A.H.C. Ng et al. (Eds.)

doi:10.3233/ATDE220147

Preconditions of Circular Business Model Innovation for the Electric Vehicle Battery Second Life: An Ecosystem Perspective

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Abstract. There is a strong interconnection between transportation and sustainability. Therefore, electric vehicles (EVs) have received a great deal of attention, and their sales and market share have been growing rapidly. Soon, a huge amount of EV batteries will reach their end of life that need to be handled appropriately. The second life applications are suggested as a potential solution. However, to implement such applications, there is a need to shift towards new business models, which have a central focus on circularity. Therefore, this paper studies preconditions of circular business model innovation (CBMI) for the electric vehicle battery second life from the ecosystem perspective. It also identifies current (as is) and upcoming (to be) business models. Data has been collected from fourteen companies representing the electric vehicle battery second life (EVBSL) ecosystem. Results show three types of current and three types of upcoming business models in the EVBSL ecosystem. Further, four preconditions for CBMI were found, namely, 2nd life value proposition, 2nd life value network development, 2nd life-based revenue model, and digital technologies.

Keywords. EV battery, battery second life, ecosystem collaboration, circular business model innovation

1. Introduction

Transportation is one of the major influencing factors on sustainability [1]. The fundamental interconnections between transportation and sustainability have been highlighted in various studies [2,3] specifically its footprint on the environment [4]. Hence, Electric Vehicles (EVs) are introduced as a critical part of sustainable transportation. As a result, the demand, and the market for EVs have been growing rapidly [5]. This growth has raised questions regarding the challenges of handling used batteries after their first life in the EV.

It is estimated that approximately 250,000 metric tons of EV li-ion batteries will have reached end-of-life in the next 5 years' timeframe. Inadequate handling of such batteries will not only diminish the environmental benefits of EVs but also entails irrecoverable damage to natural resources. From the suggested solutions for handling

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end-of-life (EoL) batteries, electric vehicle battery second life (EVBSL) holds the potential due to the high remaining capacity of the used batteries (around 80%) [55]. The typical second life applications include less demanding and stationary applications such as energy storage systems, solar-/wind-powered renewable systems, EV charging stations, small scale industrial, residential, and commercial applications, off-grid stationary use, mobile power use in remote or temporary locations, and older vehicles up-gradation etc [37]. The second life alternatives are also more compatible to achieve sustainability targets of the EU and the United Nations' sustainable development goals (SDGs).

To implement EVBSL, there is the need to develop new business models that facilitate this transition towards circularity. A business model describes the underlying logic an organization uses to create, deliver, and capture value to customers [6]. Business models are dynamic and develop over time resultant from the constant pressure to adapt the business itself and other drivers from the outside environment [7]. Such changes or dynamic adjustments in business models from the current ones are referred to as business model shifts, which comprises shifts such as in value propositions, customer segments, revenue streams, or resources. For example, from the study of analyzing 150 business models Van der pijl et al. [8] identified six business model shifts, which include the platform shift, the digital shift, the services shift, the exponential shift, the stakeholder shift, and the circular shift. In addition, several authors indicated business model shifts in different contexts [9–11]. Some of the prominent new business models forms that are discussed in the context of EVBSL and circularity are sustainable business models [12], circular business models (CBM) [13], sharing business models [14], or digitalized business models [15].

Although there has been a growing understanding of different business model configurations and types [12], the shifts from the current ones to the new ones are always challenging for companies, especially in switching from a linear business model to a circular one [16–18]. Even the actors' constellation in the EVBSL ecosystem related to the second life has still been evolving, since there are no commercial solutions available in the market [12]. The typical discussed EVBSL ecosystem related to the second life includes battery manufacturer, vehicle manufacturer, energy utility company, refurbisher/third-party provider, and a recycling company. Identifying the right second-life applications is challenging for several vehicle manufacturers and stakeholders in the battery value chain - specifically, identifying and designing a new business model in the battery ecosystem that is profitable [13,16]. The diversity of EVs including cars, busses, trucks, heavy-duty vehicles, and the differences in batteries such as chemistry, size, and configuration, make it complicated to gain knowledge of second-life strategies.

Hence, additional insights on the shifts from traditional business models to new business models such as CBMs in the EVBSL ecosystem are needed. There is a need for a deeper understanding of different available actors in the EVBSL ecosystem, their current business models, potential new business models in the future, and the main shifts that might be evident in terms of business models. This knowledge will not only provide a holistic understanding of business model transitions in the EVBSL ecosystem but also indicate how to guide actors in the EVBSL ecosystem in such transition. Therefore, the purpose of this study is to identify the preconditions of CBMI in the electric vehicle battery ecosystem for second-life applications.

The study is based on explorative interviews and workshops with the key actors in the EVBSL ecosystem. The study contributes to the discussion of CBM, or business model innovation (BMI) literature related to the battery second life.

The remainder of the paper is structured as follows: Section 2 presents the theoretical background related to the focus of this paper, and section 3 explains the research methodology. Section 4 describes the empirical findings and finally, the paper discusses the major implications of this study.

2. Theorical background

Companies already understand the need for BMI to ensure survival and growth as they deal with an external threat of continual innovation [19]. BMI comprises changing 'the way of doing business, rather than 'what you do', hence, going beyond products and services [20]. BMI is about having a different approach to create, capture, and deliver value. It is concerned with developing novel configurations of the business model by changing one or more components of it [21]. BMI also includes shifting the focus away from developing individual configurations towards creating new systems. BMI may be a key point in changing businesses towards more sustainable development [22]. Therefore, the current focus is on transitioning from linear business models (LBM) or "the old way of doing things" to enable circular strategies and in consequence create greater environmental and social value while delivering economic sustainability.

The CBM is an emerging field of research [24] that contributes to the mission to achieve sustainability and reduce the carbon print. A CBM is a business model concept that captures, creates, and delivers, according to the principles of CE [9]. The focus of such business models is to close, narrow, intensify, slow, and dematerialize the material loops [10,11]. CBMs incorporate co-creating value propositions with the customers by including the environment and society as equal to all the other stakeholders' interests [17]. The concept is more recent in comparison to the original concept of circular economy. The concept of CBM was introduced in 2006 in an article by [12] which studied different business model types for circular value creation [10]. Organizations can take diverse approaches to develop their CBM. Such approaches for CBMs can be categorized into strategies to slow loops (prolonging the life of the product), close loops (recycling of used products and materials back into the economy at the end of their functional life), and narrow resource loops (designing products, services, and systems for resource efficiency) [25]. Geissdoerfer et al. (2018) further extend this view with additional two resource loops, namely, intensifying resource loops, and dematerializing resource loops [26].

In addition, there are also business models proposed under the umbrella of Product-Service System (PSS), describing a shift in manufacturers' strategic focus from selling a physical product to selling its performance or availability [27,28]. The type of value embedded in the business offering (mainly product- or service related) is chosen as the main criterion for this classification, which gives in total 8 types of PSS category [27]: 1) product related, 2) advice and consultancy, 3) product lease, 4) product renting/sharing, 5) product pooling, 6) activity management, 7) pay per service unit, 8) functional result.

Finally, digitalization and digital technologies (e.g., Internet of Things, Cloud computing, Big Data, Artificial Intelligence, Blockchain) are seen as key enablers for upscaling the circular economy and the transition [29]. The smart circular economy framework proposed by [30] establishes a link between digital technologies and sustainable resource management, which guides how to leverage data and analytics to maximize circularity (i.e., optimizing functionality and resource intensity). Similarly, Jiao and Enans (2016) explored PSS evolution in the era of Industry 4.0 and discussed

how these advanced technologies could enable a wide variety of improvements to the existing PSS offers, entailing the possibility of making them digital and more connected [31].

Concerning EVBSL business models, the literature is still evolving. Jiao and Evans [13] identified three important factors essential for functioning EVBSL business models: battery ownership, inter-industry partnerships, and policy support [32]. Moreover, implementing second-life batteries and the relevant applications and enhancing the recycling rates involves overcoming various challenges such as economic and technical barriers; companies can overcome such challenges by adopting CBMs and employing circular strategies [8]. Reinhardt et al. [12] conceptualized the EVBSL business model framework that embodies the cross-sector multi-stakeholder impact and the shared value creation mechanism for the EV industry and emerging battery second life market. They emphasized that second life applications can be implemented by taking a multi-stakeholder network-centric business model design compared to traditionally firm-centric models, which ultimately refreshes the traditional business models on sustainability.

Various CBMs are identified in the literature, from which the main types for the EV batteries include “remanufacturing”, “repurposing” and “recycling” [33]. To choose the right option, firms need to consider several factors, including technical and economic aspects of each CBM in addition to its contribution to their CE goals [34,35]. The use of batteries for the second life in different industries is still in its infancy [36,37]. The key elements of the CBMs such as the value proposition and roles within the stakeholders are still unclear [36,37]. Therefore, by changing the elements of the existing business models [21,24], new sources of value creation can be developed.

3. Methodology

This study has adopted an explorative qualitative approach, following mixed methods for data collection, including semi-structured interviews and workshops. This study is started by reviewing the existing literature. A narrative literature review is conducted to primarily get a grasp of the current perspectives and the related state-of-the-art. It also helped to formulate the research objective and develop the research steps. Following the process, a comprehensive set of 14 interviews and 10 workshops were conducted with the key ecosystem actors, who represent 14 companies. Moreover, at least two interviewers participated in each conversation. All meeting sessions were recorded using online meetings applications (ZOOM and Microsoft Teams). After the collection of audio and video files, they were transcribed and rechecked to ensure the quality of the transcribed text. The empirical data was analyzed based on the thematic analysis method. Reports of the finding from the empirical data were communicated to partner companies and checked by the interviewees to ensure precision and quality.

Through the analysis, three existing business model concepts, three potential CBM concepts, and four preconditions in the EVBSL ecosystem were identified and categorized. The identified concepts, shifts, and preconditions were further revised and discussed in the researcher panel team to refine the outcomes and enhance the transparency of the outcomes. And finally, discussions and suggestions for future research related to EVBSL were provided.

4. Findings

Throughout the literature, researchers mean different things when they mention the concept of business models [7]. However, this is a fixed part of almost all business model concepts that it is the rationale behind how a company works to provide a specific value and generate revenue [38,39]. 14 extensive interviews were conducted with the major EVBSL ecosystem actors to gather empirical data. Three main elements are extracted through the interviews with the companies. First, the current linear business models, second, upcoming circular business models that companies are moving towards. And third, the preconditions for such CBMI. As figure 1 illustrates, current business models are influenced by new shifts based on some preconditions, which are leading actors to potential CBMs. These shifts are fundamentally impacting the EVBSL ecosystem.

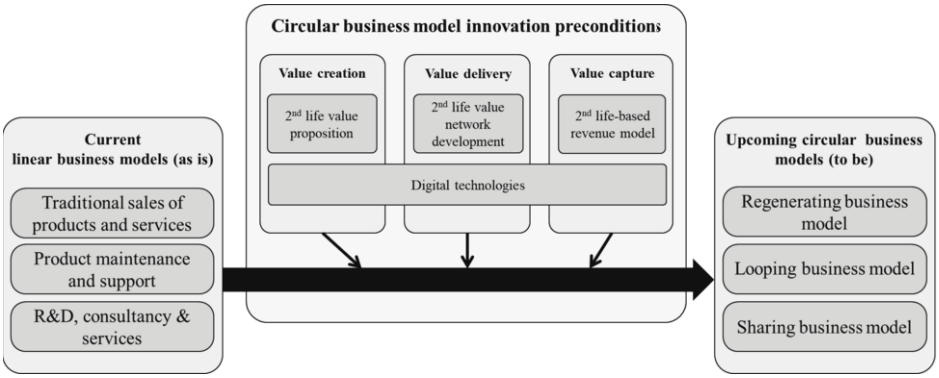

Figure 1. Current and upcoming business models and the CBMI preconditions

4.1. Current linear business models in the EVBSL ecosystem (as-is)

A business model is foundational to any company since it leads to understanding, analyzing, communicating, and managing strategic choices [38,40] and helps the company to generate revenue [41,42]. The basic idea of the business model concept is that it should describe the specific value proposition of the company and how it can be implemented [43]. This concept becomes even more important for companies that are considering a shift in their business model and modifying it to generate new revenue streams or increase market adaptability. As mentioned in the methodology section, explorative interviews have been conducted with 14 actors in the EVBSL ecosystem to identify the current and potential CBMs (see table 1). Some companies have more than one role in the ecosystem and as a result, they have several offerings and business models for them. First, the offerings of each company are identified, and further their business model and value chain role are discovered. In this regard, three main business model concepts are identified for the EVBSL actors that include: traditional sales of products and services, product maintenance and support, R&D, consultancy, and sustainability services.

Table 1. List of interviewed companies, current offerings, offering category and the type of the actor

Company code	Current offerings	Offering category	Ecosystem actor category
A	Construction equipment and technologies	RDS, Trad	Original Equipment Manufacturers (OEMs)
B	Mining and infrastructure equipment	Trad	
C	Transportation technology, mobility solutions, ERTMS	RDS, Trad	
D	Green batteries	Trad	Battery manufacturer
E	Recycling, battery parts	RDS, Trad	Recycling companies
G	Recycling	RDS, Trad	
F	Vehicle parts, remanufacturing	Trad, PMS	Remanufacturer
H	Energy management solutions, Smart city applications	RDS, Trad	Energy utility companies
I	Energy and power sales, ESS	Trad	
J	Charging infrastructure, Power as a service (PaaS)	Trad	
K	Energy and power sales, environmental services	RDS, Trad	
L	Wire harness, consultancy	PMS, RDS, Trad	Material supplier (battery parts)
M	Residential properties, R&D	RDS, Trad	Construction & housing
N	City transportation	Trad	Transportation

Trad: Traditional sales of products and services
PMS: Product maintenance and support
RDS: R&D, consultancy, and sustainability services

- **Traditional sales of products and services:** Almost all ecosystem actors in our research traditionally provide products and services. This is the base business model for the actors in the ecosystem. Each actor, based on its role in the ecosystem, pool of customers, and relationships with other actors, provides specific products or services that form the basis of its business model and other offerings are built on top of these products and services. OEMs including companies A, B, and C, are consecutively providers of construction, mining, and transportation equipment and technologies. All three are among the most renowned brands of the world in their area and have a very large pool of customers with billions of dollars of annual turnovers, all of which are based on the sales of their products. As another example, company H is an internationally renowned brand that provides a variety of services including energy management solutions, simulation, and digital services.

- **Product maintenance and support:** Several companies provide product maintenance and support as part of their business model. Although there is no company whose business model relies solely on maintenance or support of their product, many companies provide that, especially for their products that are already sold to their customers. This type of business model is more prevailing for companies who have traditional sales of products and services as the basis of their business model, as explained in the previous section.

- **R&D, consultancy, and sustainability services:** According to the empirical results, several companies have business models based on R&D, consultancy, and sustainability services. Company M for instance, who is a provider of residential facilities and buildings, works on many R&D projects within their organization. This company owns apartment buildings in a Swedish municipality and has partnerships with startups and solar energy companies. Therefore, R&D projects are conducted in parallel with other projects related to their business models. Company L has a major focus on consultancy as a part of its business model. This company is a contract manufacturer of cables and harnesses in the ecosystem, however, selling consultancy is a major part of their business model due to their experience in the area. "We are selling our consultancy of knowledge in the wire [and] harness area. And then we move over to prototype building [for customers]". Interestingly, some companies have already incorporated sustainability into their business models. Such business models chiefly focus on recycling, smart applications, energy management systems, and so forth. Company E is a global materials technology and recycling firm. Their business model has three main pillars. First, the production of automotive catalysts which is a large part of the business model resulted in one in every three cars in the world having a catalyst with their brand. Second, energy and surface technology (battery materials) where they make cathodes and sell them to battery makers and finally recycling. They focus on main waste streams and extract about 20 different types of metals. According to the company representative, they are one of the renowned gold producers without owning a gold mine. Their experience with recycling has made a reputation for them and they work with many customers around the world. Company G is also a recycler, and its business model is mainly based on industrial recycling activities. Currently, they focus on two main areas of recycling and second life, and they are active in three main markets; miscellaneous industrial systems, OEMs which are their biggest customers, and the end-of-life market. There are other examples of this type of business model such as company K providing environmental services, and company H providing smart city applications.

4.2. Upcoming circular business models in the EVBSL ecosystem (to be)

The empirical results reveal a movement towards CBMs by actors in the EVBSL ecosystem. Companies are feeling the need for utilizing the circular opportunities and they are innovating their business models to harness this power. Three categories of upcoming CBMs are identified:

- **Regenerating business models:** Energy infrastructure as a form of circular supplies [48,49], has emerged as one of the key themes in the discussion of potential new business model scenarios. OEMs (companies A and C) and energy utility companies (companies H, I, J K) are pioneers of utilizing this type of business model. According to them, infrastructure-related business models could provide possibilities to offer total energy management solutions to their key customers in the form of lifecycle care battery infrastructure, and network development. Providing such offerings is even more facilitated with the advancement of digital technologies, which provide possibilities to capture, store and manage data to enable remote monitoring services. Few OEMs and

energy utility companies see the possibilities to develop charging infrastructure solutions to fulfill their customer demands and their expectations on productivity. The infrastructure solutions can be built closer to the customer premises or different parts of the city in a sustainable way to improve productivity and performance. This type of sustainable product location [49,50] is also another business model that companies are moving towards.

- **Looping business models:** loop-based business models [49] have emerged from the idea of keeping products and materials in closed and extended loops as much as possible. The empirical results show two main types of loop-based business models in the EVBSL ecosystem: remanufacturing and recycling [48,51]. Remanufacturing is a concept that is not only mentioned by some companies as their new business models but also is an influential part of the EVBSL value chain as well. Company F is already a remanufacturing company however, they are planning to expand their business and incorporate 2nd life batteries into their processes. Also, company A is working on remanufacturing the batteries and to be a part of the 2nd life battery remanufacturing business. On the other hand, companies C and E are more focused on enhancing recycling and the extraction of materials and collecting batteries for 2nd life applications. One of the most important points revealed by our empirical results is that several companies have already started working on developing new CBMs. For some, this is at an early stage such as reviewing and developing ideas internally, for some, this is already evident in the current business model. However, the latter situation is rarer. Company E for instance, they are already closing the loops by recycling the resources and providing different options for their customers, which is convenient for them. They offer three options to the customers. First, they can recycle the materials and sell the extracted metals in the market on behalf of the customer. Second, they can recycle the materials and buy them directly from the customer. And third, they can deliver the recycled material to the customer. However, their new business model will have some shifts, in terms of increasing efficiency and effectiveness in closing the loops, "strengthening the companies impact on material extraction and recycling" and enhancing the relationship with their customers.

- **Sharing business models:** the third category of business models addresses the sharing idea. Share-based business models intend to maximize the utilization of products by sharing them among users [49]. Empirical results reveal two types of share-based business models: gap exploiter [52,53] and leasing [49,54]. One of the popular new business models that companies are showing interest in is battery leasing. Different ecosystem actors realize their part differently in such a transaction and therefore, define their potential business model following their part. Battery leasing also called battery as a service (BaaS) could be seen from two sides according to our empirical results. First, being the owner of the battery and leasing the battery out to the user. Second, being the user of a leased battery and using it as a service during a specific period. Company J, which is a power company, showed interest in the total value chain of the batteries and electrification of transportation. In the new business model that they are shifting towards, their role is the owner of batteries, and they intend to lease the battery to the battery users. Companies H and M on the other hand, see themselves as

user of 2nd life batteries. While the former is also interested in simulation, data processing, optimization of the batteries, the latter is interested in collaborations with charging station companies as partnerships. Finally, company B is moving towards BaaS as well. They are interested in the separation of the ownership of the battery from the rest of the vehicle. "If we make the batteries its business line and then we can focus on it, a contract that and we can make that grow, otherwise it will not grow because it's only going to be a part of the machine" (company B's representative). The gap exploiter business models are based on utilizing the opportunities caused by other actors' activities and business models [53]. An example of these types of business models is the third parties and facilitators in an ecosystem. In the EVBSL ecosystem, third-party business model concepts include middleman and battery sorting and analysis business models. Company I who is a provider of power and ESSs, intends to utilize its large pool of customers and act as a middleman and develop a new business model concept based on this role. Moreover, company G intends to take control of most 2nd life processes and analyze sort and group the batteries for the end-users of the batteries.

4.3. Preconditions for circular business model innovation

Circular innovation in business models requires changes and modifications in the business models elements. These changes turn each of the business model elements into a new one where a new type of circular value can be created, delivered, and captured. The empirical results reveal these changes for each of the business model elements as follows:

- **Value creation-2nd life value proposition:** The first identified precondition is the value proposition based on the 2nd life batteries. This element concerns the movement of ecosystem actors towards circularity with the centrality of 2nd life batteries for value creation and proposition. In this sense, batteries are the central element in closing, narrowing, and slowing the loops. Employing batteries in a 2nd life application prolongs the use period of the battery, which represents the slowing phase. Analyzing, sorting, and grouping the batteries for such applications leads to more efficient use of the batteries and represents the narrowing phase. And finally, enhanced recycling and continuous use of the materials represent the closing phase.

- **Value delivery-2nd life value network development:** The second precondition that the empirical analysis reveals is the development of value networks for the 2nd life applications. This has been evident specifically by the inclination of the EVBSL ecosystem actors towards network-centric business models. Actors develop new business models in the network to define their value creation and appropriation [44]. Fundamentally, any alteration in a business model will represent a change in the firm's relationships, and ultimately, a change in other firms' 8business models, which implies the importance of networks and relationships in the business model concept. However, the shifts towards network-centric business models in the EVBSL ecosystem are getting pace recently, because of the need for cooperation, collaborations, and joint ventures

in the next 5 to 10 years. Similarly in academia, the idea of network-centric business models is an emerging theme to analyze the value creation between different stakeholders, moving beyond the boundaries of an individual company [45]. Current literature views the concepts of "network business models", "networked business models", "network-centric business models", "network-embedded business models", and "ecosystem business models" similarly [46] and defines a network-centric business model as "a collective business model which "guides how a net of companies will create customer and network value by developing a collective understanding of the business opportunities and shaping the actions to exploit them" [46,47] and finally deliver them through cooperation and competition.

- **Value capture-2nd life-based revenue models:** Another shift in the ecosystem actors' business models which is also related to the 2nd life value network development, is value capturing through 2nd life-based revenue models. As mentioned, the upcoming business models are based on different value propositions. This allows the EVBSL ecosystem actors to capture value through new and innovative ways that have not been possible before. These revenue streams include revenue from leasing 2nd life batteries or products made by them, increased profit margins due to using 2nd life batteries with lower costs, recurrent revenues from service contracts of 2nd life batteries, revenues from recycling and remanufacturing batteries, etc. Moreover, circular value capturing can include exploring new markets and incorporating product service systems (PSS) into the business models. Empirical analysis of the data shows that several ecosystem actors are exploring new ways of expanding their offerings. From the explored options, product-service systems and after-sales services and consultancy are notable. The expansion of the boundaries of the firm and accordingly the business model requires more collaboration among the actors. Several companies mentioned that they are looking for or are already part of joint ventures or collaborations with other actors. For instance, company I is collaborating with company D, company H has a multitude of collaborations with power companies across Sweden, and company B has a partnership with companies D and H. It is also noteworthy that expanding the boundaries can entail higher levels of competition in the ecosystem. This can finally lead to lower costs of services and a larger variety of options for the end-users.

- **Digital technologies:** One of the most important preconditions for CBMI is the utilization of digital technologies. Seven out of 14 companies have directly mentioned the importance of this factor in their businesses and the fact that they are looking for ways to incorporate such technologies in their business model. The reason for this is primarily the importance of data. With the emergence of new tools, systems, and products, huge sets of data are produced. These big data sets, need to be gathered, analyzed, stored and shared inside the focal firm as well as the ecosystem. That's when technologies such as IoT (for data collection and connections), AI (data analysis, optimization, etc.), Blockchain (data storage, authentication, communication, transfer, bookkeeping, etc.), and cloud computing (data storage, analysis, etc.) come into play. Company C's representative mentioned: "I guess it depends on what you mean by industry 4.0 …But in terms of monitoring and you know, collecting data on the operation,

that is certainly something …we are looking to". Or company J's representative mentioned that: "Big data from batteries on cycling and performance, state of health, state of charge and how it has varied over the whole lifetime of the battery, from new battery to leaving first life application, temperature… temperatures …that's big data and you need digitalization to collect that data". other use cases of such technologies are also mentioned by other companies such as communication with customers, optimization, simulation, and so forth. Therefore, the upcoming CBMs in the EVBSL ecosystem will rely heavily on the digital technologies.

5. Discussion and concluding remarks

The age of electromobility is upon us. The exponential growth of used EV batteries that are no longer usable in vehicles will happen soon. Therefore, there is a need to handle such batteries. Among the available solutions, EVBSL holds great potential [31,11,32] references since it leads to closing, narrowing, slowing, and intensifying the material loops [55], lowers the upfront cost of EVs, and positively contributes to the environment. To implement EVBSL, new business models are needed that comply with the principles of the circular economy. To support the ecosystem actors to transition towards CBMs, first, the existing and upcoming business models should be identified. This study addresses the current gap in the literature by conducting extensive explorative interviews with key ecosystem actors and identifying the current business models, upcoming CBMs, and the preconditions for shifts in the business models. Four preconditions are identified, namely second life value proposition, second life value network development, second life-based revenue model, and digital technologies.

Moreover, the following suggestions, are provided for future research in this area. Developing or innovating business models is followed by identifying tactics for implementation. Tactics are "the residual choices open to a firm by virtue of the business model that it employs" [56]. Therefore, studies on identifying relevant tactics in the EVBSL ecosystem are recommended as there is a gap in the current literature. The development of new CBMs in the EVBSL ecosystem is deeply dependent on policies and regulations. Thus, research on regulatory and policy factors affecting CBMs for the EVBSL ecosystem is necessary soon. Currently, the actors in the EVBSL ecosystem have a scattered and unstructured approach towards partnerships and cooperation. Therefore, conducting research that focuses on the ecosystem actors to form alliances, partnerships, and joint ventures is highly suggested. Like other industries, data has become an important asset and leverage in the EVBSL industry. New industry 4.0 technologies are among the strongest tools to employ the power of data. However, current literature is noticeably limited regarding the latest advancements in such technologies and their applications on new CBMs in the EVBSL ecosystem. Artificial intelligence, blockchain, IoT, cloud computing, and smart manufacturing are critical areas and technologies that need immediate attention from researchers to be addressed in this context.

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