FAME scheme. It is increased by the EV rate of change and decreased by the retirement of EVs, based on a lifetime of 10 years.	Electrified vehicle fleet	By 2050: FAME II scenario 1: 201,200 EVs FAME II scenario 2: 140,200 EVs FAME II scenario 3: 238,600 EVs FAME II scenario 4: 391,500 EVs	Model output
Investment cost of power generation	The total investment cost of power generation is the sum of the investment cost from large-scale hydropower (50% of the energy mix) and the investment cost from large-scale solar photovoltaic (PV) power (50% of the energy mix).[1] The investment costs for each technology are found by multiplying the cost per MW and the construction rate.	Investment cost per MW of hydropower largescale	By 2019: USD 1,800,000/MW By 2040: USD 1,950,000/MW	Masson et al., 2020
		Investment cost per MW of large-scale solar PV power	USD 862,738/MW	
		Construction rate of large-scale hydropower	By 2023: FAME II scenario 1: 9.64 MW/year FAME II scenario 2: 18.47 MW/year FAME II scenario 3: 23.88 MW/year FAME II scenario 4: 46.04 MW/year	Model output

[1] This assumption is ambitious but in line with India's aim to progressively increase its share of renewable energy sources. India is currently the world's third-largest producer of renewable energy, with 40% of its installed electricity capacity coming from renewable energy sources (Press Information Bureau, 2022).

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
		Construction rate of large-scale solar PV power	By 2023: FAME II scenario 1: 14.22 MW/year FAME II scenario 2: 27.26 MW/year FAME II scenario 3: 35.24 MW/year FAME II scenario 4: 67.93 MW/year	Model output
O&M costs of power generation	The total O&M costs of power generation are determined by adding the O&M costs from large-scale hydropower (50% of the energy mix) and the O&M costs from large-scale solar PV power (50% of the energy mix). The O&M costs for each technology are found by multiplying the O&M cost per MW and the power generation capacity.	O&M cost per MW of large-scale hydropower	USD 45,000/MW/year	Masson et al., 2020
		O&M cost per MW of large-scale solar PV power	USD 8,562/MW/year	
		Power generation capacity of large-scale hydropower	By 2050: FAME II scenario 1: 51.93 MW FAME II scenario 2: 76.86 MW FAME II scenario 3: 92.13 MW FAME II scenario 4: 154.6 MW	Model output
		Power generation capacity of large-scale solar PV power	By 2050: FAME II scenario 1: 74.46 MW FAME II scenario 2: 109.2 MW FAME II scenario 3: 130.6 MW FAME II scenario 4: 217.8 MW	Model output

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
Added benefits				
Income creation from EV-related employment	Total income creation from EVs is the total income generation from EVs multiplied by the fraction of discretionary spending. This benefit accounts only for the part of the employee's income that will circulate back to the economy. The total income generation from EVs is calculated as the sum of income generation from battery manufacturing and income generation from EV manufacturing. The former is the multiplication of the average manufacturing employment per battery produced, the EV rate of change, and the average annual salary in India. The latter is the multiplication of the average manufacturing employment per EV, the EV rate of change, and the average annual salary in India.	Average manufacturing employment per battery produced	0.02625 jobs/vehicle/year	European Association of Electrical Contractors–AIE, 2018
		Average manufacturing employment per EV	0.2 jobs/vehicle/year	Assumption
		Fraction of discretionary spending	30%	Assumption
		Average annual salary in India	INR 383,000/person/year	Salary Explorer, 2023
	The 2023 rates repeat every 10 years, aligned with the EVs' lifetime.	EV rate of change	By 2023: FAME II scenario 1: 43,100 EVs/year FAME II scenario 2: 22,460 EVs/year FAME II scenario 3: 55,730 EVs/year FAME II scenario 4: 106,500 EVs/year	Model output

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
Income creation from power generation-related employment		Construction and installation employment per MW of hydropower capacity	By 2010: 6 jobs/MW By 2030: 7.91 jobs/MW	Rutovitz et al., 2015
		Manufacturing employment per MW of hydropower capacity	By 2010: 1.5 jobs/MW By 2030: 3.74 jobs/MW	Rutovitz et al., 2015
		Power generation capacity under construction, large-scale hydropower	By 2023: FAME II scenario 1: 0.56 MW FAME II scenario 2: 1.08 MW FAME II scenario 3: 1.39 MW FAME II scenario 4: 2.69 MW	Model output
		Construction time	0.0833 years	Assumption
		Construction and installation employment per MW of solar PV power capacity	By 2010: 11 jobs/MW By 2030: 7.67 jobs/MW	Assumption
		Manufacturing employment per MW of solar PV power capacity	By 2010: 6.9 jobs/MW By 2030: 3.95 jobs/MW	Assumption

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
		Power generation capacity under construction, large-scale solar PV power	By 2023: FAME II scenario 1: 0.83 MW FAME II scenario 2: 1.59 MW FAME II scenario 3: 2.06 MW FAME II scenario 4: 3.97 MW	Model output
		Fraction of construction and installation taking place domestically	1	Assumption
		O&M employment per MW of hydropower capacity	By 2012: 0.30 jobs/MW By 2030: 0.214 jobs/MW	Rutovitz et al., 2015
		Power generation capacity of large-scale hydropower	By 2050: FAME II scenario 1: 51.93 MW FAME II scenario: 76.86 MW FAME II scenario 3: 92.13 MW FAME II scenario 4: 154.6 MW	Model output
		O&M employment per MW of solar PV power capacity	By 2012: 0.30 jobs/MW By 2030: 0.413 jobs/MW	Assumption

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
		Power generation capacity of large-scale solar PV power	By 2050: FAME II scenario 1: 74.46 MW FAME II scenario 2: 109.2 MW FAME II scenario 3: 130.6 MW FAME II scenario 4: 217.8 MW	Model output
		Average annual salary in India	INR 383,000/person/year	Salary Explorer, 2023
		Fraction of discretionary spending	30%	Assumption
Avoided costs				
Investment costs of ICE vehicles	To estimate the total avoided investment costs of ICE vehicles, the number of ICE vehicles that are replaced by EVs was multiplied by the cost of each ICE vehicle.	Average cost per ICE vehicle	USD 67,000/vehicle	Economic Research Institute for ASEAN and East Asia, 2018
	The 2023 rates repeat every 10 years, aligned with the EVs' lifetime.	EV rate of change	By 2023: FAME II scenario 1: 43,100 EVs/year FAME II scenario 2: 22,460 EVs/year FAME II scenario 3: 55,730 EVs/year FAME II scenario 4: 106,500 EVs/year	Model output

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
O&M costs of ICE vehicles	To estimate the total avoided O&M costs of ICE vehicles, the average yearly number of ICE vehicles (the vehicle stock of ICE vehicles) was multiplied by the yearly O&M costs per ICE vehicle.	Average O&M cost per ICE vehicle	USD 1,500/vehicle/year	Assumption
	Stock variable that represents the cumulative number of EVs obtained under the FAME scheme. It is increased by the EV rate of change and decreased by the retirement of EVs based on a lifetime of 10 years.	Electrified vehicle fleet	By 2050: FAME II scenario 1: 201,200 EVs FAME II scenario 2: 140,200 EVs FAME II scenario 3: 238,600 EVs FAME II scenario 4: 391,500 EVs	Model output
Air pollution	This cost considers the avoided air pollution from the decrease in use of ICE vehicles. It is calculated as the total km travelled by ICE vehicles multiplied by the cost of air pollution per vehicle-km (v-km).	Cost of air pollution per v-km	IDR 1.53/v-km or USD 0.02/v-km	International Institute of Sustainable Development, 2019
		Total km travelled for ICE vehicles	By 2023: Business-as-usual (BAU) scenario: 152.2 billion v-km FAME II scenario 1: 152 billion v-km FAME II scenario 2: 151.9 billion v-km FAME II scenario 3: 151.8 billion v-km FAME II scenario 4: 151.4 billion v-km	Model output

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
CO_2 emissions		Social cost of carbon	USD 0.031 kg	Nordhaus, 2017
		Emission intensity of vehicle fuel	73.3 tonnes CO_2/TJ	Volker Quaschning, 2022
		Energy use of ICE vehicles	By 2050: BAU scenario: 532,112 TJ/year FAME II scenario 1: 529,299 TJ/year FAME II scenario 2: 526,488 TJ/year FAME II scenario 3: 524,766 TJ/year FAME II scenario 4: 517,717 TJ/year	Model output
		Grid emission factor of electrified vehicles	0	Model output
		Energy use of EVs	By 2050: BAU scenario: 433.56 TJ/year FAME II scenario 1: 889.82 TJ/year FAME II scenario 2: 1346.09 TJ/year FAME II scenario 3: 1625.43 TJ/year FAME II scenario 4: 2769.56 TJ/year	Model output

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
Accidents		Cost of accidents per severity for ICE vehicles	Fatal: INR 2,838,770/ accident Serious injury: INR 217,924/accident Minor injury: 36,953 INR/accident	Bora et al., 2018
		Total annual number of accidents per severity for ICE vehicles	Example for minor injury accident type, year 2050: BAU scenario: 1,536 accidents/year FAME II scenario 1: 1,528 accidents/year FAME II scenario 2: 1,520 accidents/ year FAME II scenario 3: 1,515 accidents/year FAME II scenario 4: 1,494 accidents/ year	Model output
		Cost of accidents per severity for EVs	Fatal: INR 2,838,770/ accident Serious injury: INR 217,924/accident Minor injury: INR 36,953/accident	Assumption of the same values for ICE vehicles
		Total annual number of accidents per severity for EVs	Example for minor injury accident type, year 2050: BAU scenario: 6.94 accidents/year FAME II scenario 1: 14.24 accidents/year FAME II scenario 2: 21.55 accidents/year FAME II scenario 3: 26.02 accidents/year FAME II scenario 4: 44.34 accidents/ year	Model output

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
		Percentage of reduction in accidents per v-km for EVs	10%	Assumption
		Share of accidents per severity	Fatal: 20% Serious injury: 16% Minor injury: 64%	Assumption
Fuel use	The total avoided costs of fuel use as a result of the introduction of EVs are estimated based on the reduction in ICE vehicle trips. The calculation is determined by multiplying the total km travelled of ICE vehicles, the average fuel use per v-km in litres, and the cost of fuel per litre.	Average fuel use per v-km in litres	0.08 litre/km	School of Oceanography, University of Washington, 2005
		Total km travelled by ICE vehicles	By 2023: BAU scenario: 152.2 billion v-km; FAME II scenario 1: 152 billion v-km; FAME II scenario 2: 151.9 billion v-km; FAME II scenario 3: 151.8 billion v-km; FAME II scenario 4: 151.4 billion v-km	
		Cost of fuel per litre	INR 104.18/litre	GlobalPetrolPrices.com, 2023

Parameters for calculating added benefits and avoided costs

Investment and costs, added benefits, and avoided costs	Description	Indicator	Value	Data source
Noise pollution	The total cost of noise pollution is the sum of the cost of noise pollution from ICE vehicles and the cost of noise pollution from EVs. Given that the unit cost per km of EVs is lower than ICE vehicles, a transition to EVs generated avoided noise pollution costs. The cost of noise pollution from ICE vehicles is determined by multiplying the cost of noise per km for ICE vehicles and the total km travelled by ICE vehicles. The cost of noise pollution from EVs is determined by multiplying the cost of noise per km for EVs and the total km travelled by EVs.	Cost of noise per km for ICE vehicles	EUR 0.14/km	van Essen et al., 2011
		Total km travelled by ICE vehicles	By 2023 BAU scenario: 152.2 billion v-km FAME II scenario 1: 152 billion v-km FAME II scenario 2: 151.9 billion v-km FAME II scenario 3: 151.8 billion v-km FAME II scenario 4: 151.4 billion v-km	Model output
		Cost of noise per km for EVs	0.1 EUR/km	Assumption based on the costs of noise from ICE vehicles
		Total km travelled by EVs	By 2023: BAU scenario: 84.2 million v-km FAME II scenario 1: 229.8 million v-km FAME II scenario 2: 375.4 million v-km FAME II scenario 3: 464.5 million v-km FAME II scenario 4: 829.7 million v-km	Model output

4.0 Results

The results of the SAVi assessment of the FAME II policy in India are presented in two parts: a summary and analysis of the integrated CBA table, followed by a summary of the benefit-cost ratios (BCRs) calculated. The second part will also examine the valued economic, social, and environmental added benefits and avoided costs of the analysis, independently.

Table 5 shows the integrated CBA that includes cumulative values over the project period (2022–2050). It is called an integrated analysis because, in addition to the investments and costs, a wide range of valued economic, social, and environmental added benefits and avoided costs are integrated in the analysis.

4.1 Integrated CBA

Table 5. Integrated CBA (discounted at 3.5% over 28 years)

Integrated CBA	FAME II scenario 1 (Subsidy 50%, contribution 40%)	FAME II scenario 2 (Subsidy 100%, contribution 40%)	FAME II scenario 3 (Subsidy 100%, contribution 35%)	FAME II scenario 4 (Subsidy 100%, contribution 25%)
Investment and costs (INR billion)	**539.07**	**1,078.34**	**1,408.59**	**2,761.30**
Subsidies for EVs	39.63	79.26	79.26	79.26
Investment cost of EVs after subsidies	453.14	906.27	1,207.96	2,443.70
Investment cost of EV chargers	8.54	17.08	22.30	43.71
O&M costs of EVs	30.91	61.82	80.74	158.26
Investment cost of power generation	5.17	10.55	13.92	27.75
O&M costs of power generation	1.69	3.37	4.40	8.63
Added benefits (INR billion)	**3.55**	**7.09**	**9.27**	**18.17**
Income generation from EV-related employment	3.43	6.85	8.95	17.54

Integrated CBA	FAME II scenario 1 (Subsidy 50%, contribution 40%)	FAME II scenario 2 (Subsidy 100%, contribution 40%)	FAME II scenario 3 (Subsidy 100%, contribution 35%)	FAME II scenario 4 (Subsidy 100%, contribution 25%)
Income generation from power generation-related employment	0.12	0.24	0.32	0.63
Avoided costs (INR billion)	**849.66**	**1,699.25**	**2,219.45**	**4,350.03**
Investment cost of ICE vehicles	599.11	1,198.23	1,565.03	3,067.46
O&M costs of ICE vehicles	105.37	210.75	275.26	539.51
Air pollution	21.29	42.57	55.60	108.96
CO_2 emissions	7.35	14.70	19.20	37.62
Accidents	0.01	0.03	0.03	0.07
Fuel use	115.97	231.87	302.87	593.56
Noise pollution	0.56	1.11	1.45	2.85
Cumulative net benefits	**314.14**	**628.00**	**820.12**	**1,606.90**
BCR	1.58	1.58	1.58	1.58
BCR – government	0.83	0.83	1.08	1.45
BCR – households and private sector	1.67	1.67	1.63	1.59

Source: Authors' modelling.

FAME II scenario 4 yields cumulative benefits of INR 1,606.90 billion. Scenario 3 shows the highest net benefits from the perspective of the government because the government's contribution is lowest, at 25%. This means that the share of the cost of the EV that will be covered by the consumer/user will be higher. FAME II scenario 3 shows the second-highest net benefits (INR 820.12 billion) from the perspective of the government because the government's contribution is at 35%. FAME II scenarios 1 and 2 include a 40% contribution from the government. FAME II scenario 2 has double the cumulative net benefits (INR 628 billion) compared to FAME II scenario 1 (INR 314.14 billion) because in the former, 100% of the subsidy money for the promotion of EVs (INR 100 billion) is used, and in the latter case only 50% of the subsidy money is used.

The SAVi assessment of the FAME II policy in India starts with the investments and costs. As shown in the first part of the integrated CBA in Table 5, the investments and costs include subsidies for EVs, investment costs for EVs and EV chargers, O&M costs for EVs and investment, and O&M costs for power generation. Across all four FAME II scenarios, the investment costs for EVs after subsidies are the highest costs, followed by the cost of the subsidy itself and the O&M costs of EVs. Of these three types of costs, only the subsidy itself is borne by the government, with the other two costs being borne by consumers/users. Table 6 displays all the investments and costs of the different FAME II scenarios as cumulative values over the period 2022–2050.

Table 6. Investment and costs of the FAME II scenarios (INR billion, discounted at 3.5%)

Integrated CBA	FAME II scenario 1 (subsidy 50%, contribution 40%)	FAME II scenario 2 (subsidy 100%, contribution 40%)	FAME II scenario 3 (subsidy 100%, contribution 35%)	FAME II scenario 4 (subsidy 100%, contribution 25%)
Investment and costs	**539.07**	**1,078.34**	**1,408.59**	**2,761.30**
Subsidies for EVs	39.63	79.26	79.26	79.26
Investment cost of EVs after subsidies	453.14	906.27	1,207.96	2,443.70
Investment cost of EV chargers	8.54	17.08	22.30	43.71
O&M costs of EVs	30.91	61.82	80.74	158.26
Investment cost of power generation	5.17	10.55	13.92	27.75
O&M costs of power generation	1.69	3.37	4.40	8.63

Source: Authors' modelling.

The SAVI assessment of the FAME II policy in India also calculates monetary values for a range of added benefits and avoided costs of the FAME II policy scenarios. Table 7 excludes the investments and costs section of the integrated CBA and summarizes the cumulative monetary values of the added benefits and avoided costs over the project period (2022–2050). The avoided investment costs of ICE vehicles show the highest values across all four FAME II scenarios, followed by the avoided costs of fuel use as a result of the replacement of ICE vehicles with EVs, and to a lesser extent the avoided O&M costs of ICE vehicles. All of the above costs are borne by consumers/users and not by the government.

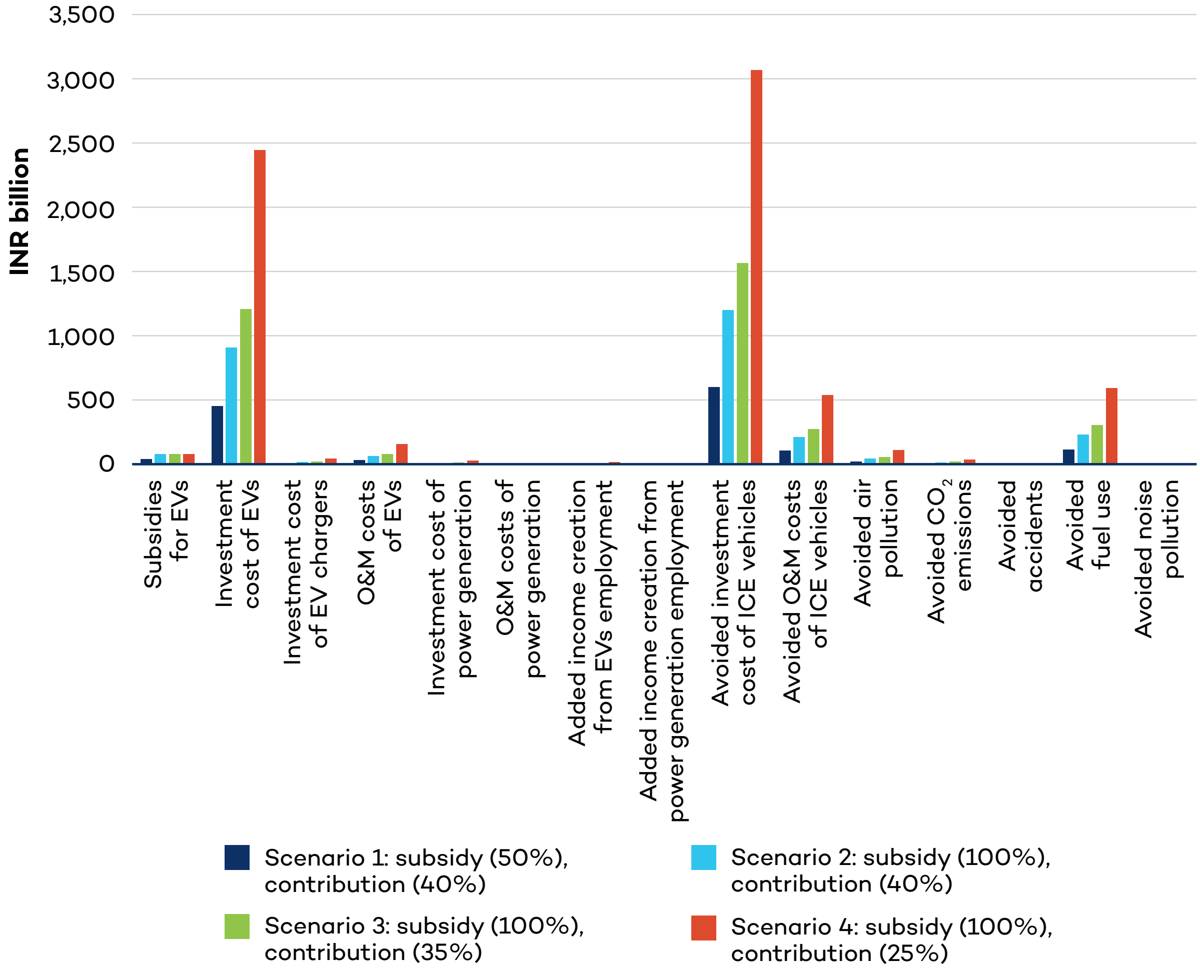
Table 7. Added benefits and avoided costs of the FAME II scenarios (INR billion, discounted at 3.5%)

Integrated CBA	FAME II scenario 1 (Subsidy 50%, contribution 40%)	FAME II scenario 2 (Subsidy 100%, contribution 40%)	FAME II scenario 3 (Subsidy 100%, contribution 35%)	FAME II scenario 4 (Subsidy 100%, contribution 25%)
Total added benefits and avoided costs	**853.21**	**1,706.34**	**2,228.71**	**4,368.20**
Added benefits	**3.55**	**7.09**	**9.27**	**18.17**
Income generation from EV-related employment	3.43	6.85	8.95	17.54
Income generation from power generation-related employment	0.12	0.24	0.32	0.63
Avoided costs	**849.66**	**1,699.25**	**2,219.45**	**4,350.03**
Investment cost of ICE vehicles	599.11	1,198.23	1,565.03	3,067.46
O&M costs of ICE vehicles	105.37	210.75	275.26	539.51
Air pollution	21.29	42.57	55.60	108.96
CO_2 emissions	7.35	14.70	19.20	37.62
Accidents	0.01	0.03	0.03	0.07
Fuel use	115.97	231.87	302.87	593.56
Noise pollution	0.56	1.11	1.45	2.85

Source: Authors' modelling.

All of the above investment costs, added benefits, and avoided costs of the FAME II policy across all four FAME II scenarios are shown in Figure 2.

Figure 2. Investment costs, added benefits, and avoided costs of the FAME II policy in India



Source: Authors' modelling

In addition, three BCRs have been calculated: the conventional BCR, the BCR from the perspective of the government, and the BCR from the perspective of households and the private sector. The conventional BCR considers all investments and costs and the full range of economic, social, and environmental added benefits and avoided costs. The BCR from the perspective of the government considers only the impacts that are borne by the government and excludes the ones that are borne by consumers/users, such as investment in EVs, EV chargers, and the O&M costs of EVs, as well as avoided investment and O&M costs of ICE vehicles and fuel use. The BCR from the perspective of households and the private sector considers only the impacts that are borne by the consumers/users of EVs and excludes the ones that are mostly borne by the government, such as the subsidy itself, income creation from EV- and power generation-related employment, and avoided costs of air and noise pollution, CO_2 emissions, and traffic accidents.

The conventional BCR is the same across all four FAME II scenarios (1.58) because regardless of the investment, the benefits per EV sold are the same. In other words, the return on investment stays the same, and any changes are proportional. The benefits are accrued per EV, and, therefore, the more EVs that are sold, the more the absolute benefits. For this reason, we modelled the BCR from the perspective of the government that provides the subsidy for the EVs and the BCR from the perspective of consumers/users that want to buy the EVs. If we consider both the government and consumers/users, the BCR does not change, whereas if we consider the government and households individually, the BCR changes. Table 8 shows the two BCRs across the four FAME II scenarios.

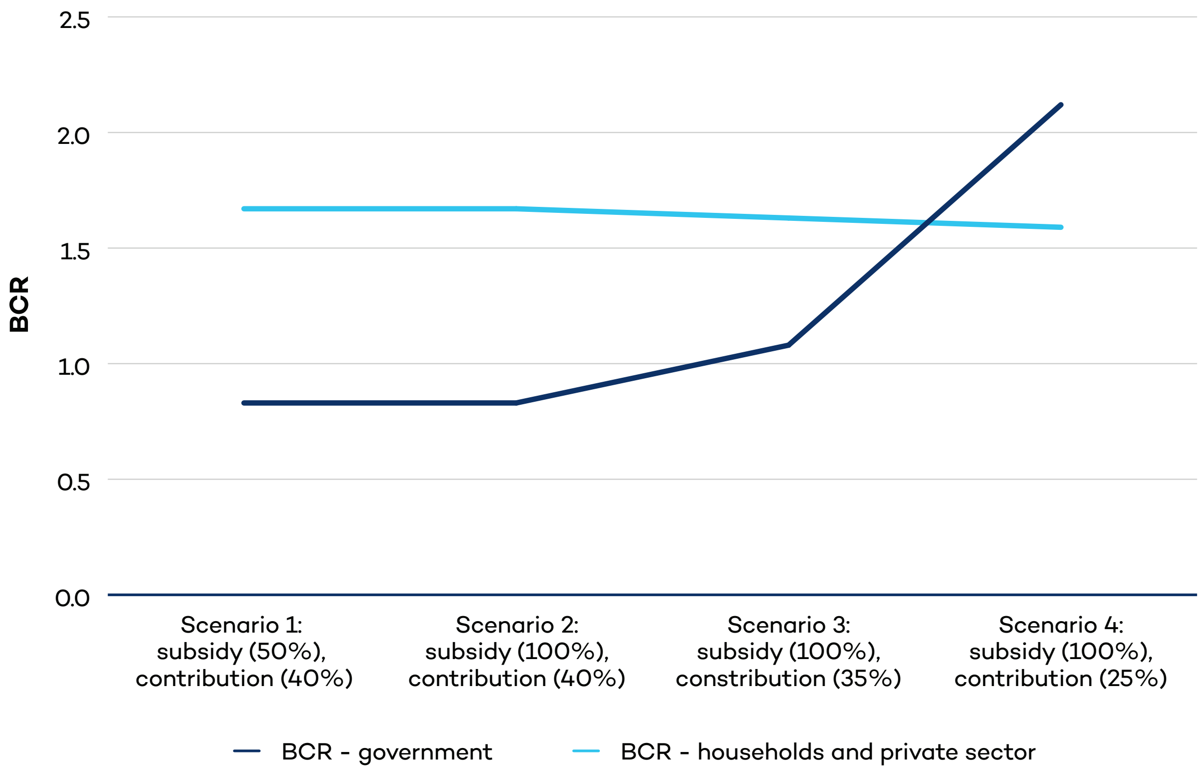
Table 8. BCRs across FAME II scenarios (discounted at 3.5%)

	Scenarios			
BCRs (based on discounted values)	**FAME II scenario 1**	**FAME II scenario 2**	**FAME II scenario 3**	**FAME II scenario 4**
BCR	1.58	1.58	1.58	1.58
BCR – government	0.83	0.83	1.08	2.12
BCR – households and the private sector	1.67	1.67	1.63	1.59

Source: Authors' modelling.

According to Table 8, the lower the government's subsidy contribution to the total cost of an EV, the lower the BCR from the perspective of households and the private sector and the higher the BCR from the perspective of the government. This is shown clearly in Figure 3.

Figure 3. BCRs from the perspective of the government and households and the private sector across all four FAME II scenarios



Source: Authors' modelling

The above findings are intuitive because the BCR from the perspective of the government becomes significant as the subsidy's contribution is reduced, whereas the BCR from the perspective of households and the private sector decreases as a higher share of the cost of an EV is borne by these groups. It is important to find the right balance between reducing the government's subsidy contribution in order for a higher number of EVs to be subsidized and providing the right incentives for households and the private sector to buy EVs.

5.0 Discussion and Conclusion

The SAVi assessment of the FAME II policy provides a range of comprehensive results that aim to inform decision-makers responsible for deciding whether to invest in sustainable transport policy in India. Considering all four FAME II scenarios, the results highlight some key takeaways:

- The two FAME II scenarios that include a lower government contribution or share of the cost of the EV that will be covered by the consumer/user (FAME II scenario 4 – subsidy 100%, contribution 25% and FAME II scenario 3 – subsidy 100%, contribution 35%) show the highest and second-highest cumulative benefits from the perspective of the government among all FAME II scenarios considered. Between FAME II scenario 1 (subsidy 50%, contribution 40%) and FAME II scenario 2 (subsidy 100%, contribution 40%), the latter has double the cumulative net benefits of the former because 100% of the subsidy money for the promotion of EVs (INR 100 billion) is used, as opposed to only 50%.
- Among all the investment costs, added benefits, and avoided costs calculated in this SAVi assessment, the avoided investment costs of ICE vehicles show the highest values across all four FAME II scenarios, followed by the avoided costs of fuel use, as a result of the replacement of ICE vehicles with EVs, and the avoided O&M costs of ICE vehicles. Importantly, all of these costs are borne by consumers/users and not by the government.
- Lastly, the conventional BCR is the same across all four FAME II scenarios (1.58) because regardless of the investment, the benefits per EV sold are the same. The benefits are accrued per EV, and, therefore, the more EVs that are sold, the more the absolute benefits. If we consider both the government and households and the private sector or consumers/users, the BCR does not change, whereas if we consider the government and households individually, the BCR changes. The lower the government's subsidy contribution to the total cost of an EV, the lower the BCR from the perspective of households and the private sector and the higher the BCR from the perspective of the government.

The above findings are intuitive because the BCR from the perspective of the government becomes significant as the subsidy's contribution is reduced, whereas the BCR from the perspective of households and the private sector decreases as a higher share of the cost of an EV is borne by them. It is important to find the right balance between reducing the government's subsidy contribution in order for a higher number of EVs to be subsidized and providing the right incentives for households and the private sector to buy EVs.

Lastly, this SAVi assessment assumes that private investment in EVs will cover the government's gap in the event that the subsidy is not provided. Similar assumptions are based on a combination of factors that are difficult to quantify, including the speed of the global uptake of EVs, the EV market maturity in India, technological advances, future policies, and so on. The EV market in India has currently reached a certain level of maturity for some types of EVs, such as two-wheelers. In this context, it is assumed that reducing the subsidy will not have an enormous impact on the advancement of EVs in the long term.

Integrated assessments such as this one conducted by employing the SAVi methodology can help make a stronger case for sustainable transport policies and other forms of sustainable mobility solutions. The application of SAVi facilitates a wide range of performance assessments beyond those currently employed in assessing the FAME II policy in India. It offers valuable insights to government, citizens, and investors regarding the various elements that contribute to the creation of value in sustainable infrastructure projects and policies. This can inform future strategies for sustainable mobility and support the case for improved transportation investments in cities. Additionally, it aids in identifying sources of funding and financing that align with the diverse financial and social returns of the project.

It is crucial that policy-makers design and implement processes that enable the recognition and accounting of the wider benefits of sustainable mobility infrastructure so that decisions are made in favour of transport investments that provide the greatest benefits to society while minimizing the environmental impacts.

6.0 References

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Appendix A. Causal Loop Diagram Description of the FAME II Policy in India

Description of the FAME II Policy Causal Loop Diagram

REINFORCING LOOPS (R)

The R1 is a reinforcing loop that represents the demand shift dynamics between internal combustion engines (ICEs) and electric vehicles (EVs). An increase in EV demand generates a decrease in ICE vehicle demand, which in turn generates more increase in EV demand. Conversely, if the demand for EVs decreases, the demand for ICE vehicles increases, decreasing the demand for EVs next time around.

The R2 loop describes how the demand for EVs is driven by employment related to EVs. An increase in EV demand generates an increase in the EV fleet, increasing the employment related to EVs and total employment in transport. Increasing employment in transport generates an increase in total factor productivity, increasing the GDP, which increases the investment in EV infrastructure and EV demand next time around.

The R3 loop describes the demand for ICE vehicles driven by employment related to ICE vehicles. An increase in ICE vehicle demand generates an increase in the ICE vehicle fleet, increasing the employment related to ICE vehicles and total employment in transport. Increasing employment in transport increases total factor productivity, resulting in an increase in GDP, which increases the investment in ICE vehicle infrastructure and ICE vehicle demand again.

The R4 loop describes the demand for EVs driven by employment from electricity generation. An increase in EV demand generates an increase in the EV fleet, increasing the electricity demand and hence the power generation capacity, which generates employment. Employment from electricity generation increases total factor productivity, resulting in an increase in GDP, which increases the investment in EV infrastructure and EV demand next time around.

The R5 loop represents the EV demand driven by fuel use from ICE vehicles. An increase in EV demand increases the EV fleet and decreases the ICE vehicle fleet as a consequence. A smaller number of ICE vehicles generates less fuel use and less carbon dioxide (CO_2) emissions and air pollution, which increases air quality for the labour force. An increase in air quality results in an increase in the total factor productivity, increasing the GDP and the investment in EV infrastructure, increasing EV demand next time around.

The R6 loop explains how EV demand is driven by noise pollution. An increase in EV demand produces an increase in the EV fleet and a decrease in the ICE vehicle fleet. Such a decrease generates less noise pollution and increases air quality for the labour force, increasing the total factor productivity, as well. Increasing the total factor productivity increases GDP, which increases the investment in EV infrastructure and hence the demand for EVs.

BALANCING LOOPS (B)

The B1 balancing feedback loop shows the effect of accidents on EV demand. The more EV demand, the larger the EV fleet and the more accidents. The more traffic accidents, the less total factor productivity, the lower the GDP, and the less investment in EV infrastructure, generating less EV demand.

The B2 loop represents the effect of accidents on ICE vehicle demand. An increase in ICE vehicle demand generates an increase in the ICE vehicle fleet and an increase in traffic accidents as a consequence. The increase in traffic accidents produces a decrease in the total factor productivity, decreasing GDP and investment in ICE vehicle infrastructure, which in turn generates a decrease in demand for ICE vehicles.

The B3 loop reflects the effect of CO_2 emissions and air pollution on ICE vehicle demand. The greater the ICE vehicle demand, the larger the ICE vehicle fleet and the more fuel use. The more fuel use, the more CO_2 emissions and air pollution and the poorer the air quality for the labour force. The lower the air quality, the lower the total factor productivity and GDP, which reduces the investment in ICE vehicle infrastructure and ICE vehicle demand next time around.

The B4 loop explains the effect of noise pollution on ICE vehicle demand. An increase in ICE vehicle demand and hence the ICE vehicle fleet generates an increase in the noise pollution from traffic, which decreases the air quality for the labour force and the total factor productivity as a consequence. This decrease generates a decrease in GDP and in the investment in ICE vehicle infrastructure, decreasing the ICE vehicle demand the next time around.

The B5 loop reflects the effect of CO_2 emissions and air pollution on EV demand. The lower the EV demand, the smaller the EV fleet and the larger the ICE vehicle fleet. The larger the ICE vehicle fleet, the greater the fuel use, CO_2 emissions, and air pollution, which generates more pressure to shift to EVs. The more pressure, the more investment in EV infrastructure and the more EV demand next time around.

The B6 loop explains the effect of CO_2 emissions from power generation on EV demand. An increase in EV demand generates an increase in the EV fleet and in the electricity demand. An increase in electricity demand increases the power generation capacity, CO_2 emissions, and air pollution. An increase in emissions decreases the labour force's air and health quality and the total factor productivity, decreasing GDP as well. A decrease in GDP generates a decrease in investment in EV infrastructure, generating a decrease in EV demand.

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