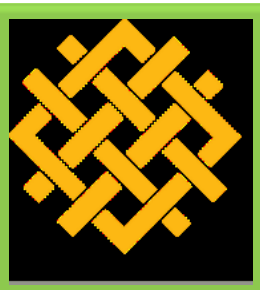
Implementation of E Buses - Challenges and Opportunities



Workshop on
Electrification of Public Transport
Ahmedabad, India
Sept. 23, 2019

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DIMTS
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Outline

- Project ?
- Process
- Challenges
- Opportunities

Project ?

History Of Private Sector Bus Operation In Delhi

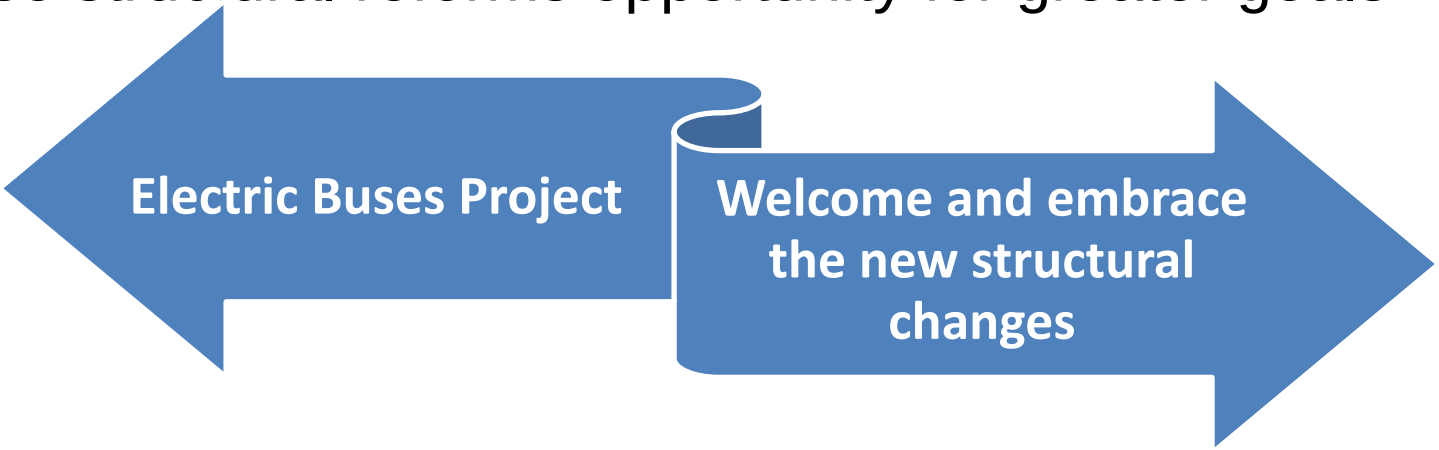
S. No	Particulars	Year	Number of Permits
1	Pre 1950 stage carriage operation	1940-50	108 permits
2	Old scheme	1971	100 mini buses
3	Ex-servicemen scheme	1973-74	120 mini buses
4	Graduate scheme	1975	100 mini buses
5	Scheme for SC/ST	1981	68 permits
6	Point to point scheme (Asiad)	1982	300 permits
7	Luxury (White line scheme)	1991	100 permits
8	Red line/Blue line scheme	1992	3000 permits
9	Suvidha	1993	609 permits
10	New scheme for CNG buses	2002	637 permits
11	Erstwhile KM scheme	2002 (April)	2,772 permits
12	Cluster Scheme	2010	5,000 (Target)
13	E-bus	2019	1000 (Target)

60 years

20 years

Initial Thoughts

- Change in :
  - Fuel : Diesel → CNG → Electric
  - Outsourced Operations : State owned → Private → Managed Private
- Once a generation reforms may not remain the norm
  - Shared Mobility ?? STUs, pioneers of shared mobility,
    - New technology -> an assumed monopoly of private sector
  - Define the market - how one could reduce risks and remain profitable
- Fuel change, manifestation of, deep rooted structural changes
- Use structural reforms opportunity for greater goals



World Economic Forum 2018

- Delved on issue of “Electric Vehicles for Smarter Cities: The Future of Energy and Mobility”
- By 2050, about 70% of the world’s population will live, commute and work in urban areas.
- **Mobility and Energy** defined as twin pillars of these transformations, and both will require radical adaptation to meet demographic and economic growth without increasing congestion and pollution.
- Solutions would need to be sustainable, affordable, secure and inclusive, and integrated with customer-centric infrastructure and services.
- Convergence of energy and mobility is critical.

Project vs Transformation approach could increase EV km/year share from 10% to 35% in USA by 2030

1 Take multistakeholder & market-specific approach

2 Prioritize high-use vehicles

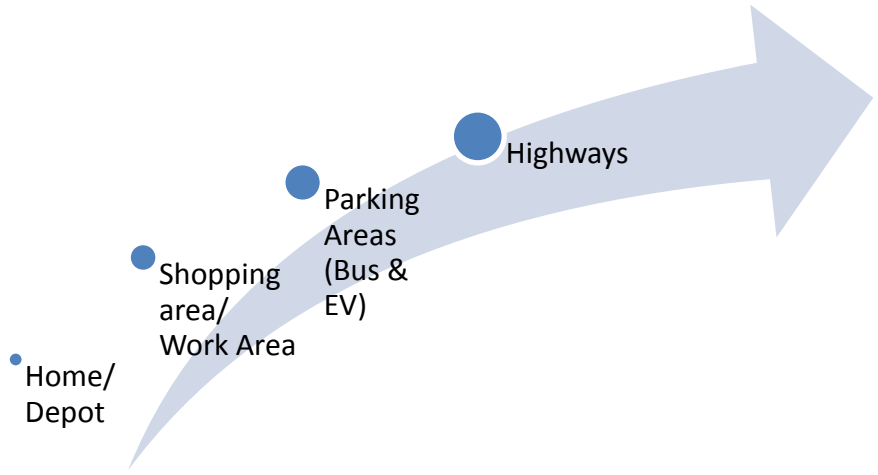
- Focus on electrifying **public and commercial fleets**, including mobility-as-a-service
- Complete electrification of **public transport** system
- Enable the integration of **autonomous vehicles** (AV)

3 Deploy critical charging infrastructure today while anticipating mobility transformation

- Focus on reducing **range anxiety** and promoting **interoperability**
- Prioritize energy-efficient **charging hubs** with **grid edge technologies** and **smart charging**
- Develop **digital end-to-end** customer experience to **enhance access** to charging services

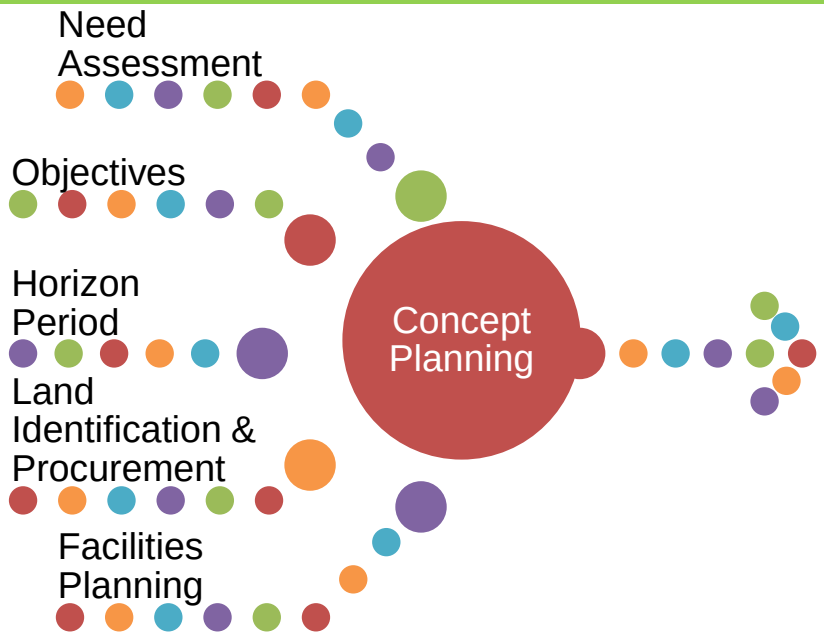
Prioritize High Use Vehicles

- Stress on E-Mobility as a Service and Public vehicles can quadruple the benefits
- Project vs Transformation approach could increase EV km/year share from 10% to 35% in USA by 2030
- Range Anxiety is the highest rated reason for switchover to EV in UK (45%)
- Multiple day charging options in “sunny state” like California can deliver additional USD 700 million, vs night charging only – Imagine what “sunnier” India can do
- Smart grids, disaggregated power generation, i.e. ability to charge at the right time and right location can increase use of renewable energy, reduce peak loads, to improve smart mobility will lead to high efficiency networks plummeting the cost of mobility and improved competitiveness of a city



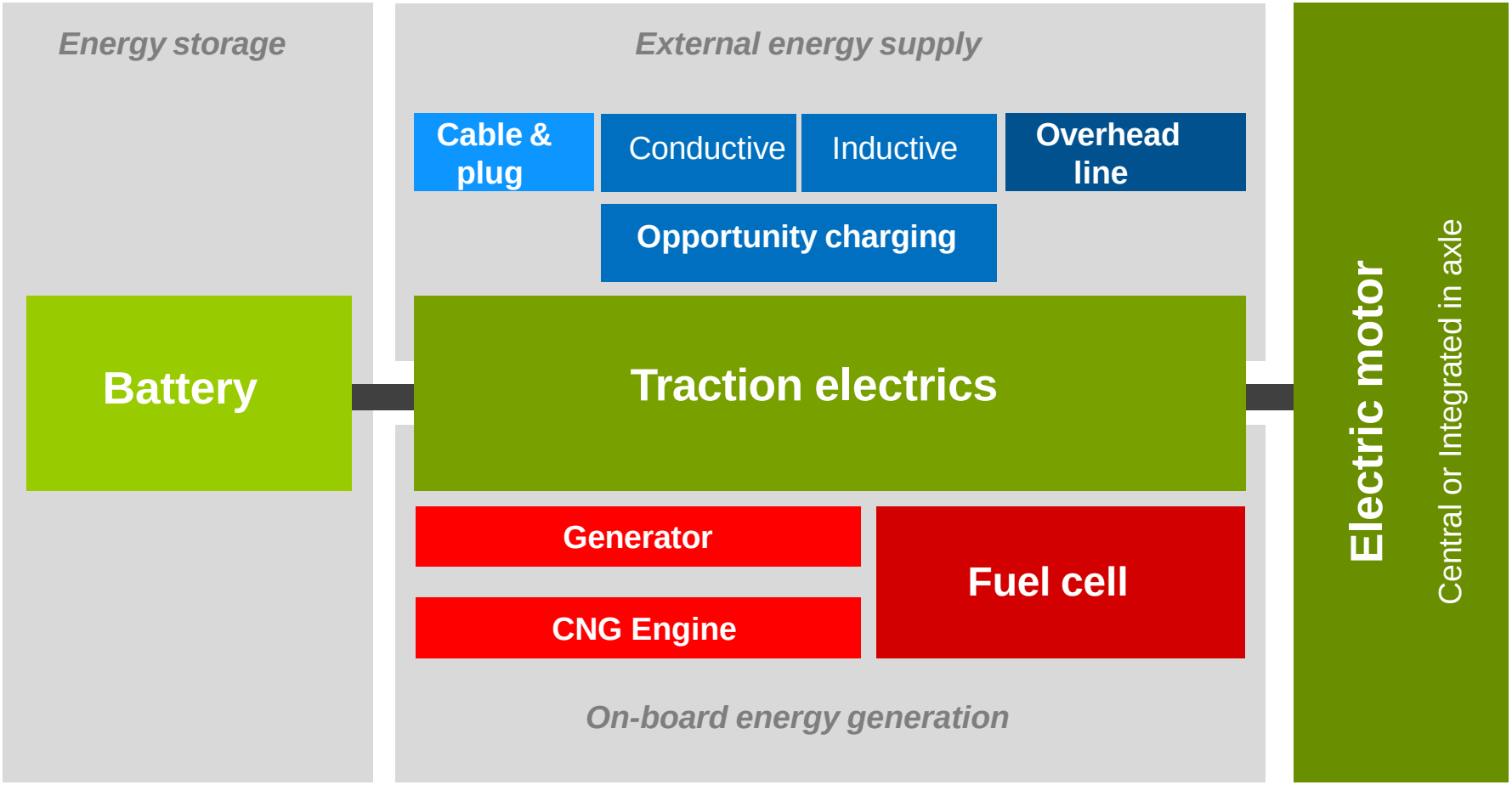
Process

Project Development and Implementation Process



- Design Development
- Resource Allocation
- Approvals
- Prioritization of procurement activities
- Procurement Process
- Setting up project progress monitoring system
- Project Commissioning

Electric Bus Driveline



Presentation Deals with Battery Electric Vehicles Only

International Scenario

- Majority of Electric buses are getting manufactured and operated in China and Europe.
- China Operates and produces more than 98% Electric Buses across the world.

Characteristic and Strategic Differences

	Europe	China
Bus Types	Large & Articulated Buses	Large & Articulated Buses
Passenger Carrying capacity	Large due to smaller battery size	Lesser in comparison due to large battery size
Typical Battery Sizes	Relatively lower capacity batteries	Generally high capacity Batteries
Charging Power	Opportunity Charging/ fast charging more prevalent	Typically using slow Depot Charging
Bus Duty Cycles	Very large – Buses get charged on the go and return to depots after long duty cycles as high as 400kms	Buses return to depots for charging
Life of Bus	~15-18 years	~8 -10years
Major Determining Factors	High Driver Costs – More utilization of drivers High cost of buses – More utilization of buses & requirement of high passenger carrying capacity	Lower cost of drivers & buses High level of Policy & Govt promotion through subsidies

Observations from China

- Battery risk is borne by the supplier with an 8 year warranty
- Battery charging is sub-contracted, charged @ USD 10c, lower cost than diesel
- Key for induction of EVs is Charging Infrastructure.
- Multiple options for charging across country evaluated
- New depots constructed in first phase, Old depots upgraded in 2nd phase.
- Unladen weight of Bus-Light weight Body
- Cooling System for Batteries had to upgraded
- Floor mounted Batteries preferred than roof mounted Batteries
- DC Charger preferred due to faster than AC charger.
- Bus by-back in RFP for EVs (initially inducted but sub-optimal performance)
- Route Category-wise charging strategy was worked out.
- Charging Service Provider: Unit electricity consumed, 5 yrs, Land by Govt.
- Replacement of Battery set during mid of contract period planned in contract.

Components of Process

Planning

Buses Specifications	**Commuter Perspective : Better Build Quality, upgraded services leading to Specifications towards air-conditioning, low floor, more comfortable interiors (suspension, wifi etc.), even better EXTERIOR**
	Technical Perspective
Legacy Infrastructure of Depots and Workshops	**Practices – Current and Changes**
	Mixing of Buses
	Capacity
	Redevelopment potential
Routes	**Route planning-based selection of charging**
	Integration with legacy fleets
Manpower	**Existing manpower training**

Feasibility Assessment

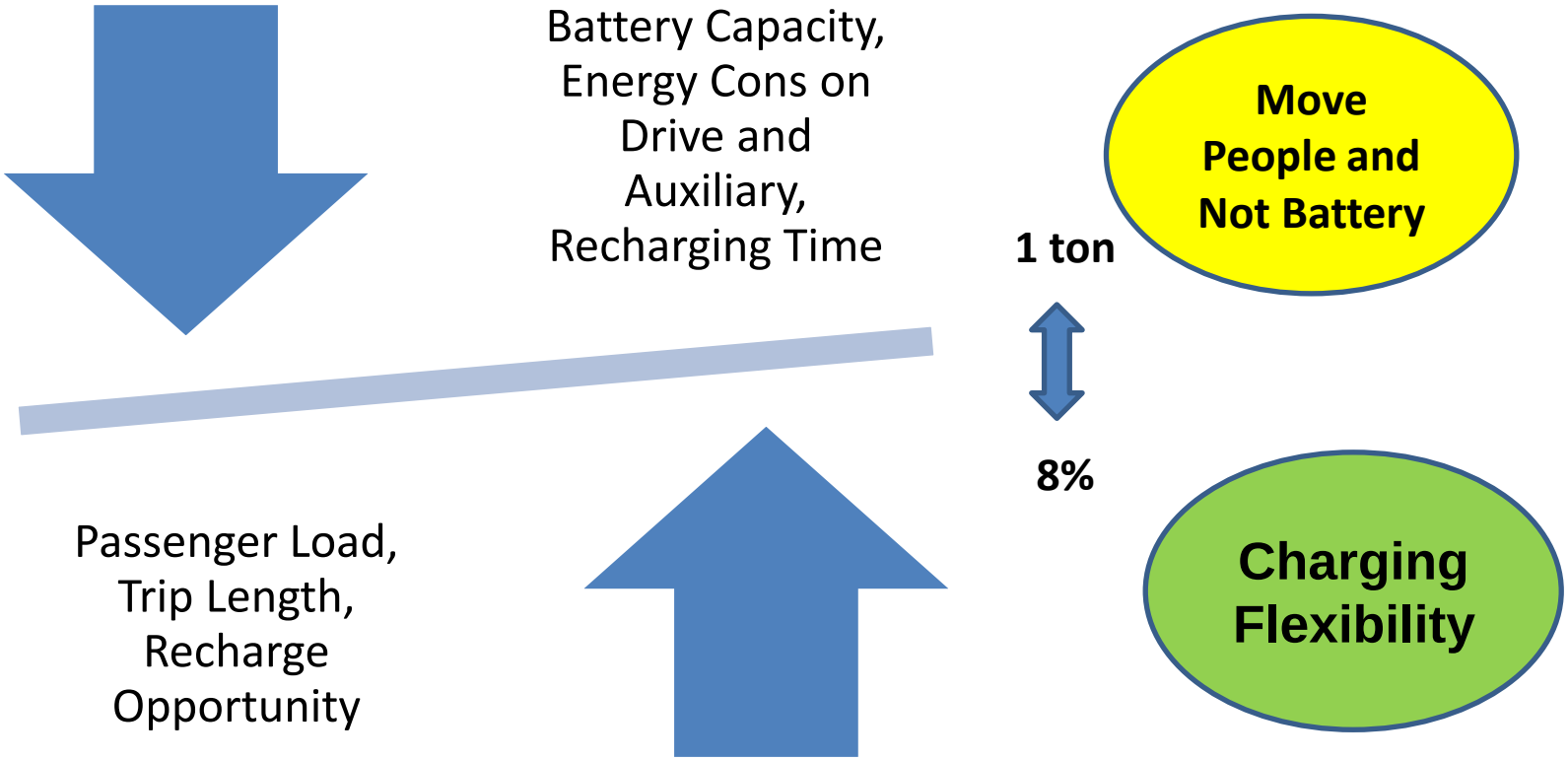
Autonomy/ Range of battery buses

- is the “maximum distance” vehicle can travel, in one charge, with “usable energy content” under “specified conditions”

- **Variables**
  - Usable energy content,
  - Specific energy consumption,
  - Ideal driving conditions
  - Heating and/ or air conditioning.

- **Requirement**
  - 80 passengers (68+7)kgs, & gross weight of 19tons, permanently available autonomy of more than 200 km.

Operational Needs vs E-bus technology



Cost of Bus

Options Available

- High energy (large battery size), long range with low power (slow charging)
- Low Energy (smaller battery), smaller range with high power (fast Charging)

Price of 12 Bus in International Markets

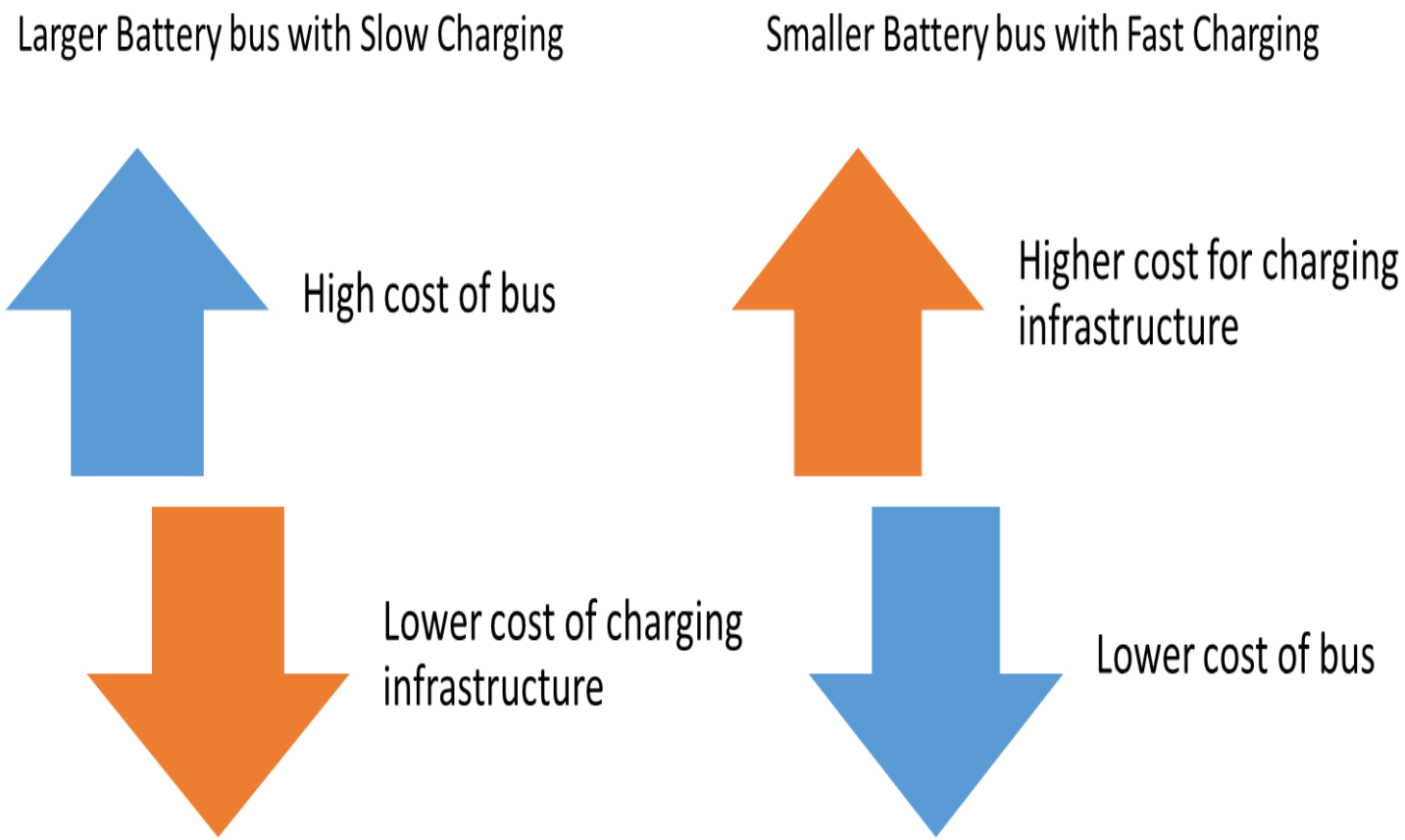
Origin	China	Europe
BEV (12 m)	1.5 to 2.1 cr. (a)	4.2 to 5.9 cr
Charging Devices (b)	0.42 - 0.5 Lakh Rs/ kw	0.42 - 0.5 Lakh Rs/ kw
Charging Stations	0.34 - 0.5 Lakh Rs/ kw	0.6 - 0.76 Lakh Rs/ kw
Note		
a) Not sold in Europe, Australia and North America		
b) Max. charging power, without transformers and installations		

Re-cap Price of 12 Bus in Under FAME 1 Scheme

City under FAME 1	Bus Specs	#	Bus Price	Remarks
Kolkata	12m, 150km range, 900mm, 125kwh bus	20	Rs 88 lakhs/bus	Not a low floor, AC bus with less battery capacity
Bangalore	12m low floor AC bus, 320kwh battery	40	Rs 240 lakhs/bus	Price is not market discovered since bidding parameter was Opex model
Hyderabad	12m low floor AC bus, 320kwh battery	40	Rs 240 lakhs/bus	Price is not market discovered since bidding parameter was Opex model

The benchmarked price for 12m low floor AC electric bus with 320kwH battery was fixed at Rs 1.75 cr (inc. all taxes & GST)

Charging Infrastructure Strategy



Charging Strategy

- **Overnight dedicated without Opportunity charging**
- **Overnight + Opportunity Charging**
- **Flash Charging etc.**
- **Swapping**

Slow Charging – charging @ 0.2C to 0.5C
Fast Charging – charging @ 1C to 3C
Ultra Fast Charging – charging at 4C to 5C
Battery Swap – within 03 minutes

Option 1 – Depot Charging Only

Pros

- More flexibility in routes and operations of buses
- Infrastructure can be concentrated at one or two location (Depots)

Cons

- Majority bus schedules > 200+ km/ day.

Charging Strategy

Option 2 – Depot + Opportunity Charging

Pros

- Existing bus schedules can be serviced
- Charging infrastructure gets created over the city
- Inter-operability in future

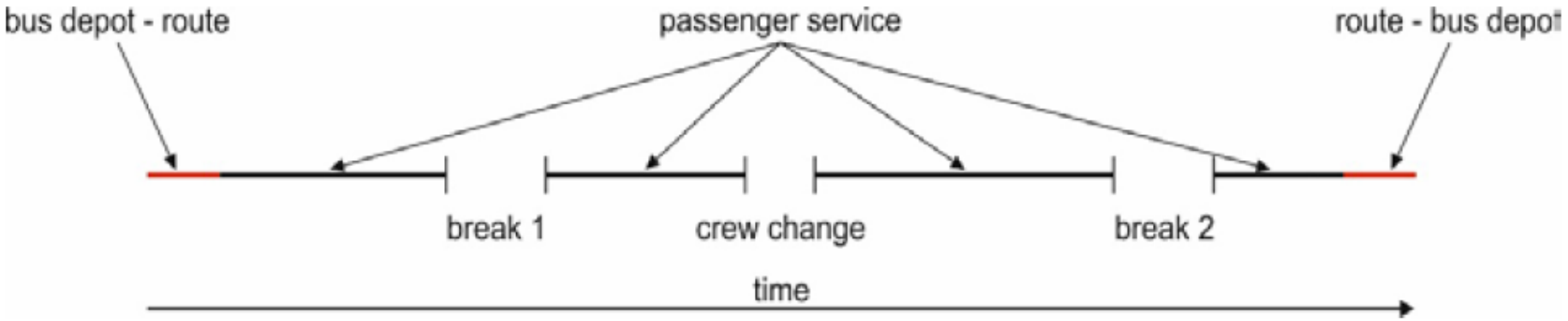
Cons

- Land availability at the Day Charging Centres
- **Scheduling flexibility needed**

A typical Service schedule for a bus in Delhi:

- 4-4.5 hrs of operation
- 30 minutes of break

3 breaks in a day provide an opportunity for quick charging



Charging Strategy

Option 3 – Reduced / Re-planned Routes and Operations Time

Pros

- Will not strain the specifications
- New technology, new ways to plan and undertake operations

Cons

- Mix and match of routes will be a Planning challenge
- Solution may appear sub-optimal, however, over a period of time , more stable solutions would be available.

Suggestion :

Do not make the operational requirements too onerous
Do not try to transfer ALL risks on operator !

– Designed to fail !!

– I told you So !!!

Ownership & Standard : Charging Infrastructure

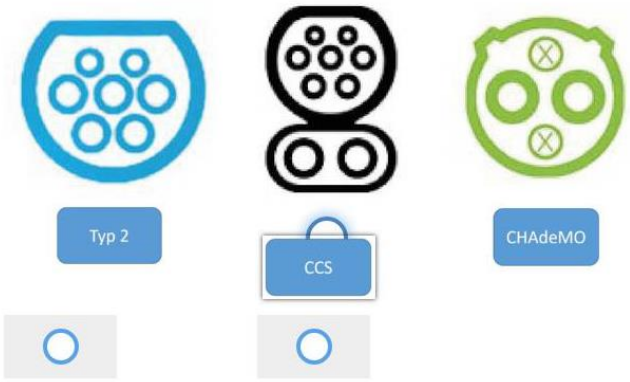
Aspects of Standardisation

- the physical design of the connecting components,
- the charging mode (e.g. slow or fast charging), and
- the communication between the vehicle and the charging infrastructure.

Standards become necessary to enable the recharging of electric buses of different manufacturers at the same charging station or charging device.

- The Japanese CHAdeMO,
- The European Combined Charging Standard (CCS),
- The Chinese GB/T.

- Indian Standard shall become applicable



Service Provider for Charging Infrastructure

	Ownership & O&M by 3rd Party (other than concessionaire)	Ownership and O&M by Concessionaire
Contracting	• Increased competition • Tri-party Contractual structure for design, installation, construction, operation • Separate bidding process	• Single party will have lesser of contractual issues. • Players will be limited to bus operators only.
Standards and Design	• Indian standards yet to be in place	• Responsibility of Concessionaire
Operational issues	• More difficult to assign responsibility for an Event	• Easier
Inter-operability and scalability	• Scalable, Inter-operability, Other EV users	• High consumption, not much spare capacity

Ownership of Charging Infrastructure

Installation	Utility Company	Contractor for Charging Infrastructure	Contractor for Bus Operations
High Voltage Grid	X		
Medium Voltage Grid	X		
Transformers at Bus Depots		X	
Transformers at Terminals		X	
Cabling between Transformers and charging station		X	
Charging station at Depot			X
Charging Station at Terminals		X	
Charging Management at Depot			X

Location and Shape of Depot

SN	Location	Remarks
1	Less Dead mileage	Best suited for development of bus depot
	BUT NOW	
	Power Infrastructure Cost needs to be evaluated	

SN	Shape of land parcel	Remarks
1	Square	Best suited for development of bus depot
2	Rectangle	Will be preferred if minimum frontage/ width is available
3	Irregular	Area wastage at site edges is more, so, will be least preferred
	BUT NOW	
	Long Linear Depot is also welcome **It provides ease of placement of Charging Infrastructure**	

Ownership and Funding of Power Infrastructure

Based on number of buses/chargers
Load Assessment at Main Depots : Parallel factor of XX%
Load Assessment at Day Charging Centres : Parallel factor of XX%

Options	Funding	Design & Development Responsibility	Ownership & Operations during Concession period	Transfer at end of Concession Period
Option 1	Govt	Concessionaire	Concessionaire	Transferred to Govt
Option 2	Concessionaire	Concessionaire	Concessionaire	Transferred to Govt

Option 1

- Cost realized over total life span of Power equipment i.e. 30 years
- Bidders are freed from the responsibility of cost estimation at bidding stage (Play on this cost will be reduced)
- Potential contractual issues during operations

Option 2

- Concessionaire cost amortized in 10 years
- Each Bidder has different power demand/ charging strategy
- Estimated cost may vary amongst bidders
- Requirement of Govt. supervision and monitoring
- Need of transfer of assets after Concession Period

Power Equipment (30 yrs) and Charging stations (15 yrs) typically have a life beyond concession period. So cost is amortized over 10 years.

Challenges in Financial Estimates

CASE 1 - Depot only Charging Case with X% extra fleet
CASE 2 - Depot + Opportunity Charging Case
CASE 3 – Depot only charging with no increase in fleet size

- Capital Charge
- Maintenance cost
- Manpower Charge
- Power consumption charge

Project Cost Components
Buses
Depot Chargers
Opportunity Chargers
Grid Connection & Substation at Main Depot
Grid Connection & Substation at Day Charging Centres

Operations Cost Components
Average KM per bus per day
Number of Drivers per bus
Number of Charging personnel per Charger at Depot (night) and Terminals (day)
Cost of Driver
Cost of Terminal Staff
Maintenance Cost of Buses (including battery)
Maintenance Cost of Chargers
Maintenance Cost of Electrical Substations
Cost of Electricity Consumption
Yearly increase in O&M cost of buses
Yearly increase in O&M cost of electrical systems
Yearly increase in Energy charges
Yearly increase in Manpower Charges
Energy consumption per bus per km

Challenges in Financial Assessment

Depot Charging vs Depot + Opportunity Charging
Increase in number of buses to maintain schedules
Increase in number of drivers to maintain schedules
Ratio of Main Depot chargers to number of buses (Charger rating, Parallel factor)
Ratio of Day Chargers to number of buses (Charger rating, Parallel factor)
Average KM run per bus per day
Average Total run per bus including dead kilometres
Number of charging personnel for Main Depot
Number of charging personnel for Day Chargers

Eligibility of Bidders

	Option 1	Option 2
Structure	Manufacturer or JV of Operator + Manufacturer	Operator (Lead) + Letter of Association (MOU) with Manufacturer
Pros	Manufacturer directly responsible by virtue of being party to the contract.	• One Manufacturer can supply to multiple operators • Increased competition and number of players
Cons	• Bus Manufacturers response could be more city / state time of year specific • Less aware of City's conditions • Concentrate on large deals	• Ability of Operators to obtain iron clad MoU

Procurement planning and time frame

Phasing

Purchase, Lease, Concession

Balanced risk, reward, responsibility distribution

Battery Replacement and Disposal, Subsidy, Infrastructure, Data Analytics for BBMS

Who should be the Bidder ?

Contract length

Project Phasing

Option 1 – All in one Go

Pros	Cons
• Substantial Impact	• Supply Capacity • Benchmark price • Infrastructure Readiness

Option 2 – Phases

Pros	Cons
• Benchmark price in phase 1. • Better price discovery in phase 2 • Learnings from previous phases can be assimilated • Time for infrastructure readiness	• Delivery dates for phase 2 may go beyond target dates.

Electric Bus Procurement Packaging

- Optimized Routes Lengths with reasonable opportunity for charging
- Infrastructure Preparedness (Charging and Power Infrastructure)
- Critical mass of Buses (~200 or more) – Maintenance, management, training, retooling costs can be onerous
- Routes in close proximity to Depots (to reduce idle runs)
- Aim for value added services
- Aim for variety in fleet (More flexible demand)
- Use of technology e.g. Conducter-less buses with entry before front wheel for midi buses
- Develop flexible contracts with adequate options for review

Operations and Maintenance

Additional Operational Requirements

Safety

- Equipment
- Battery Packs
- Fire – Bus and Charging Infra
- Floods, Earthquake
- Decommissioning of Battery Packs and Reuse

Manpower

Manpower Training

Supervisors and Drivers

- Night Parking and Charging (dedicated staff ?)
- Physical checking and minor on-site repairs
- Driving

Maintenance Crew

- Washing
- Battery Charging
- Inventory and Waste Management
- Minor and Scheduled Maintenance

Management

- Major Maintenance and Accidental repairs, altogether different management practices
- Tyre Wear vs Cost (16 ply, 11.5 (change in GVW))
- Body and paint shop
- Inventory
- Scrap disposal
- Capacity building

THANK YOU

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