

A DEMATEL-Based Analysis of synergy between Electric Vehicles and Green Building

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Abstract

Rapid urbanization and intensifying climate commitments necessitate integrated solutions that simultaneously address sustainable mobility and energy-efficient construction. Electric vehicle (EV) infrastructure and green buildings have independently emerged as critical pillars of low-carbon urban transitions; however, their development has largely remained fragmented. This study investigates the **systemic synergy between EV infrastructure and green buildings**, emphasizing the role of **entrepreneurship as a catalytic mechanism** for sustainable urban transformation.

Adopting a **mixed-method research design**, the study integrates a **Systematic Literature Review (SLR)** with the **Decision-Making Trial and Evaluation Laboratory (DEMATEL)** technique to identify and model the causal interrelationships among policy, technological, entrepreneurial, financial, and social factors influencing EV–green building integration. DEMATEL is employed to distinguish **driving (cause) factors** from **dependent (effect) factors**, enabling prioritization within complex socio-technical systems.

Findings reveal that **policy and regulatory alignment, technological readiness, and entrepreneurial ecosystems** constitute the dominant causal drivers, while renewable energy integration, financing mechanisms, and social adoption emerge as outcome-oriented factors. The results underscore that entrepreneurship functions as a structural bridge translating policy intent and technological potential into scalable urban solutions. The study concludes by offering targeted recommendations for policymakers, entrepreneurs, investors, and urban planners, contributing both methodologically and practically to sustainable city research.

Keywords: Electric vehicles, Green buildings, DEMATEL, Sustainable entrepreneurship, Smart cities, V2G/V2B, Urban sustainability

1. Introduction

Urban areas account for over 70% of global energy consumption and nearly three-quarters of carbon emissions, positioning cities at the center of climate mitigation efforts. In response, **electric mobility** and **green building practices** have gained policy and market traction as essential components of sustainable urban development. Electric vehicles reduce reliance on fossil fuels in transportation systems, while green buildings minimize lifecycle energy use through efficient design, renewable integration, and intelligent energy management.

Despite their shared sustainability objectives, EV infrastructure and green buildings are frequently planned and implemented as **isolated systems**, resulting in missed opportunities for energy optimization, cost efficiency, and resilience. Integrating EV charging infrastructure within green buildings—particularly when coupled with renewable energy systems and smart energy management—can transform buildings into **distributed energy hubs** supporting urban decarbonization.

Entrepreneurship plays a pivotal role in operationalizing this integration by translating policy frameworks and technological innovations into viable business models. Startups, public–private partnerships, and green finance mechanisms enable experimentation, scalability, and local adaptation. However, the interdependencies among policy, technology, entrepreneurship, finance, and social adoption remain complex and underexplored.

To address this gap, the present study employs the **DEMATEL technique**, a causal modeling approach well-suited for analyzing complex systems with interrelated factors, to systematically evaluate the drivers and dependencies shaping EV–green building synergy.

2. Literature Review

2.1 Smart Cities and Digital–Environmental Convergence

Smart cities represent digitally enabled urban systems that integrate data analytics, IoT, and artificial intelligence to enhance sustainability and governance. Prior research indicates that the convergence of **digital policy frameworks and environmental regulations** significantly accelerates eco-innovation and urban green economic efficiency. Such convergence creates favorable conditions for integrating EV infrastructure with green buildings through real-time energy optimization and demand-side management.

2.2 EV Infrastructure and Renewable Energy Integration

The global EV market—particularly in emerging economies like India—is expanding rapidly, driven by policy initiatives such as national EV missions and incentive schemes. Nevertheless, challenges related to charging infrastructure density, grid stress, and high upfront costs persist. Integrating EV charging with **renewable-powered green buildings** mitigates these challenges by reducing grid dependency and lifecycle emissions.

2.3 Green Buildings as Distributed Energy Nodes

Green buildings increasingly function as decentralized energy systems incorporating solar photovoltaics, energy storage, and building management systems. When combined with EV charging and vehicle-to-building (V2B) or vehicle-to-grid (V2G) technologies, these structures can enhance urban energy flexibility and efficiency, achieving significant reductions in operational energy consumption.

2.4 Entrepreneurship, Policy Innovation, and Finance

Sustainable entrepreneurship bridges technological innovation and market adoption by developing business models aligned with environmental objectives. Green startups, supported by ESG finance, green bonds, and public–private partnerships, are instrumental in scaling EV–building integration. However,

policy fragmentation and lack of interoperability standards often constrain entrepreneurial effectiveness, underscoring the need for systemic alignment.

3. Research Design and Methodology

3.1 Research Design

This study adopts an **exploratory–explanatory mixed-method approach**, integrating qualitative synthesis with causal quantitative modeling. A **Systematic Literature Review (SLR)** identifies key influencing factors, while the **DEMATEL technique** is applied to examine causal relationships and interaction strengths among these factors.

The methodological rationale aligns with prior DEMATEL applications in complex decision environments, where traditional statistical independence assumptions are unsuitable .

3.2 Systematic Literature Review (SLR)

The SLR examined peer-reviewed journal articles and policy documents published between 2018 and 2024 across databases including Scopus, Web of Science, and ScienceDirect. After screening 82 studies using PRISMA guidelines, 38 publications were retained based on relevance to EV infrastructure, green buildings, smart cities, and entrepreneurship.

The review categorized findings across three domains:

1. Policy and regulatory frameworks
2. Technological integration and energy systems
3. Entrepreneurial and financial mechanisms

3.3 Identification of Key Factors

Based on the SLR, six critical factors influencing EV–green building integration were identified:

Code	Factor
F1	Policy and Regulatory Alignment
F2	Technological Readiness (V2G/V2B, smart grids, EMS)
F3	Renewable Energy Integration
F4	Entrepreneurial Ecosystem and Innovation
F5	Financing and Investment Mechanisms
F6	Social Adoption and Inclusivity

3.4 DEMATEL Procedure

The DEMATEL method was implemented following established steps :

1. **Expert Evaluation:** Domain experts assessed pairwise influence among factors using a five-point scale.
2. **Direct-Relation Matrix:** Aggregated expert judgments formed the initial influence matrix.

3. **Normalization and Total-Relation Matrix:** Direct and indirect influences were calculated.

4. **Cause–Effect Analysis:**

- D (*Driving power*) and R (*Receiving power*) were computed.
- $(D + R)$ indicates prominence; $(D - R)$ distinguishes cause and effect factors.

4. DEMATEL Results and Analysis

The DEMATEL analysis classifies factors into **cause (driving)** and **effect (dependent)** groups:

Cause Group (Driving Factors)

- **F1: Policy and Regulatory Alignment**
- **F2: Technological Readiness**
- **F4: Entrepreneurial Ecosystem and Innovation**

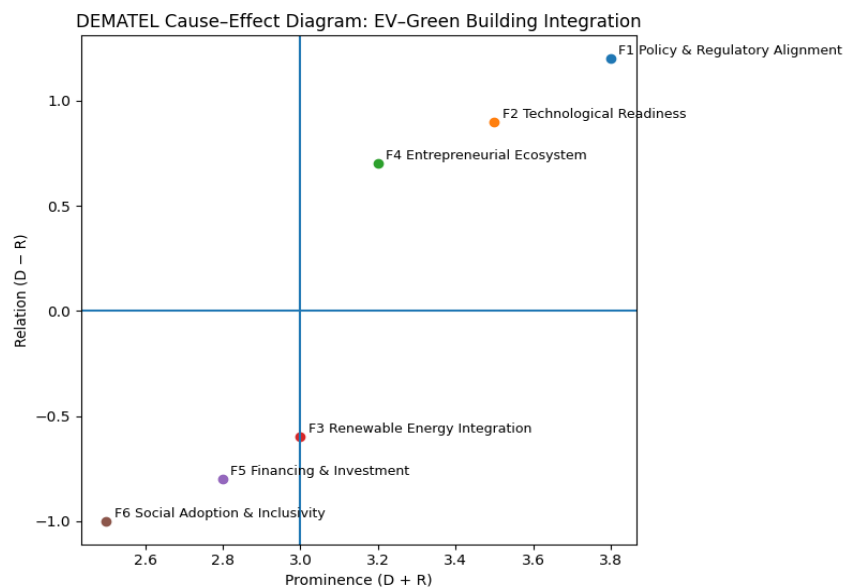
These factors exert strong causal influence, indicating that regulatory coherence, interoperable technology, and entrepreneurial capacity are foundational enablers.

Effect Group (Dependent Factors)

- **F3: Renewable Energy Integration**
- **F5: Financing and Investment Mechanisms**
- **F6: Social Adoption and Inclusivity**

These outcomes improve when upstream drivers are effectively addressed.

The causal structure confirms that **entrepreneurship acts as an operational conduit**, translating policy and technology into market and societal outcomes.



5. Discussion

The results demonstrate that EV–green building integration is a **system-level transition**, not merely a technological alignment. Policymakers play a decisive role by harmonizing EV and green building codes, while entrepreneurs leverage emerging technologies to develop localized, scalable solutions. Financing and social acceptance follow once systemic readiness is achieved.

Importantly, the DEMATEL findings validate prior conceptual claims while providing **empirical prioritization**, strengthening both theoretical rigor and policy relevance.

6. Strategic Recommendations

Stakeholder	Strategic Action	Expected Outcome
Government	Integrate EV readiness into green building regulations	Policy coherence
Entrepreneurs	Develop V2B/V2G-enabled business models	Market scalability
Investors	Expand ESG-linked financing instruments	Risk mitigation
Academia	Establish urban living labs	Knowledge diffusion
Communities	Promote participatory ownership models	Inclusive adoption

7. Conclusion and Future Research

This study establishes that the synergy between EV infrastructure and green buildings is driven by **policy alignment, technological readiness, and entrepreneurial ecosystems**, with other dimensions functioning as dependent outcomes. Methodologically, the integration of SLR and DEMATEL offers a robust framework for analyzing complex sustainability transitions.

Future research may extend this model using **fuzzy DEMATEL**, longitudinal data, or hybrid approaches integrating DEMATEL with ANP or ISM to further enhance decision-support capabilities in smart and circular city planning.

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