Forecast of retired electric vehicle lithium-ion batteries in China

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Keywords: retired electric vehicle batteries, scrap volume, lifespan, prediction.
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The Chinese government has introduced a series of policies to support the development of battery electric vehicles (BEVs) since 2011. In 2017, China's BEVs production jumped 140 times more than production in 2011, reaching 692 269, a 62.97% increase from 2016. With the rapid diffusion of the BEVs, there are growing concerns for the environmental problems and the disposal pressure of the power batteries, a key component of BEVs and containing heavy metals and toxic chemicals, after their service life in vehicles. Recycling and re-using spent batteries are critical for the treatment of waste, the recovery of useful resources, and the maximum utilization rate of power capacity. However, China's current collection and recycling systems of discarded power batteries do not have sufficient dealing capacity for the upcoming millions of retired BEVs batteries. Therefore, there is an urgent need to predict the amount of power battery scrap in advance for making a plan for expanding the collection and disposal systems.

In this study, we propose a reliable generation estimation approach of retired BEVs power batteries to forecast the generation of lithium-ion battery scrap in China. We combine the battery lifespan, the distribution of the lifespan, and the amount of the battery electric vehicle production into a scrap BEVs batteries forecast model. We discuss three main cathodes Lithium iron phosphate ($LiFePO_4$), $Li(NiCoMn)O_2$ and lithium titanate (LTO) based on prior studies showing that the environmental performance and the lifespan of batteries are strongly dependent on the cathode chemistries. We also categorize automobiles into passenger vehicles, buses, and special vehicles because of vehicle type's influence on the using frequency and lifespan of the batteries. We decompose the solution into three steps. Firstly, calculate the battery lifespan. We combine cycle aging (battery working operation) and calendar aging (battery storage mode) and set up two models according to their life decay law to estimate the service life of the three types of battery. We used the database which is set up by Peters *et al.*, 2017 and contains 563 datasets from 1999 to 2016. Secondly, for predicting the production of three types of BEVs, we consider the effect of a new policy - double integral policy and use the exponential smoothing model and vector autoregression model, which add the selection of economic indicators to improve the forecast of the BEV production. We used the monthly data of BEVs production and other economic indicators, which originate from Wind database. Finally, we combine the distribution of lifespan (Weibull distribution) and the production of BEVs to forecast the battery scrap. The results show that the battery lifespan is strongly dependent on the cathode chemistries and the vehicle types. LFP batteries have longer lifespans than the NMC-batteries in the same vehicle type. Moreover, buses have shorter lifespans than passenger vehicles and special vehicles because of their higher frequency of use.

We suggest considering the effect of the new policy - double integral policy - on the vehicle production, aiming at passenger car production enterprises. The estimation result shows that massive battery scrap will be ushered in 2020 and has an increasing growth rate due to the production growth and the battery replacement, owing to battery lifespan shorter than automobile lifespan. Based on the result, we propose that collection and recovery mechanism of BEVs battery should be preliminary establishment before 2020. It is necessary to establish collection and recovery mechanism with greater processing capacity in advance to cope with the dramatic increase in the amount of battery scrap. Besides, as the number of scrap increases, the second use and recycling of spent batteries are more economical so that the subsidy can be reduced. The prediction of the scrap volume and the life calculation of the power battery in this study can form the bases of many other researches on power batteries, such as the future perspective on lithium-ion battery waste flows, life cycle analysis of power batteries and so on.

References:

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