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INDO GERMAN WORKSHOP ON INNOVATIVE CHARGING TECHNOLOGIES FOR HEAVY DUTY VEHICLES (IChargeHDV)

February 18, 2021

Workshop Summary

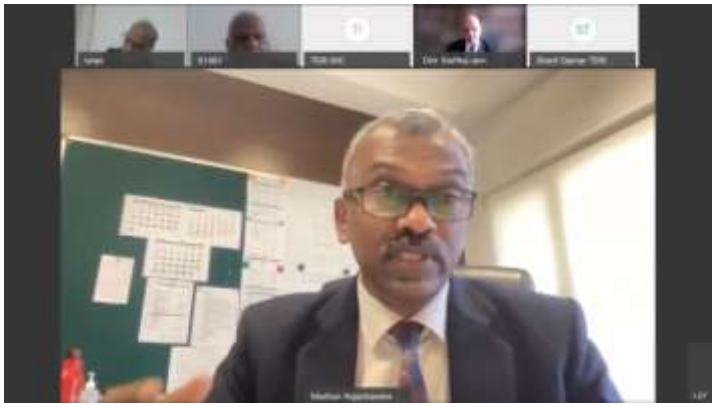
Introduction

The Indo-German workshop on Innovative Charging Technology for Heavy Duty Vehicles (IChargeHDV) was organized on February 18, 2021. It aimed to provide a platform for policy makers, infrastructure developers, research and development institutes, and leading industry players in freight transport technology/rolling stock supply to advance industrial research partnership in catenary truck technology, which is of interest for both the nations. The workshop, which was supported by Indo-German Science and Technology Centre (IGSTC), aimed to enable stakeholders to share on-field experience in the sector, combined with an overview of strategies to support each other in reducing the GHG emissions and pollutants from the freight transport sector. The workshop is one of the few first steps towards enhancing the technological partnership between nations under the ongoing bilateral projects like promotion of transformation to sustainable and climate friendly electro mobility by inviting young scientists from Germany.

The workshop witnessed participation from various stakeholders from both the countries and involved serious deliberations on the benefits as well as challenges in the IChargeHDV sector. A brief summary of the workshop proceeding, along with the final agenda, is presented in this document.

Inaugural Session

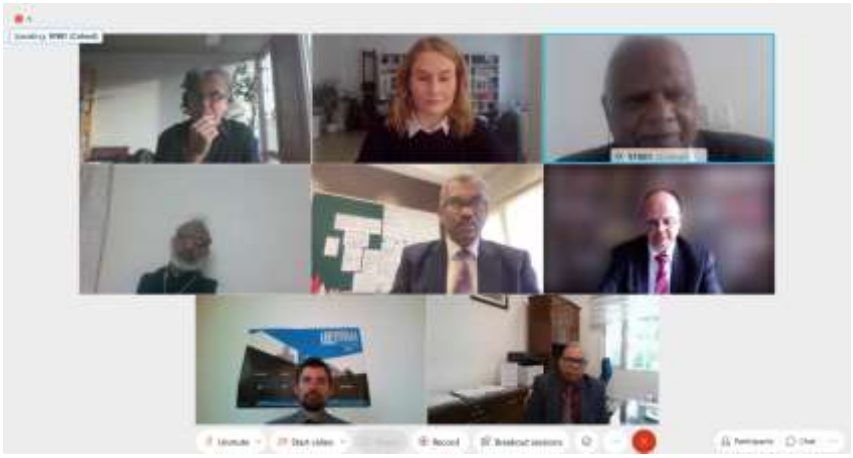
The inaugural session was moderated by **Ms Lena Stiller, Transport Policy Advisor, GIZ GmbH**.



The welcome address was delivered by **Mr. R Madhan, Director, Indo-German Science and Technology Centre (IGSTC)**. He expressed his happiness in supporting the workshop on a very important topic – IChargeHDV. While delivering the welcome address, he mentioned that IGSTC has supported 41 projects so far, where researchers from India and Germany have collaborated. He emphasized the need to build collaborations between industry and academia towards innovative and sustainable solutions. Through the workshop, he hoped that the outcomes of the project may lead to some of the projects in India.

The joint opening remarks were delivered by Mr Udo Lambrecht, Board Member, ifeu (Germany) and Mr Shri Prakash, Distinguished Fellow, Transport & Urban Governance, TERI (India). **Mr Udo Lambrecht, Executive Board Member, ifeu**, was pleased to see so many experts joining the virtual Indo-German workshop about innovative charging technologies for heavy duty vehicles. He touched upon the climate crisis, which is becoming increasingly apparent and emphasized that the international community must push innovative approaches to reduce GHG in the coming years. In the transport sector, the consumption of diesel in particular is in the foreground. The largest share of crude oil is imported in India. Road freight transport poses particular challenges. He also mentioned that road freight continues to grow strongly, it is almost entirely dependent on diesel,

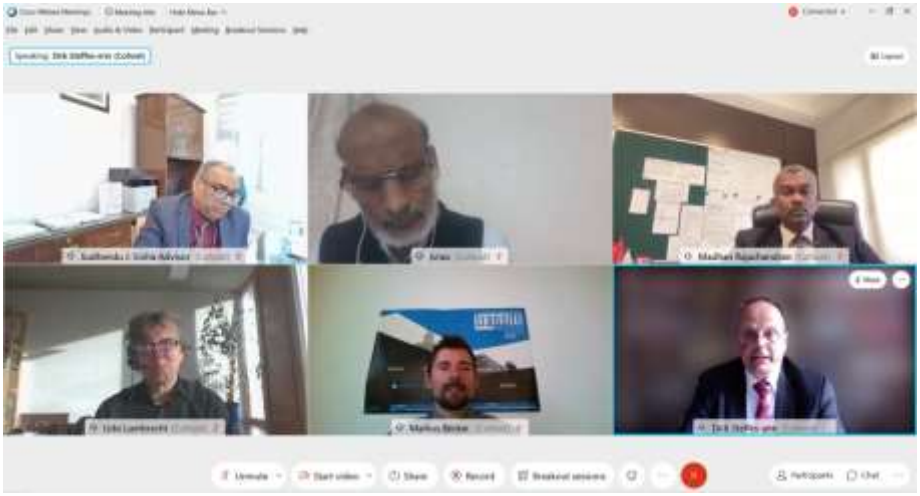
and, thus, it contributes significantly to our climate change. The challenge here is to develop solutions to reduce GHG worldwide and put new ideas into practice. A few months ago, the idea came up to discuss possible reduction technologies for road freight transport between India and Germany. Research and Transport Professionals from ifeu, TERI, BBSCET, GIZ and IGSTC have realized the urgent need for information and exchange on the electrification of trucks. In Germany, the catenary truck technology is currently being tested in several pilots on the Autobahn (highway) and on other roads. Ongoing research projects analyse transition pathways, business models and the role of a regulatory framework. Some relevant results will be presented today. He wrapped up by thanking IGSTC and Humboldt Foundation.



Mr Shri Prakash, Distinguished Fellow, The Energy and Resources Institute (TERI) thanked the organizers for bringing together experts from the two countries on a topic which is critical for India as well. He mentioned that India is a developing country and its transport sector is growing at 8-10% per year. India has vibrant railway system. However, it is not able to cater to the growing demand from the freight as well as passenger segment. The government is concerned about carbon emissions and one of the major strategies is to increase the share of railways. Significant effort is also made towards increasing the efficiency of the vehicles. HDV sector accounts for higher share of 36-40% in total emissions from the transport sector. Also, the green solutions are limited in the HDV segment. He mentioned that, going forward, road sector is going to dominate the transportation of goods and passenger and the possibility of decarbonize the sector in the business as usual scenario is slim. He highlighted that IChargeHDV technology has a high potential to decarbonize the HDV segment in India, however, it is important that research work in the field of technology, economics, environmental, etc. is undertaken through collaboration with the German counterparts.

Mr Sudhendu J Sinha, Advisor, Transport, NITI Aayog, began by thanking and congratulating the organizers of the workshop - TERI, IFEU, GIZ, and IGSTC. He mentioned that the esteemed speakers and experts who will be deliberating on the technology, which has a huge potential in reducing emissions from the heavy duty vehicles, including buses.

While the transport sector generates massive positive externalities like enabling mobility and job creation, it also contributes to India's import burden, GHG emissions and air pollution. He highlighted that during the last two decades, India's oil demand from the road transport sector has recorded the highest growth in the world. Concerted efforts are made by the governments (Central and States) towards cleaner transportation system. Scrappage policy, planned to be rolled out shortly by the Ministry of Road Transport and Highways (MoRTH), aims to nudge people to go for newer and efficient vehicles. Electrification of vehicles and financial support scheme [Faster Adoption and Manufacturing of Hybrid and EV (FAME)] is undertaken by the government to make electric vehicles affordable to the end customers. He highlighted that commercial vehicles are responsible for majority of the fuel consumption, especially diesel, and emissions. Talking about the technology, he mentioned that it is a cutting-edge solution and solves the problem of last-mile faced by the railways. We understand that the UK has planned for a massive network of overhead cables, and an estimated 13 million tonne of CO_2 emissions is expected to be saved per year. He mentioned that there is a need to look at the viability of the IChargeHDV technology for India, for which immense amount of research work and support of different stakeholders are required to be able to implement it in India. He wished best wishes to the organizers of the event and looked forward to receive the proceedings of the event.

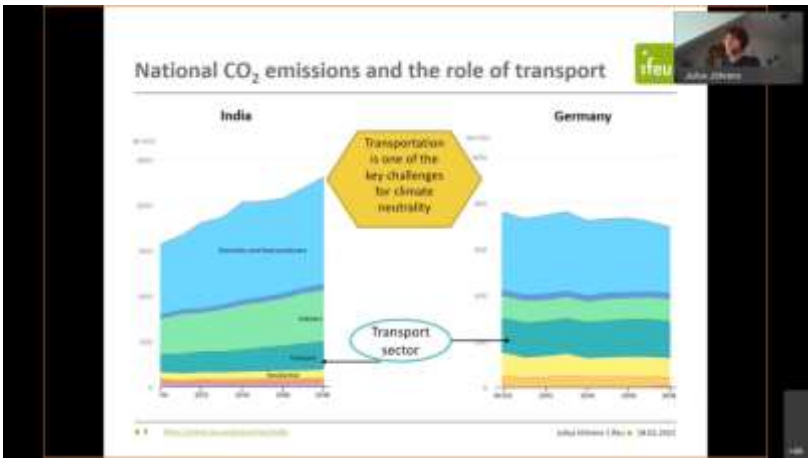


Mr Dirk Steffes-enn, Deputy Head of Economic Cooperation and Development Division, German Embassy, New Delhi was pleased to speak during the inaugural session of the workshop on *Indo-German cooperation on sustainable e-mobility*. As in-charge of the Indo-German cooperation, he highlighted the need to focus on climate change and solutions to mitigate the threats of natural disasters. In India, the division allocates highest share of funding towards climate and energy, and is working with number of Indian states in the field of energy and energy efficiency and sustainable mobility solutions. For example, projects like water metro in Kochi, metro projects in the cities of Coimbatore and Surat, as well as Green Freight Initiative in India are supported by the Indo-German Cooperation. In 2019, BMZ and Ministry of Housing and Urban Affairs (MoHUA) established partnership on green urban mobility. From their perspective, cooperation with the private players is equally critical. Sharing of inputs from the experts and identification of areas of cooperation on the green freight technology will be critical going forward.

In his presentation on *Germany's E-Highway Ambitions Pilot Learnings & Next Steps*, **Mr Markus Becker, Advisor, Unit of emobility, BMU,** talked about Germany's e-highway ambitions pilot learnings and next steps. He highlighted that the road sector in Germany accounts for the majority share in total freight transport as well emissions. He said that going forward it is envisaged that road sector will continue dominate in freight transportation. As per estimation, 10% of the trucks, which

are 40 tonne-gross vehicle weight (GVW) and above, account for about 50% of the CO2 emissions coming from the transport sector. Mr Becker talked about the key measures taken up by Germany's federal government are vehicle funding, without favouring any specific technology; E Trucks: 80% of additional costs are covered by the government; Infrastructure deployment, including electric road system (ERS) pilots; and differentiation of HGV tolls by CO_2 emissions from vehicles. By 2030, the government aims to move 1/3rd of heavy duty road transport from conventional fuel to electric or powered by ERS. At the end, he highlighted few pilot projects undertaken by Germany and shared some of the learnings from the pilot projects.

Julius Jöhrens, Head of Road Freight Research, ifeu, shared the challenges posed by the transport sector of India and Germany and also the experience of pilot ERS deployed in Germany. Talking about the cost characteristics of a catenary truck system, Mr Jöhrens mentioned that for the German case, higher up-front costs are mostly offset by lower operating costs, provided that a sufficient overhead line network is available. He also highlighted that operators' costs are highly sensitive to taxation/fiscal framework. He talked about how to tap CO_2 mitigation potential of catenary trucks during pilot and network level. At the pilot level, Mr Jöhrens talked about the need to define a possible role for catenary truck technology in a sustainable transport system, create a major pilot as a nucleus for future network expansion, and initiate a business ecosystem for catenary trucks (supply and operation of vehicles/infrastructure). At the network phase of ERS deployment, he talked about the need for international standardization of equipment and technology, and aligning fiscal framing conditions with network expansion to ensure high network utilization. Mr Jöhrens ended his presentation by putting across three recommendations: (1) Think of an Electric Road System (ERS) just as an additional charging possibility for HDV while in motion. It will eventually make battery-electric trucks more efficient; (2) consider ERS-readiness when planning new infrastructure; and (3) align a potential ERS roll-out strategy with developments in the energy sector.



Mr Sharif Qamar, Fellow, TERI talked about the current scenario of Indian freight traffic demand and its contribution in total energy consumption and emissions. He also talked about the government initiatives and current status of availability of alternative low/zero carbon solutions for the Indian freight sector, especially HDV sector. He highlighted the need to research the Indian trucking sector and many other areas to understand the techno-economic feasibility of ERS in India. Some of the areas of challenge, where solutions are required to be put in place, that were mentioned by Mr Qamar, include: Road Design (How important is the road design factor in deploying the traction technology? Is it technologically feasible for the brownfield highways in India?); Selection of Pilot Highways (What are the criteria required to deploy traction technology on Indian highways?); Ownership of trucks (What is the implication on ownership on IChargeHDV technology and vice versa? Is there any study done in countries where the technology has been piloted?); Current dimension of trucks: standardization (What is the operational dimension that is relevant?

Are there limitations to the dimension?); ODC movement (A lot of ODC movement happens on Indian highways, what are the relevant requirements for managing ODC traffic?); Opportunity for Retrofitted IChargeHDV (What are the learnings that could be drawn from the experiences of ongoing projects? Is this applicable to the make and models available in India?); Electric supply reliability and network capacity (What is the electricity infrastructure requirement? What is the share of electricity infrastructure in the total cost?); and Traffic operation on Indian Highways (What are the interventions required to train the drivers/operators of the fleet?).

Prof. Manfred Boltze, Institute of Traffic and Transport, Technical University of Darmstadt shared the learnings from the ELISA Project, *highlighting the objectives and first results of the German e-highway field test*. He talked about different stages of technology readiness levels – from laboratory to field to system deployment, where ELISA project falls under the field test under real-road operations. The field test led to answering a number of questions regarding how much electric energy and fuel are consumed by over-head trucks, impacts of driving behavior and road safety, problems related to the visibility of traffic signs, complications in cleaning traffic signs and cutting/pruning of trees. Prof. Boltze highlighted that several private companies were willing to participate in the ERS, including the transport partners and manufacturers. He emphasized the need to capture the acceptance of different stakeholder groups –socio-political, market, local, etc. and also to work on factors that influence the acceptance rate over time. He also talked about development of sub-systems, which the ELISA project facilitated. Some of the sample sub-systems included planning, approval and tendering process for ERS, processes for emergency and rescue services, software and processes for control center operations, and aspects related to formal registration of vehicles. Prof. Boltze highlighted the need to undertake awareness and dissemination exercises to increase the acceptance of ERS technology. Lastly, he mentioned that experience from the field tests could be used as a facilitator to identify needs for system amendments and potential partners.

Plot I - Session 1: Pilot Project Steering & Management

Speaker: Mr Igor Rudgartser, Autobahn GmbH

Session Summary:

The project, called Elisa (electrified, innovative heavy traffic on the Autobahn) is divided in 2 Phases - ELISA I (2 years) and ELISA II. The Autobahn Project (Hessen) in Central Europe was started in 2017. It had been tested under different scenarios, challenges and obstacles that may occur during its operation. The project has seen no obstacles so far and a larger-rollout is expected very soon.

Q&A Session - Key points discussed:

- A separate lane was never planned for the IChargeHDV project as it runs on a single mixed-use lane. However, there were no safety issues identified during its operation.
- The catenary trucks can also be moved to another lane. These are hybrid trucks which may run both on diesel and battery. The limitation is on the size of the battery and not the size of the truck. It was planned to keep the batteries small to cover 10-15 km range.
- There are no speed-related issues anticipated. However, the scientific results after the evaluation during the field test are yet to come.
- A discussion on the various challenges that may arise in the Indian context resulted in the identification of the following major differences when it comes to Indian Highways (as compared to German Highways):
  - No lane-discipline in India (safety issues as the HDV runs on a single lane)
  - Mixed Traffic (safety and speed issues)
  - Side friction may be a challenge
  - Driving Behavior (Safety issues)
  - Movement of Trucks on the Median side in India (central lane electrification could be a challenge)
  - A coordination between roads and electrification department (have to be initiated which currently work in silos)

Plot I – Session 2: Overhead Supply System Technology

Speaker: Patrik Akerman, Business Developer e-Highways, Siemens

Session Summary:

- Concept for heavy road freight to reach climate goals requires spending essential amount of money in the short term (4.1 bn euros spent on infrastructure on clean road transport)
- Trucks are the biggest CO_2 source in India
- Number of trucks in the next 20 years is expected to be triple the amount today
- Even in IEA's most ambitious climate – sustainable development scenario, the emissions from heavy duty trucks are double.
- eHighway system has four subsystems –
    - Vehicle
        - Pantograph
        - Drive system
        - Energy storage
        - Control system
    - Power supply
        - Substation
        - Contact line
    - Drive way
        - Infrastructure
        - Traffic management
    - Operation
        - Maintenance
        - SCADA
- Power supply test track – started with 0.5 MVA rate power and connected it to 10-kV public grid.
- Infrastructure on the overhead contact line include:
    - Lane
    - Pole
    - Traverse beam
    - Droper column
    - Steady arm
    - Toprope
    - Messenger wire
    - Contact wire
    - Foundation

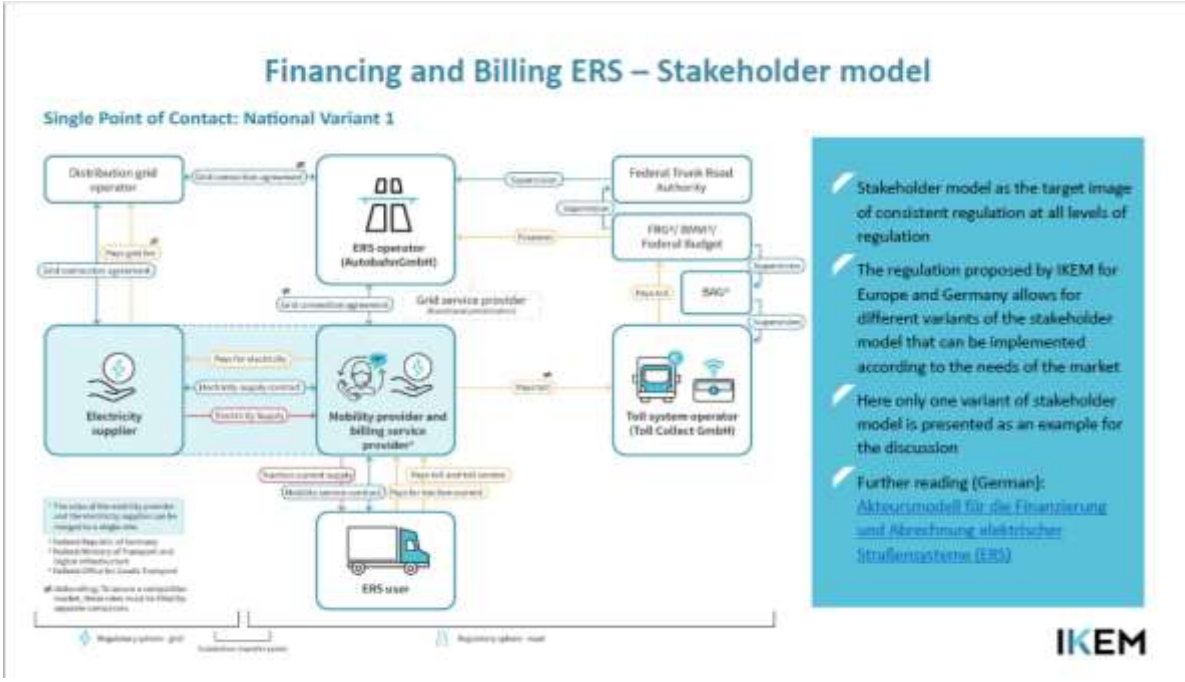
- For the pantograph to be in touch with the contact lines, the contact lines have to follow the curve designs. In railways, the overhead line has a zig zag pattern however in eHighways, it follows the lane.
- Safety feature –
    - Contact Monitoring System (CMS) allows to shut down power in the system if anything goes wrong
    - Feed-in-pole – allows to ground the system, feed current into the system
- eHighway Truck technology
    - Truck should be able to go up to 80 km/hour (Maximum speed for HDV in Germany is 80 km/hour and 100 km/hour for buses)
    - Connection and disconnection to catenary system in motion
    - Recharging of on-board energy storage while driving
    - No limits in terms of first and last mile
- As per Germany's expert commission, the CO_2 abatement costs of overhead contact line system are much lower than fuel system in the year 2030.

Plot II - Session 1: E-Highways – Regulatory Framework

Speaker: Anna Bußmann-Welsch, Senior Scientist, Institute for Climate Protection, Energy and Mobility

Session Summary:

- The session dealt with discussions on the legal and regulatory framework of the Electric Road Systems (ERS). Under the regulatory framework in Germany, the highway department regulates the highway lanes and the electricity department regulates the electricity grid.
- The e-highway infrastructure is funded through user charges.



- There are many stakeholder models prevalent in Germany and rest of the Europe. The most preferable model was discussed in the session as below:
  - ERS Operator: The ERS operator is not the electricity expertise. In most cases (such as the Autobahn project), it is the federal government of Germany. Highway infrastructure is a monopoly. There is a legal change required in order to bring in more PPPs and create a competitive market for mobility services as currently the law limits PPPs to operate up to a maximum of 100 kilometers.
  - Toll System Operator (TSO): The responsibility of the TSO is to procure/mediate contracts to provide line services. The TSO can also be the mobility provider as they work as a monopoly. However, the TSO is not interested in the role as much as the electricity providers. There should ideally be a competitive market of mobility providers.

- Mobility Provider: The role of mobility providers is to also provide data reporting services like user information and toll payments. The mobility providers can also be the electricity providers and vice-versa.

➢ The problem of creating stationary charging infrastructure in Germany was also discussed during the session.

Indo-German Comparison – answers to some of the questions pertaining to ERS:

- Will the ERS be part of a public road?
  - Run by public road operator (GER: Autobahn GmbH)
- Does the public road operator have the expertise to run an electric facility?
  - Germany: Private expertise for network operation through functional privatization
- Are there any financial instruments for road infrastructure (Tolls or user charges) and for utilities for electricity grids? Which of these instruments suit the operation of ERS best?
  - Germany: Financing of ERS infrastructure only via the toll (no double financing via network charges) and removal from the network regulation of energy law.
  - Many law/policy changes are required to be able to work on such kind of models.
- Which stakeholders of the current road and electricity system could play a role with regard to ERS as well?
  - Germany: Toll system operator, electricity suppliers and EETS operators are already on the market and bring the expertise for billing.
  - Many law/policy changes are required to be able to work on such kind of models in India.
- How can a competitive market for electricity distribution via the ERS be created?
  - Germany: energy law provides a pattern where different electricity suppliers compete as a single point of contact for the customer within a monopoly but highly regulated electricity grid. ERS can copy this regulation and adjust it to the system needs.
- Will the ERS be part of a public road?
  - Road regulation and stakeholders in India. The market is scattered (similar to Germany).
- Does the public road operator have the expertise to run an electric facility?
  - Regulation of the electricity girds and stakeholders in India would be required
- Are there financing instruments for roads (Road Toll or user charges) and for provision of an electricity gird? Which of these instrument suits the operation of ERS best? Financing instruments for roads and electricity grids in India?
  - Financing is a major issue that could be foreseen for IChargeHDV projects. There is a limited understanding in the Indian finance sector about different

kinds of models for funding these projects. PPPs are there wherein the private party takes the risk. Banks are disconnected and they don't want to invest.

- Which stakeholders of the current road infrastructure and electricity market could play a role for ERS?
    - The National Highways come under NHAI and others under State PWDs. Even NHAI leases to private agencies for construction which are later handed over back to NHAI. The legal and regulatory frameworks are very different from Germany.
- How can we ensure a competitive market for electricity supply with regard to ERS?
- How will the stakeholder model for ERS look like in India?

Plot II - Session 2: Retrofit technology – Conventional to IMC

Speaker: Prof Dr Michael Lehmann, University of Applied Sciences, Erfurt - Department of Railway Systems

Title: "Retrofitting and migration strategies for ERS infrastructures and vehicles"

Session summary

Dr. Michael discussed the concepts of Electric road systems and its architecture- traction power supply, existing highway infrastructure, electric vehicle and its operation and control. Later he had also discussed the key parameters to be considered while planning and designing ERS infrastructure and vehicles (for the case of Europe and India). The following tables summarizes the key discussion points with respect to ERS infrastructure and ERS vehicles.

ERS infrastructure considerations- principles

Equipping existing highways	*Planning and building new ERS highways*
Upgrade or modernization	*ERS ready design*
Key points of interest – construction • Height restriction at crossings/tunnels • Side margin including crash barriers • Directing lanes at turn-outs, junctions • Individual constructions, possibly short interruptions	*Key points of interest – construction* • ERS ready planning of crossings, tunnels, bridges etc • Sufficient side margins (land acquisition) • Adapted design guidelines for highway and electrification
Planning & integration: • Construction works under traffic • Co-ordination with other highway works • Careful planning of site states • Integration into existing traffic control safety structures	*Planning & integration:* • Longer planning cycles • Integrated financing incl toiling possible • Dedicated truck highways possible (similar to dedicated freight railway corridors)

While discussing the ERS Vehicle considerations and principles, Dr. Michael had also explained stating examples such as the railway rolling stock case (in Europe) where the vehicles designed to last at least 30 years. Main overhaul/maintenance works every 6-8 years (depending on mileage) and lastly often combined with change of items, modernization etc. He had also discussed the considerations involved in Indian market (with regard to heavy duty trucks) such as Independent markets, second markets and vehicle average lifetime. Further he had also discussed the various refurbishing strategies (opted by European markets) such as growing affinity to monitoring and telematics in second market, Interior renovation (refurbish) and Technical robustness including adaption to lower diesel quality.

Key points discussed during the open session:

- ERS vehicles feature a number of internal and external interfaces
- A retrofit requires anticipation of interfaces to avoid rebuilding
- A retrofit after x years differs largely depending on the base vehicle (battery electric vs conventional diesel truck)
- Unused equipment causes costs, weight, maintenance
- Infrastructure roll out can be done by developing ERS infrastructure implementation plan, studying decade growth according regional needs and increasing benefits of ERS vehicles
- Electric vehicle strategy involves planning for BEV and ERS vehicles (with respect to components like cabling, batteries, electronics), Considering ERS-readiness in heavy duty vehicles depending on application
- Compare fleet changes among applications against retrofitting in same application
- Retrofitting of vehicles is one of many solutions

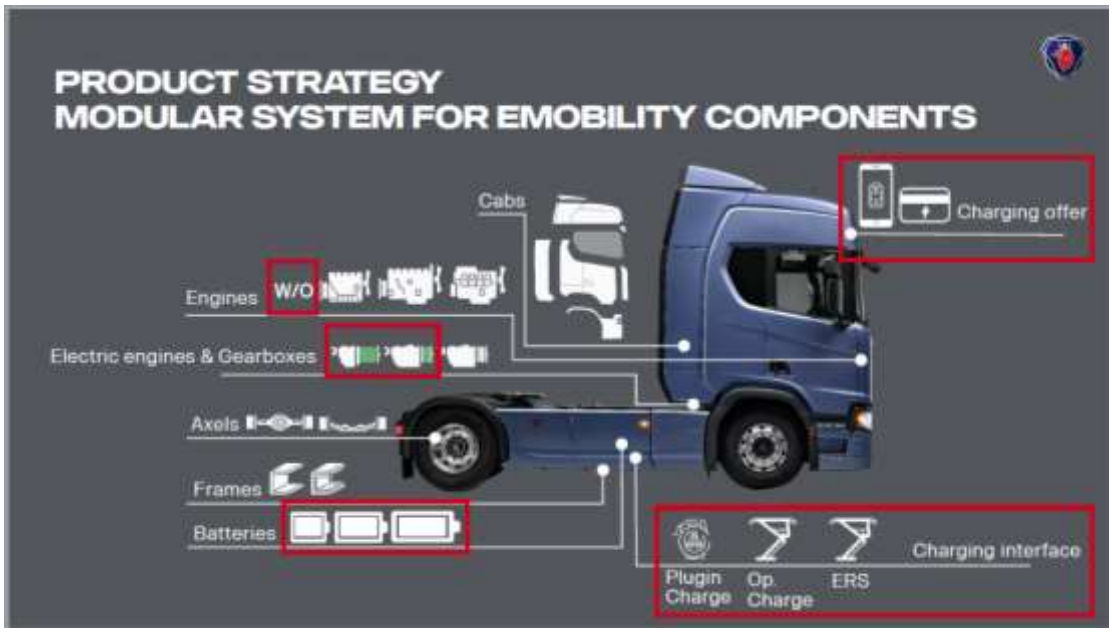
Plot III - Session 1: IMC Technology Trucks - Germany

Speaker: Mr Christer Thorén, Project Manager, Electrification, Scania

Summary: Mr Thorén presented on the perspective of OEMs on the technology and also how SCANIA participated in pilot projects.

ERS adaption of heavy vehicles in Scania

- Purpose of ERS
  - Reduce batteries in the truck
  - Infinite charge as long as the truck is on the road, it doesn't consume any power from the battery i.e., it provides long range if there is presence of ERS network.
  - It is based on railway technology
  - 100kV is used for propulsion
- Design of ERS
  - Hybrid or electric truck required
  - Main components include pantograph, contactor with pre-charge, DC/DC converter
  - Currently voltage is 600
- Future based would includes
  - BEV
  - HEV
  - Fuel cell truck
- Challenges faced
  - Problems during rain and sharp shine in the ADAS system which helps the driver to stay in the right place on the road
  - Catenary interruptions creates overvoltage – filters need to be optimized



Plot III - Session 2: IMC Technology Buses - Germany

Speaker: Ms. Kristin Follmann, Institute of Traffic and Transport, Technical University of Darmstadt

Title: "Coaches as part of the eHighway system: State of research and development"

Session summary:

Ms. Kristin explained the research scope and motivation for the pilot study undertaken in Darmstadt. Further she had also discussed the methodology of the project. The process involved identifying a reference bus based on operational and technical requirements and Identifying an additional charging location. Simulation of an existing bus line schedule from the Airliner to derive the necessary technical requirements was also being planned before the derivation of simulation scenarios. Later, the speaker discussed the basic assumptions including the process how does a vehicle switch to an electric operation mode when entering the city centre of Darmstadt or the airport area (Entry-electric, Exit-diesel). The speed while using the catenary system was 80 km/h and there were three buses which were operating per day.

Further she had also shared the key findings from the base scenario of the study. For the base scenario an electric operation of the coach in the city center of Darmstadt and at the airport in both directions in possible. No diesel operation within the city centre of Darmstadt. The battery capacity and the charging power are sufficient to operate the buses fully electric within the necessary areas. The unexploited capacity seems to be adequate.

Q&A Session - Key points discussed:

- For the base case scenario, a partially electric operation of the airliner within the city centre and at the airport is possible with an adequate battery buffer
- For the best case scenario an operation of the Airliner with a relatively small battery is possible in the inner city area.
- Delays should be analyzed and considered as a stochastic element in the studies
- Pilot study for testing the Airliner operation under realistic conditions

Indian Technology and R&D Collaboration

Moderator: Mr IV Rao, TERI

Key Indian OEMS and related stakeholders present during the session were from Tata Motors, Volvo Eicher, Ashok Leyland Limited (ALL) and SIAM.

Key questions directed to the Indian OEM and R&D institutes raised by the moderator:

- Which potential benefits do you see in the technology from an OEM perspective?
- Which technical challenges do you expect for Indian OEMs?
- What would be important politicial prerequisites for the introduction of the technology?
- When could such a technology be introduced on the Indian market?

Summary of the discussion:

- OEMs are currently going through a major financial crisis and currently see very mere scopes in investing into a whole new experimental technology. Some OEMs, like Ashok Leyland are working on the technical aspects of electric HDVs, but there is no clear comment on the production of the same.
- OEMs believe that stepping into city specific electric vehicles on initial phase is advisable over directly entering into electric highways as Indian OEMs are still experimenting with the technologies and success is not guaranteed. Government could also first experiment with the BRTS systems for electrification and then deploy the pilots on highways.
- Talking about the different technologies available as an alternate option to the electric vehicles; speakers noted that Aluminum Air Batteries could be an option but the efficiency of 40% affects the feasibility. Also, Hydrogen fuel cells could be used, but it seems difficult financially. OEMs could start with fast charging vehicles if not continuous overhead electric supply.
- Unlike the US Government, Indian government is only incentivizing and encouraging the electrification of the freight, but it is voluntary in nature. The US government kick-started the electrification of highways with incentivization along with pressure to switch, and OEMs also voluntarily got involved.
- India is running behind 12-15 years in the technological and infrastructure development and it has its own set of difficulties and challenges, so government cannot force a quick switch to electric highways. OEMs seek government support (financial and infrastructural) to get into research and production of competent electric HDVs.
- Government has been vocal about the electric highways, but no concrete actions are seen for the infrastructural development for the same. So, OEMs find it better to stay engaged with government and start investing in the project only after concrete

actions by government towards electrification and support for the production is declared.

- After all, while changing the eco-system of highway freight, OEMs alone cannot take any lead. It will be a success only when all the stakeholders come on one platform and work in coordination for electrification of highways.

Round-Table Discussion and the Way Forward

Overview of the round-table discussion

The round-table discussion among the important stakeholders was focused on the pre-requisites for electric highways and best possible ways to implement the project in India.

- Economies of scale will play an important role for the successful implementation of the project. The learnings from Electric Highways, Germany says that production of vehicle in large quantity results in the decreased price of the vehicle. Also, higher traffic volume on the highways results into optimum consumption of the electricity. Government had also raised the pays of Electricity Generation sector which attracted more players and healthy competition resulted into fair prices for electricity also.
- For Indian context, development and implementation of the Electric Highways will require substantial time as development of Pantograph charging technology for Indian vehicles will be time consuming. The entire HDV has to be reengineered to fit the Indian context and facilitate the movement of different types of goods.
- It is crucial to develop the robust ecosystem safe from potential hazards including safety from high voltage power lines, driving etiquettes and nature of goods being transported.
- In such a scenario, it is advisable to run the pilot project for 100-200 km long starch of electric highway and then procced further for longer runs. Government could also give the research project to a research organisation and intensive studies are carried out by the organisation to develop the best ecosystem for electric highways in India based on the case studies of the foreign countries. Further the most feasible solution can be implemented in India.
- Government shall also come out with the binding targets for emission reduction to kick-start such projects at proper time. Constant support and funding from the government is also desired for such high investment project. In addition to that, better financing methods like PPP, Public funding, etc. shall be explored to meet the financial need of the project.
- Research work to assess the feasibility and viability of ERS projects in India to be undertaken, in collaboration with German R&D institutes.

Inputs by speakers/panelists

Germany's experience

Sharing his observations about the electric highways in Germany, Mr. Julius noted 3 key points that facilitated the mentioned technology in Germany: High Traffic Volumes on Highways, High Pays for Electricity Generation and Economies of Scale. High traffic volumes on highways and higher demand of electrical vehicle raised by government resulted into maximum utilisation of resources and efficient production (economies of scale). Also, the

higher pays in electricity generation attracted more jobs and potential to fulfil the energy demand of electric highway. The Electric Highway Program was partially funded by government and had substantial government support.

For the Indian scenario Mr. Julius suggested that rather than starting with 1000 km long highway, starting with a pilot project of 100-200 km long electric highway will give better understanding of the system, issues and challenges.

The current financial funding of the government is not focused on the decarbonisation. Mr. Julius suggested that Government should come out with binding targets for emission reduction, as, such targets will accelerate the shift to cleaner technologies. For such heavy financing projects, public financing or user charges model can be adopted to reduce the financial burden.

India's experience

Speaker from one of the OEMs emphasized on the fact that development of pantograph charging technology for HDVs will take a long time, as it has to fit in the Indian ecosystem smoothly. A company needs to re-engineer the technology to come up with the most feasible and suitable vehicle for India. Other Indian automobile expert hoped that Government continuous the policy regime and stays firm and confident about electrifying the highways. He said that now it is the time for industries and OEMs to take the torch and lead to the way of electrification.

Mr. Rohan Modi from GIZ said if research and development model similar to Agriculture practices in India can be proposed for electrification. Going into detail he said that, government can fund a proper R&D project for electric highways to a research organisation. The research organisation is supposed to carry out the intensive study with data collection, assessment along with best practices adopted in foreign countries and come up with the best suitable technology and electric highway design for India. Once the best suitable option is identified, government can put it into the practice along with other stakeholders.

Another participant from GIZ India raised concerns regarding safety. Safety concerns for electrification are higher in India, as the goods being transported by road vary in shape, size and packaging, as well as they are hazardous at times. The design of vehicles must incorporate and address all these issues.

Mr. I V Rao from TERI elaborated other concerns like, driving etiquettes, speed requirement and lane sense of Indian HDV drivers. The high voltage power lines might also cause fatalities. He advised the development of a whole sustainable, feasible and safe ecosystem of Electric Highways to overcome raised issues.

Closing remarks were made by Mr Udo Lambrecht, Board Member, ifeu and Mr Sharif Qamar, TERI.

AGENDA

	IST	CET	Agenda Item		Speaker		Duration (min)
BLOCK 1	13:00	8:30	Moderation		GIZ/TUMIVolt		0:05
	13:05	8:35	Welcome Address		Mr. R Madhan, Director IGSTC		0:05
	13:10	8:40	Opening Remarks		Udo Lambrecht, Board Member, ifeu + Shri Prakash, Distinguished Fellow Transport & Urban Governance, TERI		0:05
	13:15	8:45	India's E-Highway ambitions and vision: Learning expectations from the event		Mr. Shudhendu J Sinha, Advisor, Transport, NITI Aayog		0:15
	13:30	9:00	Indo-German cooperation on sustainable e-mobility		Mr Dirk Steffes-enn, Deputy Head of Economic Cooperation and Development Division, German Embassy New Delhi		0:10
	13:40	9:10	Germany's E-Highway Ambitions Pilot Learnings & next steps		Markus Becker, Unit of emobility, BMU		0:10
	13:50	9:20	Climate-friendly road transportation - putting Electric Road Systems into context		Julius Jöhrens, Head of road freight research, ifeu		0:10
	14:00	9:30	Presentation on India-specific research studies		Mr Sharif Qamar, Fellow, TERI		0:10
	14:10	9:40	Break				0:10
	14:20	9:50	Presentation from 'ELISA Project' - "Objectives and First Results of the German eHighway Field Test ELISA"		Prof. Manfred Boltze, Institute of Traffic and Transport, Technical University of Darmstadt		0:15
	14:35	10:05	Q&A		GIZ/TUMIVolt		0:10
BLOCK 2			**Pilot Project Steering & Management**		**Overhead Supply System Technology**		
	14:55	10:25	Session 1 topic: Pilot Project Management & Control Moderator: Hinrich Helms (ifeu) Presentation from ELISA Project – Planning, permitting, installing and operating + video from VZH	Session 1 speaker: Dr Achim Reusswig, Head of Traffic Management, Autobahn GmbH	Session 2 topic: Current Collector Technology, Overhead Supply Line Moderator: GIZ/TUMIVolt : Lena Stiller Film from Field Trial: current collector technology, substation, (video)	Session 2 speaker: Patrik Akerman, Business Developer e-Highways, Siemens	00:20 +00:15 (Q&A)

		control centre + Q&A		+ Q&A		
15:30	11:00	Break				0:10
		E-Highways – Regulatory Framework		**Retrofit Technology - Conventional to IMC**		
15:40	11:10	Session 1 topic: Regulatory Framework & Business Model for E-Highways Moderator: Julius Jöhrens (ifeu) Presentation: "AMELIE project - Financing and Billing ERS" + Q&A	Session 1 speaker: Anna Bußmann-Welsch, Senior Scientist, Institute for Climate Protection, Energy and Mobility	Session 2 topic: Perspective on retrofitting conventional Buses / Trucks Moderator: GIZ / TUMIVolt - Rohan Modi Presentation: "Retrofitting and migration strategies for ERS infrastructures and vehicles" + Q&A	Session 2 speaker: Prof. Dr. Michael Lehmann, University of Applied Sciences, Erfurt - Department of Railway Systems	00:15 + 00:15 (Q&A)
		Platform for collaboration – Indian OEMs & R&D projects				
16:10	11:40	Topic: Indian Technology & R&D Collaboration Introduction by Sharif Moderator: Mr IV Rao - TERI Presentation by Indian Trolley Bus / Truck manufacturer on Technology; R&D & Opportunity for Collaboration OEMS - TATA Motors Volvo Eicher Ashok Leyland SIAM + Q&A				00:20 + 00:10 (Q&A)
16:40	12:10	Break				0:10
		IMC Technology Trucks - Germany		**IMC Technology Buses - Germany**		
16:50	12:20	Session 1 topic: In Motion Charging (IMC) Technology, Trucks Moderator: Hinrich Helms	Session 1 speaker: Christer Thorén, Project manager electrification, Scania	Session 2 topic: In Motion Charging Technology, Buses Moderator: GIZ/TUMIVolt -	Session 2 speaker: Kristin Follmann, Institute of Traffic and Transport, Technical University of Darmstadt	00:15

			(ifeu) Presentation: "Electrification at Scania – an ERS perspective" + Q&A		Rohan Modi Presentation: "Coaches as part of the eHighway system: State of research and development" + Q&A		+ 00:10 (Q&A)
Block 3	17:15	12:45	Roundtable Discussion: · Research & Academia + Industry + Policy makers Moderator: IV Rao, Visiting Senior Fellow, TERI				0:45
	18:00	13:30	Closing Remarks		ifeu/TERI		0:10

Speaker details

Organisation	Speaker	Bio
IGSTC	R. Madhan, Director	Director at Indo-German Science and Technology Centre (IGSTC) since 29th December 2020. Mr. Madhan has served as the Science Counselor at the Embassy of India, Berlin, Germany for three years during which he ably facilitated, coordinated and contributed in enhancing bilateral cooperation between India and Germany. He played a major role in connecting scientists and academicians of India & Germany on several areas including clean energy, next generation batteries, high energy physics, marine robotics, biotechnology, molecular biology, space research, climate research, education and sustainable studies. He contributed significantly in connecting German institutions (including Fraunhofer, Leibniz, Helmholtz, Max Planck Institutes, TU9, Excellence Initiative Universities) with Indian counterparts (including CSIR, DBT, DST, MoES, ICAR, IISc, IIT).
ifeu	Udo Lambrecht, Board Member, ifeu udo.lambrecht@ifeu.de	Udo Lambrecht is Scientific Director and executive board member at ifeu Institute since 2009. He is head of the department "Mobility". He studied Physics and did his diploma thesis on ultrafast exhaust analysis. His research focuses on the development of policies and strategies to reduce the impact from the transport sector (incl. energy efficiency, electro mobility) on the environment and on the development of mitigation strategies. The core question is how can the transformation of the transport sector towards a renewable energy supply succeed. To this end, comprehensive models (e.g. the transport emissions model "TREMOD", the life cycle assessment model "eLCAr", vehicle simulation model "VEHMOD") have been continuously developed and used. Udo and his group have carried out more than 100 projects in this field. ifeu carried published his first LCA of electric vehicles in the 1990s. Since 2016 ifeu reseach about ERS systems. With the analyses of complex technical and environmental issues in the transport sector, Udo and his team support comprehensive political and stakeholder processes.
TERI	Shri Prakash, Distinguished Fellow Transport & Urban Governance,TERI shri.prakash@teri.res.in	He is a Post Graduate in Mathematics and has an additional degree of M.B.A. His career with the Indian Railways spanned over 37 years where he held numerous key positions in different Zonal Railways and the Railway Board. Mr Prakash retired as Member (Traffic), Indian Railway Board and Secretary to Government of India in December 2009. Mr Shri Prakash joined TERI in July 2011 as Distinguished Fellow. His association with TERI goes back to 2003-2004 as a Visiting Senior Fellow. For over 9 years he is guiding research in sustainable transport policies in Centre for Research in Sustainable Mobility in TERI. https://www.teriin.org/profile/shri-prakash
NITI Aayog	Sudhendu J Sinha,	He is the Adviser at the NITI Aayog (National Institution for Transformation of

	Advisor Transport, NITI Aayog	India), the apex 'Think Tank' of the Govt. of India. An alumnus of St. Stephen's College, Delhi did his Major in History. He has experience of over 27 years in operations, infrastructure planning, coordination and management at field and policy making levels in Indian Railways. He also served as Dean of the Indian Railway Institute of Transport Management (IRITM), Lucknow, and General Manager Web Applications at the Centre for Railway Information Systems (CRIS).
BMZ	Mr. Dirk Steffes-enn, Deputy Head of Economic Cooperation and Development, German Embassy India	07/2019 German Embassy New Delhi Deputy Head of Economic Cooperation and Development 03/2017 German Federal Ministry for Economic Cooperation and Development (BMZ) Coordinator, IT-Development 01/2013 German Embassy Kathmandu, Nepal Deputy Head of Economic Cooperation and Development 01/2008 German Embassy Beijing, China Development Advisor **Professional Experience** Degree in Public Administration More than 15 years of experience in municipal administration and German state government Joined BMZ in 2003
BMU	Markus Becker, Federal Ministry of Environment, Nature Conservation and Nuclear Safety markus.becker@bmu.bund.de	Master in Geography, Transport Science and Urban and Regional Planning. Working as Advisor at the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety since 2009.
ifeu	Julius Jöhrens, Head of Road Frieght Research, ifeu julius.joehrens@ifeu.de	Julius Jöhrens studied physics and political science at the University of Jena . Since 2010 he has been working at ifeu in the Transport and Environment department. He leads ifeu's activities on road freight electrification, focusing on comparison of drive technologies, analysis of technology choice in heavy-duty transport and design of policy instruments for decarbonisation.
TERI	Sharif Qamar, Fellow, TERI sharif.qamar@teri.res.in	Sharif Qamar works on the research, policy analysis and project implementation within the Centre for Sustainable Mobility. Working in TERI as a researcher, he is involved in a number of transport related projects in the field of public transportation, freight movement and EVs. He has earlier worked in the railways sector involving freight, national highways sector, inter-model comparison study, and urban mass transit projects. A post graduate in Economics from Jamia Millia Islamia, he has an experience of about ten years in the field of transportation research.
TU Darmstadt	Dr.-Ing. Manfred Boltze, Institute of Traffic and Transport, Technical University of Darmstadt boltze@verkehr.tu-darmstadt.de	Manfred Boltze is professor for Transport Planning and Traffic Engineering at Technische Universität Darmstadt (Germany) since 1997. He studied civil engineering and received a doctor degree for his work on traffic signal control in 1988. His research covers a broad range of traffic and transport related topics, such as planning methodology, traffic management, Intelligent Transport Systems, road traffic signals, traffic safety, and transport and health. Since 2016 he is involved in eHighway-related projects, currently as the coordinator of the scientific research program for the ELISA field test on motorway A5 in Germany. 38 doctoral students and more than 250 Diploma and Master students graduated under his supervision. More than 200 publications, memberships in editorial boards and advisory boards, and many other activities indicate his comprehensive commitment to promote research and education in his discipline.
Autobahn GmbH	Mr. Igor Rudgartser Igor.Rudgartser@a	M.Sc. Igor Rudgartser studied mechanical engineering with a specialization in energy and process engineering at the Ruhr-University Bochum, operational manager of ELISA eHighway Hessen at Autobahn GmbH. Works since 2017 for ELISA eHighway Project in all project stages from planning, permitting and

	utobahn.de	construction to operation.
Institute for Climate Protection, Energy and Mobility - IKEM	Ms. Anna Bussmann-Welsch, Research Associate, Institute for Climate Protection, Energy and Mobility anna.bussmann-welsch@ikem.de	Anna Bußmann-Welsch is a Research Associate at IKEM since March 2020 and works on topics in the field of electromobility and projects concerning the electrification of trucks through an infrastructure of overhead power lines. She studied Law at the Free University of Berlin and the Istanbul University and specialized in european law and international law. She conducted her Legal Traineeship at Kammergericht Berlin, including a stage at the German Embassy Bangkok. She gained further professional experience as a Research Associate at the European University Viadrina, Frankfurt (Oder).
University of Applied Sciences, Erfurt - Department of railway Systems	Prof. Dr. Michael Lehmann, University of Applied Sciences, Erfurt - Department of Railway Systems michael.lehmann @fh-erfurt.de	Prof. Dr. Michael Lehmann (40) holds the chair for International Railway Systems at Erfurt University of Applied Sciences since May 2019. He studied transport and traffic engineering at Transport Faculty „Friedrich List" at Dresden University of Technology specializing in electric transport systems. Between 2006 to 2009 he has conducted research into railways with higher system voltages at the chair for Electric Railways at TU Dresden. In 2009 he joined Siemens as specialist for system design of railway power supplies and over the subsequent years there he concentrated on R&D projects, system integration and standardization on the topic of on electric road systems (ERS). Currently he is involved in different ERS and railway related research projects and member of standardization working groups and steering committees.
TERI	I.V. Rao, Senior Fellow iv.rao@teri.res.in	As Visiting Senior Fellow in Centre for sustainable Mobility at TERI, Mr Rao is currently working on studies about alternate low carbon technology options for future sustainable mobility. At Maruti Suzuki, spanning 36 years, he made significant contribution in different roles in the areas of technology transfer, new product planning and development, component localization, quality assurance & service and manufacturing engineering functions. With the vast experience of technology development and understanding of Indian context, played active role in formulation of automotive regulations in India. He held key positions in different industry/ government bodies
Ashok Leyland	Karthick Atmanathan	Karthick Athmanathan is working as BU Head- EV's & eMobility in the Ashok Leyland
SIAM	PK Banerjee	P.K. Banerjee is Executive Director, Society of Indian Automobile Manufacturers (SIAM)
SCANIA	Christer Thorén, Project manager electrification, Scania	At Scania since 2002, working as technical project leader. Since 2011 I have worked with electrification of our trucks and buses and since 2012 with ERS technology. I was the project leader for the Swedish ERS project in Sandviken and I lead our German ERS projects.
Technical University Darmstadt, Institute of Transport Planning and Traffic Engineering	Ms. Kristin Follmann, Research Associate, Institute of Traffic and Transport, Technical University of Darmstadt	Kristin Follmann is a research associate at the Institute of Transport Planning and Traffic Engineering of TU Darmstadt in the field of eHighway systems since October 2019. She has a master degree from Hochschule Darmstadt University of Applied Sciences in civil engineering with a specialization in traffic engineering. Earlier, she had worked for a public transport organization within the areas of planning public transport lines, expanding bus stops, and implementing on-demand based ride-sharing systems.
ifeu	Hinrich Helms, Deputy Head of Department Mobility, ifeu hinrich.helms@ifeu.de	Hinrich Helms studied Geography at the University of Heidelberg and is part of the scientific ifeu staff in the field 'Transport and Environment' since 2002. Hinrich Helms works on inventories and the evaluation of environmental impacts of different transport systems and mobile equipment and machinery. He has carried out and managed a wide range of projects on environment aspects of transport and associated policy measures. An important focus of his work is the life cycle assessment of new power train concepts with a focus on electric mobility. Further fields of research are mobile machinery as well as impacts of light weighting and alternative fuels

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Workshop Summary Report prepared by teri