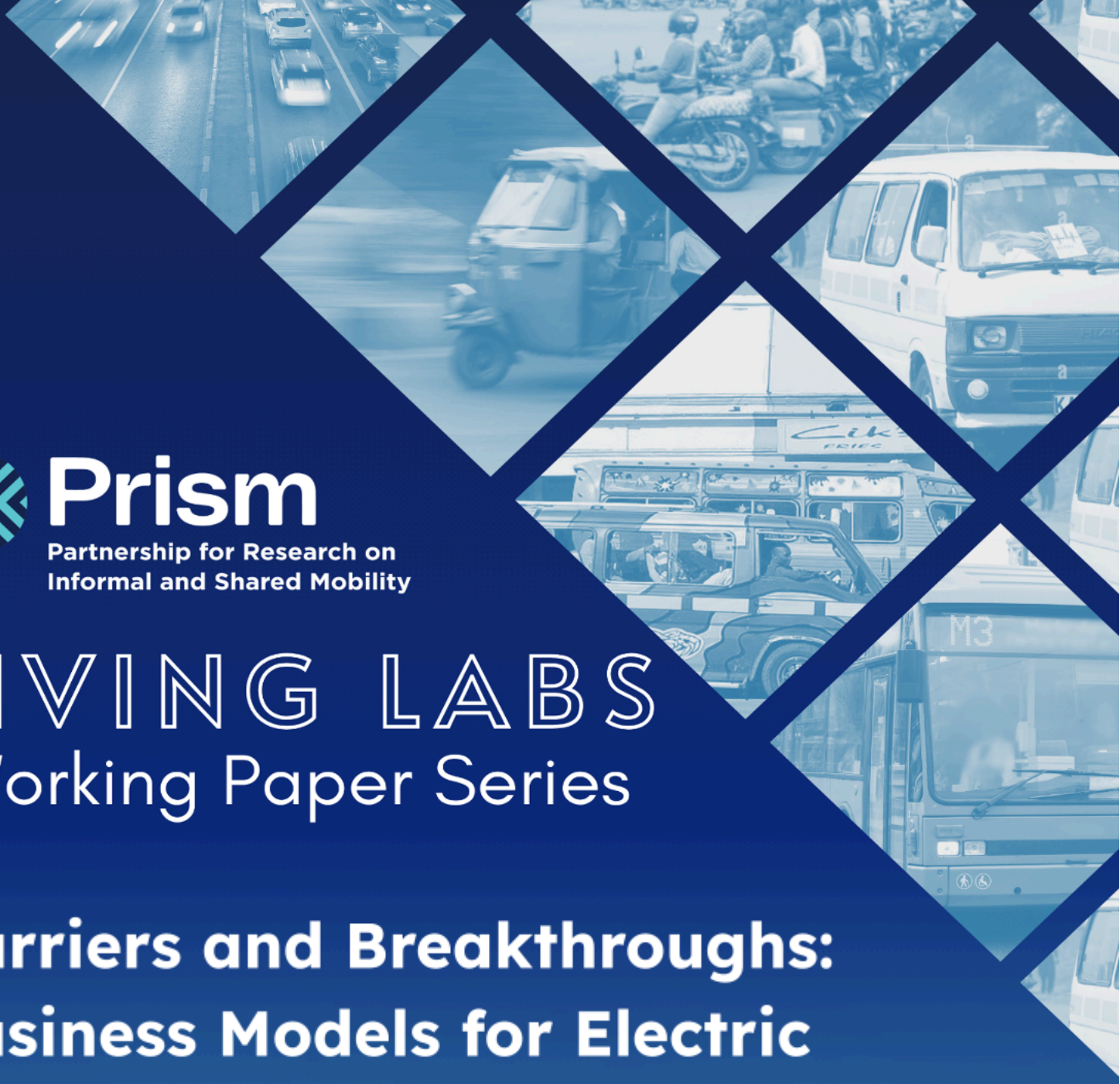

Prism
Partnership for Research on Informal and Shared Mobility

LIVING LABS
Working Paper Series

Barriers and Breakthroughs: Business Models for Electric Motorcycle Taxis in Bangkok

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The Partnership for Research on Informal and Shared Mobility (PRISM) is a global consortium that focuses on better understanding informal transport and shared mobility (ISM) with a focus on Asia, Africa, and Latin America. Centered on the "3 Es"- equity, ecosystems and engagement-PRISM relies on the methodology of urban living labs, located in eight cities (Accra, Bangkok, Beijing, Bogotá, Cape Town, Kumasi, Mumbai, and San José) to co-create knowledge and solutions for the inter-related challenges around ISM like access, affordability, safety, emissions reduction, inclusion, integration, labor conditions and public health.

This first PRISM Working Papers series pursues two main objectives. First, it aims to provide a platform for living labs to share the research stemming from their specific contexts and highlighting specific research gaps. Second, it intends to stimulate discussion among the living labs and other researchers across a wide range of academic disciplines to foster future comparative research.

The papers in this series vary in their level of technicality and specialization. Therefore, this series aims as much to wide and interdisciplinary audiences as to technical and specialist ones. The papers have been reviewed by at least one member of another living lab before publication. The content of these working papers can be cited as follows: Last name author(s), First name author(s) (Year). *Title of paper*. Partnership for Research on Informal and Shared Mobility (PRISM), New York (USA).

As an example: Anuchitchanchai, O., Wantanasombut, A., Ratanawaraha, A., & Chalermpong, S. (2025). Barriers and Breakthroughs: Business Models for Electric Motorcycle Taxis in Bangkok. Partnership for Research on Informal and Shared Mobility (PRISM), New York (USA).

Abstract

The transition to electric mobility offers a promising pathway for sustainable urban transport, yet adoption in informal sectors remains poorly understood. This paper examines business models for promoting electric motorcycle uptake among Bangkok's motorcycle taxi drivers: full ownership, partial battery leasing, full battery leasing, and rental. Adopting a case study approach, we draw on stakeholder interviews and pilot project documentation to identify systemic barriers and enabling factors.

Three system-level constraints limit scalability: network effects in which inadequate and brand-specific battery swapping infrastructure discourages adoption and investment; sociotechnical misalignments between new business approaches and entrenched regulations and driver routines; and justice-related exclusions disadvantage informal, low-income operators through financial risks and policy neglect. This study finds that high upfront costs, income volatility, resale uncertainty, and restrictive registration rules intersect with infrastructure fragmentation to stall adoption despite pilots demonstrating feasibility.

Policy recommendations include reforming vehicle registration to allow cooperative or fleet-based ownership, expanding and standardizing battery-swapping networks, introducing flexible financing and resale guarantees tailored to informal workers, and co-designing programs with drivers to align with occupational culture and needs. By reframing adoption challenges through network, institutional, and justice lenses, the paper offers insights for scaling low-carbon mobility transitions in informal transport sectors across the Global South.

Keywords: Motorcycle taxis, Electric motorcycles, EV adoption, Business models, Informal transport, Global South.

1. Introduction

Electric motorcycles (EMs) offer a promising solution for dense, fast-growing cities in developing countries, with the potential to reduce emissions, operational costs, and urban noise in line with sustainable urban development goals (Koossalapeerom et al., 2019; La Fleur et al., 2024; Montoya-Torres et al., 2023; Rizki et al., 2024; Truong et al., 2024) . Yet adoption remains relatively low, particularly where motorcycles are central to daily mobility, such as in many parts of Asia and Africa (Bijen et al., 2022; Chinda, 2022; Mukherjee & Ryan, 2020; Plötz et al., 2014).

This challenge is especially pronounced in low- and middle-income countries, where limited private car ownership places motorcycles and informal transport at the heart of urban mobility. In many cities, motorcycle taxis—known locally as ojek in Indonesia, xe-om in Vietnam, boda-boda in East Africa, and win motosai in Thailand—dominate local transport, yet electrification support in these sectors remains limited. Notable exceptions include Vietnam's progress through local manufacturers like VinFast and supportive tax policies (Anh et al., 2022); Indonesia's target of 2.1 million e-motorcycles by 2025 under Presidential Regulation 55/2019 (Mahalana & Yang, 2021); and pilot initiatives in Rwanda and Kenya supported by public-private partnerships and international donors (UNDP, 2021; UNEP, 2021).

Affordability and infrastructure access remain key constraints. Studies from Turkey, Korea, Macau, and India consistently identify income as a major determinant of electric vehicle (EV) (Erdem et al., 2010; Mahalana et al., 2021; Yoo & Kwak, 2009), with similar barriers reported for lower-income groups across low- and middle-income countries (L. Zhang & Shi, 2025).

Despite this importance, informal transport electrification—especially in the motorcycle taxi sector—remains an understudied frontier in EV research. The literature is dominated by studies of private consumers or formal fleets, often explained through classical market failure frameworks that emphasize high upfront costs, information gaps, and negative externalities. These perspectives, while valuable, overlook the structural realities of informal transport: fragmented infrastructure, regulations designed for internal combustion ownership, and exclusion of low-income operators from finance and policy processes.

This paper addresses that gap by providing a comparative analysis of four business approaches for electric motorcycle adoption in Bangkok's motorcycle taxi sector: (1) Full Ownership, (2) Partial Battery Leasing, (3) Full Battery Leasing, and (4) Rental. Unlike most prior studies, which focus on consumer choice or technical performance, we assess how each approach interacts with systemic barriers related to network

effects, sociotechnical misalignments, and justice-related exclusions. Drawing on stakeholder interviews and project documentation from recent pilot initiatives, analyzed qualitatively, the study examines why promising approaches have struggled to scale and what structural reforms are needed for a just and sustainable transition.

Bangkok's motorcycle taxi system illustrates both the opportunities and complexities of electrifying informal transport. Serving millions of trips daily, win motosai provides flexible and affordable connections in the city's superblock layout (Chalermpong et al., 2023; Phun et al., 2019). Yet despite the "Thailand 4.0" vision, the EV Promotion Plan, multiple pilot projects, and government incentives (Wattana et al., 2024), electric motorcycle adoption among motorcycle taxi drivers remains negligible (Anuchitchanchai & Chalermpong, 2024). While common explanations often cite high upfront costs, limited financing, technical limitations, and regulatory misalignment (Bijen et al., 2022; Ghasri et al., 2019), repeated pilot failures point to deeper structural barriers, including infrastructure fragmentation, institutional rigidity, and the exclusion of informal actors.

Guided by a theoretical lens combining urban informality and just transitions, this study focuses on three interlinked dimensions: network effects that reinforce system lock-in through infrastructure interdependencies and lack of interoperability (Katz & Shapiro, 1994); sociotechnical misalignments between new business models and existing institutional frameworks (Roy, 2005); and justice-related barriers that exclude informal workers lacking protections or bargaining power (Harada, 2023). These dimensions underscore the need for low-carbon transport strategies that address inequality and systemic constraints—not just financial or technical challenges.

This paper contributes to the emerging literature on electric mobility in informal transport systems in three key ways. First, it provides a comparative analysis of real-world business models implemented in Bangkok's motorcycle taxi sector, moving beyond hypothetical or consumer-based studies. Second, it identifies system-level barriers—including network effects, sociotechnical misalignments, and justice-related exclusions—that constrain the scalability of these models. Third, it proposes a set of 'breakthrough conditions' that highlight the structural and policy changes required to enable a just and sustainable transition to electric mobility in informal contexts.

This paper is organized as follows. Section 2 provides the literature review, while Section 3 describes the background and operational context of motorcycle taxis in Bangkok. The methodology is presented in Section 4, followed by Section 5, which

presents the findings through an in-depth analysis of four existing business models for electric motorcycle adoption among motorcycle taxi drivers in Bangkok. Section 6 discusses the implications of these findings, followed by the conclusion in Section 7.

2. Literature Review

2.1 Economic Market-Based Perspectives on EV Adoption

Classical economic theory has often been used to explain the limited adoption of EVs, particularly in developing and informal contexts (Coffman et al., 2017; Rapson & Muehlegger, 2023). These explanations focus on market failures such as information asymmetries, negative externalities, and high upfront costs (Jamaludin et al., 2021; Verma et al., 2020). For instance, limited consumer awareness of EV performance and benefits constitutes an information asymmetry (Coffman et al., 2017; Krause et al., 2013), while emissions and noise from internal combustion engines are widely recognized as negative externalities that are often not fully priced in transport markets (Santos, 2017). High capital costs, uncertain resale values, and limited access to credit are frequently cited as major barriers to EV adoption, particularly among low income populations and informal transport operators (Bijen et al., 2022; Coffman et al., 2017; Ghasri et al., 2019; Jain et al., 2022; Wahab & Jiang, 2019).

Rooted in neoclassical economic assumptions, these frameworks typically portray individuals as rational actors who respond predictably to prices, incentives, and risk signals. As a result, policies informed by this thinking often focus on correcting market distortions—through purchase subsidies, tax incentives, and information campaigns (Mikropoulos et al., 2025; Sykes & Axsen, 2017; L. Zhang & Shi, 2025; X. Zhang et al., 2017). However, while such measures have yielded results in formal market segments, the informal sector, particularly motorcycle taxis, has received far less policy and research attention, and evidence of their impact remains limited (Vanatta et al., 2022).

This limitation is especially evident in low- and middle-income settings where informal transport plays a dominant role. Studies from Southeast Asia, Latin America, and parts of Africa—suggest that informal transport workers face structural constraints that go beyond what market corrections can address (Cervero & Golub, 2007). These include unstable income, exclusion from formal finance, and lack of regulatory clarity. Prior research further notes that informal actors are often overlooked in formal governance systems, which restricts their access to infrastructure and institutional support (Roy, 2005).

Accordingly, while market-based explanations provide useful insights into specific economic barriers, they are insufficient for understanding the persistent, system-wide challenges surrounding electric motorcycle adoption in informal contexts. Consequently, understanding barriers to EV adoption in informal transport requires broader analytical frameworks that account for infrastructure interdependencies, institutional misalignment, and socio-political exclusion—concerns increasingly addressed in transition studies and urban informality literature.

2.2 Conceptual framework

While traditional market failure explanations—such as high upfront costs, information asymmetries, and externalities—help explain why adoption of electric motorcycles has been slow, they fail to capture the complex interplay of infrastructure, institutions, and inequality, particularly within urban informality and decarbonization efforts in the Global South. In informal transport systems like Bangkok's motorcycle taxi sector, barriers are not simply financial or behavioral but deeply embedded in structural and systemic dynamics. To understand the persistent challenges, this study draws on three interrelated bodies of literature on network effects, sociotechnical transitions, and just transition. These perspectives provide a deeper analytical lens than classical economic theories of market failure.

The theory of network effects emphasizes how technological adoption is constrained by infrastructure interdependencies and systemic lock-in. As Katz and Shapiro (1994) explain, the value of a new technology often depends on the existence of complementary systems—such as interoperable battery-swapping networks, standardized charging stations, and maintenance support. In their absence, users face adoption inertia, even when the technology itself is viable.

Sociotechnical transition frameworks, particularly the Multi-Level Perspective (MLP), highlight how innovations struggle to diffuse when they clash with entrenched regulatory regimes and cultural practices (Geels, 2002; Schot & Geels, 2008). Roy (2005) introduces the "state of exception" to describe how informal actors are often left out of formal governance systems, resulting in regulatory voids where new technologies lack institutional support. These misalignments produce structural frictions that stall experimentation and hinder systemic change.

Just transition literature adds a normative dimension, drawing attention to how decarbonization efforts can marginalize precarious groups when equity is not prioritized. Informal transport workers—such as motorcycle taxi drivers—often lack access to finance, insurance, and political voice, making them particularly vulnerable

to exclusion from transition processes. Harada (2023) and others argue for inclusive mobility planning that centers the needs and agency of such groups. Without targeted support mechanisms—such as flexible financing, ownership options, and resale protections—transition strategies may inadvertently reinforce existing inequalities.

Building on these perspectives, this study examines not only the financial and institutional constraints to EM adoption, but also the structural dynamics influencing business model viability. These include infrastructure interdependencies, regulatory path dependencies, and the degree to which existing business models align—or fail to align—with the lived economic realities and operational practices of informal transport operators. By analyzing how these structural factors affect the feasibility and uptake of four electric motorcycle business models, the study sheds light on why certain models struggle to scale despite initial policy and technical support.

3. Background and Operational Context of Motorcycle Taxis in Bangkok

Motorcycle taxis are an integral part of Bangkok's informal transport system. Their origins trace back to the early 1980s, when a group of Thai Navy personnel began operating an informal motorcycle taxi service (Puapongsakorn, 1994). Initially self-regulated, these services were later reviewed by the National Police Agency and deemed lawful under the Motor Vehicle Act in 1982, paving the way for widespread growth (Oshima et al., 2007; Phun et al., 2019; Puapongsakorn, 1994). Since then, motorcycle taxi stands, known as wins, have proliferated across the city, particularly around transit stations, commercial hubs, and educational institutions. Each win operates within a designated zone to avoid territorial conflicts (Ratanawaraha & Chalermpong, 2015). Their typical service range spans 0.3 to 2 kilometers—ideal for navigating deep, narrow soils that are difficult to access by foot or larger vehicles (Sereerat & Sirijintana, 2020). A key informal rule maintains that drivers must pick up passengers only from their own win; after drop-offs, they are expected to return to their base empty and await the next fare (Anuchitchanchai & Chalermpong, 2024; Chalermpong et al., 2023).

The operation of motorcycle taxis is regulated by the Department of Land Transport (DLT). Under current regulations, all vehicles used for public transport must obtain a yellow commercial license plate. However, motorcycles without batteries—such as those used in certain electric vehicle leasing models, where drivers rent or subscribe to battery services separately—are not eligible for registration. Additionally, public motorcycles must be registered in the driver's name, and each vehicle must be owned by only one individual. This ownership requirement effectively excludes fleet-based

or company-owned rental models from legally operating as public motorcycle taxis, regardless of their potential affordability or operational efficiency.

4. Study Context and Methodology

4.1 Overview of Electric Vehicles in Thailand

Electric vehicles (EVs) are reshaping the global transportation landscape, driven by technological innovation and the urgent need for environmental sustainability. This momentum spans cars, buses, and two- and three-wheelers, with global EV registrations increasing by 41% in 2020 and projected to grow by 35.6% annually through 2026 (Sathiyan et al., 2022). By 2023, EVs accounted for 18% of global car sales, with China, the EU, and the U.S. comprising over 95% of the market (International Energy Agency, 2024).

Governments are reinforcing this shift through comprehensive industrial and policy strategies. The EU's "Fit for 55" package aims to ban new ICE vehicles by 2035 (Mikropoulos et al., 2025), while the U.S. Inflation Reduction Act provides generous incentives for EV purchases and domestic supply chain development (L. Zhang & Shi, 2025). China's New Energy Vehicle (NEV) program integrates subsidies, tax incentives, and government procurement to reduce emissions and promote industrial growth (X. Zhang et al., 2017). Broader Zero-Emission Vehicle (ZEV) targets have also been set, such as 100% ZEV sales by 2025 in Norway and by 2030 in countries like Denmark, the Netherlands, Sweden, and Singapore. France and Canada target full ZEV adoption by 2040 (International Energy Agency, 2021). These goals align with international collaborations like the EV30@30 Campaign, in which 13 countries—including Thailand— commit to a 30% EV market share by 2030 (Clean Energy Ministerial, 2017).

Thailand has made remarkable progress in promoting the adoption of electric vehicles as part of its sustainability goals. The number of EVs has increased by more than double over the past five years. (Department of Land Transport, 2023), driven by initiatives like "Thailand 4.0" and the National EV Policy Committee, which have positioned the country as a regional EV hub (Paudel et al., 2023). These efforts are supported by key policies offering financial incentives (e.g., subsidies, tax exemptions) and non-financial measures such as streamlined registration processes (Wattana et al., 2024).

To further this momentum, the Electric Vehicle Promotion Plan under the National Energy Plan aims for EVs to comprise 30% of vehicle production by 2030 (Clean Energy Ministerial, 2017). Policies include reduced excise taxes, import duty

exemptions on battery cells, and support for infrastructure development. The Energy Regulatory Commission has also introduced guidelines to encourage private investments in battery-swapping networks. However, targeted support remains limited for sectors like motorcycle taxis, (Anuchitchanchai & Chalermpong, 2024), where policy gaps hinder adoption.

Building on these national initiatives, recent efforts to promote electric motorcycles in the motorcycle taxi sector have gained traction in Thailand's broader EV transition agenda. Several pilot programs have been launched in Bangkok with support from both public and private actors, experimenting with different business models such as vehicle rental, battery leasing, and partial subsidies (Electricity Generating Authority of Thailand, 2023; National Energy Technology Center, 2023; PR Bangkok, 2024). However, uptake remains limited. As of 2023, electric motorcycles accounted for 0.52% of the total accumulated registered motorcycles in Bangkok, and only 0.07% of registered motorcycle taxis were electric motorcycles (Department of Land Transport, 2023), reflecting a slower adoption rate compared to neighboring countries like Vietnam and China (Rajper & Albrecht, 2020). Several barriers hinder market penetration, including technical inefficiency, high upfront costs, limited charging and battery-swapping infrastructure, and a lack of accessible financing options for end-users (Coffman et al., 2017; Ghasri et al., 2019; Jain et al., 2022; Wahab & Jiang, 2019). Pilot programs and public reports have consistently highlighted challenges related to infrastructure gaps and affordability. While various initiatives have tested different business models, these structural limitations have continued to constrain large-scale adoption.

Thailand's EV growth has focused primarily on passenger cars and buses, while electric motorcycles (EMs) remain a smaller segment (Koossalapeerom et al., 2019). Nonetheless, pilot programs and collaborations between manufacturers, service providers, and policymakers have laid the groundwork for future growth. Localized production and emerging business models, such as battery-swapping and leasing systems, are beginning to address these gaps.

EMs offer clear advantages in urban areas. They reduce greenhouse gas emissions and air pollution (Koossalapeerom et al., 2019), which is critical in cities like Bangkok that face persistent air quality challenges. They also generate much less noise, helping create quieter, more livable urban environments (Chhikara et al., 2021; Sundar et al., 2020). They are also cost-effective, with lower fuel and maintenance expenses—particularly beneficial for motorcycle taxi drivers. Simpler drivetrains enhance reliability, while battery swapping provides a fast and convenient alternative to charging, minimizing downtime for high usage riders.

Despite global growth in electric cars, the adoption of electric motorcycles remains limited. Challenges such as affordability, limited infrastructure, and low user awareness remain significant barriers (Coffman et al., 2017; Higueras-Castillo et al., 2021). Addressing these issues will be essential to unlocking the full potential of electric motorcycles in Thailand and ensuring their contribution to the country's sustainability goals. While these challenges are frequently cited in global and national policy discourse, this paper argues that they are insufficient to explain persistently low adoption in informal contexts. In the case of Bangkok's motorcycle taxi sector, such challenges are compounded by structural and institutional constraints that go beyond affordability or infrastructure alone.

4.2 Methodology

This study adopts a qualitative case study approach to examine barriers to adopting electric motorcycles in Bangkok's motorcycle taxi sector, focusing on business models tried in past and ongoing pilot projects. Bangkok was selected because of its extensive motorcycle taxi network, its inclusion in multiple electric mobility pilots, and its relevance as a representative informal transport system in a low and middle-income country context. The analysis concentrates on identifying structural, operational, and behavioral factors that have limited adoption.

Data collection and analysis were guided by the three thematic dimensions introduced in the conceptual framework — network effects, sociotechnical misalignments, and justice-related exclusions — which informed the development of interview questions and the coding of findings.

The research began with a desk review of relevant literature, policy documents, and project reports to understand the structure of Thailand's EV ecosystem, particularly in the two-wheeler segment. Primary data were collected through 16 semi-structured interviews conducted between August and October 2024 with key stakeholders involved in deploying electric motorcycles. Participants were selected using purposive and snowball sampling techniques and included 23 motorcycle taxi drivers, 5 manufacturers of electric motorcycles, 3 battery-swapping providers, 2 government regulators, and 4 representatives from industry associations, NGOs, and pilot project coordinators. The interviews explored technical, financial, operational, and policy-related dimensions of adoption within the informal transport context, including perceptions of performance, infrastructure reliability, regulatory constraints, and business approach viability.

All interviews were analyzed thematically, and findings were triangulated with secondary data from project reports, policy documents, and relevant literature to enhance the validity of the conclusions. Ethical approval for the study was granted by the Research Ethics Review Committee at Chulalongkorn University.

5. Current business models for EM

In recent years, several pilot projects in Bangkok have tried different business approaches for introducing electric motorcycles into the motorcycle taxi sector. This section examines four prominent approaches—Full Ownership, Partial Battery Leasing, Full Battery Leasing, and Rental—and the structural, operational, and behavioral challenges associated with each, based on stakeholder interviews and project documentation.

5.1 Full ownership model

The full ownership model refers to the standard practice in which motorcycle taxi drivers purchase an electric motorcycle, either through a one-time payment or via installment plans. This model offers drivers full ownership and control, aligning with existing norms in Bangkok's motorcycle taxi sector. In Thailand, this corresponds to retail products offered by brands such as Strom, Deco, and NIU. These vehicles are marketed through conventional dealerships and distributors, with some models also gaining popularity among app-based delivery riders. This model reflects the standard retail pathway for individual consumers and it is the most familiar and straightforward approach, mirroring acquisition patterns for ICE motorcycles.

Despite its familiarity, this model poses significant barriers. The high upfront cost is one of the most pressing challenges. Based on stakeholder interviews, a standard electric motorcycle with two batteries ranges from THB 80,000 to 170,000 (USD 2,370–5,040), depending on driving range and durability. These attributes are particularly valued by drivers who often cover long daily distances. For reference, a survey by Anuchitchanchai & Chalermpong (2024) found that the average motorcycle taxi driver travels 77 km per day, with 5% exceeding 200 km (Wantanasombut, 2024). This makes electric motorcycles significantly more expensive than many commonly used gasoline motorcycles.

Formal financing mechanisms remain largely inaccessible to most drivers. Due to their informal employment status and lack of collateral or credit history, many are unable to secure loans, or face prohibitively high interest rates. As a result, this model primarily benefits drivers with greater financial security, exacerbating inequality within the sector.

Another critical concern is resale anxiety. Unlike ICE motorcycles with established second-hand markets, resale values of electric motorcycles in Thailand are unpredictable and tend to depreciate faster. Publicly available data from manufacturer websites and second-hand platforms indicate that ICE motorcycles like the Honda Wave 110i retain about 70% of their value after two years. In contrast, comparable EMs often lose over 50% of their original value within the same period, driven by battery degradation, limited parts availability, and unclear valuation standards. By the third year, resale value may drop below 40% of the purchase price.

Maintenance and service issues further deter adoption. Unlike ICE vehicles, which can be repaired at almost any neighborhood shop, electric motorcycles require specialized knowledge and access to specific parts—often only available through authorized dealers. Many drivers, particularly older ones, hesitate to switch without training or trusted repair networks.

Lastly, while electric motorcycles are marketed as having lower operating costs, drivers remain skeptical. Concerns about battery reliability, charging logistics, and overall durability persist, especially in the absence of firsthand experience. Similar skepticism has emerged in other Asian contexts, including China, Korea, and Indonesia, where early adopters cited inadequate infrastructure and battery limitations as key barriers (Agustina et al., 2025; Chu et al., 2019).

In sum, although the conventional model provides autonomy and aligns with driver preferences, its high financial burden, limited financing access, resale uncertainty, and insufficient service networks render it inaccessible to much of Bangkok's motorcycle taxi workforce. Without systemic reforms—such as financing support, resale guarantees, and robust after-sales service—this model is unlikely to drive widespread adoption of electric motorcycles in Thailand.

5.2 Partial battery leasing model

The partial battery leasing model aims to reduce the upfront cost of electric motorcycle ownership by providing vehicles with only one battery included. Drivers then access additional energy via leasing-based battery swapping at designated stations. In this hybrid model, common in Bangkok pilot programs, drivers charge the provided battery at home and rely on a second battery—accessed through a network of swapping stations—for extended use. This model has been implemented in projects such as the Electricity Generating Authority of Thailand (EGAT)'s pilot project in Bangkok and the Bangkok Metropolitan Administration-led GreenWin initiative.

The EGAT's pilot project was implemented in Bang Kruay District, Nonthaburi. It was officially launched on 27 December 2021 as part of EGAT's 52nd anniversary Corporate Social Responsibility campaign. Fifty-one electric motorcycles were distributed to drivers, often with only one battery or none at all. The aim was to test the feasibility of a swapping-based model under real-world conditions. The project was planned to have three swapping stations around the Bangkok Kruay area. The project also developed a mobile application called "ENGY Rider" to allow drivers to monitor battery status and availability at the stations. However, infrastructure rollout delays meant drivers had to rely initially on home charging, with EGAT reimbursing electricity costs. This inadvertently entrenched a preference for self-managed charging.

Once the swapping station became operational, drivers were required to transition to the leasing model. Many expressed frustration with this change, citing wide variability in battery performance and the inconvenience of traveling to a swapping point. Some began physically marking their original battery to avoid using unfamiliar or lower-performing ones. According to several interviewees, a fully charged swapped battery could provide anywhere from 45 to 90 kilometers per charge, but drivers preferred to maintain known battery routines they could trust. Over the following two years, further challenges arose, including inconsistent battery performance, delayed maintenance, and limited station availability. These experiences reinforced drivers' preference for home charging and created negative perceptions of the swapping model, undermining EGAT's original aim of demonstrating a scalable business approach.

The GreenWin initiative launched in 2024 is another pilot project representing a more ambitious effort to embed the partial leasing model directly into Bangkok's motorcycle taxi sector. Led by the Bangkok Metropolitan Administration (BMA) in collaboration with private sector partners, the pilot was conducted in Sukhumvit 81, where 20 electric motorcycles were distributed to participating drivers. These vehicles, with ranges of up to 200 kilometers per charge and top speeds of 95 km/h, were intended for trial use and data collection. Beyond the pilot, the program set a long-term target of converting all registered motorcycle taxis in Bangkok to electric within five years, a shift projected to reduce carbon emissions by over 160,000 tons annually, equivalent to planting more than 15 million trees per year. Unlike earlier pilot projects by EGAT, GreenWin incorporated lessons from earlier pilots—such as improved station availability and training. However, the results from the interview indicated that concerns persisted. Key concerns included battery compatibility across brands, wait times at stations, and limited station coverage in certain districts.

These experiences reflect a clear sociotechnical misalignment: while the technology supports modular battery use, drivers' operational habits and trust in consistent performance have not aligned with the system's logic. Battery performance inconsistency, coupled with a sense of reduced control, created reluctance to adopt the swapping model fully.

The model also suffers from network failure. Effective swapping depends on a tightly coordinated system of hardware, software, and logistics—battery standardization, station density, real-time availability tracking—all of which remain incomplete or unreliable in many pilot zones. Without full interoperability or sufficient coverage, drivers perceive the system as fragmented and unpredictable.

In sum, although the partial battery leasing model offers a viable financial entry point for adoption of electric motorcycles, its success requires more than reduced cost. It demands attention to driver behavior, battery performance consistency, and a robust, user-friendly infrastructure network. Without these, the model risks entrenching user distrust and reinforcing existing barriers to electric mobility adoption.

5.3 Full battery leasing model

The full battery leasing model emerged through the SOLUTIONSplus project, titled "Electric Mobility Two-Wheelers Toward Sustainable Society," implemented in 2023 in an area close to Bangkok's Central Business District and Chulalongkorn University where the authors work. In this model, drivers receive an electric motorcycle either for free or without batteries and are required to subscribe to a battery swapping service for daily use. Unlike the partial battery leasing model, this approach provides no option for home charging—drivers must rely entirely on swapping infrastructure.

The pilot, conducted in collaboration with academic institutions and private sector partners, targeted dense urban areas with high traffic volumes and aimed to test the viability of a cost-effective, low emission solution. Drivers were exempt from vehicle purchase costs but paid a fixed daily fee—up to 150 THB—for battery access. While this eliminated initial capital investment, it introduced a rigid cost structure misaligned with drivers' volatile income patterns.

Interview findings revealed that some drivers earned only THB 100–120 (USD 3-4) per day, especially during off-peak periods or rainy weather. Because the leasing fee applied regardless of daily use, many drivers were burdened by costs even on non-working days. This lack of sensitivity to income volatility reflects how pricing

models ignore the economic instability of informal labor and inadvertently penalize the very group the model aimed to support.

In addition to cost-related concerns, drivers reported unease about vehicle and battery performance. The motorcycles used in the pilot had limited acceleration and range compared to their gasoline-powered counterparts, and many participants questioned their suitability for long hours of operation in congested urban conditions. Some drivers also noted issues with battery availability at stations, including inconsistent charge levels and occasional station downtime.

These problems point to a broader sociotechnical misalignment. Drivers accustomed to managing their own fueling routines struggled with the dependency imposed by a leasing system, particularly when it lacked sufficient infrastructure or performance guarantees. The lack of battery ownership eroded a sense of control, leading to perceptions that the vehicles were not fully theirs.

Infrastructure limitations further compounded adoption barriers. Although the project intended to place swapping stations in accessible locations, coverage was uneven and insufficient for seamless operation. These issues exemplify a network failure, where the supporting ecosystem—charging infrastructure, logistics coordination, battery standardization—remained incomplete.

Institutional constraints added another layer of complexity. At the time of the pilot, Thailand's regulatory environment had not fully adapted to support battery-leasing-based motorcycle taxis at scale, particularly in terms of licensing, vehicle registration, and commercial use permissions.

In summary, while the full battery leasing model offers an innovative pathway to reduce upfront costs, its success depends on tailoring leasing plans to income volatility, building robust and user-centered infrastructure, and addressing policy gaps. Without these supports, the model risks becoming financially unsustainable and institutionally unscalable for the very drivers it seeks to empower.

5.4 Rental model

The rental model, as piloted by initiatives such as Winnonie initiative (a program supported by Bangchak Corporation), provides an alternative route to electric motorcycle adoption by eliminating the need for drivers to make large upfront investments. Instead of purchasing a vehicle, drivers pay a fixed daily rental fee—approximately THB 150—which includes bundled access to an electric motorcycle, unlimited battery swapping, basic maintenance, and insurance (Bangchak, 2023). The model is designed to minimize financial risk and remove

common barriers related to ownership, repair costs, and financing eligibility, making it attractive for low-income or credit-ineligible drivers.

Winnonie was initially launched in 2020 with the goal of supporting motorcycle taxi drivers in Bangkok's informal transport sector. However, the initiative encountered a critical regulatory barrier: under Thai law, public motorcycle taxis must be registered in the name of the individual driver to receive a yellow license plate for commercial operation. Since rental vehicles are legally registered to companies, they are ineligible for such plates, effectively disqualifying them from legal operation in the motorcycle taxi sector.

This regime-level lock-in, where outdated regulatory structures restrict the entry of new ownership and business models, forced the project to pivot. Instead of serving taxi drivers, Winnonie shifted its focus to app-based delivery riders, who are not subject to the same registration constraints. Partnerships with delivery platforms like foodpanda allowed the rental model to scale within a more flexible regulatory environment (Green Network Thailand, 2023).

Despite the pivot, demand for rental options remains high among motorcycle taxi drivers, particularly those unable to afford an electric motorcycle through full ownership or leasing-based plans. However, focus group interviews highlighted ongoing tensions around the rental format. Drivers expressed concern over maintenance liability, especially in the event of accidents or component wear. While maintenance was officially included in the rental agreement, some drivers feared potential disputes over responsibility for vehicle condition.

In addition, drivers noted a psychological and cultural dimension to the issue: renting was sometimes perceived as a lack of independence or professional dignity. In the context of Bangkok's motorcycle taxi culture where ownership often reflects self-reliance, this perception may reduce the appeal of vehicle rental, even among financially constrained drivers. Interviewees also emphasized that while they prioritized safety, many lacked the technical knowledge or training needed to operate and maintain electric motorcycles confidently, especially given differences from ICE models.

From an operational standpoint, the success of the rental model is also tied to the robustness of battery-swapping infrastructure. Interviews revealed that station coverage remains limited in most parts of Bangkok. Long travel distances to reach a swapping point or arriving to find undercharged or unavailable batteries were common complaints, especially in time-sensitive delivery work. These issues underscore an ongoing network failure, where critical system elements—such as

infrastructure density, battery logistics, and service availability—are not yet sufficient to support seamless use of electric motorcycles.

In summary, the rental model offers a promising financial alternative by lowering entry barriers and bundling essential services. Yet, its broader application to motorcycle taxis is currently obstructed by regulatory misalignment, infrastructural insufficiencies, and cultural reservations surrounding ownership. For the rental model to scale inclusively, reforms are needed across three fronts: vehicle registration rules must be adapted to accommodate rental-based public transport; infrastructure investment must ensure widespread access to reliable battery-swapping; and training programs must equip drivers with the skills to navigate EM use confidently. Without these shifts, the model's transformative potential will remain limited to adjacent sectors like delivery services, rather than fulfilling its promise for urban public transport decarbonization.

While each model presents its own unique structure and operational focus, it is helpful to compare them side-by-side to understand shared challenges and differentiated opportunities.

Table 1 provides a summary comparison of all four business models presented in Sections 5.1 to 5.4.

Table 1. Summary Comparison of Electric Motorcycle Business Models

Business Model	Summary	Cost Structure	Infrastructure Dependency	User Fit	Key Opportunities	Systemic Barriers
Full ownership model	Full purchase of vehicle and battery	Full vehicle and battery purchase; user cost risk = high	Low to Moderate	Drivers with stable income; preference for asset ownership	Perceived long-term control and ownership; familiar model for drivers; may appeal to those seeking asset possession despite high initial cost.	High upfront cost; limited financing; uncertain resale; low support; skepticism over savings
Partial battery leasing model	Purchase vehicle only and subscribe to battery separately	Vehicle purchase; battery accessed via swap; user cost risk = moderate	Moderate to High	Medium- to high-usage drivers valuing partial ownership	Reduced upfront cost; some flexibility (home charging or swapping)	Delays in infrastructure; low trust in swapping; inconsistent battery standards; behavioral resistance
Full battery leasing model	Free or low-cost empty vehicle, battery accessed only via leasing	Vehicle and battery bundled in leasing; user cost risk = low	High	High-mileage drivers seeking predictable daily costs	No upfront vehicle/battery cost, suited for urban zones; predictable daily costs	Rigid leasing fees; reliance on battery swap networks; lack of battery ownership leads to lower trust
Rental model	Daily/monthly rental with bundled services	Pay per day/week; bundled with battery services; user cost risk = low	High	Delivery riders; less suitable for formal taxi registration	No upfront cost; inclusive service package (vehicle, battery, maintenance); low financial risk for cash-constrained drivers	Legal barriers for motorcycle taxi registration; regulatory mismatch; not scalable to public motorcycles yet; viable mostly for delivery drivers

6. Discussion

Despite growing interest in electric motorcycles as a low-carbon alternative for urban mobility in the Global South, this study reveals that existing business models—whether based on ownership, leasing, or rental—face systemic constraints that go well beyond simple cost barriers or consumer hesitancy. Each model, while offering partial solutions, runs up against distinct layers of institutional, infrastructural, and social friction. These frictions stem from deeper structural conditions—fragmented infrastructure systems, rigid regulatory regimes, and exclusionary financing and support structures—that collectively shape the trajectory of electric motorcycle adoption in Bangkok's informal motorcycle taxi sector.

A cross-case comparison shows three major trade-offs that cut across the four approaches:

1. **Energy Access vs. Infrastructure Dependency** – Full Battery Leasing and Rental externalize energy access to swapping networks, making service quality (station density, uptime, interoperability) directly determinant of daily earnings. Partial Battery Leasing mitigates some risk through an owned battery, while Full Ownership is least dependent on swapping, relying instead on home or ad-hoc charging.

2. **Cost Risk vs. Income Volatility** – Fixed daily fees (Full Battery Leasing, Rental) transfer utilization risk to drivers in a market with unpredictable demand. Full Ownership concentrates risk upfront in a single large investment, and Partial Battery Leasing sits in between, combining moderate capital outlay with ongoing variable costs.

3. **Regulatory Fit vs. Scalability** – Current rules accommodate Full Ownership most easily, are ambiguous for Partial Battery Leasing, and actively block Rental. Full Battery Leasing faces grey areas where vehicle–battery separation is not recognized in ICE-era definitions of a "complete" vehicle.

These trade-offs help explain why pilots that remove upfront costs did not automatically scale: in doing so, they increased exposure to infrastructure and regulatory risks that drivers cannot control. To understand why these models have not achieved meaningful scale, we must move beyond individual-level explanations and instead examine three interlocking system-level barriers that underpin the recurring patterns of limited adoption.

1. Infrastructure interdependence and the limits of network effects

Business models like the full battery leasing and vehicle rental have attempted to bypass high capital costs by decoupling energy access from ownership. Yet their success is critically dependent on the availability, reliability, and interoperability of battery-swapping infrastructure. When such infrastructure remains limited in coverage, brand-specific, or unreliable—as seen in pilots like SOLUTIONSplus and Winnonie—the result is a classic negative network effect: user uptake declines due to poor service availability, further reducing the incentive for providers to invest, thereby reinforcing the status quo.

This infrastructural underdevelopment is not a mere operational glitch—it reflects a deeper coordination failure among public agencies, utilities, and private sector actors. Without unified investment strategies, national standards for batteries, or interoperability mandates, the electric motorcycle ecosystem remains fragmented. Proprietary battery formats also create vendor lock-in, raising coordination costs and discouraging cross-platform compatibility. In such conditions, business model innovation is effectively constrained by infrastructure inertia.

2. Sociotechnical misalignments: when innovation clashes with rules and routines

Across all non-ownership models, a second pattern emerges: misalignment between business model design and the regulatory and behavioral structures that shape everyday transport work. The most glaring example is the legal exclusion of rental vehicles from commercial registration—a single clause in Thailand's Motor Vehicle Act that renders promising fleet-based solutions legally inoperable for motorcycle taxis. This rigidity exemplifies what transitions scholars call regime resistance: existing institutions are optimized for the old system and systematically undercut new models that do not fit. But misalignment is not just institutional—it's cultural and practical. Battery leasing systems, for example, assume a degree of operational flexibility and behavioral adaptation that drivers have not been supported to make. Interviews consistently show that drivers value autonomy, reliability, and known routines, particularly in a precarious labor context where a single malfunction or delay can result in lost income. The expectation that drivers will readily accept unfamiliar batteries, unfamiliar pricing, or unfamiliar vehicle dynamics—without guarantees or training—is a misreading of how risk is experienced on the ground.

These mismatches are reinforced by regulatory path dependence. Rules built around individually owned ICE motorcycles do not easily accommodate battery–vehicle separation or non-owner operation. Amending them requires inter-agency

coordination and may provoke resistance from incumbents who benefit from the status quo.

In this context, technological novelty without behavioral and regulatory fit becomes a liability rather than a catalyst. Innovation introduced without co-design or adaptation to driver realities breeds mistrust and low uptake.

3. Justice exclusions: when low-carbon transitions burden the vulnerable

While infrastructure and institutional gaps are widely acknowledged, the equity implications of current electric-motorcycle transition strategies remain under-theorized. This study shows that even well intentioned business models can reproduce exclusion if they ignore the lived constraints of informal labor. Financial exclusion is perhaps the most obvious: drivers operating outside the formal economy cannot access credit, installment plans, or risk mitigation instruments like resale guarantees. Models that require large upfront payments (Full Ownership), or fixed daily fees (Full Battery Leasing), penalize the volatility of informal incomes.

Equally important is the symbolic and psychological value of ownership. For many drivers, the motorcycle is not only a tool of work but a marker of autonomy and dignity. Business models that decouple drivers from ownership—especially when offered without commensurate benefits in reliability, flexibility, or support—risk undermining their professional identity and occupational control.

These are not just behavioral obstacles; they are structural features of inequality. If unaddressed, electrification policies may create a dual transition: one for formalized, well-capitalized actors (like app based delivery services), and another stagnant or stalled for informal transport workers.

Together, these three systemic barriers form reinforcing loops that limit the scale of adoption. Fragmented and proprietary technologies reduce the utility of battery-swapping networks, discouraging driver uptake and further investment, which in turn perpetuates network underdevelopment. Legacy ICE era regulations exclude some approaches entirely and constrain others, reinforcing regime lock-in. Fixed fee structures in the context of volatile incomes shift financial risk to drivers, prompting rational avoidance of otherwise promising offers. Incumbent interests and misaligned incentives slow the move toward interoperability and coordinated investment. These dynamics explain why pilots frequently succeed in demonstrating technical feasibility but stall at achieving institutional feasibility, and why business approach innovation alone will not deliver scale without parallel reforms in infrastructure governance, regulation, and financing.

7. Conclusions

This study examined four business approaches for introducing electric motorcycles into Bangkok's motorcycle taxi sector—Full Ownership, Partial Battery Leasing, Full Battery Leasing, and Rental. While electric motorcycles hold clear promise for reducing urban emissions and long-term operating costs, our findings show that their limited scale is driven not only by consumer hesitancy or technology immaturity, but by deeper systemic barriers. Instead, adoption is held back by reinforcing cycles of infrastructural fragmentation, regulatory lock-in, inequitable risk transfer, and resistance from incumbents. These dynamics—proprietary technologies that limit network utility, ICE-era regulations that exclude or constrain viable formats, fixed cost structures that penalize volatile incomes, and vested interests that delay interoperability—help explain why many pilots demonstrate technical feasibility but fail to achieve sustained, scalable transitions. Overcoming these loops will require coordinated reforms in infrastructure governance, regulation, and financing, alongside innovation in business approaches.

Based on these findings, five priorities emerge for enabling a just and scalable transition:

1. **Mandate interoperability and coverage for swapping infrastructure –** Establish national battery interface standards (physical and communication protocols) and minimum station density requirements in high-demand areas to counter negative network effects.

2. **Reform vehicle registration rules –** Create a legal track for cooperative or company ownership of public motorcycles and recognize vehicle–battery separation in inspection and licensing processes.

3. **Introduce risk-sharing tariffs –** Replace fixed daily fees with pay-per-use or income-contingent caps, and offer off-day waivers for drivers facing demand fluctuations.

4. **Secure asset value and after-sales support –** Implement buy-back or resale guarantee schemes for Full Ownership and incentivize independent service networks to reduce maintenance bottlenecks.

5. **Institutionalize driver co-design –** Involve drivers directly in pilot design and governance, enabling early identification of performance issues and ensuring business approaches fit occupational realities.

This study has certain limitations. It draws on qualitative case studies and stakeholder interviews conducted in a single urban setting and does not include longitudinal financial or behavioral impact data. Future research should investigate long-term livelihood effects of EM adoption and assess the comparative performance of business models across different regulatory and urban settings.

By reframing adoption barriers through the lenses of network effects, sociotechnical alignment, and justice, this study extends the literature on EV adoption into the underexamined realm of informal transport systems in the Global South. It shows that business approach innovation, while necessary, is insufficient without systemic change in how infrastructure, regulation, and finance interact. Enabling Bangkok's motorcycle taxi sector to shift toward electric motorcycles will require more than proving technical viability—it will demand a coordinated policy agenda that dismantles structural barriers, shares risks fairly, and gives drivers a genuine stake in the transition. Only then can the sector contribute fully to a low-carbon, inclusive urban mobility future.

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9. Version Note

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