

Economic Viability of Second Life Applications of Lithium-ion Traction Batteries

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Summary

Main research question of this study was, if used lithium-ion traction batteries (LITBs) can be applied economically, so that the Total Cost of Ownership (TCO) of a battery-electric vehicle (BEV) can be reduced. Economically evaluated SL-applications are amongst others provision of primary control and house storage system in combination with a photovoltaic system. Identified success factors are a high share of the battery costs to the total investment costs, a long operating time and low absolute battery costs [1-3]. A TCO reduction potential of 3.4 % was determined.

Keywords: second-life battery, LCC (life cycle cost), lithium battery, recycling, BEV (battery electric vehicle)

1 Introduction

In 2001 the German federal government set the target of one million electric vehicles (EVs) on German roads up to 2020. The stock of BEVs on German roads amounted to 25,000 in January 2016 [4]. According to Vögt & Bongard 2015 the main reason for the reserved buying behavior is the comparatively poor economy of the EVs [5]. With 25 % of the purchase price of a BEV the traction battery carries a large cost share [6]. These acquisition costs are also reflected in the TCO of a BEV. In order to reduce them or distribute the battery costs over a longer period, SL applications could be a possible concept. At the end of the use phase of a LITB in the BEV, it has not lost its entire residual value, but only a part of its storage capacity [1].

Within the research project SeLiBa an analysis of the economic viability of different Second Life (SL) applications was carried out on the basis of a literature evaluation. The study will serve as basis for future research regarding potential business models for lithium-ion battery technology.

1.1 Objective

Goals are a comprehensive business analysis and assessment of SL applications of LITBs after use in a BEV and the determination of the impact on the TCO of a BEV as well as an economic comparison between recycling and reuse. Key research questions are:

- Can used LITBs be applied economically so that the TCO of a BEV can be improved?

- Which SL applications offer economic potential?
- Which are identified success factors of these applications?
- How is the economic situation compared to recycling of used LITB?

2 Method

The analysis and assessment of the economic potential is based on the evaluation of the current literature. The approach of the systematic research is divided into the following steps:

- Systematic literature search: Research of SL applications, their economic viability, safety issues and market conditions as well as of recycling options and related costs
- Literature analysis and evaluation of current available economic assessments of SL-applications
- Economic comparison between reuse and recycling of used LITBs
- Determination of the impacts on the TCO of a BEV
- Presentation of the results and critical discussion

The databases „Science Direct“, „WISO“, „Springer Link“, „Google Scholar“ and „Research Gate“ were used. Search criteria were the publication period from 2001 to 2016, SL applications based on the reuse of LITBs from pure electric vehicles and only publications with an economic evaluation of SL-applications were considered. Six publications were identified and further analyzed. Different business calculation methods, such as the method of capital value, the amortization period and the profitability index were used in the selected publications. SL applications were compared internally and across the application. In addition, market considerations were conducted for the economically evaluated SL applications in order to present possible potentials. The economic comparisons with recycling are based on the results of the research project LithoRec [7]. For own calculations the availability of used LITBs in Germany was analyzed, in particular, the current and forecast inventory of BEVs as well as a forecast of the waste battery volume.

3 Results

In the identified literature an economic further use of LITBs from BEVs was shown (Table 1). For five of the 16 different analyzed SL applications reuse is evaluated profitable. This includes provision of primary control, house storage system in combination with a photovoltaic system, microgrid, deferral of network investments and ensuring the quality of the network. In addition, a potential economic value for the use of SL batteries against new batteries could be demonstrated [8,1]. The success factors for SL-applications vary between applications. However, a high share of the battery costs to the total investment costs, a long operating time of the SL battery (SLB) and low absolute SLB costs are generally advantageous [1-3].

The profitable reuse of LITBs can be carried out both in the commercial and private field. In view of the German market environment, the quantitative market analysis did not provide any great insights. However, it should be noted that in principle a large market volume is present within the scope of the applications for the provision of primary control capacity and the house storage system in combination with a PV-system. In 2015, for example, 19,328 house storage systems were installed in Germany in connection with a PV system [9].

Table 1: Overview of the analyzed SL applications in the literature considered

Autor/s of the study	SL application	Region of the study	Evaluation		
Fischhaber, S. et al.	Provision of primary control	Germany	x	x	
Narula, C. et al.	Frequency regulation	USA	x		
Fischhaber, S. et al.	House storage system (in comb. with a PV-System)	Germany		x	x
Assunção, A. et al.	House storage system (in comb. with a PV-System)	Portugal	x	x	
Heymans, C. et al.	Energy cost management (private)	Canada		x	x
Narula, C. et al.	Energy cost management (private)	USA			x
Narula, C. et al.	Energy cost management (commercial/industrial)	USA			x
Ambrose, H. et al.	Microgrid (Comparison battery type)	USA	x		
Wolfs, P.	Current load / current peak compensation	Australia	x		
Narula, C. et al.	Current load / current peak compensation	USA			x
Narula, C. et al.	Deferral of network investments	USA	x		
Narula, C. et al.	Ensuring the quality of service (private)	USA	x		
Narula, C. et al.	Ensuring the quality of service (commercial/industrial)	USA	x		
Narula, C. et al.	Offer of additional supply capacity	USA			x
Narula, C. et al.	Use in load operation	USA			x
Narula, C. et al.	Network service reserve	USA			x
Narula, C. et al.	Voltage support	USA			x
Narula, C. et al.	Transmission support	USA			x
Narula, C. et al.	Transmission interference avoidance	USA			x
Narula, C. et al.	Interruption-free power supply (private)	USA			x
Narula, C. et al.	Interruption-free power supply (commercial/private)	USA			x
Narula, C. et al.	Optimization of feed-in revenues from renewable energies (private)	USA			x
Narula, C. et al.	Optimization of feed-in revenues from renewable energies (commercial/industrial)	USA			x
Narula, C. et al.	Capacity Supporting Use of Renewable Energy (commercial/industrial)	USA			x
Narula, C. et al.	Capacity Supporting Use of Renewable Energy (commercial / industrial)	USA			x

Legend:

■	SL application as being economically valued
■	Used SLB economically advantageous compared to a new battery
■	SL application as being uneconomically valued

3.1 Comparison to Recycling

At present, there are no procedures and capacities available to ensure efficient recycling [10]. According to a realistic scenario of the LithoRec project, a profitable recycling of LITBs is expected at the earliest from 2023 onwards [7]. Compared to recycling, the economic SL applications are therefore preferred at least until recycling is economically feasible with regard to process efficiency and capacity aspects.

3.2 Impact on TCO

Based on own calculations, a TCO reduction potential (with SL application) of 3.4 % was determined as well as comparable reductions of the acquisition costs of a BEV with 6.2 % for a VW e-Golf, 6.6 % for a Smart fortwo electric drive and 7.3 % for a Nissan Leaf Visia. Since no profitable recycling of LITBs can be carried out, positive TCO effects can be excluded by this time [7]. In the case of an economic recycling of LITBs from 2023 onwards, it is theoretically possible that this would have an impact on the provision costs of BEV manufacturers, which could reduce the costs of BEVs.

4 Discussion & Conclusion

For an economic reuse of LITBs, it is necessary to clarify the extent to which a basis for an active SL application battery market exists. A prerequisite for a dynamic SLB market is a strong return on BEVs [1]. This return is dependent on an agile and growing registration of BEVs, which is expected to be in 2020 at the earliest [1,11,12]. Assuming an automobile use phase of eight years, a dynamic market is available from 2028 onward. The already existing revenue potentials should nevertheless be realized, since the reuse of LITBs is currently in several applications economically feasible.

Currently, profitable reuse of LITB is to be preferred to recycling. A common recycling system is recommended [10]. For an exemplary combination of the recycling costs provision costs per LITB weighing 220 kg for an NMC battery system amount to 459 € and for an LFP battery system 778 € [10]. By extending the useful life of the LITB, the discounting effect could result in lower provision costs.

The reuse of a LITB can have a lessening effect on the TCO of a BEV and thus to the TCO difference compared to vehicles with conventional drives, which is about € 4,000 [13] and thereby support a faster market penetration of BEVs. The TCO-results are based on the assumption that the residual value after reconstruction will be constant. This premise can be strongly criticized, as the new battery costs are expected to continue to fall. As a result, lower residual values can be assumed, which is why the economic effects on TCO will probably be lower in the future. While low residual values have a positive effect on the profitability of SL applications, they have a diminishing effect on the reduction of TCO and on the proceeds for the LITB owner. In this context, therefore, a competing target relationship exists.

Although the reduction of TCO is not significantly high, the SL application is also proving to be of great benefit from an ecological point of view [14,15,1]. A further benefit for society could be realized due to the integration of renewable energy supported by the use of cheaper SLBs [1]. The actual financial profit is generated within the scope of the SL application, of which the owner of the vehicle does not profit [1]. Overall, there is however an economic and ecological potential.

To be critically emphasized are the facts that only few economic analyzes of the reuse of LITBs are available, studies vary in regional context and base on different assumptions. Safety aspects of SL applications and associated costs show a big gap in literature. It is necessary to specify the legal framework for SL applications, since only assumptions can currently be made. In this context, the technical standardization should also be introduced, since the reconditioning for reuse and recycling could be made more efficient and cost-effective. The assessment of potential markets for SLBs has so far only been a small consideration in literature. These gaps should be removed.

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