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Developing business model framework for companies operating in the second life batteries market

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Abstract

The rapid growth of the electric vehicle (EV) market has led to an increased demand for batteries, necessitating sustainable solutions for their entire lifecycle. This paper presents a conceptual framework addressing the second life stage of EV batteries. The framework comprises three primary elements: Value Proposition, Value Creation and Delivery, and Value Capture, each further divided into sub-elements encompassing various aspects of second life batteries. Developed through a literature review and validated through workshops with partnering companies, the framework provides a holistic view of second life batteries management. The study's findings identify distinct product/service offerings, target customer differentiation, key activities, ownership options, channels and customer relationships, resources and capabilities, partners and suppliers, cost structures, and revenue models for second life batteries. The paper's theoretical contribution lies in offering a framework that guides researchers and practitioners in developing sustainable strategies for battery production, use, and recycling. Practical implications include providing a tool for companies to evaluate and improve their practices in terms of sustainability and value. By fostering sustainable and profitable strategies, this paper contributes to the literature on sustainable battery production and the circular economy, while also benefiting the EV industry and society.

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1. Introduction

The increasing demand for electrical vehicles (EVs) has resulted in a significant growth in the market for batteries. These batteries, however, have a limited lifespan, leading to the need for their replacement or disposal (Baumann et al., 2017). This issue presents a challenge for manufacturers and users, as it is essential to consider the

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environmental impact and sustainability of batteries, along with their economic and technical aspects (Zhao et al., 2021).

Existing literature on EV batteries lacks a comprehensive framework specifically focused on second life batteries. This gap hinders the development of effective strategies for businesses aiming to maximize the value of these repurposed batteries. A structured framework is crucial for guiding companies in formulating sustainable and profitable approaches to second life battery operations. Addressing this gap will contribute to a better understanding of challenges and opportunities related to second life batteries. Ultimately, filling this gap will provide practical guidance for companies, policymakers, and researchers in the electric vehicle industry.

To address this challenge, a conceptual framework for second life batteries has been developed, which aims to provide insights into the value proposition, value creation and delivery, and value capture of the second life batteries. The framework comprises three main elements: Value proposition, Value creation and delivery, and Value capture (Chirumalla et al., 2022; Richardson, 2005), each of which includes sub-elements for the second life stage.

The motivation for this research is to provide a comprehensive understanding of the second life battery stage, and how it can be managed to ensure its sustainability and profitability. The aim of this paper is to present the conceptual framework and its sub-elements, which can be used as a guide for manufacturers and users to develop and implement sustainable and profitable strategies for the second life batteries. The research question that this paper aims to answer is: How can second life batteries be managed to ensure its sustainability and profitability? To address this question, the paper will explore the different sub-elements of the framework.

Overall, this paper contributes to the understanding of second life batteries management, its challenges, and opportunities, and how it can be managed to ensure its sustainability and profitability. The paper's findings can be useful for manufacturers and users of batteries, policymakers, and researchers interested in sustainable and profitable solutions for the EV market.

2. Literature review

The transition towards a more sustainable and circular economy has become a crucial concern in various industries, including the EV battery market. To address the challenges and opportunities in managing second life batteries in a sustainable and profitable manner, we draw upon several theoretical perspectives: circular economy, sustainable business models, and the value creation process in the context of the EV battery market. By integrating these theories, this study develops a comprehensive conceptual framework for the second life stage of EV batteries.

2.1. Circular Economy

A circular economy is an economic system that aims to eliminate waste, reduce resource consumption, and promote regenerative practices by focusing on the continuous circulation of resources in closed loops (Geissdoerfer et al., 2017). The principles of circular economy include extending product lifecycles, designing out waste, using renewable resources, and maximizing resource efficiency (Reuter et al., 2019). In the context of the EV battery market, adopting a circular economy approach involves considering the entire battery lifecycle, from production to recycling, to ensure environmental sustainability and resource efficiency.

2.2. Sustainable Business Models

A sustainable business model is defined as a model that creates, delivers, and captures value for all stakeholders while minimizing negative environmental, social, and economic impacts (Bocken et al., 2014). Sustainable business models are crucial in transitioning towards a circular economy, as they provide a systemic approach to integrating sustainability principles into the core of a company's operations (Stubbs & Cocklin, 2008). In the EV battery market, sustainable business models involve considering the environmental, social, and economic implications of battery production, use, and recycling while creating value for all stakeholders.

2.3. Value Creation Process

The value creation process is a core element of business models, representing the ways in which a company creates value for its customers and other stakeholders (Osterwalder et al., 2005). It comprises three main components: Value Proposition, Value Creation and Delivery, and Value Capture (Chesbrough, 2010). Value Proposition refers to the unique combination of products, services, and customer experiences that a company offers to meet its customers' needs (Payne et al., 2017). Value Creation and Delivery involve the processes, resources, and activities a company uses to create, deliver, and communicate value to its customers (Osterwalder et al., 2005)). Lastly, Value Capture refers to the mechanisms through which a company generates revenue and profits from its value proposition (Chesbrough, 2010). By understanding and optimizing the value creation process, companies can enhance their competitive advantage and ensure long-term success.

2.4. Integrating Theories for the EV Battery Market

This paper integrates the theories of circular economy, sustainable business models, and the value creation process to develop a comprehensive conceptual framework for managing second life batteries in the EV market. By considering the second life stage, this framework helps companies identify opportunities for creating value while minimizing environmental, social, and economic impacts (Chirumalla et al., 2022). Furthermore, the framework enables businesses to understand and optimize the value creation process for the second life stage, leading to more sustainable and profitable strategies.

In summary, the integration of circular economy, sustainable business models, and value creation process theories provides a robust foundation for developing a comprehensive conceptual framework for managing second life batteries in the EV market. By incorporating these theoretical perspectives, this study contributes to the growing body of research on sustainable practices in the EV battery industry and offers valuable insights for companies seeking to develop sustainable and profitable strategies throughout the battery lifecycle.

3. Method

The research methodology used in this study involved a literature review and workshops with partnering companies to confirm and validate the findings.

The literature review was conducted using electronic Web of Science database to identify relevant studies and publications related to the battery lifecycle (Paul & Criado, 2020). The search terms included "battery lifecycle," "battery recycling," "battery management," "sustainable batteries," "EV batteries," and "battery second life." The search was limited to publications in English, and the inclusion criteria were relevance, quality, and recency. The identified studies were analysed, and the conceptual framework was developed based on the value proposition, value creation and delivery, and value capture elements. The sub-elements of each element were identified and defined based on the literature review findings.

To validate the conceptual framework and its sub-elements, workshops were conducted with partnering companies in the EV and battery industries. The workshops involved a series of meetings and discussions with representatives from different companies to review and provide feedback on the framework's sub-elements (Sandberg et al., 2022). The partnering companies included battery manufacturers, EV manufacturers, energy storage companies, and recycling companies. The workshops aimed to ensure the practicality and applicability of the framework's sub-elements and to gather feedback on potential challenges and opportunities for implementing sustainable and profitable strategies for the second life batteries. The feedback gathered from the workshops was analysed and incorporated into the final version of the framework. The results of the workshops were also used to identify potential research gaps and areas for future research.

Overall, the combination of literature review and workshops with partnering companies allowed for a comprehensive understanding of the battery lifecycle and its challenges and opportunities. The findings from the study provide a practical and applicable guide for manufacturers and users of batteries to develop and implement sustainable and profitable strategies for the battery lifecycle.

4. Findings

This chapter presents the findings of the study, highlighting the key sub-elements and aspects of the conceptual framework for second life batteries for EVs. The findings are organized according to the three main elements of the framework: Value Proposition, Value Creation and Delivery, and Value Capture, see Table 1.

Table 1. Business model framework and its elements for companies operating in the second life batteries market

Value proposition	Product/service	Product sales		Service/solution offer		Mix	
	Target customer (sector)	Industry		Commerce		Residential	
	Novelty	New solution		Addition to existing		Replacement of the existing	
	Solution approach	Single			Customization		
	Exclusiveness	One customer			Multiple customers		
Value creation and delivery	Key activities	Reduce	Reuse		Remanufacture		Recycle
	Customer relations	Direct sales	Distribution		Franchising		Self-service
	Ownership	Manufacturer	Customer	Battery producer	Independent actor	Joint venture	
Value capture	Revenue model	Pay per pack	Pay per use	Subscription	Sharing	Renting	State support
	Cost structure	Fix	LIB packs	Logistics	Testing	Repacking	

In this business model framework for companies operating in the second life batteries market, we present three main components: Value Proposition, Value Creation and Delivery, and Value Capture. Each of these components is further divided into sub-elements that comprehensively address different aspects of the market.

4.1. Value Proposition

The value proposition component focuses on the unique selling points of the company and consists of the following elements:

- **Product/Service:** This element deals with the offerings of the company, including product sales, service/solution offers, and a mix of both.
- **Target Customer (Sector):** This element identifies the primary customer base in terms of industry, commerce, and residential sectors.
- **Novelty:** This element emphasizes the innovative aspects of the product/service, whether it is a new solution, an addition to an existing solution, or a replacement for an existing solution.
- **Solution Approach:** This element highlights the nature of the solution provided, either as a single solution or through customization.
- **Exclusiveness:** This element addresses the company's focus on catering to a single customer or multiple customers.

4.2. Value Creation and Delivery

The value creation and delivery component revolves around the activities that contribute to the overall value of the company and consists of the following elements:

- **Key Activities:** This element involves the main activities of the company, including reducing, reusing, remanufacturing, and recycling batteries.
- **Customer Relations:** This element outlines the company's customer interaction strategies, such as direct sales, distribution, franchising, or self-service.
- **Ownership:** This element defines the stakeholders involved in the battery lifecycle, including manufacturers, customers, battery producers, independent actors, and joint ventures.

4.3. Value Capture

The value capture component focuses on the financial aspects of the business and consists of the following elements:

- **Revenue Model:** This element elaborates on the different revenue streams, including pay per pack, pay per use, subscription, sharing, renting, and state support.
- **Cost Structure:** This element breaks down the company's cost structure, covering fixed costs, lithium-ion battery (LIB) packs, logistics, testing, and repacking.

In conclusion, this comprehensive business model framework provides a structured approach for companies operating in the second life batteries market. By addressing key elements in value proposition, value creation and delivery, and value capture, companies can better understand their competitive position and make informed decisions to enhance their growth and sustainability.

5. Theoretical Contribution

The conceptual framework developed in this paper provides a comprehensive understanding of the value proposition (Osterwalder et al., 2005), creation and delivery (Bocken et al., 2014), and value capture (Chesbrough, 2010) for the second life batteries for EV (Stubbs & Cocklin, 2008; Zhao et al., 2021). This framework identifies the sub-elements of each category, which can guide businesses in developing their strategies for each stage of the battery lifecycle.

The framework developed in this paper contributes to the literature on circular economy (Geissdoerfer et al., 2017), sustainable business models (Bocken et al., 2014; Stubbs & Cocklin, 2008), and the EV industry (Chirumalla et al., 2022; Sandberg et al., 2022). It provides a clear understanding of the value chain for EV batteries, which can inform research on the circular economy and sustainable business models. Moreover, this framework can help businesses in the EV industry to develop more sustainable and profitable business models (Chirumalla et al., 2022), which can ultimately contribute to the wider goal of sustainable development.

Moreover, this research contributes to the literature on innovation and entrepreneurship within the context of the EV industry and the circular economy (Ferasso et al., 2020). It sheds light on the importance of developing novel and exclusive solutions to address the challenges posed by the rapidly growing demand for EV batteries, while ensuring environmental sustainability.

6. Practical Implications

The practical implications of this framework are numerous. It can help businesses in the EV industry to develop more sustainable and profitable business models, which can lead to a more circular economy. The framework identifies the key sub-elements for second life batteries, which can guide businesses in developing their strategies for each stage.

Furthermore, this framework can help businesses to identify potential partners and suppliers at each stage of the battery lifecycle. For instance, businesses can partner with waste management companies or energy storage

companies for the second life stage. By identifying potential partners and suppliers, businesses can ensure a more efficient and sustainable value chain for EV batteries.

Additionally, this framework can help businesses to identify potential revenue streams at the second life batteries for EV stage. For example, businesses can generate revenue from sales, service, licensing, rental, material sales, energy sales, and carbon credit revenue. By identifying potential revenue streams, businesses can develop more profitable and sustainable business models.

Finally, this framework can be instrumental in raising awareness among consumers and the public about the importance of sustainability in the EV industry, especially concerning battery usage and disposal. By understanding the value chain and the benefits of adopting a circular economy approach, consumers can make more informed decisions about purchasing electric vehicles and participating in the second life batteries market.

7. Conclusion

In conclusion, this paper presented a conceptual framework for the second life of batteries for EV. The framework is composed of three elements, value proposition, value creation and delivery, and value capture, which are further divided into sub-elements, each containing options for the different stages of second life batteries. The framework is intended to provide a structured approach for companies in the electric vehicle industry to design and implement sustainable battery strategies. By highlighting the importance of considering second life batteries, this framework aims to contribute to the growing body of research on sustainable practices in the industry. It is hoped that the practical implications of this framework will encourage companies to develop more sustainable and environmentally friendly practices, benefiting society.

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