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CASIC PERSPECTIVES

Who is CASIC? China Automobile Standards Internationalization Center (Geneva), a "Non-Profit Organization" based in Geneva, Switzerland, since 2020, is the first standardization specialized agency in overseas established by China's automobile industries in collaboration with various stakeholders. CASIC adheres to the concept of openness, cooperation, integration, and contribution, is committed to fully integrating and deeply participating in the formulation and coordination of international standards and regulations in the automotive field.

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Add: Boulevard Helvétique 36, 1207 Genève **Tel**: +41 (0)22 736 2417

CASIC Perspectives on Battery Swap

Executive summary

This article was prepared by China Automobile Standards Internationalization Center (Geneva) (CASIC) to promote consensus in the automotive industry on the battery swap mode of electric vehicles. This innovative method of energy replenishment is not only a technological breakthrough but also an innovation in business models. With its increasing acceptance in China and expanding influence in other regions, the battery swap model deserves close attention and research from regulatory bodies and industry standardization organizations.

In total, global sales of EVs, including BEVs, PHEVs, and FCVs, reached 13 millions in 2023, bearing a growth rate of 29.8% compared to 2022. Along with the increasing penetration rate, EVs still face certain dilemmas on their way to entering more families' garage, for instance, range anxiety for long trips, high time consumption for vehicle charging, safety concerns on battery packs, lack of charging infrastructures around, etc.. Finding an optimal charging solution is key to solving these problems and a common goal that manufacturers have been working towards. Different resolutions on this topic are raised by different stakeholders, like innovation of fast charging technology, promotion of family charging post, and also new energy replenishment like battery swap (BS).

Battery swap is a technology by which the traction battery can be quickly replaced through special devices and artificial assistance to quickly and smoothly perform the charging of electric vehicles. Due to its convenience of use, the battery swap mode has been promoted and widely applied in China and has gradually been promoted to other countries such as Norway, Denmark, Sweden, Germany and the Netherlands.

CASIC notes that battery swap has become an important technical solution for rechargeable electric vehicles, but the current international standards and regulations might have not considered the special details of battery swap, like the capacity modification of swappable batteries and etc., leading to certain unexpected restrictions to its application. It is suggested to update the related standards by taking battery swap into account, and also to facilitate the battery swappable electric vehicles' registration and usage by introducing corresponding policies or technical management methodologies.

CASIC suggests international organizations, authorities, manufacturers and other stakeholders to engage in standardization cooperation. Our common goal is to establish industry-recognized standards for the battery swap infrastructures, battery swap systems and the communication protocols between them, thereby fostering the healthy development of the entire industry and promoting the wider adoption of this technology.

1. Development and Application of Battery Swap

What is Battery Swap and its Business Model ?

The battery swap system mainly includes a swappable battery pack, easy assembly and disassembly cooling and electrical connectors, and a set of lock mechanism as shown in Fig. 1. The system is designed for frequent swaps and the battery is fitted to the vehicle chassis by the lock mechanism. The empty batteries can be quickly removed and replaced with fully charged ones at automated drive-in swap stations within 5 minutes. The replaced batteries are centrally charged and managed in the battery swap station.

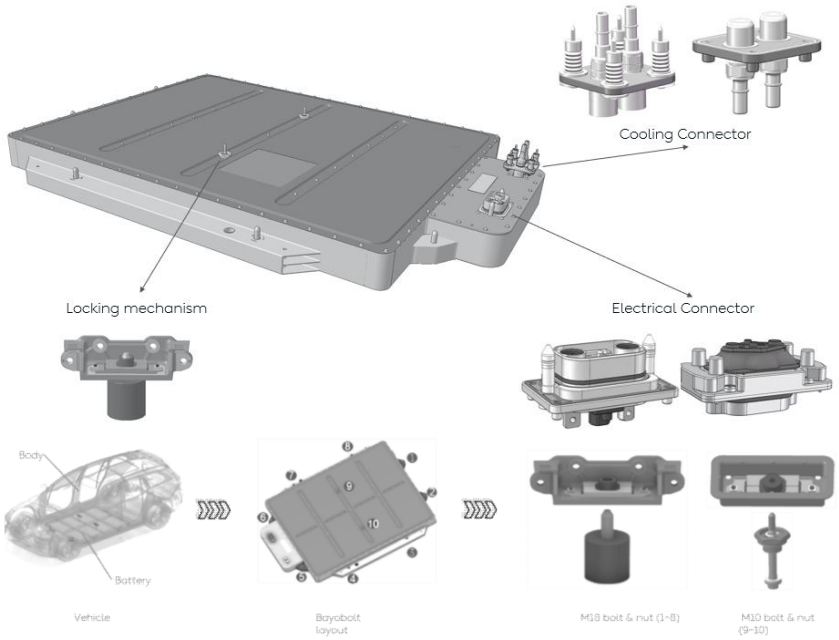

Fig. 1 The structure of battery swap system

The idea of battery swapping is not new. Starting in 2007, the battery swap model was gradually launched in Israel, Japan, the United States, and Denmark and had certain impact in these countries. Since 2015, many OEMs actively promoted the application of battery swap mode, which has been widely used in China, and extended to Germany, Sweden and other countries.

The battery swap technology makes the ‘vehicle-battery separation’ business model possible. ‘Vehicle-battery separation‘means that the ownership of the battery and the ownership of the vehicle are separated by introducing a battery assets holding and operation company between the original equipment manufacturer (OEM) and the customer. The battery assets holding and operation company purchases the batteries

from OEMs, manages them centrally, and provides personalized battery services to the end users. Meanwhile, the customers no longer need to buy the battery when purchasing a car, as they buy the battery-related services from the battery holding company. The users, the OEMs, and the battery holding companies all benefit from this model. In this model, electric vehicles become constantly renewing, advanced, and permanently valuable.

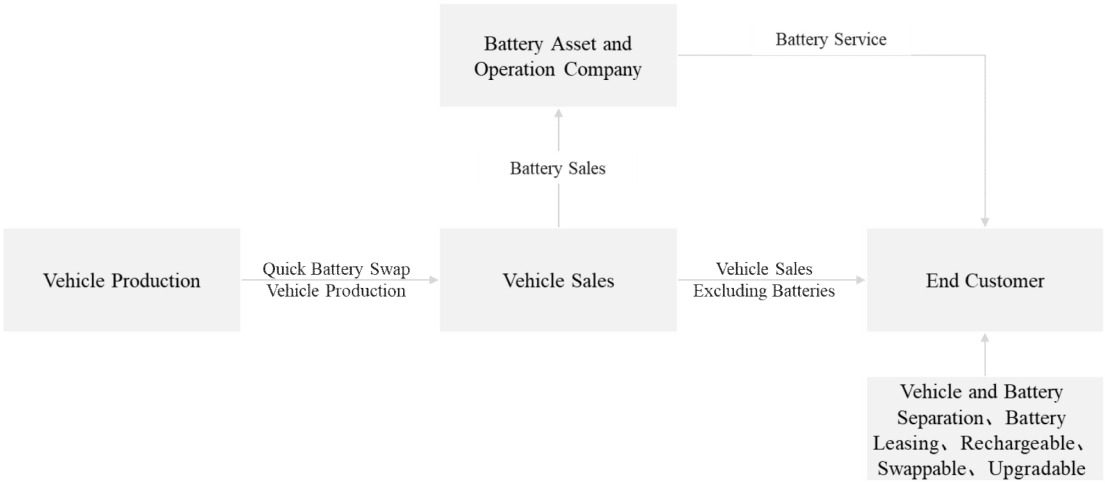

Fig. 2 The business model of vehicle-battery separation

Advantage of Battery Swap

The battery swap model benefits the users by the following advantages:

Quick Power Up The most significant advantage of battery swap to the customer would be the quick process of getting fully recharged batteries within 5 minutes, which enormously solves users' range anxiety of using electric vehicles. Furthermore, the swap process is designed to be highly automated and intelligent, the user can stay in the car during the whole process which provides them with a safety and comfortable experience.

Cost Saving As the battery constitutes the highest cost of a vehicle with fast technology integration, the business mode enables users to buy vehicles without batteries, which can help users save up to 40% up-front cost of buying vehicles. This mode can also improve the vehicle's residual value as the battery devaluation is not borne by the customer.

Fulfill Flexible Needs The battery swap mode makes it possible for vehicles to be installed with batteries of different capacities. The flexible selection service for battery capacity could help users to select suitable batteries to meet their concrete needs under different circumstances. The customer can rent a battery with higher capacity for occasional long-distance travelling to avoid buying an unnecessarily large battery in the first place.

Intelligent Battery Monitoring Batteries are centrally managed in the swap stations. Performance deterioration or potential risks can be quickly detected and intercepted from the system to ensure safety. Meanwhile a battery monitoring platform is established that utilizes cloud-based big data algorithms to monitor the health status of the battery in real-time. All key parameters of the battery, such as cell voltage, charge or discharge current, temperature, self-discharge status, insulation status, are under monitoring. Batteries with issues or that don't meet the operation criteria will be promptly removed.

Battery swap meanwhile has great significance for ESG (Environmental, Social and Governance) and SDG (Sustainable Development Goals):

Carbon Emissions Reduce By means of flexible battery swapping, carbon emissions from battery production can be effectively reduced. On one hand, demands for batteries with high capacity decline, leading to reduction of carbon emissions for large batteries. On the other hand, through intelligent matching and dispatching, the usage of batteries is more balanced when compared with the traditional battery-vehicle binding mode, since it significantly extends the battery's service life and reduces CO2 emissions throughout its entire lifecycle. As shown in Fig.3, the swappable batteries have significant less variance than the vehicle in 10 years.

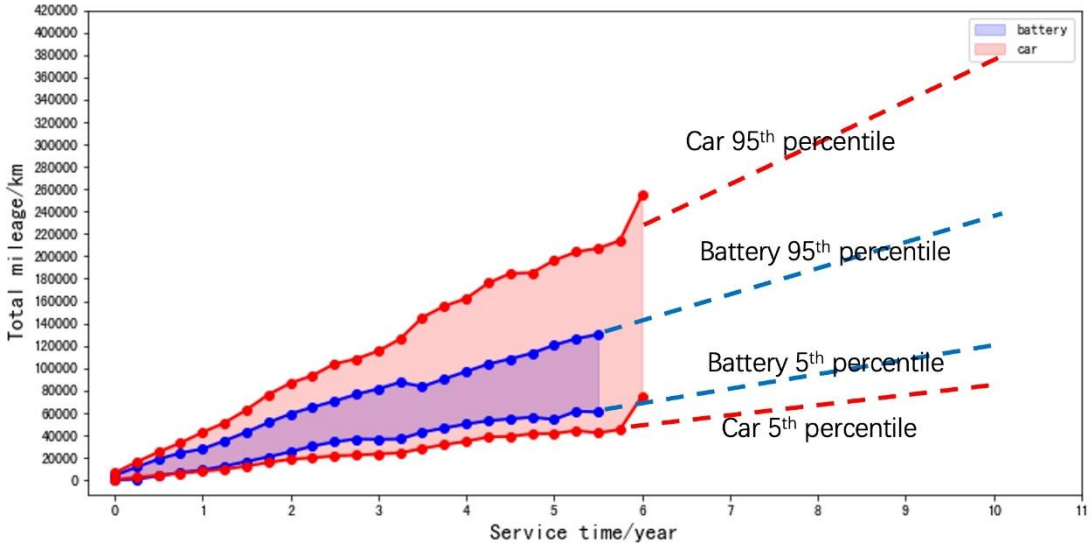

Fig. 3 Batteries' quantity required for the fleet's life-cycle have been reduced

Battery Recycling and Reusing As battery swap stations take batteries in a whole life-cycle control, battery swap has the natural advantages of efficient recycling of withdrawn batteries. It's beneficial for the battery cascade utilization industry, which further contributes to making sufficient use of resources.

Optimization of Electricity Utilization Centralized valley charging can reduce peak-valley grid load difference, which assists the grid to maintain stability. Meanwhile, charging swappable batteries with valley electricity, which normally contains higher proportion of clean energy, also promotes clean energy consumption rate and reduces energy waste during the valley period. As shown in Fig.4, valley charging with clean energy also has a positive impact on reducing carbon emissions.

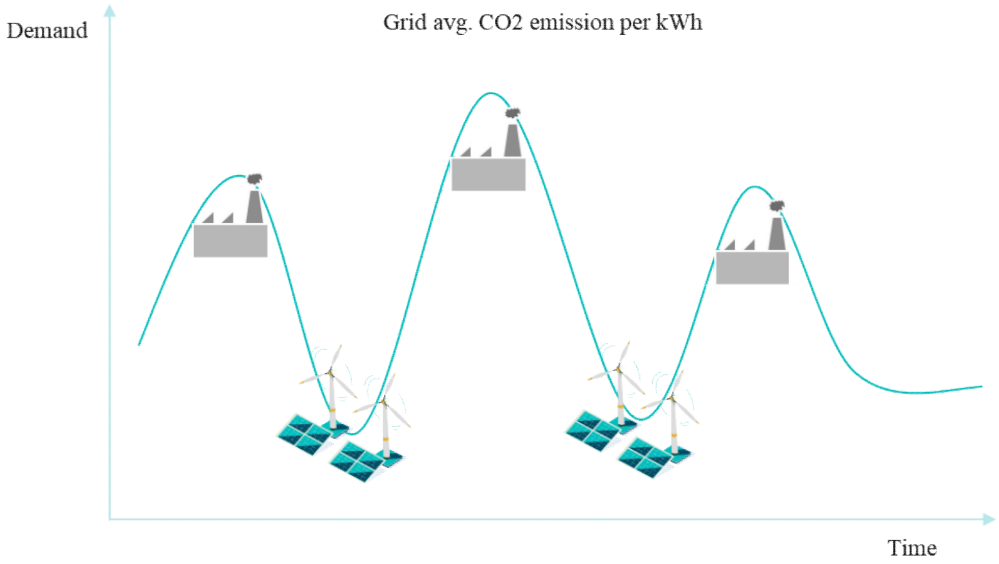

Fig. 4 Charging with cleaner valley electricity

Enhancing Grid Resilience The battery swap station, acting as a virtual special power plant, participates in the coordination of power supply in the electricity market and power grid operations. With the aid of advanced and precise sensors and intelligent control technologies, it achieves grid interaction functions such as peak load regulation, dynamic energy storage, and orderly charging, thereby enhancing the compatibility and friendliness of the battery swap facilities to the power grid.

3. Challenges in the development of battery swap

But currently the battery swap also has its weaknesses.

Heavy Investment on Infrastructure Construction The investment in infrastructure construction and operation cost for battery swap networks is huge. It is hard to launch such projects and especially to encourage the widespread participation of the public and private resources.

Incompatible Between Brands The battery swap systems are mostly not compatible among different brands. As battery pack is a major structural element of a vehicle, it's not easy to specify unified dimensions for batteries.

In addition, the development of battery swap mode needs policies and standards support.

Current standards may not be applicable or there may be management issues in the registration or use of new vehicles, such as flexible battery swaps with changes in battery capacity and version that lead to consistency issues during vehicle registration or annual inspection.

It is worth noting that some countries and industry organizations have already begun to formulate relevant standards, including China's GB/T for vehicles and power swap stations, and the IEC for battery swap stations as shown in Fig.5.

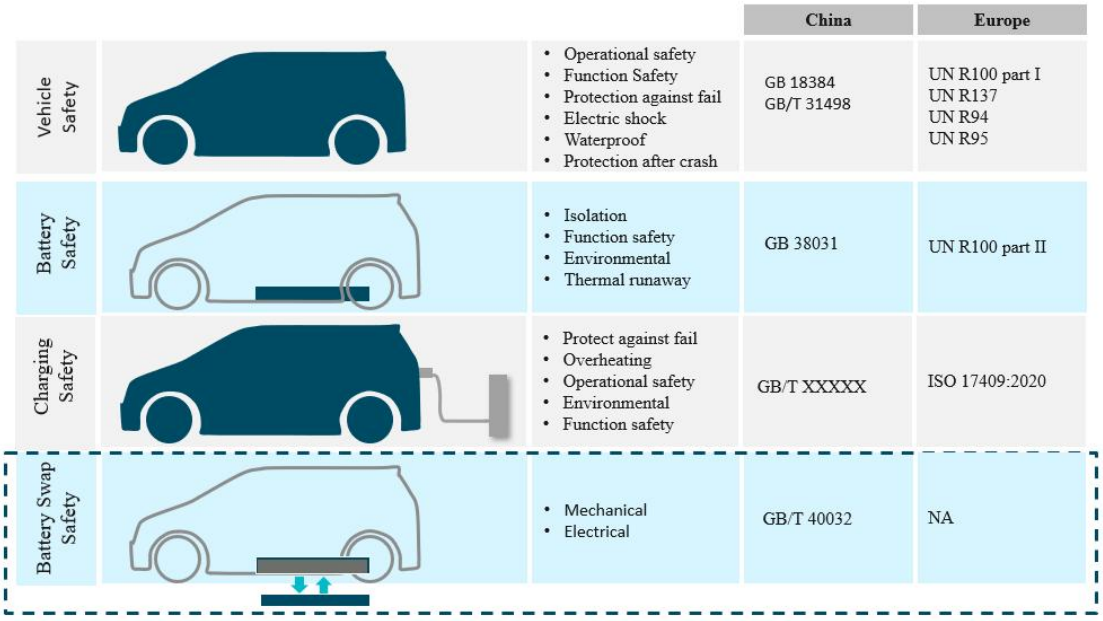

Fig. 5 Battery Swap Related Standards

4. Conclusions and Suggestions

Battery swapping plays a significant role in addressing key challenges in the development of electric vehicles, such as insufficient charging resources, suboptimal charging experience, battery safety concerns, and low efficiency in recycling and utilization. It is an integral part of the electric vehicle (EV) energy replenishment ecosystem. The widespread application and promotion of this technology across more brands are expected to create greater economic and social value, propelling the rapid development of the smart electric vehicle industry.

CASIC and its members are willing to share their experience in battery swapping and call on stakeholders to participate in the cooperation of developing battery swapping. Some of the essential suggestions are as follows:

1. Technically innovating the design of vehicle chassis centered around the battery, the design of battery packs with unified physical dimensions for compatibility, and the universal design of battery swap stations.

2. Universally establishing industry-recognized standards for hardware and software, fostering the sustainable development of the entire industry.

3. Administratively facilitating the approval and supervision of the battery swapping vehicles and equipment, improving the accessibility of such products.

4. Widely promoting the battery swap infrastructure construction both in urban and rural areas, enabling the vast utilization of battery swap vehicles.

5. Globally enhancing the exchange on technical regulations and standards developments of battery swap, creating a universal ecosystem suitable for different environments and requirements.