INITIATIVE FOR Climate Action Transparency (ICAT)

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Strengthening National MRV Systems – Options and Approaches for India

MRV Framework for Passenger Road Transport Policies and Actions

Initiative for Climate Action Transparency

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Initiative for Climate Action Transparency: ICAT
MRV Framework for Energy Conservation Building Code for Large Commercial Buildings

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Source:
https://www.eeslindia.org/content/raj/eesl/en/Programmes/ElectricVehicles/PhotoGallery.html

Date of the deliverable: March 2019

DISCLAIMER

PREPARED UNDER

Initiative for Climate Action Transparency (ICAT) project supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Children's Investment Fund Foundation (CIFF), the Italian Ministry of Ecological Transition (IMET) and ClimateWorks.

The ICAT project is managed by the United Nations Office for Project Services (UNOPS)

PUBLISHED BY

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ACKNOWLEDGEMENTS

We want to acknowledge and express gratitude to the project advisory team, comprising Mr I. V. Rao (Visiting Senior Fellow, TERI), Mr Sanjay Seth (Senior Director, TERI),

Mr Karan Mangotra (Associate Director, TERI) and Ms Neha Pahuja (Fellow, TERI) for their valuable guidance and suggestions throughout the preparation of this report.

We would like to thank Mr Narasimha Raju (Senior Director, Southern Chapter, TERI) and Mr Shashidhar (Karnataka Udyog Mitra) for providing valuable inputs on the recent policy developments and implementation status of e-vehicle policies in the State of Karnataka. Thanks are also due to Mr Didar Singh (Senior Fellow, Society for Development Studies) for providing valuable inputs on the existing institutional framework for implementing FAME Scheme and possible approaches for developing MRV framework in the road transport sector. We are grateful to representatives from Karnataka State Finance Corporation for guiding us to understand the data collection mechanisms and institutional set up related to transport-related policies and schemes at the state level.

We extend our gratitude to Ms Manju Menon (Project Manager, Namma auto), Mr Zafar Iqbal (Goenka Motors) and representatives from start-ups in e- mobility domain such as Bounce, RYDES for highlighting the role of non-state actors (including private sector) in establishing an integrated MRV framework and sharing information related to key implementation barriers (policy and finance) in the states and cities.

Our sincere thanks to Dr Jyoti Painuly for the overall guidance and extensive review comments on various drafts of the report.

LIST OF ACRONYMS

ASSOCHAM: The Associated Chambers of Commerce and Industry of India
BS: Bharat Stage
CAFE: Corporate Average Fuel Economy
CAGR: Compound Annual Growth Rate
CIFF: The Children´s Investment Fund Foundation
CNG: Compressed Natural Gas
DFCs: Dedicated Freight Corridors
DHI: Department of Heavy Industries
EV: Electric Vehicle
EY: Ernst & Young
FAME: Faster Adoption and Manufacture of (Hybrid and) Electric Vehicles
GDP: Gross Domestic Product
GHG: Greenhouse Gas
GST: Goods and Services Tax
GVW: Gross Vehicle Weight
IC: Internal Combustion
ICAT: Initiative for Climate Action Transparency
IEA: International Energy Agency
IPCC: Intergovernmental Panel on Climate Change
LCMP: Low-carbon Mobility Plan
LDVs: Light-duty Vehicles
MoEFCC: Ministry of Environment, Forest and Climate Change
MoRTH: Ministry of Road Transport and Highways
MoSPI: Ministry of Statistics and Programme Implementation
MRTS: Mass Rapid Transit System
MRV: Monitoring, Reporting, and Verification
MSMEs: Ministry of Micro, Small, and Medium Enterprises
MTOE: Million Tonnes of Oil Equivalent
NDCs: Nationally Determined Contributions
NEMMP: National Electric Mobility Mission Plan
PKM: Passenger kilometres
PPAC: Petroleum Planning and Analysis Cell
PUC: Pollution Under Control
RTO: Regional Transport Office
TEDDY: TERI Energy & Environment Data Diary and Yearbook
TERI: The Energy and Resources Institute
UDP: UNEP DTU Partnership
UNFCCC: United Nations Framework Convention on Climate Change
UNOPS: United Nations Office for Project Services
VKM: Vehicle Kilometres
xEV: Hybrid/electric vehicle

EXECUTIVE SUMMARY

Background

The transport sector in India accounted for 24% of the commercial energy demand in 2016 and it was the second-largest energy consumer after the industry sector (TEDDY 2018). In 2010, the sector accounted for 10% of the greenhouse gas (GHG) emissions of India and therefore holds an important place for achievement of India's Nationally Determined Contributions (NDCs) targets to reduce the emissions intensity of its gross domestic product (GDP) by 33%–35% below 2005 levels by 2030 and NDC targets in future.

India is taking several initiatives for low-carbon mobility and promotion of electric mobility is an important strategy for this. Ambitious targets for electric vehicle have been set in the recently announced Faster Adoption and Manufacture of (Hybrid and) Electric Vehicles (FAME) Scheme. The success of FAME is dependent on how efficiently and effectively the announced targets are met. Hence, there is a need to put in place an assessment framework which may help policymakers to review the progress towards the goals for electric mobility and also their contribution towards reduction in emissions intensity.

A lot of developing countries find it a challenging task to collate information regarding the implementation of transport sector policies due to weak institutional structures and a lack of coordination amongst relevant stakeholders. The International Climate Action for Transparency (ICAT) is helping several developing countries to improve transparency regarding their mitigation and adaptation actions and in developing frameworks for monitoring, reporting, and verification (MRV). This report provides MRV approaches that could be useful to track the progress of the electric vehicles (EV) policies for light-duty vehicles (LDVs) in India.

Framework for Analysing Mitigation Policies and Schemes to Promote Electric Mobility

Electric vehicles are being promoted through the FAME policy at the national level and supported by state-level EV policies in several states. FAME also includes hybrid vehicles and therefore, will lead to an improvement in the efficiency of vehicles running on fossil fuels. Similarly, Corporate Average Fuel Economy (CAFÉ) standards that have come in force in 2017 will progressively improve the efficiency standards for LDVs. Enhanced efficiency standards will increase the upfront cost of the conventional IC engine vehicles and thereby reduce the price difference between electric/ hybrid cars and conventional IC engine vehicles. In addition to the above two policies, the decision to move directly from pollution standard BS-IV to BS-VI is expected to create a favourable enabling environment for electric vehicles since electric vehicles have zero local pollution.

Thus, electric vehicles are being promoted through multiple policies/programmes at the national and state levels. In this kind of scenario, it is not feasible to analyse the impact of a single policy, and therefore, we have adapted methodology available in the Compendium on Greenhouse Gas Baselines and Monitoring for Passenger and Freight Transport[1] for developing an MRV framework for EVs in India, which analyses combined impact of policies. The compendium uses causal diagrams to relate the policies to intended effects and rebound effects and then to the results (outcomes) measured through indicators. The indicators provide the basis for estimating the GHG impacts of the policies.

The overall impact of the FAME Scheme, BS Standards and CAFÉ standards on GHG reduction will come

1 Compendium on GHG Baselines and Monitoring for Passenger and Freight Transport, Second revised edition, February 2018. Details available at: https://unfccc.int/sites/default/files/resource/Transport_0.pdf

from two opposite effects. Reduction in fossil fuel use from business as usual scenario is inevitable and this will bring down GHG emissions; however, there will be increased use of electricity due to increased share of EVs, which will increase the GHG emissions. Therefore, the net effect will depend on the GHG intensity of the electricity used by electric vehicles.

Methodology for Estimating GHG Emissions

A wide variety of tools are available for estimating GHG emissions, and a compilation of the same is provided in Annexure V. The report provides a simple and transparent way of estimating GHG emissions for the base year, business as usual scenario, and the policy scenario. The computations were done using the TERI transport model; however, the key results are tabulated in the report so that if one would like to do these computations using an Excel spreadsheet, these are still possible.

Assessment of Mitigation Policies

In order to measure the impact of GHG mitigations policies, it is important to create a baseline scenario which acts as a reference for the evaluation of achieved policy targets. A baseline scenario with two horizon years of 2020 and 2030 was developed. The baseline assessment for this analysis is undertaken for 2020 and 2030 since these are the assessment years for NDC targets.

The next step is to undertake an ex-ante assessment for the mitigation policies for the same horizon years, i.e., 2020 and 2030. An ex-ante assessment aims to measure the impact in case the policy targets are effectively met. The importance of ex-ante assessment is that it serves as a benchmark for comparing the actual policy outcomes. A comparison of ex-ante and ex-post assessment can give key insights if the policy targets have been overachieved or underachieved. The ex-ante assessment done using the TERI transport model shows that full implementation of FAME Scheme, CAFÉ standards, and BS-VI policy can help in reducing CO_2 emissions by 27% in 2030 (Table E1).

Table E1 CO_2 emisions in baseline scenario and policy scenario

CO2 emissions (1000 tCO2)						
Year	**Petrol**	**Diesel**	**CNG**	**LPG**	**Electric**	**Total**
Baseline scenario						
2020	36,473	24,056	4,431	653	216	65,829
2030	68,570	45,007	11,812	1,155	893	127,438
Ex-ante policy scenario						
2020	29,428	21,735	3,698	577	1,502	56,941
Reduction in emissions from baseline:						8,888
2030	39,654	31,632	7,500	856	12,603	92,245
Reduction in emissions from baseline:						35,193

MRV System

The MRV system is based on the needs of the bottom-up methodology, proposed in the Section 3, and lays down how the data on the different variables are currently collected and what would need to be enhanced for data collection. An effort has also been made to identify the institution which would be the focal point for data collection and the periodicity of data collection. The data collection proposed is mainly using secondary data sources and would be needed, both at the national and state levels. At the state level, since currently there is no data collection for monitoring the GHG emissions, it would require appointing a nodal person in each state for coordinating data collection efforts.

1. Introduction

The transport sector is one of the largest and fastest-growing sectors in India. Accounting for 24% of the commercial energy demand at present, it is the second-largest energy consumer after the industry sector (TERI, 2018). In 2010, the sector accounted for 10% of the GHG emissions in the country, an increase of 22% from 2007 levels (MoEFCC, 2015) Accordingly, the transport sector holds an important place in terms of how the relative share of resultant emissions may change and how it may influence India's NDC targets in future.

Therefore, a prerequisite to meet the challenges associated with growing mobility demand of the country is to formulate the appropriate mitigation strategies in the transport sector. This becomes even more important with India's commitment to the Paris Agreement in terms of its NDCs and more specifically the goal related to reducing the emissions intensity of its GDP by 33%–35% below 2005 levels by 2030 (UNFCCC, 2015).

In order to move towards low-carbon mobility, India is taking several initiatives (Section 2), but the success of these initiatives is dependent on how efficiently and effectively the policies are implemented, and related targets are met. There exists a need to put in place an assessment framework which enables policymakers to review the progress of targets. However, developing countries find it challenging to collate information and data required for Measuring, Reporting, and Verification (MRV) systems.

The report provides MRV approaches and methodologies that could be useful to track the progress of transport-related policies, programmes, and projects with exemplification for EV Policies for LDVs in India in terms of its contribution towards meeting India's NDC emission intensity reduction goal of 33%–35% by 2030 compared to 2005 level.

1.1. Transport-related Actions: India's NDC

To reduce emissions from the transport sector and to move towards a low-carbon economy, India is focusing on many initiatives to build up energy-efficient and low-carbon transport systems. Transportation energy use and its impact on GHG emissions is determined by several factors such as vehicle efficiency, vehicle use and distance travelled, type of fuels and energy sources and overall system efficiency of transport infrastructure (Gulati, 2012). In order to reduce the emissions intensity of GDP by 33%–35% by 2030 from 2005 level, India has a definite plan of action for promotion of clean energy sources and energy-efficiency improvements in various sectors including transport with a focus on low-carbon transport infrastructure, public transport systems and energy-efficient railways to reduce environmental impact of transport sector. In order to achieve a safe, smart, and sustainable green transport network, the government has come up with several mitigation strategies and actions (UNFCCC, 2015).

- Government endeavours to increase the share of Railways in land transportation from 36% to 45%, thereby decreasing the load on less efficient diesel-operated road traffic.
- Dedicated Freight Corridors (DFCs) are being introduced to shift the freight from road to the low-carbon-intensive mode rail transport. Indian Railways is also installing solar power on its land and rooftops of coaches. Apart from the implementation of above-cited programmes, Indian Railways is also taking other sustainability-related initiatives in the areas of energy efficiency and conservation, renewable energy, use of alternative fuel, afforestation, and water-use efficiency.
- With the focus on moving 'people' rather 'vehicles,' Mass Rapid Transit System (MRTS) is being introduced.
- To promote hybrid and electric vehicles in the country, the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) Scheme is being implemented as a part of the National Electric Mobility Mission Plan (NEMMP) 2020.
- Under the Vehicle Fuel Efficiency Programme, in 2014, Government of India finalized India's

first light-duty passenger vehicle fuel efficiency standards and is in the process of bringing out the norms for heavy-duty vehicles. India also aims to improve fuel standards by switching from Bharat Stage IV (BS-IV) to Bharat Stage V (BS-V) / Bharat Stage VI (BS-VI) across the country in the near future.

- National Policy on Biofuels (2015) has adopted an aspirational target of 20% blending of biofuels, both for bio-diesel and bio-ethanol.
- To address the issue of climate change, the Government of India has also laid down policy guidelines for all the airlines and airports to check their carbon footprint on an annual basis.

As has been discussed in the aforementioned section, India is developing and implementing ambitious policy strategies to reduce GHG emissions from the transport sector. In order to track the performance of these strategies, an effective support system is required. Frameworks that can effectively measure the impact of mitigation actions in terms of GHG emission reduction may allow policymakers to identify successful policies. Also, considering the lack of a mandated system for comprehensive data collection for the transport system in India, the evaluation of GHG emissions becomes a challenging task. As transport sector in India is observing diverse trends of development across regions, there is a need to identify various factors that determine the mobility patterns and subsequently impact the energy consumption and emissions from the transport sector. In this context, MRV system can prove to be a starting point for developing GHG emission inventory at different levels and sub-sectors within the transport sector.

Prioritization of Transport Actions for MRV

Increase in transport demand in India has been commensurate with an increase in industrial and commercial activities. Increased demand for both passenger and freight transport along with better road infrastructure have led to the rapid expansion of road transport in India with higher penetration of motorized-road vehicles (NTDPC, 2014). The road transport sector in India accounts for a dominant share of total traffic movement in the country. It is estimated that 90% of the passenger traffic and 67% of the freight traffic in India moves via road transport (MoRTH 2016). Road transport is overwhelmingly dependent on oil for energy. According to the International Energy Agency (IEA, 2019), fuel consumption by India's transport sector was 86 million tonnes of oil equivalent (MTOE) in 2015, growing at a CAGR of 8.3% from 38.8 MTOE in 2005 (Figure 1) and since India imports more than 80% of its oil it is a drain on foreign exchange.

The transport sector accounts for 13.2% of the total CO_2 emissions from fuel combustion across sectors in the country, of which 87% is from the road transport sector (UIC/IEA, 2016). As India is experiencing rapid economic growth along with increasing per capita income and urbanization, the use of private vehicles will increase leading to higher GHG emissions. Further, given that the transport sector has the potential to achieve maximum efficiency gains through the implementation of EV policy there is a need to monitor the progress of these policies through better data management and collection systems.

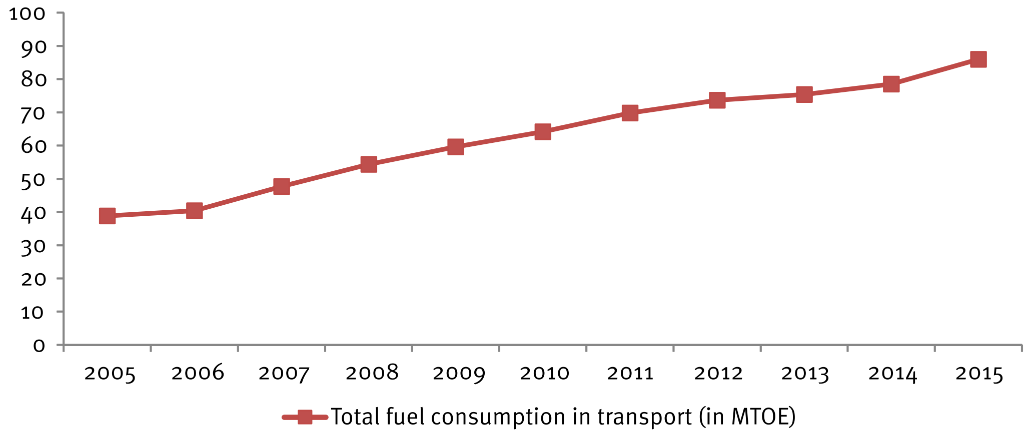

Figure 1 Fuel consumption by transport sector in India
Source IEA, 2019

2. Policies for Electric Vehicles

As a fast-growing economy, India is experiencing a rapid increase in transport demand for moving people and freight. Increase in transport demand is largely being met by road transport, which is highly energy intensive. Road transport use, as discussed earlier, contributes to increased oil imports, increased CO_2 emissions and air pollution within cities. Hence, faster adoption of electric vehicles is one of the key policy priority for the Indian Government.

The Government of India is focusing on creating charging infrastructure and policy framework so that by 2030 more than 30% of the total vehicles can be electricity driven[1]. In order to promote the uptake of electric vehicles, the initial road map was laid out through the National Electric Mobility Mission Plan (NEMMP) 2020 in 2013. Further, under NEMMP, the implementation and adoption of electric vehicles were supported by a scheme named, Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles, 2015 (FAME India).

2.1. National Electric Mobility Mission Plan 2020

The National Electric Mobility Mission Plan (NEMMP) aims to provide upfront and continued support for promoting hybrid/electric vehicle (xEV) technologies in the country. It intends to address concerns related to the country‘s energy security and growth of domestic manufacturing capabilities for xEVs. The plan targets total xEV sales of 6–7 million units, thus enabling Indian automotive industry to achieve global xEV manufacturing leadership. The Mission Plan aspires at providing an initial boost to create demand for xEVs, which would then stimulate the manufacturing of these vehicles in larger volumes. The four key principles that guide the future road map for xEVs penetration include:

1. Creating consumer acceptability for xEVs
2. Developing infrastructure to support ownership and use of xEVs
3. Development/acquisition of xEV technology
4. Creation of local manufacturing capability

2.2 Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles

Launched under NEMMP in 2015, the main objective of the scheme was to provide fiscal and monetary incentives for market creation and adoption of electric vehicles in the country. Initially launched for two years, Phase I of this scheme is implemented by the Department of Heavy Industries (DHI) under the Ministry of Heavy Industries and Public Enterprises, the scheme has the following focus areas:

- Technology platform
- Demand incentives
- Charging infrastructure
- Pilot projects, and
- Operations

Under FAME I, demand incentives are provided to buyers of hybrids and EVs, which can be availed by buyers upfront at the point of purchase and the same is reimbursed to the manufacturers by DHI every month. In order to spearhead the adoption of electric vehicles in India, an investment outlay of INR 7950 million was approved under FAME-I for technology development, infrastructure creation, boosting demand through subsidies and pilot projects (ASSOCHAM, EY 2018). The FAME-I Scheme was extended till March 2019, with an additional outlay of INR 1000 million. In March 2019 government announced FAME-II Scheme with a significantly higher outlay of INR 96,340 million till 2022 (Details of budget allocations, incentives and target are provided in Annex II)

2.2.1. Focus on Passenger Transport

India, the second most populated country in the world, is experiencing rapid economic

1 Details available at https://www.financialexpress.com/auto/car-news/government-finally-wakes-up-sets-a-realistic-goal-of-30-electric-vehicles-by-2030-from-existing-100-target/1091075/

growth along with increasing per capita income and urbanization. Over the last decade, total passenger kilometres have increased at a CAGR of 14% (MoRTH, 2016). Greater need for mobility has led to higher penetration of personalized motor vehicles in the country with two-wheelers and cars accounting for 86% of the total registered vehicles in India in 2016. While the total registered vehicles grew at a CAGR of 9.9% in 2006–16, cars and two-wheelers grew at a CAGR of 10.1% in the same period (MoRTH, 2016), indicating increasing ownership of personalized motor vehicles. India's urban population is expected to reach 600 million by 2030; this demographic shift along with increased workforce participation is expected to increase personal vehicle ownership.

Among passenger vehicles, four-wheelers in India account for a significant proportion of total fuel consumption and are a major source of GHG emissions[2]. It is also estimated that the number of cars in India is likely to grow to 175 per 1000 persons by 2040 as compared to 20 at present. Consequently, passenger cars in India could account for 54% of the passenger road fuel demand (IEO, 2015).

As car ownership and use in India is expected to grow exponentially, India is employing several policy measures to improve vehicular efficiency. The key measures include the adoption of BS-VI emission standard by 2020, Corporate Average Fuel Economy Norms (CAFÉ), and FAME. While the focus of BS Standards is on reducing local pollution, the focus of CAFÉ is on reducing CO_2 emissions for new vehicles, from 130 g/km in 2017 to 113 g/km in 2022. Both these policies implemented together with electrification of four-wheelers will lead to a reduction in pollution and will also lower down CO_2 emissions if electricity production is progressively decarbonized (Dhar et al., 2018).

2.2.2. Incentives for Passenger LDVs Under FAME

Incentives play a key role in increasing the demand for electric vehicles. While from the buyers' perspective, the high upfront cost and easy availability of charging infrastructure are the major barriers, the same from suppliers' perspective includes the cost on R & D and development of charging infrastructure.

Incentives under FAME-I were provided to the buyers in the form of an upfront reduction in the purchase price and the same is reimbursed to the manufacturers from DHI. In the case of passenger four-wheeler, incentives varied, depending on the length of the vehicle, battery type and also if the vehicle is a hybrid or pure electric (Annexure-II).

The following table highlights key regulatory, financial, and infrastructure support measures towards implementing FAME Scheme:

Table 1: Supporting mechanisms for FAME Scheme

Types of Support	Description
Regulations and standards	• Bharat EV Charger AC 0001 and Bharat EV Charger DC 0001 standards: These charging standards were announced in 2017 for Electric Vehicle Supply Equipment (EVSE)
Subsidies and incentives	• Subsidy on-road price of EV • Tax Exemption (GST, Registration tax, Road Tax) • Interest-free loans • Concessional tariff for manufacturing firms
Infrastructure programmes	• Installation of EV chargers at fuel stations • EV battery and charging equipment manufacturing units • Development of charging infrastructure
Research and development (R& D)	• Government support towards developing indigenous, low-cost electric technology • Technical Development Project for Advanced Lead–Acid Battery • Development of sub-systems like electric motor, controller, converters

2.2.3. Incentives at the State and City Levels

Several states in India are leading the way to roll out policies and programmes to support the FAME Scheme. States of Karnataka, Telangana, Maharashtra, Uttar Pradesh, Kerala, Uttarakhand, Andhra Pradesh, Delhi and a few more have rolled out their EV/Draft EV policies. These states are proposing several fiscal incentives to car and

2 As per PPAC study, four-wheelers account for 22% of the total diesel consumption and almost 36% of the total petrol consumption in the country.

battery manufacturers, charging infrastructure companies and consumers. Maharashtra EV policy, for example, proposes an exemption from Registration Tax and Road Tax[3] to the buyers and has proposed electricity at a tariff that is on par with residential electricity rates to the charging stations. State of Karnataka has proposed investment to set up 5 GWh of EV battery manufacturing capacity and to generate 5000 direct jobs and 7500 overall jobs, in addition to a specific focus on public transportation. Uttarakhand has offered loans for MSMEs to manufacture EVs and has proposed Motor Vehicle Tax Exemption for a period of 5 years for first 100,000 consumers. Additionally, states are also engaging with civic bodies and energy companies for the creation of charging infrastructure (refer to Annexure I).

[3] As per Maharashtra's Electric Vehicle and related Infrastructure Policy 2018, issued by Department of Industries, Energy and Labor (Government of Maharashtra). Details available at https://di.maharashtra.gov.in/_layouts/15/doistaticsite/english/pdf/MaharashtrasElectricalVechiclePolicy.pdf, retrieved on 12 April 2019

3. GHG Impact Assessment of Actions to Promote Actions to EVs

In order to assess GHG impact of mitigation policy, it is important to define the assessment boundary, methodologies for assessing impacts – in absence of policy, during and after policy implementation and institutional framework for monitoring progress. The following section highlights step-wise approach towards MRV of EV policies and schemes. The methodology has borrowed many aspects from existing methodologies, in particular, Compendium on Greenhouse Gas Baselines and Monitoring for passenger and freight transport[1]. The same has been further customized to support GHG impact assessment for EV policies and schemes and tailored to the Indian context.

3.1. Framework for Analysing Mitigation Policies and Schemes

The causal chain diagram provided in the Compendium on Greenhouse Gas Baselines and Monitoring for passenger and freight transport provides a simple framework for analysing the impacts of mitigation actions for GHG emissions.

In India, EVs are being promoted through the FAME policy at the national level and supported by state-level EV policies in some states, mainly to increase the share of EVs. FAME, however, has a broader remit and it also includes hybrid vehicles and therefore it will also lead to an improvement in the efficiency of vehicles running on fossil fuels. This feature of the FAME complements CAFÉ standards that came in force in 2017. The CAFÉ standards will progressively improve the efficiency standards for cars (a higher efficiency standard will come into effect in 2022). In order to meet CAFÉ standards, vehicle manufacturers need to enhance the technology which will increase the cost of IC engine vehicle and therefore reduce the price difference with electric/hybrid cars. The BS-VI standards will also increase the vehicle and fuel costs for IC engine vehicles. Together these three policies consist of mitigation actions, which will take place concurrently and therefore, it is not feasible to analyse them separately.

These three mitigation actions have two intended effects (Figure 2): (i) they will lead to an increased share of electric and hybrid cars and (ii) will result in improvement in fuel economy of fossil-fueled IC engine vehicles. More efficient IC engine vehicles reduce fuel costs and are akin to a reduction in fuel prices. In general, fuel price reductions is likely to result in an increased demand [2] for travel by four-wheelers. This increased demand for travel is a rebound effect. There can be other rebound effects of these two policies such as shifting people from public transport to cars. We, however, consider these effects insignificant due to the relatively small share of cars in transportation.

The causal diagram (Figure 2) also provides the indicators for various effects of the policies and relates them to both intended effects, leakage, and rebound effects. The data on indicators provide the basis for estimating the GHG impacts of the policies. However, to arrive at the GHG impacts, a few intermediate indicators are needed. These intermediate indicators are passenger kilometres (PKM) and vehicle kilometres (VKM), which are commonly used in transportation planning. Further, these intermediate indicators are linked to fuel and electricity consumption, based on vehicular efficiencies. In order to assess final GHG emissions, appropriate coefficients are used to transform fuel consumption into

1 Compendium on GHG Baselines and Monitoring- Passenger and freight transport, Second revised edition, February 2018. Details available at https://unfccc.int/sites/default/files/resource/Transport_0.pdf

2 The long run elasticity between fuel prices and demand for four-wheeler travel demand varies between -0.05 to -0.55 (Dhar, S., Pathak, M., and Shukla, P. R. 2018. Transformation of India's transport sector under global warming of 2°C and 1.5°C scenario. Journal of Cleaner Production, 172: 417-427)

emissions. For fossil fuels (crude oil and natural gas), standard emission coefficients (at global level) are available in the 2006 IPCC guidelines for national GHG inventories, and for electricity, India-specific grid emission coefficient developed and updated every year[3] by Central Electricity Authority can be used.

The overall impact of the FAME Scheme, BS Standards and CAFÉ standards on GHG reduction will depend on two opposite effects. Reduction in fossil fuel use from business as usual scenario is inevitable and this will bring down GHG emissions; however, there will be increased use of electricity due to increased share of EVs, which will increase the GHG emissions. Therefore, the net effect will depend on the GHG intensity of the electricity used by EVs.

3.2. Methodological Approach

Two of the most widely applied approaches to estimate GHG emissions from transport sector are:

- Top-down approach
- Bottom-up approach

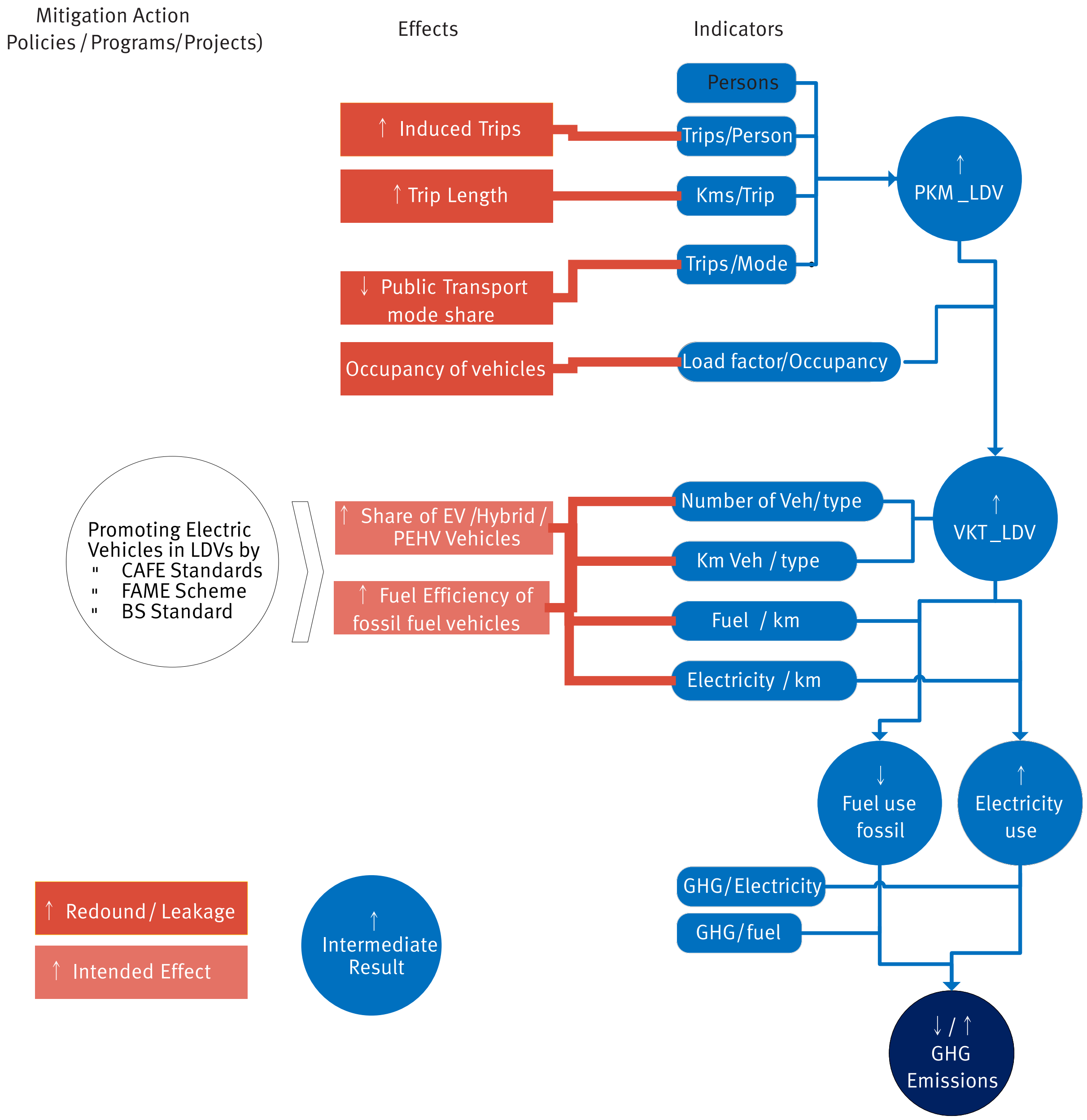

Figure 2 Causal chain diagram to represent GHG impacts of EV policies

3 CO_2 baseline database for the Indian Power sector, User Guide, Version 14.0, December 2018. Central Electricity Authority, Ministry of Power (Goverment of India). Details available at http://www.cea.nic.in/reports/others/thermal/tpece/cdm_co2/user_guide_ver14.pdf

The **Top-down** approach is based on final energy consumption. This approach estimates final fuel consumption in the transport sector based on fuel sales. The final fuel consumption is then multiplied by CO_2 emission factor for each fuel type to estimate the total emissions. As top-down approach does not take into account the activity level data, it is usually undertaken at the national level or at sectoral level (GIZ, 2016).

The **Bottom-up** approach, on the other hand, is based on ASIF model, which takes into account transport activity levels (A), the mode share (S), fuel intensities, (I) and emissions per unit of fuel by mode and type (F). The bottom-up approach gives a detailed overview of the emissions by vehicle type, fuel type, trip purpose, etc. and hence can be used for evaluations of specific projects and policies. Through this approach, the impact of specific investments in transportation systems can be observed (Schipper, Fabian, & Leather, 2009).

3.3. Assessment Boundary and Period

In order to define the overall assessment including methodologies (ex-ante and ex-post), the first step is to define the assessment boundary and determine the time period for assessing the GHG impacts of mitigation actions (policies, programmes, and projects).

3.3.1. Spatial Boundary

With several states coming up with their EV policies, MRV at state level can prove to be more effective and robust. Hence, the spatial boundary for MRV will primarily look into the factors that determine the vehicular demand or composition at a state level. As transport activity levels differ across states due to their demography and land use patterns. Setting up spatial boundary can play a crucial role in carrying out ex-ante assessment as demand for EVs is largely dependent on incentives provided across different vehicle segments. While some states might promote the substitution of conventional private motor vehicles by electric cars/two-wheelers, others might focus on promoting public modes of transport. Hence, emission reduction trajectory of one state will differ from another in long-term.

3.3.2. Temporal Scope

The base year for the assessment is considered as 2015 since the FAME Scheme was launched in the same year. Temporal scope of the MRV can be aligned with India's NDC target of 2030. Further, considering that FAME policy was implemented in the year 2015 and the policy targets have been set till 2030 for EV penetration at the national level, the timeframe of the assessment period can be from 2015 to 2030. As various states are also implementing their EV policies, monitoring of state-level policies can also be done in line with national-level targets.

Similarly, the temporal scope of the framework will vary from region to region with a common baseline scenario. The final impact of the policies under FAME can assessed till 2030, in line with India's NDC targets, but the trajectory will largely be dependent on implementation timelines of various states.

Going forward, setting up an MRV system for electric vehicles, specifically passenger cars can help in the monitoring and regulation of the implementation process.

3.4. Methodology for Estimating GHG emissions

3.4.1. Top-down Approach for Estimating GHG Emissions

The approach for top-down estimation of CO_2 emissions is defined from LCMP toolkit[4] and includes the following steps

- Preparation of Energy Balance

Energy balances are a way of representing aggregate energy flows from energy suppliers to consumers, and are used as an accounting tool for estimating energy-related emissions. In general, energy balances cover all fuels; however, since the focus is on transport, diesel, petrol, LPG, CNG, and electricity need to be covered. The data on the consumption of fossil fuels can be collected from the companies supplying fuels and for electricity from transport utilities or electricity utilities. This kind of data is also collected for emissions estimation within the National Communications using the Tier I methodology of IPCC at the national level.

- Emission Coefficient of Fuels

CO_2 emissions can be calculated from the energy balance based on the CO_2 content of fuels. If available, local emission factors should be used. National emission factors are published in

[4] UNEP. 2016. A Toolkit for Preparation of Low Carbon Mobility Plan. Nairobi: United Nations Environment Programme, Downloaded on 8 Nov 2016. Details available at from <http://www.unep.org/transport/lowcarbon/toolkit/>

National Communications and Biennial Reports submitted to the UNFCCC[5]. If these are not available, default factors available from IPCC should be used.

Table 2 Default CO2 Emission Coefficients for Fossil Fuels from IPCC[6]

Fuel	Giga gram CO_2/ Petajoule	Kg CO_2/ tonne of fuel	Kg CO_2/lit of fuel
Petrol	69.3	3101	2.30
High-speed diesel (diesel)	74.1	3214	2.71
Compressed natural gas (CNG)	56.1	1691	1.69*
Liquefied petroleum gas (LPG)	63.1	2912	2.91*

* kg CO_2/ kg of fuel

3.4.2. Bottom-up approach for estimating GHG emissions

GHG emissions from passenger road transport in a given year can be estimated by first determining the fuel consumption for various fuels (Equation 2) used based on relevant vehicle activity (Equation 1). Once the total fuel consumption for various fuels is available, relevant emission coefficients can be used to calculate GHG emissions (Equations 3 and 4).

Equation 1 : $PKM\_LDV_{i,j} = V\_LDV * FT\_LDV_{i,j} * VU\_LDV_i * O\_LDV_i$

Equation 2: $FC\_LDV_{i,j} = PKM\_LDV_i * FE\_LDV_{i,j}$

Equation 3 : $Emissions_{LDV\,j} = \Sigma_i FC\_LDV_{i,j} * EF_j$

Equation 4 : $Emissions_{LDV} = \Sigma_j Emissions_{LDV\,j}$

Where:

PKM_LDVi = Passenger kilometre LDV by vehicle type i (pkms)	*VU_LDVi* = Vehicle utilization by vehicle type i (km/year)
V_LDV = On-road stock of LDVs (number)	*FC_LDVi,j* = Fuel consumption by vehicle type i of fuel j (PJ)
$FT\_LDV_{i,j}$ = Share of vehicle type i and fuel type j within LDV (%)	*FE_LDVi,j* = Fuel efficiency of vehicle type i for fuel j (PJ/ million km)
O_LDVi = Occupancy factor for vehicle type i (number)	*EFj* = Emission coefficient for fuel j (1000 tonnes CO_2/ PJ)
$Emissions_{LDV\,j}$ = CO2 emissions per year from use of fuel j by LDV type i	

Next, we will show an estimation of base year emissions using the bottom-up approach followed by future projection of emissions in the Baseline scenario till 2030 and ex-ante assessment of mitigation policies.[7]

3.5. Baseline Scenario

In order to measure the impact of GHG mitigations policies, it is important to create a baseline scenario which is considered as a point of reference for the evaluation of achieved policy targets. The first step towards setting a baseline scenario is to select a base year which is representative of the state before policy implementation. Once the base year is determined, the next step is to identify the data sources required for undertaking the assessment using methodology described in Section 3.4. The data sources for variables are provided in Annexure III. To analyse the impact of electric four-wheelers on GHG emissions, 2015 has been considered as a base year which is in line with the NEMMP policy and CAFÉ standards implementation under NDC. Following the methodology described in Section 3.4, an assessment of emissions for the base year is undertaken (Table 3).

Once the assessment for the base year is done, a baseline scenario is created to observe the transition in emissions in the absence of any mitigation policy. The baseline assessment for the purpose of this analysis is undertaken for 2020 and 2030, which are the assessment years for NDC targets.

The final step in the creation of measuring framework is to undertake an ex-ante assessment for the policy realization period, in this case, 2020 and 2030. An ex-ante assessment aims to measure the impact in case the policy targets are effectively met. The importance of ex-ante assessment is that it serves as a benchmark for comparing the actual policy outcomes. A comparison of ex-ante and ex-post assessment can give key insights if the policy targets have been over achieved or underachieved.

To estimate the baseline scenario for the present

[5] Details available at http://unfccc.int/national_reports/non-annex_i_natcom/reporting_on_climate_change/items/8722.php Last accessed on 27 April 2016

[6] Details available at http://www.ipcc-nggip.iges.or.jp/EFDB/main.php Accessed 25 April 25 2016

[7] Further details of assumptions and data sources are provided in Annexure III and IV.

Table 3 Emissions calculation for Base Year (2015)

Total stock of LDVs on road						
Year	**Petrol**	**Diesel**	**CNG**	**LPG**	**Electric**	**Total**
2014-15	16,718,340	6,103,173	1,679,246	258,797	29,147	24,788,703
Total BPKMs of LDVs						
2014-15	475	236	29	6	1	746
Fuel consumption (PJ)						
2014-15	363	199	40	7	0.3	609.3
CO2 emissions, (1000 tCO2)						
2014-15	25,149	14,769	2,218	442	60	42,638

analysis two horizon years are relevant 2020 (linked to the NDC submitted to the Paris Climate Agreement by India) and 2030, which is related to the revised NDC that will be submitted in 2020. First, the travel demand is projected for the future years 2020 and 2030 using methodology for travel demand projection provided in Annexure IV. CO_2 emissions in 2020 and 2030 are estimated similar to base year following the methodology described in Section 3.4. An assessment of the baseline scenario (horizon years 2020 and 2030) is provided in Table 4.

3.6. Ex-ante Assessment of Emissions Impacts of Mitigation Policies

An ex-ante analysis is done to primarily assess the emission reduction impacts of various policies and programs for promoting the EVs. A simplified approach for the estimation of emission impacts is provided below. However, more advanced methods/models/tools are available for undertaking the ex-ante analysis and the same are briefly described in Annexure V. These can also assess the co-benefits of mitigation actions and cost-effectiveness of mitigation actions.

The inputs parameters that will be affected with the implementation of the mitigation actions are analysed with the help of causal chain diagram (Figure 2):

- **Vehicular stock LDV (V_LDV) and Share of Vehicle (**FT_LDV_i**):** FAME Scheme has a target of providing financial incentives for 35,000 EVs by 2022. A few states are also providing incentives and providing targets with respect to electric four-wheelers that they seek to deploy over the years. The composition of passenger LDV fleet will change depending upon the incentives that are being provided and also

Table 4 Emission calculation for horizon year (2020, 2030)

Total stock of LDVs on road						
Year	**Petrol**	**Diesel**	**CNG**	**LPG**	**Electric**	**Total**
2020	23,551,103	9,369,160	3,206,014	362,856	97,412	36,586,546
2030	42087086	17049044	7955,381	606,678	376,127	68,074,317
Total BPKMs of LDVs						
2020	703	380	59	9	2	1,152
2030	1,372	708	160	15	9	2,264
Fuel consumption (PJ)						
2020	526	325	79	10	1	941
2030	989	607	211	18	4	1,830
CO_2 emissions, (1000 tCO_2)						
2020	36,473	24,056	4,431	653	216	65,829
2030	68,570	45,007	11,812	1,155	893	127,438

the ease of charging. In addition to FAME the implementation of CAFÉ standards, make the fuel efficiency norm stringent for fossil fuel vehicles and to achieve these vehicles would need to go for advanced vehicle technologies that will increase capital costs and reduce price difference with EVs. Therefore, it is quite likely that the modest target for EV in 2022 set in FAME Scheme will be achieved. Beyond 2022 we assume that FAME Scheme would continue in some form and further reduction in EV costs will allow increasing market share of EVs and an exponential growth post 2022 is considered.

- **Vehicle Utilization Rate** (VU_LDV_i)**:** More efficient cars and EVs both have lower fuel and operating costs and this can result in a rebound effect in the form of additional trips or longer trip lengths. All this means that vehicle utilization rate will go up for both fossil and EVs as compared to the BAU.
- **Fuel Efficiency** ($FE\_LDV_{i,j}$)**:** Fuel efficiency of a vehicle plays a critical role in determining the emissions as it directly impacts the total fuel consumption by impacting the mileage. The efficiency of fossil fuel vehicles will improve due to CAFÉ standards and also since hybrid vehicles will get subsidy in the FAME Scheme. The fuel efficiency of electric vehicles is higher than fossil fuel vehicles.

In ex-ante analysis the impact of mitigation actions is assessed for the year 2020 and 2030.

3.7. Ex-post Assessment

Ex-post assessment is undertaken to review the impact of policy implementation. It aims to identify the gaps, if any between actual policy outcome and the ex-ante analysis result. The outcome of this assessment gives an overview of the parameters that need more focus or require any revision. The focus of ex-post assessment is on analyzing the effectiveness of the proposed mitigation policy and to determine the sustainability of the same.

The methodology for ex-post assessment remains the same. However, the CO_2 emissions are revised based on the actual stock of vehicles in terms of vehicle type and age of vehicle. For simplification the vehicle utilization and vehicle occupancy can be left unchanged. The actual change in stock of vehicles will depend on the implementation of FAME Scheme, CAFÉ standards and BS-VI standards. The analysis will help government and key policy makers in identifying the gaps in the implementation process. For instance, in case of electric four wheelers, targeted sales are a crucial parameter on which the success of the policy depends. Expected GHG emission reduction would only happen if the IC cars are being replaced by electric cars as per the targeted volumes. Any deviation in the sales volumes can provide insights to the government for the required interventions. The assessment will also help policy makers to identify the data gaps due to the existing collection and reporting framework.

Table 5 Emission calculation for Mitigation Scenario for Horizon Year (2020, 2030)

Total stock of LDVs on road						
Year	**Petrol**	**Diesel**	**CNG**	**LPG**	**Electric**	**Total**
2020	23,277,064	8,965,237	3,206,014	362,856	775,375	36,586,546
2030	40,960,490	12,295,519	7,955,381	606,678	6,256,247	68,074,317
Total BPKMs of LDVs						
2020	695	370	59	9	20	1,152
2030	1,338	594	160	15	158	2,264
Fuel consumption (PJ)						
2020	425	293	66	9	7	800
2030	572	427	134	14	55	1,202
CO2 emissions, (1000 tCO2)						
2020	29,428	21,735	3,698	577	1,502	56,941
Reduction in emissions from Baseline : 8888						
2030	39,654	31,632	7,500	856	12,603	92,245
Reduction in emissions from baseline: 35,193						

4. Monitoring Plan for MRV systems

The Table 6 enlists some of the key data variables that are required in order to assess ex-post the impact of mitigation policies and the associated timelines and responsible agency for the same.

Table 6 Data collection mechanism and reporting bodies

Data parameter	Primary / secondary source	Proposed responsible agency	Data collection mechanism (current)	Data Collection mechanism (Proposed changes)	Timelines
1. On-road stock of vehicles (V_LDVi) and share of vehicle type i and fuel type j (FT_LDVi,j)	Secondary	Ministry of Road Transport and Highways (MoRTH) together with Regional Transport Offices (RTO) in respective states	Reporting of this data is done through various sources like 'Road Transport Year Book' published by MoRTH and on VAHAN Dashboard and includes details of • Total registered vehicles annually at National and State Level • Monthly and annual registrations of vehicles at RTO level • Data is reported under two categories: transport* and non-transport** • Fuel-wise split of all the vehicles • Data is also reported at city level for cities with million plus population	To better estimate the on-road stock, data on scrapped vehicles can also be collected Age profile of on road vehicles also needs to included and these can be done when vehicles come for pollution checks (PUC) at gas stations	Annual
1. Vehicle utilization (VU_LDVi) and occupancy factor for vehicles (O_LDVi)	Primary	Ministry of Road Transport and Highways together with Regional Transport Offices in respective states	Currently, these data points are extracted from comprehensive mobility plans (CMP) and low-carbon mobility plans and independent research reports	These can be collected by doing survey at a periodic basis. However, data on vehicle utilization can be collected by RTO when they do fitness for vehicles or at time of PUC.	Every Five Years

Data parameter	Primary / secondary source	Proposed responsible agency	Data collection mechanism (current)	Data Collection mechanism (Proposed changes)	Timelines
2. Fuel efficiency of vehicle type i for fuel j (FE_LDVi,j)	Secondary	Bureau of Energy Efficiency (BEE)	Global Fuel Economy Initiative (GFEI) has been on an annual basis looking at the fuel efficiency of LDVs in India. GoI has also notified the CAFÉ standards which mandate CO_2 standards for different manufactures. Reports from GFEI do provide an overview in terms of CO_2 emissions per km for different manufacturers#	BEE as part of reporting for CAFE would be keeping a record of CO2 emissions per km for different manufacturers. Fuel efficiency per km values can, therefore, be recorded within the same	Annual
3. Emission Factor (EFj) a. Fuel b. Electricity	Secondary	Ministry of Environment, Forest and Climate Change and Ministry of Power	Emission factors for different fuels are assessed and finalized by MoEF&CC for reporting to UNFCCC. Grid Emission factor for electricity are available from the CEA Database##	No changes for fuel but for CEA Database the main audience were CDM projects and it would be important to keep this database alive under market mechanism envisaged under Artilce 6 of Paris agreement	Annual
4. Data verification using Fuel Consumption (FC_LDVi,j)	Secondary	Ministry of Petroleum and Natural Gas (MoP&NG)	Fuel consumption estimated using equation (2) can also be verified with actual fuel consumption Currently, PPAC reports data on total fuel consumption in a sector e.g., transport as a whole but not at the level of LDVs. International Energy Agency also reports fuel consumption at this level	Oil companies do collect data on retail sales by vehicle categories: 2-wheeler, 4-wheeler and trucks – MoP&NG through PPAC can get this data	Annual

* Transport includes vehicles used for commercial purposes, multi- axle/articulated vehicles/ trucks and lorries, light motor vehicles (passengers), light motor vehicles (goods), buses, and taxi.

** Non-transport data, the categories are: two-wheelers, cars, jeeps, omni buses, tractors and trailers.

\# Compliance with India's first fuel consumption standards for new passenger cars (FY 2017–2018). Details available at https://theicct.org/sites/default/files/publications/India_fuel_consumption_standards_20180925.pdf

\## CO_2 Baseline Database for the Indian Power Sector. Details available at http://www.cea.nic.in/reports/others/thermal/tpece/cdm_co2/user_guide_ver13.pdf

5. Institutional Framework

The information required for GHG estimation is often widely dispersed and collected at various sources. Collating all relevant data for is a challenge. Currently, existing data for the transport sector is insufficient for creating the MRV framework (Table 6). In order to make the framework more robust, roles of nodal agencies should be clearly defined and a specific time frame for data collection and monitoring should also be taken into account. Considering the scope of MRV is mainly from the perspective of climate change mitigation actions, it is important that the governing institute should have the necessary expertise and experience to enhance data collection.

While policy formulation will continue to happen at national level and states are subsequently going to adopt these policies along with their own interventions. There is also a difference in terms of institutions responsible for policy formulation and entities that will bear the responsibility for collecting data. It also came out during stakeholder interactions in Karnataka that no state level data is collected for monitoring GHG emissions. Therefore it is important to appoint a nodal agency at state level which will be responsible for collecting data from various agencies at state level (RTOs, Oil Companies,etc.) and submitting data annually to the data analysis and GHG impact assessment wing of MoSPI. It is important that data collection for monitoring the policy effectiveness should happen at state level with nodal agency being the climate change department. This department will be responsible for sensitizing various departments associated with transport sector energy and emission data management. It will further ensure timely collection, verification and reporting of all the relevant data parameters.

The Figure 3 provides an overview of institutions that can play a key role in enhancing the data collection mechanism and strengthening the reporting framework.

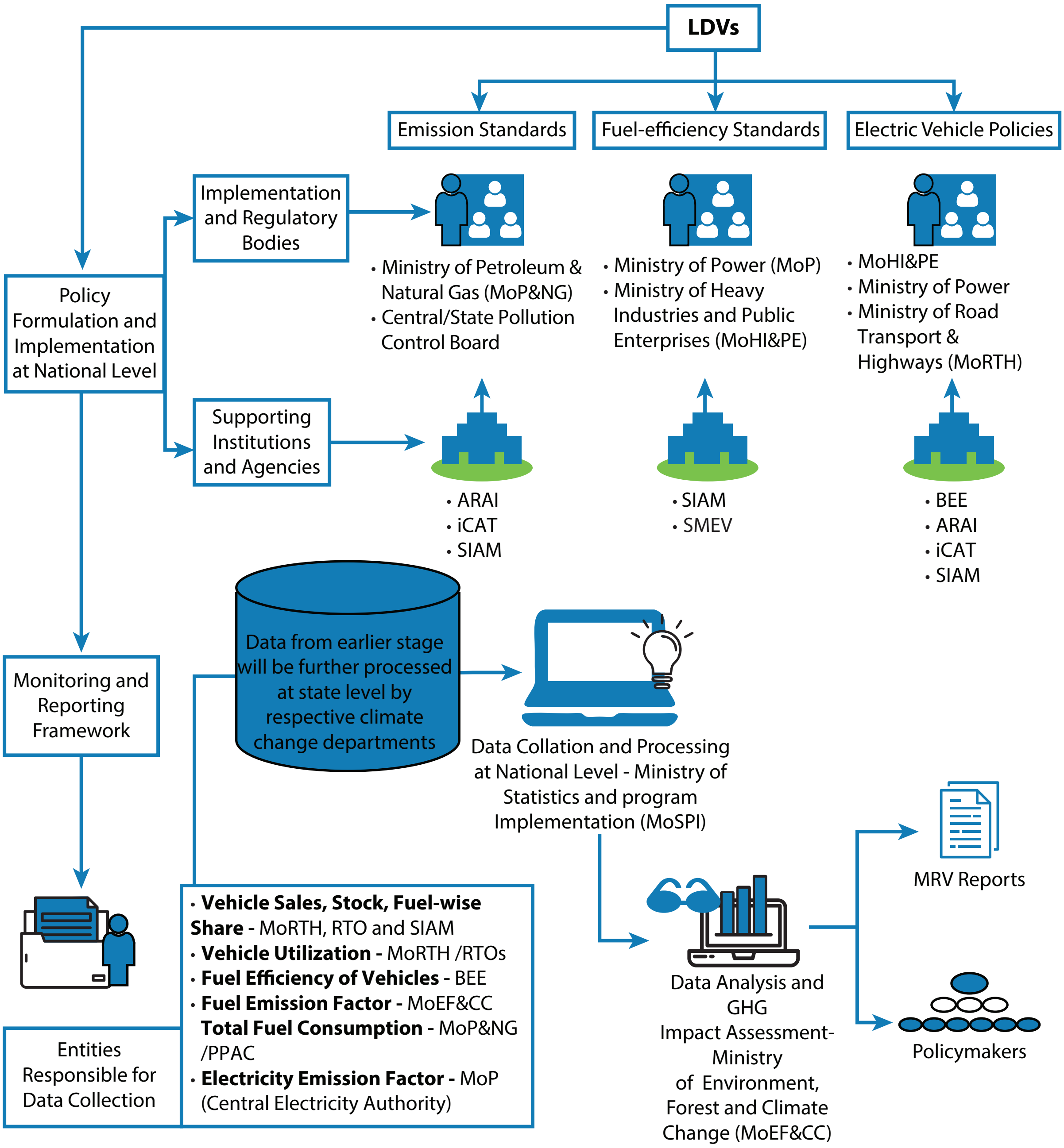

Figure 3 Institutions that can play a key role in enhancing the data collection mechanism and strengthening the reporting framework

Annexure

Annexure I: State-level EV policies

EV policy	Objective	Targets	Incentives	Policy valid
Karnataka Electric vehicle and Energy Storage Policy 2017	1. To maintain lead share of Karnataka as the preferred destination for attracting investments in the manufacture of electric vehicles. 2. To attract investment of ₹31,000 crore and create employment opportunities to 55,000 persons both from supply and demand side. 3. To create a conducive environment to transit from ICE to electric vehicles. 4. To provide opportunities for R&D in electric mobility.	1. 1000 EV buses in policy period 2. 100% three-wheelers/four-wheelers moving goods will be encourage to transit to electric mobility by 2030. 3. Incentives for first 100 fast charging stations.	1. Incentives to the manufacturers: micro enterprises — 25% of value of fixed assets (max. 15 lakh), small enterprises – 20% of value of fixed assets (max ₹40 lakh), medium and manufacturing enterprise – ₹50 lakh 2. Exemption for the stamp duty 3. Registration charges at. concessional rate of ₹1 to 1000. 4. 100% reimbursement for land conversion fees. 5. One time capital subsidy up to 50% of the cost of ETP.	5 years
Telangana Electric Vehicle Policy Draft 2017	1. To attract investments worth 3.0 billion USD and create employment for 50,000 persons by 2022 through EV manufacturing and charging infrastructure development. 2. Provide best in class ecosystem and infrastructure to make Telangana the EV hub of India 3. Develop a proving ground for viable Business models through accelerated demand for EVS 4. Promote innovation in EVs and other emerging trends such as autonomous/ connected mobility 5. Make Telangana state the preferred destination for EV and component manufacturing 6. Creating of a pool of skilled workforce for the industry 7. Create a conducive environment for industry and research institutions to focus on cutting edge research in EV technologies	1. Telangana State Transport Corporation to set a target of 100% electric buses by 2030 for intra-city, intercity, and interstate transport (key milestones – 25% by 2022, 50% by 2025 and 100% by 2030). 2. Government will set up first 100 fast charging stations in GHMC and other cities in a phased manner.	Demand Side Incentives: Road tax exemption for all EVs till 2025, expected year of price parity with ICE vehicles, Supply Side Incentives: Government will provide benefits/incentives, depending upon the scale of investment as per the categories defined in MSMED Act 2006 and Telangana Industrial Policy framework 2014. Investments beyond 200 crore in EVs will be treated as mega projects and will be offered tailor- made benefits.	5 years

EV policy	Objective	Targets	Incentives	Policy valid
Maharashtra's Electric Vehicle and Related Infrastructure Policy 2018	1. To develop Maharashtra as the leader in EV manufacturing and use of EV. 2. To create newer employment opportunity. 3. To promote export of EV, component, battery, charging infrastructure. 4. To promote R& D and skill development in EV. 5. To promote sustainable transportation.	1. Increase number of EVs registered in Maharashtra to 5 lakh. 2. To generate an investment of ₹25,000 crores in EV. 3. To create job for 1 lakh persons.	1. Incentives for EV manufactures, EV component manufacturers and EV battery manufacturing/ assembly enterprise, manufacturer of electrical battery charger 2. Incentives and assistance for EV charging : common charging points, amendments in development control rules 3. Incentives and Provision of EV buyers-Exemption from road tax and registration fees, 15% subsidy to private vehicle for first 1 lakh vehicles (2-wheeler, cars, 3-wheelers), 10% subsidy to the buses (max. limit of ₹20 lakh per vehicle) for first 1000 buses 4. Promotion of R&D, Innovation and skill development in EV sector- centre of excellence will be developed, state board will provide training-based certification.	5 years
Uttar Pradesh Electric Vehicles Manufacturing Policy 2018	1. To establish Uttar Pradesh as preferred destination for attracting investments in manufacturing of EVs. 2. To create employment opportunities both from supply side and demand side. 3. To create a conducive environment for shift from internal combustion engines to EVs. 4. To encourage use of hybrid EVs in Uttar Pradesh during the transition phase. 5. To develop human capital and augment the power capacity to meet the needs of the industry promoting electric mobility in the state.	1. Public transportation: In order to promote EV vehicles in public transportation, 1000 EV buses will be introduced by the state by 2030, in 3 phases: 25% in phase I by 2020, remaining 35% in phase II by 2022, and rest 40% in phase III by 2030. Further in this context, green routes will be identified by 2020 in GB Nagar, Ghaziabad, Lucknow, Kanpur, Varanasi for 100% EV public transportation. 2. Private transportation: State government will encourage electric 2-wheeler taxis for short distance mobility, and existing auto rickshaws will be encouraged to resort to EV technology. Further in this context, auto rickshaws, cabs, school buses/vans, etc. will be targeted to achieve 100% electric mobility by 2030 in five cities: GB Nagar, Ghaziabad, Lucknow, Kanpur, Varanasi. 3. Goods transportation: Further, to promote adaptability of EV in goods transportation, 3-wheelers (EV), 4-wheelers mini goods vehicles (EVs) will be encouraged in GB Nagar, Ghaziabad, Agra, Lucknow, Kanpur, Varanasi, and Jhansi.	1. Private EV Parks (PEV Parks) – Both manufacturing and assembling units: 100 acres of land area in NCR districts and Kanpur, and minimum 150 acres in other districts, by private developers. 2. Capital Interest Subsidy to the extent of 5% per annum for 5 years in the form of reimbursement on loan taken for procurement of plant and machinery, subject to an annual ceiling of ₹ 50 lakh 3. Tax exemptions to buyers: 100% exemption of road tax on transportation EVs purchased within Uttar Pradesh, applicable over the period of this policy. 4. 100% interest-free loans to state government employees for purchase of EVs in the state.	5 years

EV policy	Objective	Targets	Incentives	Policy valid
Delhi Electric Vehicle Policy 2018*	To bring about a material improvement in Delhi's air quality by bringing down emissions from transport sector. This policy will also seek to put in place measures to support the creation of jobs in driving, selling, financing, servicing and charging of EVs.	To drive rapid adoption of battery electric vehicles (BEVs) in a manner where they contribute to 25% of all new vehicle registrations by 2023.	• For pure electric - battery electric vehicles: Purchase incentive, top-up incentive and scrapping incentive (all incentives applicable at time of purchase and payable to auto OEM or dealer) • For two-wheelers: Purchase and top-up incentives for specific vehicle categories (i.e., high power with advance Battery); ₹11,000 –22,000 per vehicle and scrapping Incentive of up to ₹15,000 • For three-wheelers (passenger)/e-autos: E-auto permits issued without any restrictions, grant for down payment and interest subvention to individual drivers for vehicles with swappable batteries (~₹ 50,000 per vehicle over a 3-year period), Scrapping Incentive of up to ₹15,000 and cash back for passengers up to ₹ 10 per trip • For E-rickshaws: Hire purchase scheme at concessional terms (~₹49,000 over a 3-year period) for vehicles with advance, swappable batteries • For Three wheeler (goods)/ e-Carriers: Purchase Incentive of ₹12,500-20,500 for vehicles with advance, swappable batteries • For buses and other stage carriage vehicles: Subsidy as decided by GNCTD from time to time to ensure 50% of fleets comprise of EVs by 2023. • For assenger cars/e-cabs: Waiver registration fees, road tax and MCD one-time parking fee (also for LCVs) and cash back for passengers up to ₹10 per trip.	5 years from date of notification (27/11/2018)
Kerala Electric Vehicle Policy 2018	• To promote local production of the vehicles through skill development training programmes, to create a common charging infrastructure for electric vehicles that will have the required power availability and a network of charging points.	• To have around one million EVs by 2022, to create around 200,000 two-wheelers, 50,000 three-wheelers, 1000 goods carriers, 3000 buses and 100 ferry boats by 2020. • Full electrification of all types of motor vehicles by 2030.	• An incentive of ₹ 30,000 or 25 per cent of EVs in the first year to purchase of three-wheelers. It has mapped out Thiruvananthapuram, Kochi, and Kozhikode as zones for EV autorickshaws initially. • Exempts EV buyers from road taxes for the first three years.	

EV policy	Objective	Targets	Incentives	Policy valid
Andhra Pradesh Electric Mobility Policy 2018-23**	1. To make AP a global hub for electric mobility development and manufacturing. 2. Attract manufacturers across the EV ecosystem to the state to setup their manufacturing units and supply to a global market. 3. Promote innovation actively through grants and venture funds to research organizations, incubators, and start-ups working on next generation battery technology, fuel cell technologies, EV power trains and EV electronics. 4. To create best in class ecosystem via Industrial parks to hasten product development, manufacturing, and testing. 5. Enable investment into charging/battery swapping infrastructure and hydrogen generation and fueling station development. 6. Create a skilled workforce which is attuned to the needs of EV ecosystem. 7. Promote usage of EVs to enable transition to environmentally friendly cities. 8. Build next-generation transportation infrastructure using Vehicle to Everything (V2X) platforms.	• Attract combined investments of over ₹30,000 crore in the next 5 years across the electric mobility ecosystem with an employment potential for 60,000 people. • Target to bring in manufacturing units of high density energy storage of at least 10 GWh capacity in the next 5 years to cater to both domestic as well as export market. • Target to convert 100% of APSRTC bus fleet of over 11,000 buses into electric buses (BEVs/FCEVs) by 2029, with the first phase of 100% conversion of bus fleet in top 4 cities by 2024. • Phase out all fossil fuel-based commercial fleets and logistics vehicles in top 4 cities by 2024 and all cities by 2030. • All forms of government vehicles, including vehicles under government corporations, boards and government ambulances etc. will be converted to EVs by 2024. • Target to have 10 lakh EVs, combined across all segment of vehicles, by 2024. • Target to have 100,000 slow and fast charging stations by 2024–25.	• 10% subsidy for the two electric car manufacturing firms. • Stamp duty and GST reimbursements on purchase or lease of land in Amaravathi. • No registration fee on Electric vehicles. • Development of EV manufacturing hubs. • 10 lakh electric vehicles on roads in the next 5 years.	5 years

* Details available at http://transport.delhi.gov.in/sites/default/files/All-PDF/Electric%20Policy%202018.pdf
** Details available at http://63qmu69ykmn502p2een091cx-wpengine.netdna-ssl.com/wp-content/uploads/2019/02/ANDHRA-PRADESH-EV-Policy-Document.pdf

Annexure II: FAME Scheme Details

Demand incentives under FAME I for electric four-wheelers (Category M1)

Segment	Incentive (in ₹)	
	Level 1	Level 2
Length not exceeding 4 m		
Mild HEV(conventional battery)	13,000	16,000
Mild HEV(advance battery)	19,000	23,000
Strong HEV(advance battery)	59,000	71,000
Plug in HEV(advance battery)	98,000	118,000
BEV(advance battery)	76,000	124,000
Length exceeding 4 m		
Mild HEV(conventional battery)	11,000	13,000
Mild HEV(advance battery)	20,000	24,000
Strong HEV(advance battery)	58,000	70,000
Plug in HEV(advance battery)	98,000	118,000
BEV(advance battery)	60,000	138,000

Incentive and target for different vehicle categories under FAME-II

Vehicle segment	Maximum number of vehicles to be supported	Approximate incentive per vehicle (in ₹)	Total fund support (in million ₹)
e-2 wheelers	1,000,000	20,000	20,000
e-3 wheelers	500,000	50,000	25,000
e-4 wheelers	35,000	150,000	5,250
e-buses	7,090	5,000,000	35,450

Annexure III: Data Sources for Variables Needed for GHG Emissions Estimation

Variable	Variable description	Data source
V_LDV	On-road stock of LDVs	Estimation based on Per Capita GDP (UN estimates), vehicle registration data as provided by MoRTH
FT_LDV_i	Share of vehicle type i within LDV	Based on estimates provided by SIAM
O_LDV_i	Occupancy factor for Vehicle Type i	TERI analysis based on detailed project reports (DPRs)
VU_LDV_i	Vehicle utilization by vehicle type i	TERI analysis
$FE\_LDV_{i,j}$	Fuel efficiency of vehicle type i for fuel j	TERI analysis
EF_j	Emission coefficient for fuel j	IPCC default values or those provided by Ministry of Petroleum and Natural Gas
	Emission factors for Electricity	India-specific grid emission factors provided by CEA

Annexure IV: Methodology for Projecting Transport Demand

In order to project the transport demand in billion passenger kilometres (BPKM) using a bottom-up activity-based approach following approach has been followed.

Stock of LDV (V_LDV): India has low ownership of LDV and the ownership of vehicles will grow with an increase in per capita incomes. A relationship between per capita vehicle ownership and GDP per capita has been established through regression analysis and prediction of vehicle ownership has been done till 2030. Vehicle ownership (vehicles per 1000 persons) multiplied by population gives us a number of on-road stock of vehicles (V_LDV) over the time-frame of the analysis. To undertake regression analysis time series of total registered stock of LDVs (available in reports published by MoRTH), GDP, and population have to be collected.

Considering that urban and intercity vehicles have different usage patterns, further segregation can be done between the vehicle stocks.

Share of vehicle type (FT_LDVi): As a next step, the LDV stock is segregated on the basis of different fuel technologies. The estimates for this segregation can be obtained from literature or through road-traffic or petrol pump surveys for the base year. Normally changes in fuel choices for vehicles have been determined by government policies and there fuel shares for future would be dependent on the policy scenario envisaged.

Obtaining occupancy factors(O_LDVi) and vehicle utilization levels (VU_LDVi): LDVs have different vehicle utilisation levels in real-world, however, for bottom-up modelling exercises, some standard values are generally assumed. In this report, an annual utilization of 15,000 km has been assumed based on discussions with transport experts.

Estimating transport activity level (VKM_LDVi): Once all the data above have been obtained, the methodology specified in Equation 1, Section 3.4.2 have been used to calculate total passenger kilometres by LDVs.

Annexure V: Advanced Methods and Tools Note for Estimation of GHG Emissions

Most commonly used tools for ex-ante analysis of mitigation actions including EVs policies/ programs / projects are:

- *Spreadsheet tools with local/National Travel Data (AFLEET)*: The AFLEET (Alternative Fuel Life-Cycle Environmental and Economic Transportation) tool allows users to examine both the environmental and the economic costs and benefits of alternative fuel and advanced vehicles. It was developed for stakeholders to estimate petroleum use, GHG emissions, air pollutant emissions and cost of ownership of light-duty and heavy-duty vehicles using simple spreadsheet inputs.
- *Travel Models to forecast travel demand (EERPAT tool)*: The EERPAT tool is a non-spatial policy analysis tool, designed to provide rapid analysis of many scenarios that combine effects of various policy and transportation system changes. In order to provide a quick response comparing many scenarios, it makes a number of simplifying assumptions (consistent with emissions and advanced regional travel demand modelling practice) that somewhat limit the detail and precision of its outputs compared to a properly set up MOVES[1] implementation.
- *Transport Emissions Evaluation Model for Projects (TEEMP)*: TEEMP is a suite of excel-based, free-of-charge, suite of spreadsheet models and methods that can be used to evaluate the greenhouse gas (GHG), air pollution, and other impacts of many types of transportation projects. Project-level TEEMP models exist for BRT, bicycle, pedestrian, MRT, and highway projects, as well as travel demand management measures. It has the by ITDP, the CAI-Asia, ADB, Cambridge Systematics, and the Scientific and Technical Advisory Panel of the GEF. TEEMP has been applied to ADB projects, ITDP projects, and six World Bank projects (Source: Institute for Transportation and Development Policy).
- *COPERT emissions and energy consumption model*: COPERT is the EU standard vehicle

[1] Developed by US EPA, MOVES is an emissions modelling system that estimates emissions for mobile sources at the national, county and project level for criteria air pollutants, GHGs and air toxics

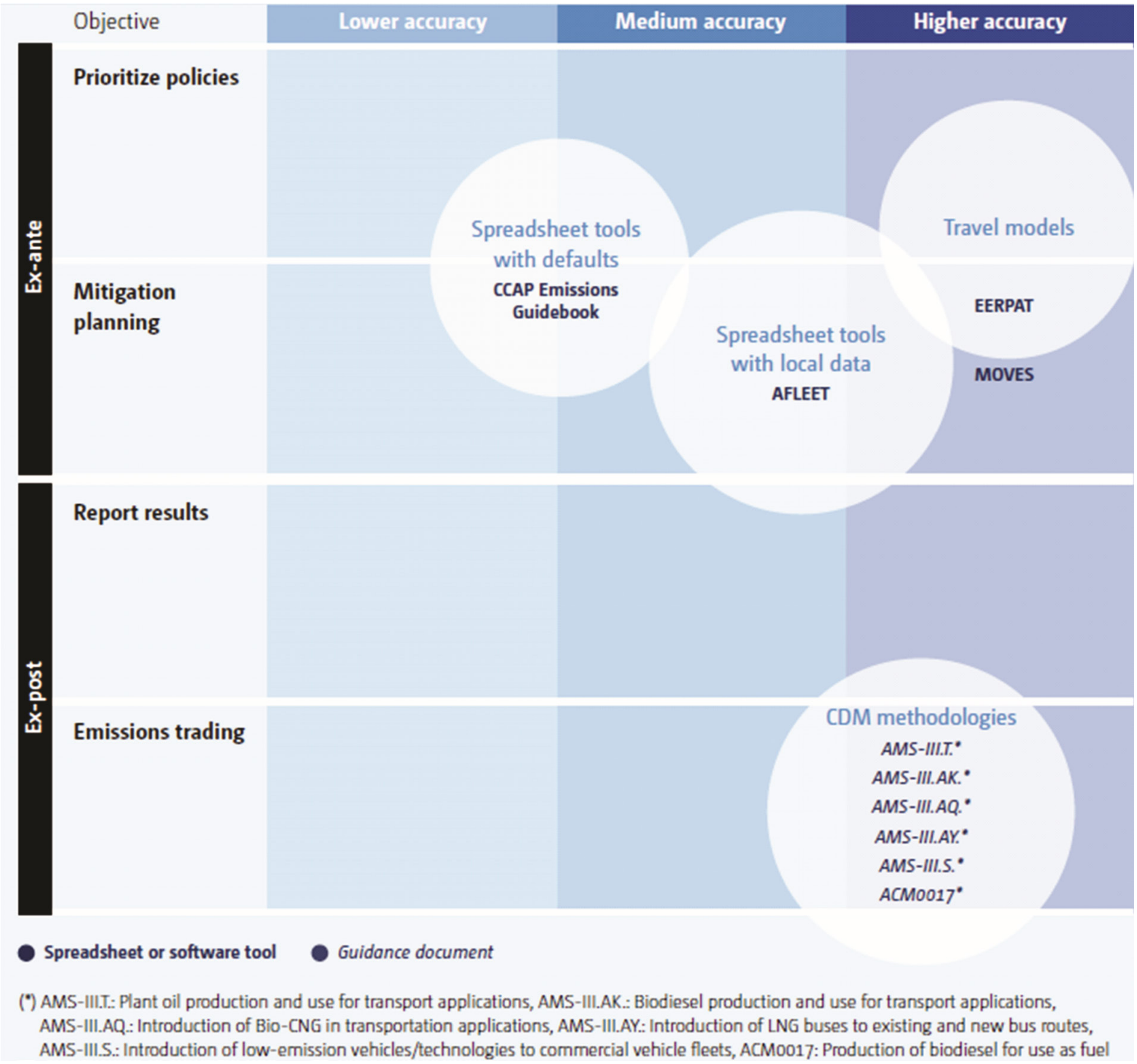

Figure A1: Available methods and associated tools for alternative fuel mitigation actions
Source: UNFCCC, GIZ

emissions calculator. It uses vehicle population, mileage, speed and other data such as ambient temperature and calculates emissions and energy consumption for a specific country or region. The COPERT methodology is part of the EMEP/EEA air pollutant emission inventory guidebook for the calculation of air pollutant emissions and is consistent with the 2006 IPCC Guidelines for the calculation of greenhouse gas emissions (Source: EMISIA).

- *IEA Mobility Model (MOMO)*: The Mobility Model (also known as MoMo) is a global transport spreadsheet model that has been developed since 2003. It contains detailed by-mode, by-fuel and by-region historical data and projections to 2050 for the transport sector as well as the sector's energy and greenhouse gas implications. The model is used within the IEA to provide quantitative analysis and to contribute to publications such as Energy Technology Perspectives. It also provides data input to the World Energy Outlook (Source: International Energy Agency).

Annexure VI: Key Outcomes from the Stakeholder Discussion

Key Stakeholders

1. Mr Shashidhar, Karnataka Udyog Mitra
2. Ms Manju Menon, Project Manager, Namma auto
3. Mr Narsimah Raju, Senior Director, Southern Chapter, TERI
4. Representative(s) from Karnataka State Finance Corporation
5. Representative(s) from Start-ups in e-mobility domain Bounce, RYDES
6. Mr Zafar Iqbal, Goenka Motors
7. Mr Didar Singh, Senior Fellow, Society for Development Studies

- At central level, a lot of work is being done in e mobility domain and FAME policy has given push to elevate and bring innovative mechanisms to address the mobility concerns within the urban areas.
- At state level, EV policies have incentivized deployment of charging infrastructure and electric vehicle adoption but there has been no template for data collection and quantifying the benefit.
- Since most of the interventions are at city level the data collection and monitoring should be initiated at city level.
- Adoption of holistic approach should be focused for EV mapping in in cities including battery disposal systems.
- In the process adoption, scrapping of existing ICE is also important as policy interventions are required not only to push electric vehicles but to also reduce congestion. Thus, involving RTO's become crucial.
- It was observed during the interactions that as per the Climate action plan for state of Karnataka, no state level data is collected for monitoring GHG emissions. The action plan estimates the impact from the national-level data. The state level climate change wing should collect data with respect to policy impact on GHG emissions. The state-level ministries responsible for GHG emission should appoint nodal person for submitting data annually to climate change department. This data can further add up to the national-level repository.

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