Industry Assessment & Roadmap for Zero-Emission Medium and Heavy-Duty Trucks in India

D5 - ZE-MHDT Roadmap

Enabling Smart & Clean Tech Markets

Research	Consulting	Program	Data

Energy | E-Mobility | LVDC | Enviro | Urban

P' in our name stands for triple bottom line sustainability of people, profit and planet that we want to bring in all our internal functioning, projects we do, and industries we support. It also keeps us prompt, progressive and partnership valuing. **Manifold** represent abstraction of complex problem to smaller dimension, still preserving elements which matters and are available to influence/control and also measure the system dynamics. We are **'small data'** company and take pride in collecting and analysing most relevant data to help our clients with decisions and actions.

TABLE OF CONTENT

ZE-MHDT Roadmap Methodology

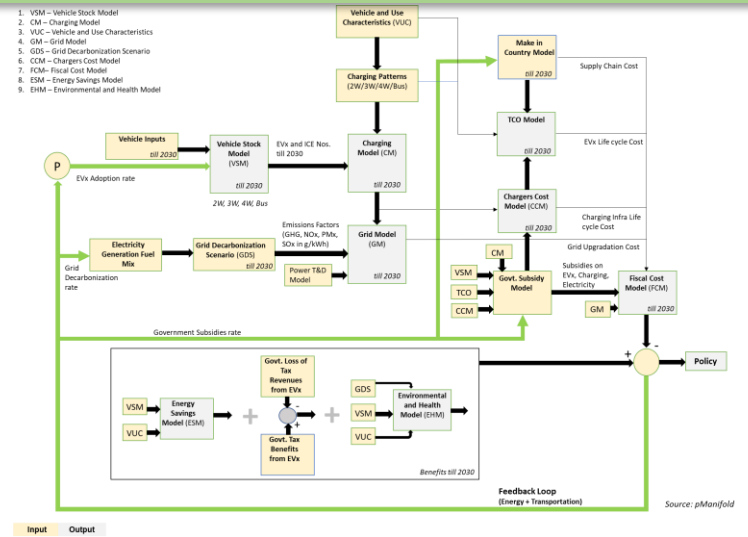
Set Target → Identify Potential policy options (Fiscal/ Non-fiscal) → Carry cost-benefit analysis of fiscal & non-fiscal incentives → Develop ZE-MHDT Roadmap → Finalize ZE-MHDT Roadmap with Industry Consultants

Potential policy options

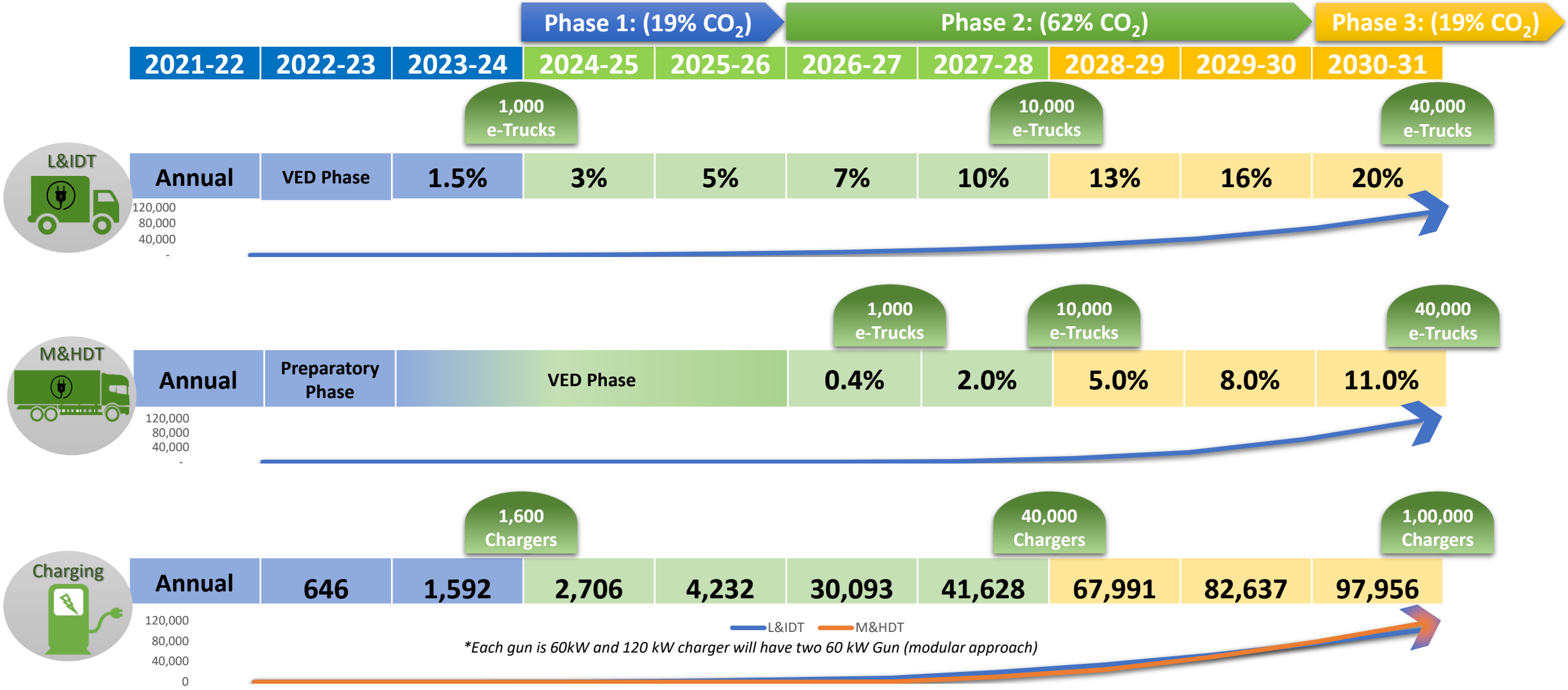
Policy Elements	Sub-elements
Supply Side	
EVs Targets	Define clear EV targets with timelines
Vehicle emission standards	Specify a required maximum level of emissions
xEV Mandate for OEMs	Mandate automakers to sell minimum share of light-duty xEVs
Financial Incentives for OEMs	Lower production cost
Public Charging Infrastructure	Standardization around Public chargers
	Lower Charging setup and usage cost
	Ease and lower cost of Financing
Power reliability	Access to required electricity supply
Grid Management	Define Charging Standards
	Define incentivized tariff for EV charging
	Promote Use of Renewables, Energy Storage and V2G
Vehicle Scrappage	Develop guidelines for vehicle scrappage
Battery Re-use and Recycling	Develop guidelines for battery re-use and recycling
Local manufacture and or assembly	Incentivise local manufacturing of EV components
Capacity Building	Support R&D. Capacitation of R&D institutions (grants) Important for local ownership and sustainability

Policy Elements	Sub-elements
Demand Side	
Financial incentives for users	Provide Subsidy to lower Purchase Cost
	Ease of Approvals
	Ease and lower cost of Financing
	Reduction in fees, taxes to lower usage cost
Non-financial Incentives for users	Provide Preference to EVs (parking zones)
Market Activation	Mandate Parastatals, Government Arms and Departments to procure EVs as service vehicles. Accurate Information deployment, communication strategies and media campaigns etc. (To be infused in national strategies and policy frameworks)
Home, Work and pan city slow AC Charging Infrastructure	Provide financial incentive to lower cost to ZEV Charging
Building codes	Amend laws for charging access in new buildings
Penalties	Penalise behaviours to drive important changes
	Discourage use of fuels that generate carbon emissions through carbon tax or cap-and-trade
Others	Others…

IETEM Model for cost-benefit analysis

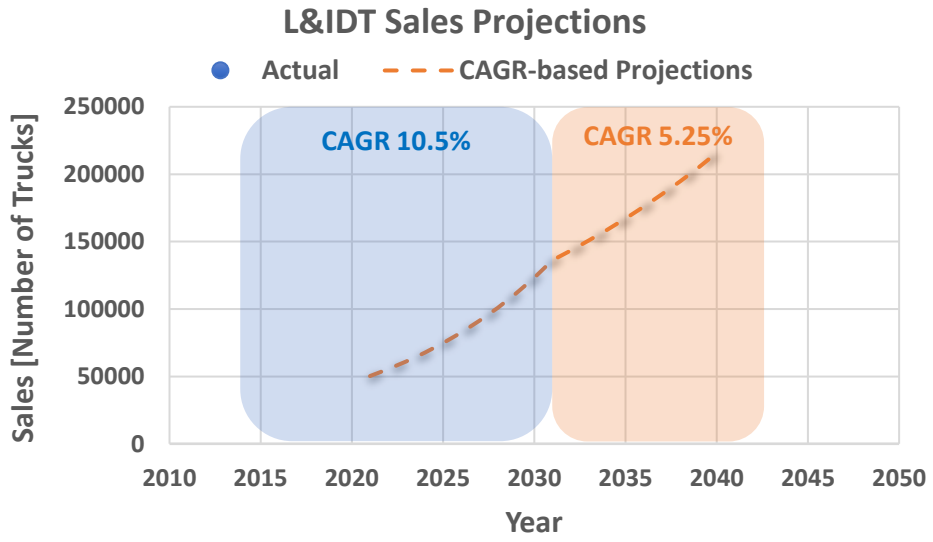


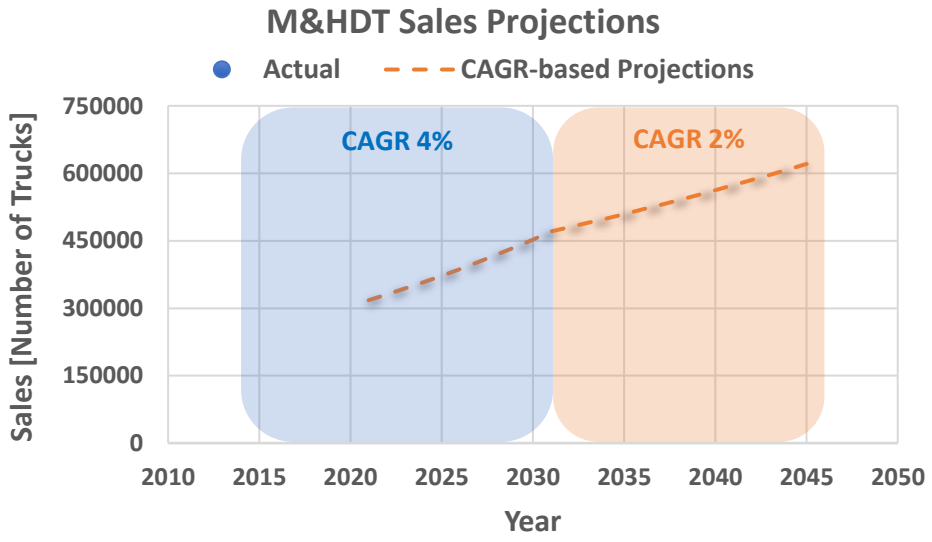
Supply Side Target Setting

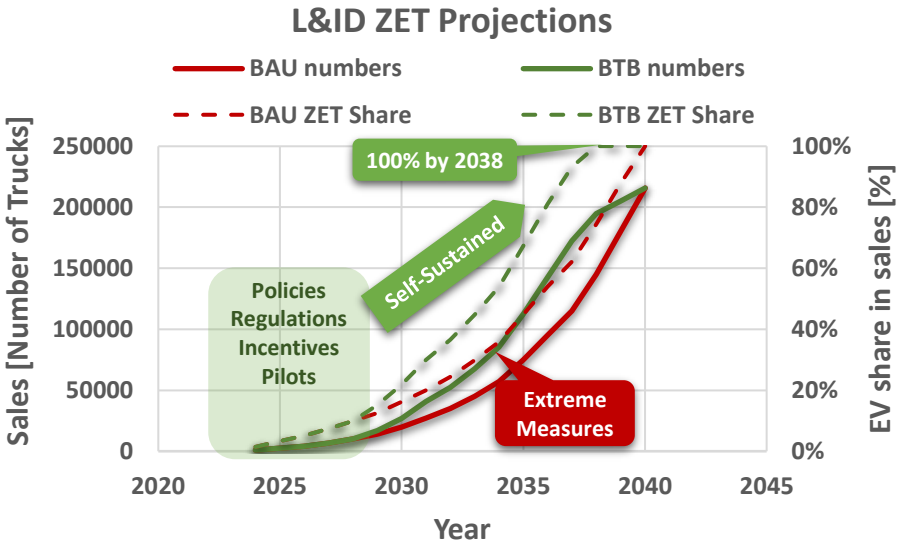


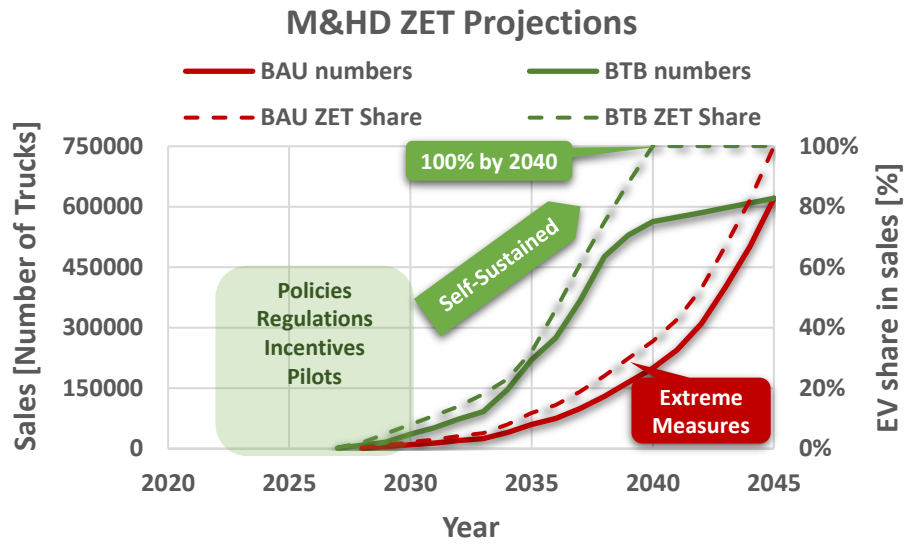
*VED refers to Vehicle Engineering & Development activities

MHDT Projections, BAU & BTB Scenarios – Annual sales



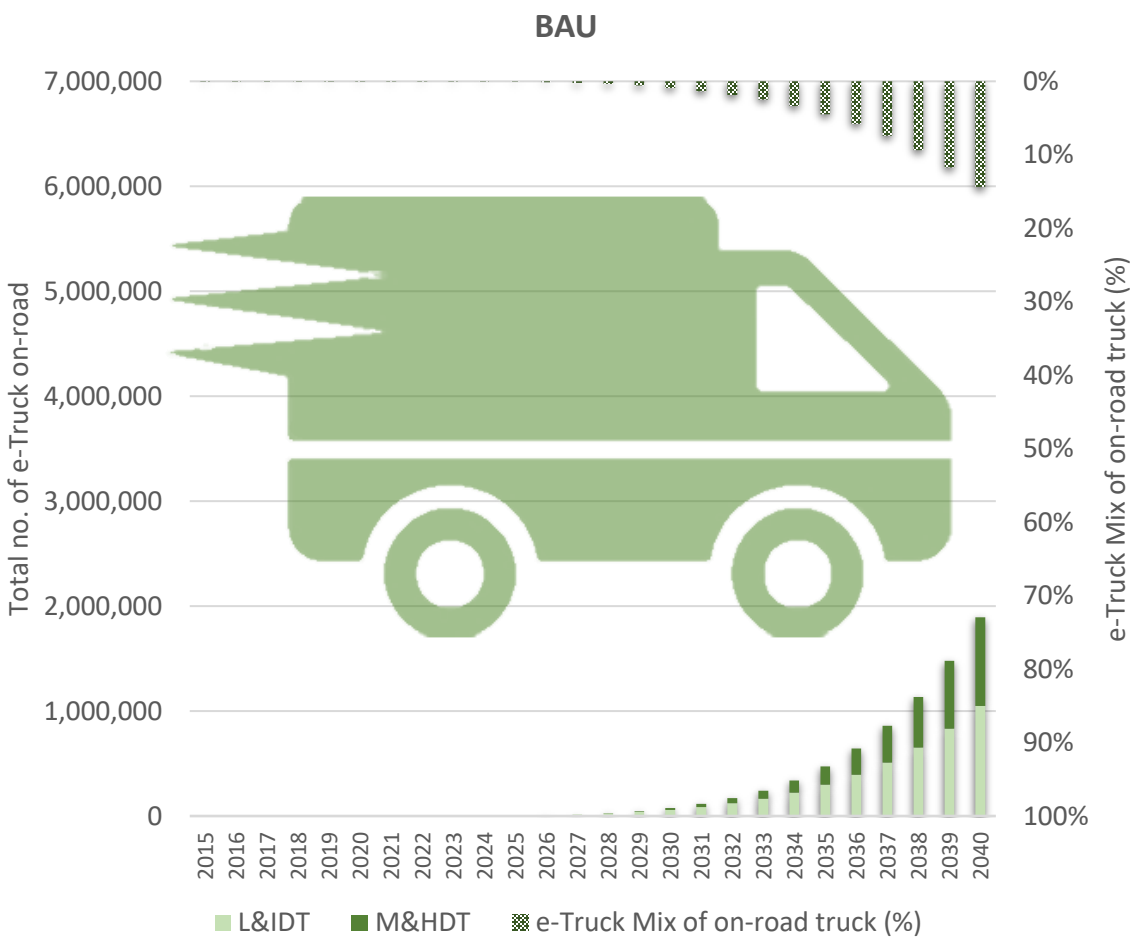




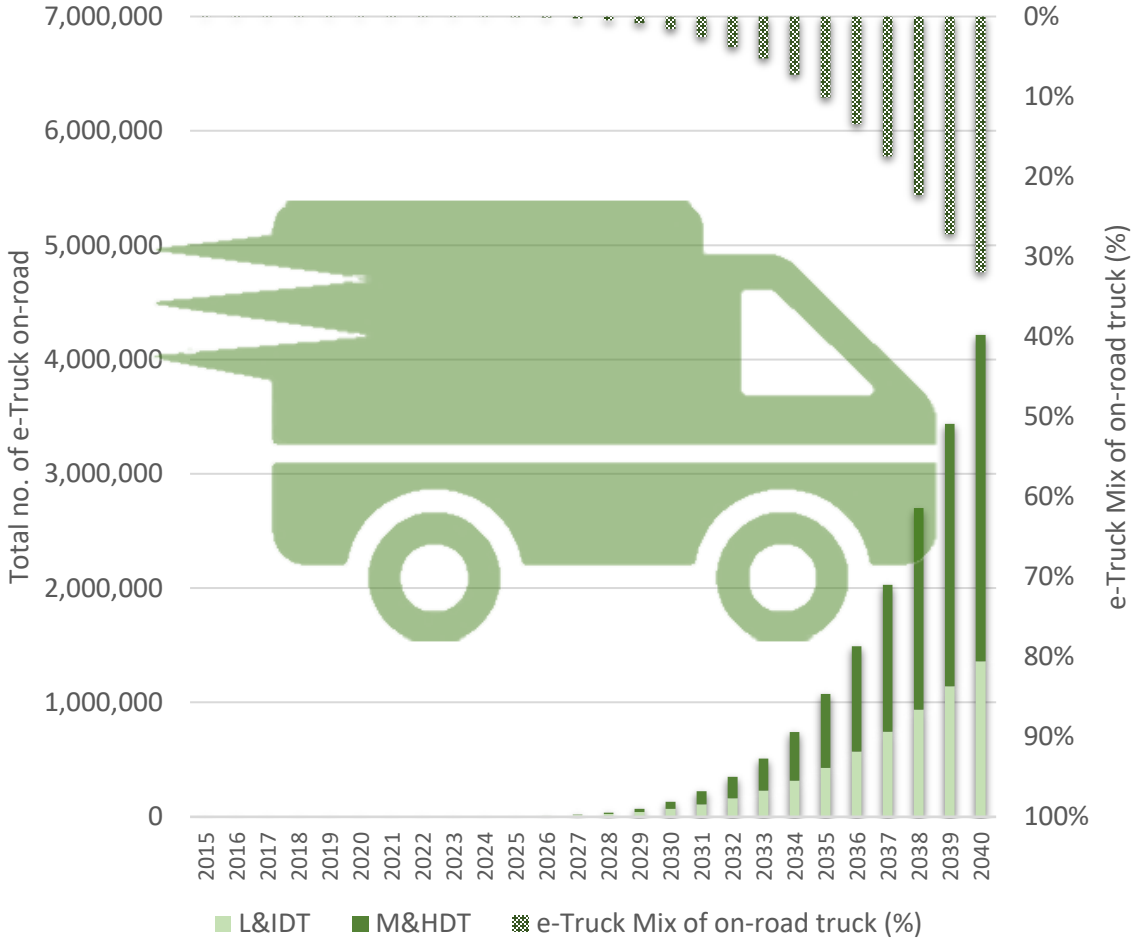


Electrification of MHDT – On-road Stock

Business-As-Usual (BAU)

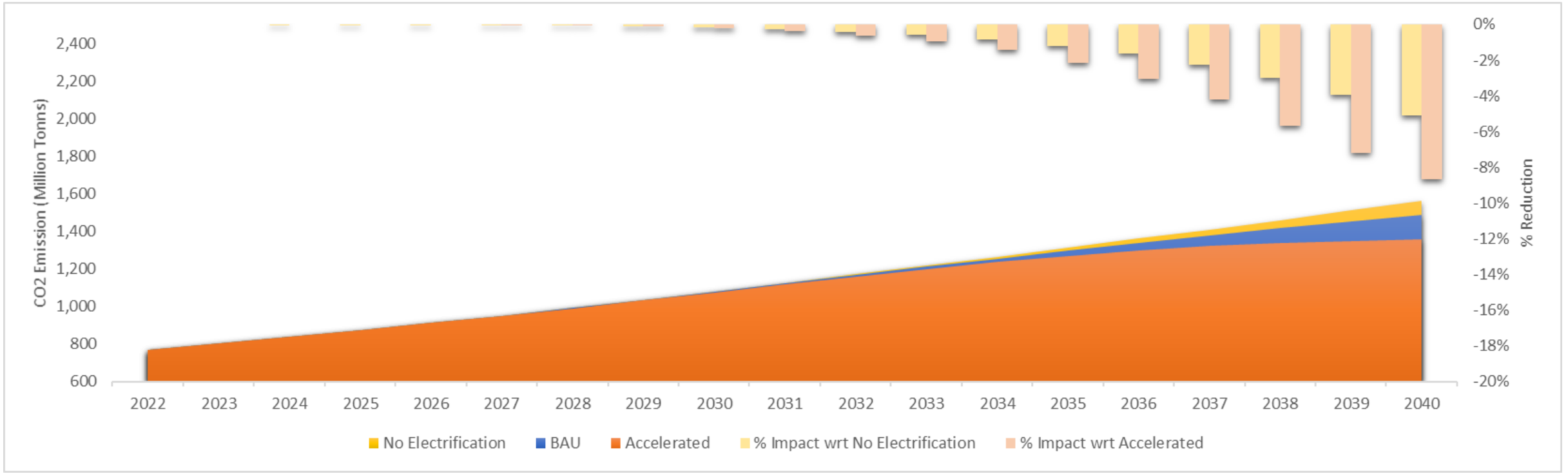


Target - Business-To-Be (BTB)



Impact on CO2 emission: BAU vs BTB vs No Electrification

Well to Wheel CO2 emissions from MHDT – BAU vs BTB vs No Electrification



Up to 2040, 340 Million Tons of cumulative CO2 reduction as compared to BAU, estimated cost of which is 2.6 quadrillion INR (34 Billion USD)

Benefits of Accelerated Electrification of MHDT over BAU

	Short Term (2021-23)	Medium Term (2024-27)	Long Term (2028-30)
GHG emissions reduction	0 kTons	65 kTons	7,800 kTons
		6 Million USD saved	800 Million USD saved
Fuel Consumption Reduction	0 Million Litres	66 Million Litres	7,000 Million Litres

- Electrification has a huge role...

Barrier Analysis

Economical barriers

- High e-Truck purchase cost
  - High import duties on sub-system component
  - High battery costs
  - Low volumes with minimal demand aggregation

Technology & Market barriers

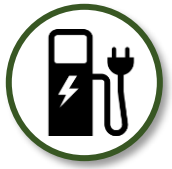
- Low energy and power density of batteries as compared to fossil fuels
- Lack of local supply chain for e-Truck manufacturing
- No e-Truck products available in market
- ZE-Range-extender technologies (fuel cells) not matured
- Long waiting time for charging

Awareness and Promotional Barrier

- EV technology apprehension

Institutional Barriers

- Limited local capacity on automotive R&M & services



Infrastructure barriers

- Lack of charging infra
- Low access to grid and poor power quality

Regulatory & Policy barriers

- Body-building standards not yet implemented
- Vehicle scrappages policy not yet implemented
- No Battery recycling/re-use policy existing for EV
- No vehicle salvage value assurance on loan default

Source: Stakeholder consultation

Proposed Interventions

1. Pilot deployment across India for generating success stories

1.1 Objective

- To establish that TCO parity is possible for certain application + segment
- Develop visibility with Central and State govt. to initiate ZET Policy measures
- Develop fiscal models for financing and risk mitigation

1.2 Assumptions & Success Factors

- Government funding is not considered for deployment and running for this pilot
- Adequate funding is arranged to provide e-Trucks and charging facilities free of cost to fleet operators (except electricity tariff)
- Suitable project management firm to plan, execute, run, and close the pilot
- No Govt. policy or intervention is considered for the success of the pilot

1.3 Application + Segment Selection Criteria

- Adequate range per charge (e-Truck capability)
- Adequate distance per day (application demand)
- e-Truck TCO ≤ 95% of diesel truck TCO
- Real estate and power availability for charging
- High share of annual CO2 emissions
- High share of volumes (stock and sale)
- Corporate drive for ZET (EV100+ signatories, etc.)
- Adequate size of fleet to back-up e-Trucks with ICE

Pilot deployment across India for generating success stories

- Fleet of 150 L&IDT 11 Tonnes e-Trucks
- Battery Size of 124 kWh
- Charger Size 60 kW

Estimated Cost
or Pilot Deploymer

Total investment per e-Truck

INR 41 Lacs		INR 10 Lacs		INR 5 Lacs		INR 46 Lacs		INR 103 Lacs
e-Truck Cost (with battery)	+	Charger cost per Truck	+	EMI on Diesel	+	Electrification & Property development (with land, transformer, grid)	=	Total Cost
40%		10%		5%		45%		

Estimated cost for Pilot Deployment

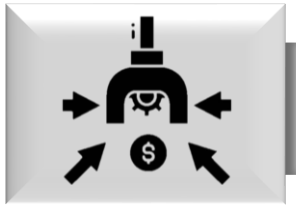
INR 102 Crores Upto $14 Million	INR 123 Crores Upto $16 Million	INR 164 Crores Upto $22 Million	INR 205 Crores Upto $30 Million
100 e-Truck	120 e-Truck	160 e-Truck	200 e-Truck
20 per region	30 per region	40 per region	50 per region

Proposed Interventions

2. Fiscal Incentives

2.1 Direct Incentives

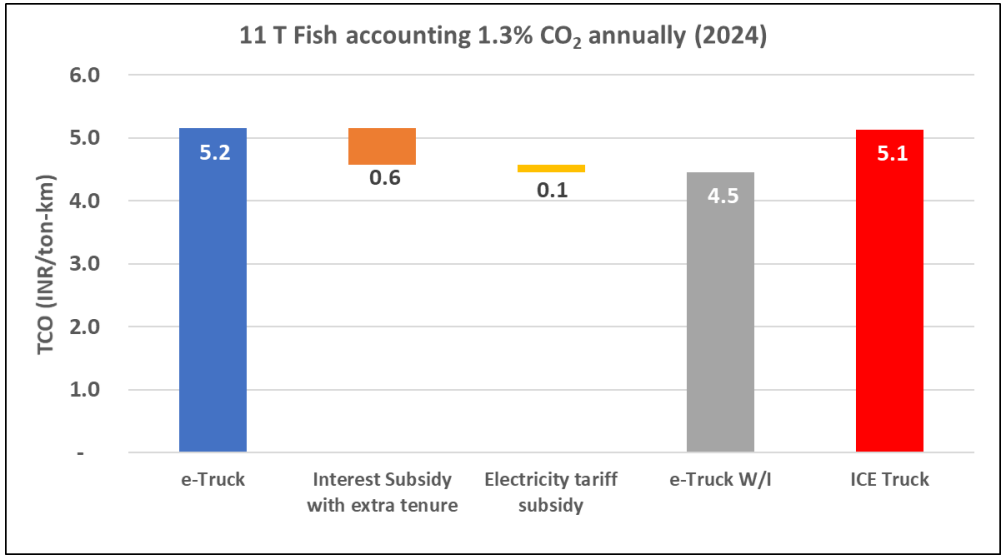
- Zero Emission Truck technologies. Eg High energy and power density batteries, Hydrogen economy, aluminium air, etc



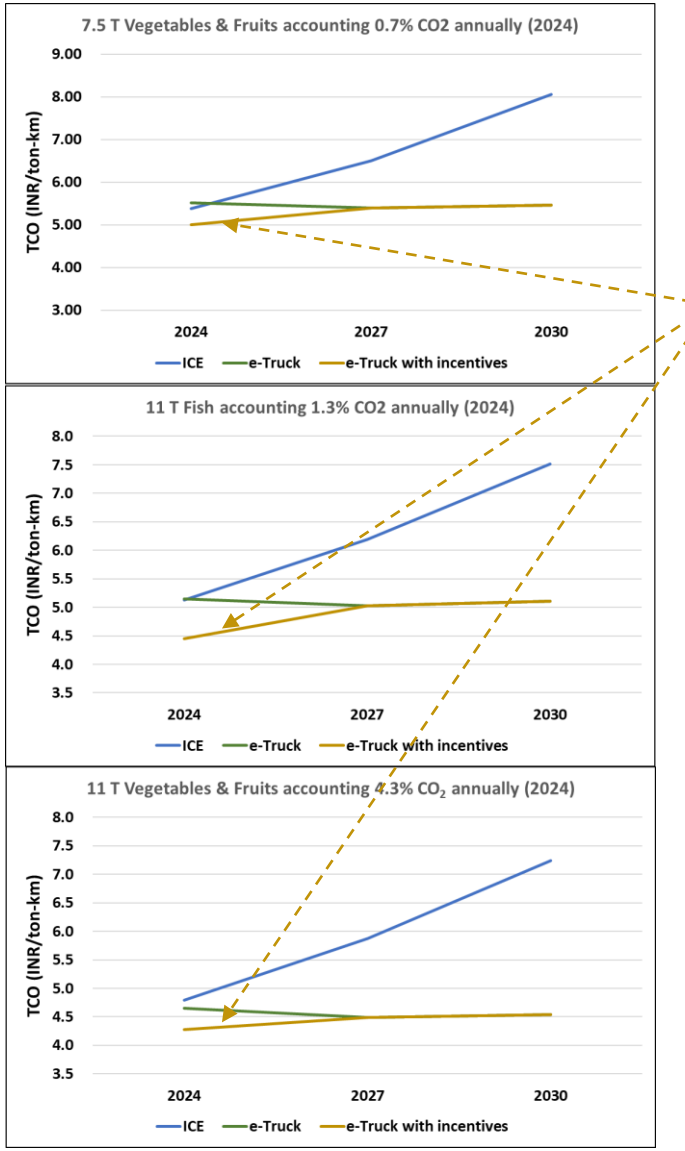
2.2 Financing Scheme

- Lower interest rates on e-Truck and chargers
- Extended tenure while managing battery life
- Framework for refinancing of NBFC loan
- Depreciated value assurance

Need for Fiscal Incentives



- ZET TCO expected to won't get parity with ICE in 2024, to get TCO parity in 2024 financing intervention will be needed from 2024 till 2025.
- To prefer ZET over ICE trucks, ZET TCO should get parity with 90% of ICE TCO.



Proposed Financing Interventions	
Interest rate subsidy	**Extended Tenure**
2.5 %	7 years

Considerations

- Increasing cost of diesel
- Increasing cost of electricity
- Life-time of 7 Years
- Diesel Truck re-sale value
- e-Truck no re-sale value
- Subsidised electricity tariff

Cost Impact of Fiscal Incentives and Benefits

Increased Electricity Demand

1,250 Million kWh

Reduced Emission

1,654 kTons

Phase-I and Phase-II Deployment of 62,384 e-Trucks by FY 2029

Reduced Fuel Consumption

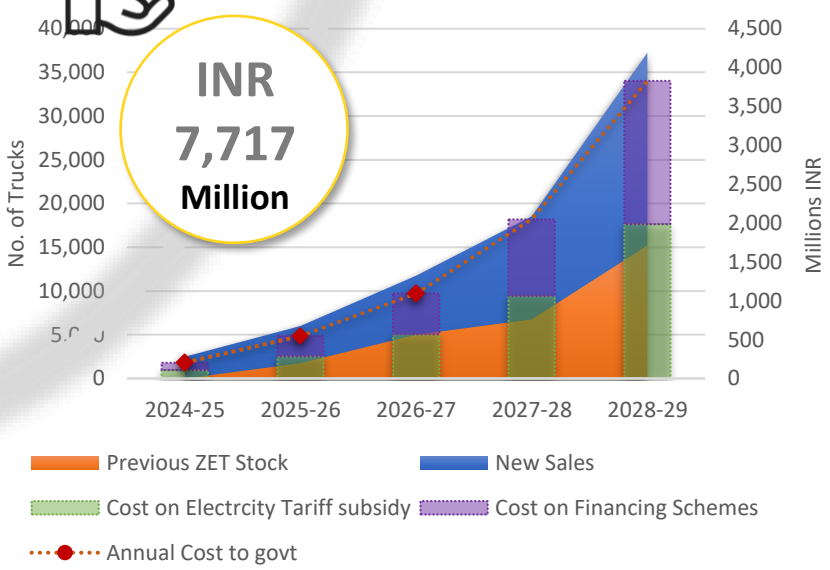
3,030 Million litres

Charging Infrastructure Requirement

17,800 Charging station

Cost to Government

INR 7,717 Million



Proposed Interventions

3. Government Standard & Regulations

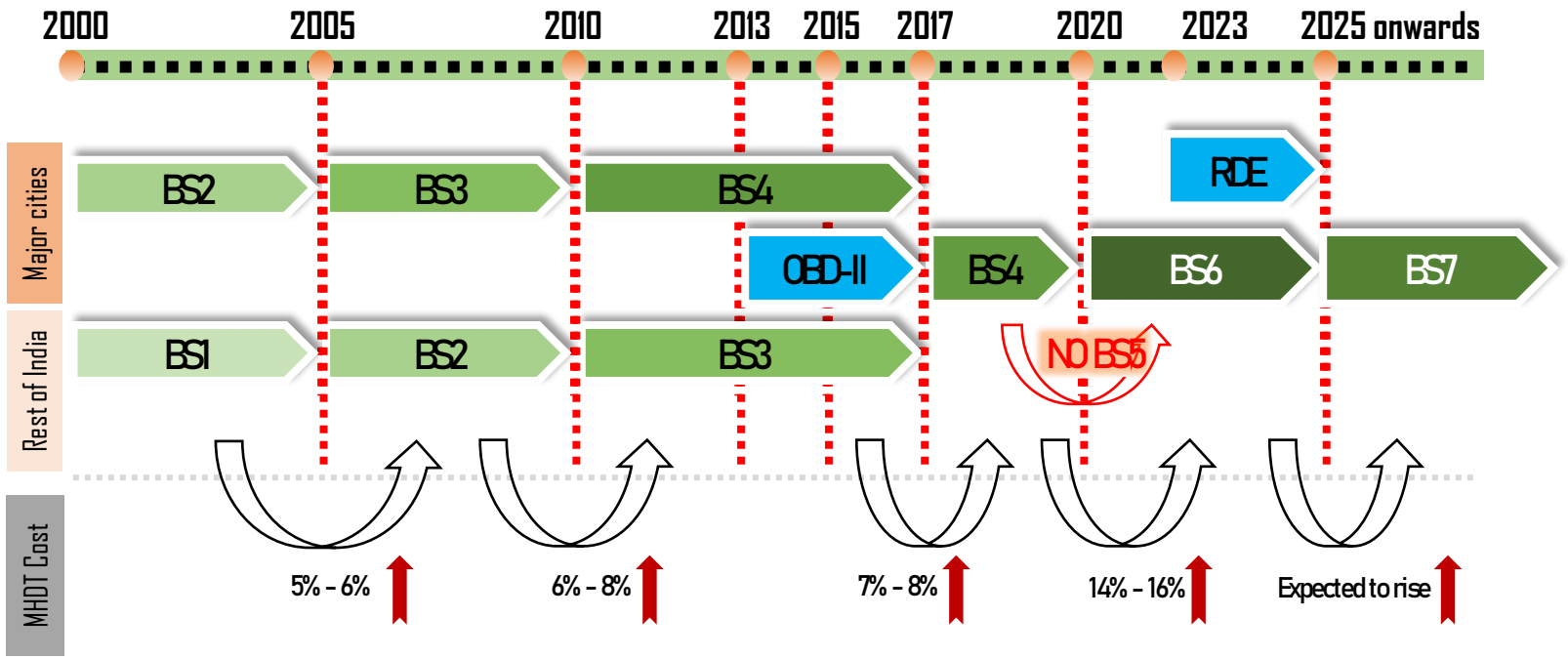
3.1 Regulatory Framework

- E-Truck operation/charging safety and security regulations to assure demand side
- Step wise plan for phasing out ICE truck registrations (starting with critical cities, other cities and pan India like BS4)
- Framework for risk assurance and liability for enabling e-truck finance
- Free national permit for ZE-Trucks for 5 years (2024-29)

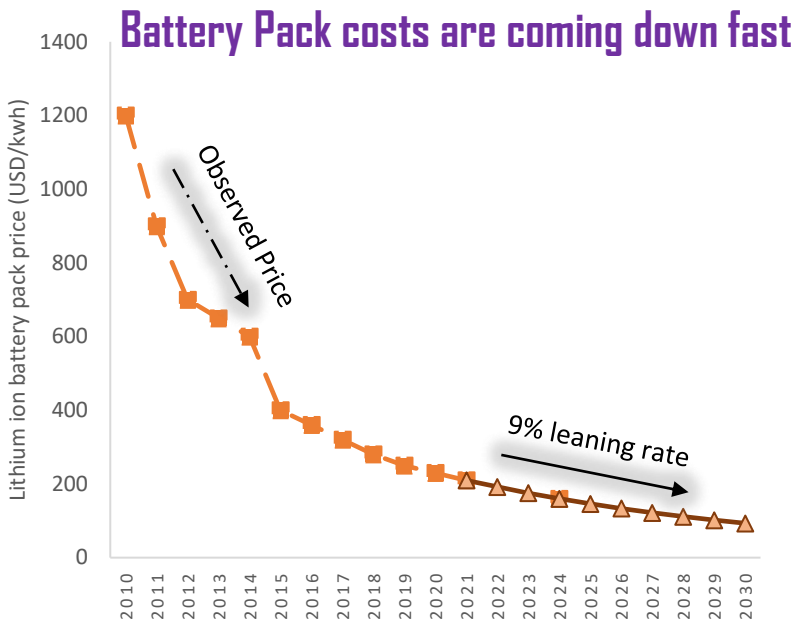
3.2 Supply Side Standardization

- Modular Batteries
- Common minimum e-Truck specification for regulated application
- Other standardization opportunities for demand aggregation

Impact of ZET Favourable Regulations & Standards



Source: https://theicct.org/sites/default/files/publications/ICCT_LDVcostsreport_2012.pdf

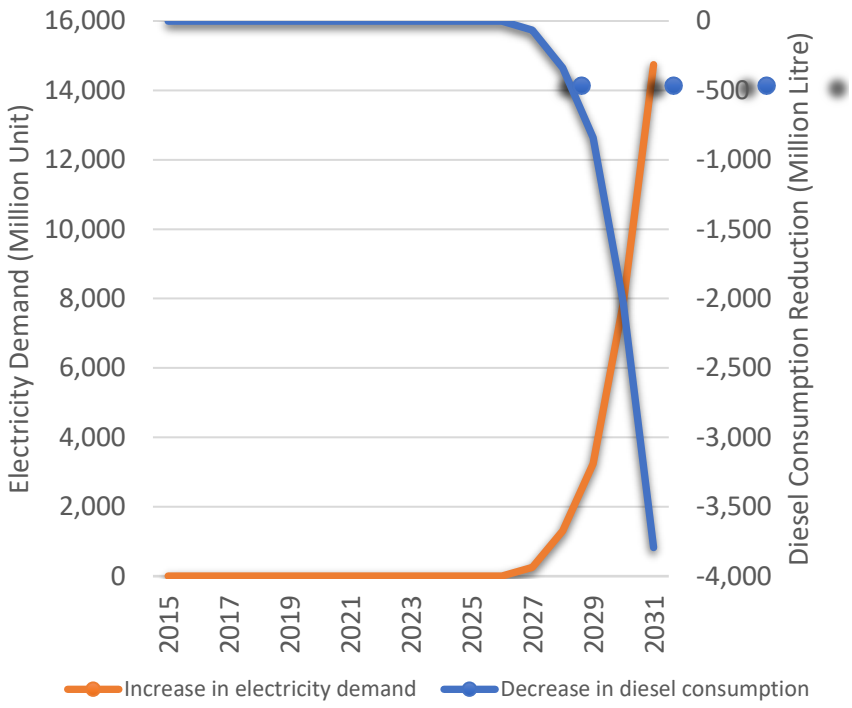


Source: BloombergNEF

- Plunging air quality of multiple cities will necessitate ZET mandate, which should be anticipated and phased
- ICE Truck cost rises with stringent tailpipe emission regulations, which will accelerate e-Truck price parity with ICE
- Demand aggregation for e-Truck, e-Powertrain sub-systems and charging stations will bring down e-Truck price

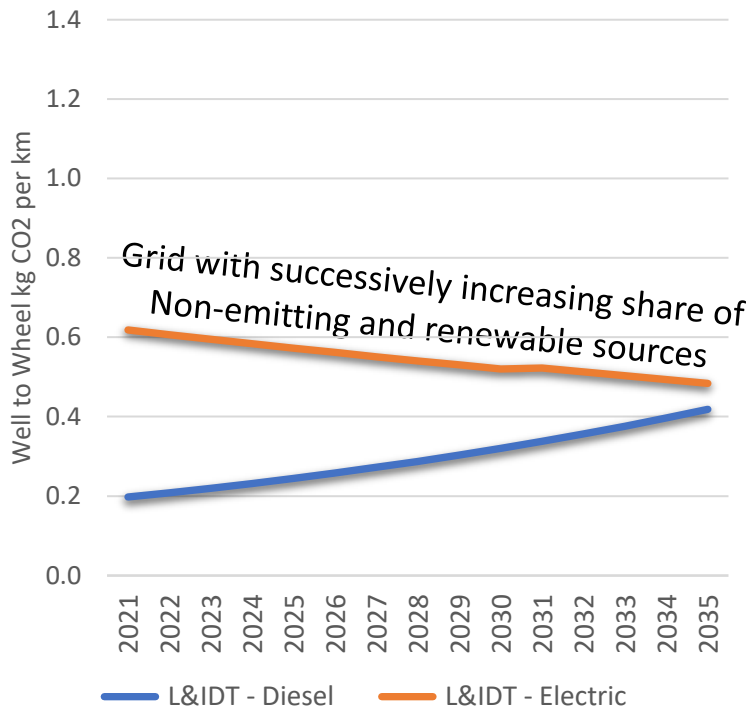
Impact of ZET Favourable Regulations & Standards

Demand of Diesel and Electricity

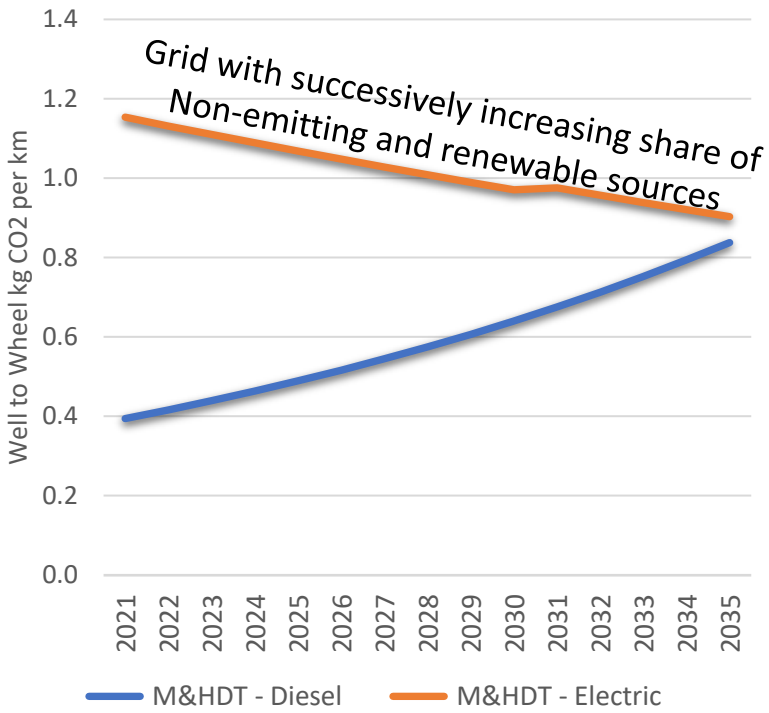


Note: Above comparison has been done for BTB Scenario with respect to BAU Scenario

L&IDT - Well to Wheel Emission per km



M&HDT - Well to Wheel Emission per km



- E-Truck adoption will decrease the consumption of diesel fuels, but total fuel consumption is still expected to grow over the years but at a slower rate. This may have impact on government revenue linked with fuel sales.
- Power distribution companies will have another source of revenue through sale of electricity for e-Truck charging.
- By 2035, the demand for diesel will fall by 60% compared to 2015 under BTB scenario.
- YOY, Well to Wheel Emission of Diesel vehicle is increasing and that of electric is decreasing, which is strongly phasing need towards electrification

Proposed Interventions

4. Supply side plan for transition to ZET

4.1 Technology development

- Technology Road map
- International partnership with OEMs governments
- ZET technology supplier development

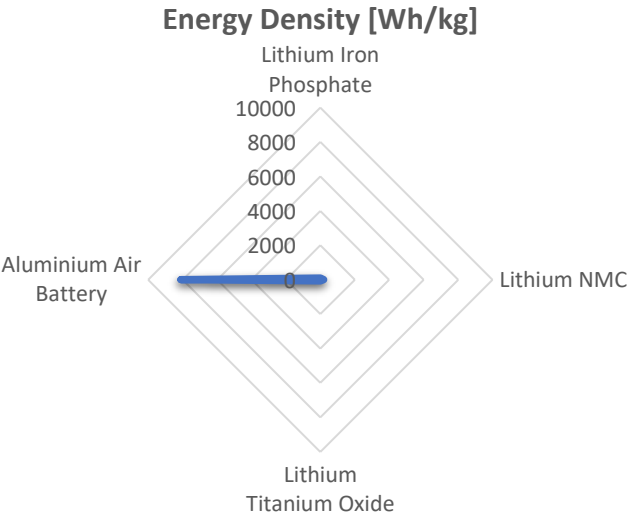
4.2 Upscaling capacity

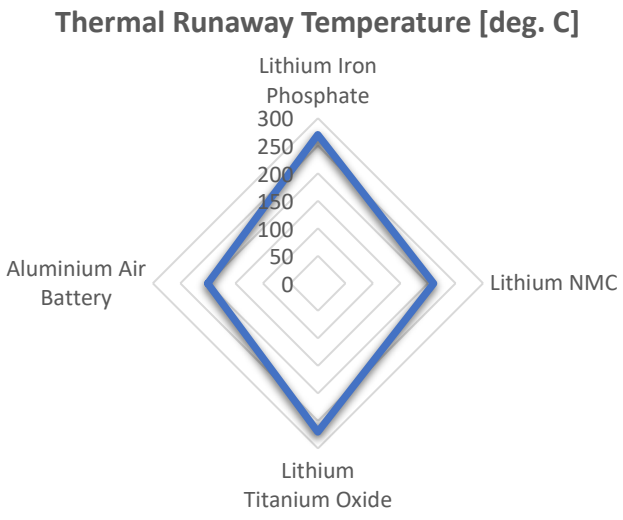
- Leveraging existing ICE truck manufacturing with e-powertrain assembly glide paths
- Decentralized assembly
- Key partnership for after market cabin and load body building

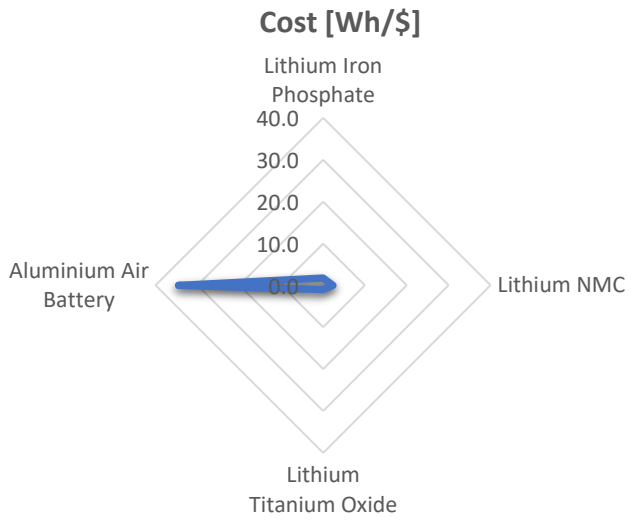
4.2 Upskilling resources

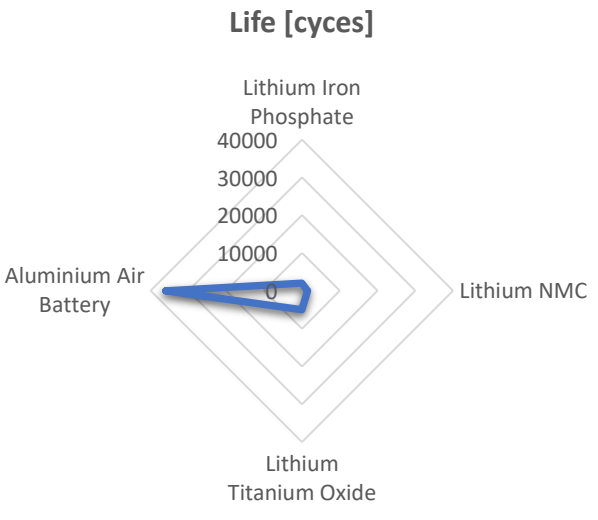
- Engineering teams for adapting and integrating ZE powertrains
- Marketing teams for effective communication of ZET benefits
- After market teams for infield support to ZET

Impact of Technology on ZET





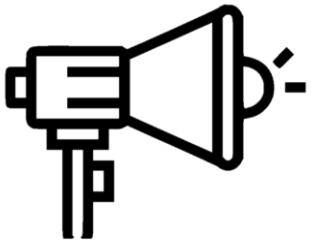




- Higher **Energy Density** batteries → less loss of e-Truck payload capacity with respect to ICE Truck
- Higher the **Thermal runaway temperature** → safer battery
- Cheaper battery → higher e-Truck **TCO** advantage over ICE Truck
- Higher **cycle life** of battery → lower battery replacement cost over e-Truck lifetime

Proposed Interventions

5. Awareness Campaigns



5.1 Awareness Program & e-Truck Campaign

- e-Truck awareness program for Demand Side (individual, fleet) e.g., EV100+
- e-Truck awareness program for supply side
- E-Truck awareness program for Finance and insurance

5.2 Success Stories

- Forums for sharing pilots' success stories in regional language From global experiences

Requirement of effective communication

For word of mouth to happen people must talk and people will talk from listening or looking to practical experience

India is hanging on to coal but its EV education campaign is visionary

India's E-Amrit is a government-run portal that may shape EV adoption globally.

ALSO READ

- COP26 Glasgow 2021: What can India hope to achieve?
- Global banks' new decarbonisation initiative at COP26 is a step backwards
- UN chief says outcome of COP26 'not enough'
- CIL Q4 net marginally down at Rs 4,589 cr; declares Rs 3.5 final dividend
- Coal India arm NCL dispatches 387k tonnes of highest-ever coal in one day

India may appear to be stalling on climate goals, having fought to maintain coal use at the COP26 summit and setting faraway targets for cutting emissions. But it's got one thing right: building awareness about electric vehicles.

Last week in Glasgow, India unveiled E-Amrit, a government-run portal that's a one-stop shop for all your electric vehicle questions. From subsidies for drivers and manufacturers to charging facility locations and financing options, the goal is to boost consumer knowledge.

This is a masterstroke of sorts and will shape the EV adoption story globally. The more drivers know about their options--and the more governments can address worries about how far EVs can travel--the less likely they will be to resort to old, fossil-fuel driven habits. It's not just about making the technology available, but equipping potential buyers with the tools to make informed decisions.

No doubt, there's plenty of information on the internet. But relying on various reviews, news articles and disparate sources isn't necessarily the clearest or easiest mode of getting details. In India, where a significant portion of oil consumption goes to motor fuel, this education campaign has the chance to make a big difference. There is a better, cleaner alternative--at the same price.

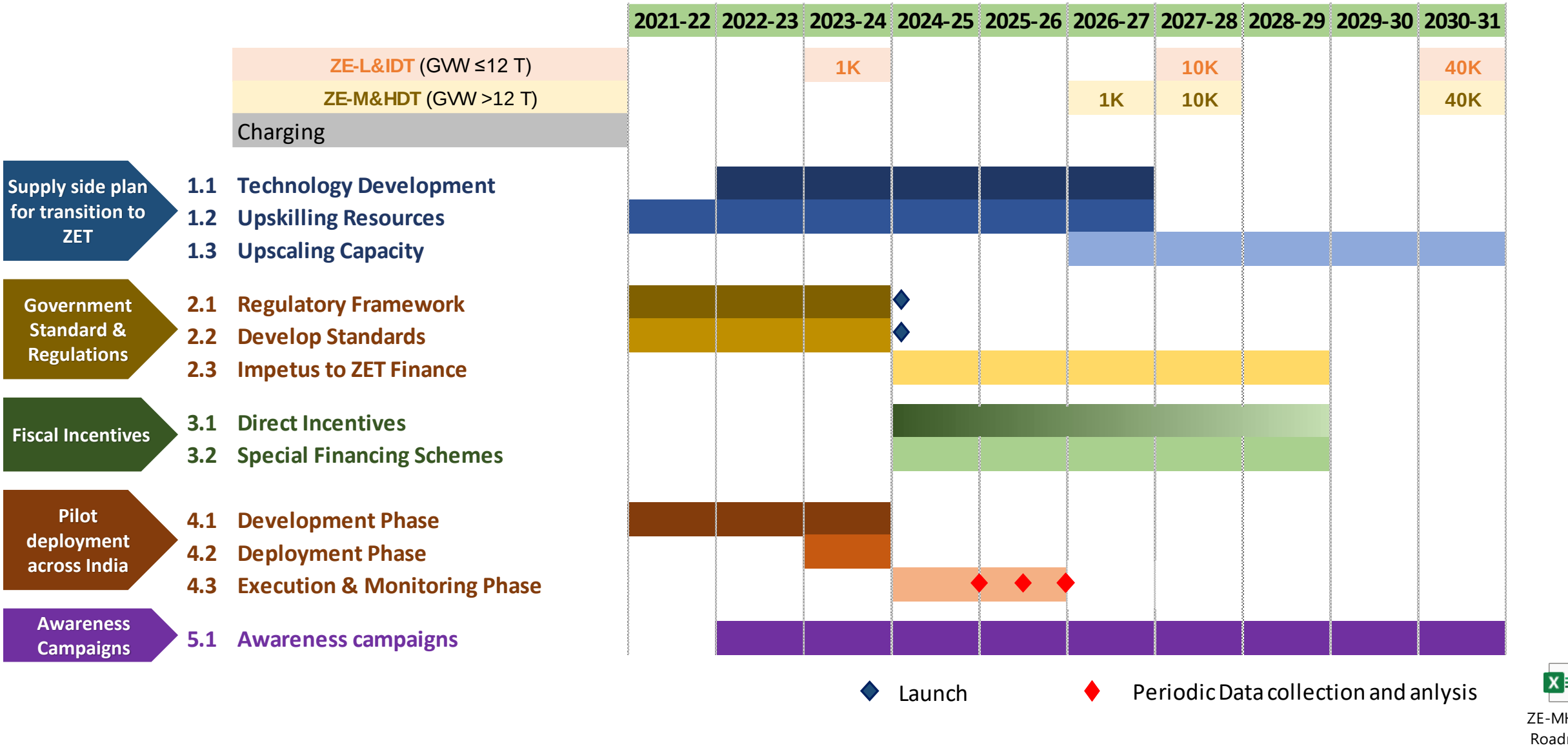
E-Mobility at a Glance

India stands at the cusp of a ground-breaking revolution in Electric Mobility

WORD OF MOUTH...

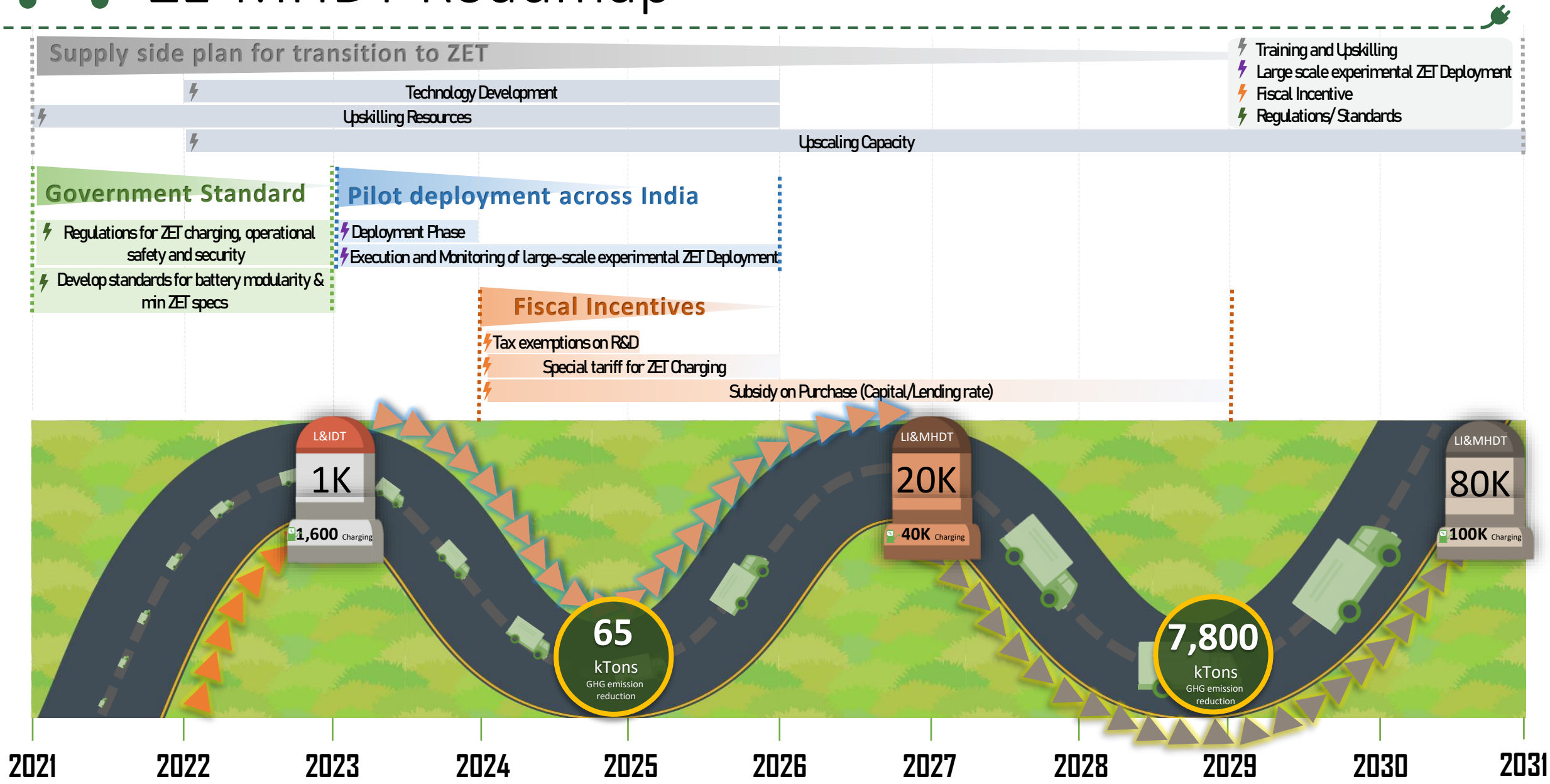
Natural conversation between real people

ZE-MHDT Roadmap



ZE-MHDT Roadmap

ZE-MHDT Roadmap



http://www.pmanifold.com

Strategy	Reports	Business Plans
Feasibility	City EV Charging Infra	Workshops
Industry Outlook	Pilots Management	Policy

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Annexure

Methodology for GHG Emissions Calculations

Based on the estimated MHDT growth and e-Truck mix, the GHG emission (or CO_2 emission) is calculated for the three scenarios (i.e., No electrification, BAU and BTB). The parameters considered in sequence for calculation of GHG emissions are as follows:

<table>
<tr><th>Parameter</th><th>IETEM Modelling</th></tr>
<tr><td>Vehicle kilometers travelled (VKT)</td><td>For all scenarios:
❑ VKT (for L&IDT and M&HDT) = vehicle stock x annual distance travelled
**VKT is the measure of the total annual distance travelled by the vehicle stock in a given year</td></tr>
<tr><td>Vehicle technology/ fuel mix (petrol, diesel, and electricity)</td><td>Vehicle segment wise percentage distribution across fuel mix is
For No Electrification scenario
❑ Assumed 0% electrification of truck across L&IDT and M&HDT is used up to 2035
For BAU scenario
❑ Based on projection and EV sales target across L&IDT and M&HDT, the fuel mix percentage distribution is used up to 2040 as
<table>
<tr><th></th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th><th>2031</th><th>2032</th><th>2033</th><th>2034</th><th>2035</th><th>2036</th><th>2037</th><th>2038</th><th>2039</th><th>2040</th></tr>
<tr><td>L&IDT</td><td>0%</td><td>0%</td><td>1%</td><td>3%</td><td>5%</td><td>7%</td><td>10%</td><td>13%</td><td>16%</td><td>20%</td><td>24%</td><td>30%</td><td>36%</td><td>45%</td><td>54%</td><td>62%</td><td>74%</td><td>88%</td><td>100%</td></tr>
<tr><td>M&HDT</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0.4%</td><td>1%</td><td>2%</td><td>3%</td><td>4%</td><td>5%</td><td>8%</td><td>12%</td><td>14%</td><td>19%</td><td>24%</td><td>30%</td><td>36%</td></tr>
</table>
For BTB scenario
❑ Based on EV sales target across L&IDT and M&HDT, the fuel mix percentage distribution is used up to 2040 as
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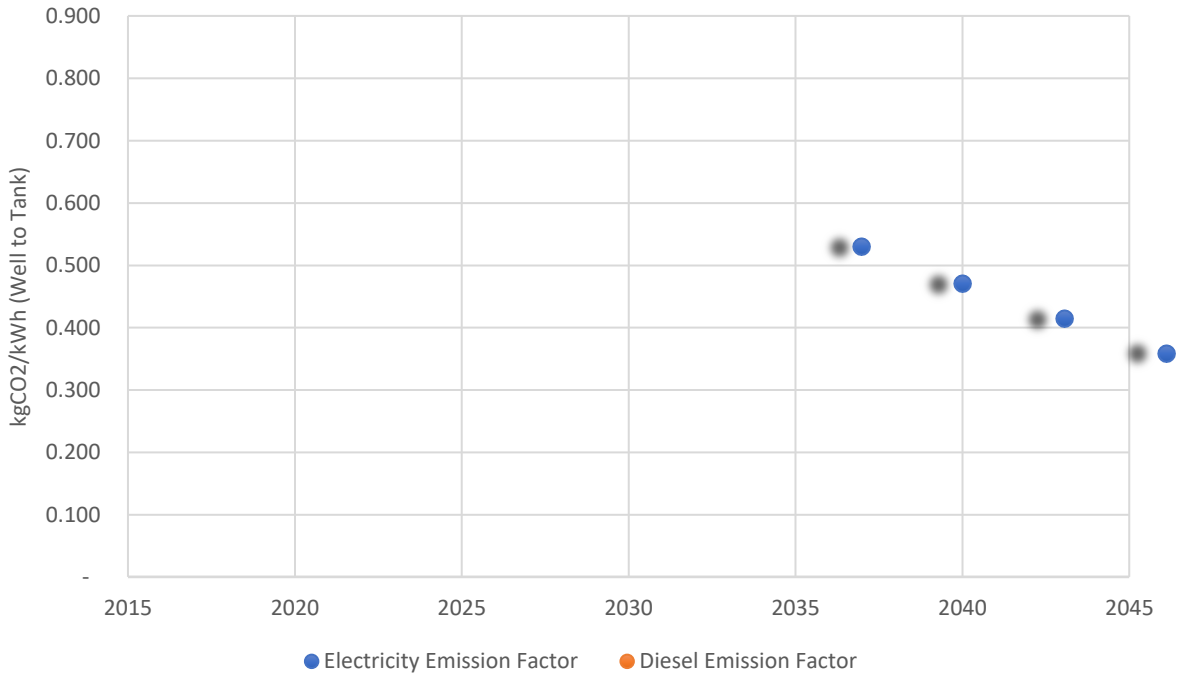
<tr><th></th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th><th>2031</th><th>2032</th><th>2033</th><th>2034</th><th>2035</th><th>2036</th><th>2037</th><th>2038</th><th>2039</th><th>2040</th></tr>
<tr><td>L&IDT</td><td>0%</td><td>0%</td><td>1%</td><td>3%</td><td>5%</td><td>7%</td><td>10%</td><td>15%</td><td>22%</td><td>30%</td><td>37%</td><td>45%</td><td>54%</td><td>67%</td><td>81%</td><td>93%</td><td>100%</td><td>100%</td><td>100%</td></tr>
<tr><td>M&HDT</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0.4%</td><td>2%</td><td>4%</td><td>8%</td><td>11%</td><td>15%</td><td>19%</td><td>29%</td><td>43%</td><td>53%</td><td>69%</td><td>88%</td><td>96%</td><td>100%</td></tr>
</table></td></tr>
<tr><td>Vehicle fuel efficiency</td><td>For all scenarios, vehicle fuel efficiency for the base year (2021) is shown below.
<table>
<tr><th>Fuel Efficiency</th><th>ICE diesel (km/Litre)</th><th>BEV (km/kWh)</th></tr>
<tr><td>L&IDT</td><td>5.00</td><td>1.25</td></tr>
<tr><td>M&HDT</td><td>2.50</td><td>0.67</td></tr>
</table>
The efficiency of vehicle in ICE will see an improvement of 0.5% Y-o-Y for every L/100km and 0.2% Y-o-Y for electric for every kWh/100km</td></tr>
<tr><td>Well to wheel emission factor by fuel type</td><td>Well to Tank emission factor (Refer next slide)
For diesel: Emission factor is increasing due to increased energy use per barrel of crude
For electricity: Emission due to electricity will vary based on the renewable and non-renewable share in the country

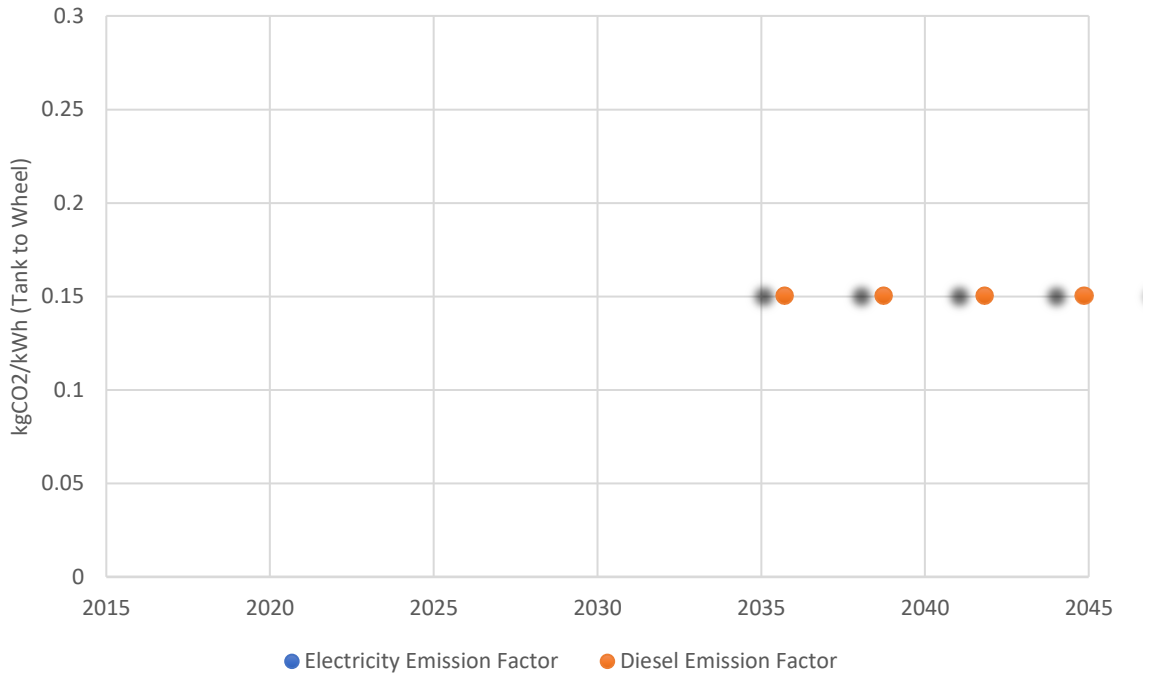
Tank to Wheel emission factor (Refer next slide)
For diesel: Emission ($KgCO_2$) per unit (i.e., Litre (L)) is derived using the calorific value for the liquid fuel (diesel) and this is constant over year
For electricity: It has no operational emission. Hence Tank to Wheel emission factor will be 0</td></tr>
</table>

Well to Tank and Tank to Wheel Emission Factor

Well to Tank Emission Factor



Tank to Wheel Emission Factor



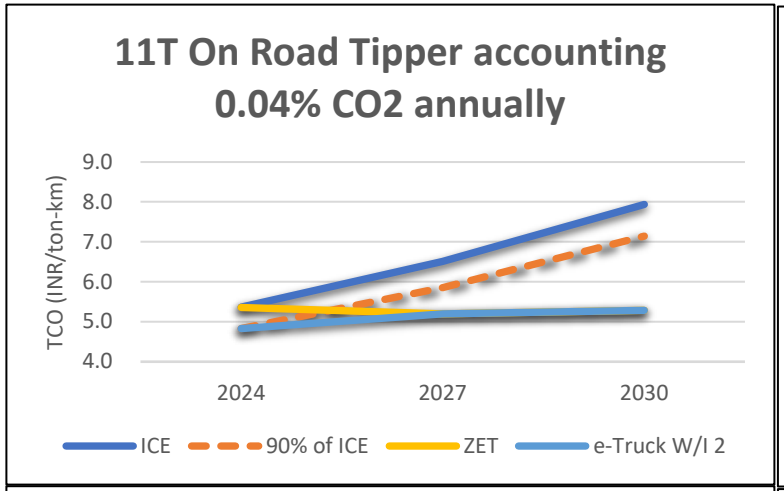
Number of Chargers Estimation

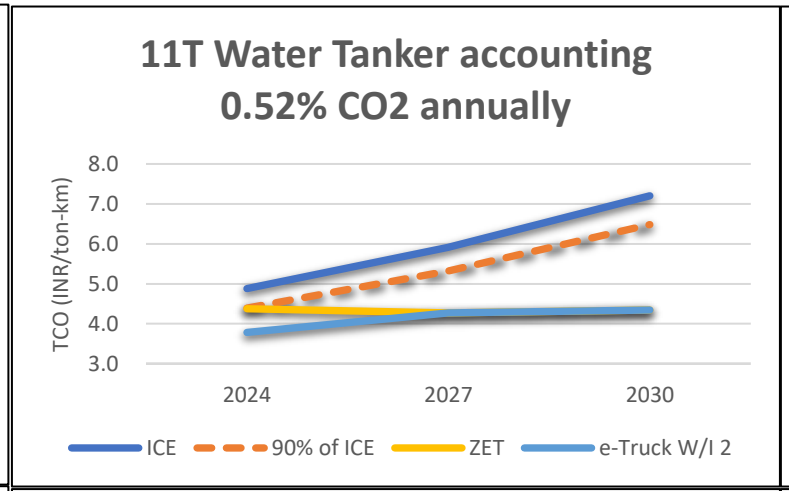
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Total e-Truck Sales (Nos)	**3**	**1,015**	**2,500**	**4,250**	**8,360**	**18,464**	**33,000**	**63,217**	**92,644**	**1,25,831**
L&IDT	3	1,015	2,500	4,250	6,750	10,093	17,000	27,000	40,854	52,500
M&HDT	-	-	-	-	1,610	8,371	16,000	36,217	51,790	73,331
Charging Utilization	17%	17%	17%	17%	25%	25%	33%	41%	49%	57%
Total no. of Trucks shared per charging point										
L&IDT	2	2	2	2	3	3	4	5	6	7
M&HDT	2	2	2	2	3	3	4	5	6	7
Total no. of Chargers to be Installed	**646**	**1,592**	**2,706**	**3,548**	**20,705**	**28,035**	**43,226**	**53,005**	**61,889**	
L&IDT (60 kWh)	646	1,592	2,706	2,865	11,318	14,442	18,462	23,374	25,822	
M&HDT (120 kWh)	-	-	-	683	9,387	13,593	24,764	29,631	36,067	
Estimated No. of Gun										
L&IDT	646	1,592	2,706	2,865	11,318	14,442	18,462	23,374	25,822	
M&HDT	-	-	-	1,367	18,774	27,185	49,529	59,262	72,134	
*Each gun is 60kW and 120 kW charger will have two 60 kW Gun (modular approach)										
Cumulative No. of Chargers	**646**	**2,238**	**4,944**	**8,492**	**29,198**	**57,233**	**1,00,459**	**1,53,465**	**2,15,353**	
L&IDT (60 kWh)	646	2,238	4,944	7,809	19,127	33,569	52,031	75,406	1,01,227	
M&HDT (120 kWh)	-	-	-	683	10,071	23,663	48,428	78,059	1,14,126	

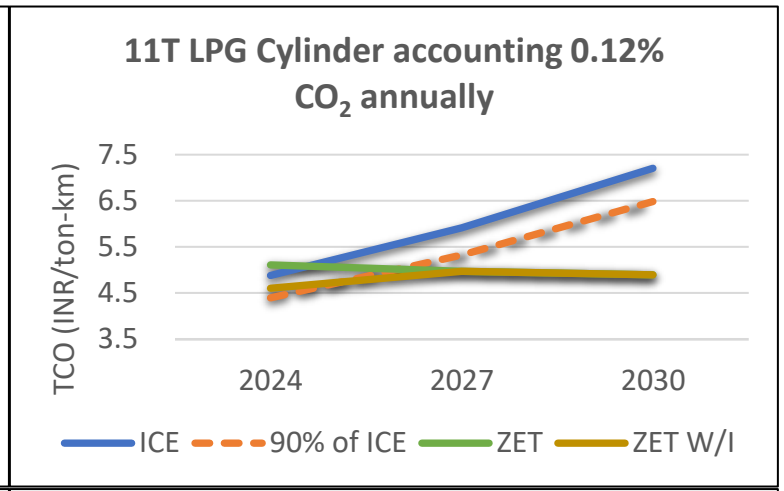
Assumption

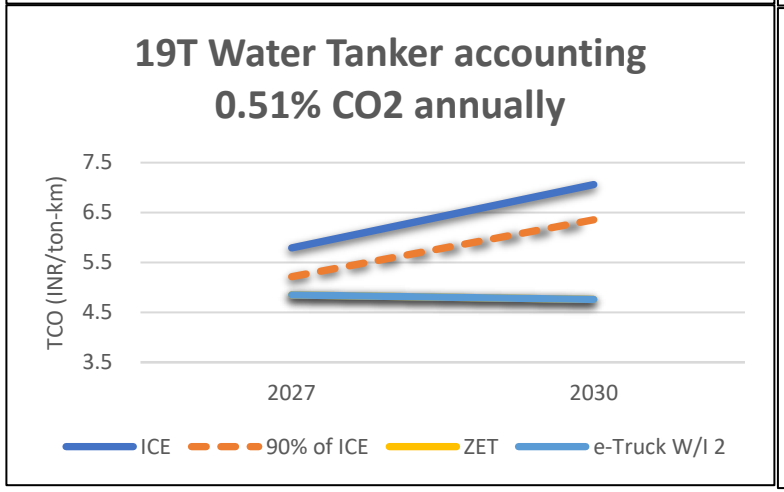
- Average charging time for L&IDT and M&HDT is 2 hours.
- Total no. of Trucks shared per charging point = (Charging Utilization x 24)/ (Average charging time)
- Charging event is based on Charging frequency and time required for daily usage as per application
- Total No. of Chargers to be installed = (Total no. of e-Truck Sales x Charging event)/ Total no. of Trucks shared per charging point
- It is assumed that chargers should install a year ago before e-Truck deployment

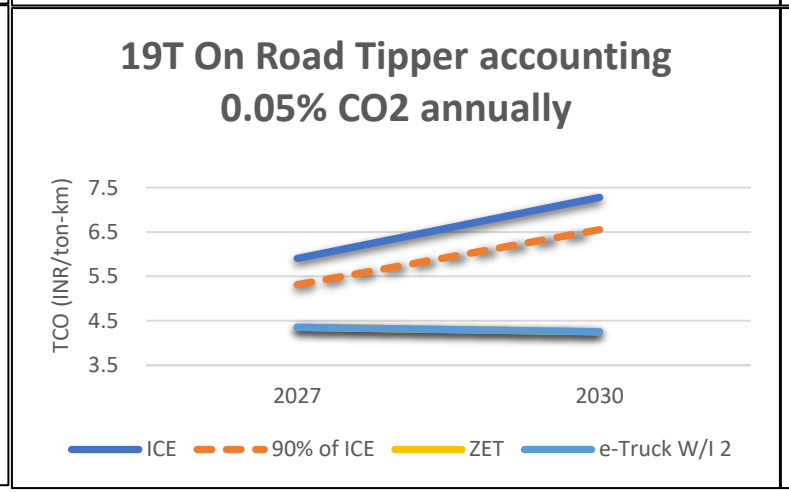
TCO Trends of use-cases

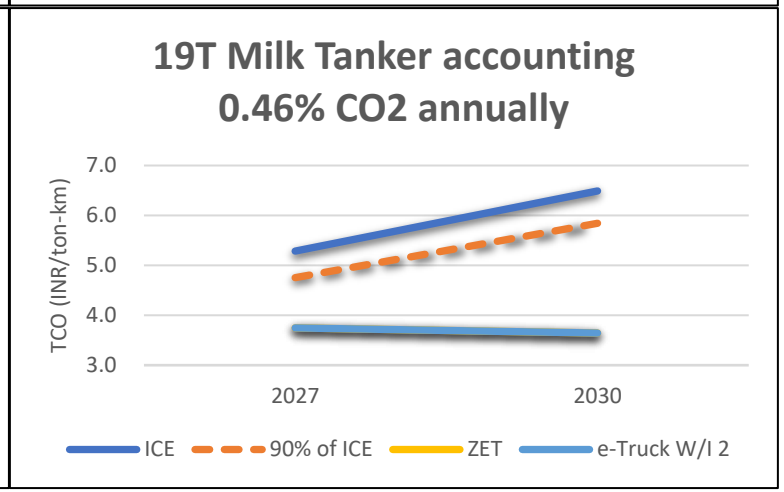












TCO Trends of use-cases