Evaluation and recovery of power batteries based on trusted blockchain traceability

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Abstract. In order to solve the new threats to human health and the earth environment brought by the large number of discarded power batteries in the future, we propose a method of power battery evaluation and recovery. We use trusted blockchain technology to build a scientific, efficient and reliable power battery evaluation and recovery platform, through the power battery production, sales, use and recovery process, contact the manufacturers, dealers, users, charging stations, and other nodes. At the same time, through the battery built-in BMS system and wireless communication terminal, real-time access to the battery usage and performance parameters. When it is detected that the power battery meets the recycling standard, the battery can be transported to the waste battery treatment center through the logistics network established by the manufacturer. The treatment center uses alkaline precipitation and biocatalysis to centrally process the recycled materials and realize the recycling of the recycled materials. The method breaks down the technical barriers in the field of power battery evaluation and recovery, and provides scientific, efficient and advanced support for environmental protection.

1. Introduction

We have established a brand new system of power battery assessment, recovery and traceability, which based on the blockchain technology, and evaluated the cycle charging and discharging process of the battery as well as the applicable scenarios of the whole life cycle of the battery, so as to achieve a comprehensive assessment of the power battery.

The platform combines the technique of BMS to read the battery case and make it on the chain. The number of the battery, its capacity, the manufacturer's entire production chain, and its transportation, purchase and use are recorded on the chain. Each trading entity uses the non-tamperability of blockchain information to share trading information. The whole platform provides convenience for users of various batteries. Users can obtain battery information at any time through the mobile phone client, and at the same time improve the sharing and security of transaction information. According to the information recorded in the chain, while ensuring that the battery trading chain and usage are recorded so as to trace the source of battery production, we can judge the battery usage according to the evaluation system and identify the battery that meets the recycling standard. Next, the waste batteries are transported to the waste battery processing center for centralized processing through the logistics network set up by the manufacturer. Thus we have
established a sound and scientific battery recording, tracing and recycling system. The system can effectively deal with the difficulties in recovering power batteries and the incompleteness of the system. The proposed technology can fundamentally solve the current recycling problem of waste batteries is not profitable, recycling standards are not scientific, the evaluation system is not perfect and recycling efficiency is low.

2. Research approach
We start from the storage layer, network layer and application layer of the blockchain. The storage layer is mainly used to store BMS data and production and circulation data of batteries. Manufacturers, distributors and users, as important components of the application layer, share information through the network layer. Each node has the ability to prove battery information. If one trading entity tampers with the information without authorization, other trading entities can easily identify it, thus increasing the reliability of the information.

Before the battery leaves the factory, RFID electronic tags (including antenna, storage module and processor) should first be put into the battery. In the flow process of the battery after leaving the factory, each node needs to use RFID reading and writing devices to write the current usage (mainly battery capacity Volume) and flow information (including time, place, logistics/dealer information, current RFID reading device ID, etc.) of the power battery to the electronic tag and upload it to the database. The ID of each node needs to be unique for identification purposes.

BMS battery system, also known as battery nanny or battery housekeeper, is an important component of electric vehicle power battery system. On the one hand, it detects, collects and preliminarily calculates the real-time state parameters of the battery. On the other hand, the collected key data is reported to the data receiving terminal to achieve man-machine interaction.

2.1. Implementation of power battery evaluation system
Full charge and discharge refers to that the battery is operated to less than 10% of the electric quantity, and then plugged into the charging power supply and charged to more than 90%, which is regarded as a complete cycle charge. If it fails to discharge to 90%, the accumulative discharge and reaching 90% can also be regarded as a complete charge and discharge. Cycle charge and discharge number refers to the number of times the battery has been fully charged and discharged since the beginning of use.

Just as the fuel car will take "total mileage" and "purchase time" as maintenance conditions, the design also uses a variety of standards to evaluate the health status of the battery. When any value reaches the set threshold, the battery can be deemed to be recycled.

2.2. Implementation of blockchain to store battery information
According to the network hierarchy of blockchain, the architecture design can be simply divided into three layers: blockchain storage layer, blockchain network layer and application layer. Blockchain storage and blockchain network are independent but inseparable from each other.

Blockchain storage layer: it is mainly used to store the capacity information of nodes, namely the transaction information between battery circulation and usage information. Once it is successfully stored in the block, it cannot be changed.

Blockchain network layer: all battery users in the supply chain exist as miner nodes in the designed blockchain network. When the user receives the query of battery information, the participant nodes in the blockchain network start to "mine", and the first miner found gets the bookkeeping right of this information. In this layer, the Pow consensus mechanism based on blockchain technology is mainly adopted to calculate a random number that meets the rules through or operation, that is, to obtain the accounting right, issue the data that needs to be recorded in this round, and store the transaction information together with other nodes in the network after verification. The mechanism is completely decentralized, with nodes entering and leaving freely. Tamper-proof is also provided by the layer's consensus mechanism, with nodes added to the network jointly maintaining the operation of the entire chain.
Application layer: judge whether the battery is recycled. When the battery capacity information reaches the threshold set by us, if it is set as the capacity has reached 70%, it will be recycled according to the specific situation of the battery.

2.3. Implementation of evaluation and recovery of power battery

The criteria for the end of power battery life vary with battery model, vehicle performance, battery quality and other factors, but the main criteria can be summarized as the following two points.

The first is to meet the need for electric vehicle range. A typical value of an 18650 cell capacity is 2950mAh, and the power unit of an ev is usually composed of multiple battery packs containing modules. Take an electric car of Dongfeng as an example, it is composed of four modules with different proportions, and its typical range is about 350km, while the commuting distance between two cities in China is about 240km. In order to guarantee user experience, the charging frequency should be controlled within one time during long-distance commuting, so it requires that the battery SoC should be kept at more than 70% of FCC.

The second is the need to ensure the safety of the battery. In the electric vehicle batteries, for example, adopted by the electric vehicles during the period of service, large discharge scenario will happen frequently, under the condition of the battery capacity is about 70%, the length of the lithium dendrite is about 5 nm, and lithium battery anode diaphragm thickness of typical values for 7 nm, so the threshold is set at 70% of the battery capacity is more reasonable.

Therefore, for this electric vehicle, 70% can be set as a threshold, and the same threshold estimation method can be applied to other types of electric vehicles.

3. Specific implementation plan

The implementation process of this project is mainly divided into the following three parts: matching of battery labels, data linking of each link, and client platform interaction. Then describe each part in detail.

3.1. Label matching design

We choose RFID as the medium of traceable information. Each battery is assigned an exclusive RFID tag, which is embedded in the battery using certain technologies to ensure that it is unique, non-replaceable, non-destructible and easy to read. See Figure 1.

![Figure 1. The power battery matches the label.](image)

The label contains the factory information (static information) and use information (dynamic information) of the power battery. The use scenarios are as follows:

When leaving the factory, each power battery shall be assigned an exclusive label as its id IC;

When the link requiring data writing is encountered, the staff shall first scan the IC of the battery, and according to the obtained information, check the current state of the power battery, confirm it is correct, and then write the data with the platform as the interface to form a block. In case of information contradiction, the state bit shall be set;

Stakeholders of power battery can obtain all information by scanning IC code.
3.2. Data link design
The person in charge of each link writes the relevant information of the power battery into the block, as shown in Figure 2. The specific methods are as follows:

- **Power battery manufacturers** provide information about the battery leaving the factory, which is mostly static data that cannot be changed. The person in charge first scans the IC of the battery and writes the static data into the block through the interface provided by the platform.

- The logistics provider scans the IC code and writes all kinds of logistics information about the delivery of power batteries into the block.

- The seller obtains all the battery information as a reference for sale. Change the mark position when selling, increase the time information.

- The user can get the battery information by scanning IC code. Users hope to upload information about the battery in time when they charge, discharge, maintain or operate the battery.

- The recycler starts to judge the recycling direction of the battery according to the obtained battery information, such as scrap, processing and utilization, gradient utilization, etc. The processing information is also written to the block.

- After the data is transmitted to the platform to form a block, the miners in ethereum will take the place to form a block chain. Due to the non-tamperability of the block chain, once the data information is written into the block chain, it is difficult to be tampered with.

BatteryData's properties are: ID, Origin Year, Volume, Ad, etc. Each property can be set to more than one child, with its state set to 0 when the value is null.

3.3. Client platform design
The realization of data writing function of the platform: after the data uploader scans the IC code, the platform calls the intelligent contract through the data upload interface in solidity, so that the data is written into the block, waiting for the miners in ethereum to make the block chain, in which a certain amount of ether currency needs to be paid for the miners. See Figure 3.

The test platform is remix of ethereum, where addInfoToStore is the input function to add information and getInfo is the function to get information. The client platform call interface can write and read data.

Realization of the platform's data reading function: after the user scans the IC code, the platform also calls the data reading interface to read the corresponding data. After that, the data are analyzed and visualized to present the results in the mobile terminal.
4. Conclusion
This project uses the time stamp, consensus mechanism and other technical means of blockchain to realize the non-tampering and tracing of data and other functions, providing strong technical support for the establishment of this platform. Compared with the cluster storage, the distributed storage characteristics of blockchain show great advantages when applied to the construction of this platform.

For the car factory, the battery information is linked up in real time during the circulation process and the information sharing of all nodes is realized, so that the car factory can timely obtain the current battery health status in circulation and timely adjust the input of production factors and productivity according to the situation to maximize the production capacity. For users, once the data is linked, it cannot be changed, and automobile manufacturers cannot maliciously tamper with the data of battery use for their own personal gain, which to a large extent ensures users’ right to know and creates a supervision system. For the government, it can avoid environmental pollution and waste of resources, improve the recycling level of battery raw materials, and avoid the potential harm of waste power batteries to people and the environment is battery recycling. For the industry, battery recycling is an indispensable part of the whole cycle of the new energy vehicle industry, forming a closed loop of the industrial chain from production, sales, operation, after-sales service to recycling and reuse. For battery manufacturers, power battery recycling contains business opportunities and has a positive impact on their social image.

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