Lecture Notes in Mobility

Beate Müller
Gereon Meyer *Editors*

Electric Vehicle Systems Architecture and Standardization Needs

Reports of the PPP European Green Vehicles Initiative

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Foreword

Electronic components and ICT systems are ubiquitous and bring a high value to today's vehicles. Steady electrification is conferring them an even more defining role and value share in the transportation means of the future with ICT being instrumental for most building blocks of an electric car.

Complementing materials innovation, ICT-enabled components and services are significantly reducing the energy demand of vehicles and improving the safety of the transport system, directly leading to a large societal impact. Beyond that, they make driving more comfortable.

DG CONNECT is the driver of the ICT pillar of the European Green Vehicle Initiative PPP (EGVI PPP). More than 30 R&D projects with over 110 million € funding were launched since the first call in 2009. Several large-scale automotive ICT projects are also supported under the Joint Technology Initiatives ENIAC and ARTEMIS. All these projects are now delivering tangible results. Research on electronic/electronical architectures has been a ground-breaking topic with a significant industrial impact. Projects like eFuture or OpEneR are showcasing the benefits of cross-border cooperation along the value-chain granting the European industry a competitive edge.

The EGVI has grown from a recovery programme for crisis-ridden sectors into a strategic longer-term consolidated instrument with a strongly committed and active community. The contractual arrangement of the European Green Vehicles PPP was signed on 17 December 2013 by the Commission and representatives of the sector, showing the long-term commitment of the European Union to financing R&D&I in the sector under Horizon 2020.

A further substantial opportunity to support collaborative automotive R&D&I under H2020 is available through the JTI Electronic Components and Systems for European Leadership (ECSEL) launched in early 2014. Automotive stakeholders and platforms are encouraged to actively participate.

Identifying future European policy and support priorities is a non-trivial task. It needs a close cooperation of all actors in a rapidly evolving landscape with changing paradigms. Standardised architectures and by-wire technologies have the potential to pave the way for European automotive USP. The "programmable car" enabling functional integration may generate competitive vehicle performance and added value. Autonomous driving made it from private research labs to collaborative programmes and enjoys strong media coverage. Big data and data security are also considered key for the smart, connected vehicles of tomorrow.

With strong public and private support, the first fully electric vehicles from series production have recently rolled out, roughly one century after the invention of the electric car. Old and new value-chain players could now grasp this window opportunity and momentum to foster positions and innovate further.

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Preface

The objectives of sustainable road mobility, i.e. energy efficiency, climate protection and zero emissions, imply a paradigm shift in the concept of the automobile regarding its architecture, design, materials and propulsion technology. The electric vehicle (EV) is seen as the most viable option. However, it is still facing a multitude of challenges in terms of product maturity and user acceptance. Moreover, the growing market share of EVs inevitably leads to a renovation of the classical automotive value chain and will result in a shift in the creation of added value in the supply chain.

The Coordination and Support Action "Smart Electric Vehicle Value Chains (Smart EV-VC)" funded in the Seventh European Framework Programme, analysed these novel smart EV supply chains and possible supporting measures for their strengthening in Europe. This analysis was based on the identification of the unique selling propositions (USP) of the European smart EV which should be served by the adapted value chains. These USPs have been found to be: affordability, smartness and connectivity, adaptation to mobility needs and use patterns and safety and reliability. On technology level, most of these USPs are related to overcoming today's drawbacks of EV batteries that lack energy density, lifetime and affordability.

In a smart approach range extension may be reached in an intelligent way by enabling battery downsizing through implementing ICT and smart systems and components, since integrating a high degree of electronic control, adaptive capabilities and intelligence to the system may raise energy efficiency significantly. Especially, since in EVs most mechanical control functions can easily be replaced by electronic means and are supported digitally by embedded software, these synergies present a parallel path to innovations in cell technology or use of lightweight materials. Hence, they may greatly support the removal of barriers to the wide implementation of the electric vehicle.

Experience with comparable transitions from mechanically via electrically to electronically and digitally controlled systems (e.g. from the typewriter to the computer) tells that a significant cost reduction can be achieved when a complete redesign of the platform is undertaken. Hence, for the future generation EVs that conform to the aforementioned USPs, a real paradigm shift can be foreseen: a complete redesign of the electric, electronic and ICT architecture of the fully electric vehicle.

Several research projects of the European Green Vehicles Initiative Public Private Partnership (EGVI PPP) are already addressing topics connected to the USPs and the development of new vehicle architectures and ICT platforms. Some of them were reviewed within a workshop of the EGVI PPP on the topic of electrical and electronic architecture of EVs and EV standardization needs which took place on 23 October 2013 in Brussels. The workshop strived to evaluate the research activities within the EGVI PPP and also to directly gather feedback from the stakeholder groups regarding R&I strategies and funding policies. The scientific talks were complemented by talks on the strategic topics of standardization and support of SMEs. Both topics are important when discussing measures for strengthening the European smart EV value chain. Papers of selected presentations of this workshop are collected in this book.

The EGVI PPP was established as European Green Cars Initiative PPP within the scope of the 7th Framework Programme. In Horizon 2020, the EGVI PPP focuses on energy efficiency and alternative powertrains. Through the duration of the Public Private Partnership in FP7, a close dialogue between the stakeholders of the industry, research institutes and European Commission has been constituted. Among other things, this is expressed in the continuously held expert workshops which are a collaborative activity of the European Commission and the industry platforms European Technology Platform on Smart Systems Integration (EPoSS) and European Road Transport Research Advisory Council (ERTRAC). These workshops were organized by the Coordination Actions "Implementation for Road Transport Electrification" (CAPIRE) and Smart EV-VC.

The aim of this volume of the "Reports of the PPP European Green Vehicles Initiative" is to disseminate the results of the European Green Vehicles Initiative PPP to a wider stakeholder community and to further reinforce the dialogue among the stakeholders as well as with policy makers.

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Invited Papers

Current Issues in EV Standardization

Peter Van den Bossche, Noshin Omar, Thierry Coosemans and Joeri Van Mierlo

Abstract In urban traffic, due to their beneficial effect on environment, electrically propelled vehicles are an important factor for improvement of traffic and more particularly for a healthier living environment. The operation of the electrically propelled vehicle is dependent on the availability of efficient electric energy storage devices: the traction batteries, which have to access suitable recharging infrastructures. For all these components, standards are essential for ensuring safety and compatibility. This article gives an overview of current developments in the field of international standardization of electrically propelled vehicles, focusing on two essential matters for electric vehicles: batteries and charging.

Keywords Electric vehicles · Standardization · Charging infrastructure

1 Introduction

The electric vehicle encompassing both automotive and electrical technologies, standardization is not a very straightforward issue. Standardization, on a global level, being mainly dealt with by two institutions: the *International Electrotechnical Commission* (IEC), and the *International Organization for Standardization* (ISO), the question arose which standardization body would have the main responsibility for electric vehicle standards.

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Table 1 Basic division of work IEC/ISO

ISO	IEC
Work related to the electric vehicle as a whole	Work related to electric components and electric supply infrastructure

One can discern a fundamentally different approach taken towards the concept of standardization in the automotive and the electrotechnical world. There is a different "standardization culture", the origin of which can be traced back to historical reasons.

This difference is further reflected in the constitution of the technical committees and their working groups which deal with electric vehicle standardization in respectively IEC and ISO. In the IEC committees many of the delegated experts are electricians or component manufacturers, whileas in ISO there is a much stronger input from vehicle manufacturers. During the years, there have been considerable discussions between the two groups as to the division of the work, leading to a consensus defining the specific compentences of the respective committees, as shown in Table 1.

Within Europe, CENELEC and CEN operate as the pendants of IEC and ISO. Both have been active in electric vehicle standardization in the 1990s, through their technical committees CENELEC TC69X and CeN TC301. Initially working in parallel to the global standardization work, these committees went dormant around the turn of the century, but TC69X was reactivated in 2011, with the aim of expediting the European adoption of IEC TC69 documents.

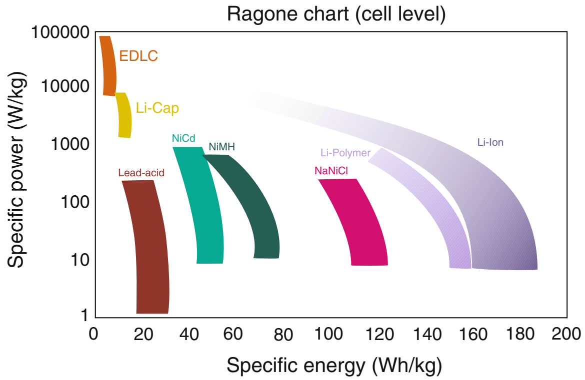
2 Battery Standards

The standardization of batteries for electric vehicle traction presents several aspects, including performance, dimensions and safety.

2.1 Battery Performance Standards

The aim of battery performance standards is to assess the operational characteristics of the battery as a "RESS": rechargeable energy storage system. RESS need to provide both energy (for driving range) and power (for acceleration), and are characterized by specific energy (Wh/kg) and specific power (W/kg), both values being illustrated in the Ragone diagram (Fig. 1). For determining the actual performances of the battery, suitable test cycles are needed which reflect the actual use of the battery in the vehicle.

Fig. 1 Ragone diagram



Traditional test cycles such as used for lead-acid industrial traction batteries [1] are based on constant current cycling and are not suited for electric vehicle applications, where the batteries are discharged in a much more dynamic way, and where regenerative braking is used.

New challenges for standardization included both the emergence of new battery chemistries besides lead-acid (alkaline nickel batteries, and of course lithium-ion) and the development of new applications such as hybrid vehicles where the batteries are being used in a different way more based on power storage.

For non-lithium technologies, the IEC61982 "Secondary batteries (except lithium) for the propulsion of electric road vehicles—Performance and endurance tests" [2] describes dynamic power performance tests featuring acceleration, cruising and regenerative braking (Fig. 2).

For lithium traction batteries, standardization has been addressed both by ISO and IEC, focusing respectively on the battery system as vehicle component, and the individual battery cells, leading to the standards ISO12405-1 [3] for power-oriented batteries, ISO12405-2 [4] for energy-oriented batteries, and IEC62660-1 [5] for individual cells.

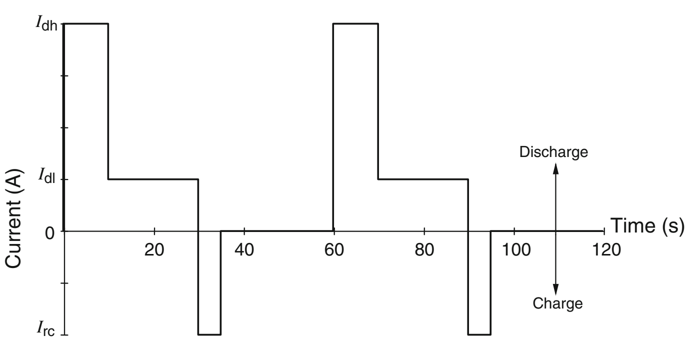


Fig. 2 Dynamic power performance test micro-cycle [2]

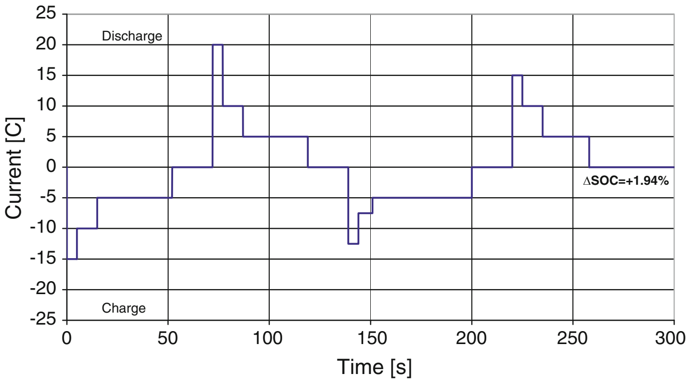
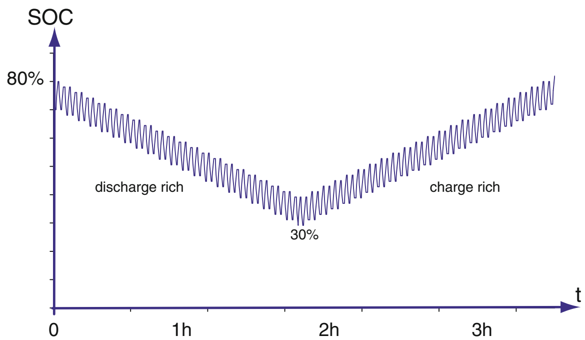


Fig. 3 Hybrid micro-cycle [3]

Fig. 4 State of charge evolution for hybrid test [3]



The micro-cycles for hybrid operation are charge-rich (Fig. 3) or discharge rich, and are performed in a limited state-of-charge window (Fig. 4) as is customary for hybrid operation.

The power oriented operation of the battery also necessitates test cycles for pulse power and internal resistance, described on both battery and cell level in the respective ISO and IEC standards. An example is given in Fig. 5.

New developments may be necessary in view of the exchange of batteries between vehicles and the deployment of "second life" vehicle batteries for other applications such as stationary energy storage for grid support. Such applications need a means to accurately estimate the "state of health" of a battery, a difficult process as it is highly dependent on the understanding of a battery's chemistry and environment and the evolution of ageing processes. The CEN-CENELEC Focus Group recommends that parameters for state of health should be defined in standards to allow for second life use of batteries [6].

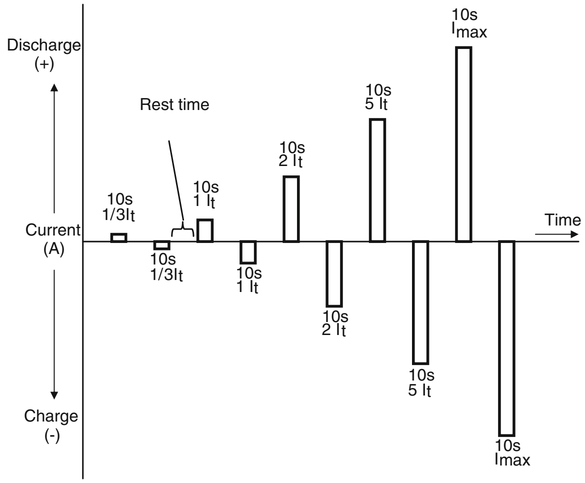


Fig. 5 Pulse power test [5]

2.2 *Battery Safety Standards*

Safe installation of the battery onboard the electric vehicle is treated by ISO6469-1 [7]. Special considerations for post-crash safety, focusing on the risks for emergency personnel, are described in the new ISO6469-4 now under development [8].

For batteries with aqueous electrolyte, such as lead or nickel batteries, hydrogen emission during charging may be a safety hazard, which is treated in IEC62485-3 [9].

Lithium batteries however may present specific hazards due to thermal runaway which may affect some lithium chemistries. This is addressed two-fold in the standards: on one hand, thermal, mechanical and electrical abuse tests are described in the standards ISO12405-1 [3], ISO12405-2 [4] and IEC 62660-2 [10]; on the other hand, pass/fail criteria for these tests are developed in the forthcoming standards ISO12405-3 [11] and IEC62660-3 [12], with ISO and IEC acting respectively on system and cell level.

2.3 *Battery Dimensional Standards*

For mature technologies such as industrial lead-acid batteries, dimensional standards such as IEC60254-2 [13] are well established. For lithium however, the technology is still evolving and it might be stifling to fully standardize dimensions just now. Lithium cells come in various sizes and shapes (cylindrical, prismatical, pouch-format) and various chemistries. In order to provide design guidelines, the Publicly Available Specification (not a full-fledged standard) ISO/IEC16898 [14] was issued, defining designations and markings of cell dimensions, configurations and position of terminals and venting mechanism, which are to be used for design