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MDPI

Editorial

Battery Performance, Ageing, Reliability and Safety

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1. Context

The development of portable equipment, electric or electrified vehicles and renewable energy is associated with the development of efficient Energy Storage Systems (ESS), such as batteries or supercapacitors. One of the problems with the use of these electrochemical systems is their limited lifespan associated with unavoidable ageing. This ageing affects their performance, cost of ownership and environmental impacts and may affect their safety.

To avoid these complications, it is, therefore, necessary to study the means to improve the dependability (reliability, maintainability, availability and safety) of these ESS.

2. Characterisations, Studies and Analysis of Ageing and Failures

For this purpose, the first step is to study and analyse the failure or ageing mechanisms and modes [1–6]. To do this, either the existing data must be exploited, or data must be created by performing accelerated ageing (cycling and/or calendar) of cells [7,8]. This requires the characterisation of each cell in the pack [9]. The study of ageing mechanisms can be conducted through electrical measurements, thermal measurements, chemical measurements, physical measurements or through post-mortem analyses [10–14]. Modelling of the ageing process, taking into account the temperature, state of charge, depth of discharge, C rate, etc., can then be performed [15,16]. When a large amount of data is available, a statistical study or the use of artificial intelligence is also possible [17–19].

3. Exploitation of the Results to Improve the Dependability

This knowledge of ageing and failures can be used to optimise the design or maintenance of ESS. This can be done at the cell level or the pack level, considering the dispersions between the cells [20].

It can also allow us to carry out a diagnosis by the intermediary of measurements and adequate methods to ensure the detection of ESS failures or ageing [21,22]. Knowing the level of ageing allows us to estimate the ESS state of health and, in the best case, the remaining useful life can be estimated [17]. The state of health estimation is a function of the BMS (Battery Management System) [18,19]. Considering this state of the BMS can also allow optimal electrical management between cells (during balancing) or thermal management [23].

In multi-source systems, the health status of each energy storage system can also be considered for optimal power management.

The study of different battery charges (especially fast charges) is also important because these can affect their ageing and lifetime [24].

Considering the ageing process is also essential in technical–economic or environmental analyses. For example, the use of second-life batteries can be studied with these criteria [25].

Finally, given the risk of ignition or explosion in the event of a defect or misuse, improving the operational safety of these components is essential [26–28]. To investigate this, abuse tests can be performed and/or accidents can be analysed. This can lead to

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the design of safe cells and packs by integrating dedicated sensors [29] or by integrating specific functions in the BMS.

Numerous studies are, therefore, to be carried out and presented, especially as these depend completely on the battery chemistries.

Many challenges remain to be met to improve the reliability, availability and safety of ESS. Addressing these challenges will make the widespread use of ESS possible.

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