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Entrepreneurship and Innovation in Green Technology

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Abstract

Green technology is increasingly positioned as a key solution to environmental challenges, but the rates of its successful diffusion would seem to depend not solely on the technology's performance, but also on the acceptance by society. This thesis analyses green technology from a strategic and socio-economic perspective and investigates the interplay between technological innovation, business strategy, and public perception in shaping sustainable competitive advantage. This study employs analytical qualitative desk research methods, comprehensively analyzing peer-reviewed academic literature, secondary empirical studies, and comparative case studies at the company level to explore the conditions for green technologies to gain market acceptance.

The analysis demonstrates that green technology adoption is mediated by public perception, which operates through cognitive, affective, and behavioral dimensions. Environmental concern is not enough to stimulate adoption, as consumers' assessments of functional performance, economic value, trust, and emotional appeal are also considered critical factors. The results also suggest that firms that demonstrate a good fit between innovation strategy, credible communication, and affordability will be better placed to convert environmental problems into business opportunities. By integrating company-level analysis with societal-level evidence, this thesis contributes to the literature on sustainable entrepreneurship and highlights public perception as a strategic resource in green technology development.

Chapter 1: Definition and Current Context

1.1: Definition of green technology

Green technology refers to technologies, processes, and products that reduce environmental pollution, lower energy and resource consumption, and promote sustainable economic development. It encompasses innovations that minimize energy consumption, reduce greenhouse gas emissions, promote the use of renewable energy, enable pollution prevention and control, and enhance recycling and circular use of resources.

Unlike traditional environmental technologies that focus on end-of-pipe treatment, green technology highlights systemic change across the entire production and consumption chain, including eco-design, resource recycling, and digital technologies, such as blockchain-based systems, which can support green innovation by enhancing transparency, coordination, and entrepreneurial activity within sustainability-oriented innovation ecosystems.[1]

1.2: Current context of green technology and why it is necessary to innovate

Climate change and environmental degradation represent major challenges facing the world today, posing serious threats to the sustainable development of human society[2]. Terms such as climate change, sustainable development, eco-friendliness, green environmental protection, minimizing carbon footprint, carbon neutrality, and net-zero emissions have become buzzwords of our era, attracting widespread societal attention. Hence, consequently, green technology has emerged as a major policy and business instrument to balance between economic development and environmental sustainability.

At the policy level, governments around the world are promoting the development of green technologies by formulating rules, providing emission targets, and introducing incentive mechanisms. They are racing ahead with a common purpose and focus under the United Nations, and by signing development pacts such as the Paris Agreement. This has driven a growing need for low-carbon technologies within the energy, transport, and manufacturing industries.

However, the diffusion and effectiveness of green technologies neither follow a uniform distribution nor exhibit linear growth. Empirical research indicates that during the early adoption phase, emissions may temporarily increase due to high energy inputs, limited economies of scale, and immature production processes[3]. With technological development and scale effects, emission reduction benefits are evident enough, and spatial spillover effects may also arise beyond the first region.

Moreover, the implementation of green technological innovations aims to address structural challenges such as technological dependency, energy security, and industrial transformation. The case of China's electric vehicle industry demonstrates that green technology innovation can enable leapfrog technological development, allowing nations to bypass traditional high-emission industrialization stages.[4]

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[1] Mohammad Rashed Hasan Polas, Ahmed Imran Kabir, Abu Saleh Md. Sohel-Uz-Zaman, Ridoan Karim, and Mosab I. Tabash, "Blockchain technology as a game changer for green innovation: Green entrepreneurship as a roadmap to green economic sustainability in Peru," *Journal of Open Innovation: Technology, Market, and Complexity 2022, 8, 62.*

[2] Huanyu Chen, Jizheng Yi, Aibin Chen, Duanxiang Peng, and Jieqiong Yang, "Green technology innovation and CO_2 emissions in China: Evidence from a spatial–temporal analysis and a nonlinear spatial Durbin model," *Energy Policy 172 (2023) 113338*

[3] Ruiheng Liu, Zhengning Pu, Yasong Zhao, Cheng Yu, and Jiawei Wang, "The impact of green technology innovation on the comprehensive utilization rate of non-hazardous industrial solid waste," *Circular Economy 4 (2025) 100169*

[4] Pengyu Zhu, Zining Wang, Renu Singh, and Xinying Tan, "China's model of technology leapfrogging: Electric vehicle policies

Drivers of green innovation technology are not only environmental. Companies also recognize green technology as a competitive advantage, product differentiation, cost reduction, and access to new markets. This shift underlines the increasing focus on entrepreneurship and business strategy for the successful commercialization and scaling of green technologies.,

1.3: Problem statement

Despite growing recognition of green technology as a cornerstone of sustainable development, several unresolved issues persist.

First, the environmental benefits of green technology innovations vary significantly across regions, industries, and levels of economic development. Some studies confirm their positive role in reducing emissions, while others indicate short-term increases in emissions or diminishing marginal benefits. This disparity raises the question: When and how can green technologies deliver significant environmental benefits?

Secondly, many economies—particularly emerging and developing economies—face numerous constraints, such as high initial investment costs, technological uncertainties, and reliance on foreign technologies. Such constraints may influence governmental priorities and public perceptions, potentially mitigating enthusiasm for green technological development. Although the long-term necessity of green technology innovation is widely acknowledged in both policy and academic spheres, its short-term economic implications are less clear, particularly in contexts where pressing development needs compete for limited resources.[5] Thus, the question remains whether such economies should allocate scarce resources to green innovation at the expense of short-term development objectives, and whether public confidence in green technologies can be sustained under these conditions.

Third, debates persist over whether "green credentials" translate into long-term competitiveness. Many firms adopt green technologies due to regulatory or social pressures rather than embedding sustainability at the core of their business models. This raises a fundamental challenge: When exactly do green technologies shift from compliance costs to sources of competitive advantage? The central question of this paper is: How can firms achieve dual objectives of environmental sustainability and competitive advantage through green technological innovation?

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and the development of green technology," *Renewable and Sustainable Energy Reviews 226 (2026) 116414*

[5] Liu et al. "The impact of green technology innovation on the comprehensive utilization rate of non-hazardous industrial solid waste,"

Therefore, the core focus of this study lies in analyzing existing companies' technological approaches and innovative methods to identify how environmental challenges can be transformed into business opportunities, while also examining public acceptance and whether society is willing to pay for green technology models.

1.4: Method of study

To address the above research questions, this study employs a comprehensive multi-method analytical framework, integrating literature review, case-oriented analysis, and survey-based empirical research to conduct a holistic examination of green technological innovation.

First, it systematically reviews existing academic literature on green technology, green innovation, and sustainable entrepreneurship. By synthesizing prior research rather than examining it in isolation, the literature review establishes a robust theoretical foundation for this study and identifies the theoretical gaps it aims to address.

Second, based on prior quantitative analyses and findings in spatial econometric models, this study adopts a multi-region and multi-period perspective to investigate the impact of green technological innovation on carbon intensity. While not directly constructing new econometric models, this study critically interprets existing empirical findings to analyze both the direct effects of green technological innovation on emissions reduction and the indirect impacts arising from spatial spillover effects and industrial linkages.

Lastly, based on qualitative desk research methodology involving the systematic reading and synthesizing of existing academic literature and secondary empirical studies. Methodological rigor and theoretical coherence are maintained by treating peer-reviewed journal articles and other authoritative sources as the primary empirical units of analysis. This literature-driven methodology enables the integration of firm-level analysis with societal-level insights. This serves to increase the validity of the study as arguments are based on established empirical evidence and not on data generated during the course of the study.

Chapter 2: Analysis of Green Technology Entrepreneurship

This chapter analyzes green technology entrepreneurship through three representative case studies—Tesla, BYD, and LONGi. These firms are active in diverse areas within the cleantech industry, such as electric cars, energy storage, and solar energy production. Based on their entrepreneurial backgrounds, technological innovations, business models, and competitive advantages, this chapter illustrates how green technology enterprises transform environmental challenges into sustainable business opportunities.

2.1: Case study – Tesla

2.1.1: Entrepreneurial background and strategy

Tesla, Inc. was founded in 2003 with the mission "to accelerate the world's transition to sustainable energy".[6] Rather than operating solely as an automotive manufacturer, Tesla has positioned itself as a technology-driven firm aiming to reshape the broader energy and mobility system. According to Fernanda et al.[7], Tesla's entrepreneurial strategy is characterized by the integration of digital technologies, vertical integration, and a long-term vision oriented towards societal transformation rather than short-term profit maximization.

The leadership of Elon Musk plays a central role in this process. The literature highlights Musk's role as a systemic entrepreneur mobilizing financial, social, and human capital to bring about transformative change. His strategic vision, outlined in Tesla's "Secret Master Plans," positions electric mobility not just as a green alternative but as a better technological solution that can reshape consumer expectations and industry norms.

2.1.2: Main technological innovation

Tesla's technological innovation isn't confined to just battery electric vehicles. Its innovative journey covers battery systems, electric powertrains, autonomous driving software, and enabling infrastructure like the supercharger network. The Supercharger network evolved into a global system of high-speed DC charging stations designed specifically for Tesla vehicles, providing rapid charging and significantly extending the range in a brief time.[8] This ecosystem-based innovation approach aligns with the concept of disruptive and systemic innovation, where value is created through the interaction of multiple technologies rather than isolated product improvements.

Moreover, the real-time learning loops between Tesla's fleet and its artificial intelligence and data-driven training methods allow vehicle performance and experience to be optimized in real time. This digital capability strengthens both technological leadership and environmental performance by improving energy efficiency and extending product lifecycles.

2.1.3: How the company turned environmental challenges into opportunities

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[6] Source: Tesla Website, www.tesla.com/about

[7] Francesco Arreola, Filippo Platania, Carlos Toscano Hernandez, and Gregory Unruh, "Systemic Entrepreneurship in the Digital Era: Tesla's Vision and Social Transformation," *Journal of Engineering and Technology Management 74 (2024): 101844*

[8] Arreola et al., "Systemic Entrepreneurship in the Digital Era."

Environmental regulations and climate change are seen by many as a burden on the traditional car manufacturer. Instead, Tesla has strategically turned those challenges into market opportunities. Framing electric cars as high-performance, technologically advanced, and aspirational vehicles, Tesla successfully avoided common sustainability framing as a sacrifice or moral obligation. Survey evidence shows that Tesla is strongly associated with innovation, environmental benefits, and the "future of mobility," thereby increasing consumer interest in BEVs more broadly.[9]

However, this market-based approach also suggests that Tesla's impact on the environment depends on wider systemic factors such as decarbonization of the electricity grid and sustainable sourcing of raw materials.

2.1.4: Business innovation model

Tesla's breakthrough success in the traditional automotive industry did not follow the classic bottom-up disruptive innovation path. A comprehensive analysis of two studies reveals that its core competitive advantage stems from a composite strategy: by choosing to compete in domains that force incumbents to confront "architectural innovation," Tesla systematically builds and leverages "attacker advantages" throughout this process.[10]

From a systemic entrepreneurship perspective, this vertically integrated and digitally connected model facilitates rapid experimentation and alignment between sustainability objectives and commercial performance.[11] Meanwhile, Tesla aims to become energy positive. The Secret Tesla Motors Master Plan mentions that:

Tesla Motors will be co-marketing sustainable energy products from other companies along with the car. For example, among other choices, we will be offering a modestly sized and priced solar panel from SolarCity, a photovoltaics company (where I am also the principal financier). This system can be installed on your roof in an out-of-the-way location, because of its small size, or set up as a carport and will generate about 50 miles per day of electricity.[12]

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9 Zoe Long, Jonn Axsen, Inger Miller, and Christine Kormos, "What does Tesla mean to car buyers? Exploring the role of automotive brand in perceptions of battery electric vehicles," *Transportation Research Part A 129 (2019) 185-204*

10 V.J. Thomas, and Elicia Maine, "Market entry strategies for electric vehicle start-ups in the automotive industry e Lessons from Tesla Motors" *Journal of Cleaner Production 235 (2019) 653-663*

11 Arreola et al., "Systemic Entrepreneurship in the Digital Era."

12 Source: Elon Mask, "The Secret Tesla Motors Master Plan (just between you and me)," 2006 The Secret Tesla Motors Master Plan (just between you and me) | Tesla

demonstrates Tesla's plans for integration and collaboration across the entire green industry

2.1.5: Competition advantages

Tesla's competitive advantage derives from the combination of technological leadership, brand symbolism, and ecosystem dominance. Consumer surveys show that Tesla is seen not simply as a car company, but as a technology brand offering a vision of the future of mobility.[13] Tesla's competitive advantage is also rooted in its unique Silicon Valley DNA and open innovation ecosystem. Its team integrates mindsets from the internet, software, and consumer electronics industries, operating as a "technology company" rather than a traditional automaker, emphasizing rapid iteration and software-defined hardware.[14] Furthermore, Tesla has opened its patents—a move aimed at advancing the entire electric vehicle industry and positioning its technological approach as a de facto standard. This strategy seeks to cultivate an industry innovation ecosystem more favorable to its own technology stack.[15]

2.2: Case study – BYD

2.2.1: Entrepreneurial background and strategy

BYD (Build Your Dreams) was formed in 1995 as a battery firm in Shenzhen. As a global leader in electric vehicles and batteries is rooted in the strategic vision of its founder, Wang Chuanfu. BYD gradually expanded into electric vehicles and renewable energy solutions, following a development trajectory markedly different from Tesla's market-driven and brand-oriented strategy[16]

Studies at the firm level of China's electric vehicle industry indicate that BYD's entrepreneurial success lies in its capacity to internalize core technologies and transition from imitation-based learning to indigenous innovation. Research on technological catch-up and leapfrogging highlights that BYD strategically accumulated capabilities in batteries, motors, and electronic control systems, enabling the firm to reduce dependence on foreign suppliers and establish a self-reinforcing innovation system.[17]

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[13] Long et al., "What Does Tesla Mean to Car Buyers?"

[14] Ibid

[15] Ibid

[16] Jian-hua Liu, and Zhan Meng, "Innovation model analysis of new energy vehicles: taking Toyota, Tesla and BYD as an example," *Procedia Engineering 174 (2017) 965 – 972*

[17] Lindsay Whitfield, and Tobias Wuttke, "China's technological catch-up and leapfrogging in electric vehicles: A firm-level study of BYD and CATL" *Progress in Economic Geography 4 (2026) 100054*

From a green entrepreneurship perspective, BYD exemplifies an inclusive and manufacturing-led pathway that aligns environmental objectives with economic feasibility. From a sustainability perspective, BYD is important in the widespread dissemination of green technologies.

2.2.2: Main technological innovation

The core technology innovations of BYD lie in battery technology, the vehicle platform, and the manufacturing process. BYD's most significant technological innovation is that in its unyielding pursuit to improve the lithium iron phosphate (LFP) technology. Blade Battery, which was introduced in 2020. It was a cell-to-pack (CTP) design innovation that significantly boosted the volumetric energy density and safety of LFP batteries. By positioning long, slender cells straight into the battery pack, BYD does away with modular designs, which increases space, reduces weight, and enhances thermal stability.[18] Comparing the innovation patterns of new energy vehicle enterprises, BYD is the platform-based and incremental innovator. This approach integrates multiple core technologies through standardized vehicle platforms, enabling continuous improvement while maintaining cost control.[19]

2.2.3: How the company turned environmental challenges into opportunities

BYD proactively turned national and global environmental challenges into a strategic window of opportunity. While concerns about air pollution and energy security were leading the Chinese government to encourage the use of New Energy Vehicles (NEVs), BYD's investments came before these policies and actually helped to shape them rather than just reacting to them.[20]

BYD took advantage of increasing public concern about air pollution and energy security, by aligning its innovation strategy with national environmental priorities. Instead of passively reacting to regulations, the company used policy frameworks to help stabilize demand and bring down costs through economies of scale. In this regard, environmental regulation operated as a form of market shaping rather than a compliance constraint.

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[18] Source: BYD website, www.byd.com/cn/brand-center/leading-in-technology-security-branding-markets

[19] Liu, and Meng, "Innovation model analysis of new energy vehicles"

[20] Whitfield, and Wuttke, "China's technological catch-up and leapfrogging in electric vehicles"

However, such an arrangement does make institutions reliant on one another, and has caused some to question how strong BYD's competitive position would be if the regulations were to be changed.

2.2.4: Business innovation model

BYD's business innovation model is characterized by policy-responsive vertical integration and an unprecedented degree of vertical integration within the EV value chain, coupled with a dynamic innovation ecosystem evolution. Liu and Meng's article[21] describes the evolution of BYD's innovation ecosystem in three stages:

1. ***Niche:*** *Building a minimal viable system by grafting its proprietary ET-Power battery technology into acquired traditional auto manufacturing capabilities.*
2. ***Open Platform:*** *Establishing itself as a core enterprise, attracting multiple component suppliers to participate in an open innovation platform around its key technologies (LFP battery, permanent magnet motor, battery management).*
3. ***Comprehensive Expansion:*** *Deeply integrating its innovation and supporting technologies to expand into diverse markets (public transport, leasing, logistics) and globally.*

Based very loosely on principles from low-cost and high-strength electronics manufacturing, this model delivers the following key benefits: better cost control by protecting from supply chain volatilities, faster co-developed innovation between parts, and rigid quality control.

Additionally, BYD has also been innovative in sales and financing, by introducing to the market products such as lease financing, and business leasing for taxi companies, making it easier for them to acquire the vehicles and reducing the upfront cost barrier for fleet adoption, working with banks and grid companies to offer integrated solutions.[22] BYD has rapidly achieved broad coverage and deep penetration of the Chinese new energy vehicle market through a tiered product portfolio, a tightly controlled distribution network, a sales narrative centered on cost-effectiveness, and flexible pricing strategies, thereby creating a competitive advantage in scale and cost that is difficult to replicate.

2.2.5: Competition advantages

The competitive advantage of BYD is grounded in its cost leadership, production scale, and institutional compatibility. Its delivery of low-cost, yet highly dependable green technology

[21] Liu, and Meng, "Innovation model analysis of new energy vehicles"

[22] Ibid

has made it particularly successful in public transportation systems and emerging markets in bringing green technologies to a wider audience. Comparative studies indicate that this strategy enhances the diffusion of electric vehicles, particularly in emerging and developing economies.[23] While BYD cannot approach the global brand symbolism of Tesla, its capacity to provide dependable and cost-effective green solutions represents a sustainable competitive advantage in cost-conscious markets.[24] BYD's success is a multifaceted case of firm-level technological entrepreneurship and strategic ecosystem building. It combines strategic foresight in battery chemistry, a unique vertically integrated and cost-focused business model, astute early market positioning, and the dynamic development of an innovation platform to exploit the window of opportunity created by the global electric transition.[25]

2.3: Case study – LONGi

2.3.1: Entrepreneurial background and strategy

LONGi Green Energy Technology Co., Ltd. was established in 2000 in Xi'an, China, by the long-term dedicated strategy of specializing in monocrystalline silicon, and it has become one of the world's leading solar photovoltaic technology companies. LONGi aims "to make the best of solar energy to build a green world" and positions itself as a core enabler of the global energy transition rather than a diversified energy conglomerate.[26]

This strategic focus aligns closely with empirical research on renewable energy industries in China, which indicates that persistent green technology innovation—rather than short-term diversification—is a key driver of renewable energy sustainability at the regional level.[27]

LONGi did not seek to just make panels, but to innovate throughout the value chain — from silicon ingots and wafers to cells and modules. The company's vision, "Popularizing the Superior Solar Energy," toward solar energy utilization reflects its long-term vision for the Earth's environment preservation through technology leadership.[28]

2.3.2: Main technological innovation

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[23] Masiero et al. "Electric vehicles in China: BYD strategies and government subsidies,"

[24] Liu, and Meng, "Innovation model analysis of new energy vehicles"

[25] Whitfield, and Wuttke, "China's technological catch-up and leapfrogging in electric vehicles"

[26] Source: LONGI website, The World's Leading Supplier of Solar PV Solutions-LONGi

[27] Ishfaq Hamid, Md Shabbir Alam, and Magdalena Radulescu, "Are environmental regulations and green technology innovations catalysts for renewable energy sustainability in Chinese provinces?" *Energy Reports 14 (2025) 4936–4949*

[28] Source: LONGi website, Environmental - LONGi

The main innovations of LONGi's technology are the RCZ technology, Diamond wire wafer-silicon technology, PERC cell technology, and bifacial technology,[29] which provide better conversion efficiency and lower life-cycle emission than polycrystalline products. Studies on renewable energy sustainability in Chinese provinces demonstrate that green technology innovation improves sustainability outcomes primarily through efficiency enhancement and energy structure optimization, rather than through mere capacity expansion.[30] The trend of LONGi's technology path is the same mechanism, that is, small increases of conversion efficiency bring less land utilization, less materials consumption, and better system performance.

2.3.3: How the company turned environmental challenges into opportunities

LONGi has masterfully turned the global imperative to combat climate change into its core business opportunity. The company doesn't just present itself as a supplier of parts; it's a key driver of the global energy transition. The world is facing core environmental challenges—high carbon emissions from fossil fuels, energy security, and climate change. UN commitments and national policy goals (carbon neutrality and carbon peaking) are more than empty slogans, but compulsory institutional limitations. LONGi anticipated the changes and needs of the future, seeing photovoltaics as one of the lowest-cost options. That gave them a first-mover edge, technological superiority, and a mature industrial chain. LONGi converted environmental protection from a "burden" to a "competitive advantage" through endless innovation. In other words, LONGi turned the environmental challenge from "external constraints" to "internal drivers of technology substitution and cost restructuring."

2.3.4: Business innovation model

LONGi supports the "Solar for Solar" business model. While creating low-cost clean energy products for the world, the company uses clean energy and green manufacturing practices in its operations whenever possible.[31] Meanwhile, LONGi focuses on technology specialization combined with green supply chain integration. Unlike BYD, full vertical integration into downstream applications, LONGi concentrates on upstream technology excellence and works with project developers, utilities, and governments around the world.

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[29] Source: LONGi website, Governance - LONGi

[30] Hamid et al. "Are environmental regulations and green technology innovations catalysts for renewable energy sustainability in Chinese provinces?"

[31] Source: LONGi website, Governance - LONGi

Research by Feng et al.[32] highlights that environmental performance improvements depend on coordinated innovation across suppliers, manufacturers, and downstream users, rather than isolated actions by individual firms. LONGi promotes "Win-Win Collaboration, Joint Innovation, Green Decarbonization." LONGi collaborates with its suppliers and partners to think more deeply and broadly, aiming to achieve a responsible supply chain.[33]

2.3.5: Competition advantages

LONGi's competitive advantages primarily derive from its technological leadership, alignment with sustainable development, and strong brand reputation and trust. LONGi is not simply a technology company, but a manufacturing-technology enterprise with large-scale monocrystalline silicon wafer production capacity, highly automated and standardized production lines, and continuously reducing silicon consumption, electricity consumption, and water consumption. The result is that low cost is not achieved at the expense of quality, but rather through economies of scale and process optimization.

Furthermore, unlike Tesla's approach to system-level innovation and BYD's scaling model enhanced by manufacturing capabilities and policy support, LONGi exemplifies a science- and efficiency-based approach to green entrepreneurship. Its competitiveness is relatively insulated from the short-term policy swings, as it is based on technological feasibility and on the long-term demand for sustainability.

2.4: How to determine whether a company is green

With the term "green" being ever more a strategic descriptor in the language of corporations, its meaning as an object of analysis is at risk of becoming rote. Many companies assert environmental responsibility for their end products or through narratives of sustainability, while the environmental costs integrated in production systems, supply chains, and waste disposal are hidden. For example, at its 2022 product launch event, Apple Inc. announced that purchased iPhones would no longer include a charging adapter and earphones. Apple Inc. stated that this move was to reduce e-waste and achieve carbon neutrality, potentially reducing carbon emissions by millions of tons annually. However, many customers expressed dissatisfaction, claiming that it increases the cost when purchasing the devices. Is Apple Inc. leveraging the protection of the environment as a cover to slash costs and increase profits?

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[32] Yunting Feng, Kee-hung Lai, and Qinghua Zhu, "Green supply chain innovation: Emergence, adoption, and challenges," *International Journal of Production Economics 248 (2022) 108497*

[33] Source: LONGi website, Green Supply Chain

Hence, this part applies to a critical assessment lens that separates substantive green performance from symbolic or compliance-based sustainability.

2.4.1: Raw materials production

Raw material sourcing represents one of the most frequently overlooked sources of environmental externalities. Although companies may sell low-carbon or "clean" end products, activities such as mining, refining, and transporting materials upstream can have a significant environmental impact.[34] The literature on green supply chains suggests that shifting environmental responsibility upstream can be considered as a form of green-washing of green claims.[35] In industries such as electric vehicles and photovoltaics, reliance on lithium, cobalt, rare earth elements, or high-purity silicon poses existential questions. From this perspective, Tesla and BYD are structurally challenged in the same way, as they are dependent on battery-related minerals, while LONGi's dependence on silicon is an environmental strain focused mainly on energy-intensive purification processes. An authentic green company would not only be expected to recognize these upstream effects, but also to participate in supplier auditing, material substitution, or technology-based reduction of material intensity. But that statement is suspect when leaving out the environmental impacts of raw material extraction. Under these situations, sustainability is not the result of true environmental responsibility, but rather the outsourcing of pollution to upstream suppliers.

2.4.2: CO_2 emissions in the production process

A second critical criterion concerns carbon emissions generated during the production process. Although many companies highlight emissions avoided during product usage, high carbon emissions in manufacturing are hard to avoid, and it is yet to be seen whether emissions in the production stage will counterbalance much of the environmental gains downstream. Some companies consider partial carbon neutrality framed as total achievement. Boundary setting reduces the number of emissions that need to be offset, but it does not constitute offsetting itself as the main tool of emissions reduction. While these measures may improve companies' reported carbon footprint, they do not eliminate emissions across the entire value chain.

Applying this criterion highlights important differences among the three cases: LONGi's incremental process efficiency improvements are focused specifically on manufacturing emissions, while Tesla and BYD's environmental performance is more reliant on the

[34] Feng et al. "Green supply chain innovation"

[35] Ibid

decarbonization of electricity grids and upstream supply chains. Therefore, green credibility is not only determined by the results of innovation but also by practices of boundary-drawing and carbon accounting transparency.

Furthermore, companies that use fossil-fuel-based energy in the manufacturing of low-emission products have a paradoxical product performance and production reality. Research on green technology innovation in Chinese provinces indicates that reductions in the carbon intensity are largely a result of technological upgrading on the production side and optimizing energy structure, instead of symbolic green positioning.[36]

2.4.3: Ways to recycle

Recycling systems are frequently cited as indicators of corporate environmental responsibility. However, this is often a technical definition and is far removed from actual recycling rates and material closed-loop systems. There are systemic flaws in the recycling system. For example, ***recycled** is* not the same as ***recyclable***. Many recyclable items end up in landfills or incineration because their complex materials make it difficult to decompose. The company does not handle recycling; it only advertises recyclability.

Hence, a crucial differentiation is needed between active recycling models. Where companies design products that can be recycled and passive models that place the burden on consumers or public waste management systems. Green firms with recycling abilities have to develop more full recycling loops, and those that say they are circular but have no practical recycling infrastructure probably do very little in material recovery.

Under this lens, Tesla's battery recycling goals, BYD's closed-loop battery system, and LONGi's material efficiency approaches can be evaluated not on stated goals but on how circularity is embedded in their business model.

2.4.4: Scrape treatment process

As the final process, scrap and waste treatment processes offer a critical examination of the extent to which a firm's innovation system is geared towards environmental responsibility, or whether it is simply coerced by regulation. While traditional incineration and landfill are the lowest-cost methods, they can also induce secondary pollution. For example, batteries are considered hazardous waste, requiring the company to be more cautious in its waste disposal. Studies on high-level green technology innovation indicate that companies with excellent

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[36] Hamid et al. "Are environmental regulations and green technology innovations catalysts for renewable energy sustainability in Chinese provinces?"

environmental performance are those that take an active part in turning waste into secondary resources by technological upgrading, process coordination, and system innovation.[37]

Thus, battery recycling in Tesla and BYD or silicon waste recovery in LONGi serve as key indicators of whether environmental constraints are treated as costs or as innovation opportunities.

2.5 Comparative summary of green technology entrepreneurship

Building on the analytical framework established in Section 2.4, this section provides a structured comparative assessment of Tesla, BYD, and LONGi. While all three companies are green technology entrepreneurs under the general heading, the three companies are quite different in the way that the environmental limits are factored into their innovation strategies, business models, and sources of core competitiveness.

From an innovative orientation perspective, Tesla can be considered a system-level, market-creating example, where sustainability is baked into product performance, digital integration, and consumer perception. Its green value claim is quite perceptible to the end-user, but its ecological effectiveness is dependent on external systemic factors like decarbonization of the electricity grid and sourcing of materials upstream.

BYD adopts a green entrepreneurial model, which is a scale-based and policy-aligned model in which environmental regulation becomes a market-forming instrument rather than a market-constraining one. BYD has allowed for the widespread adoption of green technologies, especially in price-sensitive and developing markets, by being deeply vertically integrated and pursuing cost leadership. However, this model also implies a certain degree of institutional dependence, so the question of how it holds up under changing regulatory regimes arises.

In contrast, LONGi represents an efficiency-based, process-driven model, in which green competitiveness is mainly realized by means of manufacturing process upgrading in a sustainable way of technology. Instead of leaning on consumer branding or policy incentives, LONGi's environmental record is based on differentiating itself through incremental efficiency improvements, supply-chain coordination, and long-term clean energy infrastructure demand.

The following table(*Table2-1*) applies these considerations to the three case firms. The table(*Table2-1*) transforms the conceptual framework to a firm-level evaluation by

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[37] Jianling Jiao, Yuqin Chen, Jingjing Li, Shanlin Yang, "The secrets to high-level green technology innovation of China's waste power battery recycling enterprises," *Journal of Environmental Management 375 (2025) 124343*

systematically analyzing Tesla, BYD, and LONGi for their raw material sourcing, production emissions, recycling schemes, and treatment of waste.

DIMENSION / COMPANY	***TESLA***	***BYD***	***LONG***
RAW MATERIALS PRODUCTION	High dependence on critical minerals such as lithium and nickel shifts environmental pressure primarily to the upstream supply chain, resulting in the externalization of green performance.	The LFP technology route reduces reliance on scarce metals but still requires significant resource investment.	Reliance on high-purity silicon materials places environmental pressure primarily on energy-intensive purification processes.
CO_2 *EMISSIONS IN THE PRODUCTION PROCESS*	Manufacturing emissions reductions heavily depend on the decarbonization of the power system, with enterprises having limited control capabilities.	Mass production reduces emissions per unit, but absolute emission levels remain high.	Directly reduce carbon intensity at the manufacturing end through continuous process optimization.
WAYS TO RECYCLE	While emphasizing battery recycling targets and technological potential, the closed-loop system remains in its developmental stage.	A relatively systematic mechanism for battery recycling and cascading utilization has been established.	Resource waste has been reduced through enhanced material efficiency and silicon recovery.
SCRAPE TREATMENT PROCESS	Green entrepreneurship relies on system-level coordination, with environmental performance being conditional.	Green entrepreneurship is oriented toward scale diffusion and exhibits high institutional embeddedness.	Green entrepreneurship is driven by endogenous technological efficiency, following relatively stable pathways.

Table 2-1

Chapters 3: Sustainable Entrepreneurship and Eco-Innovation

3.1: Definition of sustainable entrepreneurship and eco-innovation

Sustainable entrepreneurship relates to those business activities and operations which are geared towards management of the economic, social, and environmental aspects of an enterprise in a sustainable manner. In contrast to traditional entrepreneurship, which focuses on the maximization of profits, sustainable entrepreneurship integrates sustainability goals in the business model, in processes of decision-making, and in strategies for innovation. It aims to address environmental and social challenges through market-based solutions, thereby transforming sustainability constraints into entrepreneurial opportunities.[38]

Eco-innovation is a related but distinct concept, commonly defined, and is typically defined as the introduction, application, or adoption of new or significantly improved products, processes, organizational methods, or business models that reduce environmental burdens. Eco-innovation is not only about technological advancement, but also systemic change including energy transition, circular economy practice, and green value-chain reconfiguration. As Leola et al.[39] studied, eco-innovation serves as a key operational mechanism through which sustainable entrepreneurship materializes in practice.

In addition, sustainable entrepreneurship and eco-innovation are interrelated. Sustainable entrepreneurship is the strategic and organizational context, and eco-innovation is the specific technological and management solutions. Previous studies suggest that firms that implement eco-innovation are also more prone to develop a sustainable competitive advantage through enhancing resource efficiency, mitigating regulatory pressures, and addressing the environmental concerns of consumers and policymakers.

From a macro viewpoint, eco-innovation is currently considered a positive determinant of sustainable development, especially in energy and environmental degradation. Empirical evidence from the European Union indicates that eco-innovation reduces ecological footprints through cleaner energy, energy efficiency, and low-carbon economic structures. This reinforces the view that sustainable entrepreneurship and eco-innovation are essential components of broader sustainability transitions rather than isolated firm-level practices.[40]

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[38] Leola Dewiyani, Arita Marini, Gusti Yarmi, Nelfiyanti, Dwi Atmanto, Sardi Salim, Desy Safitri, Parulian Irwansyah, Musril Zahari, Rezeqi Hardam Saputro, Asep Marfu, "Eco-innovation and green entrepreneurship: Transforming challenges into opportunities for the environment", *Cleaner Environmental Systems 19 (2025) 100345*

[39] Ibid

[40] Xiaoli Wang, Mahmood Ahmad, Zahoor Ahmed, Xiyue Yang, "Shaping the green future: How energy transition and eco-innovation can influence the financial development-ecological footprint nexus in EU countries", *Gondwana Research 153 (2026) 291–304*

3.2: Drivers of sustainable entrepreneurship and eco-innovation

A combination of institutional, economic, and regional innovation structures drives the proliferation of sustainable entrepreneurship and eco-innovation.

Energy transition and environmental regulation are sovereign drivers at the institutional level. Studies concerning the EU indicate that ambitious climate targets, renewable energy strategies, and innovation-focused policy schemes foster eco-innovation activities. [41]These policies apply pressure on firms and provide incentives to behave as sustainable entrepreneurs, especially in those energy-intensive industries, in which environmental regulation is tied to competitiveness and so it becomes challenging for firms to comply or improve their environmental performance.

Economic and financial factors also play a critical role. The financial development and eco-innovation interaction implies that having access to financial sources allows firms to absorb the high up-front costs associated with green technologies. Targeted investments, green finance instruments, and innovation funding mechanisms reduce uncertainty and support the commercialization of eco-innovative solutions. Without sufficiently developed financial markets, sustainable entrepreneurship continues to be constrained, in particular in capital-intensive sectors such as solar energy production and electrification of transport.[42]

From a regional perspective, innovation networks and regional collaboration significantly enhance eco-innovation efficiency. The study of the Yangtze River Economic Belt illustrates that although innovation networks allow for positive environmental spillovers, such benefits are unevenly.[43] Core regions with dense networks capture disproportionate advantages, while peripheral areas are structurally disempowered. This questions the idea that eco-innovation networks automatically contribute to a balanced and inclusive sustainable development.

3.3: Challenges in sustainable entrepreneurship

Challenges in sustainable entrepreneurship are frequently approached as technical or managerial problems. However, by studying literature, many challenges are structural and systemic, limiting the transformative potential of eco-innovation.

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[41] Wang et al. “Shaping the green future”

[42] Ibid

[43] Yang Yang, Yi Guo, Senlin Hu, Erling Li, Wei Zhao, Gang Zeng, “The regional environmental benefits and heterogeneity of eco-innovation networks: Evidence from the Yangtze River Economic Belt in China” *Applied Geography 186 (2026) 103851*

The expensive and uncertain nature of eco-innovation produces a strong bias in favor of large firms and enterprises supported by the state. This restricts the participation of smaller actors and challenges the narrative that sustainable entrepreneurship is a free and accessible route to environmental change.[44]

Furthermore, the diversity among regions marks not only a gap in policy application, but also a limitation in policy design. Differences in institutional quality, innovation capacity, and network embeddedness result in uneven environmental outcomes, even within the same national sustainability framework. As in China, green technology does not uniformly alleviate environmental pressure but brings about local gains and regional gaps.[45]

Lastly, the risk for symbolic sustainability seems to be still high. When Eco-innovation is assessed based on indicators such as number of innovations or efficiency improvements, more fundamental questions on absolute environmental impact and long-term ecological boundaries are often overlooked. This facilitates space for green narratives focusing on the intensity of innovation rather than the persistence of environmental externalities.

3.4: Critical assessment of eco-innovation in Tesla, LONGi, and BYD

The cases of Tesla, LONGi, and BYD illustrate both the potential and the limitations of sustainable entrepreneurship in practice.

Tesla exemplifies a market-driven eco-innovation model aligned with global energy transition goals. While the vehicles are helping to reduce emissions intensity and the energy systems contributed to that, this model is still reliant on ever-growing markets and ever-growing battery production, that's resource intensive. In line with EU evidence[46], Tesla's environmental contribution is therefore conditional on broader systemic decarbonization rather than guaranteed by innovation alone.

BYD is a market solution aligned with policy in which rapid growth is supported by strong institutional support for sustainable entrepreneurship. As also demonstrated by the results of the Chinese regional level analysis, BYD's achievement demonstrates how certain key institutional and network provisions are required to support the growth of eco-innovation. Although this model enables large-scale deployment of eco-innovation, it also exposes the firm to policy dependency and raises concerns regarding the durability of environmental outcomes once regulatory conditions change. Nevertheless, this model points up the difficulty

[44] Wang et al. "Shaping the green future"

[45] Yang et al. "The regional environmental benefits and heterogeneity of eco-innovation networks"

[46] Wang et al. "Shaping the green future"

of policy dependence, since environmental performance over time is highly contingent on the continuity of regulation and strategic synergy.

LONGi demonstrates how process-oriented eco-innovation can enhance environmental efficiency within manufacturing. However, its success is embedded in dense regional innovation systems which magnify the advantages of leading firms. While environmental performance is improving at the local level, this raises the question of whether efficiency improvements implemented at the firm-level also translate into net environmental benefits for the entire photovoltaic value chain.

In summary, these cases demonstrate that eco-innovation should not be equated with sustainability itself. Sustainable entrepreneurship has to be judged in relation to its infrastructural reliance, regional disparities, and its potential to induce absolute environmental betterment (as opposed to just relative efficiency improvement).

Table 3-1 comprehensively examines the sustainable entrepreneurship and eco-innovation of the three companies.

Dimension/Company	***Tesla***	***BYD***	***LONGi***
Firm Type and Industry Positioning	Global leader in electric vehicles and integrated energy solutions	Integrated new energy enterprise	Global leader in photovoltaic wafers and module manufacturing
Sustainable Entrepreneurship	Market-creating sustainable entrepreneurship driven by disruptive innovation	System-oriented sustainable entrepreneurship combining policy alignment and scale expansion	Process efficiency-driven sustainable entrepreneurship: achieving sustainability through manufacturing optimization.
Type of Eco-Innovation	Product- and system-level eco-innovation	Product and organizational eco-innovation	Process-oriented eco-innovation

Table 3-1

Chapter 4: Desk Research on Public Perceptions of Green Technology

This chapter presents a desk research study based exclusively on existing academic literature to examine public perceptions of green technology. Based on existing empirical literature, it investigates the impact of cognitive and emotive factors on consumer participation in green innovation and their effect on green product purchase intention. Drawing on secondary empirical studies, this chapter offers a theoretically informed and methodologically coherent analysis of societal reactions to green technology.

4.1 Research objective and scope

This study aims to summarize empirical studies with regard to the public image of green technology and the related concepts of public image that influence its performance in terms of public involvement and behavioral expression. Public opinion plays an important role in determining whether green technologies can advance from technological possibility to mass application. Even when green innovations demonstrate clear environmental benefits, their diffusion depends heavily on how they are understood, trusted, and emotionally evaluated by consumers.

This chapter explores consumers' cognitive evaluations of green technologies, their emotional reactions to environmental technological innovation, and how these perceptions influence their engagement and intent to purchase. Instead of the public as a uniform mass, the literature reviewed reveals perceptual differences based on levels of knowledge, trust in corporations, and perceived personal relevance. Hence, this desk-based review of the literature integrates empirical explanations for why certain green technologies become widely accepted, while others are met with skepticisms or resistance.

The analytical scope of this chapter is limited to peer-reviewed empirical studies on consumer engagement and green product purchase intention, ensuring that the discussion remains evidence-based. In this respect, the chapter draws from the previous chapters on the firm level analysis and generalizes the thesis from organizational strategy to societal reception.

4.2 Conceptual framework: cognitive, affective, and behavioral dimensions

Desk research adopts an analytical framework derived from reviewed literature, which conceptualizes public perception as a dynamic process linking cognition, affect, and behavior based on Fethi's literature[47] and Agnieszka et al. This framework provides a structured lens through which consumer responses to green technology can be systematically analyzed.

Cognitive factors refer to how individuals process and evaluate information related to green technology. These are environmental knowledge, perceived environmental benefit, perceived functional performance, perceived quality, and economic value. Empirical research reveal that consumers will not adopt green technologies if they consider them to be inferior substitutes or if they are financially damaging, no matter how much they care for the environment.

Affective factors refer to emotional reactions towards green technologies and green companies. Trust, moral satisfaction, pride, and emotional commitment to green brands are also important in determining attitudes, especially in a situation of information asymmetry and technological uncertainty. Affective reactions have been found to modulate the influence of cognitive appraisals on behavioral intention.

Behavioral factors represent the observable consequences of cognitive and affective perception. These factors include consumer engagement—such as willingness to interact with firms, support green innovation initiatives, and advocate for sustainable solutions—as well as purchase intentions.

Together, these dimensions illustrate how perception is translated into action. *Figure 4-1* comprehensively displays these dimensions.

[47] Fethi Klabi, "Factors affecting green product purchase intention in an emerging country: An empirical investigation" *Social Sciences & Humanities Open 11 (2025) 101570*

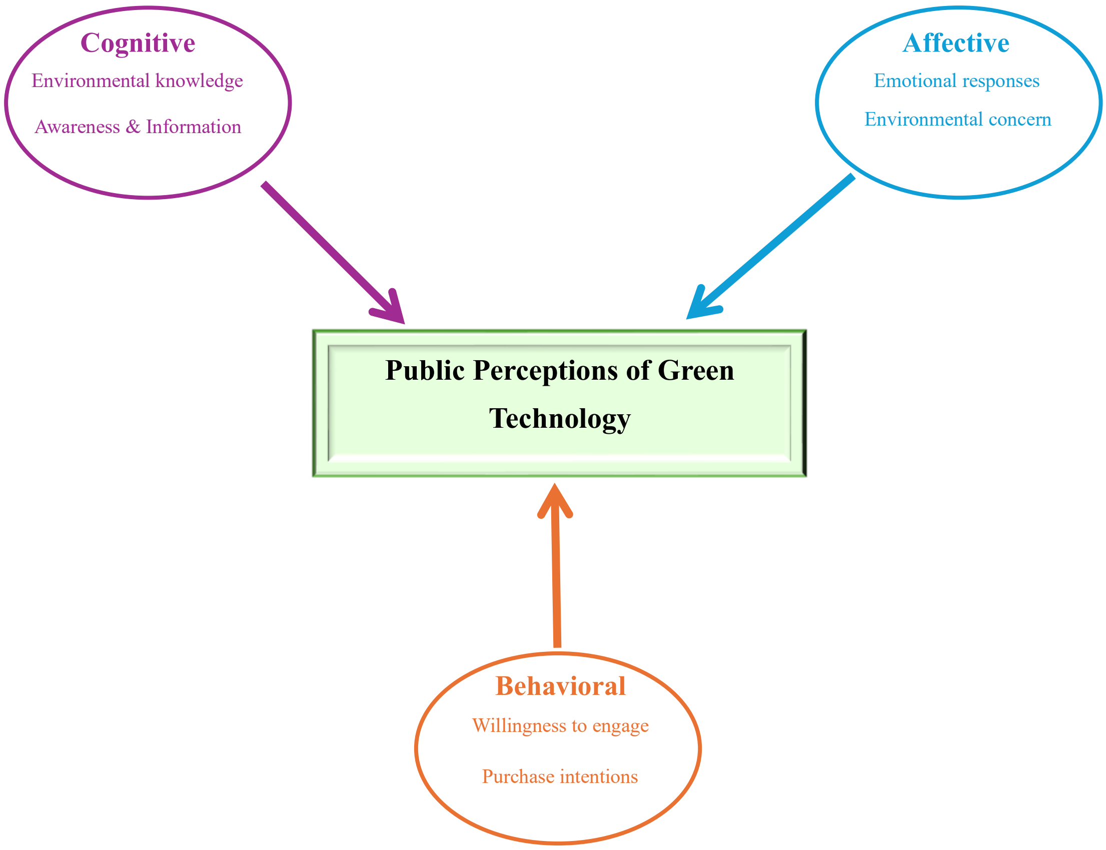

Figure 4-1

4.3 Synthesis of empirical findings

Although the existing evidence gives us useful understanding of the public perception of green technology, the findings also reveal several conceptual and practical tensions. A prevalent finding in the literature is that environmental concern is only weakly, if at all, predictive of green consumption. While a lot of consumers share a green attitude, it is far less certain that this attitude leads to changes in behavior. This attitude–behavior gap suggests that moral alignment with environmental values is insufficient when green technology is deemed to be functionally inferior, financially costly, or socially distracting.[48]

From a cognitive perspective, perceived performance and economic value are strongly emphasized in literature. But this attention is prone to underestimating consumer decision-making complexity by implicitly considering a rational evaluation. In practice, consumers often rely on heuristics and incomplete information, particularly when assessing technologically complex green innovations. Consequently, green products or technologies that are strictly energy efficient, but whose advantages are not immediately visible or clearly

[48] Fethi, "Factors affecting green product purchase intention in an emerging country"

communicated, might even face resistance. This limitation suggests that cognitive appraisal is very situation-specific rather than unknowably predictive.

Affective factors are often portrayed as enablers of green adoption, especially through trust and emotional involvement. However, this focus also seems to reveal a weakness in green innovation strategies. Trust-based acceptance is particularly vulnerable in an environment where there is a high degree of suspicion about claims of corporate environmental responsibility. Emotional Engagement may turn quickly into distrust when green technologies are linked with perceived greenwashing, negatively impacting both consumer engagement and willingness to purchase.[49] Consequently, affective appeal should not be treated as a substitute for demonstrable environmental and functional performance.

Research on consumer engagement in green innovation further suggests that engagement is unevenly distributed across populations. Engaged consumers are more likely to accept uncertainties and to join innovative processes, but they tend to constitute a relatively well-informed and environmentally aware minority.[50] This raises questions about whether engagement-driven green innovation models can be scaled and extended to mass markets. Engagement, then, should be seen as complementary rather than a panacea mechanism.

In developing countries, empirical studies have consistently pointed out that price sensitivity and perceived economic risk are two structural constraints of green consumption.[51] While framing green technologies as investments that save money in the long-run and improve personal health may ameliorate some of these worries, such messaging may ignore immediate financial constraints of many individuals. This limitation suggests that market-based solutions alone may be insufficient to achieve widespread adoption without supportive institutional or policy frameworks.

4.4 Critical implications for green technology development and strategy

The critical synthesis above indicates that public perception should not be viewed as a passive outcome of green innovation, but as an active and contested process. Companies frequently take for granted that being technologically superior or better for the environment will simply lead to the public embracing their product. However, empirical evidence suggests that

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[49] Wiśniewska et al. “Cognitive and affective antecedents of consumer engagement in green innovation processes”

[50] Ibid

[51] Fethi, “Factors affecting green product purchase intention in an emerging country”

acceptance emerges only when cognitive clarity, affective credibility, and practical affordability align.[52]

From a strategic perspective, an overemphasis on either cognitive or affective framing of the A-frame is risky. Technical performance and cost-based strategies may not be suited to overcoming deficits of trust and emotional disengagement. By contrast, emotional appeal-based strategies without adequate transparency may increase skepticism and charges of greenwashing. Therefore, sustainable competitive advantage depends on balancing measurable performance with credible communication.

These findings also challenge the assumption that public engagement alone can drive large-scale green transitions. Engagement-driven frameworks, such as collaborative management, are excellent for experimentation and early adoption, but they are limited in scope by macro-organizational support. This implies that companies operating in the green technology industry need to align innovation strategies with policy measures, infrastructure provision, and regulatory criteria to minimize risk and cost barriers for potential adopters.

In sustainable entrepreneurship, the public perception functions both as a limitation and a strategic resource. Companies that actively shape perception through transparent practices, consistent performance, and long-term commitment to environmental outcomes are more likely to secure durable legitimacy.[53] Rather than treating societal approval as an exogenous factor, high-performing green technology companies consider social perception as a central element in their innovation and corporate strategies.

4.5: Strategic implications in relation to case studies

The desk research findings reinforce the claim that public opinion management needs to be considered as a strategic tool and not as an external limitation. Compared to the case studies of Chapter 2, it is clear that various green technology companies use different perception management techniques tailored to their technology type and market position.

Tesla's strategy demonstrates the effectiveness of cognitively driven perception management, where the framing of technology leadership and performance acts as a moderator for perceived risk of innovation among consumers. However, the literature on this also points to a potential fragility: if expectations are raised too high, inconsistencies in perceptions or

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[52] Wiśniewska et al. "Cognitive and affective antecedents of consumer engagement in green innovation processes"

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unfulfilled promises can quickly undermine trust. This points to the need to maintain effective credibility in the face of cognitive dominance.

BYD's strategy demonstrates how green innovation, made affordable and practical for everyday use, can break through economic structural barriers, as observed by empirical research. The company's approach aligns with the findings of the literature, which indicate that perceived economic value plays a crucial role in emerging markets. Nevertheless, the desk research also indicates that overreliance on cost-based advantages may limit the potential for effective differ- initiation, suggesting that future competitiveness may depend on stronger brand-based emotional engagement.

LONGi's strategy is most closely with affective and institutional trust-building mechanisms discussed in the literature. The focus on reliability, scale, and long-term environmental outcomes assuages skepticism around green claims and enables LONGi to gain legitimacy with policy makers and industry actors.

Overall, the direct mapping from empirical literature to strategies at the firm level indicates that the success of green technology diffusion relies on matching the trajectory of innovation with the dynamics of public perceptions. The case studies demonstrate that cognitive, affective, and engagement-based mechanisms do not operate in isolation but co-evolve with firm strategy, market structure, and institutional context. These explanations can account for the differences in green innovation strategies between the case studies outlined in previous chapters. Companies focused on cost-effectiveness, dependability, and mass-market environmental benefit tend to depend on cognitive framing to generate consent, and those that frame green technology as aspirational and cutting-edge use affective appeal to influence how the public views them.

Chapters 5: Conclusion

This thesis aimed to consider green technology not just as a technological fix to environmental challenges, but rather as an innovation whose market success is shaped by the relationship between firms, markets, and society. The research adopted the literature based desk research method and looked at the ways firms develop and commercialize green technologies, and the ways in which the public responds to and assesses these types of innovation.

The findings demonstrate that technological efficiency and environmental benefit, while necessary, are insufficient conditions for widespread adoption. Public perception is a key mediating factor influencing whether green technologies can move from innovation to large-scale deployment. Desk research evidence suggests that consumer responses revolve around cognitive evaluations of performance and value, emotional responses such as trust and moral satisfaction, and behavioral outcomes such as engagement and purchase intention. Even with strong environmental motivations, inconsistencies across these dimensions can significantly limit market acceptance.

The thesis combines corporate-level case studies with empirical research on public perception, emphasizing that green technology can only become a source of sustainable competitive advantage when innovative strategies align with societal expectations. Companies that can balance functionality, economic accessibility, and credible environmental commitments are better positioned to dispel public skepticism and establish long-term legitimacy. Conversely, strategies relying solely on symbolic environmental claims or technological superiority face heightened resistance and risks of distrust.

In conclusion, this study contributes to the literature on sustainable entrepreneurship by demonstrating that public perception should not be viewed as an external constraint but rather as a strategic resource that co-evolves with green innovation.Future studies might extend the present study by investigating the dynamics in specific sectors or by analyzing additional mediators, such as policies regimes and institutional support.

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