DEVELOPING NEW BUSINESS MODEL IN CASE OF PURE ELECTRIC BUS (PEB) IN CHINA

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This thesis analyzed the environmental development of Chinese pure electric bus (PEB) industry. It indicated that the main problems which blocked the PEB promotion are the immaturity of battery technology and the lack of a suitable business model. According to current battery technology, the solution should be designing new business model for PEB then gradually enhance PEB function.

This study analyzed the original Chinese PEB business model, which was based on the three different periods for the PEB commercialization roadmap. The main characteristic of Chinese PEB original business model is that the public transport company operates independently during the whole PEB life cycling, including PEB purchasing, operation, maintenance and disposal. Such structure would cause problems, such as: higher purchasing cost, the second purchasing for the power batteries, state subsidies do not form an effective incentive for comprehensive benefits, and PEB driving range cannot meet the actual capacity needs. Such problems are the main reasons to block Chinese PEB promotion.

To solve the issue of the original Chinese PEB business model, a new business model is designed with the separation purchasing between vehicle and battery. The public transport companies should purchase only the vehicle without the battery included. As previously, the charging infrastructure would be constructed from the fund by the National Grid (Energy Company). Furthermore the National Grid would also lease the battery from the battery manufacturers with unified battery management. The public transport companies could then replace the battery according to the PEB operation needs and pay the energy company by battery usage and electrical energy cost. It is also recommended to have the original optimized program under the new business model structure, which includes subsidy program, financial program, and the whole vehicle purchasing mechanism. The new business model went through the pure electric bus (PEB) value network analysis and was assessed as reasonable with the value creation activity flow.

The new business model suggests several proposals for the vehicle design, the PEB charging, PEB operation, PEB marketing, PEB service and PEB recycling aspects. All these proposals were implemented to the Tianjin bus line 638 in real market case.

The comprehensive PEB benefits concern three aspects: economical, social and environmental. In addition, the enterprises from whole PEB industry value chain were evaluated for their own benefit effects. These evaluations constructed the whole PEB implementation appraisal system. The evaluation results showed that under new business model, the benefits for PEB in economic, social and environmental perspectives are higher than the ones under the original business model. The new business model would inject new vitality to the industry value networks, which could be operated effectively and also promote the interests of all stakeholders by benefited from the industry networks. A win-win situation can be achieved.
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1 INTRODUCTION

1.1 The background of the research topic

1.1.1 The introduction of new energy bus

During the high speed development occurring over the whole world the last decades, more and more energy and environmental challenges came up, thus the development of new energy vehicles has become the world’s auto industry direction. To solve traffic congestion problems which was caused by the city population rapid increasing, many countries have put priority to public transportation. New energy buses became the focus and priority area for the development of new energy vehicles for the whole world (Chen et al. 2008).

In accordance to the definition of new energy vehicles, generally new energy buses can be divided into three categories: Pure Electric Bus (PEB), Hybrid Electric Bus (HEB) and Fuel Cell Electric Bus (FCEB) (Chen et al. 2008).

HEB integrates two powered engines by fuel motor and battery motor. With the balance usage of these two powered engines, it optimizes engine operation and makes a significantly higher fuel economy and provides lower emissions in comparison to the traditional vehicles. But HEB cannot avoid the dependence on oil. Therefore HEB can only be considered as a transitional product for the next period of the public transport.

FCEB is based on the electrochemical reaction of hydrogen and oxygen. The final product is water without any pollution problem. There would be many ways for the preparation of hydrogen. Most likely it would become future ideal public transport, but still many technical problems remain such as poor power, short life and very high cost. So it is difficult to apply it for a wide use in the near future.

PEB uses the electric battery as the only power source. Electric power can be produced in many ways. Electric power gets rid of the dependence on oil, and also helps to optimize the country's energy structure. More importantly, the PEB
technically more suitable for city bus especially. Firstly, the city bus has to stop and go frequently, which is unfavorable for the traditional diesel-powered bus. PEB can charge the battery using the whole vehicle kinetic energy during braking or gliding, which can save huge amount of energy. Secondly, PEB daily driving distance is relatively short comparing with other vehicles and with a fixed driving route. In most cases it is less demanding on the driving range. The charging station construction is relatively solid. Therefore, the supporting facilities could be easily managed and improved. Again, PEB's low noise and low emissions characteristics could just meet urban environment demands. Thirdly, pure electric bus can be charged during the evening outage. It not only has the benefit for the country power grid by load shifting effect, but it can also save a lot of costs.

1.1.2 The general status of pure electric bus (PEB) in China

Except the common technical advantage of pure electric bus (PEB), there are few specific development opportunities for Chinese PEB (Chen et al. 2008, Chen 2011).

1. **Marketing view:**

China has the world's largest transit bus market with over 40% world market share. The Chinese public transport industry is facing the same dilemma than the vast majority of bus companies: fuel costs accounted for 80 percent of all bus companies operating expenditures. With the oil price continuous rising up, the bus usage cost would also go higher and higher. In addition, with the increase of urban population and ageing of people, there is a rapid growth in demand for buses. Although state subsidies are constantly improved, this operating cost pressures is still increased every year. With pure electric bus, fuel costs can be reduced by more than 80%, greatly reducing the financial pressures for the public transport company.

2. **Technology and resource view:**

In China, few PEB key technologies have made a breakthrough progress, such as in battery, drive motor, vehicle network communication and the system matches, etc. Nowadays, China has independently developed Nickel-metal hydride (NiMH) and
lithium-ion battery products which satisfy PEB requirements. The battery energy and power densities reach the international standards. Such technologies also break the bottleneck of battery safety hazards and achieve a large-scale applicability. The bus drive motor also has a high performance, in which the power and efficiency ratio reached the international advanced level. These advanced battery and drive motor created the foundation for the entire pure electric bus development. China has fully mastered pure electric bus core technology with 158 mature products (ZhengZhou YuTong Bus Co. Ltd Internal Report 2012). All those products demonstrated their large-scale application during the activities such as Beijing Olympic 2008, Shanghai World Expo 2010, and inside China “Ten City with 1000 PEBs” project. In addition, China has essential resources for the PEB development. The rare earth material is the raw resources of the permanent magnet for drive motor. China's rare earth reserve is the first position in the world. The lithium reserve is the second position in the world, which is the anode material for lithium batteries. Those material reserves provide the necessary requirements for the PEB industrialization in China.

3. Economic and social view:

Currently the Chinese economic is in the critical period from extensive to intensive growth mode transformation. PEB development would be beneficial for the improvement of the product output, quality and efficiency by the advanced science and technology. Therefore the economic growth would be in higher output and efficiency with lower investments and consumption, which is the important strategy for the national economic growth mode transformation. Because it faces the increase of serious energy and environmental problems, the Chinese government provides a lot of support to the development of new energy vehicles from the policy level. The State Council has made it clear that the new energy vehicles are included in one of the country's seven strategic emerging industries. The Science and technology Ministry released “National 12th Five Year Plan for Science and Technology Development” (Chinese policy document 2011) and "Electric Vehicle Technology Development 12th Five Year 5 Special Regulations Scheme” (Chinese policy document 2012a). The Industry Ministry issued the "Energy-saving and new energy automotive industry development plan (2012-2020)” (Chinese Policy Document 2012b). All those plans had the detailed deployment for the technology roadmap and
new energy vehicles industrialization. Under the guidance of central policies, the government has also introduced a number of policies and measures at all levels to encourage the local development of new energy vehicles, which created better atmosphere for the rapid PEB development.

1.1.3 The Chinese pure electric bus (PEB) development problems

PEB is very suitable for the city public transport and can create value from a technological point of view. Also, from the above macro environment analysis, it can be said that China PEB is in the best period of development. Many companies have done a lot of preparation before the technical reserves and industrialization. But the commercialization of PEB promotion did not meet the expectations of many industrial experts. The state project "energy-saving and new energy vehicle application engineering demonstration" was started in February 2009. It was planned to promote all types of new energy vehicles (in total 51707) during three years. But at the end of 2012, the real total number for all types of new energy vehicles was only 31078. And the PEB number was less than 3000 (ZhengZhou YuTong Bus Co. Ltd Internal Report 2012).

Through the investigation and research for the state promotion project, it was found that the main problems of Chinese PEB development were as follow:

(1). The PEB market price is too high and cannot be accepted by most public transport companies. Because of the technological complexity of PEB battery, PEB had to be installed with multi-battery in order to meet the continued driving mileage requirements. The high cost of multi-battery increased the PEB price. Meanwhile, the own weight of PEB was also increased. Therefore the energy cost per hundred kilometers was also increased. Although the operation cost of PEB was only one third of conventional bus, but the much higher purchasing price has weakened the PEB demand for the most of public transport companies.

(2). Battery life is short and it needs to overcome the technical bottlenecks. Battery is the power source of PEB, it has also been a key factor restricting the PEB development. From the survey results for PEB operation in Zhengzhou, Shenzhen,
Hefei and other cities, the battery decay is approximately 10% per year (ZhengZhou YuTong Bus Co. Ltd Internal Report 2012). So if one PEB battery driving range for the first year is 100km, the second year would be 90km, and then the following third year would drop around 80km. The battery warranty period ends after the third year. The new battery purchase increases the cost.

(3). There are not enough supporting services. For examples, for a large scale PEB promotion, the routine charging stations are the must-have services. But from the existing battery charging characteristics and the high cost of the charging station construction, there is no profitable attraction for the investors. Currently, only in Beijing, Shanghai and some other cities there are few demonstrating charging stations, which were built under the support from national electric grid.

(4). There is no suitable business model, which is the most important problem for Chinese PEB development. PEB is quite new in China and it concerns complex and multi-layers systems. There is no existing business model as reference. The old business model was concerning only the public transport company and the national electric grid. Despite the support of the government and the compensations, there is no observable market value for both stakeholders. There is an urgent need for the new business model. With the new business model, each enterprise of value chain could profit from a reasonable allocation and get what they want. Further businesses and capital would be involved, and jointly promote the PEB commercialization as soon as possible, and would create value for whole society.

### 1.2 Business model perspective

Business model was another current hot topic, which had a widespread use for decades (Zott, Amit & Massa 2010). With the new technology emergence and development, the term has gained prominence attention by both practices and business scholars. Business model is defined simply as “how the business makes money”. It is the accumulation of all of the sales, marketing, operations, administration, R&D, finance, and everything else that goes into a business -- all the strategies and tactics -- that determine if the company makes or does not make money. Although business models have been integrated to trading and economic
behaviors since pre-classical times (Teece 2010), nowadays the business model study is becoming more and more a cutting-edge issues and a hot topic. Related researches have focused on it for the past 15 years (Zott, Amit & Massa 2010). According to the current literature, there are many studies about the definition of the business model, the approaches of business model, the business model design and innovation, and the successful key factors for implementing the business model structure. However, because the researchers were from several different perspectives, the basic concepts of business model, structure, system, theoretical aspects had different understandings. According to Zott, Amit and Massa latest review paper (2010), they listed three main interest area for business model study; 1) e-business and the use of information technology in organizations; 2) strategy issues, such as value creation, competitive advantage, and firm performance; and 3) innovation and technology management.

The present study will focus on the business model with the strategy issues, especially with the value creation. The new digital economy has provided to the firms the possibility to renew their value creation mechanism with networked markets (Zott, Amit & Massa 2010). The networked markets could be the firm and its partners. The redefinition of value used the concept of business model to explain value creation in networked markets. The re-configuration of value chain is also necessary for the new value creation mechanisms. The concept of the value network was developed from the original value chain. The value chain was firstly issued by Porter (1985, 1986), which describes the sequence of activities performed by a firm in the process of adding value to its product and delivering value to the customer. The original value chain concept set up the firm as an autonomous entity. In the networked world (Mansfield & Fourie 2004), this original concept is not enough to capture the value creation, in which firms are more and more embedded in networks of social, professional, and exchange relationships with other individuals and organizational networks. The concept of value network addresses the increasing complexity and intricacy of inter-firm relationship. Value can also be created through revolutionary business model. According to Hamel (2000), to grow and develop in the age of revolution, companies must adopt a new, radial innovation agenda, and develop new business models. One of the primary characteristic of new business models is that both value creation and value capture occur in a value network, which
can include suppliers, partners, distribution channels, and coalitions that extend the company’s resources.

This study is based on the current theories and research results for business model in a value network, analyzing deeply the important factors of each participant in the value networks through the business model renew development process. The study was focused on Chinese PEB case during the development of a new business model, which including the new business design, new business implementation, and new business evaluation. This case study would be an additional proof for the concept about value network.

1.3 Study questions

The research question of this study can be presented as the following:

*How does the new business model develop for pure electric bus (PEB) in China under value network concept?*

The solution to this research question is generated through finding answers to the following sub-questions:

1. *What are the structures and the problems of the Chinese PEB original business model?*
2. *How to design new business model for Chinese PEB under the value network concept?*
3. *How to implement the designed new business model to Chinese PEB industry?*
4. *How to evaluate the designed business model for Chinese PEB industry?*

The first sub-question will assess the problems and challenges of Chinese PEB development. The second sub-question will list the main impact factors to the business model of Chinese PEB, and how to combine them through a new way especially under the value network concept. The third sub-question will show the detail implement steps for the new designed business model in practices. The fourth and last sub-question will list one detailed example for the evaluation of the new business model from social and environmental points of view.
1.4 Structure of the research

This paper starts with the first chapter introduction, which describes the background of this study and the research questions. Chapter 2 presents the theoretical roots. It reviews the business model and its renovation, the business model design through the networked value creation, and the business model evaluation systems. Chapter 3 is the methodological research description. It reviews the case study method with qualitative research, deductive view of the relationship between theory and empirical data, data collection and data analysis methods. Chapter 4 describes the old business model for Chinese PEB. Chapter 5 provides the new business model for Chinese PEB. Chapter 5 listed the detailed implement methods for the new designed business model for Chinese PEB. Chapter 6 describes the evaluation results from the detailed implement example. Chapter 7 is the final conclusion for the research questions and the suggestions for the future study.
2 BUSINESS MODEL LITERATURE REVIEW

The literature overview of the business model is presented in this chapter. Mainly it includes three parts: the definition of the business model; the business model design, and the evaluation systems of business model. Based on these literature reviews, it forms the theoretical framework for this study according to the research questions, which will be summarized in the last of this chapter.

2.1 Definition of business model

Since the “business model” has been emerged, there is no generally accepted definition for this term. It is somewhat unexpected that the business model is actually studied without a clear definition of the concept (Zott, Amit & Massa 2010). The current available definitions have been defined and conceptualized differently with respects to different focus. Zott, Amit and Massa (2010) and Baden-Fuller and Morgan (2010) have studied the different definitions and listed them in their papers. Burkhart et.al. (2011) study shows that business model considers static as well as dynamic aspects. They can be mainly divided in two perspectives: static view and transformational perspective (Enev & Liao 2014).

Static view by constituent-component Model

The static view of business model provides a clear framework view of the constituent component which allows the act of creating, capturing, and delivering value. According to the studies, almost half (44%) business model definitions are explained by the listing of components (Zott, Amit & Massa 2010). Osterwalder et al. (2005) suggested the definition as: “A business model is conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm”. Osterwalder et al. (2005) put forward that business model consists of nine building blocks, and expressed it by so-called “Business Model Canvas”. The nine building blocks are rooted by four cornerstones: 1. Product (with value proposition); 2. Customer interface: it contains target customer, distribution channel, and relationship; 3. Infrastructure management: it considers value configuration, core competency and partner network; 4. Financial Aspects: it composes cost structure
and revenue model. The detailed nine building block can be included as: value proposition; customer segments; customer relationships; channels; key activities; key resources; partners; cost structure; and revenue streams. Johnson (2008) suggested that business model consists of four interlocking elements to create and deliver value. These are: customer value proposition, profit formula, key resources, and key processes.

**Transformational perspective by activity-system model**

Differently from static point of view, the transformational perspective issues the managerial questions on how to realize the value creation and value capture activities (Demin & Lecocq 2010). In Amit and Zott earlier work (2001) it was suggested that business model could be defined as “the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities”, and they further conceptualized it as activity-system “a system of interdependent activities that transcends the focal firm and spans its boundaries”. Interdependencies among the activities are central to the concept of an activity system, and are created by the firms who shape and design both the organizational activities and the links connecting activities together into the system. Such purposeful design is performed within and across firm boundaries. Briefly, it is performed by the firm itself or by its suppliers, partners and/or customers, and is the essence of the business model (Amit & Zott 2001).

This activity-system model is more suitable for this study according to the research questions. Zott and Amit (2010) also reported the benefits of an activity–system perspective on business model. Firstly, an activity–system perspective is focused on the activities, which is a natural way to design the business model. Secondly, the active-system perspective encourages the firm in systemic and holistic thinking to design the business model, rather than focusing on isolated and individual choices. Thirdly, a focus on the activities allows the consistency among all activities, which are the assumptions mode in the transaction cost economics literature. Finally, the activity-system perspective contains rich possibilities for further theoretical development and refinement. It encourages the researchers to consider what goes on
the “black box” of activities, and suggests possibilities for probing and gaining better understanding of business model.

Some other business model definitions also support an activity system perspective. For example, Chesbrough & Rosenbloom (2002) defined that the business model is “the heuristic logic that connects technical potential with the realization of economic value”. Teece (2010) mentioned that the essence and purpose of business model is to define a manner by which the enterprise delivers the value to the customer, entices customers to pay for value and converts those payments to profit. He mentioned that it provides a structure and framework on which the business could logically create and deliver value to customers. It also outlines the architecture of revenues, and profits associated with the business enterprise delivering that value.

Accordingly, the business model defines the structure of the value chain, creating value, thereby applying the inherent logic of how the firm delivers value to its customers at an appropriate cost.

2.2 Strategy and business model

There are lots of concerns about the relationship between the strategy and the business model. General opinion is that the business model extends central ideas in business strategy and associated theoretical traditions (Amit & Zott 2001). Teece (2010) also mentioned that a business model is more generic than a business strategy. Coupling strategy and business model analysis is needed to protect competitive advantage resulting from new business model design.

Zott, Amit and Massa (2010) reviewed recent publications and summarized two main differentiating factors between the business strategy and the business model. The first is the emphasis of strategy on competition, while the business model focus more on cooperation, partnerships, and joint value creation (Magretta 2002). More general, the business strategy of a firm is more concerned with the value capture and competitive advantage than with the value creation. From another side, business model is more concerned for sustainable value creation, more exactly in terms of total value creation, with value capture and value distribution (Mäkinen & Seppänen...
This total value creation is the value created for all the business model stakeholders, which can be includes focal firm, customers, suppliers, and other exchanging partners etc. Such total value is much more than the value that can be captured by the focal firm. The second factor is that the business model focuses on the role of the customer, which is much less emphasized in the strategy literatures. Zott, Amit and Massa (2010) review revealed that the business model center on the general concept of customer-focused value creation. Mansfield and Fourie (2004) said that it is a customer-centric construct from the value creation perspective. Amit and Zott (2001) also highlight that it is the networked architecture of value creation pattern. Zott and Amit (2008) investigated this issue and suggested the pattern of the firm’s economic exchanges with the external parties in its addressable factor and product markets. Other scholars (Seddon et al. 2004) listed the essential details of a firm’s proposition for its various stakeholders, and the activity system the firms uses to create the value and to deliver it to its customers.

Despite the differences between the strategy and the business model, the recent studies also emphasized that the business model can play an important role for strategy. Richardson (2008) mentioned that the business model explains how the firm activities work together to execute its strategy and bridge strategy formulation and implementation. Casdesus-Masanell and Ricart (2010) viewed the business model as a reflection of a firm realized strategy.

In another hand, Teece (2010) said that developing a successful business model, no matter how novel, is insufficient in and of itself to assure competitive advantage. So coupling strategy and business model analysis is needed to protect competitive advantage resulting from new business model design. Strategy analysis is thus an essential step in designing a competitively sustainable business model. Otherwise many features of the business model can be easily imitated. Having a differentiated and hard-to-imitate, but at the same time effective and efficient, architecture for a firm’s business model is important for the establishment of competitive advantage. The various elements need to be co-specialized to each other, and work well together as a system.
2.3 Business model design under value networks

According to Zott and Amit’s activity-system view for the business model, the purposeful design, performed within and across firm boundaries, is the essence of the business model. In details, they also described two sets of design parameters that capture the firm-centric design of activity systems: design elements and design themes (Zott & Amit 2010). Before the discussion about the design parameters, it is necessary to review two important concepts of value chain and value networks, which are tightly connected to such activities for the business model.

2.3.1 The concept of value chain and value network

The concept of the value network was developed from the original value chain. The value chain concept was put forward by Porter (1986, 1985), to describe the sequence of the activities performed by a firm in the process of adding the value to its product and delivering the value to the customer. The value chain has two-level general value creation activities: primary activities and secondary or support activities. The primary activities mainly include inbound & outbound logistics, operations, marketing, sales, and services. The support activities can be indicted the administrative functions, technology, human resource management, and procurement. The primary activities have the direct impact for the value creation, while the support activities affect the value creation by their impact on the performance of the primary activities. The value chain provides the perspective on the macro-view of the firm exchanges by considering the good flows from the raw material to the consumptions. Value chain mainly focuses on the intra-organizational and organizational activities. However Porter himself also noticed that a form’s value chain is also embedded in a system value chain (Porter 1985). Therefore the inter-organizational relation should be considered as the focal firm value chain links to the value chain of the suppliers and buyers. Value creation is envisioned as longitudinal process, a sequence of value-adding activities. After few decades of economical development, more and more new networked organizational forms and service firms are born, which are different from the traditional manufacturing firms from where the value chain was originally conceived. The longitudinal character of the value creation process defined by the value chain proved to be more inadequate to the
analysis of value creation process in firms. So concepts such as vertical architecture (Jacobides & Billinger 2006), open innovation (Chesbrough & Appleyard, 2007), innovation value chain (Hansen & Birkinshaw 2007), strategy networks (Gulati 1998), and value networks (Allee 2002; Norman & Ramirez 1993; Parolin 1999) emerged in response to the embedded limitations in value chain frameworks. These concepts were built on the base of value chain, but at the same time they provided complementary views which allow consideration of new forms of network. Such new form of network plays as well as the co-evolutionary dynamics and co-dependencies that exist between the firm and the environment.

The concept of the value network and related work on strategy networks and alliances addresses the increasing complexity and intricacy of inter-firm relationship. Allee (2002) sees a value networks as “a complex set of social and technical resources that work together via relationship to create economic value in the form of knowledge, intelligence, a product (business), service, or social goods”. Allee’s value networks especially emphasized the knowledge and intangible value importance, and extended the notion of value as purely economic.

This definition allows the value network perspective application to internal value creating activities as well as external facing networks. Internal value networks include activity-focused on the relationships within the organization (e.g., those within and between the manufacturing, research and development, or sales departments), and among the various groups or departments from the organization. External-facing value networks include those between the organization and its suppliers, its investors (including venture capitalists), its strategic business partners (e.g., a business with a complementary product), and its customers.

The value network is conceptualized as purposive system, which aims at the satisfaction of value proposition for the end customer. Value network analysis is a primary visual representation of patterns of exchanges between participants, mapping both traditional business transactions and critical intangible exchanges. Intangible exchanges are those mostly informal knowledge exchanges and benefits, or supports that build relationships and keep things running smoothly. These informal exchanges
are actually the key to create trust and to open pathways for innovation and new ideas.

2.3.2 Business model design parameters

According to the activity system perspective, the business model design describes how firms do business. Questions about business model design can thus be framed as questions about activity systems design, and how to capture the essence of the business model. There are two sets of the business model design parameters: design elements and design themes (Zott & Amit 2010).

The design elements can include the content, structure and governance, which go beyond interdependencies among activities or notions of network structure. The content refers to the selection of activities, for which the activity system is performed. The structure describes how the activities are linked and defines the sequences among the activities. The structure also captures the importance of the activities for the business model. The structure defines the core activity and the supporting or peripheral nature activities. The governance refers to who performs the activities. Zott and Amit (2010) also emphasized that managers often need to make decisions on all these parameters, often simultaneously. The design parameters of activity systems can be seen as independent and orthogonal, but they can also be highly interdependent.

The design themes are another way to characterize the activity system. These themes are also the system’s dominant value creation drivers. Design themes are configurations of design elements. From Zott and Amit, the design themes orchestrate and connect the elements of an activity system (Zott & Amit 2010). The authors provided the four design themes: Novelty, lock-In, Complementarities and Efficiency (summarized by the acronym NICE).

Novelty means to adopt innovative content, structure and governance for the system activities. The essence of novelty-centered activity system design is the adoption of new activities (content), and/or new ways of linking the activities (structure), and/or new ways of governing the activities (governance). Lock-in means to build in
elements to retain business model stakeholders. Activity systems can also be designed for lock-in, their power to keep third parties attracted as business model participants. Lock-in can be realized by switching costs, or by enhancing incentives that derive from the structure, content and/or governance of the activity system. Complementarities mean to bundle activities and generate more value. It refers to the value-enhancing effect of the interdependencies among business model activities. Eventually the bundling activities within a system provide more value than operating activities separately. Efficiency means to reorganize activities and reduce transaction costs. Efficiency-centered design refers to how firms use their activity system design to aim at achieving greater efficiency through reducing transaction costs. The NICE value drivers can be mutually enforcing: the presence of each value driver can enhance the effectiveness of any other driver.

Except the above design elements and themes, Teece (2010) mentioned in his study that a competitively sustainable business model requires a strategy analysis filter. Four detailed steps have been suggested: 1. Set up the segment of the market; 2. Create the value propositions of each segment; 3. Design and implement the mechanisms to capture the value from each segment; 4. Figure out and implement the “isolating mechanisms” to hinder or block imitations by the competitors, and disintermediation by the suppliers and customers.

2.4 Evaluation of business models

There is not the theoretical evaluation system for the business model so far. During the literature review process, it was found that the previous studies for the evaluation business model were from three perspectives: the ecosystems, the PESTEL analysis and the corporation social responsibility view.

2.4.1 Evaluation business model by the ecosystem

Once the designed business model is provisioned, the quality of the business model must be evaluated. Teece (2010) mentioned that business model must be evaluated not only against the current state of the business ecosystem, but also against its evolution. Business ecosystem was declared and extended from the original biology
and earth sciences notion by Moore (1996). Business ecosystem is an economic community supported by a foundation of interacting organizations and individuals. Similarly as the natural ecosystem, the firms cannot survive alone and must develop in clusters. The ecosystem concept put the further understanding for the competition and cooperation. If the competition is a specific mode of relationship among the firms in the market, the different firms with different situations would be drawn together in a relationship of complementarily or even dependency. This type of relationship might involve various forms of cooperation rather than competition. Cooperation in ecosystem is a consequence of their networked nature. The interdependence occurs, not only within competitors, but also with customers, complementors, and other stakeholders. Same as value chain analysis, the business model evaluation also should be mapped systemically for all the stakeholders whom the model concerned. Teece (2010) listed the detailed questions to ask about the business model, which is summarized in Figure 1

![Figure 1 Question lists to ask about a business model (adapted from Teece 2010).](image-url)
2.4.2 Evaluation business model by the PESTEL analysis

PESTEL analysis refers to the political (P), economic (E), social (S), technological (T), environmental (E) and legal (L) factors. A PESTEL analysis is a framework or tool used to analyze and monitor the macro-environmental factors that have an impact on an organization. PESTEL analysis can be used as a technique for strategic analysis. PESTEL analysis can also be used in different fields (Katko 2006; Richardson, 2006; Shilei & Yong, 2009). Abt and Erath (2014) suggested to evaluate the business model by the PESTEL analysis for Osterwalder et al. (2005) nine building blocks, ie. value proposition; customer segments; customer relationships; channels; key activities; key resources; partners; cost structure; and revenue streams. A comprehensive set of questions is the base of the PESTEL analysis that is used to analyze their case companies (Abt and Erath 2014)

2.4.3 Corporate social responsibility for the business model

In addition, it is needed to emphasize the important of social responsibility or social outcomes for the designed business model. Over the decades, the concept of corporate social responsibility (CSR) has continued to grow in importance and significance. It has been the subject of considerable debates, commentaries, theories and researches. The center idea is that business enterprises have some responsibilities to society beyond that of making profits for the shareholders. In the past, many definitions for corporate social responsibility (CSR) were developed by the scholars based on the social, economical, political, legal and environmental context of those periods. The corporate social responsibility (CSR) has a long history, which evolved with the development of businesses to respond to the emerging needs of the society. Many scholars (Carroll 1999; Weber 2008) studied carefully the CSR definitions throughout its history during last few decades. In 1950s, CSP dimension was mainly concerned by the obligations to the society. Literature during this 50’s period discussed about the obligations of the businesses towards achieving the desired objectives, values and policies for the society (Bowen 1953; Heald 1957). In 1960s, moral issues in business were raised on a record level. During this time, many businesses were selling unsafe products harmful for the environment; society was unsuccessful to help economically deprived citizens (Carroll 1999). In 1970s, CSR
main dimension was stakeholders’ involvement. More responsibilities came up for the firms at this period, such as economic, legal, ethical and discretionary responsibilities. In 1980s, there were more discussions about identifying the relation between CSR and profitability (Rahman 2011). It is commonly agreed that CSR activities increased reputations of the corporations, which increased the confidence of the consumers on the products and services of those companies. In 1990s, the CRS also came from the planet, people, and profits issues, such as the questions about: what is good for the environment; what is good for the society; what is also good for the financial performance of the business. The 21st Century is the era of emerging CSR industry. CSR is a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis (European Commission 2002).

Rahman (2011) summarized that CSR can be in ten major dimensions as the following:

- Obligation to the society;
- Stakeholders involvement;
- Improving the quality of life;
- Economic development;
- Ethical business practice;
- Law abiding;
- Voluntariness;
- Human rights;
- Protection of Environment;
- Transparency & accountability.

2.5 Summary the theoretical framework for this study

Through the above literature reviews about the business model, the theoretical framework for this study can be formed according to the research questions. The whole study would base on the business model transformation perspective by activity-system. The new business model design would consider the design elements and the design themes. During the design process, coupling strategy and business
model analysis is needed to protect competitive advantage. The business model evaluation would combine three evaluation approaches, i.e. ecosystem, PESTEL analysis and CSR three perspectives. Because of the huge work load and time limitation, there is not one by one study for all three approaches during this research. The new business model was evaluated from four most important parts: economic benefit, social benefit, environmental benefit and the industry value network. Figure 2 showed the theoretical framework for this study with the corresponding research questions.

Figure 2 The summary of the theoretical framework for this study.
3 RESEARCH METHODOLOGY

Research methodology is the science and philosophy behind all research (Adams 2007). This study adopted the similar methodological choices as Abt and Erath (2014) used with a similar setting and context. This chapter presents my research approach, research strategy, and research method. Furthermore, it explains in detail the methodological approach of how this thesis was carried out. It also presents the process about the data collection methods and resources.

3.1 Research approach

Bell and Brymen (2007) mentioned that Research approach can be divided into two categories: deductive approach and inductive approach.

“A deductive approach is concerned with developing a hypothesis (or hypotheses) based on existing theory, and then designing a research strategy to test the hypothesis” (Wilson 2011). Deductive approach can be explained by the means of hypotheses, which can be derived from the theory. Eventually, this approach provides conclusions from series of deductions based on premises or suggestions. “Deduction begins with an expected pattern that is tested against observations, whereas induction begins with observations and seeks to find a pattern within them” (Babbie 2010)

Inductive approach starts with the observations and theories formulated towards the end of the research (Goddard and Melville 2004). Inductive research “involves the search for pattern from observation and the development of explanations – theories – for those patterns through series of hypotheses” (Babbie 2010). As no theories are applied in inductive studies at the beginning of the research, the researcher is free to alter the direction of the study after the start of the research process.

The main distinction between inductive and deductive research approach relates to the existence and placement of hypotheses and theories. Deductive research is more based on science theories and hypotheses, tested from empirical findings to obtain certain conclusions. Inductive research by contrast implies the researcher developing
a new theory based on gathered data (Saunders et al. 2009), to be tested against apparent theory (Bell and Brymen 2007).

This research used the theoretical framework, developed the research questions based on the existing theories, and tested my empirical data. So by the means, it belongs to the deductive research approach. Generally, deductive approach is a top down approach. It mainly includes few steps as: set up the investigation area; propose the formulation; apply the framework of references; collect the data and analyze them, and then get the conclusions or results. It allows isolating data from a data surplus step by step and finally extracting the necessary core data, which represents the relationship between theory and research. Because of my Chinese background and personal relations with one Chinese leading battery industry (EVE energy Co.ltd), I chose the electrical automobile as my investigation area. As a Chinese, I can see a strong demand for the use of environmentally friendly technologies in China. Furthermore, China has a huge potential market for such new technologies. I narrowed down the area to the electric bus because it is the current carrying on project in EVE energy Co.ltd and its partners. The business model for the electric bus in China is a very natural topic inside project of EVE energy Co.ltd with its partners. From this investigation area I derived my purpose and formulated the corresponding research questions. Then I started to review the business model literatures from existing theories and developed some conclusions to my research questions, which led my approach to a deductive one.

According to Cua and Theivananthampillai (2009) study, the main weak point of a deductive approach is the limited amount of organizations, which might be not enough for adequate analysis. But for this study, it was focused on a PEB specific industry in a region where the number of competing companies is not too high yet; the selected organizations could provide the best insights and get a result with high quality and credibility.

3.2 Research strategy

The purpose of the research strategy is to provide a plan for the researcher to find an answer to the research questions. Due to the interdependency of the research strategy
and the formulated research questions, as well as the researcher’s knowledge, the strategy is very important for the research process (Saunders et al. 2009). According to Yin (2003) there are five different strategies existed with common usage: experiments, archival analysis, survey, history and case study. As my investigation area already focus on certain specific industry, and my research question was a “how” question, the case study was chosen for my research strategy.

The case study is a research strategy which focuses on understanding the dynamic present within a single setting (Eisenhardt 1989; Yin 2003). The purpose of the case study research design is to analyze one or a few cases in detail (Bryman and Bell 2007). According to Saunders et al. (2009) the case study is the right strategy for the researcher to understand “how” decisions were made by a company and to analyze the incentives behind the corresponding choices. There are three categories of case studies (Yin 2003): exploratory, explanatory and descriptive. Exploratory case studies are often conducted to define research questions and hypotheses. Explanatory case studies seek to link an event with its effects and are suitable for investigating causality. Descriptive case studies are often used to illustrate events and their specific context. According to Saunders et al. (2009) the purpose of an exploratory study is to obtain a deep understanding of the actual problem, the current situation and to gain useful insights. My research question of how to explore the new business model for PEB in China is in the main focus of the exploratory research in this study. The exploratory gives more flexibility to examine the case from the surface to deeper levels (Saunders et al. 2009) until the research question is answered. 

Yin (2003) also mentioned the single case strategy and the multiple case strategies. By using a single case strategy, the disadvantage appears to be dependent on one single source. Case study research is often criticized for the limited number of investigated cases which is said to limit the generalization of the findings (external validity). However, Flyvbjerg (2006) argued this opinion and indicted that one can generalize from a single case, depending on the context. In this study, I chose one signal case about the PEB industry in China. PEB industry is a very specific area, which is with very country-specific politic impact inside China. Using deep analysis, the designed business model for this specific area was able to find a solution which
could benefit the whole related industry. Based on these findings, it can also give recommendations which might be beneficial to similar industry in other countries.

3.3 Research method

Broadly speaking, there are two main domains of research method observed in the literature and these include Quantitative and Qualitative research. Quantitative research refers to the systematic empirical investigation of social phenomena via computational techniques (e.g. statistics) to analyze numerical data with the objective to develop and apply mathematical models, theories and/or hypotheses pertinent to the phenomena (Given 2008). In contrast, qualitative research uses a number of methodological approaches based on diverse theoretical principles (phenomenology, hermeneutics and study of social interactions). It employs methods of data collection and analysis that are non-quantitative, aims towards the exploration of social relations, and describes reality as experienced by the respondents (Adams 2007). The main difference between these two methods is the protocol used for the data collection and analysis. A qualitative research method focuses on the explanation of the studied area within the topic’s natural setting (Hyde 2000) and creates findings out of collected evidences. Qualitative research uses various methods to collect data in order to get a deeper understanding of the studied topic.

In this study, as mentioned above with the exploratory case study, qualitative research was used. However, some calculations were also applied. By adding quantitative measures to the concept of qualitative in-depth case studies, we draw a picture of each case that is as complete as possible with regard to the relevant characteristics. The completeness of the picture drawn is not just a question of the nature of the data, but also relates to the use of data collection methods: case study research suggests the use of multiple methods (Yin 2003; Eisenhardt 1989).

3.4 Data collection

Data collection is considered to be an important part of the research work. Without the correct data, the research objectives cannot be fulfilled. The general data collection can be divided into primary and secondary (Adams 2007). Primary data
can be seen as a first hand source (Bell and Brymen 2007). This data can be considered as new, collected with a specific purpose (Saunders et al., 2009). There are different methods to collect primary data. The most commons are interviews, observations and questionnaires (Yin 2003). Secondary data is data collected by someone else and there is a great deal available to us from books, libraries and on the web. One can use this data as the main source for the research or as a supplement to data already collected (Adams 2007).

**Primary data collection**

In this case study, the primary data was mainly collected by interviews. Because all the data came from China, the time difference and distance between locations was inconvenient for face to face interviews. Eventually, the interviews were carried out by email communications and other social media tools. The social networking application tool “WeChat” was used quite often, as it is the most popular communication tool within China.

The person with direct interview was Dr. Jincheng Liu, who is CEO of EVE energy Co.ltd. During the interviews, Dr. Liu introduced the current PEB status inside China, the energy battery technology for PEB and their own projects concerning the Chinese PEB development. In addition, Dr. Liu forwarded many materials from his project partners, which mainly concerned the new PEB business model implementation. The following persons can also be counted as my in-direct interview persons:

*Wenming Zhou: General Manager, Bader automotive leather (Dalian) Co., Ltd,*

*Gaopeng Li: Technology Director, ZhengZhou YuTong Bus Co., Ltd*

**Secondary data collection**

The secondary data can be collected from the books, the libraries, and on the web. Such secondary resources included the company official website, the annual report, the official published materials, academy research literatures and professional
analysis reports related to case company, as well as official data from the related Chinese organizations etc.

In addition, it is worth to emphasize that web search took a very important role in this study. Google Scholar has been used. Oulu University Library database Nelli-portal was also used. Secondary data is often easier to use and tends to be more comprehensive, reliable and valid. Nonetheless, one should be aware that the secondary data might mismatch with their own research questions because of the different time scale or region scale (Adams 2007).

3.5 Data analysis

After all the data was collected, I categorized the data as two classes: case description and business model evaluation. In the case description session, I quote the results from interviews and listed them in chapters corresponding to the older business description with the problems, the new business model designing, and the new business model implantation process.

In the business model evaluation session, I combined three evaluation approaches, which are listed in the chapter 2 for lecture review, i.e. ecosystem, PESTEL analysis and CSR three perspectives. Because of the huge work load and time limitation, I did not study all three approaches one by one during this research. I evaluated the new business model from four most important parts: economical benefit, social benefit, environmental benefit and the industry value network.
4 PURE ELECTRIC BUS (PEB) ORIGINAL BUSINESS MODEL IN CHINA

4.1 Pure electric bus (PEB) business model in China

PEB business model is a complex multi-level system and currently there is no clear theoretical framework, especially for China with the specific country condition. According to Ye and Wang’s study (Ye & Wang 2012); the system mainly includes all levels of government authorities, the vehicle and the key parts manufacturers, service operators and the consumer’s multi-participant. As shown in Figure 3, the bottom layer consists of the governmental authorities. The totality of the policies about the environment and resource allocation are formed in this layer. The middle layer is the enterprise layer and includes all the PEB supply chain companies. The top layer represents the PEB consumers. The system peripheral is the consumer environment, which is formed by multi-factors joint action. The information was exchanged between the levels but also within the same levels. The middle enterprise layer undertakes a two-way information function: acceptance and feedback. In addition, logistics and cash flow also exist inside the system. The government allocates funds to the enterprise. The enterprise provides the products to the consumers and gets the profit from them.
The final objective for PEB business model is to build a system which is most suitable for PEB development under the current environment and the policies conditions. Such system is based on the cooperation of all the party to reach the Pareto optimal state, which means to get the maximization overall revenue, rather than only benefits for few participants.

It is important to explore right PEB business model for all levels. For the government, PEB commercialization is an important measure to achieve emission reduction targets for the whole society. Meanwhile, it is also important to promote industrial restructuring and upgrading. For the enterprises, PEB represents the future direction of the passenger car industry. PEB development would effectively enhance the firm’s R&D and manufacturing level, and increase the competitive advantage for the future. For consumers, the travel cost would be greatly reduced by PEB, which meets energy conservation and low-carbon travel needs.
4.2 New pure electric bus (PEB) commercialization roadmap in China

Ye and Wang’s (2012) study suggested three different periods for the PEB commercialization. As shown in Figure 4, Three curves in the figure represent the trend of manufacturing cost of PEB, manufacturing revenue and operation revenue, with the point A being the breakeven point for manufacturers, as threshold indicator of profits for the electric car manufacturers and the point B indicating that the cost of electric cars consumers becomes more sensitive than the car costs (Ye & Wang 2012). According to the roadmap, commercial promotion PEB process can be divided into the following three stages (Ye & Wang 2012).

1. The first demonstration period

This period is the PEB commercial preparation stage, in which the core feature is "government-leading with subsidy". At this period, the whole industry profit is negative because the battery, drive motor, electronic control systems and other key parts of PEB technology is not mature. The market is still in the exploring stage. In this case, the government-leading industrial alliance is set-up, which is the joint of the whole vehicle, key-parts manufacturers, and the operation service units. Such alliance uses micro cars and PEB as a breakthrough, and jointly promotes to establish common technology platform and technical standards. It also develops the whole coordinated PEB industry chain with a graduated self cultivated function. Meanwhile, under the guiding roles of incentives and financial subsidies from the government, venture capital system could be established to attract the external capital for the PEB industry development. It is for the benefits of building a perfect environment, which can be conducive to the development of R&D and industrialization. A number of growth-oriented high-tech enterprises could come out. Based on the current Chinese PEB demonstration situation and the industrial conditions, the duration of this period might be long, such as five to ten years.

2. The second transition period to commercialization

This period is characterized by "the demonstration in the public scope and commercialization in firm-own vehicles." During this period, PEB key technologies
breakthrough, especially the battery technology, will gradually help the manufacturing costs to decline, and thus boost industry profit growth. At this stage, the government will keep the leading position by the PEB demonstration and promotion. However, it will consider setting up the independent firms, which can be composed by the government as the main holding and other enterprise equity stake. When it is necessary, the government could supplement small amount subsidies by preferential policies. In this stage, consumers are more concerned about car costs; the government could introduce some reduced tax policies for energy saving cuts to stimulate the development of the PEB market. Furthermore, it encourages vehicle and parts manufacturing companies to form their own core competitiveness as soon as possible, in order to reduce manufacturing costs.

3. **Large-scale commercialization period**

This period is characterized by “market-driven and business-oriented”. During this period, PEB technologies are already in mature level. The manufacturing costs have been decreased substantially. The production scale has rapid expansion, so the industry profits can be stable. In the meantime, with the vehicle ownership rapidly increasing, the electric charge, maintenance and other cost are likely to exceed the vehicle cost itself, which can become a significant factor to affect consumer choice. Therefore, during this period the infrastructure services company operation can play a leading role in the commercial promotion. With regards to this issue, the government can consider lowering the PEB usage taxes, while it continues to improve the legal system construction and standardize the market development for PEB market. The introduction of fair competition mechanism promotes the PEB industry with healthy development by continuously improving PEB service and reducing costs.
4.3 The structure and the problem of the pure electric bus (PEB) original business model in China

Figure 5 shows the original structure of the business model for Chinese PEB. The model is based on the whole vehicle purchase. The public transportation companies purchase the vehicle (including the battery) from the vehicle manufacturers. The charging infrastructure is constructed by the fund from the National Grid (Energy Company). The vehicle users (the public transportation companies) charge the batteries according to their own requirements. The vehicle manufacturers provide the maintenance service to the vehicle users. In addition, the battery manufacturers provide normal three-year warranty period for battery maintenance and replacement. After this warranty period, the battery manufacturers can charge service fee for battery maintenance. If necessary, the users buy a secondary battery for replacement. After the batteries are scrapped, a negotiation starts between the users and the battery recycling companies, concerning the battery recycling and disposal.
With such business model, there are few problems showing up as the following:

1. **Higher purchasing cost**

Due to the high initial investment for the PEB related industries; the key components technologies, especially the battery, are not mature enough and the PEB production scale has not yet been formed, therefore the PEB prices are generally 2 to 3 times higher while compared to a conventional bus with the same size. Although the PEB operation cost is significant lower comparing with the traditional bus, the public transport companies still feel strong pressure from the high purchasing cost.

2. **The second purchase for the power batteries**

Limited by the current battery technologies, the normal PEB battery lifetime is only about 3 years. Under the original business model, battery charging and discharging processes are completed by the users themselves. The professional battery service cannot have the real time maintenance and repair during the PEB operation time. Unfortunately, the actual battery life time is often less than 3 years. The general bus
life time is about 8 years. It means that during the whole PEB lifetime, the users must change the new batteries several times to meet the needs. Current power battery is expensive, reaching about half of the cost of the whole vehicle. Ultimately, the users need to pay twice or even three times the battery power purchasing costs, which in turn is equivalent to an increase of the user's cost.

3  **State subsidies are not formed an effective incentive for comprehensive benefits**

As mentioned in the introduction chapter, PEBs not only have lower life-cycle costs, but they also have significant social and environmental benefits; the overall efficiency being very significant. In order to improve the Chinese energy structure and achieve the emission reduction targets efficiently, the State Council announced “Decision of the State Council on strengthening energy conservation” (Chinese Policy Document 2006); “The State Council on the issuance of a comprehensive energy reduction program” (Chinese Policy Document 2007); and “State Council on further strengthening the fuel reduction” (Chinese Policy Document 2008). Chinese Central Budgets arranged the financial support for new energy vehicle demonstration promotion from the special funds of energy conservation. The Central Budgets also announced “State Subsidies Management Interim Measures to Promote Energy Conservation and New Energy Vehicle Demonstration” (Chinese Policy Document 2009) in order to improve the capital efficiency. This measurement proposed that "the subsidies are based primarily on the basic price difference between new energy vehicles and the similar conventional ones with certain considerations about the factors of technology and scale effect”. But there is no detailed content concerning technology and energy saving benefits. For example, PEB longer than 10 meters would have 500,000 RMB standard subsidies. No matter whether the PEB is operating, and how much the operating mileage length, the acquired subsidies would be the same. Therefore there is no effective incentive for the PEB operation after purchasing.

4.  **PEB driving range cannot meet the actual capacity needs**

Currently, the city bus should operate about 15-18 hours per day and the operating mileage would be over 200 km. However, the current majority PEB actual daily
driving range is less than 200 km due to the poor battery energy density. Under the original business model, once the battery energy ended, the PEB operation ends as well because of the long time battery re-charging time. Such result causes not only a waste of resource, but also impacts the public transport company operation efficiency.
5  PURE ELECTRIC BUS (PEB) NEW BUSINESS MODEL DESIGN IN CHINA

5.1  New pure electric bus (PEB) business model structure

Figure 6 shows the new structure design of the business model for Chinese PEB. The first difference is that the public transport company purchases only the vehicle without the battery included. Similarly as before, the charging infrastructure is constructed from the National Grid fund (Energy Company). However, the National Grid also leases the battery from the battery manufacturers with unified battery management. The public transport companies replace the battery according to the PEB operation needs and pay the energy company by battery usage and electrical energy cost.

![Diagram of the new PEB business model structure.](image)

Vehicle manufacturers provide to their users (the public transport companies) sales and services only for the vehicles. Energy companies (National Grid), together with
the battery manufacturers, provide the users (the public transport companies) battery charging, replacement and maintenance services. After the battery scrap, battery manufacturers and recycling enterprise co-operate for battery recycling and disposal.

5.2 Subside program optimization

As mentioned in the previous chapter, the State subsidies do not form an effective incentive for comprehensive benefits. In order to promote PEB better in large scale and enhance the comprehensive benefits, it is recommended to have the original subsidy program optimization under the new business model structure. The optimization can be obtained from two approaches.

1. Subside calculation

The PEB comprehensive benefit is related with the energy-saving level and the operating mileage. It is suggested that the national financial subside could be divided into two parts, purchasing subside and operating subside. The ratio may be set up as initial 70% and 30% respectively. Taking into account the different energy-saving vehicles, the detail calculation is as the following:

Purchasing subside = The original subside * 70% * (The standard energy cost per hundred kilometer / current vehicle energy cost per hundred kilometer)

Operating subside = The original subside * 30% * (The actual average annual operating mileage / Theoretical annual maximum operating mileage)

Theoretical maximum operating mileage = 360 days * 200km / day = 72,000 km.

The standard energy cost per hundred kilometres is set up as 120 kwh.

The original subside in here does not involve any other state subsidies such as the fuel subside. It is only applied for the special project “Ten City with 1000 PEBs” as mentioned in the first chapter.
The overall supervision of PEB can be achieved through this incentive mechanism from research stage to operation stage. It also stimulates the technological innovation to ensure the key technical indicators such as power consumption and reliability, and finally to promote the rapid development of PEB.

2 The subside cash way

The purchasing subside could be used in the original cash way. The operating subside could be cashed according to the actual data of the year operations from the public transport companies and calculated by the related state department according to the above formula.

The purchasing subside could have the incentive for the whole vehicle energy-saving level. The operating subside could have another incentive for operating mileage. Such two incentives would motivate the major companies in PEB value chain and give a more efficient function for the state financial subsidies in PEB market.

5.3 Financial program design

Because the PEB purchasing cost is much higher than the cost for the traditional buses, it would bring the financial problem for the public transport companies. The installment purchasing plan would be the solution to decrease the initial purchasing funds and to address the funding lack for the public transport companies. During the PEB operation process, because of the low operating cost, the public transport companies would have positive cash flow after the installment and interesting payment during the PEB whole life cycle. The final results would motive the PEB promotion in big scale.

Because of the high cost of the continuous testing and maintenance of batteries, the important difference in the new business model is the separation between the vehicle and the battery. The public transport companies could lease the expensive battery, to reduce the financial and maintenance pressure.
The charging infrastructure demand would increase with the fast PEB development, which would result in the increase of funds for the charging facilities. At this stage, the government support has difficulties to meet the huge demand. So in terms of charging facilities, an innovative financing mechanism is required. On the one hand, the government social capital is responsible for the part of charging infrastructure investment, by the relevant concessions, subsidies, incentives, encouragement and guidance. On the other hand, the government can also have fuel tax reform, the new environmental taxes and other measures in order to increase tax input and partially offset charging facility costs, providing sustainable financing mechanisms to subsidize (Sun, Liu & Zuo 2011) for the PEB development.

5.4 The whole vehicle purchasing mechanism optimization

With the original business model, the public transport companies purchase the vehicle with the battery included from the car manufacturers. For the designed new business model, the public transport companies would purchase only vehicle without the battery. During the PEB operation, the public transport companies would chose the leasing or purchasing service from the battery manufacturers. Such purchasing mechanism change would have the following advantages comparing with the original business model.

(1) By separating the selling of the vehicle without the battery, the initial purchasing cost would decrease, which could attract more potential buyers.

(2) With the original business model, the vehicle requires the charging process during the operation. To ensure the driving range, the vehicles must carry enough batteries to cover the battery requirements, which increase vehicle weight and the energy consumption. Under the new business model, the vehicles would just need to change the battery from the charging station service, which could substantially decrease the vehicle energy consumption, and improve the efficiency.

(3) Under the new battery leasing model, the cooperation between the leasing companies and the battery manufacturers would provide professional battery management and maintenance, which could significantly improve battery life cycle
and decrease the repairing cost. In addition, the battery change process could remove the battery inside for charging, which would avoid the low temperature impact for the charging process.

5.5 The pure electric bus (PEB) value network analysis under the new business model

As described in the chapter 2 in the literature review, the value network analysis can map patterns of exchanges among all the participants during value creation process and give the primary visual representation of how purposeful networks (such as organizations, cross boundary task networks, public agency collaborations, and societal change networks) can more effectively create value, achieve business outcomes, and generate sustainable success.

In this study, I mainly carried out the value creation analysis from the value network (Allee 2008). It means the best way to create, extend, and leverage value, either through adding value, extending value to other roles, or converting one type of value to another. The organization value creation activity can be divided into value input, value-added and value output. The value input allocates the capital or funds rationally in a variety of resources to enable the organization to achieve the best results for its economic and social responsibility. The value-added refers to the value creation by certain techniques and labor skills. From value network perspective, this means that when a role receives a value input, ideally the people playing that role would find ways to use that input to provide greater value in the form of products and services. The value output refers that all the participants in value network can gain value for themselves and also leverage that input for a greater value output, then that is really maximizing value.

Figure 7 shows all the participants from the PEB value network perspective and their value creation activity (value input, value-added, and value output) flow direction. The detailed explanations are listed as the following:
(1). The raw material is provided by the suppliers as value input to both vehicles and other parts manufacturers. The other parts manufacturers produce their products to the vehicle manufacturers in order to realize the value-added. The vehicle manufacturers produce the parts by the raw materials and assemble the whole vehicle to realize the value-added. The whole vehicle is then sold to the public transportation companies to realize the value output. After the PEB are scrapped, the public transportation companies send them to the recycling companies as the value input. Finally, the recycling companies provide the recycling raw material to the raw material suppliers as value input to realize the whole value creation cycles.

(2). The raw material is also provided to battery manufacturers as value input. The battery manufacturers produce the power battery from the raw materials, lease it to the energy companies (national grid) and realize the value-added. The energy companies invest to build the PEB charging infrastructures and carry out the value-added. The energy companies supply the battery charging service to the public.
transportation companies, charge the related costs and realize the value output. After the batteries are scrapped, the battery manufacturers carried out the battery re-using to realize the value-added. The battery manufacturers can also send the scrapped batteries to the recycling companies as value input.

(3). In order to solve the lack of the purchasing funds for the public transportation companies, the financial institutions supply the loan as value input.

(4). The Chinese government supplies PEB subsides to the public transportation companies and compensates the lack of the purchasing fund to stimulate PEB application. It is a value input from the national comprehensive benefit perspective. The value output can be realized through PEB promotion and comprehensive benefit improvement.

In the whole PEB value network as described above, the public transportation companies are the real value source during the value creation activities. The value input for the whole value network is constrained by the demand of the public transportation companies. Such demands also determine the extent of the value-added and value output (Chen 2007). Under the new business model, the problem of the lack of purchasing funds can be solved by the government subsides and by the loan service from the financial institutions. The purchasing capacity increase infuses the value input increase, which drives the performances for the raw material suppliers, the other parts manufacturers, the whole vehicle selling and the recycling companies. It also prompts to the entire value network an overall profit growth. In addition, the raising PEB operation makes the usages of the charging infrastructures efficient for the energy companies (national grid), which also prompt the demand of the power battery and consequently create more profit for the energy companies and battery manufacturers. At the same time, the battery manufacturers can gain extra benefits from the battery re-using. Therefore, PEB new business model could prompt a whole new value network development and be beneficial for all the participants.
6 NEW PURE ELECTRIC BUS (PEB) BUSINESS MODEL IMPLEMENTATION IN CHINA

6.1 Pure electric bus (PEB) whole vehicle designing

The main highlight of the new business model is the separation between the whole bus vehicle and the electrical battery. According to this requirement, Zheng Zhou Yutong Bus Co. Ltd. specially designed the new bus type ZK6125BEVG1.

ZK6125BEVG1 was designed for fast battery changing within 10 minutes by XJ standard battery fast changing box to ensure the continuing operation. The bus is made out of aluminum material, including the body and all pipes, for total weight of 12 tons. The passenger capacity can be up to 90 people. ZK6125BEVG1 is 1.5 tons lighter than the traditional similar bus. The new bus type has been implemented in the Tianjin market, as shown in Figures 8 and 9 for Tianjin bus line 638.

Yutong ZK6125BEVG1 fast changing battery PEB has direct-driving mechanism without complex gear transmission structure to achieve a continuously variable transmission. There is no shifting process making it more comfortable. It uses Yutong own vehicle control system. The power battery is in high quality iron (phosphate lithium battery) with high power capacity, light weight, and reliable safety. The battery system specification is 537.6V and 264Ah. The energy storage is 142kWh with 80% available energy (approximately 114kWh). The motor is highly efficient. The braking energy is recyclable, while reducing the consumption of compressed air brake and reducing the energy consumption of the air compressor.
Figure 8 Yutong ZK6125BEVG1 pure electric bus.

Figure 9 Yutong ZK6125BEVG1 pure electric bus.
6.2 Pure electric bus (PEB) charging proposal

The current electric vehicle charging solutions mainly have charging piles, direct charging stations and exchanging battery stations. According to different operation models and different types of pure electric vehicles, a suitable charging proposal can be chosen. Table 1 lists the pros and cons of these three charging schemes. For the purpose of the PEB operation under new business models, it needs the separation between the vehicle and the battery to reduce the purchasing cost and reduce the charging time. The bus manufacturers sell the bus to the customer without the batteries. The batteries can be leased from the battery charging station operators, which not only reduces the purchasing cost, but also professionally maintains the batteries. Based on these conditions, the exchanging battery proposal is more suitable for PEB operation. This way not only takes the advantage of lower electrical price in the night period to reduce the charging cost, but also reduces the bus weight without extra battery configuration to reduce energy consumption and improve the bus utilization. Therefore, the exchanging battery station was chosen as the charging proposal in this case.

Table 1 The pros and cons lists for three charging schemes

<table>
<thead>
<tr>
<th></th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct charging</strong></td>
<td>Charging operator perspective</td>
<td>Large area with high land costs</td>
</tr>
<tr>
<td></td>
<td>1. power supply stable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Low technical difficulty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Customer perspective</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Without regarding the matching between PEB and battery</td>
<td>1. long charging time;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. fast charging would impact battery life;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. increasing battery second purchasing costs</td>
</tr>
<tr>
<td><strong>Exchanging battery</strong></td>
<td>Charging operator perspective</td>
<td>Requiring the match between the battery and the PEB</td>
</tr>
<tr>
<td></td>
<td>The replaced battery can be charged at the trough time for cost saving</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Customer perspective</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. saving charging time;</td>
<td>The exchanging service might charge high electrical costs</td>
</tr>
<tr>
<td></td>
<td>2. reducing the purchasing cost;</td>
<td>comparing with the industry electrical price</td>
</tr>
<tr>
<td></td>
<td>3. without regarding the battery life and maintenance costs</td>
<td></td>
</tr>
<tr>
<td><strong>Charging pile</strong></td>
<td>Charging operator perspective</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Small land area with low land costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Customer perspective</td>
<td>Only for slow charging and cannot satisfy the emergence usage</td>
</tr>
</tbody>
</table>
6.3 Pure electric bus (PEB) operation proposal

Figure 10 shows the operation proposal for the new PEB business implantation in Tianjin PEB demonstration program. The energy companies (National Grid) lease the batteries from the battery manufacturers. National Grid as operating company cooperates with the battery manufacturers to have jointly professional management and maintenance for the batteries, and offer the battery fast changing service to the public transport companies with excellent performance. The public transport companies pay the National Grid as the form of electrical fee.

Both in the battery exchanging station and bus dispatching center, there is real-time monitoring platform, which is based on geographic information system (GIS) for the remote vehicle management. Through the visual display for the bus line route and the geographical location, it is possible to have the real-time monitoring and dynamic management for the bus operational status. Service support team can get real-time operating data (batteries, motors, electrical control units, etc.) from the bus core system and dialogue with the driver to resolve operational issues. Such demonstrating operational experience accumulates large amount of data and enhances the foundation for PEB further promotion.

Tianjin bus line 638 was selected for this demonstration program, which starts from Hai-Tai-Nan bus center terminal to the railway station through the downtown commercial district. This route has longer mileage and intensive crowded street
while compared with other Tianjin city bus routes. Table 2 shows the operation and schedule information for the entire 638 line.

Table 2 The operation and schedule information for Tianjin bus line 638

<table>
<thead>
<tr>
<th>Start-End</th>
<th>mileage</th>
<th>Operation duration</th>
<th>Daily operation times</th>
<th>Daily operation mileage</th>
<th>Daily battery exchanging times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hai-Tai-Nan bus centre terminal – Tianjin railway station</td>
<td>One way 25.45 km</td>
<td>About 3 hours for two-way</td>
<td>4</td>
<td>203.6 km</td>
<td>4</td>
</tr>
</tbody>
</table>

6.4 Pure electric bus (PEB) marketing proposal

Chinese PEB is still in the starting period, which is under the condition of the immature battery technology and immature operation model. It is needed to develop the PEB marketing proposals to ensure the successful promotion of the new business model. Two proposals were suggested for Tianjin demonstration program.

(1). In order to ensure the impact and subsequent promotion of new business models, it is needed to select the city as a demonstration which has big market with the high demonstration effect, such as Beijing, Tianjin, or other big cities. In addition, the tourist cities, such as Qingdao, Xiamen and etc., should also be considered to develop certain amount of PEB, which can expend the operational impact and collect sufficient operational data for the analysis and evaluation of the business model.

(2). It is emphasized again the separation between the vehicle and the battery during the purchasing process. Because of the complex maintenance of the energy battery, the vehicle manufacturers only sell the vehicles without the battery. PEB operators lease the batteries from the energy companies or battery manufacturers. The batteries can have the professional management and maintenance, which can significantly improve battery life, decrease repair costs, and reduce risk caused by battery maintenance.
6.5 Pure electric bus (PEB) service proposal

Tianjin Yutong Bus Co. Ltd. specially provides the new service model after selling in order to match the new business model demonstration program. This new service model can have three stages, i.e. the production line tracking after the vehicle order issued; the service guarantee after the delivery to the market; and the conjunction training program. The detail proposal can have the following characteristics.

1. Professional and standardized services

Yutong service department has established a team for PEB special service support. According to the PEB characteristics and operational conditions, this team would monitor the whole vehicle life cycle operations and resolve customer worries. At the same time, the standardized terms for new PEB can be implemented as well as the improved service equipments to ensure the professional and standardized service.

2. Special services policy and process

According to the PEB market characteristics, Yutong developed a targeted service with priority policies, such as through a special process to guarantee the implementation of the service and ensure the effect of the PEB service.

3. Specify or tracking service

Yutong established the new PEB customer data base and set up special unit for the archive management. In the PEB selling area it is set up a "regional coordinated operations" conjunction service team for each new PEB. Combined with the other service personal it reaches the target of tracking the PEB life-long concerns.

6.6 Pure electric bus (PEB) recycling proposal

PEB (including battery) is manufactured from a variety of materials, which are not recyclable by direct burial. Without thoughtful recycling process, it would enhance the environmental pollution, which is already a serious problem in China. In the
other hand, simple disposing of PEB is also a big resource waste. It is suggested that the scrapped PEB should have rational dismantling and promote the material recovery and recycling to achieve sustainable development (Yu 2011). Scrapped PEB treatment options include scrapped power battery treatment and scrapped vehicle treatment. Figure 11 shows all the recycling options for PEB different material, which was implemented in Tianjin demonstration program. Good recycling proposal would increase the value of the whole industry chain. The following describes the detailed options.

![Scrapped PEB Treatment Diagram](image)

**Figure 11 The scrapped PEB treatment proposals.**

*The power battery disposal proposal*

Because PEB requires high energy density for the power battery, disposed PEB from PEB doesn’t mean the end life of the battery itself. The disposal battery from PEB still has enough energy for other usages. If the battery looks good visually without damages, the functional elements are valid. It can have secondary development and utilization for other purposes as clean energy sources, for example, the power source for solar energy and wind energy; charging the electrode plate for solar lights; the power for small electrical vehicles with short distance (public park area tour buses, golf field mini car, etc.); storage power for building emergency lighting. By such
second development, it not only allows the battery performance to get a full utilization, but it also relieves the pressure of large amount of battery cycling. After the battery is completely scrapped, the metal recycling can be carried out by the battery recycling technology, for example, the lithium can be recycled for lithium-ion battery. Under the new business model, the battery recycling program should be supervised and operated by the battery manufacturers.

*The vehicle disposal proposal*

The materials for current PEB are mainly composed by metal, plastic, rubber, glass and paint, in which the composition are about 69 wt% steel material, 9.6 wt% non-ferrous metals (such as copper, tin, etc.), 8.6 wt% plastic, 2.8% glass, and 10% others. For the steel and nonferrous metals from the automotive, there are more than 90% which can be recycled. The glass and plastic recycling rates also can be up to 50%. For some expensive car component materials, the recycling value is even higher (Fang 2011). Under the new business model, the vehicle disposal would be carried out by the vehicle purchasers, i.e. the public transport companies (Fang 2011).
7  PURE ELECTRIC BUS (PEB) NEW BUSINESS MODEL EVALUATION IN CHINA

The comprehensive PEB benefits are mainly in three aspects: economical, social and environmental benefits. To evaluate the implementation effect of the PEB new business models, it also includes the economic, social and environmental benefit effect. In addition, the enterprises from whole PEB industry value chain are evaluated their own benefit effects. These evaluations construct the whole PEB implementation appraisal system.

7.1  New pure electric bus (PEB) business model economic benefit evaluation

7.1.1  The introduction of PEB life cycle cost (LCC)

PEB economic benefit is mainly reflected by the entire life cycle cost (LCC). LCC refers to all of the product costs within the product validity period. PEB’s LCC includes the investment (purchasing) cost (CI), operating costs (CO), maintenance cost (CM), fixing costs (CF), waste disposal costs (CD) and environmental costs (CE) (Ren et al 2009). In order to evaluate the PEB economic benefits under the new business model, a LCC-based assessment system for PEB is constructed, as shown in Figure 12.

![Figure 12 The structure of PEB life cycle cost (LCC) system.](image)

The PEB is considered to have almost the same cost for CM, CF and CD while compared with the traditional passenger buses. But the CI is much higher than
traditional passenger bus. In term of CE, there is no pollution and damage to the environment, which reduces the environmental costs related to PEB. The Table 3 compares the CO between 12 meters long traditional passenger bus and PEB. It can be seen from the table that there is a good energy saving effect for PEB. Thus PEB reduced LCC mainly from the CO.

Table 3 The operation cost comparison between 12m long traditional bus and PEB

<table>
<thead>
<tr>
<th></th>
<th>Traditional bus</th>
<th>PEB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy needed per 100km</td>
<td>Oil cost: 35 liter</td>
<td>Electrical cost: 90 kwh</td>
</tr>
<tr>
<td>Energy price</td>
<td>Diesel: 7.8 RMB / L</td>
<td>Electrical price: 0.9 RMB / kwh</td>
</tr>
<tr>
<td>Operating cost per 100 km</td>
<td>273 RMB</td>
<td>81 RMB</td>
</tr>
<tr>
<td>Operating cost yearly</td>
<td>235,872 RMB</td>
<td>69,984 RMB</td>
</tr>
<tr>
<td>Operating cost saving yearly</td>
<td>- 165,888 RMB</td>
<td></td>
</tr>
</tbody>
</table>

Note: The yearly operating cost is calculated by the 240 km/day and 360 day/year.

7.1.2 LCC cost analysis for PEB under the new business model

With the same bus operation capacity (daily operating mileage 240km for 360 days per year and life time 8 years), Table 4 shows the LCC comparison result between the original business model and the implemented new business model. The data was taken from 12m bus as an example.

From the table results, LCC costs from the new business model are much lower than the one from original business model, which could be summarized by the following reasons:

(1). Under the old business model, because of the current battery technology limitation, PEB must configure more battery power to meet the operating requirements, which increased the purchasing cost. In addition, because of the lack of professional experience for the battery charging and maintenance, the battery life cycle was decreased and the secondary battery purchasing was must-do, which again increased investment (purchasing) cost (CI). Although the disposal battery could get more compensation under the old business model, but the purchasing cost was much more.
(2) Under the new business models, the electricity cost (inside CO) is higher than the one under the original business model, because of the battery replacement strategy. But from the PEB whole life cycle, such cost is much less than battery purchasing cost. It can be concluded that the economic benefit under the new business model is better than the one under the original business model.

Table 4 The PEB LCC analysis under old and new business model (unit: kRMB) (The detail calculation method can be referred by Appendix 1)

<table>
<thead>
<tr>
<th>LCC elements</th>
<th>Sub-components</th>
<th>Description</th>
<th>New business model (kRMB)</th>
<th>Original business model (kRMB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI</td>
<td>First investment (purchasing) cost</td>
<td>According to the purchasing receipt</td>
<td>1,200</td>
<td>2,200</td>
</tr>
<tr>
<td></td>
<td>Government subside</td>
<td>According to the government subside policy</td>
<td>- 500</td>
<td>- 500</td>
</tr>
<tr>
<td></td>
<td>Loan cost</td>
<td>Referring the Appendix 1</td>
<td>111.72</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Replacing battery cost</td>
<td>The power battery price 1, 000 kRMB per package</td>
<td>0</td>
<td>2200</td>
</tr>
<tr>
<td>CO</td>
<td>Labor cost</td>
<td>The driver salary 35 kRMB per year; The repairing worker salary 35 kRMB per year; The management employee salary 45 kRMB per year</td>
<td>920</td>
<td>920</td>
</tr>
<tr>
<td></td>
<td>Energy cost</td>
<td>Old model 0.9 RMB / kwh; New model 2.7 RMB / kwh</td>
<td>1679.62</td>
<td>559.87</td>
</tr>
<tr>
<td></td>
<td>Insurance cost</td>
<td>Obligation insurance 3020 RMB per PEB per year</td>
<td>24.16</td>
<td>24.16</td>
</tr>
<tr>
<td></td>
<td>Road maintenance</td>
<td>No road maintenance</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CM</td>
<td>Normal maintenance cost</td>
<td>2 kRMB per year</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>CF</td>
<td>Normal repairing cost</td>
<td>2.8 kRMB per year</td>
<td>22.4</td>
<td>22.4</td>
</tr>
<tr>
<td></td>
<td>Big parts replacing or repairing cost</td>
<td>No big parts replacing</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CD</td>
<td>Disposal benefit &amp; cost</td>
<td>Recycling battery and vehicle benefit</td>
<td>-2</td>
<td>-5</td>
</tr>
<tr>
<td>LCC</td>
<td></td>
<td></td>
<td>3471.90</td>
<td>5437.43</td>
</tr>
</tbody>
</table>

7.2 New pure electric bus (PEB) business model social benefit evaluation

Mainly based on the dimensions of corporate social responsibility (CSR) and the data which I collected from the case Zheng Zhou Yutong PEB project in Tianjing market, the PEB social benefits in this study are composed by few aspects, i.e., energy
structure optimization, technological innovation, energy grid deployment, state tax income growth, employment stimulation and others. Figure 13 shows the whole social benefit evaluation system for PEB in this study.

![Figure 13 The evaluation system for the PEB social benefit.](image)

In terms of optimizing energy structure, PEB not only reduce oil consumption, but also promote the improvement of the ratio proportion of clean energy usage. Therefore the total fossil energy consumption ratio is decreased and contributes to the country's energy structure optimization.

In terms of technological innovation, PEB promote the rapid development in electronic technology, new energy, new materials, motor technology, battery technology, modern high-tech integration, and other related technologies (Li 2004).

In addition, PEB promote rational energy grid deployment, increase of state tax income and stimulate whole society employment.

The scores were given to the different aspects of the social benefits under the new and original business model. The results are listed in the following Table 5.
The comparative results showed that the new business model had better social benefits from the state tax revenue, national energy structure, and reasonable allocation energy of the national grid, technology innovation and employment environment.
<table>
<thead>
<tr>
<th></th>
<th>New business model</th>
<th>Original business model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Evaluation</td>
<td>Score</td>
</tr>
<tr>
<td>State Tax Income Growth</td>
<td>Price advantage in the market competitiveness, favor to large promotion and increase national revenue.</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Expensive purchasing price and affect the PEB sales.</td>
<td>4</td>
</tr>
<tr>
<td>Energy Structure</td>
<td>With the PEB promotion program, the battery charging has good management, which can greatly facilitate grid load balancing and the usage of clean energy, optimizing energy structure</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Facilitating grid load balancing and the usage of clean energy, optimizing energy structure</td>
<td>4</td>
</tr>
<tr>
<td>National Grid</td>
<td>Battery charging is carried out with centralized management at low-loading period, which has &quot;load shifting&quot; effect</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Vehicle charging time and spatial distribution is uncertain, and charging load is randomness, which increase the difficulty of grid control.</td>
<td>3</td>
</tr>
<tr>
<td>Technology Innovation</td>
<td>PEB development led to the development of electronic, electrical power batteries and automotive engine and other technologies, promoting technological innovation</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>PEB development led to the development of electronic, electrical power batteries and automotive engine and other technologies, promoting technological innovation</td>
<td>5</td>
</tr>
<tr>
<td>Employment Stimulation</td>
<td>Better market competitiveness, which stimulate the rapid development of the automobile industry under the large-scale program, and improve the employment environment.</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Less market competitive, which has limited effect for the development of the automobile industry and the employment environment.</td>
<td>4</td>
</tr>
<tr>
<td>Total Score</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>
7.3 New pure electric bus (PEB) business model environmental evaluation

PEB environmental benefits are mainly reflected by two aspects: emission and noise reduction. PEB is completely powered by full electrical energy, which is a typical zero emission during the driving operation. There is a big contribution for the environment protection and clean air. The noise of the traditional bus is generated mainly by the energy and transmission system vibration, the rolling of the wheels, and the effect between the vehicle body and the air (Li 2004). For PEB, the special engine noise is lower than the one from traditional bus, which reduces the noise to the out environment and improves passenger comfort at the same time (Li 2004).

By the comparison of emissions between different primary energy and electrical energy conversion process, the emissions generated by traditional buses and electric buses during full life cycle are assessed. Using the Multiple Weighted Coefficient Analysis (Granovskii et al. 2006), the PEB environment effectiveness evaluation system by Zheng Zhou Yutong was built, as shown in Figure 14.

![Figure 14 The PEB environmental benefit evaluation system.](image)
The detailed analysis belongs to the engineering scope (Granovskii et al. 2006). From the data from Zheng Zhou Yutong PEB project in Tianjing market, the Environmental benefits of buses concern mostly emission reduction and noise reduction. Under the new business model, due to PEB low cost for both purchasing and LCC, there is a price advantage, which can be easily recognized and accepted by the customers. With the large-scale promotion, PEB market share increases. From another side point of view, the number of the traditional buses is decreasing and eventually indirectly reduces the emissions pollutant and noise pollution. Finally it results that the urban living environment is improving.

7.4 The value network industry profit evaluation under new pure electric bus (PEB) business model

As indicted in chapter 3, the PEB related value networks under the new business model include raw material suppliers, parts manufacturers (not including battery manufacturers), power battery manufacturers, vehicle manufacturers, financial institutions, public transport companies, and etc. The detailed analysis is as the following:

The raw material suppliers:

PEB raw material suppliers are involved in very broad area. It almost includes all industries of the raw material, such as steel, rubber, plastics, petrochemicals, electronics, and textiles and so on. Under the new business model with the PEB sales growth, it thus boosts raw material suppliers to increase overall profits.

Parts manufacturers (not including battery manufacturer):

With the PEB development and large-scale promotion, it prompts the parts manufacturers’ technology innovation and stimulating profitable growth.

Vehicle Manufacturers:
Compared with the original business model, the vehicle manufacturers do not need to sale the vehicle with the battery together, which would save the battery installation time, save debugging time and improve productivity. Without the battery together, the whole vehicle price would decrease, which would attract the public transport company to purchase the vehicle and therefore achieve maximum benefits.

**Power Battery Manufacturers:**

With the increasing sales of PEB, the power battery demand increases. It results in the increase of the power battery manufacturer profits. In addition, the battery manufacturers facilitate routine professional maintenance to improve the battery life cycle because of the separated sales of the vehicle and battery. Indirectly, it reduces the battery cost and allows using the batteries again and again by different applications, which would give the battery full role and thereby increase the profitability.

**Energy Companies (National Grid):**

With the PEB operation growing under the new business model, the charging infrastructure utilization is also growing. The investment of the charging station can be rewarded by the PEB electrical costs. In addition, energy companies would have unified battery management by the leasing the battery from the battery manufacturers. The batteries can be charged during the low loading shifting, which will help the power grid balance.

**Recycling companies:**

When the buses scrapped and are sold to the recycling companies, the scrapped vehicles would be will be dismantled, sorted, re-used by different applications, and sold to the raw materials suppliers to achieve profitability.

**The public transport companies:**
The formation of the whole PEB value networks must detect the demands of the public transport companies at the starting point, and meeting these demands at the ending point. With such repeating and cycling, the value networks innovation can be realized and upgraded. Under the new business model, the public transport companies use the capital funding through financial institutions and the government subsidies to purchase the vehicles. It can greatly reduce the pressure of the acquisition cost. Through the passenger ticket fee and the government subsidies, the public transport companies can recover the acquisition costs and operation costs to achieve the profit.

*Financial institutions:*

The participants of the financial institutions promote the development of the whole PEB industry value networks. By providing loans and other services to the public transport companies, the financial institutes also can get the profits.

*Government:*

The government plays a positive and effective role for the operation of the entire industry value networks. Through the industrial policy support and subsidy system funding, it can stimulate the consumption and encourage each enterprise for innovation and development.

From the above analysis, it can be observed that the new business model would inject new vitality to the industry value networks, which could be operated effectively and promote the interests of all stakeholders to benefit from the industry networks. A win-win situation could be achieved.
8 CONCLUSION

8.1 Answers for the research questions

From the above case study and analysis, some possible answers to the research questions can be derived.

Research sub-question 1: What are the structures and the problems of the Chinese PEB original business model?

This study analyzed the original Chinese PEB business model, which was based on the three different periods for the PEB commercialization roadmap. The main characteristic of Chinese PEB original business model is that the public transport company operates independently during the whole PEB life cycling, including PEB purchasing, operation, maintenance and disposal. Such structure would cause problems such as: higher purchasing cost (the second purchasing for the power batteries), state subsidies do not form an effective incentive for comprehensive benefits, and PEB driving range cannot meet the actual capacity needs. Such problems are the main reasons to block Chinese PEB promotion.

Research sub-question 2: How to design new business model for Chinese PEB under the value network concept?

According to the problem of the Chinese PEB original business model, the new business model was designed in order to separate the purchase of vehicle and battery. The public transport companies purchase only the vehicle without the battery included. Similarly as before, the charging infrastructure is constructed by the fund from the National Grid (Energy Company). However, the National Grid also leases the battery from the battery manufacturers with unified battery management. The public transport companies replace the battery according to the PEB operation needs and pay the energy company by battery usage and electrical energy cost. It is also recommended to have the original few program optimizations under the new business model structure, which include subsidy program, financial program, and the whole vehicle purchasing mechanism. Through the PEB value network analysis
under the new business model with the value creation activity flow, the new business model design was considered reasonable.

Research sub-question 3: How to implement the designed new business model to Chinese PEB industry?

Under the designed new business model, several proposals were suggested for the vehicle designing, the PEB charging, PEB operation, PEB marketing, PEB service and PEB recycling aspects. All these proposals were implemented to the Tianjin bus line 638 in real market case.

Research sub-question 4: How to evaluate the designed business model for Chinese PEB industry?

The comprehensive PEB benefits are mainly evaluated in three aspects from the economical, social and environmental benefits. In addition, the enterprises from whole PEB industry value chain are evaluated for their own benefit effects. These evaluations would construct the whole PEB implementation appraisal system. The evaluation results showed that under new business model, the benefits for PEB in economical, social and environmental perspectives are higher than the ones under the original business model. The new business model has injected new vitality to the industry value networks, which can be operated effectively and promote the interests of all stakeholders to be benefited from the industry networks. A win-win situation can be achieved.

In conclusion, for the main research question How to develop the new business model for pure electric bus (PEB) in China? The answer is that it verified the aspects in our business model literature review about the definition of business model, and the designing business model under value networks. From the activity–system views, Chinese PEB business model can be set up towards total value creation for all parties. It is a system of interdependent activities not only for the public transport company itself. Such activities should be also performed by the suppliers and partners, such as raw material suppliers, parts manufacturers, power battery
manufacturers, vehicle manufacturers, financial institutions, and recycling companies.

The business model design parameters can include the design elements and design themes. The PEB business model design elements can be the activity contents, activity structure, and activity governance. PEB activities content can include the PEB vehicle designing, the PEB charging, PEB operation, PEB marketing, PEB service and PEB recycling. So the PEB new business model design structure start point is to link these contents together and set up the sequences for these contents. Then the governance decides that who and where should perform these contents.

The business model design themes can include the novelty, lock-in, complementarities, and efficiency. In this case study for the new business model design, the novelty can be main breakthrough for the new PEB business model, which was the separation between purchasing the vehicle and the battery. The lock-in can be the involvement of National Grid and battery manufacturers to the battery charging activity. The complementarities can be the adoption for the activity of financial institutions. The financial institutions can supply the loan to the public transport companies to solve the lack of funds problem. The efficiency can be realized from all bundle activities together to generate greater value.

In addition, the Chinese government subside policy and program is the country specific and industry specific activity content which is beyond the general design parameters. In this case study, the subside policy and program plays important role for the whole PEB development. It can be suggested to put a country specific support as a supplement parameter.

8.2 Limitation of the research

There are few limitations in this study as the following:

(1). The PEB market development relates to many impact factors. All the involved stakeholders and activities are also impacted by the complex factors. In this study,
solely the key activities in PEB industry were selected, which might ignore some other fine factors.

(2). The PEB business model evaluation system is needed to continue the improvement and refinement. Because there are different concerns during the different PEB development stage, it is needed to construct the PEB evaluation system with higher flexibility. It is also needed to further explore comprehensive new energy vehicle evaluation system with a versatile and universalized point of view.

(3). Due to many factors impact, the designed new subside program was not implement with the Tianjin market in this case study, which might have slight impact for the whole designed business model. In the future, if there is any possibility to implement the new subside program, it would verify the government incentive effect by such factor.

8.3 Future research suggestion

From the conclusion and limitation chapters, it is suggested that few further research topics are required.

The government supporting for the new energy vehicle (not only PEB) can be put as the supplement content from the theoretical perspectives.

The new designed subside program can be implemented to the real case, which would verify the government incentive effect by the subside program.
REFERENCES


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http://www.gov.cn/zwdt/2008-08/content_1062610.htm

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APPENDICE 1

The description for the PEB LCC calculation

According to the Yutong Tianjin PEB implementation project during August 2012 and April 2013, the project members visited the Tianjin bus line 638 and 862. They gave the survey the bus driver, the passengers, the repairman, the station staffs, customers, and other PEB stakeholders. The questionnaires about the new business model were received for more than questionnaire 60 copies.

PEB’s LCC model validation is based on actual results and statistic result of the visiting. The detail calculation is described as the following table, where bus operators age of 8 years.

<table>
<thead>
<tr>
<th>LCC elements</th>
<th>Sub-components</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI</td>
<td>First investment (purchasing) cost</td>
<td>According to the purchasing receipt</td>
</tr>
<tr>
<td></td>
<td>Government subside</td>
<td>According to the government subside policies (Chinese Policy Document 2009), the public transport company purchases one PEB with length longer than 10 m would get 500 kRMB subside.</td>
</tr>
<tr>
<td></td>
<td>Loan cost</td>
<td>Calculation formula: Loan cost = Loan amount * interesting rate + Guarantee fee Loan period is 3 years; The first payment is 30% of the total purchasing cost; Guarantee fee = Loan amount * 2%; The interesting rate is 11.3%, which was provided by the Zhengzhou AnChi Insurance Col Ltd.</td>
</tr>
<tr>
<td></td>
<td>Replacing battery cost</td>
<td>Calculation formula: Replacing battery cost = Power battery price * Number of the replacing times The power battery price 1, 000 kRMB per package (The price is provided by the battery manufacturer, in which the batter energy is standard 270 kwh for PEB and 3.7 RMB / wh.) Battery life time is 3 years. This value is provided by the Zhengzhou Yutong Bus from the measurement result in Test Center. The battery life is end when the energy capacities decay to 80% of the initial capacity.</td>
</tr>
<tr>
<td>CO</td>
<td>Labor cost</td>
<td>The labor cost is includes the driver salary, the repairing worker salary and the management employee salary. The salary is provided by the average survey results from Zhengzhou Yutong PEB implementation project.</td>
</tr>
<tr>
<td></td>
<td>Energy cost</td>
<td>Calculation formula: Energy cost = Daily operational kilometer mileage * Power consumption per kilometer</td>
</tr>
<tr>
<td>Mileage</td>
<td>Electricity cost</td>
<td>Operating Days</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Old model 0.9 RMB / kwh; The value is provided by the National Grid from the real PEB energy consumption 0.9 kwh / km.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New model 2.7 RMB / kwh; The value is provided by the National Grid from the real PEB energy consumption 0.9 kwh / km.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation capacity: 240 km / day and 360 days / year</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Insurance cost**

Calculation formula: Insurance cost = Obligation insurance fee * PEB operation years

There is no other insurance cost except the obligation insurance. The obligation insurance fee is 3020 RMB per PEB per year, which is provided by the policy document “Basic Obligation Insurance Fee in 2012 in China”. PEB has the same obligation insurance cost with the traditional bus.

**Road maintenance**

PEB belongs to the society welfare and there is no road maintenance cost.

<table>
<thead>
<tr>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Normal maintenance cost</strong></td>
</tr>
<tr>
<td>Calculation formula: Normal maintenance cost = Yearly maintenance cost * PEB operation years</td>
</tr>
<tr>
<td>During the Yutong Tianjin market implementation project from August 2012 to April 2013, PEB maintenance cost about 1.5 kRMB for the power system and braking system. So it is roughly evaluated that the normal maintenance cost is not over 2 kRMB per year.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Normal repairing cost</strong></td>
</tr>
<tr>
<td>Calculation formula: Normal repairing cost = Yearly repairing cost * PEB operation years</td>
</tr>
<tr>
<td>During the Yutong Tianjin market implementation project from August 2012 to April 2013, PEB repairing cost about 2.0 kRMB for the normal defect repairing. So it is roughly evaluated that the normal maintenance cost is not over 2.8 kRMB per year.</td>
</tr>
</tbody>
</table>

**Big parts replacing or repairing cost**

During 8 years PEB operation time, there is no necessary for the battery system, energy system or vehicle floor replacing, so there is no such cost.

<table>
<thead>
<tr>
<th>CD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disposal benefit &amp; cost</strong></td>
</tr>
<tr>
<td>It includes the vehicle recycling benefit and battery recycling benefit.</td>
</tr>
<tr>
<td>Recycling battery benefit: 15 kRMB / package (The value is from the battery manufacturer)</td>
</tr>
<tr>
<td>The vehicle cycling benefit: 5 kRMB / vehicle (The value is from the public transport company)</td>
</tr>
</tbody>
</table>

**LCC**

Calculation formula: LCC = CI + CO + CM + CF + CD