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Faster Reworking for Sustainable Development with EV Bus and Charging Station Infrastructure in Smart Cities

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ABSTRACT:EV's with the initiation toward clean technology and a shift is foreseeable toward public transport would be most effective with a move to alternate technologies. Electric Vehicles are no doubt the future in mobility system. Electric Vehicles are an alternative source to Internal Combustion Engine vehicles. India's cities have been witnessing an increasing trend in automobiles with waning air quality and there have been calls to promote public transport through Smart City Mission. The innovations in battery technology and zero tailpipe emissions make EVs an economically viable and sustainable mobility solution that is finding global support from policy makers and Industry leaders alike. State Road Transport undertakings, needs a better understanding of the technology and policy landscape, along with a robust assessment of the benefits. Currently, India has deployed a few electric buses and which are in operational. This paper addresses and explores the different strategies that government pursue in Smart Cities to support the Electric Vehicles and Charging Station Infrastructure.

KEYWORDS:Smart Cities, Clean Technology, Electric Vehicles (EVs), Internal Combustion Engine (ICE), Charging Station Infrastructure.

I. NEED OF EV AND EVALUATION FRAMEWORK

As India continues its demand for automobiles is anticipated to new level. A shift to an electric bus fleet necessitates an understanding of the technology. The electric buses can play a positive role, as there shift from conventional diesel buses to electric buses in terms of reduction in pollution and fuel consumption. Electric buses have already been deployed on a large scale globally, and the technology is mature and evolving continuously.

As per a study report, India can save as much as \$60 billion in energy costs by 2030 and one giga tonne of carbon emissions by adopting more electric vehicles. Government of India launched its Faster Adoption and Manufacturing of (Hybrid) Electric Vehicles scheme in 2015.

It is estimated that by 2026, around 10-12% of the total demand for vehicles would be addressed by these electric vehicles. To encourage Electric Vehicles as a viable option for long distance trips, inter regional trips with adequate charging station, it is necessary to make provisions for establishing Public Charing Stations in the regional facilities for refuelling, recharging of vehicles.

II. BEST PRACTICES ON EV POLICIES

International case-study: Norway EV Policy

Norway has made several efforts at setting policy objectives in the field of GHG emissions. In 2009, Transnova was established to support testing and demonstration of new technologies that could reduce GHG emissions from the transport sector. The government presently supports EVs with the following measures.

- EL-number plates for privileges like using bus lanes and for awareness generally.
- Exemption from the initial vehicle registration tax.
- Exemption from VAT tax (usually 25 per cent) on the purchase of an EV.
- Lowest fee band for the annual licence.
- Fringe benefit taxes (on employee benefits) half the usual rate.

In addition, there is a range of local incentives, such as access to bus lanes, toll exemption and free parking

International Case-study Germany EV Policy

Germany adopted the National Electromobility Development Plan, on drive technologies and vehicle integration, battery technology, charging infrastructure and power grid integration and general framework. The emphasis is on testing and demonstrating electric mobility in everyday life, with a special focus on linking EVs and the electricity system by using information and communication technology in the transport system.

Currently the following incentives for EVs are:

- EVs are exempted from the motor vehicle tax for ten years.
- Exemption is accompanied by a fifty percent tax reduction on the purchase price for all EVs.
- The ordinance on the licensing of motor vehicles allows interchangeable licence plates for ICVs and EVs, among other vehicles. This instrument is supposed to facilitate the ownership of an EV as second vehicle.
- Electricity used in public transport is subject to an electricity tax reduction.

A new Electromobility Act, it authorizes municipalities to grant privileges to EVs for parking and bus lanes, and for those vehicles to be specially identified in their registration numbers. In addition, Charging Infrastructure is supposed to complement to grant national.

International Case-study for New Zealand EV Policy

The need for a better development in EVs and Charging Infrastructure, the policy measures for ICVs that put proper price or regulatory pressure on their adverse effects, so that the advantages of EVs in comparison with ICVs are not masked. Character of EV Policy and New Zealand would be cleaner, greener and better off financially. That's why the government has set up some targets and initiatives to encourage EVs.

- Aims to double the number of electric vehicles in every year to reach about 64,000 by 2021
- Offers new Road User Charges exemption for heavy electric vehicles until they make up two percent of the heavy vehicle fleet
- Co-ordinates the activities of Government agencies to support the development and roll-out of public charging infrastructure, information and guidance.
- A fund has been allocated for a nation-wide electric vehicle information and promotion campaign.
- In future allow electric vehicles in bus lanes.
- Will review tax depreciation rates and the method for calculating fringe benefit tax for electric vehicles to ensure electric vehicles are not being unfairly disadvantaged
- Will establish an electric vehicles leadership group across, local and central government

III. EV POLICIES IN INDIA & UNDERSTANDING

National Electric Mobility Mission Plan (NEMMP)

NEMMP 2020 is an initiative taken by the Department of Heavy Industries (DHI) that aims to accelerate the growth of the electric and hybrid components of the automotive sector. It focuses primarily on fast-tracking the manufacturing and introduction of EVs in India. The vision statement of the NEMMP states that the aim of the policy is to encourage reliable, affordable and efficient adoption of EV technology through government and industry collaboration. It proposes that about 6–7 million EVs can be sold in India by 2020. The Plan draws up a four-phase approach for building India's EV manufacturing capabilities. These include initially developing R&D capacities, strengthening domestic capabilities and initiating localization. The latter phases focus on creating high capabilities across the value chain, developing indigenized products, sourcing components locally, creating an EV component ecosystem, targeting the export market, and investments to enhance capabilities and production plan for exports.

Faster Adoption and Manufacturing of (Hybrid) Electric Vehicles (FAME 2)

The FAME scheme is intended to provide financial incentives to support the NEMMP, which promotes the development and uptake of EVs in India. The cities covered under FAME include those covered under the "Smart Cities" initiatives, all cities with populations greater than 1 million and cities of the North-Eastern states. The scheme will target all vehicle sizes and types (from hybrid to fully electric). The scheme envisages the setting up of adequate public charging infrastructure to install confidence among EV users, through active participation and involvement of various stakeholders including government and non-government agencies. Interlinking of renewable energy sources with charging infrastructure, smart grid, use of Information and Communication technology, etc., will be encouraged. Demand incentives will be based on a combination of vehicle size, fuel efficiency and battery type.

Smart City Mission (SCM)

The Smart Cities Mission statement and guidelines released by the Ministry of Urban Development (MoUD) identifies infrastructure elements, where “sustainable development” and “public transport” are also listed. Thus, adoption and deployment of EVs can become a significant strategy in potential Smart Cities. Adhering to a common reference framework becomes particularly significant in drawing this convergence, which has remained one of the major challenges in attaining India’s urban goals.

IV. STATE LEVEL POLICY INITIATIVES IN INDIA

Telangana EV Policy

The state government unveiled Electric Vehicle & Energy Storage Policy in 2020, offering a slew of incentives for manufacture, purchase and use of Electric Vehicles. The comprehensive policy is designed to woo domestic and global players in the EV and energy storage segments. The policy’s objective is to make preferred destination for Electric Vehicle, Energy Storage Systems (ESS) and component manufacturing and to proactively support the creation of EV charging infrastructure.

- Incentives for Buses with 100% exemption of road tax & registration fee for the first 500 Electric Buses purchased & registered in state.
- State Road Transport units shall also be encouraged to purchase EV buses
- State Electricity dept. shall provide special power tariff category for EV charging station.
- State Nodal agency shall evaluate to establish Public Charging Stations
- State shall develop night time community parking with charging facility in PPP mode for all category vehicles within Industrial zones.

The efforts will be made to promote last and first mile connectivity for public transport. Steps will also be taken for gradual shift of public transport buses from internal combustion engines to EVs and to encourage general use of electric mobility.

EV Policy of Delhi

The objective of the Delhi Electric Vehicle Policy, 2020 is to accelerate the pace of EV adoption across vehicle segments. They contribute to 25% of all new vehicle registrations by 2024 and bring about a material improvement in Delhi's environment by bringing down emissions from the transport sector.

- The subsidy on buses, as decided by Government of National Capital Territory of Delhi from time to time with a commitment that pure electric buses shall constitute at least 50% of all new buses including smaller buses for last mile connectivity to be added to the city bus fleet, starting with an induction of pure e-buses by 2020.
- Road tax and registration fees to be waived for all Battery Electric Vehicles during the period of this policy.
- All financial incentives will be applicable for both fixed battery models and swappable battery models. If battery is not sold with the vehicle, 50% of the purchase incentive will be vehicle owner and rest to Energy Operators for defraying the cost of any deposit that may be required from end users for the use of a swappable battery.
- Green number plates for EVs registered in Delhi.
- Public Charging Infrastructure
 - Providing accessible public charging/battery swapping facilities within 3 km travel.
 - Energy Operators will be invited to set up charging and battery swapping stations.

V. EV SEGMENT TECHNOLOGY

Internal Combustion Engine Vehicles (ICEs): ICE vehicles are traditional engines, powered by gasoline, diesel, biofuels or even natural gas. These make up the bulk of the vehicles on the road. While today’s ICEs are significantly more efficient and have lower emissions than those from decades ago.

- Diesel based vehicle
- CNG-based vehicle

Electric Vehicles (EVs)

- **Hybrid Electric Vehicles (HEVs):** The most common of the alternative fuel vehicles we see on the road these days. The batteries can be charged in a few ways, either by spinning an electric generator when the ICE is operating or in some cases, by converting the vehicle’s kinetic energy into electric energy through systems like regenerative brakes.



- **Battery Electric Vehicles (BEVs):** The BEV has no internal combustion engine or fuel tank at all and runs on a fully electric drivetrain powered by rechargeable batteries. These vehicles need to be plugged in to a power source to charge, and depending on the vehicle, they have varying charging times and driving ranges.

However, the prices of EVs are much higher than that of ICEVs. Since HEVs are powered by an ICE and a battery with an electric motor, they cost the most among the four vehicle segments. According to a study that compared modern CNG, diesel and diesel hybrid-electric buses show better performance, with 7%–44% higher fuel economy. However, the fuel economy for a hybrid bus is reported to be the same, or lower, than that of a diesel bus at high speeds.

Tab.1.Parameters of ICE & EV’s

Parameters	EV Bus	Hybrid Bus	CNG Bus	Diesel Bus
Power source	Electricity	Electricity + fuel	CNG	Diesel
Seats	31	32	18	32
Length	12 m	12 m	12 m	12.3 m
Costs (INR)	2.6 crores	1.5 crores	20–88 lakhs	20–88 lakhs
Fuel efficiency	1.5 kWh/km	2.75–4 km/L	2–3 km/kg	2.2–3.3 km/L
Fuel cost	INR 10/km	INR 13–17/km	INR 13–20/km	INR 15–23/km
Range (km)	249 km	280-520 km	260-390 km	500 km
Charging Time	3-6 hours		-	-
Battery Type	Li-ion Iron (300 kWh)	Li-ion batteries	-	-
Emission Standard	Zero tail pipe emission	EURO III	BS IV	BS III

VI. NORMS & GUIDELINES FOR EV INFRASTRUCTURE

URDPFI Guidelines

Based on available charging technologies and their evolution, type of vehicles, the types of chargers indicating number of charging points required for setting up adequate Public Charging Station, a regional facility and with the long-term vision of implementing electric mobility, Infrastructure Planning, Distribution Services, “Norms for Distribution Services” of URDPFI (Urban and Regional Development Plans Formulation and Implementation Guidelines)

Tab.2.Guidelines for EV Charging Station

SI No	Category & Type of Facility	Area Requirement	Other Controls
1	National and State Highways: Public Charging Station (PCS) minimum requirement as per MoP Guidelines	Minimum Area 13.5 m x 5.5 m	Charging Station and all equipment layouts with respect to nearest Dispensing Unit (DU), Fuel tank to be as per PESO rules.
2	Fluid Cooled Battery Charging Station 1 CCS, 1 CHAdeMO	Minimum Area 15 m x 7 m	Equipped with Combined Charging System and Liquid Cooled Cables, as required in addition to requirements of Public Charging Station
3	Public Charging Station, Every 25 km, both sides along the Highway roads Public Charging Station with charger ratio - 1 Fast Charger for every 10 EVs 1 Slow Charger for every 3 EVs	Additional area as per total parking capacity at the Restaurants.	
4	Fast Charging facility/FCB CS (for Long Distance & Heavy Duty EVs). Every 100 km, both sides along the highway, roads at least 2 chargers 1 CCC type 1 CHAdeMO type (min 100 KW each)	Min 15 m x 7 m	May be coupled with the PCS at item A above, with Climate Control Equipment and Liquid Cooled Cables
5	Battery Swapping Station Optional Provisions as per MoP Guidelines Provided along with FBC	Min 5.5 m x 2.75 m	

SI No	Category & Type of Facility	Area Requirement	Other Controls
	charging stations		

VII. CHARGING POINT & AREA REQUIREMENT

In order to successful deploy a EV fleet and the corresponding charging infrastructure, a transport undertaking must take into account various factors such as peak electricity demand of the local region, duty cycles, terrain structure, garaging locations, and availability of on-site and off-site public charging stations. These factors can influence the decisions on the number, location and type of charging units.

Tab.3.Charging Station Area requirement

No. of EV Buses	No. of EV Charging Points	No. of Idle Bays	Area of Charging Station (Acres)
25	12	13	1.5
50	24	26	3.0
100	48	52	4.5

VIII. IMPLEMENTATION PROCESS & METHODOLOGY

Implementation Process

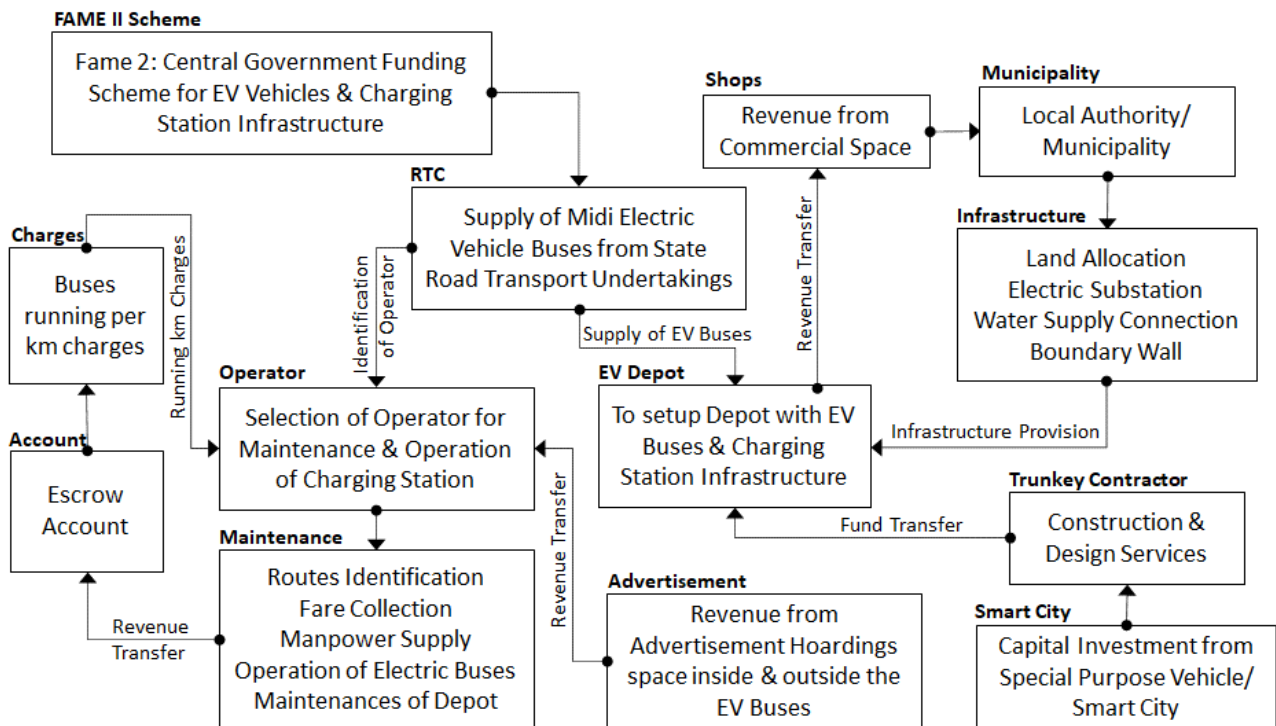


Fig.1.Implementation Process

Methodology

Stage 1: Central & State Government: Central Government under FAME 2 Schemes, selected City/State Road Transport undertakings has initiated the procurement process for deployment of electric buses on operational cost basis. The Staterepresentatives (RoadTransport Corporation Undertaking) have the process of selection of conventional EV Buses models and deployment of necessary Infrastructure.

Stage 2: Municipalities & Smart Cities: The local authority/Municipalities had given provision for land allocation, electric sub-stations, water supply connections, boundary wall and etc. In parallel to the stage, Smart City with the initiative towards the sustainable mobility system has fund the capital investment for infrastructure



development of Charging Station. Smart City will float the tender for construction of EV Depot and other civil works.

Stage 3: Operator: The State Road Transport Undertaking will provide the EV Buses and select the operator for running the buses within the city/town on identified routes.

Stage 4: Revenue Transfer: The fare collected by the operator is been transferred to Escrow Account and the Operator will be paid on the basis of running km charges by State Road Transport Undertaking.

Stage 5: Revenue Sharing System: The operator can avail the additional revenue from advertisement sources. Municipality can get the revenue from commercial space in the charging station.

IX. FINANCIAL MODEL 2030

The role of charging infrastructure evolves from being an awareness tool to becoming a commercially viable business venture. Discounted cash flow analysis method may determine the expected financial returns for EV charging infrastructure investments over the expected lifetime of the charging equipment based on inputs provided by the user. The model may plan to estimate the performance of a charging station deployment project:

Tab.4.Charging Station Particulars

Expected Equipment Lifespan [years]	15
Charging Station type	DC fast charging
Total EV Buses	25 no
Area Required	1.5 Acres
Total initial capital required [₹]	₹ 9,00,00,000
Total No of Charging Points	16 no
Max no of charging sessions per station [sessions/year/station]	9,000
Average charging energy per session [kWh/session]	180
Average time of Charging session (min)	120

Market inputs: Contains inputs related to the expected overall demand for EV charging services and expected growth in that demand. The user can select one of two options for entering expected charging station utilization. The first option attempts to derive utilization from traffic patterns along the route. The second option allows the user to enter utilization numbers directly.

Owner-operator inputs: Contains inputs for the owner-operator organization, including unique information on up to three kinds of charging equipment, revenue sources, additional costs, assumptions regarding how the investment will be funded, and assumptions used in the production of a set of financial statements for the owner-operator.

Private sector partner inputs: Inputs related to the revenue sources and costs for the private sector partner. The three sources of revenue: revenue from site leasing, revenue from sales due to increased traffic at the site, and indirect revenue (revenue unrelated to time spent by the customer at a charging site). These can be used in conjunction with each other or independently. The user can also customize the amount of revenue that be shared with the owner operator and whether the private sector partner will provide a subsidy

Public sector partner inputs: Inputs that define the involvement of the public sector including whether the public sector will provide low interest debt, equity, a one-time grant, or ongoing financial support.

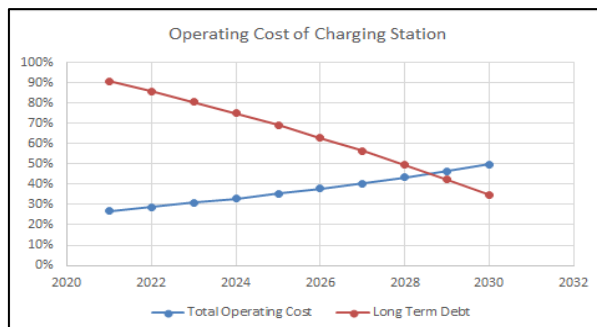


Fig.2. Operating Cost of Charging Station and Long-term Debt



The Model may contain a dashboard of outputs that displays key performance metrics for each of the partners. Financial metrics include:

- Total capital investment: The total outlay of funds by all participating organizations.
- Net present value (NPV): Shows the net profit or loss an investment by summing incoming and outgoing cash flows over the expected lifetime of the charging equipment and adjusting for the time value of money.
- Internal rate of return (IRR): Measures the profitability of an investment. Expressed in an annual rate.
- Discounted payback: A simple payback (or breakeven measure) based on cash flows adjusted for the time value of money. The dashboard also displays non-financial metrics like number of charging sites, number of new stations, projected number of charging sessions provided over the 15-year analysis timeframe and charging energy provided.

X. RECOMMENDATIONS

The challenges in the implementation of EV technology are mainly related to the supply chain, charging infrastructure, safety and cost. The cost of the charging infrastructure and civil works was approximately Rs 9.0 Cr (Approx.) for charging stations. Electric vehicles (EVs) are part of the solution towards cleaner transport and cities. The future of mobility focuses on getting shifted out of their personal vehicles and on to public transport. Smart cities have been at the front of this switch to electric transport. It is the time for the transport and smart cities to pursue innovation and lead the way. Best practice further encourages increased adoption and value at scale.

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