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Techno-Thermal Analysis and Performance Optimization of Electric Bus Battery Systems under Extreme Ambient Conditions

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Abstract: *Business-as-usual approaches based on proprietary vendor technologies, lock in inefficiencies and make integrating and upgrading systems harder. Traditional bus operations depend on various systems, such as those for Vehicle Location and Tracking (VLT), Automatic Fare Collection (AFC), and fleet management. E-buses require new services for energy management, battery health, charging schedules, and power purchase contracts. If standards for exchanging information are not clear, if each vendor must develop its own proprietary solutions, with no opportunity to share, and integrate these, costs for technology and upgrades will be far higher than necessary. Transformative outcomes seen in India's DPI efforts come from careful planning. In identity, banking, payments, e-commerce, and healthcare, these outcomes were not simply the result of isolated technological solutions but stemmed from a systemic approach that focused on creating foundational digital building blocks that were available to the ecosystem. In this case, ecosystem refers to a complex network of actors and their services that interact with and rely upon others to function effectively. The small interventions that created these building blocks allowed different actors in the ecosystem, both public and private, to innovate and create scalable solutions, proving that doing less can, in fact, achieve more. By rethinking the bus sector through the DPI model, we can envision a core framework that integrates technology architecture, governance, and market driven innovation.*

Keywords: *market driven innovation*

I. INTRODUCTION

Buses are the backbone of public transportation in India, serving around 39.9 Crores (399 million) passengers daily and accounting for over 90 percent of all public transport trips1 (see Figure 1). As the primary mode of public transportation nationwide, they provide millions of Indians with affordable and accessible mobility. However, the sector is highly fragmented, with numerous small operators and a lack of coordination, leading to inefficiencies that hinder its ability to scale and meet growing demand. Their central role underscores the need to strengthen and modernize the bus sector to enhance India's public transport system. The Government of India is increasingly recognizing the role of enhanced bus systems in reducing emissions and improving passenger experiences. Central to India's sustainable transportation strategy is the rapid adoption of electric buses (e-buses). India is aspiring to electrify a significant portion of its 23 lakh (2.3 million) bus fleet, with up to 800,000 buses estimated to be electrified by 2030 (Mukherjee and Mishra 2023). This aligns with the country's broader goal of achieving a 30 percent EV market share, a transition involving public, private and institutional fleet operators (Press Information Bureau, GoI 2024a). The government is supporting this transition through various policies and partnerships (Press Information Bureau, GoI 023; Press Information Bureau, GoI 2024b).

The transition is not just about adopting new technology but also about rethinking contracting and operating models to run these buses cost-effectively. It shifts from the traditional approach where the government procures and operates buses, towards greater involvement of the private sector through public-private partnerships (PPPs). By leveraging the private sector's strengths in financing and operational efficiency, this approach seeks to reduce the burden on government resources and enables many small and medium-sized cities to initiate and expand bus services, thus accelerating the transition to sustainable transportation.

While the transition to electric buses offers significant environmental benefits, the legacy structure of India's bus system presents several challenges that hinder progress. Ninety-three percent of buses are privately owned (for rural, intercity, and fleet operations—school, employee, tourist transport, and other use cases) and over 90 percent of operators manage fewer than five buses. So, the sector is highly fragmented, leading to inefficiencies and a lack of scale (Mulukutla and Rajagopal 2024). This fragmentation creates a low-growth environment where operators have little leeway or incentive to expand. Their small size constrains the types of investments and technology upgrades they can afford. For small operators, transitioning to e-buses is particularly challenging because, in addition to the already high cost of the buses, they must also invest in expensive charging infrastructure. The lack of a widespread public charging network forces them to set up their own charging stations, which can add 10-15 percent to the cost of each e-bus, making adoption economically unsustainable (CSTEP 2021).

Scope of the paper

This paper outlines WRI India and FIDE's current thinking on how a proposed open e-bus blueprint could create an ecosystem for software applications that accelerate the adoption of e-buses and related infrastructure services. The blueprint is designed to be versatile, not only supporting e-buses but also extending seamlessly to non-electric buses, thereby broadening its scope and applicability across the entire bus sector. The Introduction describes the current fragmented vendor-led, non-interoperable approach to bus operations and service delivery which cannot handle the complexities and scale required for the transition. The second section, "Pressing reasons for action", highlights legacy and emergent issues in the current bus ecosystem. It explains the need for a digital technology blueprint for developing applications for e-bus and related services based on DPI principles.

REFERENCES

[1]. Aadhaar. 2024. "Aadhaar Dashboard." Accessed September 27. https://uidai.gov.in/aadhaar_dashboard/india.php.

[2]. Abisla, Richard. 2019. "Open Transit Data in India". In *The Promise of Public Interest Technology: In India and the United States. Washington,* DC: New America. http://www.jstor.org/stable/resrep19980.8. ASRTU (Association of State Road Transport Undertakings). 2024.

[3]. "ASRTU at a Glance". https://www.asrtu.org/page/about. Bachu, Prashanth, Sayan Roy, and Anumita Roychowdhury. 2024.

[4]. *What Ails Intelligent Transport Systems? Roadmap for Modernizing Bus Services*. Centre for Science and Environment.

[5]. Banerjee, Amber. 2022. "India's Outstation Bus Market to Grow Up to USD 48 Billion by 2025: Here's How." *The Times of India*, June 14.

[6]. https://timesofindia.indiatimes.com/auto/indias-outstation-busmarket-to-grow-up-to-usd-48-billion-by-2025-heres-how/articleshow/92200042.cms.

[7]. Business Standard. 2023. "FAME III: India to Replace 800k Diesel

[8]. Buses with Electric over 7 Years." https://www.business-standard.

[9]. com/industry/auto/fame-iii-india-to-replace-800k-diesel-buses-withelectric-over-7-years-123122900244_1.html.

[10]. CDPI (Centre for Digital Public Infrastructure). 2023. "DPI Tech Architecture Principles".Bengaluru. https://docs.cdpi.dev/the-dpi-wiki/dpitech-architecture-principles.

[11]. CDPI. 2024a. "DPI Overview." https://docs.cdpi.dev/the-dpi-wikipedia/ dpi-overview.

[12]. CDPI. 2024b. "Payments." https://docs.cdpi.dev/technical-notes/digital-payment-networks.

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[13]. CSTEP (Charging Technology Options for E-buses in Bengaluru). 2021. CSTEP-RR-2021-08.

[14]. DBT (Direct Benefit Transfer) Bharat. 2024. “DBT Bharat.” Accessed September 27. https://dbtbharat.gov.in/.

[15]. De, Anish, Richard Threlfall, Sameer Bhatnagar, Rajaji Meshram,

[16]. Umang Jain, Nisha Fernandes, Shveta Pednekar, and Rasesh Gajjar. 2017. “Reimagining Public Transport in India.” KPMG. https://assets.kpmg.com/content/dam/kpmg/in/pdf/2017/10/Reimagining-public-transport.pdf.

[17]. DoFS, Ministry of Finance. 2024. “Account Aggregator Framework Department of Financial Services | Ministry of Finance | Government of India.” https://financialservices.gov.in/beta/en/account-aggregator-framework.

[18]. D’Silva, Derryl, Zuzana Filkova, Frank Packer, and Siddharth Tiwari. 2019. “The Design of Digital Financial Infrastructure: Lessons from India,” December. https://www.bis.org/publ/bppdf/bispap106.htm.

[19]. Fathima, J Shifa. 2015. “Implementation of Core Banking Systems (CBS) in the Banks in India—With Special Reference to Urban Co-Operative Banks (UCB).” *Shanlax International Journal of Commerce* 3. https://www.shanlaxjournals.in/pdf/COM/V3N1/COM_V3_N1_007.pdf.

[20]. Gadepalli, Ravi, Aishwarya Kachhal, Tanay Dandekar, and Madhumitha V. 2024. *Market Assessment for Intercity Electric Buses in India*. Bengaluru: Transit Intelligence.

[21]. Georgia Institute of Technology. 2011. “How the Internet Architecture Got Its Hourglass Shape and What That Means for the Future.” https://phys.org/news/2011-08-internet-architecture-hourglass- future.html.

[22]. 11.Gupta, Sangeeta, Achyuta Ghosh, Kalyan Mangalapalli, Nirmala Balakrishnan, Vandhna Babu, Satya Easwaran, Brajesh Singh, Pankaj Mann, Shubhang Kandoi, and Apar Sharma. 2024. *India’s Digital Public Infrastructure—Accelerating India’s Digital Inclusion*. NASSCOM, Arthur D. Little. https://community.nasscom.in/sites/default/files/

[23]. publicreport/Digital%20Public%20Infrastructure%2022-2-2024_compressed.pdf.

[24]. Hariharan, N.P., and K.J Reeshma. 2015. “Challenges of Core Banking Systems.” *Mediterranean Journal of Social Sciences* 6 (September). doi:10.5901/mjss.2015.v6n5p24

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