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Battery Technology of an Electric Vehicles

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Abstract: *Rising prices of fuel and dependency on exportation is big challenge to India. Electric vehicles not only reduce the dependency on fossil fuel but also diminish the impact of ozone depleting substances and promote large scale renewable deployment. India has potential to sell electric vehicles in large number to curb the menaces of degrading air quality index. Electric vehicles are becoming popular due to less movable parts, eco-friendly and ease of maintenance. The paper provides an overview of the studies of battery of Electric Vehicle, state of health and battery safety.*

Keywords: Electric Vehicle, Battery Management System, Electric Motors, Li-ion Battery, SOC, DOD SOH DOE, HEV, BEV, etc.

I. INTRODUCTION

Technology facilitates humans, improves productivity and leads to a better quality of life. Electrification is the most viable way to achieve clean and efficient transportation that is crucial to the sustainable development of the whole world. In the near future, electric vehicles (EVs) including hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and pure battery electric vehicles (BEVs) will dominate the clean vehicle market EV batteries are quite different from those used in consumer electronic devices such as laptops and cell phones. They are required to handle high power (up to a hundred kW) and high energy capacity (up to tens of kWh) within a limited space and weight and at an affordable price.

Extensive research efforts and investments have been given to the advanced battery technologies that are suitable for EVs all over the world. The U.S. government has been strongly supporting its R&D activities in advanced batteries through the Department of Energy (DOE): about $2 billion grants to accelerate the manufacturing and development of the next generation of U.S. batteries and EVs.

European Commission and governmental organizations in Europe and Japanese Ministry of Economy, Trade and Industry (METI) have also been continuously supporting the R&D activities in advanced batteries. BYD, Lishen, and Chunlan have obtained strong subsidy supports from the Chinese government for its research and manufacturing of advanced batteries and electric vehicles.

II. HISTORY OF EV

In the early years of 1900s, there was a golden period of EVs. At that time, the number of EVs was almost double that of gasoline power cars. However, EVs almost disappeared and gave the whole market to internal combustion engine (ICE) cars by 1920 due to the limitations of heavy weight, short trip range, long charging time, and poor durability of batteries at that time.

EV batteries are quite different from those used in consumer electronic devices such as laptops and cell phones. They are required to handle high power (up to a hundred kW) and high energy capacity (up to tens of kWh) within a limited space and weight and at an affordable price the current two major battery technologies used in EVs are nickel metal hydride (NiMH)and lithium ion (Li-ion).

Nearly all HEVs available in the market today use NiMH batteries because of its mature technology. Due to the potential of obtaining higher specific energy and energy density, the adoption of Li-ion batteries is expected to grow fast in EVs, particularly in PHEVs and BEVs. It should be noted that there are several types of Li-ion batteries based on similar but certainly different chemistry.

III. BASIC TERMS OF BATTERY PERFORMANCE AND CHARACTERIZATION

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Table 2.1 Batteries used in electric vehicles of selected car manufacturers.

Company	Country	Vehicle model	Battery technology
GM	USA	Chevy-Volt	Li-ion
		Saturn Vue Hybrid	NiMH
Ford	USA	Escape, Fusion, MKZ HEV	NiMH
		Escape PHEV	Li-ion
Toyota	Japan	Prius, Lexus	NiMH
Honda	Japan	Civic, Insight	NiMH
Hyundai	South Korea	Sonata	Lithium polymer
Chrysler	USA	Chrysler 200C EV	Li-ion
BMW	Germany	X6	NiMH
		Mini E (2012)	Li-ion
BYD	China	E6	Li-ion
Daimler Benz	Germany	ML450, S400	NiMH
		Smart EV (2010)	Li-ion
Mitsubishi	Japan	iMiEV (2010)	Li-ion
Nissan	Japan	Altima	NiMH
		Leaf EV (2010)	Li-ion
Tesla	USA	Roadster (2009)	Li-ion
Think	Norway	Think EV	Li-ion, Sodium/Metal Chloride

Various terms have been defined for batteries to characterize their performance. Commonly used terms are summarized in the following as a quick reference. Cell, Module, and Pack. A single cell is a complete battery with two current leads and separate compartment holding electrodes, separator, and electrolyte. A module is composed of a few cells either by physical attachment or by welding in between cells.

A pack of batteries is composed of modules and placed in a single containing for thermal management. An EV may have more than one pack of battery situated in a different location in the car. Ampere-hour Capacity. Ampere-hour (Ah) capacity is the total charge that can be discharged from a fully charged battery under specified conditions. The Rated Ah capacity is the nominal capacity of a fully charged new battery under the conditions predefined by the manufacturer. A nominal condition, for example, can be defined as 20_C and discharging at 1/20 C-rate. People also use Wh (or kWh) capacity to represent a battery capacity. The rated Wh capacity is defined as Rated Wh Capacity = Rated Ah Capacity X Rated Battery.

Voltage: State of Charge (SOC). SOC is defined as the remaining capacity of a battery and it is affected by its operating conditions such as load current and temperature. SOC ¼ Remaining Capacity Rated Capacity: Depth of Discharge (DOD). DOD is used to indicate the percentage of the total battery capacity that has been discharged. For deep-cycle batteries, they can be discharged to 80% or higher of DOD. DOD= 1- SOC: State of Health (SOH). SOH can be defined as the ratio of the maximum charge capacity of an aged battery to the maximum charge capacity when the battery was new [7]. SOH is an important parameter for indicating the degree of performance degradation of a battery and for estimating the battery remaining lifetime. SOH = Aged Energy Capacity / Rated Energy Capacity.

IV. LITERATURE REVIEW

The focus of the paper is to cover for the art of batteries to be able to handle random charging due to regenerative braking., the braking power of regenerative braking can be at the level of hundred kilowatts. Safety limitation has to be applied to guarantee the safe operation of batteries. Mechanical braking is usually used to aid regenerative braking in EVs as a supplementary and safe measure. This paper contributes to the current state-of-the-art by providing a holistic review of EV charging system Most of the recent papers address these issues separately and they focus on technological innovations.

Therefore, this paper tries to gather the conceptual frameworks with the practical aspects by illustrating the main architecture concepts and compiling the outcomes of some of the latest research about Battery technologies, including their applications, advantages and limitations. The success of EVs will be highly dependent on whether charging stations can be built for easy access. This is also critical for the potential grid supports that EVs can provide. The first place considered for charging stations should be homes and workplaces. Other potential locations with high populations include gas stations, shopping centers, restaurants, entertaining places, highway rest areas, municipal facilities, and schools.

Table 4.1: Standards related to electric vehicle charging

Standard	Title/description
SAE J2293	Energy Transfer System for Electric Vehicles
SAE J2836	Recommended Practice for Communication between Plug-in Vehicles and Utility Grid
SAE J1772	Electric Vehicle Conductive Charge Coupler
SAE J1773	Electric Vehicle Inductively Coupled Charging
IEEE 1547.3	Interconnecting Distributed Resources with Electric Power Systems

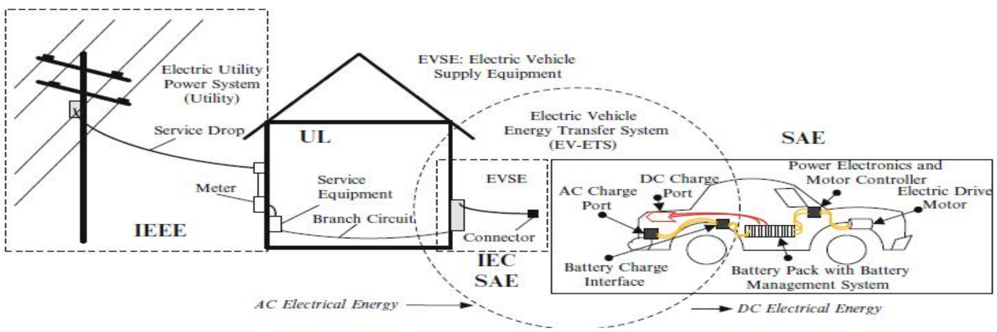

Figure 4.1: Electric vehicle energy transfer system applicable standards. Modified from

V. CONCLUSION AND RESEARCH DIRECTIONS

Extensive research has been carried out on battery modeling and a variety of models have been developed from different aspects and for different purposes. It would be desirable to have a comprehensive, unified electrical model that is developed based on physical properties of battery cells. The model should have the capability to estimate SOC and SOH accurately. A conceptual, unified model with Main circuit, thermodynamic, SOC, and SOH sub-models.

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