From crisis of mobility to electric mobility

Anumita Roychowdhury
Shubham Srivastava, Sayan Roy
Global transport emissions: Difficult to tame

Transport: Business-as-Usual CO2 Emissions (2050)

- IPCC, (2022) -- Transport is 15% of the global GHG. Fastest growing source of emissions.

Source: Slocat 2016
Road transport to upset energy and carbon budget in India

- IEA: India - Final energy use of transport by subsector and road transport by fuel in the Stated Policies Scenario, 2010-2040

Source: IEA 2021, Air Quality and Climate Policy Integration in India
Vehicles among the highest polluters in cities

Very high exposure on roads

Vehicles are among the top three polluters in cities

Source of high toxic exposure: contribute to low birth weight, heart disease, cancer etc

Cannot meet clean air target without effective action on vehicles

Source: Based on CSE exposure monitoring and DPCC data for ambient levels
The battle of car bulge: Is this solvable?
Since 2000, new vehicle registrations have doubled every 5-6 years.

Post pandemic year of 2020, it took only 2 years for vehicle registration to bounce back to pre-pandemic level.

Source: Vahan Database
Personal vehicles dominate

Share of new personal vehicles in new registrations, and trend of buses, cabs and goods vehicles

Average two-wheeler share – 72.6%
Average car share – 15.3%
Personal vehicle share on an average 85-90%.

Source: Vahan Database
Travel demand increasing; but share of public transport declining

- Passenger km to increase more than 3 times by 2050
- Trip length and rate to increase with city size and income
- Private transport to overtake public transport by 2040.

Source: UNEP, 2015
Electric vehicle market share increased from 0.1% in FY 2015-16, to 6.51% in FY 2023-24. E-rickshaws dominate -- 92% share in FY 2017. Post FAME II, two-wheeler share has increased; increase in bus numbers.
Bigger opportunity for change in India: Majority still walk, cycle and use public transport and .... Yet......

How can India plan mobility differently?

Source: India Census 2011
Modal share: dependence on private transport high – more in smaller cities

Personal vehicle dependence range between 35-45%
IPT dependence - 10% on an average,
Public transport modal share -- an average of 25%.

Source: NIUA, IIT-Delhi, Wilbur-Smith Associates, Respective city CMPs and CTTS studies
How will Delhi meet its future travel demand?

<table>
<thead>
<tr>
<th></th>
<th>Daily Ridership/trips (lakh)</th>
<th>Passenger km (lakh)</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTC Buses</td>
<td>15.62</td>
<td>221.80</td>
<td>14.40%</td>
</tr>
<tr>
<td>Cluster Buses</td>
<td>9.87</td>
<td>140.15</td>
<td>9.10%</td>
</tr>
<tr>
<td>Metro</td>
<td>25.16</td>
<td>420.18</td>
<td>27.27%</td>
</tr>
<tr>
<td><strong>Total Public Transport</strong></td>
<td><strong>782.14</strong></td>
<td><strong>50.77%</strong></td>
<td></td>
</tr>
<tr>
<td>Cars/Cabs</td>
<td>29.27</td>
<td>333.64</td>
<td>21.66%</td>
</tr>
<tr>
<td>Auto Rickshaw</td>
<td>16.54</td>
<td>59.55</td>
<td>3.87%</td>
</tr>
<tr>
<td>Two-wheeler</td>
<td>41.99</td>
<td>365.32</td>
<td>23.71%</td>
</tr>
<tr>
<td><strong>Total all modes</strong></td>
<td><strong>1540.65</strong></td>
<td><strong>100.00%</strong></td>
<td></td>
</tr>
</tbody>
</table>

42% of all trips are walking and cycling trips; 23% public transport

Out of the 1540 lakh motorised passenger KM travelled daily, half is by public transport.

Users of auto and aggregators, (about 390 lakh passenger kilometres), will move to private transport if public transport is inadequate.
EPCA estimates in 2018

Out of 1512 lakh motorised passenger KM travelled daily, 49% by public transport.

<table>
<thead>
<tr>
<th>Daily Ridership/trips (lakh)</th>
<th>Passenger km (lakh)</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTC Buses</td>
<td>20-25</td>
<td>160-200</td>
</tr>
<tr>
<td>Cluster Buses</td>
<td>12</td>
<td>96</td>
</tr>
<tr>
<td>Metro</td>
<td>25</td>
<td>440</td>
</tr>
<tr>
<td><strong>Total Public Transport</strong></td>
<td></td>
<td><strong>736</strong></td>
</tr>
<tr>
<td>Total private vehicles and others</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total all modes</strong></td>
<td></td>
<td><strong>1512</strong></td>
</tr>
</tbody>
</table>

Share of public transport needs urgent scaling up.
How can electric buses deliver if mobility crisis persists?

Delhi: More modern and electric buses but losing ridership ...

- **Bus fleet has increased** from 5,695 in 2017-18 to 7,072 in 2021-22. …to increase even further. Highest number of electric buses - 1600
- **But bus ridership plummets sharply**
- A sharp drop of 48.5% in bus ridership since 2017-18 – more empty kilometres.
- **Slow buses caught in congestion and poor level of service are not unattractive ….**
Affordability matters

Modern public transport system unaffordable for the majority:

In relation to the threshold of 10-15 per cent of income can be spent on transport as the upper cap for affordability, -- almost 1/3rd or 34 per cent of Delhi’s population stand excluded from basic non-AC bus services --- as it cannot afford it. (CSE 2018)

Source: Cost of Urban Commute, CSE
### Inequitable tax burden on buses

<table>
<thead>
<tr>
<th>Categories of Taxes</th>
<th>Tax/Levies/Charges</th>
<th>Applicability</th>
</tr>
</thead>
</table>
| Development of Immovable Assets such as stations, depots and terminals | ▪ Goods and Service Tax (GST)  
▪ Stamp Duty  
▪ Property Tax | Metro and **Bus** Systems             |
| Procurement of Movable Assets       | ▪ Goods and Service Tax  
▪ Custom Duty for imported components / vehicles | Metro and **Bus** Systems             |
| Vehicle Registration                | ▪ Motor Vehicle Tax  
▪ Vehicle Registration (Negligible)  
▪ Stage Carriage Permit (Negligible)  
▪ Municipal Tax | **Bus** Systems                             |
| Operational Taxes                   | ▪ Taxes on Fuel - excise and VAT  
▪ GST (on operational costs & AC fares)  
▪ Passenger Tax  
▪ Advertisement Tax | Metro and **Bus** Systems (except for Passenger Tax applicable to **Bus** Systems.) |

**Source:** Draft Report – Missing the bus
CSE assessment: Journey cost of personal vehicles lower than public transport – interchange and last mile increase travel cost

Case of a 5-km journey in South Delhi

Per kilometer journey cost **without IPT** as last mile

<table>
<thead>
<tr>
<th></th>
<th>w/o IPT</th>
<th>w/ IPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unskilled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus VS car</td>
<td>17.98%</td>
<td>39.63%</td>
</tr>
<tr>
<td>Metro vs Car</td>
<td>-6.45%</td>
<td>24.69%</td>
</tr>
<tr>
<td>Skilled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus VS car</td>
<td>31.18%</td>
<td>47.66%</td>
</tr>
<tr>
<td>Metro vs Car</td>
<td>0.76%</td>
<td>28.01%</td>
</tr>
<tr>
<td>Highly Skilled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus VS car</td>
<td>37.20%</td>
<td>51.32%</td>
</tr>
<tr>
<td>Metro vs Car</td>
<td>4.05%</td>
<td>29.53%</td>
</tr>
</tbody>
</table>

Per kilometer journey cost **with IPT** as last mile

Source: CSE estimates based on DMRC, DTC, Google, primary survey data
Bus transport in crisis
Dwindling bus fleet

Bus numbers stagnant in most STUs

Bus numbers have increased by only 4.6% in the last 5 years across 19 STUs

Source: MoRTH
Plummerting ridership in STUs

Based on data from RTIs, 13 cities have reported ridership loss of 40.8 lakhs.

Ridership lost between 2013-18

Source: MoRTH, RTIs filed by CSE
Between FY 2014-15 and FY 2018-19, losses in 19 STUs have more than tripled. To worsen with rising fuel and manpower costs.

Source: MoRTH
While bus numbers in STUs stagnating, its increasing in private sector. But service level challenged in this unorganised sector.

Private bus service needs attention going forward to induct cleaner buses, scale up electric mobility, and improve service level.

Source: Open Government Data Platform
**Delhi: Service level under stress**

Less than 1% of bus stops have a less than 10 min waiting time. 50% of bus stops in Delhi are in the high waiting time (more than 15 minutes) (Based on arrival and departure schedule in each bus stop)

<table>
<thead>
<tr>
<th>Average wait time</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low WT, Low SD</td>
<td>0.09%</td>
</tr>
<tr>
<td>Low SD, High WT</td>
<td>50.06%</td>
</tr>
<tr>
<td>High SD, Low WT</td>
<td>2.34%</td>
</tr>
<tr>
<td>High SD, High WT</td>
<td>1.11%</td>
</tr>
</tbody>
</table>

WT = Waiting Time; SD = Standard Deviation

Source: CSE calculations based on “Open Transit Data”, Delhi
Buses caught in congestion become more unattractive

CSE’s analysis in Delhi shows - traffic speeds go down by as much as 32% during morning peaks (7 AM to 12 PM) and up to 37% during evening peaks (5 PM to 8 PM) in Delhi.

Diwali holiday 2023: Reduced congestion levels

Source: CSE calculations based on Google Maps API data
What about Metro rail?
16 cities have an operational metro, with a collective network length of 862 kilometres. Another 6 cities have metro under construction. 5 cities have a proposed metro/metrolite/metro neo project, and 15 others have proposals pending for approval. If all of the proposed projects go through, then the potential is 3700 km network across India.
Ridership of currently operational metro rail systems not meeting expectations

All metro systems operating in Indian cities have 25-35% of the projected ridership on an average. Delhi’s DMRC has achieved the highest ridership compared to others, and it is less than half of the projected.

Since all benefits and revenue generation is dependent on the actual ridership, none of the systems have achieved the estimated benefits at the time of approval of the project.

Source: IIT Delhi, Metro Annual Reports
Most Metro rail systems do not have city-wise network.

Augmentation plan in the pipeline – but gestation period.
Buses enable much larger population coverage

Source: CSE calculations based on DMRC, Open Transit Data
How can electric buses catalyse mobility transformation?
Why E-buses are an opportunity?

- 4000+ e-buses are operating; Purchase order issued for another 15,000+ buses.
- FAME and NEBP have helped to establish e-buses in big/capital cities.
- PM e-bus seva scheme has a bigger ambition of introducing e-bus services (10,000 e-buses) in medium and small size cities.
- States beginning to fund e-buses - some states using clean air funds to deploy electric buses, e.g., Maharashtra.
Taming the cost curves
Changes in financing approaches

- Under FAME-1, STUs were free to choose e-bus operating model, could purchase outright – costs higher
  - FAME-2: Gross cost contract mandatory for central subsidy – Third party/OEM on GCC contract.
  - Differential price discovery (15 to 30%) under GCC lower
  - Centre adopts demand aggregation model to lower the total cost of ownership
  - Demand aggregation helped to reduce the cost of operation on per km basis, by 23 to 27%, even without subsidy
  - With subsidy -- 31 to 35%, than the diesel and CNG buses.
Changing financing strategy and enabler

• Such sharp fall in prices even without subsidy encouraged Center to introduce National Electric Bus Programme (NEBP) to deploy 50,000 e-buses by 2027. -- Only through demand aggregation, and no subsidy.

• Under NEBP, states procured e-buses using their state funds. Delhi (3980), Telangana (1000), Kerala (775) Haryana (550)

• NEBP first tender was successful but still has some inherent challenges related to payment security, high daily assured kms etc.

• Till date e-bus deployment was focused mainly in big and capital cities only. PM e-bus seva 2023 to deploy buses in smaller and medium size cities as well.

• **Introduction of payment security mechanism** – by creating payment security funds and direct debit mandate to ensure payments to bus operator even when state failed to pay them.

• Need a strategy not only increase bus numbers but also scales up electric bus services and mainstreams them to become the dominant service in cities.
Learning from e-bus service in cities

Scheduled operational km of almost all routes are quite higher than the actual operational range of electric buses.

Majority of routes either have to recharge in between to complete the trip or deploy another bus.

This increases the bus replacement ratio.

Operational range of e-buses

9m e-bus: 195 kW - 130-140 km – 1.1 kWh/km
12m e-bus: 261 kW – 135-145 km – 1.4 kWh/km
Learning from e-bus service in cities

Bringing buses to depot for charging creates a service gap in the operation.

Leads to revenue losses during operational hrs. and also forcing the authority to extend the services till late night or non-revenue hrs.

Service gaps have been created (in both morning and evening peak hrs.) for bring the e-buses to depot for charging during operational hrs.
Learning from e-bus service in cities

Bus Replacement Ratio

Scheduled v/s cancelled trips per day

Selection of buses with inadequate range, quality etc and poor deployment of charging infrastructure lead to increasing bus replacement ratio or inefficient service delivery.

Scheduled trip per day
Avg. trip cancellation per day
Learning from e-bus service in cities

Poor deployment of charging infrastructure lead to inefficient utilization of charging points.

Almost 75% chargers are being used for less than 50% of the time.
What needs to be done?

Need better and diversified product:

Available charging technology

Network level assessment:

Find out requirements (number and type of buses (AC/NAC, size – midi/standard, range, type of charging – overnight or opportunity or both, etc.), along with number of depots, routes, etc.)

Assess total cost of ownership (TCO) for entire operational period of infrastructure.

Current range offered by most bus models (120 to 150 km per charge), is lower than the daily operational requirements of most operators.

Range performance deteriorates over time and does not meet the specifications promised by OEMs.

- Overnight slow charging (> 3 hrs.)
- Overnight fast charging (up to 3 hrs.)
- Opportunity charging (flash charging with pantograph)
- Battery swapping*

Legend:
- PMI
- TATA
- Olectra
- JBM
- Switch (AL)
- VE commercial
- Pinnacle
- Veera
- Neuron
- Edison
Small scale and dispersed walking and cycling initiatives

NMT not provided as a network
Only a handful of cities have taken a network approach

Walking and cycling systems need for safe access and integration, last mile connectivity, hyperlocal active mobility, and promote low emissions zone

<table>
<thead>
<tr>
<th>City</th>
<th>Project</th>
<th>City</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delhi</td>
<td>Pedestrianisation</td>
<td>Srinagar</td>
<td>Cycle track</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>Public Bicycle Sharing (PBS)</td>
<td>Nashik</td>
<td>Cycle track</td>
</tr>
<tr>
<td>Chennai</td>
<td>NMT network plan</td>
<td>Rourkela</td>
<td>Cycle track</td>
</tr>
<tr>
<td>Pune</td>
<td>NMT network plan</td>
<td>Ajmer</td>
<td>Cycle track</td>
</tr>
<tr>
<td>Mysuru</td>
<td>PBS</td>
<td>Jaipur</td>
<td>Cycle track</td>
</tr>
<tr>
<td>Bhopal</td>
<td>PBS</td>
<td>Udaipur</td>
<td>Cycle track</td>
</tr>
<tr>
<td>Gwalior</td>
<td>PBS</td>
<td>Tirunelveli</td>
<td>Cycle track</td>
</tr>
<tr>
<td>Pimpri-Chinchwad</td>
<td>Pedestrianisation, PBS</td>
<td>New Town</td>
<td>Cycle track and</td>
</tr>
<tr>
<td>Surat</td>
<td>PBS</td>
<td>Kolkata</td>
<td>Pedestrian infrastructure</td>
</tr>
<tr>
<td>Bengaluru</td>
<td>Pedestrianisation, PBS</td>
<td>Mangaluru</td>
<td>Pedestrian infrastructure</td>
</tr>
<tr>
<td>Ranchi</td>
<td>PBS</td>
<td>Ujjain</td>
<td>Pedestrian infrastructure</td>
</tr>
<tr>
<td>Coimbatore</td>
<td>NMT network plan</td>
<td>Thane</td>
<td>Pedestrian infrastructure</td>
</tr>
<tr>
<td>Kochi</td>
<td>PBS around metro station</td>
<td>Namchi</td>
<td>Pedestrian infrastructure</td>
</tr>
<tr>
<td>Jabalpur</td>
<td>NMT corridor</td>
<td>Madurai</td>
<td>Pedestrian infrastructure</td>
</tr>
</tbody>
</table>

Source: Compiled from media sources, ITDP, GIZ, MoUA, Smart City Mission
It is possible to transform streets to make them people friendly.
22 streets in Delhi identified for pedestrianization

Restructuring Ajmal Khan road to be car free

Restructuring Chandni Chowk to be car free

Scale of change still small
Step towards multi-modal integration
Transit network: An opportunity for transit oriented urban communities

The MPD 2021 and MPD 2041 set target of modal split of 80:20 in favor of public and shared transport. Needs 1% increase in the public mode trips every year and an equal reduction in private vehicular trips.

MPD 2041: 60% of urban area will be within 15-minute walking distance from the MRTS stations.

UTTIPEC: -- after the full implementation of Delhi metro about 80% of Delhiiites will be within 400 meters of some metro station.
National mandate for transit oriented development

National TOD policy: Not just high rise and high density; But liveable and people oriented planning

-- High density, mixed land use development in TOD zones (500-800m) with spacing of metro station at 1km (mn 1 ha area).
-- Improve accessibility, NMT, increase ridership, compact walkable communities, meet basic services within the zone etc
-- Reduce private vehicle ownership, traffic and associated traffic demand,
-- Regeneration Schemes for mixed use, limited parking, built-to edge active frontage --
Prevent urban sprawl
-- Small block size with finer street network
-- Mixed income development -- EWS and affordable housing
-- Requires MMI, complete streets, last mile connectivity, inclusive habitat, optimized densities, mixed landuse, connected streets, NMT network, street oriented buildings, managed parking etc
-- Open areas (10-12 sqmt per person -URDPFI);
-- Active frontage
-- Value capture financing among others
Transit Oriented development (TOD) to bring work, home, retail and recreation closer

National Habitat Standards
-- 95% of residences to have daily needs retail, parks, primary schools and recreational areas within 400m walking distance.
-- At least 85% of all streets to have mixed use development.
-- Need small block size with high density permeable streets etc

The TOD Building typology - in Kolkata:
-- Roof of retail used as public space for residents.
-- Zero Setbacks.
-- Mixed Use (Commercial/ Civic/ Residential within same block)
-- Retail facing the street with homes overlooking, keeps pedestrians safe
Free and unlimited parking incites more car ownership and usage.
Parking Management Area Plans (PMAP) can make a difference

Pilot project Parking Management Area Plan in Delhi (Kamala Nagar)

Before

After

Source: Anuj Malhotra
Reimagine cities -- need new urban agenda for clean air and climate neutral goals

• Ambitious technology pathway for energy efficiency and zero emissions target
• Need scalable, integrated, connected and reliable public transport system and services
• Scale up network of walking and cycling infrastructure and efficient last mile connectivity
• Need restraint and demand management measures to reduce automobility
• Reform taxes to recover true cost of owning and using personal transport
• Adopt compact urban form to keep jobs and home close: Reduce distances, demand for travel and vehicle usage
• Shift budgets from road-building to public transport, active transport and zero-emissions mobility
• Reduce infrastructure degradation
• Integrate the needs of urban poor with land-use planning
• Adopt measurable and verifiable impact monitoring systems
Thank You