Office of the Principal Scientific Adviser
to the Government of India

TECHNICAL ROADMAP FOR DEPLOYMENT OF ZERO-EMISSION TRUCKING IN INDIA

VERSION - 2

July 2024

EXECUTIVE SUMMARY

The Office of the Principal Scientific Advisor (O/o PSA) to the Government of India published the first version of the "Technical Roadmap (TRM) for Deployment of Zero-Emission Trucking in India" (https://psa.gov.in/cms/web/sites/default/files/publication/zet_roadmap%20%281%29.pdf) in March 2023 to identify the urgent technical actions required for accelerating Zero Emission Trucks (ZET) adoption in India- referred to as "ZET TRM V1 (Version 1)" in this document.

It is recommended that this document is read in the context of ZET TRM V1, including this Executive Summary.

Fourteen technical actions for ZET penetration in India were identified in ZET TRM V1. Over the subsequent year after publishing, many additional technical actions have been identified on account of new technologies, market needs and ideas/ options. The ZET TRM V1 was deemed a live document, providing opportunities for subsequent updates, and a need was hence felt to extend ZET TRM V1 and prepare an addendum in the form of this document which is referred to as "ZET TRM V2". This Executive Summary of "ZET TRM V2" needs to be read in the context of the Executive Summary of "ZET TRM V1".

The field of zero-emission trucking is evolving continuously and has witnessed changes in technology and gathered learnings from similar deployments in various geographies and sectors, including passenger vehicles. Additionally, lessons learned from similar initiatives in other countries contribute to the ongoing refinement of this field. A working group was constituted by the Office of PSA in November 2023 for evaluating the addition of new actions with special focus to include India-specific technical requirements and provide ZET-specific tools to stakeholders- resulting in the preparation of ZET TRM V2 (Version 2) with the technical support of Centre of Excellence for Zero Emission Trucking (CoEZET) of IIT Madras as the Project Monitoring Unit (PMU).

The list of additional technical projects identified by this working group based on the aforementioned considerations are as follows:

1. High Power Static Induction Charging.
2. Estimation of real-world EV battery residual value.
3. Low cost, virtual reality ZET driver trainer.
4. Interactive Map identifying possible locations for ZET Charging Parks.
5. Web-enabled Tool for estimating range per charge.
6. Web-enabled Tool for solution design, Total Cost of Ownership (TCO) and business case
7. Impact assessment of ZET charging parks on the surrounding environment.
8. Assessment of emissions reductions due to ZET penetrations

Hydrogen Internal Combustion Engines (ICE), which was identified and mentioned in the ZET TRM V1 as an Annexure, is already at an advanced stage of field validation and has been hence moved to Govt. of India's Hydrogen Valley Project, and potentially may also be covered under Hydrogen Mission Transport sector initiatives. Hydrogen ICE is hence no longer considered in this Roadmap.

As was done in ZET TRM V1, the working group has provided tentative budgets and timelines for each of the identified actions. The project durations mentioned in the report ranges from 6 months to 24 months and is tentatively budgeted at a total of about ₹ 54 Crores for undertaking all 8 projects.

These projects, along with the more in ZET TRM V1 and possibly future additions in the coming years, will provide the required tools and technology across stakeholders to ensure faster adoption of ZET.

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ACD	Automated Charging Device
ARAI	The Automotive Research Association of India
BET	Battery Electric Truck
BOM	Bill of Material
CaaS	Charging as a Service
CMVR	Central Motor Vehicle Rules
CoEZET	Centre of Excellence for Zero Emission Trucking
CO2	Carbon Dioxide
DCD	Drive Cycle Data
DRA	Driver Rating Application
DISCOM	Electricity Distribution Company
eMaaS	eMobility as a Service
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EU	European Union
EV	Electric vehicle
FCET	Fuel Cell Electric Truck
ICAT	International Centre for Automotive Technology
ICE	Internal Combustion Engine
IHMCL	Indian Highways Management Company Limited
IIT	Indian Institute of Technology
MaaS	Mobility as a Service
M&HCV	Medium and Heavy-duty Commercial Vehicles

MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MoRTH	Ministry of Road Transport and Highways
NITI	National Institution for Transforming India
NTPC	National Thermal Power Corporation
OBD	Onboard diagnostics
O/o	Office of
OE, OEM	Original Equipment Manufacturer
OH-ACD	Over-Head Automated Charging Device
PMU	Project Monitoring Unit
PSA	Principal Scientific Advisor
R&D	Research and Development
RFP	Request for Proposals
RFQ	Request for Quotation
FSOH	State of Health
TCO	Total Cost of Ownership
TRM	Technical Roadmap
VR	Virtual Reality
WCS	Wireless Charging System
ZET	Zero-Emission Truck/ Zero-Emission Trucking (dual use, to be interpreted according to the context of its usage)

1. INTRODUCTION

1.1 INTRODUCTION AND JUSTIFICATION FOR VERSION 2 OF ZET TRM

India has formally committed to the international community to reducing the Emissions Intensity of its GDP by 45% by 2030, from the 2005 level and achieving about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. More significantly, the dependence on imported fuel continues to be a priority concern for the country for both strategic and economic/forex criteria.

Road transport (passenger and goods) currently contributes about 20% of the total emissions. In this, long-distance heavy trucks contribute the largest, at about 35%~40% of all road emissions, despite their very low relative inventory on the roads.

In other words, by 2050, with no action on long-distance heavy trucking, the emissions from trucking in India may account for as much as 15% of the total country's emissions. It can also be expected that 15% or more of the fossil fuel imported will be towards heavy long-distance trucking.

It is, therefore, a priority for the country to focus on converting this sector into a Zero-Emission Trucking (ZET) sector with a judicious combination of Battery Electric Trucks (BETs) and Fuel Cell Electric Trucks (FCETs) along with good greening of the national grid.

A basic commercial assessment of cost trends over the next ten years indicates that ZET with BETs will be competitive on a Total Cost of Ownership (TCO) per kilometre basis within the next few years for those applications that cover about 320 km per day. Therefore, given the long preparations, it is imperative to start activities with diligence soon.

The Office of the Principal Scientific Advisor (O/o PSA) to the Government of India published the first version of the "Technical Roadmap (TRM) for Deployment of Zero-Emission Trucking in India" (https://psa.gov.in/cms/web/sites/default/files/publication/zet_roadmap%20%281%29.pdf) in March 2023 to identify the urgent actions required for accelerating Zero Emission Trucks (ZET) adoption in India. This document has been referred to as "ZET TRM V1" in the later sections of the current document.

Considering fast technological changes being witnessed in the area of eMobility in general and zero emission trucking in particular, nature of the ZET TRM V1 has been envisaged as live and evolving document. Therefore, after periodical examination of the document , horizon scanning of current eco-system and intended progress to be made for ZET induction in India. Extension of ZET TRM V1 was conceived in September 2023. Therefore, this document referred to as ZET TRM V2 has been prepared as an addendum.

1.2 THE CURRENT STATUS OF ZET TRM V1

The status update of the projects identified in ZET TRM V1 is given in Annexure-I.

1.3 WORKING GROUP FOR ZET TRM V2

A working group was constituted by the Office of PSA for drafting ZET TRM V2 (Version 2) in November 2023 with the technical support of the Centre of Excellence for Zero Emission Trucking (CoEZET) of IIT Madras as the Project Monitoring Unit (PMU). The list of the members of this working group are listed in Section 5 of this document.

1.4 METHODOLOGY AND APPROACH

The working group has continued with the document format of ZET TRM V1. Each roadmap for identified topics are individually prepared with the following sections (these are in consistency with ZET TRM V1 document format):

1. Objective
2. Tasks
3. Stakeholders
4. Methodology
5. Deliverables
6. Timeline

As was done for the ZET TRM V1, the Working Group, while preparing this document, has carried out extensive consultations with different experts in Industry and Academia, in order to make relevant and feasible recommendations for actions. Budget estimates and timeline projections were also done in a manner that is identical to those adopted for ZET TRM V1.

1.5 HOW TO USE THIS DOCUMENT

1. This document identifies the various technical actions required for the successful implementation of ZET in India
2. For each of these actions, a Roadmap for executing the action is given in the form of a suggested methodology, the stakeholders to be dealt with, a rough-cut time plan for the various sub-actions that are to be carried out, and the overall budget for the action item
3. It is to be remembered that this is a Roadmap document and not a project plan or proposal. The experts have limited their suggestions to a broad level so that policymakers can take this up for further action
4. The individual Roadmaps can be read independently; while doing so, the user needs to refer to the specific Roadmap along with the introduction and conclusion
5. As mentioned earlier, given the constant and rapid changes in the market, technology, supply chain, costs, and policies, this document is to be treated as a live document.
6. In those cases where a certain action item is dependent on the successful completion of a previous action, such dependencies are shown in the Roadmap of the dependent action item so that the reader and user of this document will be aware of the details that are being prepared in the previous action
7. The master plan, shown in this document, has been simplified for easy reading and contains sub-activities that are consolidated and built into a single line in the master plan.

2. MASTER PLAN AND BUDGET FOR TECHNICAL ROADMAP VERSION 2

Sl. No.	Activity	Plan Duration in Months						Budget (Rs. Crores)
		5	10	15	20	25	30	
I	Technology Assessment and Development							
1	High Power Static Induction Charging							14.0
2	Measurement of Real-Wodd EV Battery Residual Value							12.0
3	Low Cost, Virtual Reality ZET Driver Trainer							20.0
4	Interactive Map identifying possible locations for ZET Charging Parks							1.5
5	Tool for Estimating Range per Charge							1.0
6	Tool for Solution Design, TCO and Business Case							3.0
7	Impact assessment of ZET charging parks on the surrounding environment							1.0
8	Assessment of Emissions Reductions due to ZET Penetrations							1.0
	Total							**53.5**

3. ZET TECHNICAL ROADMAP VERSION 2

The Working Group constituted by the Office of PSA for drafting ZET TRM Version 2 identified the following list of additional technical projects for deployment of Zero Emission Trucking (ZET) in India:

1. High Power Static Induction Charging.
2. Estimation of real-world EV battery residual value.
3. Low-cost, virtual reality ZET driver trainer.
4. Interactive Map identifying possible locations for ZET Charging Parks.
5. Tool for estimating range per charge.
6. Tool for solution design, Total Cost of Ownership (TCO) and business case.
7. Impact assessment of ZET charging parks on the surrounding environment.
8. Assessment of emissions reductions due to ZET penetration.

All the above actions fall under “Technology Assessment and Development” as categorized in ZET TRM V1.

The Working Group has prepared the Technical Roadmap V2 for the above topics/areas after due deliberation and diligence. As followed in the ZET TRM V1, each roadmap project in V2 is also prepared with the following sections:

1. Objective
2. Tasks
3. Stakeholders
4. Methodology
5. Deliverables
6. Timeline

Roadmaps for afore mentioned topics/areas are presented in detail in the following sections.

3.1 HIGH POWER STATIC INDUCTION CHARGING

OBJECTIVE

Induction charging or wireless charging with Higher Power Density and Higher Power Ratings is an area with immense potential for technology development and is especially useful for Commercial Vehicles with high power and voltages. This is being researched in several laboratories, universities, and industries as a viable alternative to conductive charging technologies. While there are definitive advantages, such as higher suitability for Autonomous driving, lack of contact-reducing abuse and wear-prone connectors and more, there are a few associated challenges such as Health and Safety, Electro Magnetic Compatibility (EMC) and Transfer Efficiency, Power Density of Wireless Charging System (WCS) and a few others. Viewed in the Indian context, better turnaround time, a critical parameter in some applications, may be achieved by the driver not leaving the cab and the system being less dependent or non-dependent on the driver or a charger operator/ technician.

TASKS

The development of High Power Static Induction Charging broadly involves the following tasks:

1. Select optimal vehicle specification ranges and application(s) for experimenting with high power static induction charging.
2. Develop vehicles for optimal application(s) along with OEMs with matching interface systems for induction charging.
3. Finalise the Power (kW) Rating and Power Density ranges for the trials.
4. Finalize optimal technology for high power static induction charging for the Indian context.
5. Benchmark the current global status - especially in the higher power and power density charger systems with fewer players.
6. Identify the mechanical and electronic/ power electronic aggregates, sensing control and alignment facilitators, both at the vehicle end and at the charger end.
7. Design Electronics / Power Electronics systems, and define measurement and communications protocols, especially considering challenges in real-world applications such as those identified above.
8. Create Prototypes, and verify/optimize design parameters.
9. Set up field trials infrastructure in specific routes/applications and conduct field trials to evaluate energy consumed as well as the charging efficiency.
10. Debug and publish designs and specifications, including supply chain and special manufacturing criteria.
11. Develop draft standards for high power static induction charging, and draft suggested modifications for vehicle regulations.

STAKEHOLDERS

1. Automotive Original Equipment Manufacturers (OEMs)
2. Vehicle fleet owners
3. Research laboratories/Certification or Standards Organization
4. Component / System suppliers
5. Distribution Companies (DISCOM)
6. eMobility as a Service (eMaaS) and Charging as a Service (CaaS) Providers

METHODOLOGY

The following steps are involved in completing the above tasks:

1. Select optimal vehicle and application based on published benefits and constraints of wireless charging in discussion with experts or with previous market research.
2. Modify the design of the vehicle (for selected application) for induction charging such as including charging pads.
3. Select optimal technology for high power static induction charging from those currently pursued for static chargers (such as Resonant Inductive or Permanent Magnet wireless charging) using parameters such as lower footprint, infrastructure and investment, Bill of Materials (BOM) Cost, safety, and training needs.
4. Development of suitable wireless communication protocol for safe operation to be implemented.
5. Seek partners to establish test facilities and propose testing to simulate applications.
6. Collect test cycle information from fleet owners/operators and possible routes (especially for pilots of high power static induction charging).
7. Conduct lab trials to validate design concepts for mechanical, power electronics, sensors and other systems including parameter optimization such as pad size and air gaps.
8. Setup pilot facilities in the application/route chosen.
9. Conduct field trials for the selected applications to test
   a. Mechanical systems,
   b. The impact of alignment, air gap and other parameters on efficiency,
   c. The impact on safety, Electromagnetic Compatibility (EMC) and others.
10. Summarize findings on the above characteristics and their feasibility to expand to larger scale pilots.
11. Prepare and publish the designs and specifications including details for part quality, build quality, manufacturing process and supply chain options.
12. Prepare a draft standard for high power static induction charging and also draft suggested modifications for vehicle regulations.

DELIVERABLES

The following are the proposed deliverables of this activity:

1. Trials for the identified charging technologies.
2. Report summarizing trial results based on economic, infrastructure, technical and operating feasibility, and possible truck use cases.
3. Designs and specifications as indicated above.
4. Draft standards and suggested modifications for regulations for high power static induction charging.

TIMELINE

The timeline for each task under this Roadmap activity is provided in Figure 1.

Figure 1: Timelines for High Power Static Induction Charging

ACTIVITY	PERIOD (Months)																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Selection of target specification for prototype and pilot and application for trials																								
Design and prototype low power device																								
Design - Mechanical, Electrical and Sensing																								
First Prototype development infrastructure setup																								
Remaining Prototype completion and trials completion																								
Development of draft standards and suggested draft vehicle regulations																								

The estimated budget for carrying out the above-mentioned activities is **₹14 Crores.**

3.2 ESTIMATION OF REAL-WORLD EV BATTERY RESIDUAL VALUE

OBJECTIVE

A significant part of the capital cost for the eTruck involves the cost of the battery. Resale value is a critical factor in the business model of a truck operator, and hence residual value of the battery must be assessed independent of the vehicle. Tracking battery residual value becomes important for establishing viability, as well as, for resale value assessment when the vehicle ownership is transferred. This will also help the financier for battery resale valuation when required. Real-life operating parameters can differ significantly in India across trucking applications, therefore it is important to assess State of Health (SOH) of EV Batteries based on these parameters to arrive at critical decisions.

The batteries come with tested and certified life from the OEMs, based on test cycles which include drive/load and ambient conditions. The actual cycles in different vehicles would vary depending on their usage and other criteria, therefore the SOH is likely to be different for different individual vehicles.

In such a scenario, it becomes commercially vital to assess the residual value of a battery (using SOH) by physically testing it on a case-to-case basis at different points during the life of the vehicle (or from Telematics/Stored OBD data), rather than using empirical estimates. The battery residual value must be derived based on a central indexed pricing for the battery based on capacity and SOH, similar to the valuation of commodities. This removes arbitrage risks and enables the market to adopt ZET trucks.

TASKS

This roadmap section broadly involves the following tasks:

1. List and evaluate techniques for battery SOH assessment.
2. Design Sampling and testing plan for measurement in real life.
3. Procure test equipment, batteries and sensors for testing.
4. Install necessary sensors.
5. Measure and assess results against already existing claims/ studies.
6. Develop standard prescribing inputs, algorithms, and computational tools for assessing SOH without compromising of electrical and functional safety of the vehicle.
7. Ensure input parameters are available on telematics and mandatory parameters are exposed in the vehicle as per the standards, at an agreed frequency.
8. Develop two separate tools to assess SOH, that can be deployed based on data availability – (1) using the telematics data and computed, and (2) using physical measurements
9. Evaluate a mechanism to assess the residual value from the battery assessment. Validate on tested batteries.

STAKEHOLDERS

1. OEMs
2. Battery Suppliers
3. Fleet owners
4. CoEZET
5. Financiers
6. Research laboratories
7. Communication companies
8. Certification bodies such as ARAI, ICAT

METHODOLOGY

The following steps are involved in completing the above tasks:

1. List various techniques along with the advantages and disadvantages of each for measurement of battery health.
2. Develop Sampling plan and checking methodology considering the different ambient and vehicle types/truck applications.
3. Procure batteries, test rigs including sensors, loads, and power electronics to accelerate and simulate degradation.
4. Check all tasks as per the above methodology and correlate algorithmic accuracies /measurements against experimental results.
5. Develop and implement a specification for ensuring all the parameters required to assess battery health are available in the vehicle network in a standardized manner across OEMs similar to the OBD-II specifications for emissions. This will ensure standardization across applications of third-party app developers. Also, the data will need to be available for records during the operating life of the vehicle through telematics. The tool must be capable of using telematics data or physical measurements.
6. Develop a tool that provides accurate SOH. The tool and test specifications, measurement and analysis should be specified in a standard enabling repeatable standardized results.
7. Publish standards for SOH assessment under prescribed conditions and inputs including telematics inputs during the operating life of the vehicle.
8. Provide a tool for deriving battery residual value based on the SOH and an indexed battery pricing that can be used to certify the residual value
9. The Technology is to be held and disseminated at NIL or negligible cost through a Neutral agency such as CoEZET with operating training material and also the ability to scale the services across the country.

DELIVERABLES

The following are the proposed deliverables of this activity:

1. Establish Standards that define SOH and publish them.
2. Standard Tool for SOH testing.

TIMELINE

The timeline for each task under this Roadmap activity is provided in Figure 2.

Figure 2 : Timelines for Estimation of Real-World Battery Residual Value

ACTIVITY	PERIOD (Months)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Benchmark and collect information for test sampling and techniques																		
Procure test equipment and batteries																		
Develop SOH testing tool, test and correlate with test results																		
Engage with stakeholders and formulate standard for SOH testing and measurement, Refine tool parameters																		
Publish standard and tool																		

The estimated budget for carrying out the activities mentioned above is **₹12 Crores.**

3.3 LOW COST, VIRTUAL REALITY ZET DRIVER TRAINER

OBJECTIVE

New driving practices such as the use of regeneration braking, “coasting”, “one-pedal highway driving” and others, suitable for electric drive trains, need to be taught. Several controls such as clutch, gear shift and others are removed/changed in electric trucks. The driving pattern/behaviours need to be suitably modified for electric trucks as they impact driving range and efficiency, which in turn determine battery sizing and hence the vehicle cost.

Truck driving is no longer seen as a lucrative profession and numbers are dwindling leaving a large gap between demand and supply. It is important to reskill the existing workforce and train the new drivers using cost-effective measures.

There are several driver training institutes set up by the OEMs in conjunction with state and central governments in important trucking centres. It will be useful to equip them with low-cost Virtual Reality (VR) training tools for achieving quality and scale. The cost-effective device will also be taken up by other bodies when electrification penetration increases in trucking.

TASKS

This roadmap section broadly involves the following tasks:

1. Prepare detailed Request for Quotation (RFQ) and Request for Proposals (RFP) and invite proposals for developing Virtual Reality (VR) training tools.
2. Select a supplier for content.
3. Select a supplier for VR programming.
4. Develop a VR ZET Trainer tool.
5. Deploy/Train pilot batch.

STAKEHOLDERS

1. Ministry of Road Transport and Highways
2. Fleet owners
3. OEMs
4. VR tool developers
5. Academic institutions/OEM driver training institutes

METHODOLOGY

The following steps are involved in completing the above tasks:

1. Identify content provider and subject matter expert/lead driver training centre [usually partnered with an OEM].
2. Identify a partner for VR material generation.
3. Develop a VR-based training tool that can be open-sourced across centres and work across a range of devices.
4. Train pilot batch and check effectiveness.

DELIVERABLES

The following are the proposed deliverables of this activity:

1. OE / Device agnostic low-cost VR tool including the relevant devices and hardware.
2. Designs and specifications.
3. Three prototypes that are functionally accepted.

TIMELINE

The timeline for each task under this Roadmap is provided in Figure 3.

Figure 3 : Timelines for Low-Cost, Virtual Reality Zet Driver Trainer

ACTIVITY	PERIOD (Months)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Benchmark and identify partners for development, domain experts for driver training																		
Domain expert inputs and iteration, detailing																		
VR tool development																		
Rollout to pilot centers and enhancements																		

The estimated budget for carrying out the above-mentioned activities is **₹20 Crores.**

3.4 INTERACTIVE MAP IDENTIFYING POSSIBLE LOCATIONS FOR ZET CHARGING PARKS

OBJECTIVE

Charging infrastructure is critical to the fast adoption of Electric Trucks. Both technically and commercially, the location of charging stations plays a critical role in the viability of a robust setup. Several parameters impact the determination of location. Unlike locating traditional fuel stations, the ZET charging parks must have the following features:

1. Availability of reliable and uninterrupted electrical supply.
2. Enough space for rest areas/food courts as charging takes more time than conventional refuelling.
3. Accessibility to highways.

An automatic identification technique provides credibility for selection and viability, enhances financier and investor confidence, and helps scale charging parks.

TASKS

This roadmap segment broadly involves the following tasks:

1. Select partners for software development of ZET charging location recommendations.
2. Collect Input Data viz Power availability (Details of grid lines), truck traffic density, truck routes, etc.
3. Prepare an algorithm for selecting a range of geographical areas based on inputs.
4. Engage with relevant government organizations (state governments, highways departments, and power boards) to review and approve algorithms.
5. Build a tool for region-wise identification of optimum charging locations.

STAKEHOLDERS

1. Power generation and distribution companies (NTPC, Power Grid, and others).
2. Relevant Government Departments/Ministries (MoRTH, MoP, and others).
3. Charging Infrastructure Players (CaaS companies).
4. Fleet operators.
5. Financiers for fleet and infrastructure.
6. Local bodies / State governments for rural land development/infrastructure.

METHODOLOGY

The following steps are involved in completing the above tasks:

1. Identify partners to collect data and develop tools for location identification.
2. Collect input data from agencies and establish a pipeline for data updates at regular frequencies.
3. Prepare an algorithm with various input parameters (Step 2 and Step 3 will be iterative) and discuss with subject matter experts in domains listed in stakeholders to tune the model.
4. Develop a simple online tool for the selection of charging areas that can act as a validated source of information for financiers/investors.

DELIVERABLES

The following are the proposed deliverables of this activity:

1. Online tool for identification of locations for charging infrastructure.
2. Data sources and update pipeline for Tool.

TIMELINE

The timeline for each task under this Roadmap is provided in Figure 4.

Figure 4 : Timelines for Interactive Map Identifying Possible Locations for Zet Charging Parks

ACTIVITY	PERIOD (Months)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Select software development partner																		
Collect input data from algorithm and setup pipeline																		
Develop algorithm in discussion with Expert panel																		
Develop simple online tool and test with few stakeholders																		

The estimated budget for carrying out the above-mentioned activities is **₹1.5 Crores.**

3.5 TOOL FOR ESTIMATING RANGE PER CHARGE

OBJECTIVE

The initial cost of the truck is driven by the size of the battery. The range per charge determines the battery size and depends on various parameters such as model configuration, road maintenance, load, and operating routes. Developing an open-source tool for range estimation, that can be configured further by OEMs to suit their models, is important for ZET adoption and success.

TASKS

This roadmap section broadly involves the following tasks:

1. Benchmark power densities, pack sizes for batteries, number of packs, common application ranges, and current range estimation methodologies in discussion with OEMs.
2. Collate input parameters for the tool.
3. Select suppliers to build a configurable range estimator tool.
4. Validate the tool by testing it in collaboration with OEMs.
5. Release source code and tool for use by OEMs.

STAKEHOLDERS

1. Fleet owners
2. OEMs
3. Supply chain companies, End consumers for Trucking
4. Charging as a Service (CaaS), Mobility as a Service (MaaS) providers
5. CoEZET
6. Financiers/ Investment bodies

METHODOLOGY

The following steps are involved in completing the above tasks:

1. Benchmark and collect application and configuration inputs for the tool with experts and OEMs.
2. List and validate parameters and establish the impact of these parameters on range per charge and sizing.
3. Prepare a tool for range estimation with configurable parameters.
4. Validate the tool for three major high-volume models and application combinations enabling one OEM to tweak the parameters and provide inputs.
5. Develop Open Source range estimation tool to be used by OEMs and fleet owners for model configuration.

DELIVERABLES

The following are the proposed deliverables of this activity:

1. Tool for range estimation with configurable parameters.
2. Sample vehicle range estimations for three applications with various parameter values.

TIMELINE

The timeline for each task under this Roadmap is provided in Figure 5.

Figure 5 : Timelines for Tool for Estimating Range Per Charge

ACTIVITY	PERIOD (Months)					
	1	2	3	4	5	6
Benchmark pack sizes for batteries, current range estimation methodologies in discussion with OEMs						
Collate input parameters for the tool						
Select suppliers and build a configurable range estimator tool						
Validate the tool by out with OEM/Fleet owners						
Release source code and tool for use by OEMs						

The estimated budget for this activity is **₹1.0 Crore.**

3.6 TOOL FOR SOLUTION DESIGN, TCO AND BUSINESS CASE

OBJECTIVE

Commercial vehicles such as trucks are used in a wide range of applications. They range from short-distance intracity applications such as garbage handling and intracity parcel delivery to long-haul hub-to-hub transport. They also cover a wide variety of loads and roads. Given the variety and commercial nature of applications of trucks, it is important to

1. Design the solution and TCO for the entire specific eMobility Project based on parameters like routes and distances to be travelled, charging infrastructure requirements, and product/component configurations (define the type and number of trucks, battery sizing, sizing of the chargers, duty cycles, define the number of chargers, define the locations for charging, define the matching power infrastructure, etc.).
2. Establish the business case for ZET operation in the identified routes.
3. Gather inputs on critical levers and sensitivity such as useful life (Battery SOH) for iteration.
4. Estimate TCO.

TASKS

This roadmap section broadly involves the following tasks:

1. Benchmark and collect application, and configuration inputs for the tool with experts and OEMs.
2. Prepare tool with all parameters for Solution design, TCO estimation and business case. Create default templates for major application use cases and simplify the tool.
3. Test the tool with operators and financiers for sensitivity, selected defaults and correctness.

STAKEHOLDERS

1. Fleet owners
2. OEMs
3. Supply chain companies, End consumers for Trucking
4. Charging as a Service (CaaS), Mobility as a Service (MaaS) providers
5. CoEZET
6. Financiers/ Investment bodies

METHODOLOGY

The following steps are involved in completing the above tasks:

1. Work with OEMs/Research labs to establish drive cycles for major applications (such as intracity, inter-city and combinations), possible product configurations and range estimation.
2. Work with fleet managers for application characteristics (wait times/specific geographical constraints), and establish critical parameters for TCO – waiting times, typical leads, trips per day/month, uptime, or utilization.
3. Evaluate the business case for various applications and critical levers impacting their adoption.
4. Develop a simple online tool for Solution design, TCO estimation and Business Cases.
5. Engage with large and small fleet operators and validate the tool.
6. Train and enable the identified agency to operate the tool for various stakeholders.
7. Promote tool usage for adoption with fleet operators and financiers.

DELIVERABLES

The following are the proposed deliverables of this activity:

1. Develop a simple tool similar to a configurator, for evaluation and adoption of electric trucks by application using application inputs to derive range, Solution design, TCO, and Business case.

TIMELINE

The timeline for each task under this Roadmap is provided in Figure 6.

Figure 6 : Timelines For Tool For Solution Design, TCO And Business Case

ACTIVITY	PERIOD (Months)											
	1	2	3	4	5	6	7	8	9	10	11	12
Benchmark and collect app inputs such as Duty Cycles, Configurations												
Prepare tool with all parameters for Solution design, TCO and business case. (Web based and Excel)												
Create defaults for major application use cases and simplify the tool												
Test the tool with operators and financiers for sensitivity, selected defaults and correctness.												
Train and enable agency to operate the tool for various stakeholders												

The estimated budget for carrying out the above-mentioned activities is **₹3 Crores.**

3.7 IMPACT ASSESSMENT OF ZET CHARGING PARKS ON THE SURROUNDING ENVIRONMENT

OBJECTIVE

ZET charge parks are significant infrastructure establishments – both in terms of number and locations across the country. It is important to assess the impact of charge parks on the surroundings and also on other facilities.

Unlike two-wheeler charging, commercial vehicle charging can place significant loads on the grid of the order of Megawatt (MW), especially when looking at large parking and charging stations along key corridors. The charging of trucks can be expected to reach around 10% of power consumption at a steady state and hence careful impact assessment is critical. The impacts may be related to power consumption lines or effects such as EMI / EMC and others.

The objective of this activity is to study the impact of EMI/ EMC and other interference, on the lines that are physically near the charging parks, and also their effect on the safety and, health of humans and other life forms nearby.

The ZET charge parks will also impact emergency support services such as medical and fire safety. ZET with high voltage power electronics pose unique requirements for training medical and fire safety personnel, as well as equipment used.

The impact on the power consumption, power line, power availability and line-related effects are not covered in this activity.

TASKS

This roadmap section broadly involves the following tasks:

1. Estimate load requirements and EMI/ EMC and other emissions at a charger and a park level.
2. Design scale models (if required) and set models to validate EMI / EMC and other effects on surroundings (including health and safety).
3. Prepare and publish norms, if required, for the distances to be maintained between grid lines and charging parks, and safety norms for measurement and certification of charging parks including safety of human and other life forms present in the vicinity.
4. Assess requirements for fire safety, emergency medical support and provide guidelines for facilities required based on charge park(s) type and scale within an area. These may be included, either in the charge-park or common infrastructure provided by the state/central agencies at the district level

STAKEHOLDERS

1. Academia
2. Ministry of Power
3. State / Central and Private Power generation and distribution companies
4. An agency with the expertise to study health and safety norms to provide inputs and in future regulate the same (if required)
5. MaaS and CaaS companies

1"Electromagnetic compatibility (EMC)" means the ability of a vehicle or component(s) or separate technical unit(s) to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

Electromagnetic interference (EMI)" is unwanted noise or interference in an electrical path or circuit caused by an outside source. It is also known as radio frequency interference. EMI can cause electronics to operate poorly, malfunction or stop working completely.

METHODOLOGY

The following steps are involved in completing the above tasks:

1. Collect inputs on load requirements and estimated sizes of charging parks from experts.
2. Theoretically calculate effects on EMI/EMC due to various charging parks by making assumptions relating to the design of parks such as density, and technologies used explicitly. Also estimate likely impacts on communication, inter-charger effects, thermal and other effects.
3. Inputs from safety and health professionals regarding the impact of charging parks on humans and other life forms typically near charging parks
4. Design (if required) a scale model to simulate effects, procure and measure for verification.
5. Prepare and discuss norms with experts on charging parks to measure and certify their effects. Also, possible parameters to be included as part of safety requirements when selecting locations or constructing parks.
6. Discuss with fire safety agencies (such as state Fire and Rescue Services) the charge park characteristics, assess impact on current infrastructure and staff.
7. Discuss with medical emergency response centres managing across national highways to understand impact of ZET Charge parks.

DELIVERABLES

The following are the proposed deliverables of this activity:

1. EMI / EMC risks (if any). Norms for human and other life forms.
2. Other emission and related risks- excluding grid-load and power management.
3. Norms and distances, if any are required, to follow in terms of park-to-transmission or distribution lines or critical safety requirements when installing charging parks.

TIMELINE

The timeline for each task under this Roadmap is provided in Figure 7.

Figure 7: Timelines for Impact Assessment of Zet Charging Parks on The Surrounding Environment

ACTIVITY	PERIOD (Months)											
	1	2	3	4	5	6	7	8	9	10	11	12
Estimate Park Sizes and EMI EMC and other emissions												
Design scale models (if required) and setup models to verify effects												
Prepare and publish norms, safety norms for measurement and certification of charging parks												
Discuss with Fire Safety and Medical Emergency Response agencies for impact assessment												

The estimated budget for carrying out above mentioned activities is **₹1 Crore.**

3.8 ASSESSMENT OF EMISSIONS REDUCTION DUE TO ZET PENETRATION

OBJECTIVE

Most countries have agreed to emission reduction with specified timelines (Paris Agreement). Hence, the contribution of the M&HCV segment to both emissions and energy security is critical.

With current economic growth, pollution could double from current levels by 2050. Zero Emission Trucking could play a vital role in emission reduction in alignment with India's plans to reduce CO2 emissions by 60% by 2050 and consequently achieve the goal of net zero emissions by 2070. The European Union (EU) has already mandated reductions upward of 60% by 2035.

TASKS

This roadmap section broadly involves the following tasks:

1. Assess the current impact of trucks on the total emissions and projected growth.
2. Collate timelines for activities for emission reduction.
3. Formulate emission reduction plans by various application segments with scenarios for adoption rate.
4. Summarize and report vehicle volumes and emissions along with scenarios.

STAKEHOLDERS

1. Ministry of Road Transport and Highways
2. Ministry of Environment, Forest and Climate Change
3. NITI Aayog
4. OEMs

METHODOLOGY

The following steps are involved in completing the above tasks:

1. Categorize the current impact of trucks (park) on emission levels by application/region.
2. Estimate the likely growth forecast by segment without ZET – by segment and region. Triangulate with other estimation methodologies.
3. Compute emission reduction due to planned ZET targets specified. OEM-wise targets for emission reduction and achievements against it can be used since the players for commercial vehicle trucks in the M&HCV segment are few. Use scenarios for adoption rates to provide the range of reduction.
4. Compute possible emission reduction based on sales numbers for ZETs over 5-year periods.

DELIVERABLES

The following are the proposed deliverables of this activity:

1. Estimated emissions with and without emission reduction efforts from ZET.
2. Emission reduction scenarios with ZET over a stipulated time frame along with additional information like electricity and fuel consumption.

TIMELINE

The timeline for each task under this Roadmap is provided in Figure 8.

Figure 8 : Timelines Assessment of Emissions Reduction on Account of Direct and Indirect Zet Actions

ACTIVITY	PERIOD (Months)					
	1	2	3	4	5	6
Assess current impact of trucks to the total emissions and projected growth						
Collate timelines for activities for emission reduction						
Compute emission reduction plan by various application segments with scenarios for adoption rate						
Summarize and report vehicle volumes and emissions along with scenarios						

The estimated budget for carrying out the above-mentioned activities is **₹1 Crore.**

4. CONCLUSION & WAY FORWARD

This section on conclusion shall be read in conjunction with the same section in ZET TRM Version 1.

The current document, i.e., ZET TRM V2 outlined eight additional technical actions required for ZET penetration in India and recommended a budget of ₹ 54 Crores with timelines ranging from 6 to 24 months.

Hydrogen Internal Combustion Engines (ICE) which were identified and mentioned in the ZET TRM V1 Report as an Annexure, are in an advanced stage of commercial validation and are part of the hydrogen production and adoption roadmap, and potentially may also be covered under Hydrogen Mission transport sector initiatives and hence no longer considered in this Roadmap. The projects in this document are likely to provide the required tools and technology across stakeholders to ensure faster adoption of ZET.

5. ADVISORY COMMITTEE, WORKING PANEL AND LIST OF CONTRIBUTORS

5.1 ADVISORY COMMITTEE

S. No.	Name, Designation, and Organisation	Role
1.	Prof. Ajay K. Sood, Principal Scientific Adviser, Government of India	Chairperson
2.	Dr. Parvinder Maini, Scientific Secretary, O/o PSA	Member
3.	Dr. Preeti Banzal, Adviser/Scientist 'G', O/o PSA	Member-Secretary
4.	Sh. Karthick Athmanathan, Honorary PSA Fellow and Professor of Practice, IIT Madras	Member

5.2 WORKING GROUP FOR DRAFTING ZET TRM V2

S. No.	Name, Designation, and Organisation	Role
1.	Dr. Preeti Banzal, Adviser/Scientist 'G', O/o PSA.	Chair
2.	Sh. Karthick Athmanathan, Honorary PSA Fellow	Vice-Chair
3.	Prof. C. S. Shankar Ram, Professor and Principal Investigator, CoEZET, IIT Madras, Chennai.	Member
4.	Sh. S. A. Sundaresan, Vice President (EV and e-Mobility Solutions), Ashok Leyland Ltd, Chennai.	Member
5.	Prof. Prashant Navalkar, Guest Faculty, IIT Bombay.	Member
6.	Prof. Deepak Ronanki, Assistant Professor and Co-Principal Investigator, CoEZET, IIT Madras, Chennai.	Member
7.	Sh. Laxmiprasad Jahagirdar, Chief Executive Officer, IPL Tech Electric Pvt. Ltd., TI Group, Gurgaon, Haryana.	Member
8.	Sh. Ravindra Mohan, Group Director, TecSo ChargeZone Ltd., Vadodara.	Member
9.	Sh. Abhijit Mulay, Deputy Director, ARAI, Pune.	Member
10.	Sh. Rajesh S, CEO, CoEZET, IIT Madras, Chennai.	Member-Secretary
11.	Ravi M, Chief of Operations, CoEZET, IIT Madras, Chennai	Convenor

5.3 ACKNOWLEDGEMENTS

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ANNEXURE-I STATUS OF PROJECTS IDENTIFIED IN ZET TRM V1

Sl. No.	PROJECTS	STATUS UPDATE ON PROGRESS OF PROJECTS (As on May 2024)
1	Field Research – Battery Electric Trucks (BET)	This project, started in July 2023 as scheduled, is currently in progress and targeted to be completed by October 2024. The data from IHMCL website and additional insights received from stakeholder interviews are being used for selection of the final 10 corridors.
2	Acquisition of Drive Cycle Data (DCD) for Selected Field Corridors	This project is dependent on and planned along with the Field Research project mentioned in Sl. No. 1 above. It would be started in July 2024 and finished by October 2024.
3	Driver Rating Application (DRA) Development	The proposals and requirements for this App are under preparation and review. On completion of implementation this App will be implemented and start running by November 2024. It will be hosted by CoEZET on Driver's mobiles with monthly rewards for efficient and safe driving.
4	Field Research – Fuel Cell Electric Trucks	This Field Research will begin after the BET Field Research in Sl. No. 1 above is completed. It is likely to start in March 2025 and finish by December 2025.
5	Updating CMVR to Incorporate OH-ACD Standards	This project is dependent on the Overhead Automatic Charging Device development project mentioned in Sl. No. 8 below. The project is slated to start in November 2024 and estimated to be completed in June 2025.
6	Updating CMVR for Battery Electric Truck	This project started as scheduled in November 2023. ARAI has confirmed that CMVR provisions are in place. Minor modifications in standards for BET is in progress. Standards are expected to be released before November 2024 with regular updates to the Standards.
7	Updating CMVR for Fuel Cell Electric Truck (FCET)	This project is slated to start in January 2026. The project end date is November 2027 given that it also involves the completion of FCET test facilities at ARAI.
8	Development of Over-Head Automated Charging Device for BET	This project started as scheduled in September 2023 and is likely to take more than the 18 months projected earlier- closer to 22 months. A firmer indication of timeline contraction is possible for consideration in August 2024, when the initial design work is completed.
9	Evaluation of Rare Earth Magnet-Free Motors for Electric Trucks	This project is planned to begin in September 2024 and end by April 2025.
10	Regulation and Supply Chain for On-board Hydrogen Storage	This project is scheduled to start in Oct 2025 and be completed by December 2027. This is likely to be part of the Hydrogen Valley and MNRE R&D Roadmap for Green Hydrogen.
11	Finance for Battery Electric Trucks	This project was scheduled to start only by May 2024 but has been initiated earlier in October 2023 itself. The planned end date is Sep 2024.
12	Safety Awareness, Training, Manuals, Guidelines for BET	These proposals and requirements are under preparation and review. The activity started in January 2024 and will end by March 2026.
13	ZET Pilots–Battery Electric Trucks	The plan for running pilots will be drawn up based on the outcome of the BET Field Research project mentioned in Sl. No. 1 above as well as suitable policy announcements by the Govt. of India. The required policies and funding are to be in place before starting the planning activity.

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