NATIONALE PLATTFORM ELEKTROMOBILITÄT

# The German Standardization Roadmap

## for Electromobility – Version 1.0.1

# Contents

# 1 Executive summary

For Germany to improve on its competitive edge in the international electromobility market, and to ensure that the development and added value of this technology remains in this country, a major focus must be placed on furthering and bundling these developments, and the interests behind them, at an early stage. If German industry is to position itself successfully, it is essential that the positive effects of standardization be incorporated into the development process right from the start so that they can be fully exploited.

Standardization in the field of electromobility is characterized by several features distinguishing it from previous standardization processes. Here, the challenge lies in coordinating and integrating diverse activities in different sectors in order to effectively meet demands. Electromobility is a breakthrough innovation that requires a new, cross-sectoral systems thinking. Up to now, standards in the electrical engineering/ energy technology and automotive technology domains have been viewed as separate entities. So far there has been little attempt to view them in an integrated manner, although this would be an important approach, particularly because these domains are merging, resulting in new points of contact and interfaces.

This Standardization Roadmap reflects the general agreement among all actors in the electromobility sector – including automobile manufacturers, the electrical industry, energy suppliers/grid operators, technical associations and public authorities - that a strategic approach to standardization of electromobility is needed. References to the relevant regulations are given in the Report of the "Vorschriftenentwicklung" (Regulatory developments) team of Working Group 4 [9]. Below is a summary of the recommendations made in this paper for the promotion of a wider use of electromobility:

| | |
|---|---|
| **Political action is needed at European and international level** | The close networking of research and development, and of regulatory and legislative frameworks with standardization is necessary. National standardization and regulation carried out by certain countries must not impede harmonization at an international level. |
| **Standardization must be timely and international** | At present, national and international standardization concepts compete with one another. However, since road vehicle markets are international, efforts must aim towards developing international standards right from the start. The same applies to interfaces between electric vehicles and infrastructure. Standardization at national or European level alone is considered to be inadequate. It is therefore essential that national standards proposals be processed quickly and that German results be transferred to international standardization as soon as possible. |
| **Coordination and focus are absolutely essential** | Because electromobility involves so many actors and sectors, collaboration among all relevant bodies, and coordination by DIN's Electromobility Office and the steering group on EMOBILITY (DKE/NAAutomobil) are necessary to avoid duplication of work. Instead of creating new bodies, the existing bodies within DIN and DKE should be strengthened. |
| **Standards must be clear and unambiguous** | To encourage innovation, standards should be function-related and should avoid defining specific technical solutions (i.e. they should be performance-based rather than descriptive).<br><br>Nevertheless, some technical solutions need to be defined in interface standards to ensure interoperability (e.g. between vehicles and the network infrastructure). |
| **A uniform worldwide charging infrastructure is necessary (interoperability)** | It must be possible to charge electric vehicles "everywhere, at all times": interoperability of vehicles of different makes with the infrastructure provided by various operators must be ensured. The standardization of charging techniques and billing/payment systems must ensure the development of a charging interface that is user-oriented, uniform, safe and easy-to-operate. User interests must have priority over the interests of individual companies. |

**Existing standards must be used and further developed without delay**

There are already a number of standards in the automotive technology and electrical engineering sectors. These must be appropriately utilized and made known. Providing information on these standardization activities and their status are a vital part of this Standardization Roadmap.

Moreover, the necessary work should focus less on initiating new standards projects than on expanding/adapting existing standards and specifications to the needs of electromobility. Cross-sectoral cooperation at international level is required particularly for the standardization of interfaces.

**Participation in European and international standardization is essential**

In order to achieve our aims – and to ensure our active influence – a greater participation at national and international level is needed. This means that German companies must play a greater part in German, European and international standards work.

Standards work is to be seen as an integral component of R&D projects and thus eligible for funding.

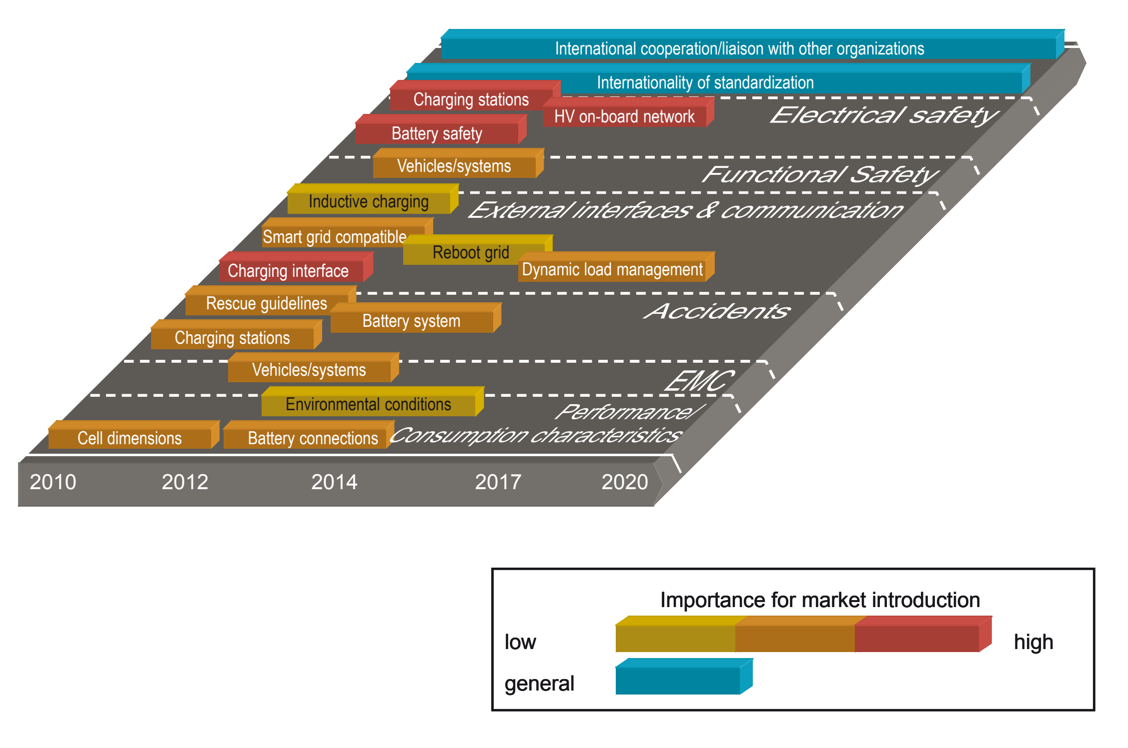



**Figure 1:** Schedule for implementing recommendations

# 2 Background

## 2.1. Introduction

Fossil fuels are a main source of our energy supply, not only for industrial and domestic applications, but also in terms of (individual) mobility. The availability of fossil fuels for internal combustion engines used to propel vehicles is decreasing, while prices are rising as a result of this shortage. Furthermore, the exhaust fumes produced by combustion have an adverse effect on our environment. To satisfy our mobility needs, not only now but in the future, energy from environmentally-friendly sources must be made available The future of our energy supply therefore depends on sustainable energy sources with a minimal ecological “footprint” which are available on a long-term basis from politically reliable sources This supply – together with compliance with the European Commission’s Ecodesign Directive [1], which calls for the environmentally-friendly design of energy-driven products over their entire life cycle and which limits energy consumption – will set the course for a future worth living. Electromobility is not just an important aspect, but is an integral component, of these goals. The establishment of resource-saving cycles and processes not only stimulates long-term progress, it also allows consumers to retain the comfort to which they have become accustomed.

The subject of alternative means of propulsion and electromobility is thus gaining global importance. It is also one of the most essential and urgent issues affecting the future of Germany as a technological stronghold. The requirements placed on the technology itself are no less manifold than the various concepts being proposed for their implementation. Which drive concept will prevail at the end of the day, and whether several drive concepts for different applications will be able to coexist “peacefully” will depend on a number of factors. It is up to the public sector as well as standardization to provide a suitable general framework for this development.

To make electricity from renewable energy sources readily available for use in electric vehicles, a strategic concept for short-, medium- and long-term solutions to the approaching challenges is needed. As regards electric drive vehicles, thinking globally is first and foremost a question of key technical parameters: performance, charging interfaces, and battery capacity. Ultimately, functionality, ecological awareness and responsibility across national borders will determine the level of user acceptance. In this respect, sound knowledge is just as important as creativity and innovation. But above all, there is a need for “round tables” at which the various actors can work together to make progress, implementing this progress in standards which can be used as a basis for further developments. Automobile manufacturers, energy suppliers, grid operators and research institutes have long realized how closely knit the electromobility network really is. The electric vehicle of the future will be a decisive element of the “smart grid”. Many new interfaces are emerging which will provide an opportunity for further developing existing interfaces. The main objective is to define efficient payment systems for “refuelling” procedures that should be uniform on a European scale at least, and preferably globally.

The large number of current national and international projects makes a systematic and transparent strategy for providing information essential, especially to prevent synergy effects from falling victim to false ambitions in the name of competition. Unilateral action is obviously just as ineffective as an attempt to conjure up, or simply wait, for successful solutions. As the saying goes, energy never dies, it merely changes its form.

Electromobility is a much-discussed topic among German and international experts. Countless studies, professional opinions and roadmaps have been produced and are the subject of intense debate. With only a few exceptions, the one thing they have in common is the highly-focused manner in which they treat the issue of electromobility. However, there has been little meaningful coordination taking various perspectives into consideration. This may be due to the increased complexity brought about by the gradual merging of the automotive and electrical engineering sectors, but this situation does not provide a basis for the wide-scale establishment of electromobility. An overall concept in which timeframes are specified is needed. However, it quickly becomes evident that there is not always sufficient interoperability among the various trades – this can only be achieved through standardization.

The aim of this document is to draft a strategic, technically-oriented standardization roadmap outlining the need for standards and specifications realizing the German vision for electromobility which can be adapted to international needs at a later date. This document also gives an overview of existing standards and specifications, current activities, necessary fields of action, ongoing international cooperation, and strategic recommendations for electromobility.

In accordance with the German Standardization Strategy [2][3], a differentiation is made in German between “Normung” (“standardization”, “formal standardization”, “consensus-based standardization”) i.e. the development, on the basis of full consensus, of rules, guidelines and characteristics for activities for general or repetitive application by an approved organization – and “Standardisierung” (“informal standardization” or “limited consensus standardization”), i.e. the process of drawing up non-consensus based standards (referred to here as “specifications”). The latter are published as several types of document, for example a VDE application guide, DIN SPEC (DIN specification), PAS (publicly available specification), ITA (industry technical agreement) or TR (technical report).

Electromobility is dealt with in federally funded programmes such as “ICT for electromobility” (funded by the Federal Ministry of Economics and Technology (BMWi) and the Federal Ministry for the Environment (BMU)), “Fraunhofer system research on electromobility” (funded by the Federal Ministry of Education and Research (BMBF)) and “Electromobility in pilot regions” (funded by the Federal Ministry of Transport (BMVBS)). Many expert groups and research projects cover this topic as well, and several high-ranking politicians and representatives of commerce and industry are involved in the “National Platform for Electromobility (NPE)”. This Standardization Roadmap for Electromobility was developed on behalf of Working Group 4 (NPE.AG4) “Standardization and Certification” of the NPE under the leadership of the steering group on EMOBILITY of the DKE and NAAutomobil, the Road Vehicle Engineering Standards Committee of DIN, in which all stakeholders are represented, such as the technical associations VDA, VDE and ZVEI. Once the Roadmap has been released by the NPE.AG4 and handed over to Chancellor Merkel, it will be presented to experts during a symposium. The Standardization Roadmap will be updated regularly on the basis of new findings, for example from research projects, work in standardization bodies, or work within the symposium. This will give experts the opportunity to take part in this process by submitting comments and participating in standardization, even after publication of this document.

The following sections describe the current national and international standardization landscape and discuss the reasons behind the development of this Standardization Roadmap for Electromobility. Subsequent sections list the expected benefits and agreed international procedures for standardizing electromobility. Next, an overview of the overall system “electromobility” as expected in phase 1 (one million electric vehicles by 2020) and the current status of the standardization process are described. Following this, recommendations are presented and perspectives for the continuation of the Standardization Roadmap in phase 2 are outlined. The document concludes with bibliographic references, a list of terms, definitions and abbreviations, and a list of the experts, boards and panels who have contributed to its development.

## 2.2 Scope of the Roadmap and vehicle classes covered

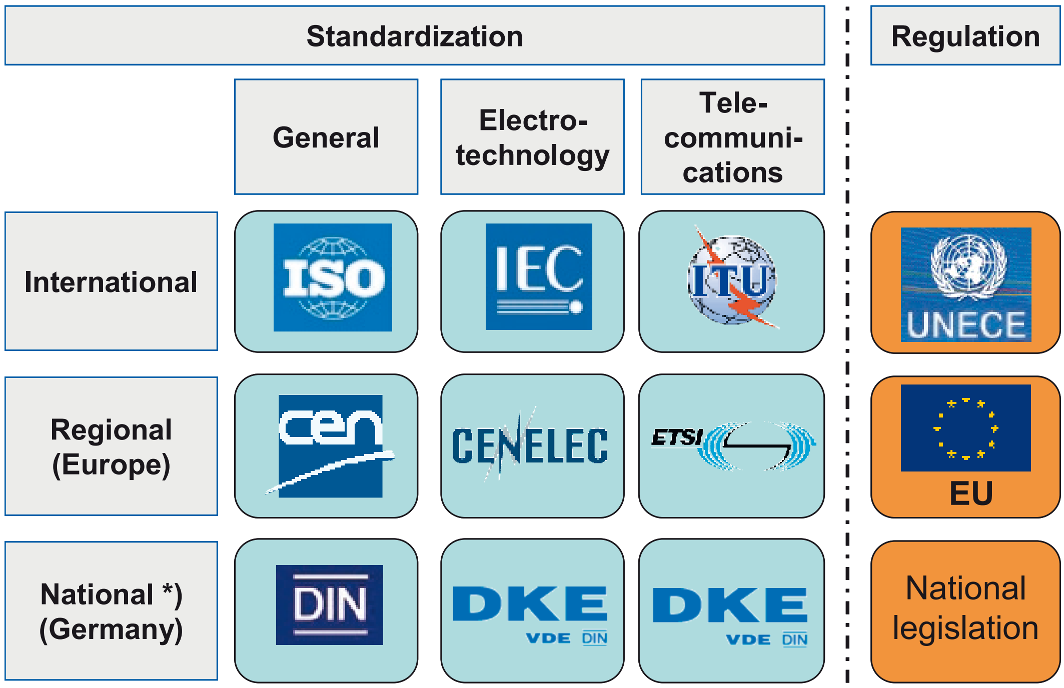
The Standardization Roadmap for Electromobility covers the following vehicle categories (cf. B.1.3):

- M1, M2, M3
- N1, N2, N3
- L3e, L4e, L5e, L7e

The Roadmap focuses mainly on categories M and N. Vehicles which can be charged using voltages lower than 60 V (e.g. electric bicycles) are not covered in the present version.

## 2.3 Structure of the standardization landscape

Standards and specifications are developed at various levels (national, European, international) in a number of different organizations. To provide a better understanding, an overview of the various standards organizations and their interrelation is given below. ISO and IEC, which constitute the main standardization landscape for this Roadmap, and their counterparts at European and national level, are described in more detail. Figure 2 shows the relationship between the various standards organizations, together with their regulatory bodies.




*) Other national organizations outside Germany include SAE, ANSI/UL International, etc.

**Figure 2:** Main components of the standardization landscape and their interrelationships together with their regulatory bodies

In terms of full consensus-based standardization ISO, IEC and ITU-T are the authoritative standards organizations. The corresponding standards organizations at European and national level are CEN and DIN (including NAAutomobil, the Road Vehicle Engineering Standards Committee), and CENELEC, ETSI and the DKE. The respective national standards organizations are members of ISO, IEC, CEN and CENELEC.

SAE is an organization that develops documents which are not based on full consensus, and is represented mainly on the American continent. Compliance with SAE specifications is often required if German automobile manufacturers and their suppliers want to gain access to the North American market.

Underwriters Laboratories (UL) is an independent product safety certification organization that also develops specifications with a focus on safety. UL is accredited by ANSI to develop national, full consensus-based US standards.

The American National Standards Institute (ANSI) is the American member of international organizations such as ISO and IEC. However, ANSI does not develop any standards itself. Rather, it relies on the services of accredited organizations such as UL for this work.

In addition to the organizations shown in Figure 3, there are a number of other organizations, many of which operate at national or regional level only (e.g. the Car2Car Communication Consortium), and which interact in networks for electromobility technology.

The internal structures of IEC and ISO and the respective European and national organizations are shown in Figure 3. The following joint bodies were set up to coordinate the activities of the electrotechnical and automotive industries:

- International level: various Joint Working Groups (JWG) and Joint Technical Committees (JTC)
- European level: the joint CEN/CENELEC Focus Group on European Electromobility, an advisory body
- National level: the steering group on EMOBILITY (joint body of the DKE and NAAutomobil) and its subordinate bodies (GK, GAK)..

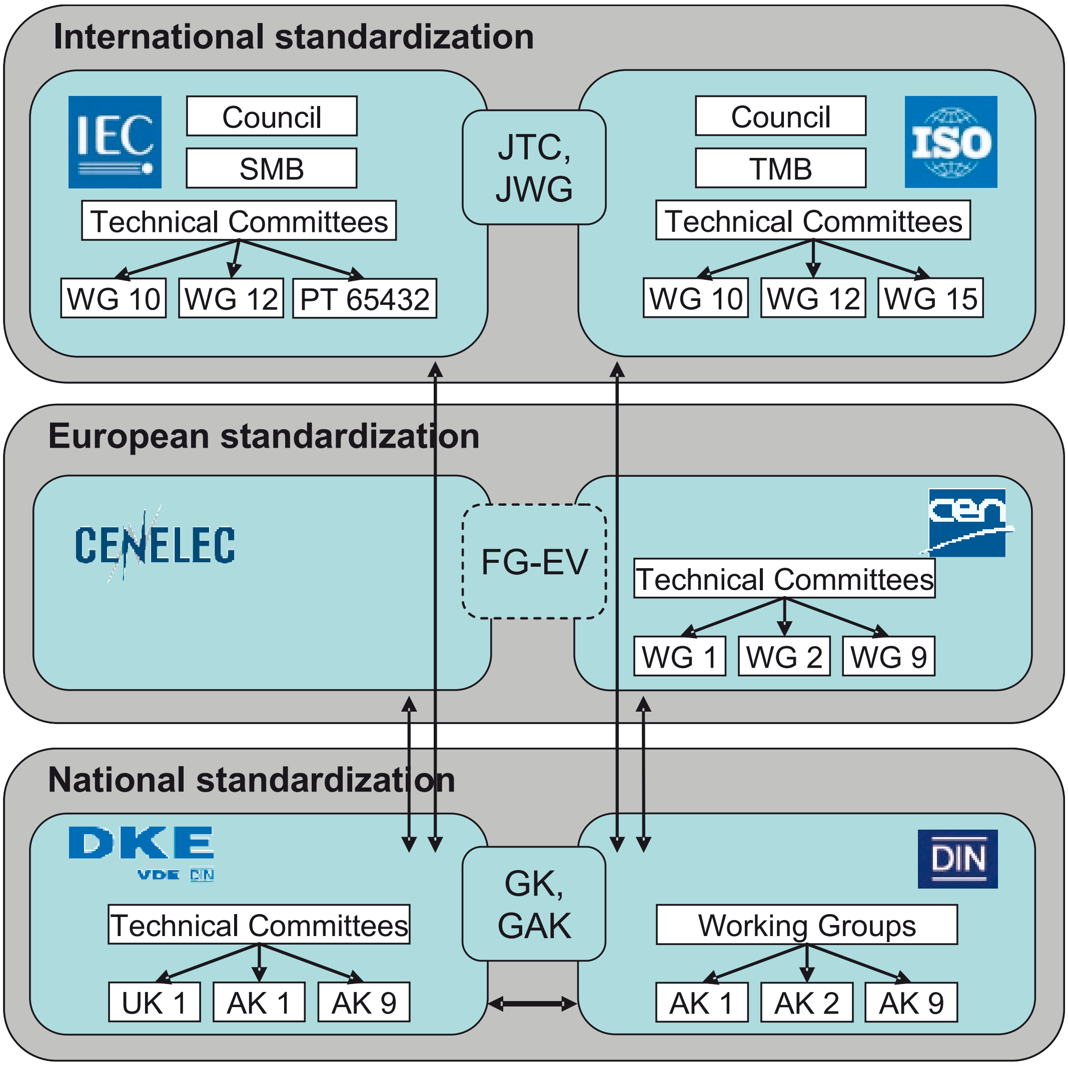



**Figure 3:** Internal structure of IEC/CENELEC/DKE and ISO/CEN/DIN

## 2.4 DIN, CEN and ISO

DIN, the German Institute for Standardization, offers stakeholders a platform for the development of standards as a service to industry, the state and society as a whole. DIN is a private organization which is registered as a non-profit association. Its members include businesses, associations, government bodies, and other institutions from industry, commerce, trade and science.

DIN's primary task is to work closely with its stakeholders to develop consensus-based standards that meet market requirements. By agreement with the German Federal Government, DIN is the acknowledged national standards body that represents German interests in European and international standards organizations.

Almost 90 percent of the standards work carried out by DIN is European and/or international in nature. DIN's staff members coordinate the entire non-electrotechnical standardization process at national level and ensure the participation of the relevant national bodies at European and international level. DIN represents Germany's standardization interests as a member of the European Committee for Standardization (CEN) and the International Organization for Standardization (ISO). DKE, a joint organ of DIN and VDE, represents Germany's interests in the field of electrical engineering (within CENELEC and IEC).

The Road Vehicle Engineering Standards Committee of DIN (NAAutomobil) is supported by the German Association of the Automotive Industry (VDA) and is responsible for standardization in all matters concerning the automobile, including accessories, parts from suppliers and systems. NAAutomobil mirrors international and regional standards work concerning automobiles within ISO/TC 22 and CEN/TC 301, and holds the secretariats of numerous working groups.

## 2.5 DKE, CENELEC and IEC

The DKE, German Association for Electrical, Electronic & Information Technologies in DIN and VDE, represents the interests of the electrical/electronic engineering and IT sectors in international and regional electrotechnical standardization, with VDE being responsible for the DKE's daily operations. The DKE is responsible for standards work in the respective international and regional organizations (primarily IEC, CENELEC and ETSI). It represents German interests in both the European Committee for Electrotechnical Standardization (CENELEC) and the International Electrotechnical Commission (IEC). The DKE is a modern, non-profit service organization promoting the safe and rational generation, distribution and use of electricity, serving the interests of the general public.

The DKE's task is to develop and publish standards in the fields of electrical engineering, electronics and information technology. The results of DKE work are published as DIN standards and thus form an integral part of the German standards collection. Where they contain safety provisions, they are also published as VDE specifications and are included in the VDE Specifications Code of safety standards.

DKE working bodies are German "mirror committees" of the relevant IEC (or CENELEC) Technical Committees, so that only one German body is responsible for all national, regional and international work and/or cooperation in each area.

## 2.6 Regulation in the fields of automotive engineering and dangerous goods transport

Safety and environmental protection matters concerning automotive vehicles and road transportation of dangerous goods are governed mainly by regulations developed at European or international level. Standards play a lesser role here or only serve to supplement regulations and directives.

In order for automotive vehicles to be licensed and approved in Germany, they have to comply with European directives and regulations, especially. In future, these directives and regulations will increasingly refer to ECE regulations or Global Technical Regulations of the United Nations Economic Commission for Europe (UN/ECE).

For safety reasons and to avoid the risk of fire and explosions, the transportation of lithium and lithium-ion batteries is subject to the requirements and regulations of international and European agreements and conventions on the transport of dangerous materials, such conventions being binding under international law.

Further details on these and other regulations and directives are described in a separate report of the “Vorschriftenentwicklung” (Regulatory developments) team in Working Group 4 [9].

# 3 National approach to electromobility standardization

## 3.1 General

The market introduction of electromobility presents a major challenge to Germany, yet at the same time offers tremendous opportunities. The automotive technology and electrical engineering/energy technology sectors, already established at a high level in terms of quality, safety and availability, will eventually merge to some extent. Later on in this chapter we will explain the motives behind drawing up a “Standardization Roadmap for Electromobility” and will describe its benefits for stakeholders.

This Roadmap frequently uses terms which have a specific meaning within the context of the topic being dealt with. To establish a common basis for discussions on electromobility standardization lists of terms and definitions, and abbreviations are given in Annex B.

## 3.2 Reasons and conditions behind the development of the Standardization Roadmap

Standardization is a central factor for disseminating electromobility, in addition to road vehicle engineering, energy supply, and the associated information and communication technologies.

The automotive engineering, electrical engineering/energy technology and information and communication technology (ICT) domains which up to now have largely been considered separately, need to converge if electromobility is to be a success. This calls for a long-term strategy that takes national interests into consideration while at the same time giving German industry access to the expanding international market. The Standardization Roadmap for Electromobility presented here is part of this strategy and embraces immediate standardization needs at one end of the scale and long-term standardization activities at the other, as well as the need for research.

System components, domains and subsectors relating to electromobility standardization are shown in Figure 4. Because of its great significance, battery technology is dealt with in a separate chapter. Product safety and communications are cross-cutting topics which affect all system components. Standardization requirements can be divided into the following main areas.

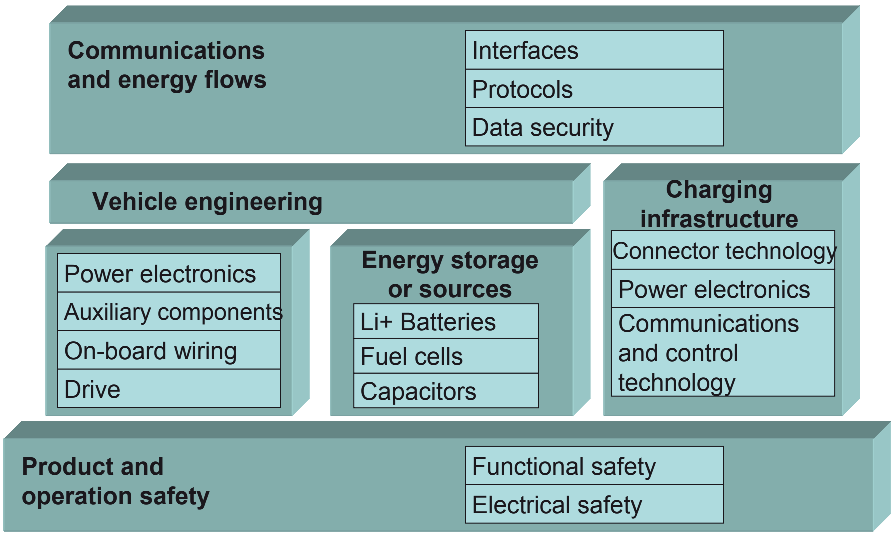



**Figure 4:** System components and domains relevant for standardization

A look at the stakeholders involved shows that the convergence of automotive technology and electrical engineering/energy technology has top priority for the market introduction of electromobility. Broadly speaking, the various stakeholders can be assigned either to the “vehicle” or the “charging infrastructure” domain, as shown in Figure 5. In this figure the battery is depicted as a separate component, since it can be assumed that this branch of industry will play a particularly significant role, and services dealing specifically with batteries will emerge.

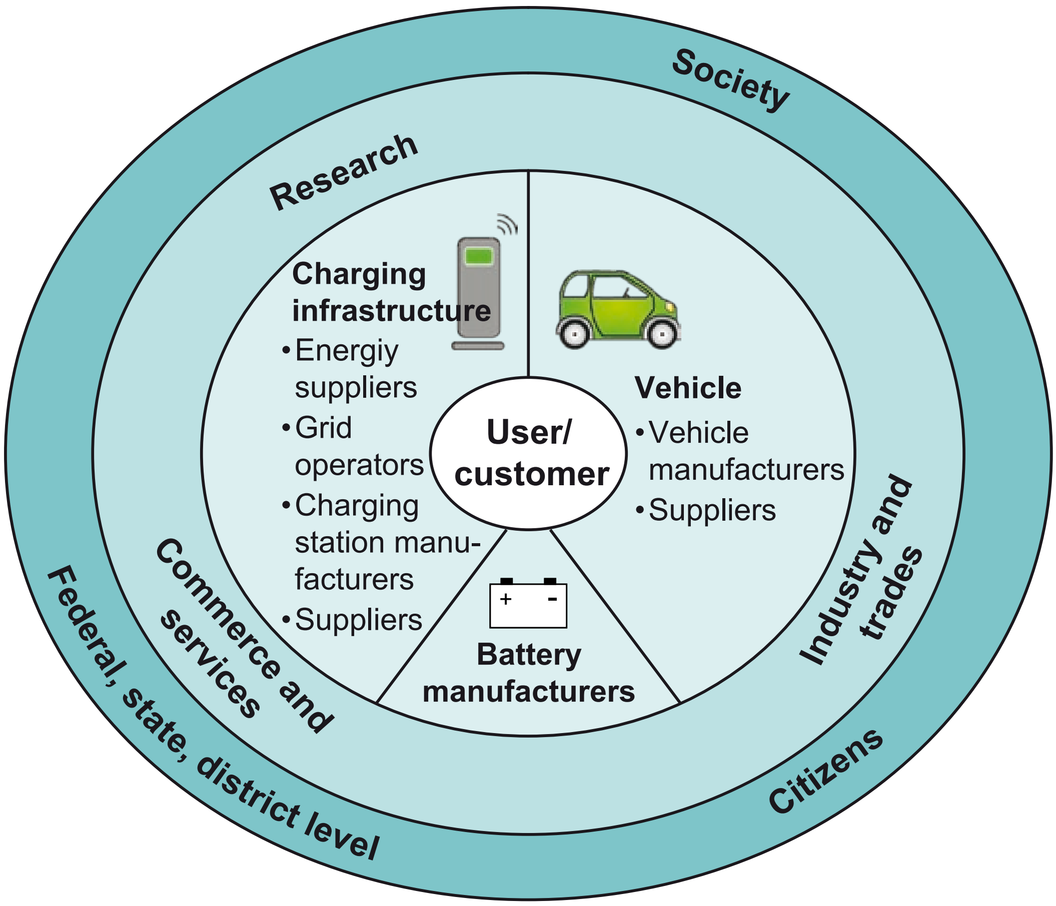



**Figure 5:** Electromobility stakeholders

In the service sector, established fields of activity will remain and new ones will emerge. This sector is closely linked with the development of new business models which are not, however, the main focus of phase 1 of electromobility standardization. Some examples of existing service providers and new ones which may emerge are listed below:

- vehicle sales
- vehicle and battery financing (rental, leasing)
- inspection, certification
- communication services (Internet, mobile telephony, …)
- electricity retailers
- parking space management (parking and battery-charging)
- financial settlement and arbitration bodies (clearing)

The benefits brought about by this Standardization Roadmap for Electromobility and the reasons for its development are explained in the following chapter. Various system approaches and the background for creating this document are explained in more detail in chapter 4. The general need for standardization from the point of view of German industry is set out in the German Standardization Strategy [2][3].

## 3.3 Benefits of electromobility and its standardization

Electromobility will be a major field of innovation throughout the coming decades. Ensuring sustainable mobility is one of the prerequisites for economic growth, and the transport and automobile industries are still major industrial sectors of enormous relevance to work and employment in Germany. We can expect to see the emergence of new business relationships and added value areas as electromobility spreads. Various stakeholders stand to benefit from electromobility and its standardization in different ways, to varying extents. This chapter describes the overall advantages of standardization for the market introduction of electromobility. The benefits of electromobility and its standardization for various stakeholders will be dealt with in a later version of this Roadmap, since this subject has to be aligned with the relevant passages in the corresponding White Paper.

**Standards and specifications prepare markets**
To ensure a broad dissemination of electromobility, individual mobility must remain at the level enjoyed today. This means people should be able to use their own vehicles throughout Europe, at least, and be able to purchase and operate vehicles at acceptable prices. Furthermore, new electric vehicles must offer the same level of safety and reliability as comparable conventional vehicles.

Standardization has a pioneering effect, particularly where the following aspects are involved:

- “Refuelling” the vehicle requires a suitable infrastructure. To facilitate unrestricted mobility in Europe, it must first be ensured that the infrastructure for recharging batteries and different makes of vehicle are compatible with each other.
- The cost of system components (vehicles and charging infrastructure) is a decisive factor for acceptance by vehicle manufacturers and consumers, and hence for marketability. These costs can be reduced not only through innovation, but also to a large extent by greater production quantities. The division of labour among component manufacturers associated with this will only be possible if interfaces to individual components are defined and standardized.
- User safety must be ensured by means of generally accepted rules and test methods, and it must be possible to prove conformity by objective means.

**Standards and specifications support innovation**
The development and implementation of electromobility is a continental-scale project requiring large investments. The framework conditions must be set down in standards and specifications to provide an acceptable level of investment security.

The degree of detail needs to be determined individually for each standard or specification. The aim is to find an optimal solution somewhere between general guidelines and specific requirements. Every standard/specification should be as “open” as possible, providing enough room to describe the general purpose while leaving enough freedom for innovative solutions that enable differentiated competition. The aim is to strive for the greatest possible security for the future, because specifications that are too detailed make future improvements difficult or even impossible. To take this aspect into account, there are a number of different types of standard which can provide the desired framework. These include:

- performance standards,
- test standards,
- interface standards/compatibility standards,
- terminology standards, and
- product standards.

**Standardization accelerates development**
In view of the considerable effort needed to drive forward the electromobility sector, a general framework needs to be defined as quickly as possible, and a number of standards and specifications must be developed rapidly; these have an “enabling” function. This requires standardization at the R&D phase. Specifications functioning as forerunners to standards can be drawn up within a short amount of time. Also, the “normative power of established facts” is another factor that helps accelerate procedures. Technical solutions which assert themselves on the market should be described in specifications and standards without delay. Individual patent rights should be avoided in standards or at least be made available under FRAND (“fair, reasonable and non-discriminatory”) terms.

## 3.4 National agreement on electromobility

### 3.4.1 Joint activities by DKE, DIN and NAAutomobil

Structures for steering standardization activities in the field of electromobility have been implemented at national level (cf. Figure 6. The EMOBILITY steering group (joint body of the DKE and NAAutomobil) was set up to coordinate activities in the electrical and automotive industries. The work of this committee is supported by the DIN Electromobility Office.

The aim of the EMOBILITY steering group is to coordinate various standardization and specification projects and to ensure a continual flow of information – to do this, the steering group needs to have sufficient powers of authority. Other tasks of the steering group are the internationalization of standardization in this area and the avoidance of isolated national solutions which would impede the international and, above all, cost-efficient introduction of electromobility and lead to new trade barriers. Issues concerning automobiles are dealt with by DIN/NAAutomobil, while infrastructure issues are dealt with by the DKE, with the EMOBILITY steering group serving as the interface between the two. Instead of creating new bodies, the existing committees within DIN and DKE should be strengthened .

The EMOBILITY steering group is made up of representatives from companies and associations active in the fields of electrical/electronic components, power generation and supply, as well as automobile manufacturers and suppliers, and testing institutes. The electrical trade is represented by the German Association of Electrical and IT Trades (ZVEH) as a future partner in developing the infrastructure.

DIN has set up an “Electromobility Office” to support the work of NAAutomobil, DKE, and the EMOBILITY steering group. This office will serve as a central, neutral contact point not only for established organizations, but above all for those who have not been much involved in standardization work up to now, for instance those in research and development. The Office will inform them on standardization issues and facilitate participation in standards work. Another important task will be the continual analysis and coordination of relevant activities in standardization and specification, and the continuous development of networks at European and international level. The Electromobility Office will provide feedback to the DKE, NAAutomobil and the steering group on relevant topics taking all approaches and developments into consideration as much as possible.

For national standards work, NAAutomobil and the DKE are in the process of establishing joint bodies to deal with topics relating to the vehicle-infrastructure interface.

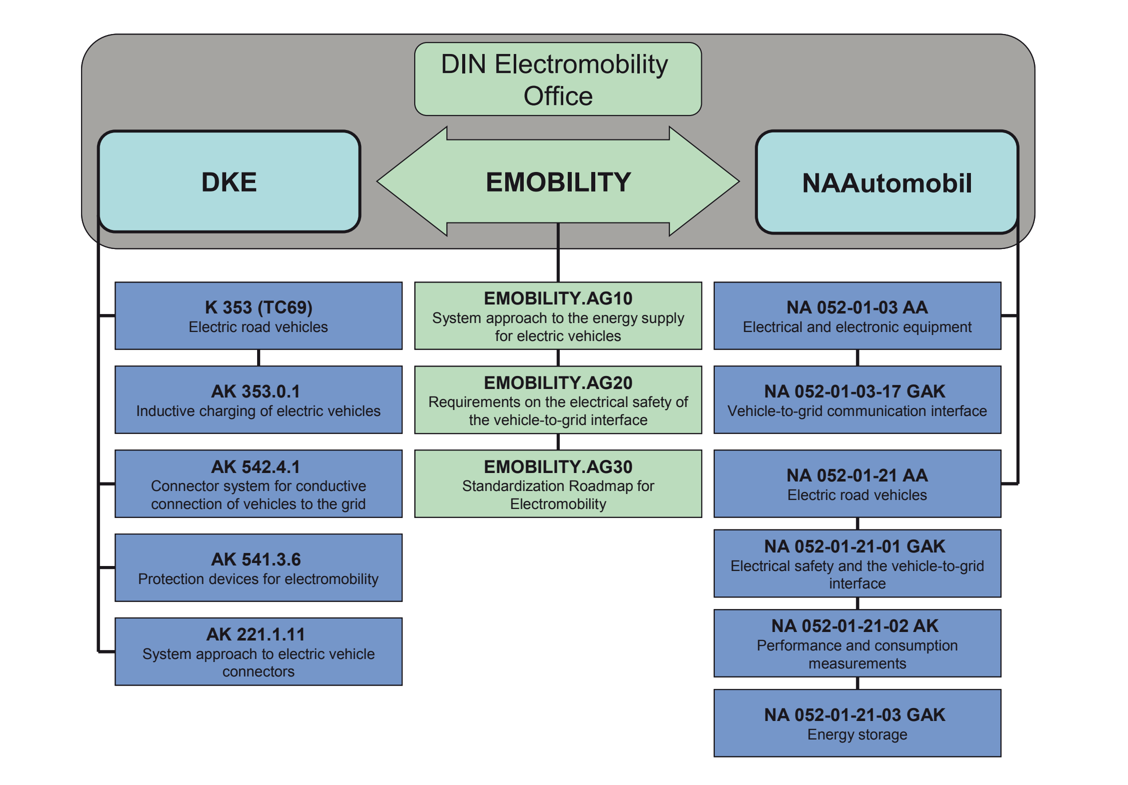



**Figure 6:** National coordination of electromobility standardization (overview)

## 3.4.2 Activities at the DKE

In addition to the aforementioned EMOBILITY steering group, whose purpose is the coordination of activities between VDE|DKE and VDA|NAAutomobil, there are numerous other DKE bodies which are involved in electromobility standardization. Figure 7 shows which bodies are active in which area.

A comprehensive overview of the relevant committees is given in Annex D.2.

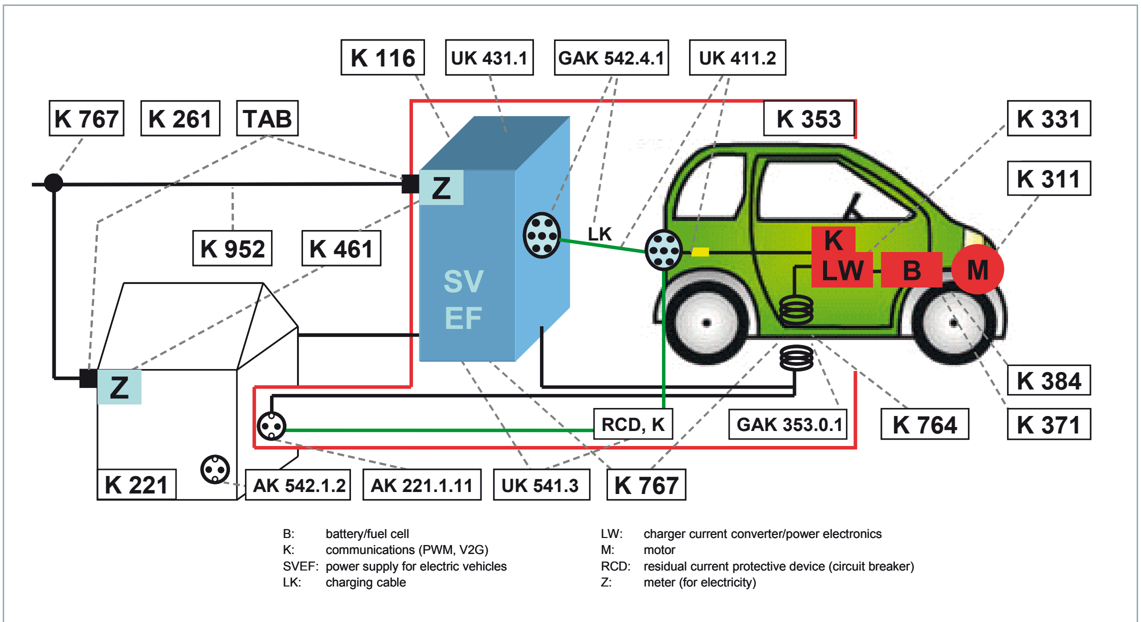



**Figure 7:** Overview of relevant DKE bodies active in the field of electromobility

### 3.4.3 Activities of NAAutomobil

Numerous bodies of NAAutomobil deal with the standardization of electrical and electronic components and systems, and with the specification of issues applicable to electric vehicles. Figure 8 shows an overview of these bodies. A comprehensive overview is given in Annex D.2.

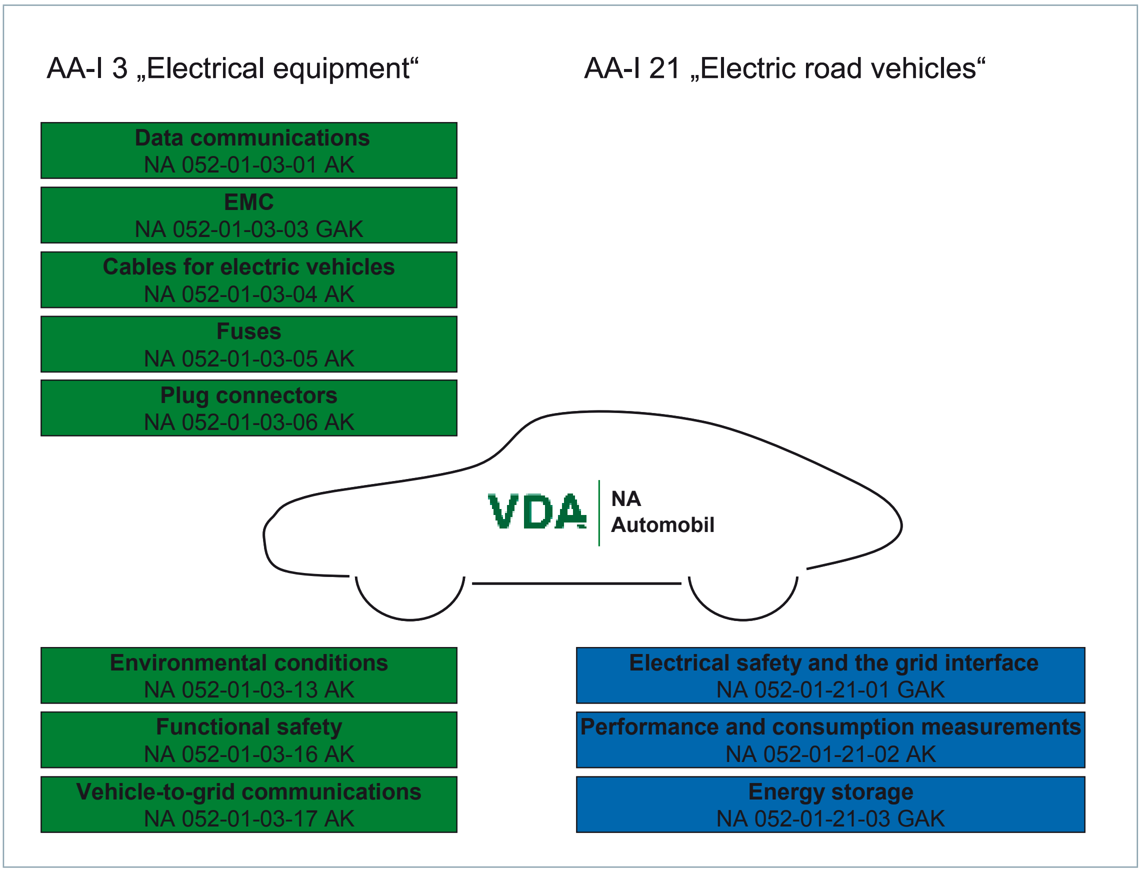



**Figure 8:** Overview of relevant committees in NAAutomobil dealing with electromobility

### 3.4.4 Standardization activities carried out within funded projects

There are currently a number of pilot and model projects being carried out in Germany. The main objective of these activities is to gather experience and gain new insights in the practical implementation of electromobility. Another major topic being dealt with in these projects and exchanges of experience is the extent to which existing standards and specifications are to be taken into consideration and/or revised and where new standards and specifications are needed. The findings need to be analyzed and assessed for their relevance to standardization on the basis of the time schedule for each project. Projects include those funded by the German Federal Government (i.e. by the ministries BMBF, BMU, BMVBS, BMWi), those initiated by the German Länder (e.g. AutoCluster.NRW) and university projects (e.g. at RWTH Aachen, Uni München). Results are not yet available for the majority of these projects, so it is not possible to assess their specific relevance for standardization at this point.

Several of these projects have a clear relationship to standardization. These are:

- The “ICT for electromobility” programme initiated by the Federal Ministry of Economics and Technology (BMWi) in conjunction with the Federal Ministry for the Environment (BMU). Information and communication technology (ICT) aspects of electromobility are being investigated and tested in seven “pilot regions” within Germany, which are closely connected to the six “e-energy” pilot regions.
- The funding programme announced by the Federal Ministry of Education and Research (BMBF), “Schlüsseltechnologien für die Elektromobilität (STROM)” (Key technologies for electromobility (STROM)), which expressly refers to the fundability of standardization and specification work.
- The long-term “Innovation with Norms and Standards (INS)” programme supported by the Federal Ministry of Economics and Technology (BMWi) in which innovative standardization projects carried out by German companies are being funded, particularly to help them uphold their interests at international level. The INS programme not only covers electromobility but also the “cutting-edge fields” identified in the Federal Government’s “High-Tech Strategy”, and is especially addressed to the needs of SMEs.

These pilot regions are also cooperating in a joint “Taskforce: Interoperability” headed by a research team in the form of a consortium commissioned by the BMWi to support work in the “ICT for electromobility” funded projects. The research team is analysing the implementation of the projects in the seven pilot regions, ensuring the sustainability of programme projects, and evaluating project results so that they can be quickly made public. A further focus is being placed on promoting cooperation among the individual projects and their environment.

One aim of the task force activities is to ensure interoperability of the pilot solutions developed in the model regions while taking consideration of current (international) standardization, and to influence the latter in the interest of German industry. To achieve this goal, the “Taskforce: Interoperability” is cooperating closely with DKE and DIN and is represented in (international) standards working groups. The main topics being dealt with are:

- Standardizing the evaluation of field research on batteries, which may result in standardized evaluation procedures.
- Standardizing access to charging stations (authentication and identification).
  Three approaches are being addressed in the funded projects:
  – Migration: Alternative access solutions using mobile phones
  – RFID: Agreement on physical/logical characteristics
  – Electric Code: Contract numbers, ID schemes
- Standardizing the exchange of charging and billing data (“roaming”)

The described procedure will ensure that results are promptly made available to the national standardization organs.

## 3.5 International agreement on electromobility

Electromobility can only be successful if there are sufficient international standards and specifications on this topic. Internationally harmonized standards ensure success and provide industry with the same conditions for all markets. International electrotechnical standardization is carried out at IEC, while these activities in the automotive sector are carried out at ISO. Before electromobility can be introduced, work within these two organizations needs to be harmonized. The coordination of ISO and IEC activities is essential in order to avoid duplication of work and to ensure the participation of all experts from the economic sectors involved in electromobility, for example in the development of standards and specifications for vehicle-to-grid interfaces. ISO and IEC are currently in the process of adopting a Memorandum of Understanding which involves setting up joint working groups (JWGs) under mode 5 to deal with all aspects of vehicle-to-grid interfaces. One joint working group – ISO/TC 22/SC 3/JWG 1 – has already been set up to deal with communication interfaces.

## 3.6 CEN/CENELEC Focus Group on Electromobility, EU mandate M/468

The European Commission has recognized the significance of electromobility in achieving climate protection targets and as an economic factor for Europe, emphasizing this by issuing standardization mandate M/468. The mandate aims at ensuring the uniform charging of electric vehicles throughout the European Union and avoiding isolated solutions by individual European member states. It focuses on the urgent topic of creating standards and specifications for charging interfaces between the vehicle and the power supply grid. The controversial debate currently taking place at European level, particularly with reference to the design of vehicle-to-grid interfaces, clearly shows that agreement is imperative. The mandate not only covers passenger cars, but other vehicle categories as well, for example scooters.

The standardization mandate was handed over to representatives of the European standards organizations CEN, CENELEC and ETSI in June 2010. CEN and CENELEC have accepted the mandate and have already set up the joint CEN/CENELEC “Focus Group on European Electro-Mobility – standardization for road vehicles and associated infrastructure”. This focus group will examine the requirements and preconditions within each European country for a uniform charging structure, as well as the need for the standardization of electromobility in Europe. To this end, the group has been divided into several working groups, each dealing with a specific topic. The working group “PT Connector” plays a vital role in this process, since it deals in principle with the mandated central task by discussing and evaluating various charging connector system solutions, for example. The objective here is to develop a recommendation for the adoption of a uniform connector system for all of Europe. This requires an examination of national installation regulations and safety analyses, the results of which were not yet available in their final form at the time this Roadmap was drawn up.

The Focus Group plans to present CEN/CENELEC with an initial report by the end of March 2011, in which it will propose recommendations outlining the way towards uniform electromobility in Europe. This report should also contain major elements of this Standardization Roadmap for Electromobility.

## 3.7 Other sources of information

A number of existing sources were consulted during the development of this Standardization Roadmap for Electromobility. Relevant information in these sources was analyzed and integrated into this Roadmap. The following studies were especially important::

- DIN study on “Normungsbedarf für alternative Antriebe & Elektromobilität” (Need for the standardization for alternative drives and electromobility), carried out under the leadership of NAAutomobil [4]
  This DIN study identifies and provides an overview of the relevant standards in the field of electromobility, including existing standards and standards which were still under development at the time the study was concluded. In addition, the study includes a number of recommendations which should be taken into account in the Standardization Roadmap for Electromobility.
- VDE study on electric vehicles [5]
  This VDE study illustrates the potential for battery-powered electric vehicles and evaluates the technical feasibility of individual components while determining the need for R&D activities. With regard to vehicle connection to the supply grid, scenarios for the introduction of 1 million electric vehicles or more are described. The study also evaluates technical aspects of the main components of electric vehicles . In addition to the key components of the drive train, it also examines auxiliary power supply, chargers, connectors and “range extenders”..

In the automotive sector there are numerous organizations whose activities influence the requirements on electric vehicles and which therefore have a direct or indirect influence on standards and specifications. Apart from this, standardization of the Internet needs to be taken into consideration, since it is expected that web-based communications will play a role in electromobility. In this context, the following are to be mentioned:

- **EuroNCAP, USNCAP**
  Test protocols and procedures for evaluating the active and passive safety of vehicles – particularly category M1 passenger vehicles – are not standards in the real sense. Nevertheless, they define performance requirements which have a great influence on vehicle design.
- **ETSI TC ITS/Car to Car Communication Consortium**
  Under European standardization mandate M/453, ETSI is working in close cooperation with the Car to Car Communication Consortium on standardizing a short-range vehicle-vehicle and vehicle-infrastructure communication based on the IEEE 802.11p standard. In this connection, the possibility of communication with electric charging stations is being discussed.
- **World Wide Web Consortium (W3C)**
  The World Wide Web Consortium (abbreviated: W3C) is the body for standardizing technologies concerning the World Wide Web (Internet). W3C is not an internationally recognized organization and is therefore not entitled to define standards. Nevertheless, W3C specifications, such as XML, form the basis for several ISO Standards. Specifications laid down by W3C affect the communications and data security sectors.

# 4 Overview of the “Electromobility” system

This section describes “Electromobility” system approaches which, according to experts from German industry, research and politics, will make a major contribution towards achieving the goals of phase 1 (1 million electric vehicles on Germany’s roads by 2020). The technologies and stakeholders involved were identified in section 3.2. The present section begins by presenting use case scenarios for electric vehicles and then describes the energy and data flows involved. This is followed by a more detailed discussion of the vehicle, energy storage and charging infrastructure domains; for each domain the relevant national and international standards and specifications are named which have been identified in current studies carried out by manufacturers, users and researchers active in the electromobility sector.

## 4.1 Electric vehicles and the smart grid

Electromobility offers the unique opportunity of combining the advantages of environmentally-friendly mobility with an efficient, optimized utilization of electricity supply grid resources and sustainably generated electric energy. This gives rise to a number of special requirements, particularly on the technology used and on standardization of the interface between electric vehicles and the grid.

The development of standards is a fundamental success factor for the numerous application cases for the battery charging process. The various application cases are described below:

- Charging
  - Charging location
    - Private (e.g. garage), semi-private (e.g. company yard), public or semi-public (e.g. supermarket parking lot) charging station.
    - In combination with parking
    - Outdoors, under a roof or in an enclosed space
    - At a normal single-phase household a.c. mains outlet (e.g. at a friend’s or relative’s house)
    - While travelling (fast charging)
  - Charging functions
    - a.c. charging with currents up to 16 A (normal charging)
    - fast charging, a.c./d.c.
    - Conductive (cable-bound) or inductive (wireless)
    - With or without communications path for individual billing
    - With or without communications path for negotiating electricity rates
    - With or without load management (local, smart grid)
    - Grid feedback option (phase 2)
  - Vehicle functions while connected to stationary grid
    - Charging process monitoring
    - Temperature control of battery and/or the vehicle interior while vehicle is stationary
- Billing
  - Without separate billing (billing as part of the “normal” electricity bill)
  - With a separate cumulative bill (separate meter)
  - With a separate detailed bill (comparable to a “fuel card”)
  - With direct payment (cash, electronic)

This list provides some idea of the complexity of the issues involved in the charging process. In addition to new standards projects dealing with these issues, there will be a need to review and, where necessary, adapt existing vehicle standards in the fields of:

- electrical safety
- EMC
- requirements on various E/E systems and components.

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Furthermore, from the viewpoint of energy suppliers and grid operators, the system must be linked to the smart grid. As a result, other load scenarios such as "tanking up with electricity" and "grid integration" will evolve in addition to the conventional "charging" scenario. Other scenarios are imaginable, as the examples in Figure 9 show.

| Tanking up | Price management | Load management | Vehicle-grid feedback |
|---|---|---|---|
| Customer chooses time and amount of energy consumed | Customer can choose most suitable tariff for charging vehicles | Customer specifies desired usage (how much charge is required by when) | Customer specifies desired usage (how much charge ist required by when) |
| Electric utility has no control over process, no possibility to switch off smart meters | Electric utility: variable pricing schemes and information to consumers about prices | Electric utility can actively adapt load to the currently available energy supply | Electric utility can actively control load and feedback |

**Figure 9:** Various scenarios for integrating electric vehicle charging into the grid

The above illustration shows, from left to right, an increasingly close integration of the electric vehicle into the smart grid and ways of providing the respective grid services. In terms of systems theory, each of these variants represents a control loop for optimizing consumption (loads) and/or the feedback of energy into the grid. With the "price management" method, the current electricity price and/or the remuneration for energy fed back into the grid is the "control parameter" for consumption and feedback, whereas the "load management" and "grid integration" methods make explicit control possible.

Other use case scenarios which are not directly associated with the charging process have also been discussed in connection with the Standardization Roadmap. Examples of these are::

- stationary vehicle
- vehicle in motion
- service (diagnosis, maintenance and repairs)
- accidents, recovery of vehicle after an accident
- towing
- decommissioning, recycling

These scenarios will be discussed in due course.

## 4.2 Interfaces, energy flows and communications

The introduction of electromobility will either lead to a need for many new energy flow and communications interfaces and protocols, and/or will require the adaptation of existing interfaces. The following interfaces are conceivable and/or need to be taken into consideration:

- vehicle – charging infrastructure
- vehicle – user
- vehicle – energy trade (pricing)
- charging infrastructure – grid
- charging infrastructure – energy trade (pricing)
- charging infrastructure – charging infrastructure operators
- charging infrastructure operators – financial settlement service companies
- users – financial settlement service companies
- charging infrastructure operators – users
- vehicle – service

In some cases, both data and energy are transmitted via these interfaces. The various abstraction levels of the individual layers can be represented as a simple layer model, as shown in Figure 10.

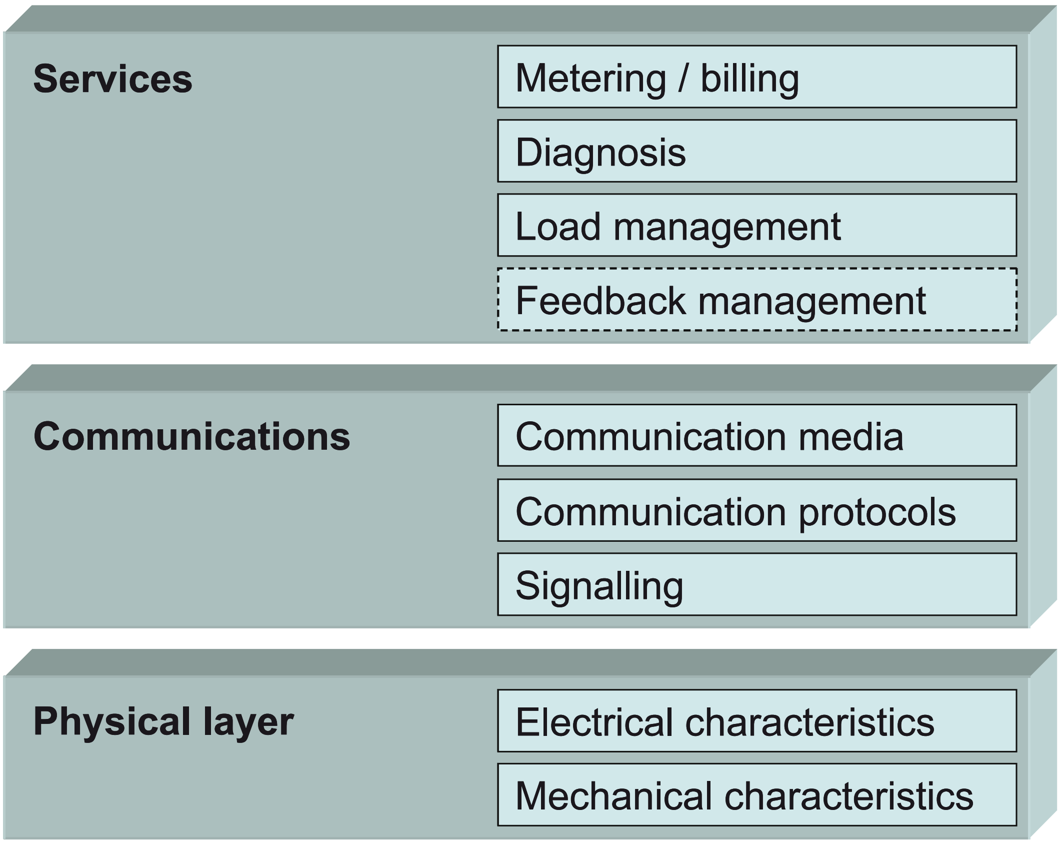


**Figure 10:** Abstraction levels of electromobility interfaces

The communications layer can be subdivided into fundamental signalling (required to ensure safety), more complex communication protocols (e.g. for billing applications), and communication media (e.g. powerline).

The following sections identify the individual aspects of energy flows and interfaces, the current state of standardization, as well as what remains to be done.

### 4.2.1 Energy flows

A significant number of national and international standardization activities deal with defining the characteristic parameters of all possible energy flows. The first type of flow that comes to mind is the (conductive) charging of a vehicle battery via a cable and mains outlet. However, other energy flows are already being considered within the electromobility framework, as shown in Figure 11, such as inductive charging, battery switching and charging by electrolyte exchange ("redox flow"). Other energy flow modes are not regarded as being practicable at present or are irrelevant for standardization activities (e.g. solar-powered cars parked under a street light).

At the moment there is no international approach to the standardization of battery exchange or switching systems. Research still has to be carried out on redox-flow charging systems before the main characteristic parameters can be defined in standards. IEC has proposed a standard on inductive charging (IEC 61980-1 "Electric vehicle inductive charging systems"). Because conductive charging will be of prime importance in phase 1 of the electromobility campaign, electromobility standardization activities in this domain are the most advanced.

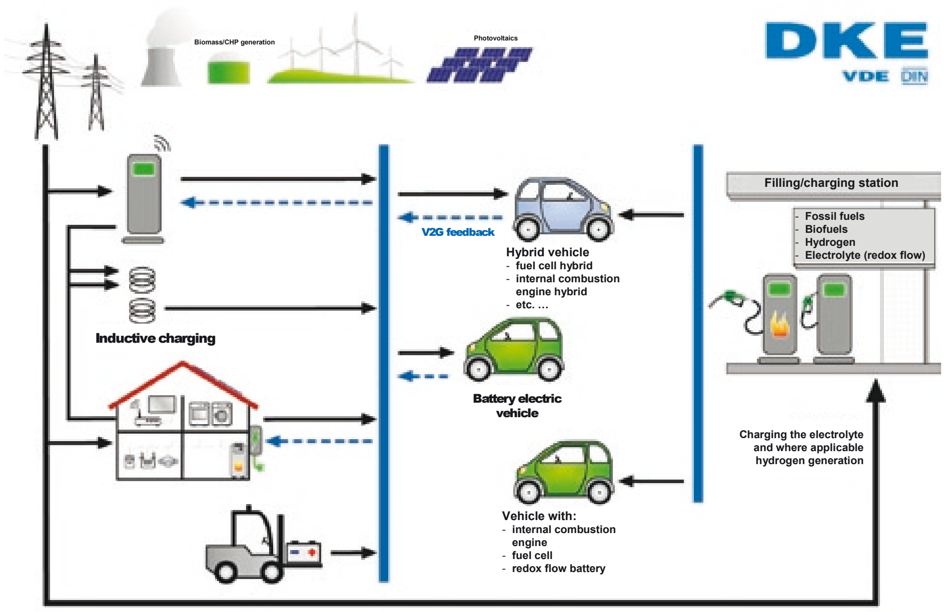


**Figure 11:** Possible electromobility energy flows

Standardization activities dealing with the energy flows for conductive charging focus on mechanical and electrical characteristic parameters and on signalling; the IEC 62196 series is of prime interest this context. Section 4.4.1 of the present document discusses details of various charging modes and system approaches to energy flows as proposed in the IEC 61851 series.

### 4.2.2 Communications

Communications between the vehicle and the charging infrastructure (vehicle to grid, V2G) has top priority in standardization activities. At present, the new standard ISO/IEC 15118 "Road vehicles – Vehicle to grid communication interface" is being drafted.

The currently preferred solution for the physical layer for a V2G communications interface is HP's "GreenPhy", which is a powerline communications system. This is downwardly compatible and can be used with the plug connector systems currently being standardized. Furthermore, IP- and XML-based technologies are being used for the higher layers and it is assumed that the charging infrastructure will act as a gateway. Also being discussed are security architectures and solutions for the current/communications flow association problem.

Operators will have to define the charging station - operator communications interface if charging stations are operated as free-standing stations. In terms of energy management, the integration of private charging stations into building automation systems is an idea worth following up. Due to higher energy consumption as compared with normal households, and to the option of feeding energy back into the grid, a wider integration of the charging station into the smart grid makes more sense. ISO/IEC 14534-3 "IT - Home electronic systems (HES) architecture" (developed by ISO/IEC JTC 1/SC 25) is a current standard in several parts that provides a basis for applications in both residential and non-residential buildings. Some application-specific details still have to be included, e.g. which parameters need to be controlled and/or reported.

### 4.2.3 Services

**Billing and financial settlement**
Infrastructure services have to be accounted, billed and paid for, primarily as regards the supply of electricity to various charging locations. Due to the continually increasing proportion of fluctuating power available in the grid, load management and storage management will pose new challenges to mass-market billing services. Suitable business models ("intelligent tariffs") based on appropriate services can be used to influence consumer behaviour and thus achieve a better balance between supply and demand in the grid. On the other hand, the consumption of electric energy without separate billing systems, or without billing systems that differentiate prices according to volume (e.g. electricity flat rates), would lead to a situation in which the contributing new, controllable and/or switchable consumer devices in electricity supply grids cannot be fully exploited. In the interest of the successful introduction of electromobility, there is therefore a need to develop billing services which provide a transparent basis for well-informed, rational and sustainable decisions by the respective actors.

To promote the swift and economical introduction of electromobility throughout Germany, existing system know-how should be explored and furthered in order to develop the required accounting and billing systems. For example, in Germany, as opposed to other countries, it is already possible for several electricity retailers to be active "in one grid", thus allowing consumers to change suppliers if they so wish. Problems can arise, for instance, if customers of a specific electricity retailer drive their electric cars to a workplace in a different grid area but still want to be billed by the same electricity supplier. There are already several possible approaches towards solving these issues, which need to be expanded upon to ensure open competition in the domain billing systems for the energy supply of electric vehicles.

Market processes and communication methods which could facilitate or enable collaboration between various – and new – market actors have been defined recently, particularly in the liberalized energy market environment. The extent to which experience gained here can be transferred to billing services in the electromobility context is to be investigated. Conversely, existing standard processes should be reviewed to determine the extent to which they have to be optimized or adapted specially for mobile consumers. The various stakeholders and the German Federal Network Agency are jointly developing standard commercial processes for the energy sector.

**Web-based financial settlement scenarios**
There are already a great many standards and specifications covering web-based financial settlements (relating to payment transactions, but not to meter readings/measurement data communications), and adherence to these is recommended. Some examples are:

- Requirements of the PCISSC (Payment Cards Industry Security Standards Council), such as PCI-DSS – (https://www.pcisecuritystandards.org)
- EMVCO specifications for POS (point of sales) terminals – (http://www.emvco.com)
- Regulations issued by major credit card companies, e.g. VISA, MasterCard, Amex etc.

**Load management**
In terms of the smart grid concept, an electric vehicle is to be regarded as a consumer of electric energy, or (in the case of V2G feedback) a mobile storage device. One of the objectives of a smart grid is to influence energy consumption in such a way that it is easier to integrate renewable, more volatile energy sources into the overall system. As electric energy can only be stored to a limited extent, the load profile is to be influenced in such a way that energy from sustainable or renewable sources can be used efficiently, e.g. consuming wind-generated energy at night so that it does not need to be stored or wind turbines do not have to be stopped due to lack of consumers. The aim of load management is therefore to influence energy consumption as a function of time in such a way that consumption is more closely aligned to the supply situation. A basic distinction is made between two types of load management:

- direct control of consumer devices
- incentive-based control
  – various price schemes/tariffs
  – electricity from $CO_2$-free sources

Both types of control could be applied to electric vehicles. For example, charging stations could be directly influenced by a decentralized control system operated by the provider or the grid operator in order to prevent grid overloads. An incentive-based control system can be a powerful motivation for users not to charge their car batteries at peak load times, but to wait until prices or sources are more favourable.

Especially in the initial introduction period, it is expected that customers will associate their electric vehicle with their environmental protection ambitions. Load management can help towards achieving the ultimate aim of CO2-optimized mobility. In the extreme case, only energy from renewable sources and which is not needed for other purposes at the time would be used for charging vehicle batteries.

Both basic approaches, direct control or influence by incentives, must be brought in line with user behaviour, e.g. by specifying the time it should take to charge the battery. The longer the time frame specified by the user, the more flexible is the choice of time at which the battery is charged and the higher is the probability that the user will be able to “tank up with electricity” with less $CO_2$ emissions and at lower prices

**Storage management**
It is conceivable that, in a further step, electric vehicle batteries will not only be used for storing energy from renewable sources, but also for helping to bridge periods in which less energy from renewable sources is fed into the grid. Simple load management would provide control in one energy flow direction only. If control in the opposite direction would also be implemented, i.e. controllable feedback into the grid, this would influence energy flow in the other direction and therefore add considerably to efficiency.

In terms of the smart grid, various strategies for minimizing the number of conventional backup power stations are being discussed and tried. One of these strategies is load management. A large number of electric vehicles which are also able to feed energy from their batteries back into the grid at short notice would open up a further possibility. Feedback from electric vehicles could contribute to grid stability, particularly where short fluctuations in the input from solar or wind farms occur, but would not drain large amounts of energy from the vehicles. Thus, in cases of emergency or short-term fluctuations, electric vehicles would be able to support grid stabilization until other power stations could be started up and synchronized with the grid.

The feedback process can affect battery service life, which will have to be taken into consideration when discussing this topic.

Basic mechanisms for load and storage management and the transmission of dynamic price information are defined in the IEC 61850, IEC 61968 and IEC 61970 standards series.

### 4.2.4 Data security

Electromobility will result in a large amount of information that will be collected and stored at various points and exchanged via various communications interfaces between the involved parties. Ensuring adequate security of these data and of the data processing systems is therefore of great importance. Since a large portion of this data is of a personal nature, ensuring comprehensive data privacy protection is particularly important for the wide-spread acceptance of electromobility. Data security is thus a cross-sectorial issue that must be dealt with for all individual systems and communication interfaces.

Owing to the many types of communication interface between the various systems, a number of data security threats and data protection violations are possible and must be taken into consideration. Examples of such threats are:

- Attacks on central systems for energy trading transactions and payment settlement, with the objective of compromising and manipulating the system.
- Attacks on central systems for controlling energy supply grids and/or attacks on the smart grid infrastructure with the aim of manipulating it, and particularly of disrupting the operation of energy supply networks.
- Attacks on central systems for services (fleet management, vehicle maintenance etc.).
- Attacks on distributed systems in the charging infrastructure, for instance with intent to manipulate or gain unauthorized access to billing data.
- Attacks on terminal devices in vehicles, for instance to manipulate billing data or possibly to gain unauthorized access to vehicle movement data or other underlying vehicle systems (control units, driver assistance systems, communications systems, value-added services) possibly via the vehicles' internal communication networks

Luckily, there are already many internationally accepted and widely applied standards concerning information security which can also be used to ensure data security, data privacy and protection in the electromobility environment. In this context, particular reference is made to the following standards:

- ISO/IEC 27000 series of standards
  The basic standard ISO/IEC 27001 describes an information security management system which is generally suitable for the appropriate handling of information security issues and for the implementation of suitable measures. Application of this standard is therefore recommended for all relevant sectors and operators of information technology systems related to electromobility. Furthermore, the recommendations made in ISO/IEC 27001 for the implementation of the ISO/IEC 27001 controls can be applied directly to trading platforms and commercial systems and their associated communication networks and interfaces.
  We do not consider that any further standardization is necessary in these areas.
- Protection of communications with the control systems of the energy supply grid
  Some mechanisms for protecting communications between grid control networks are already provided in the communication protocols used (especially in IEC 61850) or are additionally defined in supplementary standards (e.g. IEC 62351). Some of the many activities currently being undertaken to further develop existing energy supply networks into "smart grids" are the efforts being made to apply and amend these standards. We do not consider that any further standardization is necessary from the security aspect.
- The BDEW white paper "Anforderungen an sichere Steuerungs- und Telekommunikationssysteme" (Requirements for safe control and telecommunications systems) [8]
  The white paper issued by the "Bundesverband der Energie- und Wasserwirtschaft (BDEW)" (German association of energy and water supply companies) defines essential security requirements on control systems in the electric energy supply environment and can therefore also be applied to corresponding systems that are required for electromobility.

To supplement the existing standards listed above, we consider that additional standardization activities are needed in the following areas specifically for the electromobility sector:

- Protection of communications interfaces specifically used in electromobility
  The communications interfaces defined as part of electromobility standardization activities should have inherent security features and mechanisms. These include methods for the reliable authentication of communication partners, for ensuring the confidentiality and integrity of exchanged data, and for ensuring the traceability of transactions. The relevant interfaces include, for example, communication interfaces between vehicle and charging station (IEC 61851-23/24), and vehicle-to-supply grid interfaces (ISO 15118). It should be discussed whether separate standards are needed for such protection or whether the protection mechanisms can be dealt with directly in current standards.
  Since cryptographic methods are normally used for protecting communication interfaces and these require the provision of key material for all communications partners, it must also be examined whether additional standards are required for providing and distributing key material to all participants.
- Protection of devices in vehicles and charging/filling stations
  The definition of “protection profiles” according to “common criteria” (as specified in the ISO/IEC 15408 series) has proven to be a good method of defining the security features of devices. In particular, these permit a neutral verification and certification of systems made by different manufacturers. Protection profiles as defined in the ISO/IEC 15408 standards are already being used for digital tachographs, for example, or will be used in the future for meter interface systems in the smart metering/smart grid environment. With regard to the electromobility sector, we consider it necessary to define protection profiles for the communication systems and components of vehicles and charging/filling stations.

## 4.2.5 Current standardization activities relating to interfaces and communications

At present, there are several standards and projects dealing with interfaces and communications at international level. Figure 12 shows the most important standards on conductive charging. In addition, a standards proposal on inductive charging has been submitted to IEC (IEC 61980-1 “Electric vehicle inductive charging systems”).

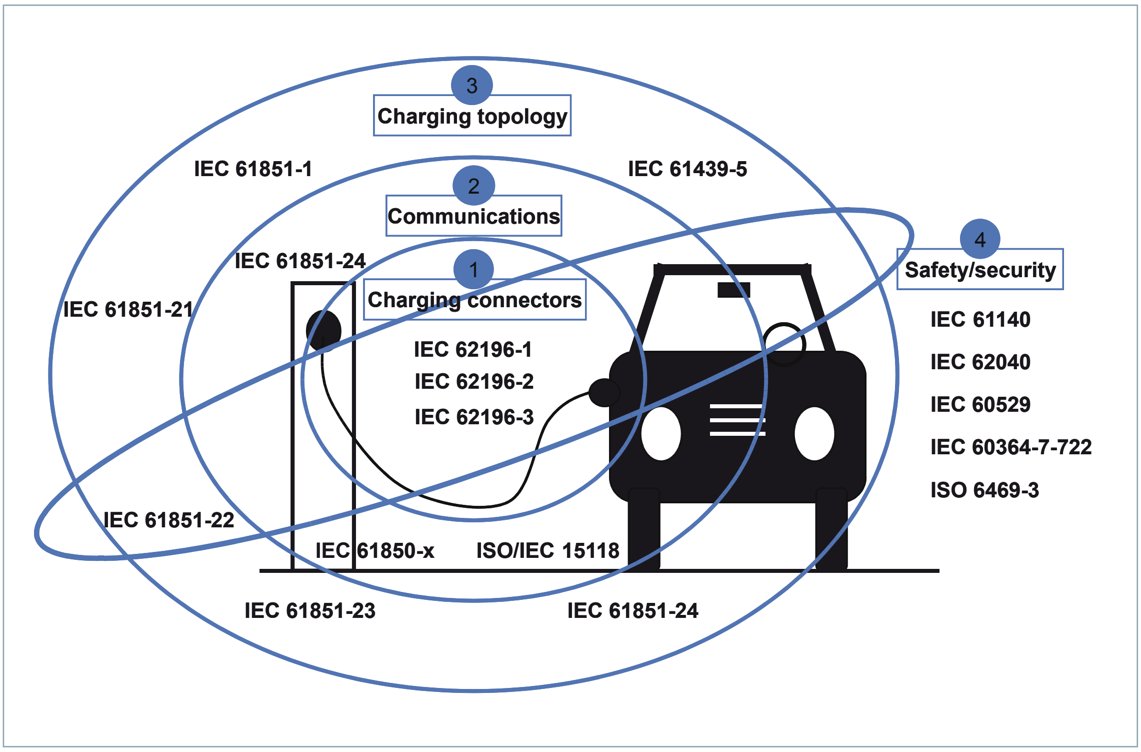


**Figure 12:** Selection of standards and projects relating to the charging interface

## 4.3 Electric vehicles

This Standardization Roadmap deals with road vehicles which are fully or partially propelled by an electric motor. Top priority is given to category M1 vehicles (passenger cars), but other vehicles, e.g. motor vehicles with two or three wheels and light quadricycles (categories L3e, L4e, L5e, L7e) as well as commercial vehicles of classes M2, M3, N1, N2, N3 are also taken into consideration (see B.1.3). Vehicles requiring charging voltages under 60 V (e.g. electric bicycles) are not included in the present version of the Standardization Roadmap.

### 4.3.1 System approaches

There are several different drive concepts for road vehicles. Figure 13 gives an overview of these, with the degree of electrification rising from left to right. Vehicles powered exclusively by internal combustion engines are not included in the present Standardization Roadmap. Considering the current market situation and product announcements by vehicle manufacturers, it is clear that hybrid vehicles will play a vital role in electromobility in the coming decade. These vehicles are characterized by the fact that they have both an internal combustion engine and an electric means of propulsion.

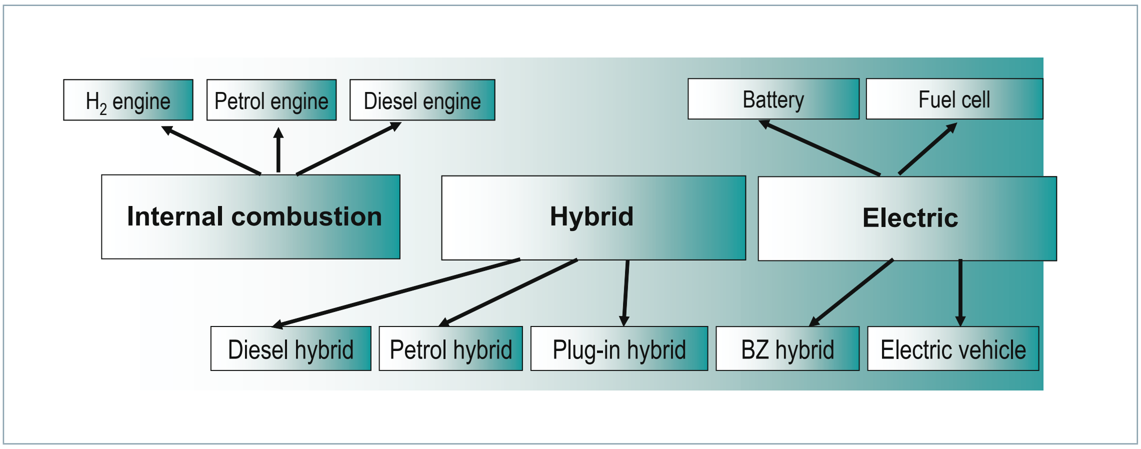


**Figure 13:** Different degrees of electrification of road vehicles

As the examples in Figure 14 show, the electric energy for vehicles propelled exclusively by electric motors can be supplied in various ways.

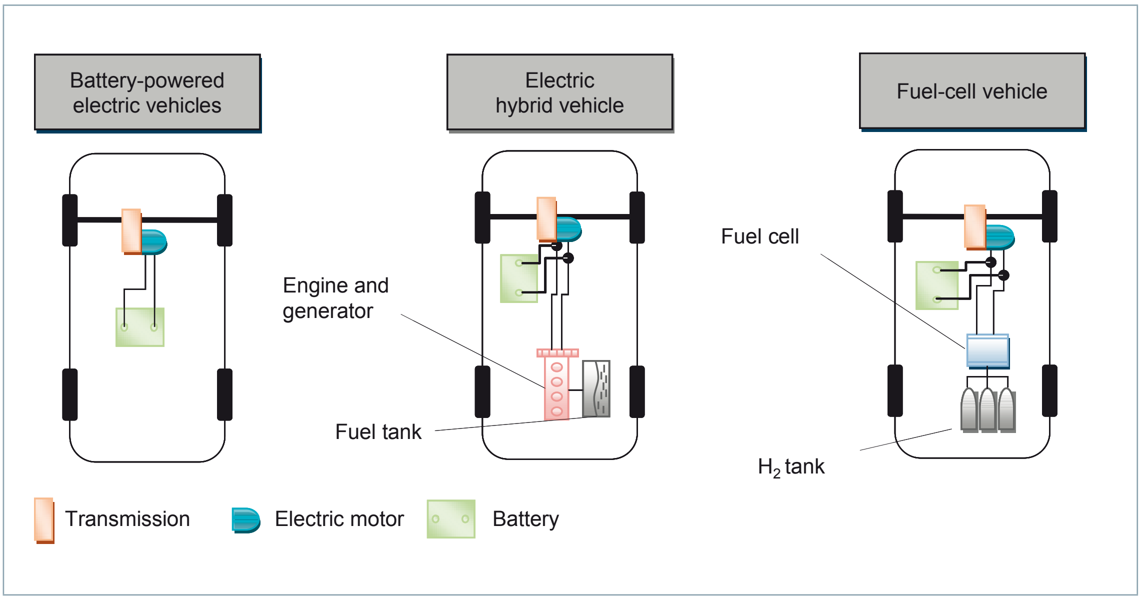


**Figure 14:** Examples of drive configurations for electric vehicles

In view of these reference vehicle features and the current state of the art it can be expected that over the next ten years battery voltages will be in the 200 V to 600 V range at battery currents of up to approximately 300 A. Higher voltages would allow lower currents and smaller cable cross-sections, but the prerequisites for standardization in this field are not yet in place. Cables and wires for use in road vehicles are standardized in ISO 6722. Currently, two voltage classes, 60 V and 600 V, are specified. As yet there are no standards for vehicle cables for voltages above 600 V.

### 4.3.2 Safety

- **Electrical safety**
  Essential safety requirements for the electric vehicle, its rechargeable energy storage system, the operational safety of electrical systems, and the safety of persons are covered in the ISO 6469 series. Cables for use in road vehicles are standardized in ISO 6722 in which two voltage classes (60 V and 600 V) are specified.
- **Accidents, crashes**
  As far as accidents are concerned, rescue guidelines also have to be taken into consideration so that rescue workers are provided with all relevant information. Due to the increased complexity of electric vehicles, the structure of rescue guidelines for such vehicles needs to be standardized.
- **Functional safety**
  – The ISO 26262 series covers functional safety in the automotive sector (HW and SW systems).
  – The ISO 26262 standards do not explicitly deal with battery systems. Due to the complexity of the battery system in electric vehicles, recommendations for action in this area should be developed.

### 4.3.3 Components

All standardization activities in the components domain of the automotive industry focus on requirements on quality and performance, classification, and, where necessary, interfaces to other components or systems. In the electromobility field, there are good opportunities for an early development of standards which can then be referred to in regulations. This is especially true of electric vehicle components and will enable synergy effects within Germany's world-leading automotive industry. Furthermore, some of the existing standards and specifications will have to be extended and modified. This applies for example to standards and specifications covering the performance characteristics of cables and fuses, and to standards on testing the suitability of components for automotive applications.

### 4.3.4 Batteries

Only lithium-ion batteries have been considered in this Standardization Roadmap. Other technologies are not explicitly discussed because, in the opinion of experts, their use will play only a subordinate role in the coming decade. As far as energy storage density and handling are concerned, lithium-ion batteries are currently the best technical solution.

Its sheer volume and mass makes the traction battery a dominant system component in vehicles. Standardizing the external geometry of the battery would lead to considerable restriction of freedom in vehicle design as well as in optimization of mass, function ranges and user-friendliness. Apart from this, the wide variety of vehicle types (city car, small car, family car, sports car, SUV etc.) counteracts the effects of standardizing battery geometry, as this would only necessitate increased efforts in vehicle design which cannot be compensated by the advantages in battery design. However, standardizing the dimensions and contact locations of battery cells for use in automotive applications would support effective system development.

ISO and IEC are standardizing test procedures for battery systems and cells in order to evaluate their safety and performance characteristics. The ISO 12405 series "Electrically propelled road vehicles – Test specification for lithium-Ion traction battery systems" applies to battery system tests, and IEC 62660 "Secondary batteries for the propulsion of electric road vehicles" applies to cell tests.

### 4.3.5 Fuel cells

Industry is developing fuel cells and the related hydrogen supply infrastructure in parallel. Many of the measures concerning corresponding regulations at the European and international level have already reached an advanced status and should be implemented as quickly as possible. In Germany, measures are being coordinated by “NOW GmbH” (Nationale Organisation Wasserstoff-Brennstoffzellen – National Organization Hydrogen and Fuel Cell Technology) in close cooperation with the relevant Federal ministries.

As opposed to batteries for electric vehicles, fuel cell deployment will experience some delay. In order to avoid forcing technological developments in a certain direction at too early a stage, standardization work in this field should be started later than for batteries.

### 4.3.6 Capacitors

Capacitors in the form of double-layer capacitors (called “supercaps” or “ultracaps”) can be used as energy storage devices for electric vehicles. At present, these are of relevance particularly for hybrid vehicle applications. The high energy storage density of capacitors plays an important role here. Procedures for testing the electric characteristics of these components are described in IEC 62576.

### 4.3.7 Current activities in electric vehicle standardization

When discussing standardization activities for electric vehicles, the extent to which the standards apply to the various vehicle categories has to be taken into consideration.

**Table 1:** Overview of current standardization activities dealing with electric vehicles

| Designation | Subject/title | Status |
|---|---|---|
| IEC 62660 | Secondary batteries for the propulsion of electric road vehicles | FDIS 2011 |
| ISO 6722-1 | Road vehicles – 60 V and 600 V single-core cables – Part 1: Dimensions, test methods and requirements for copper conductor cables | DIS 2011 |
| ISO 6722-2 | Road vehicles – 60 V and 600 V single-core cables – Part 2: Dimensions, test methods and requirements for aluminium conductor cables | CD 2011 |
| ISO 6469-3 | Electric propelled road vehicles – Safety specifications – Part 3: Protection of persons against electric shock | FDIS 2011 |
| ISO TR 8713 | Electric road vehicles – Vocabulary | DTR 2011 |
| ISO 11452-4 | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Bulk current injection (BCI) | CD 2012 |
| ISO 11452-9 | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 9: Portable transmitters | CD 2012 |
| ISO 12405-1 | Electrically propelled road vehicles – Test specification for Li-Ion traction battery systems – Part 1: High power applications | FDIS 2010 |
| ISO 12405-2 | Electrically propelled road vehicles – Test specification for Li-Ion traction battery systems – Part 2: High energy applications | DIS 2011 |

| | | |
|---|---|---|
| ISO 12405-3 | Electrically propelled road vehicles – Test specification for Li-Ion traction battery systems – Part 3: Safety performance requirements | NWIP 2012 |
| ISO 14572 | Road vehicles – Round, sheathed, 60 V and 600 V screened and unscreened single- or multi-core cables – Test methods and requirements for basic and high-performance cables | DIS 2011 |
| ISO/IEC 15118, Parts 1 – 4 | Road vehicles – Communication protocol between electric vehicle and grid | CD 2012 |
| ISO 23274-1 | Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 1: Non-externally chargeable vehicles | AWI 2014 |
| ISO 23274-2 | Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 2: Externally chargeable vehicles | CD 2013 |
| ISO 26262 Parts 1 – 10 | Road vehicles – Functional safety | FDIS 2011 |

**NOTE:** Other relevant standards relating to electromobility are listed in Table 2.

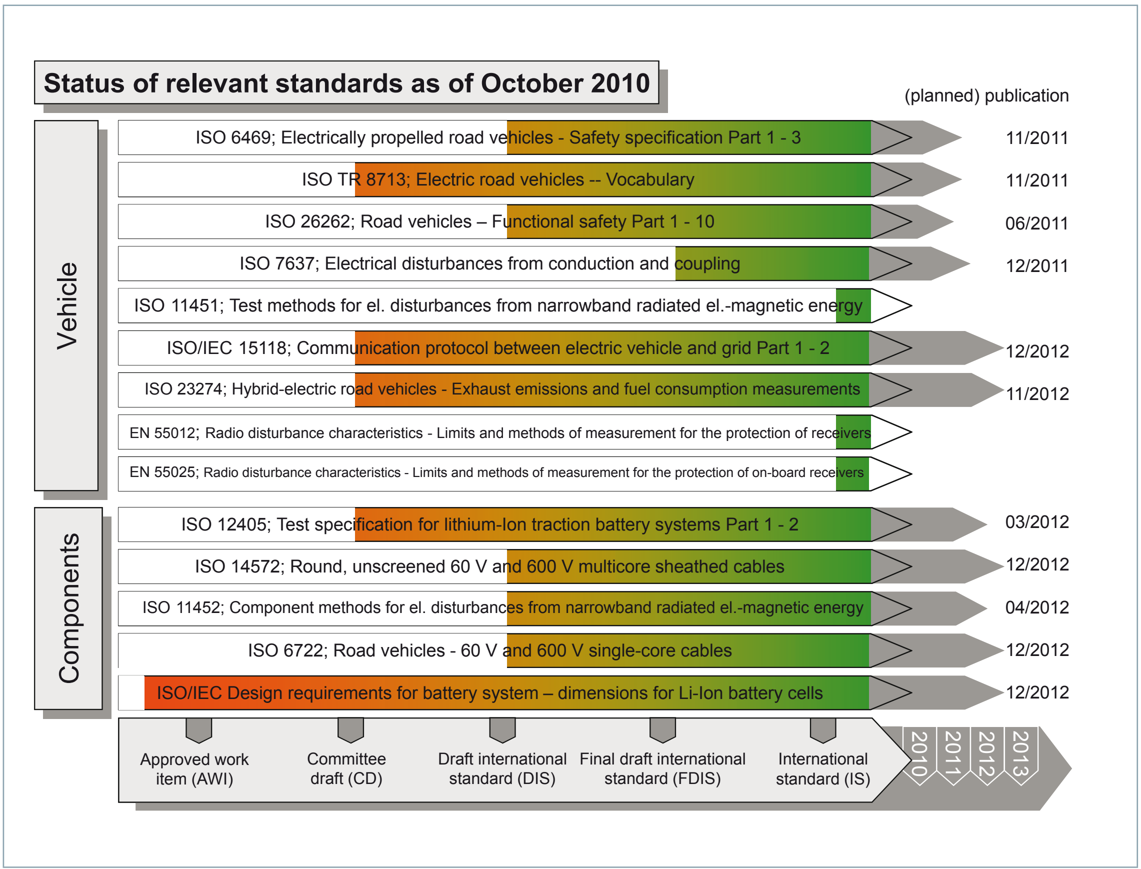


**Figure 15:** Status of the major standardization projects relating to electric vehicles

## 4.4 Charging stations

Charging stations can be installed in private, semi-private, public and semi-public areas. Depending on the location and the range of functions to be provided, several different functional units will be required. Figure 16 shows a block diagram of a charging station:

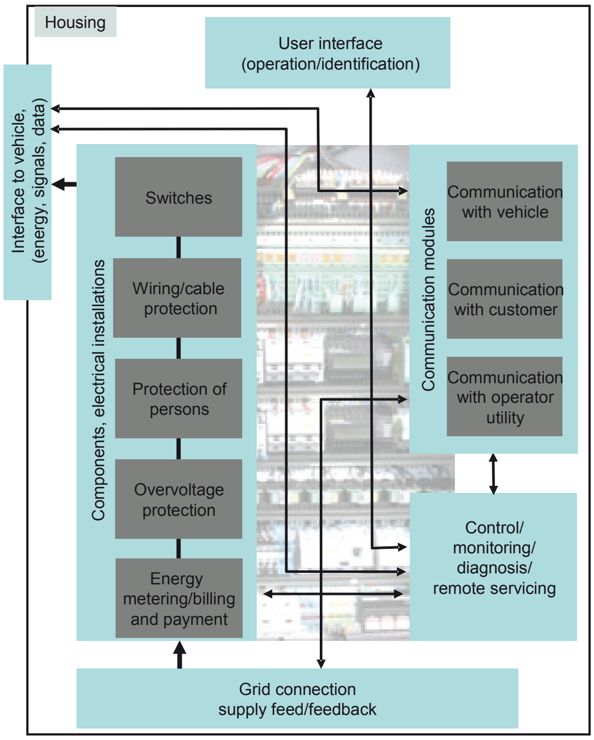


**Figure 16:** Block diagram of a public station for conductive charging of electric vehicles (schematic)

Depending on its location and the charging modes, a charging station must support different combinations of functions and meet various requirements. The following aspects need to be taken into consideration:

1. Energy flows
   – provision
   – load management (smart grid)
   – energy feedback into grid

2. Control/safety
   – pilot signal
   – plug locking
   – disconnecting, switching and protection

3. Communications
   – access permission
   – billing (“metering”)
   – user interface
   – energy feedback into grid
   – load management (smart grid)

4. Accessibility
   – The applicable standards have to be observed.

5. Value-added services
   – Work on framework conditions is still required.

### 4.4.1 Energy flow system approaches

At present, several system approaches and charging modes are being discussed. These approaches satisfy the sometimes conflicting requirements of various stakeholder groups:

- safety,
- wide availability from the very start,
- charging time,
- ease of use,
- cost, mass and space required in the vehicles,
- possibility of load management,
- possibility of feeding energy back into the grid,
- international compatibility.

IEC 61851-1 currently defines four conductive charging modes. Modes 1 to 3 are related to charging with a charger unit installed in the vehicle (on-board charger), mode 4 describes the use of an “off-board charger”.

- Mode 1:
  – a.c. charging at normal mains outlets with up to 16 A
  – single-phase 250 V (a.c.), or three-phase 480 V (a.c.)
  – no protection devices in the charging cable
  – RCD in domestic installations an essential prerequisite
  – no energy feedback, no communications
  – prohibited in the US

- Mode 2:
  – a.c. charging at normal mains outlets with up to 32 A
  – single-phase 250 V (a.c.), or three-phase 480 V (a.c.)
  – charging cable with integrated safety devices in an “in-cable control box” comprising RCD, control pilot and proximity sensor
  – without energy feedback, communication between the “in-cable control box” and the electric vehicle is possible via the control pilot.

- Mode 3:
  – a.c. charging at special charging stations with up to 63 A
  – single-phase 250 V (a.c.), or three-phase 480 V (a.c.)
  – charging cable with plug in accordance with IEC 62196-2
  – no “in-cable control box” required in the cable, as the safety equipment is an integral part of the charging station
  – plug interlock permits unguarded operation, even in a public space
  – energy feedback is possible, since communications are bidirectional throughout, control is possible and the plugs can be locked

- Mode 4:
  – d.c. charging with off-board charging equipment
  – d.c. charging with special charging stations, mostly quick-charging stations
  – charging voltage and current are system-dependent, so standardization is required
  – charging cables with energy and control cores
  – due to the use of d.c., sophisticated protection measures are necessary, e.g. insulation monitoring

The subject of inductive charging, including energy feedback options, is currently being discussed in new work item proposal 69/178/NP “Electric vehicle inductive charging systems”, which is to become standard IEC 61980-1.

The IEC 62196 series of standards contains specifications for plugs and socket outlets required for charging mode 3, conductive energy transmission between charging station and electric vehicles. Part 2 of this series describes the three configuration types for charging accessories currently being discussed for a.c. charging (see Figure 17).

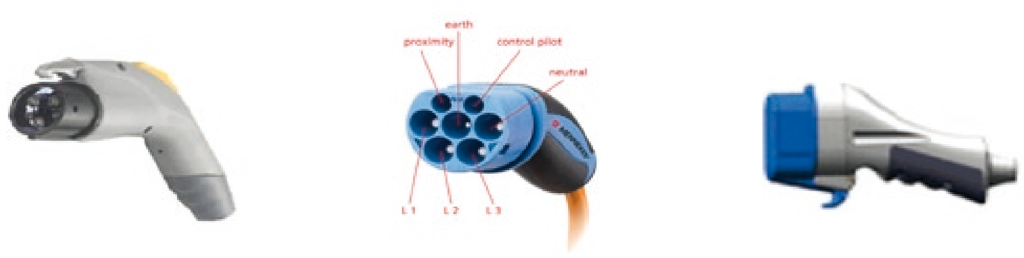


**Figure 17:** Configurations for charging accessories currently described in the IEC 62196 series of standards: type 1 (left), type 2 (centre), type 3 (right)

Configuration type 1 was proposed by Japan and has the following characteristics:

- single phase
- max. current: 32 A
- max. voltage: 250 V a.c.

Configuration type 2 was proposed by Germany and has the following characteristics:

- one to three phases
- max. current: 63 A (a.c.) and 70 A (d.c.)
- max. voltage: 480 V
- can be enhanced to form a combination plug for d.c. charging with up to 200 A

This configuration has a wide range of possible applications and is technically mature. Therefore German industry urgently recommends that this accessories system should be used throughout Europe.

Configuration type 3 was proposed by Italy and has the following characteristics:

- one to three phases
- max. current: 32 A (a.c.)
- max. voltage: 400 V

In addition to the German proposal that type 2 should be used and that this design should be extended to create the combination accessory for d.c. charging systems, the Japanese have made a further proposal of using accessory promoted by the CHAdeMO (CHArge de MOve) consortium.

Figure 18 shows the various system approaches and sub-variants, as well as their relationship to the charging modes and accessory variants.

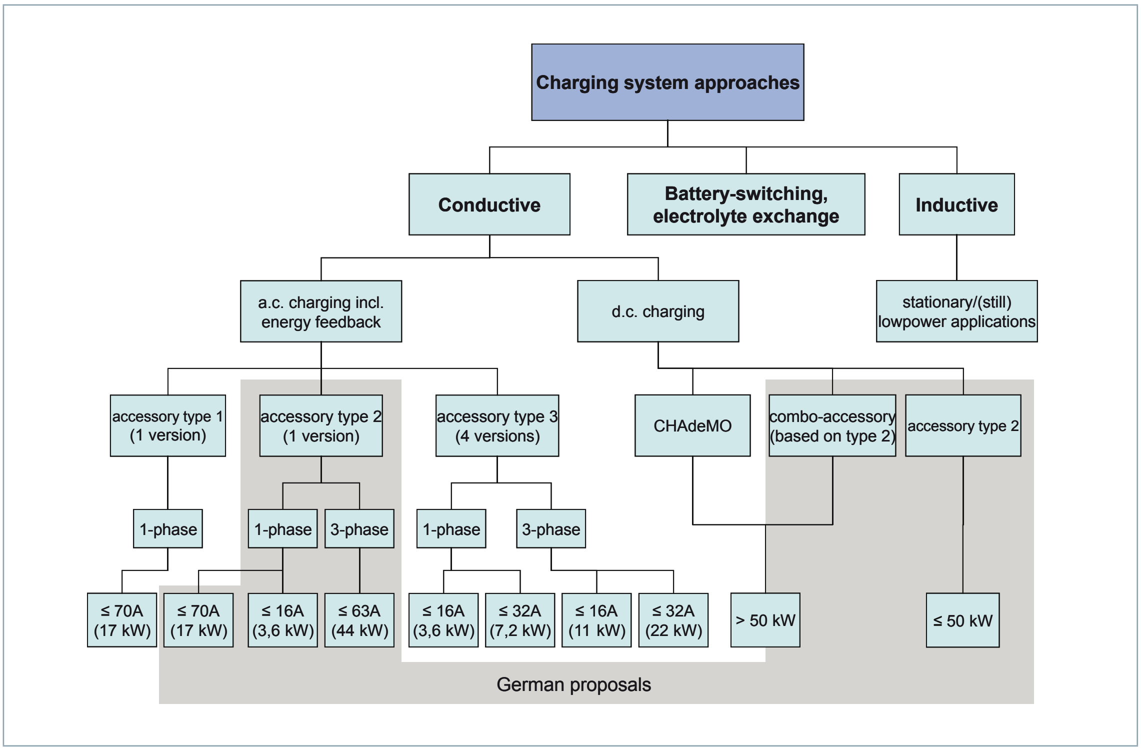


**Figure 18:** Overview of charging system approaches

To enable the rapid introduction of an interoperable charging infrastructure, it is recommended that the following priorities be set for Germany:

- Priority 1:
  - a.c. charging: Conductive a.c. charging (modes 1 to 3) with up to 63A (44 kW) three-phase (mode 3). In addition, mode 3 permits feedback of energy into the grid, thus providing optimum integration of renewable energy sources.
  - d.c. charging: Charging power of over 50 kW is expected in future (currently up to 90 kW under consideration).
- Priority 2: Inductive charging at lower powers, for ease of operation.
- Priority 3: Battery exchange ("battery-switching") or redox-flow batteries

Recommendations concerning charging modes 1, 2 and 3:

- Mode 1 as in IEC 61851 requires the provision of a residual current device (RCD) in the infrastructure. However, energy suppliers and grid operators do not recommend its use because it cannot always be ensured that a protective earth conductor and RCD are provided in installations, and the consumer cannot check this in every case.

- For existing installations, it is recommended that mode 2 be used, as the "in-cable control box" provides the required safety equipment.

- Mode 3 is recommended for new installations. Technically, mode 3 offers the option of direct load management via the charging interface, including the option of feeding energy back into the grid, and thus fulfils the conditions for linking electric vehicles to the smart grid. Furthermore, only the plug locking mechanisms in mode 3 make it possible to prevent unauthorized access and thus unsupervised charging in public spaces.

Various charging locations (e.g. private, public, indoors, outdoors) and the resulting diverse requirements (e.g. overvoltage protection, etc.) will have to be taken into consideration for the various types of charging stations.

Table 2 gives a summary of the main standards and specifications for the different system approaches.

### 4.4.2 Safety

Safety requirements have to be met under normal conditions (even under different climatic conditions), taking into consideration all foreseeable operating errors, misuse, accidents and vandalism.

**Electrical safety**
The following standards from the field of electrical installations must be observed in order to ensure protection against electric shock and thermal effects:

- DIN EN 61140 (VDE 0140-1):2007-03, Protection against electric shock – Common aspects for installation and equipment (IEC 61140: 2001 + A1: 2004, modified)
- DIN IEC/TS 60479-1 (VDE 0140-479-1):2007-05, Effects of current on human beings and livestock – Part 1: General aspects (IEC/ TS 60479-1: 2005 + Corrigendum October 2006)
- DIN VDE 0100-540 (VDE 0100-540):2007-06, Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors (IEC 60364-5-54: 2002, modified)
- DIN VDE 0100-410 (VDE 0100-410):2007-06, Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock (IEC 60364-4-41: 2005, modified)
- DIN VDE 0100-530 (VDE 0100-530) Erection of low voltage installations – Part 530: Selection and erection of electrical equipment – Switchgear and controlgear
- The future standard IEC 60364-7-722 Low voltage electrical installations – Requirements for special installations or locations – Supply of electric vehicle

**Electromagnetic compatibility (EMC)**
- DIN EN 61000-6-2 Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments
- DIN EN 61000-6-3 Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments

**Structural safety**
- with regard to installation site, identification, signs, parking instructions (optimum arrangement/ location of charging station column in relation to the parking area)
- with regard to vandalism

**Functional safety**
- Process-oriented requirements are standardized in IEC 61508.

**Lightning protection and overvoltage protection**
- It must be assumed that electric vehicles will be charged outdoors even during thunderstorms. Therefore, the subject of lightning protection and overvoltage protection must be taken into consideration in designing the overall “vehicle-charging station-distribution grid” system. Relevant provisions are specified in IEC 61851. This product standard gives detailed specifications for the various overvoltage categories and the resulting impulse withstand voltage requirements. It does not call for any additional lightning protection measures.

- The automotive industry designs its vehicles as devices for overvoltage category II, which is the same as for all other electrical equipment. If more extensive protective measures are found to be necessary, normal commercially available components can be used as surge arresters. No acute need for standardization measures beyond the specifications of IEC 61851 are considered to be necessary.

### 4.4.3 Current charging station standardization activities

Table 2 below gives an overview of the most important standards for charging stations and Figure 19 shows the status of the most important standards projects on charging stations.

**Table 2:** Overview of the main standards applicable to charging stations

| Designation | Subject/title | Status |
|---|---|---|
| IEC 60364-7-722 | Low voltage electrical installations – Part 7-722: Requirements for special installations or locations – Supply of Electric vehicle | NP accepted) |
| IEC 61000-6-2 | Electromagnetic compatibility (EMC) – Generic standards – Immunity for industrial environments | |
| IEC 61000-6-3 | Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments | |
| IEC 61140 (VDE 0140-1) | Protection against electric shock – Common aspects for installation and equipment | |
| IEC 61508 | Functional safety | IS |
| IEC 61850 | Communication networks and systems for power utility automation | CDV |
| IEC 61851-1 | Electric vehicle conductive charging system – General requirements | FDIS |
| IEC 61851-21 | Electric vehicle conductive charging system – Electric vehicle requirements for conductive connection to an a.c./d.c. supply | CD |
| IEC 61851-22 | Electric vehicle conductive charging system – a.c. electric vehicle charging station | CD |
| IEC 61851-23 | Electric vehicle conductive charging system – d.c. electric vehicle charging station | NP |
| IEC 61851-24 | Electric vehicle conductive charging system – Control communication protocol between off-board d.c. charger and electric vehicle | NP |
| IEC 62196-1 | Plugs, socket-outlets, vehicle couplers and vehicle inlets – Charging up to 250 A a.c. and 400 A d.c. | CD |
| IEC 62196-2 | Plugs, socket-outlets, vehicle couplers and vehicle inlets – Dimensional interchangeability requirements | CD |
| IEC 62196-3 | Plugs, socket-outlets, vehicle couplers and vehicle inlets – Dimensional interchangeability requirements for pin and contact-tube coupler with rated operating voltage up to 1 000 V d.c. and rated current up to 400 A for dedicated d.c. charging | NP |
| ISO/IEC 15118 | Data security of the “charging station – vehicle” communication interface | CD |

**NOTE:** Other relevant standards relating to electromobility are listed in Table 1.

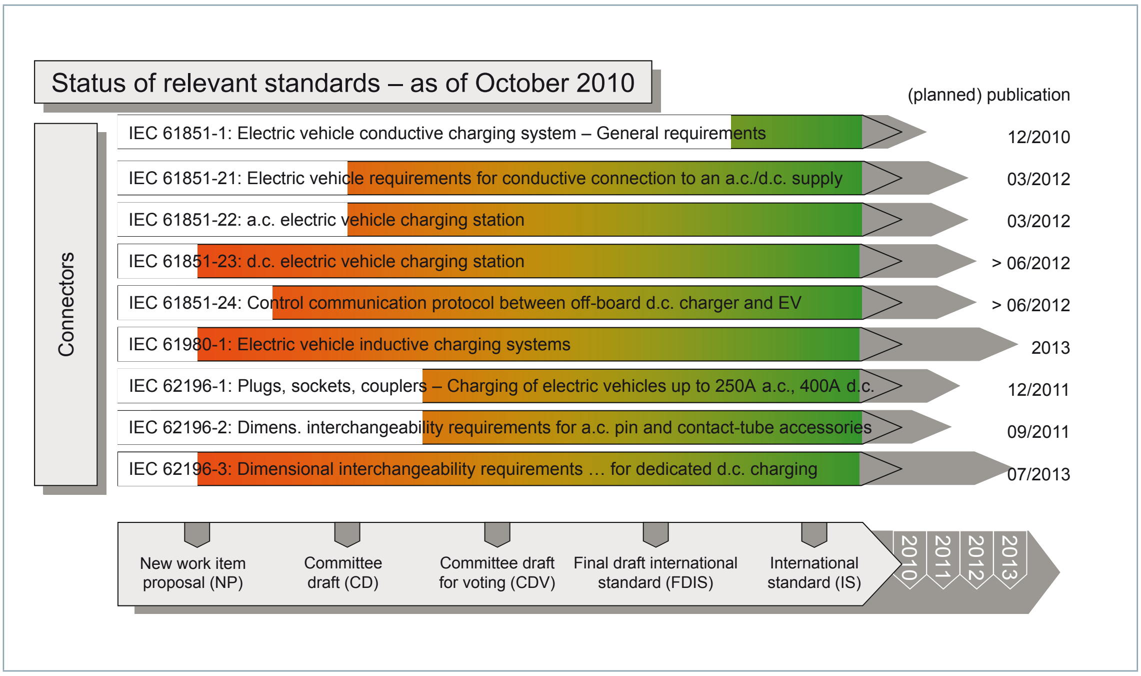


**Figure 19:** Status of the main standardization projects on charging stations

# 5 Standardization Roadmap recommendations

## 5.1 Recommendations for a German roadmap

As our analysis of strengths and weaknesses with respect to national competence in the various areas has shown, the fields of greatest relevance are system integration into the overall vehicle, the energy supply grid, safety and security, reliability, availability and interoperability. Due to the need to integrate electric vehicles into the energy supply grid, issues concerning distributed energy generation, energy storage and data management also play an important role.

The following sections take a look at infrastructure, vehicles and batteries. As batteries play a vital role in the development of electromobility, they will be discussed separately. In addition to the general recommendations, the following sectors have been identified as cross-sectoral standardization issues and as essential activities in preparation for research; this section has been structured accordingly as follows:

1. Electrical safety
2. Electromagnetic compatibility (EMC)
3. External interfaces and communications
4. Functional safety
5. IT security and data protection
6. Performance and consumption characteristics
7. Accidents
8. Research recommendations

Table 3 gives an overview of the recommendations according to cross-sectoral topic and domain.

**Table 3:** Overview of recommendations according to cross-sectoral topics and domains

| | Infrastructure | Vehicle | Battery |
|---|---|---|---|
| Electrical safety (EC) | ES 1 | ES 2, ES 3 | ES 4 |
| Electromagnetic compatibility (EMC) | – | EM 1 | EM 1 |
| External interfaces – communications (SK) | SK 1, SK 2, SK 3, SK 4, SK 8, SK 9, SK 10 | SK 5, SK 6, SK 7, SK 8, SK 11 | – |
| Functional safety (FS) | FS 1 | FS 2 | – |
| IT security and data protection (SD) | SD 1 | SD 1 | – |
| Performance and consumption characteristics (LV) | LV 4 | LV 1, LV 2 | LV 3 |
| Accidents (U) | – | U 1 | U 2 |
| Research recommendations (FL) | FL 4 | FL 3 | FL 1, FL 2 |

### 5.1.1 General recommendations (AE)

**AE 1 Political action is needed at European and international level**

The close networking of research and development, and of regulatory and legislative frameworks with standardization is necessary. National standardization and regulation carried out by certain countries must not impede harmonization at an international level.

➜ Implementation of recommendation/status: long-term

**AE 2 Standardization must be quick and international**

At present, national and international standardization concepts compete with one another. However, since road vehicle markets are international, efforts must aim towards developing international standards right from the start. The same applies to interfaces between e-vehicles and infrastructure. Standardization at national or European level alone is considered to be inadequate. It is therefore essential that national standards proposals be processed quickly and that German results be transferred to international standardization as soon as possible.

➜ Implementation of recommendation/status: long-term

**AE 3 Coordination and focus are absolutely essential**

Because electromobility involves so many actors and sectors, collaboration among all relevant bodies, and coordination by DIN's Electromobility Office and the steering group on EMOBILITY (DKE/NAAutomobil) are important to avoid duplication of work. New bodies should not be created; instead, the existing committees within DIN and DKE are to be strengthened.

➜ Implementation of recommendation/status: long-term

**AE 4 Standards must be clear and unambiguous**

To encourage innovation, standards should be function-related and should avoid the definition of specific technical solutions (i.e. they should be performance-based rather than descriptive). Nevertheless, some technical solutions need to be defined in interface standards to ensure interoperability (e.g. between vehicles and the network infrastructure).

➜ Implementation of recommendation/status: long-term

**AE 5 A uniform worldwide charging infrastructure is necessary (interoperability)**

It must be possible to charge electric vehicles "everywhere, at all times": interoperability of vehicles of different makes with various operators' infrastructure must be ensured. The standardization of charging techniques and billing/ payment systems must ensure the development of a user-oriented, uniform, safe and easy-to-operate charging interface. User interests must have priority over the interests of individual companies.

➜ Implementation of recommendation/status: long-term

**AE 6 Existing standards must be used and further developed without delay**

There are already a great many relevant standards in the established sectors "automotive technology" and "electrical engineering". These must be appropriately utilized and made known. Providing information on these standardization activities and their status is a vital part of this Standardization Roadmap.

Moreover, the necessary work should focus less on initiating new standards projects than on expanding/adapting existing standards and specifications to the needs of electromobility. Cross-sectoral cooperation at international level is required, especially for the standardization of interfaces.

➜ Implementation of recommendation/status: long-term

**AE 7 Participation in European and international standardization is essential**

In order to achieve our aims – and to ensure that we have an active influence – greater participation at national and international level is needed. This means that German companies and research organizations (including universities) must play a greater part in German, European and international standards work. Standards work is to be seen as an integral component of R&D projects and thus eligible for funding.

➜ Implementation of recommendation/status: long-term

**AE 8 Cooperation between the standards organizations ISO and IEC must be ensured**

Concerted efforts within the Joint Working Groups (JWGs) under mode 5 are needed to strengthen international consensus-building between ISO and IEC. In the field of "Charging of electric vehicles" (IEC 61851 series of standards), the most urgent need for cooperation is between IEC/TC 69 and ISO/TC 22/SC21. It remains to be seen whether or not the Memorandum of Understanding between ISO and IEC (see section 3.5), which is currently in the process of being adopted, is implemented to the necessary extent.

➜ Implementation of recommendation/status: long-term

**AE 9 Consortia must be incorporated in ISO and IEC work**

Standardization is to be carried out in the established international organizations ISO and IEC. Consortia, particularly SAE, must be called upon to participate in standards work at ISO and IEC rather than developing their own additional specifications.

It can be assumed that adherence to SAE specifications will be obligatory in many US States. Inclusion of the contents of SAE specifications in international consensus-based standards (ISO, IEC) is problematic due to copyright issues (e.g. SAE J 2929). Nevertheless, the main objective must be to harmonize the contents of SAE specifications with those of ISO and IEC standards. This is the only way of reducing the additional costs and time required for the German automotive industry to obtain approvals in the USA. It is recommended that, during the transitional period, European industry representatives participate in SAE activities in order to avoid the introduction of deviating specifications.

Furthermore, many other organizations are engaged in activities which will affect the requirements on electric vehicles or electromobility in general, and these will therefore have a direct or indirect influence on the relevant specifications and standards. It remains to be seen whether and how these activities need to be coordinated and, above all, to what extent the activities of other organizations need to be transferred to ISO and IEC.

The EMOBILITY steering group and DIN Electromobility Office should coordinate suitable procedures for liaison with other organizations. As soon as possible, other relevant organizations should be identified, contacted and asked to participate at an early stage in order to prevent the establishment of contradictory electromobility requirements. Involvement in standardization organizations other than ISO and IEC should only be regarded as a temporary and transitional option.

➜ Implementation of recommendation/status: long-term

**AE 10 Cooperation with China needs to be intensified and China must be urged to participate in ISO and IEC work**

At present, it is not expected that Chinese national electric vehicle standards will be adopted as international standards. However, it is probable that compliance with such national standards will be necessary in order to gain access to the Chinese market. Translations and interpretations of Chinese standards are often problematic. German standards-setters and the German-Chinese Joint Committee of Industry and Trade should actively work towards ensuring that China is more strongly integrated into international standardization processes.

➜ Implementation of recommendation/status: long-term

### 5.1.2 Electrical safety

**ES 1 Electrical safety of the charging station**

IEC 60364-7-722 "Low voltage electrical installations – Part 7-722: Requirements for special installations or locations – Supply of electric vehicle" is currently being prepared to supplement the relevant product standards of the IEC 61858 series. This work should be completed as soon as possible, taking the overall "charging station - charging cable - vehicle" system into consideration.

- ➜ Responsible party: DKE/AK 221.1.11
- ➜ Implementation by: 2012
- ➜ Implementation of recommendation/status: urgent

**ES 2 Electrical safety of voltage class B ("high-voltage") on-board wiring/networks**

Essential safety requirements for the electric vehicle, its rechargeable energy storage system, the operational safety of electrical systems and personal protection are covered in the ISO 6469 series. Work on ISO 6469-3 should be completed without delay.

- ➜ Responsible party: NA 052-01-21-01 GAK
- ➜ Implementation by: beginning of 2011
- ➜ Implementation of recommendation/status: urgent

**ES 3 Cables for road vehicles**

Wires and cables for use in road vehicles are standardized in ISO 6722 and ISO 14572. Currently, specifications exist for two voltage classes: 60 V and 600 V. Cables for voltages over 600 V are not covered by present standards. ISO 6722 and ISO 14572 are to be expanded to include cables for voltages up to 1 000 V and 1 500 V.

- ➜ Responsible party: NA 052-01-03 AA
- ➜ Implementation by: 2014
- ➜ Implementation of recommendation/status: short-term

**ES 4 Electrical, chemical and mechanical safety of battery systems**

The safety of battery systems is an area in which uniform standards are to be given high priority. Work on current projects (ISO 12405) in this area is to be completed as soon as possible. Whether CoP (conformity of production) standards are required to be able to check the "internal values" of battery cells following production remains to be discussed. This still has to be clarified by the participating entities and the results will then have to be included in a future version of this Roadmap. Current test methods need to be refined and continually adapted in keeping with international demands..

- ➜ Responsible party: NA 052-01-21 AA
- ➜ Implementation by: 2011
- ➜ Implementation of recommendation/status: urgent

### 5.1.3 Electromagnetic compatibility (EMC)

**EM 1 Vehicle EMC**

EMC is only taken into consideration with respect to the propulsion/drive train and overall system levels, including the battery. Tests need to be conducted under defined load conditions and requirements concerning interference immunity and field strength need to be adjusted in keeping with technological progress.
Note: In this context, the EMC standards being dealt with in cooperation with CISPR are also to be taken into account. Some of these standards should be expanded by adding new parts to the series. Attention should be paid to special needs for the various vehicle categories, e.g. for category M3.

- ➜ Responsible party: DKE/K 767 and NA 052-01-03-03 GAK
- ➜ Implementation by: 2011 to 2014
- ➜ Implementation of recommendation/status: short-term

### 5.1.4 External interfaces – communications

In this section, the functional aspect of interfaces and communications between the

- vehicle
- grid
- charging infrastructure
- energy trade
- charging infrastructure operators
- financial settlement/billing service companies
- users, and
- service companies

will be discussed. Data security aspects and electrical and functional safety will be dealt with in the corresponding sections.

**SK 1 Adaptation to/compatibility with smart grid communication methods**

In terms of the smart grid and communications, a charging station (electric vehicle connected, ready for charging) does not need to be dealt with any differently than any other connected energy consumer or generator (aside from some specific data content). Communications with the charging station must be compatible with all other smart grid communications. It is therefore recommended that relevant developments (e.g. in [standardization] bodies dealing with e-energy and international smart-grid issues) should be observed and adopted.
Smart grid standardization should be intensified, as the introduction of electric vehicles means that a relevant consumer device is being added. In view of this situation, harmonization with the smart grid standardization roadmap [10] is necessary. The time schedule for setting up the smart grid will have to be adapted to electromobility requirements; close cooperation between standardization bodies working on the smart grid and electromobility is desired. During the start-up phase (small vehicle fleet) with a relatively low charging load grid bottlenecks are not expected, but in the medium-term intelligent charging and load management will become a must as the number of vehicles increases.
This is why the design of vehicle/charging station and charging station/infrastructure communications must be a continuous process. Communications between vehicles and the charging infrastructure are being dealt with in ISO/IEC 15118 “Road vehicles – Vehicle to grid communication interface” (ISO/TC 22/SC 3/JWG 1) – this project should be completed under German leadership without delay..

➜ Responsible party: NA 052-01-03-17 GAK (and DKE/K 353)
➜ Implementation by: 2011
➜ Implementation of recommendation/status: urgent

**SK 2 Static load management (negotiating charging time, power and prices)**

It is expected that in the first stage of load management processes for the smart grid, users will be offered the option of choosing the time at which the vehicle is to be charged and the power that is to be drawn in relation to the prices offered. In this scenario, it might be feasible to determine prices at the beginning of the charging process on the basis of energy supply and demand forecasts for the next few hours. From a consumer device viewpoint, this is semi-static load management with temporal dynamics over a range of a few hours. Suitable application protocols need to be standardized for such situations.

➜ Responsible party: DKE LK E-Energy/Smart Grids
➜ Implementation by: 2014
➜ Implementation of recommendation/status: short-term

**SK 3 Dynamic load management**

Dynamic load management is the term used to describe the option of adapting the charging power consumption dynamically (e.g. within a range of several minutes) to the current power availability situation (e.g. regenerative energy sources) while a battery is being charged. Compared with the SK 2 situation, this use case has greater temporal dynamics and requires suitable communications protocols that remain to be defined.

➜ Responsible party: DKE LK E-Energy/Smart Grids
➜ Implementation by: 2018
➜ Implementation of recommendation/status: medium-term

**SK 4 Restart after power outages (reboot grid)**

After power outages, the time at which the electric grid is switched back on is a critical issue. To avoid grid instability due to a large number of vehicles needing to be charged at the same time, suitable mechanisms for a controlled restart (e.g. random distribution of delay times) of charging procedures need to be defined and standardized.

- ➜ Responsible party: DKE LK E-Energy/Smart Grids
- ➜ Implementation by: 2014
- ➜ Implementation of recommendation/status: short-term

**SK 5 Interfaces for vehicle diagnostics**

Vehicle diagnosis is defined in the relevant ECE regulations. To what extent the data exchange protocols for these interfaces defined in various ISO standards can be modified or augmented to meet the special needs of electric vehicles has to be investigated.

- ➜ Responsible party: NA 052-01-03 AA
- ➜ Implementation by: 2014
- ➜ Implementation of recommendation/status: medium-term

**SK 6 External interfaces: a.c. charging accessories**

Charging accessories are being standardized in IEC 62196-3 by IEC/SC 23H (c.f. 4.4.1). German industry recommends that the type 2 charging accessories described in IEC 62196-2 (German proposal for a charging accessories standard) be used. The use of shutters – as suggested for type 3 – has proven to be effective in many application areas, but experts are of the opinion that there is insufficient experience on the probability of failure due to wear and contamination in long-term private outdoor use. Furthermore, type 3 is only intended for use at the charging station end – the safety concept for the vehicle end of a charging cable with type 3 accessories is unclear. This is why the IEC 62196-2 type 2 accessories concept is considered to be a solution that is technically more mature. Current controversial discussions at European level (CEN/CENELEC mandate) clearly illustrate how urgently international agreement is needed. Therefore every effort must be made to support charging accessory of configuration type 2 as the more economical and technically more mature solution. The political and industrial sectors should make sure the required resources are available at short notice.

- ➜ Responsible party: DKE/AK 542.4.1
- ➜ Implementation by: 2011
- ➜ Implementation of recommendation/status: urgent

**SK 7 External interfaces: d.c. charging accessories**

d.c. charging accessories are being standardized in Part 3 of the IEC 62196 series of standards being developed by IEC/SC 23H (c.f. 4.4.1). Germany has proposed the expansion of the type 2 a.c. accessories to allow for d.c. charging.
It must be ensured that this proposal is included in the IEC standard.

- ➜ Responsible party: DKE/AK 542.4.3
- ➜ Implementation by: 2011
- ➜ Implementation of recommendation/status: urgent

**SK 8 External interfaces: charging stations**

Charging stations – including charging modes – are being dealt with by IEC/TC 69 in the IEC 61851 series “Electric vehicle conductive charging systems”. It must be ensured that IEC 61851 be formulated to allow for new technologies. Part 21 of this series describes electric vehicle requirements and should be harmonized with ISO 6469-3 accordingly, preferably in a mode 5 JWG.

- ➜ Responsible party: DKE/K 353
- ➜ Implementation by: 2011
- ➜ Implementation of recommendation/status: urgent

**SK 9 Charging station user interface**

The use of graphic symbols is recommended for the charging station user interface so as to ensure intuitive and safe operation by a wide range of users. The extent to which graphic symbols can be used for man-machine-interaction and safety marking, and the necessity of further standardization remain to be investigated, as should the need for standardization as regards accessibility.

➜ Responsible party: DKE and NAAutomobil
➜ Implementation by: 2012
➜ Implementation of recommendation/status: short-term

**SK 10 Inductive charging**

Currently, several basic technical framework conditions for the inductive charging of electric vehicles are being developed in various projects. At present, well-founded standards proposals can only be drawn up when the results of these projects are available.
Further course of action concerning the standards proposal submitted to the IEC (IEC 61980-1 “Electric vehicle inductive charging systems”) is to be voted on without delay. Active and timely participation of German experts at international level should be aimed at in order to prevent the premature standardization of technical solutions which would inhibit technical progress and unnecessarily restrict the diversity of good solutions.

➜ Responsible party: DKE/AK 353.0.1
➜ Implementation by: 2013
➜ Implementation of recommendation/status: urgent

## 5.1.5 Functional safety

**FS 1 Functional safety of charging stations**

IEC 61805 is a process-oriented reference standard upon which several application-specific standards, such as ISO 26262, are based. It does not seem wise to leave it up to the electrical installation trade to carry out a risk analysis for determining the necessary SILs for installing charging stations at various locations (private, public, semi-public, indoors, outdoors). We recommend that a procedural standard be drafted and that the risk analysis for this draft be carried out by the standardization body.

➜ Responsible party: DKE/K 952
➜ Implementation by: 2011
➜ Implementation of recommendation/status: urgent

**FS 2 Functional safety of vehicles**

Requirements on the functional safety of road vehicles are defined in the application-specific standard ISO 26262.
IEC 61508 and ISO 26262 are both process-oriented standards that in principle can be used for all electronic systems within vehicles. These standards leave developers adequate freedom, but do not eliminate the need for detailed analysis of the functional safety for all systems. In individual cases guidelines based on ISO 26262 can be compiled to support and optimize safety analyses for complex systems in vehicles. Energy storage is such a complex, extremely sensitive system. Guidelines for the functional safety of this system should be developed on the basis of ISO 26262.

➜ Responsible party: NA052-01-03 AA
➜ Implementation by: 2012
➜ Implementation of recommendation/ status: urgent

## 5.1.6 IT security and data protection

**SD 1 General recommendations concerning IT security and data protection**

This topic is very important, but is not being adequately addressed at present. The main fields to be taken into account are:

- control over data,
- avoidance of excessive data,
- pseudonymity
- economic use of data,
- granularity of the data to be transmitted,
- restriction of authorized data recipients and users,
- protection against manipulation,
- relation of data to persons, and
- requirements specified by the BSI (the German Federal Office for Information Security).

It is recommended that a Working Group be set up with BSI participation.

➜ Responsible party: NPE.AG4
➜ Implementation by: as soon as possible
➜ Implementation of recommendation/status: short-term

## 5.1.7 Performance and consumption characteristics

**LV 1 Environmental conditions for electrical and electronic systems in road vehicles**

The extent to which ISO 16750 “Road vehicles – Environmental conditions and testing for electrical and electronic equipment” can be modified or adapted to meet the special needs of electric vehicles is to be investigated.

➜ Responsible party: NA 052-01-03 AA
➜ Implementation by: 2013
➜ Implementation of recommendation/status: short-term

**LV 2 Entire vehicle – performance and consumption characteristics**

The following standards covering the entire vehicle, including the drive train, should be reviewed to see if any additions are necessary:
ISO 23828 Fuel cell road vehicles
ISO 23274-1 Hybrid-electric road vehicles
ISO 23274-2 Externally chargeable hybrid-electric road vehicles
ISO 23274-3 Charging
ISO TR 11954 and ISO TR 11955 Charge balance measurement
ISO 8715 Road operation characteristics
Furthermore, electric vehicle quiescent power consumption values must also be taken into account.

➜ Responsible party: NA 052-01-21 AA
➜ Implementation by: 2013
➜ Implementation of recommendation/status: short-term

**LV 3 Battery systems**

Current work on ISO 12405 and IEC 62660 should be concluded as soon as possible. Standardization of the dimensions of cells should be given broader support and introduced at international level. In addition, the position of the connections in the battery system are to be standardized.

➜ Responsible party: NA 052-01-21-03GAK and DKE/AK 371
➜ Implementation by:
  – 2011: ISO 12405, IEC 62660
  – 2012: cell dimensions
  – 2014: cell connections
➜ Implementation of recommendation/status: medium-term

**LV 4 Consumption of the charging infrastructure**
It is recommended that specifications be defined regarding reliable internal consumption in the charging infrastructure, particularly during periods of inactivity. The internal consumption limit in the idle state could be specified as being 1 watt for home charging stations and 5 watts for charging stations in public spaces, in analogy with the rules for domestic appliances such as television sets.
➜ Responsible party: DKE/AK 353.0.1
➜ Implementation by: 2015
➜ Implementation of recommendation/status: short-term

### 5.1.8 Accidents

**U 1 Entire vehicle after accidents**
Standardization of the structure of emergency rescue guidelines (including isolation of voltage sources by rescuers) is considered to be a medium-term requirement. Simple and reliable methods of identifying vehicles for rescue purposes (indicators for HV, Li+, hazardous substances etc) need to be defined. Urgent action is considered necessary in this field.
➜ Responsible party: NA 052-01-21AA
➜ Implementation by: 2011
➜ Implementation of recommendation/status: urgent

**U 2 Battery system after accidents**
Studies must be carried out to determine how battery systems can be brought into a safe condition after a severe crash, and the need for standardization is to be determined on the basis of these studies (see FL 1). Research results need to be implemented in standards, e.g. for defined interfaces for the safe discharging of damaged batteries, as quickly as possible.
➜ Responsible party: DKE/K 371 as well as NA 052-01-21AA
➜ Implementation by: 2014
➜ Implementation of recommendation/status: short-term

### 5.1.9 Research recommendations

The technical experts consider that the research recommendations presented here show potential for standardization and should therefore be followed up. These recommendations are to be compared and aligned with the proposals of other NPE working groups.

**FL 1 Battery condition after an accident**
A battery may be so severely damaged in a crash that immediate safe recovery of the vehicle is impossible. To eliminate danger to rescuers and vehicle recovery personnel, there must be a way for them to determine whether the battery can be transported safely or not. In cases where safe transport is not possible, they must be able to determine how and under what conditions the battery can be brought into a safe condition (e.g. whether controlled discharging is necessary). These issues have to be investigated and the need for standardization needs to be defined (see U 2).

**FL 2 Battery service life**
At present no immediate need is seen for a standard on methods to determine the remaining service life of a battery by recording the required characteristic values. This may, however, be a subject for research which can be integrated into future standardization activities.

**FL 3 Load spectra**
As the operation of purely e-vehicles may differ from that of present vehicles with internal combustion engines, research in the field of determining load spectra is considered necessary.

**FL 4 Capacitors (including ultracaps)**
Research in the field of capacitors for electric vehicle drive is considered necessary.

## 5.2 Implementation of the Standardization Roadmap – Phase 1

The time schedule for implementing the Standardization Roadmap is based on the following aspects discussed above:

- priorities,
- required effort,
- necessity of clarifying the scope of standardization (setting up an ad-hoc working group), and
- the need for more research.

The resulting time schedule is shown in Figure 20. As can be seen, there is a considerable need for standardization work over the coming years.

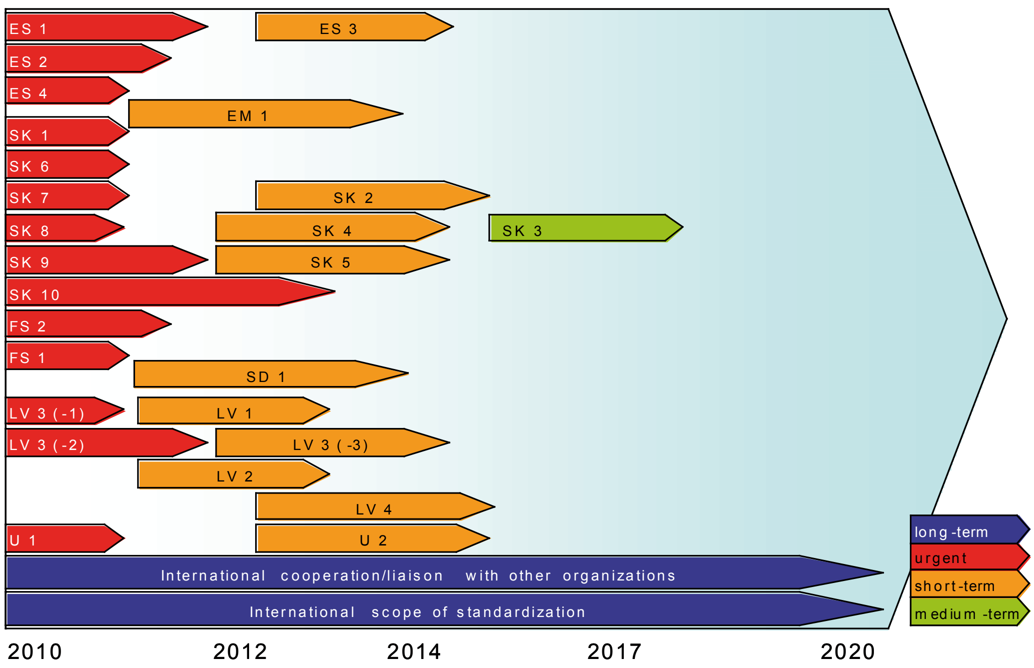


**Figure 20:** Time schedule for the implementation of recommendations

# 6 Prospects for the future

This section presents aspects which experts do not at present consider necessary preconditions for the introduction of electromobility, but which may become relevant in future technology and market scenarios.

- **Recycling of degraded batteries**
  The idea of using degraded ("second life") batteries as stationary buffer batteries (e.g. for wind and solar energy) is currently being discussed, and research is being carried out on this subject. The standardization of performance characteristics, diagnostic signals (e.g. temperature signals) and thermal requirements (cooling/heating) may have a positive effect on such applications and the corresponding business models.

- **Energy feedback into the grid**
  There are two types of energy feedback:
  – feeding back energy to bridge periods in which solar or wind generators do not provide sufficient energy to meet the current demand, and
  – feeding back energy to stabilize the grid, i.e. balance out short-term fluctuations until other power stations can be started up and synchronized with the grid.
  These two approaches are physically similar, but stabilization feedback tends to be a brief, short-term service, whereas real energy feedback would mean providing energy for several hours. The technical, economical and customer-related framework conditions required to implement these two variants still have to be investigated..

- **Communications**
  ETSI is currently working in close cooperation with the Car to Car Communication Consortium on the standardization of short-range vehicle-vehicle and vehicle-infrastructure communications on the basis of the IEEE-802.11p standard. In this context, the possibility of communications with electric charging stations is under discussion, whereby it is especially important to ensure that there are no contradictory provisions; standardization should focus on billing/financial settlements, safety and data security.

- **Standardized voltages**
  Standardized voltages allow economies of scale in development and production and therefore support market penetration, particularly during the growth phase and ensuing periods. Depending on experience gained during the introduction phase, the standardization of several discrete voltage levels should be considered.

# Annex A

## A1 German Standardization Roadmap for Electromobility

[1] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products.

[2] The German Standardization Strategy: DIN, the German Institute for Standardization Burggrafenstraße 6, 10787 Berlin, Germany, www.din.de, 2004
http://www.din.de/sixcms_upload/media/2896/DNS_english%5B1%5D.pdf

[3] The German Standardization Strategy – An Update: DIN, the German Institute for Standardization Burggrafenstraße 6, 10787 Berlin, Germany, www.din.de, 2010,,
http://www.din.de/sixcms_upload/media/2896/DNS_2010e_akt.pdf

[4] Bremer, Wolfgang: Normungsbedarf für alternative Antriebe und Elektrofahrzeuge (Need for the standardization of alternative drive and electric vehicles), Study carried out within the framework of the BMWi-supported “Innovation with Norms and Standards (INS)” project, Berlin, 2009. Supported by the Federal Ministry of Economics and Technology (BMWi) on the basis of a decision by the German Bundestag.

[5] VDE Study “Elektrofahrzeuge – Bedeutung, Stand der Technik, Handlungsbedarf” (“Electric vehicles – Significance, state of technology, need for action”), Energietechnische Gesellschaft (ETG) (Power Engineering Society in VDE), Frankfurt, Germany, 2010

[6] Homepage of the German Federal Environment Agency (Umweltbundesamt); visited on 28.09.2010:
http://www.umweltbundesamt.de/gesundheit-e/laerm/herz.htm

[7] Maschke, C.: Verkehrslärm erhöht Stress und gefährdet die Gesundheit (Traffic noise increases stress and is harmful to health), in: Bundesgesundheitsblatt – Gesundheitsforschung – Gesundheitsschutz, Springer Berlin / Heidelberg, 1999

[8] White paper “Anforderungen an sichere Steuerungs- und Telekommunikationssysteme” (Requirements for safe control and telecommunications systems), BDEW Bundesverband der Energie- und Wasserwirtschaft e.V., Berlin, 2008

[9] Elektromobilität – Vorschriften im Bereich Kraftfahrzeugtechnik und Gefahrguttransporte (Electromobility regulations in automotive technology and the transport of dangerous goods); Report of the team “Vorschriftenentwicklung” in Working Group 4 (Normung, Standardisierung, Zertifizierung) of the German National Platform for Electromobility (NPE)

[10] German Standardization Roadmap E-Energy/Smart Grid, DKE German Commission for Electrical, Electronic & Information Technologies of DIN and VDE, Frankfurt, 2010

# Annex B
# Terms and definitions; Abbreviations

For the purposes of this document, the following terms and definitions and abbreviations apply.

## B.1 Terms and definitions

**B.1.1**
**electric vehicle**
For the purposes of this Roadmap, the term "electric vehicle" refers to any vehicle that is fully or partially propelled by an electric motor. This includes

- battery electric vehicles
- switchable battery electric vehicles
- fuel cell electric vehicles
- plug-in hybrid electric vehicles
- non-chargeable hybrid electric vehicles
- redox-flow electric vehicles

**B.1.2**
**electromobility**
Electromobility refers to the use of electric vehicles for various transport needs.

**B.1.3**
**vehicle classes**
Vehicles are classified in Annex II of European Directive 2007/46/EC and Article 1 paragraph 2 of European Directive 2002/24/EC as follows.

| **Category M** | **Motor vehicles with at least four wheels designed and constructed for the carriage of passengers.** |
|---|---|
| Category M1 | Vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat. |
| Category M2 | Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 tonnes. |
| Category M3 | Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 tonnes. |
| **Category N** | **Motor vehicles with at least four wheels designed and constructed for the carriage of goods.** |
| Category N1 | Vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3,5 tonnes. |
| Category N2 | Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3,5 tonnes but not exceeding 12 tonnes. |
| Category N3 | Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes. |

| Category L | Two-, or three-wheel vehicles and light quadricycles |
|---|---|
| Category L3e | Motorcycles, i.e. two-wheel vehicles without a sidecar fitted with an engine having a cylinder capacity of more than 50 $cm^3$ if of the internal combustion type and/or having a maximum design speed of more than 45 km/h. |
| Category L4e | Motorcycles as above, with a sidecar |
| Category L5e | Motor tricycles, i.e. vehicles with three symmetrically arranged wheels (category L5e) fitted with an engine having a cylinder capacity of more than 50 $cm^3$ if of the internal combustion type and/or a maximum design speed of more than 45 km/h. |
| Category L7e | Quadricycles, other than those referred to in (a), whose unladen mass is not more than 400 kg (category L7e) (550 kg for vehicles intended for carrying goods), not including the mass of batteries in the case of electric vehicles, and whose maximum net engine power does not exceed 15 kW. These vehicles shall be considered to be motor tricycles and shall fulfil the technical requirements applicable to motor tricycles of category L5e unless specified differently in any of the separate Directives. |

**B.1.4**
**high voltage**
Voltage class B: greater than 30 V up to and including 1000 V for a.c. systems, and greater than 60 V up to and including 1500 V for d.c. systems (see ISO 6469-3).

**NOTE:** For clarity's sake this text does not refer to "high voltage on-board networks" but to "voltage class B on-board networks".

**B.1.5**
**charging mode**
The charging mode describes the method by which the electric vehicle is charged. The various modes are differentiated by the power range for energy transmission and safety characteristics. The four charging modes defined in IEC 61851-1 and a further mode that is currently under discussion are described in 4.4.1 of the present document.

**B.1.6**
**charging station (electric power supply for electric vehicles)**
A charging station refers to equipment as in IEC 61851 used for charging electric vehicles, the main elements of which are the connecting elements (plug and socket-outlet, vehicle coupler and inlet, etc.), line protection, a residual current device (RCD), a circuit breaker and a safety communication device (PWM). Depending on the place of use other functional units may be included, such as a connection to the supply mains and metering devices.

**B.1.7**
**charging accessories and charging cable assembly**
Plug-and-socket assembly needed for charging electric vehicles. The IEC 62196 series describes charging accessories intended especially for electric vehicles.

For charging modes 2 and 3 a hybrid cable with an energy core and control lines are also necessary.

## B.2 Abbreviations

| | |
|---|---|
| ANSI | American National Standards Institute |
| BDSG | Bundesdatenschutzgesetz<br>(German Federal Data Protection Act) |
| BSI | Bundesamt für Sicherheit in der Informationstechnik<br>(German Federal Office for Information Security)<br>(Translator's Note: In other standardization contexts "BSI" refers to the UK national standards organization, the British Standards Institute) |
| CEN | Comité Européen de Normalisation<br>European Committee for Standardization |
| CENELEC | Comité Européen de Normalisation Electrotechnique<br>European Committee for Electrotechnical Standardization |
| CHAdeMO | CHArge de MOve – (equivalent to "charge for moving"),<br>Japanese proposal for a DC plug |
| CISPR | Comité International Spécial des Perturbations Radioélectriques<br>(Special International Committee on Radio Interference) |
| (DIN) SPEC | (DIN) Specification |
| DIS | Draft International Standard |
| DKE | Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE<br>(DKE German Commission for Electrical, Electronic & Information Technologies of DIN and VDE) |
| DNS | Deutsche Normungsstrategie<br>(German Standardization Strategy) |
| E/E | electrical / electronic |
| EVSE | Electric vehicle supply equipment |
| EVU | Energieversorgungsunternehmen<br>(German for "Power supply company" or "utility") |
| FG-EV | CEN/CENELEC Focus Group on Electric Vehicles Standardization |
| F&U | Forschung und Entwicklung |
| GAK | Gemeinschaftsarbeitskreis<br>(Joint Working Group) |
| GK | Gemeinschaftskomitee<br>(Joint Committee) |
| ICCB | In-cable control box |
| IKT | ICT (Information and Communications Technology) |
| IP | Internet Protocol |
| ITA | Industry Technical Agreement |
| JWG | Joint Working Group |
| JTC | Joint Technical Committee |
| KMU | Kleine und mittlere Unternehmen<br>(SME = small and medium-sized enterprises) |
| MoU | Memorandum of Understanding |
| NA | Normenausschuss<br>(Standards Committee) |

| | |
|---|---|
| NPE | Nationale Plattform Elektromobilität<br>(German National Platform for Electromobility) |
| NOW | Nationale Organisation Wasserstoff Brennstoffzellen<br>(NOW GmbH = National Organisation Hydrogen and Fuel Cell Technology) |
| OBD | On-board diagnosis |
| PAS | Publicly Available Specification |
| PCISSC | Payment Cards Industry Security Standards Council |
| PWM | Pulse-width modulation |
| R&D | Research and development |
| RCD | Residual current protective device |
| RFID | Radio frequency identification |
| SAE | Society of Automotive Engineers (US organization) |
| SG | Smart Grid |
| SIL | Safety Integrity Level |
| TR | Technical Report |
| V2G | Vehicle-to-grid |
| VDE | Verband der Elektrotechnik Elektronik Informationstechnik<br>(Association for Electrical, Electronic & Information Technologies) |
| W3C | World Wide Web Consortium |
| XML | Extensible Markup Language |

# Annex C

## C1 Benefits of electromobility for various interest groups

This Annex describes the benefits of electromobility for various interest groups by listing practical examples (this is not an exhaustive list) and describing the effects of standardization in each case.

This Annex has already been completed but has been removed from the first draft of the “Roadmap” at the request of Working Group 4 “Standardization and Certification” of the National Platform for Electromobility because it needs to be brought in line with a White Paper.

# Annex D
# Overview of standards, specifications and standardization bodies relating to electromobility

## D.1 Standards and specifications

| **Standards and specifications** | | | | **Domain** | | |
|---|---|---|---|---|---|---|
| Standard / specification | German body | Title | Status | Vehicle | Energy storage | Charging infrastructure |
| EN 55012 (CISPR 12) | K 767 | Vehicles, motorboats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers | | | | |
| EN 55025 (CISPR 25) | K 767 | Vehicles, motorboats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers | | | | |
| IEC 60364-5-53 DIN VDE 0100-530 | K 221 | Erection of low voltage installations – Part 530: Selection and erection of electrical equipment – Switchgear and controlgear | CDV | | | |
| IEC 60364-5-54 DIN VDE 0100-540 | UK 221.1 | Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors | CDV | | | |
| IEC 60364-7-722 | AK 221.1.11 | Low voltage electrical installations: Requirements for special installations or locations – Supply of electric vehicle | NP | | | |
| IEC 60364-4-41 DIN VDE 0100-410 | UK 221.1 | Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock | CDV | | | |
| IEC 60479-1 (VDE 0140-479-1) | UK 221.1 | Effects of current on human beings and livestock – Part 1: General aspects | | | | |
| IEC 60529 | K 212 | Degrees of protection provided by enclosures (IP Code) | CD | | | |
| IEC 61000-6-2 | UK 767.3 | Electromagnetic compatibility (EMC) – Generic standards – Immunity for industrial environments | IS | | | |
| IEC 61000-6-3 | K 767 | Electromagnetic compatibility (EMC) – Generic standards – Emission standard for residential, commercial and light-industrial environments | | | | |
| IEC 61140 (VDE 0140-1) | 221.1 | Protection against electric shock – Common aspects for installations and equipment | | | | |
| IEC 61439-5 | 431.1 | Low-voltage switchgear and controlgear assemblies – Part 5: Assemblies for power distribution in public networks | CDV | | | |
| IEC 61508 | GK 914 | Functional safety | IS | | | |

| Standard / specification | German body | Title | Status | Vehicle | Energy storage | Charging infrastructure |
|---|---|---|---|---|---|---|
| IEC 61850 | 952 | Communication networks and systems for power utility automation | CDV | | | |
| IEC 61851-1 | 353 | Electric vehicle conductive charging system – General requirements | FDIS | | | |
| IEC 61851-21 | 353 | Electric vehicle conductive charging system – Part 21: Electric vehicle requirements for conductive connection to an a.c./d.c. supply | CD | | | |
| IEC 61851-22 | 353 | Electric vehicle conductive charging system – a.c. electric vehicle charging station | CD | | | |
| IEC 61851-23 | 353.0.2 | Electric vehicle conductive charging system – d.c electric vehicle charging station | NP | | | |
| IEC 61851-24 | 353 | Electric vehicle conductive charging system – Control communication protocol between off-board d.c. charger and electric vehicle | NP | | | |
| IEC 61968 | DKE K 952 | Application integration at electric utilities – System interfaces for distribution manage-ment | IS | | | |
| IEC 61970 | DKE K 952 | Energy management system application program interface (EMS-API) | IS | | | |
| IEC 62040 | 331 | Uninterruptible power systems (UPS) | | | | |
| IEC 62196-1 | 542.4.1 | Plugs, socket-outlets, vehicle couplers and vehicle inlets – Charging up to 250 A a.c. and 400 A d.c. | CD | | | |
| IEC 62196-2 | 542.4.1 | Plugs, socket-outlets, vehicle couplers and vehicle inlets –- Dimensional interchange-ability requirements | CD | | | |
| IEC 62196-3 | 542.4.1 | Plugs, socket-outlets, vehicle couplers and vehicle inlets – Dimensional interchangeability requirements for pin and contact-tube coupler with rated operating voltage up to 1 000 V d.c. and rated current up to 400 A for dedicated d.c. charging | NP | | | |
| IEC 62351 | 952 | Data and communication security (Security for Smart Grid) | | | | |
| IEC 62335-2 | DKE AK 541.3.6 | SPE-RCDS for inline-cable boxes | | | | |
| IEC 62443 | 931.1 | Industrial communication networks – Network and system security | | | | |
| IEC 62576 | K 353 | Electric double-layer capacitors for use in hybrid electric vehicles – Test methods for electrical characteristics | | | | |
| IEC 62660 | K 371 | Secondary batteries for the propulsion of electric road vehicles | FDIS | | | |

| Standard / specification | German body | Title | Status | Vehicle | Energy storage | Charging infrastructure |
|---|---|---|---|---|---|---|
| ISO 6469-1 | | Electrically propelled road vehicles – Safety specifications – Part 1: On-board rechargeable energy storage system (RESS) | PUB | | | |
| ISO 6469-2 | | Electrically propelled road vehicles – Safety specifications – Part 2: Vehicle operational safety means and protection against failures | PUB | | | |
| ISO 6469-3 | | Electrically propelled road vehicles – Safety specifications – Part 3: Protection of persons against electric shock | FDIS | | | |
| ISO 6722-1 | | Road vehicles – 60 V and 600 V single-core cables – Part 1: Dimensions, test methods and requirements for copper conductor cables (Ed. 2.0) | DIS | | | |
| ISO 6722-2 | | Road vehicles – 60 V and 600 V single-core cables – Part 2: Dimensions test methods and requirements for aluminium conductor cables | CD | | | |
| ISO 7637-1 | | Road vehicles – Electrical disturbances by conduction and coupling – Part 1: Definitions and general considerations | IS | | | |
| ISO 7637-2 | | Road vehicles – Electrical disturbances by conduction and coupling – Part 2: Electrical transient conduction along supply lines only | IS | | | |
| ISO 7637-3 | | Road vehicles – Electrical disturbances by conduction and coupling – Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines | IS | | | |
| ISO TR 8713 | | Electric road vehicles – Vocabulary | CD | | | |
| ISO 11451 Teil 1–4 | | Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy | IS | | | |
| ISO 11452-1 | | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General principles and terminology | IS | | | |
| ISO 11452-2 | | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Absorber-lined shielded enclosure | IS | | | |
| ISO 11452-3 | | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 3: Transverse electromagnetic mode (TEM) cell | IS | | | |
| ISO 11452-4 | | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Bulk current injection (BCI) | CD<br>2012 | | | |

| Standard / specification | German body | Title | Status | Vehicle | Energy storage | Charging infrastructure |
|---|---|---|---|---|---|---|
| ISO 11452-5 | | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 5: Stripline | IS | x | | |
| ISO 11452-7 | | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 7: Direct radio frequency (RF) power injection | IS | x | | |
| ISO 11452-8 | | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 8: Immunity to magnetic fields | IS | x | | |
| ISO 11452-9 | | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 9: Portable transmitters | CD 2012 | x | | |
| ISO 11452-10 | | Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 10: Immunity to conducted disturbances in the extended audio frequency range | IS | x | | |
| ISO 12405-1 | | Electrically propelled road vehicles – Test specification for Li-Ion traction battery systems – Part 1: High power applications | FDIS | | x | |
| ISO 12405-2 | | Electrically propelled road vehicles – Test specification for lithium-Ion traction battery systems – Part 2: High energy applications | DIS | | x | |
| ISO 12405-3 | | Electrically propelled road vehicles – Test specification for Li-Ion traction battery systems – Part 3: Safety performance requirements | NWIP 2012 | x | | |
| ISO 14572 | | Road vehicles – Round, sheathed, 60 V and 600 V screened and unscreened single- or multi-core cables – Test methods and require-ments for basic and high-performance cables (Ed. 2.0) | DIS | x | | |
| ISO/IEC 15118 Parts 1–4 | ISO/TC 22/SC 3/ JWG 1 | Road vehicles – Communication protocol between electric vehicle and grid | AWI | x | | x |
| ISO/IEC 15118-2 | | Road vehicles – Communication protocol between electric vehicle and grid – Part 2: Sequence diagrams and communication layers | AWI | x | | x |
| ISO/IEC 15408 | | Information technology - Security techniques - Evaluation criteria for IT security | PUB | x | | x |

| Standard / specification | German body | Title | Status | Vehicle | Energy storage | Charging infrastructure |
|---|---|---|---|---|---|---|
| ISO 16750 | | Road vehicles – Environmental conditions and testing for electrical and electronic equipment | PUB | ■ | | |
| ISO 23273 | | Fuel cell road vehicles – Safety specifications | PUB | ■ | | |
| ISO 23274-1 | | Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 1: Non-externally chargeable vehicles | AWI 2014 | ■ | | |
| ISO 23274-2 | | Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 2: Externally chargeable vehicles | CD 2013 | ■ | | |
| ISO 26262 | | Road vehicles – Functional safety | FDIS | ■ | | |
| ISO/IEC 27000 | | Information technology – Security techniques – Information security management systems – Overview and vocabulary | PUB | ■ | | ■ |
| ISO/IEC 27001 | | Information technology – Security techniques – Information security management systems – Requirements | PUB | ■ | | ■ |
| | | | | | | |
| SAE J 1773 | | Electric Vehicle Inductively Coupled Charging | PUB | ■ | | ■ |
| SAE J 1797 | | Recommended Practice for Packaging of Electric Vehicle Battery Modules | PUB | ■ | ■ | |
| SAE J 1798 | | Recommended Practice for Performance Rating of Electric Vehicle Battery Modules | PUB | ■ | ■ | |
| SAE J 2289 | | Electric-Drive Battery Pack System: Functional Guidelines | PUB | ■ | ■ | |
| SAE J 2464 | | Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing | PUB | ■ | ■ | |
| SAE J 2288 | | Life Cycle Testing of Electric Vehicle Battery Modules | PUB | | ■ | |
| SAE J 2929 | | Electric and Hybrid Vehicle Propulsion Battery System Safety Standard | | | ■ | |

## D.2 Standardization bodies within DIN, NAAutomobil and the DKE

**Bodies within DIN/NAAutomobil**

- NA 052-01-21 AA: Electric road vehicles
- NA 052-01-21-03 GAK: Traction batteries for electric vehicles (joint working group of NAAutomobil and the DKE)
- NA 052-01-03 AA: Electrical and electronic equipment
- NA 052-01-03-16 AK: Functional safety
- NA 052-01-03-17 GAK: Vehicle-to-grid communication interface (V2G CI) (joint working group of NAAutomobil and the DKE)

**Bodies within the DKE**

- EMOBILITY.AG10: System approach to energy supply for electric vehicles (grid connection – charging station – plug connectors and cables – battery – functional safety – risk management)
- EMOBILITY.AG20: Requirements on the electrical safety of the vehicle-to-grid interface
- EMOBILITY.AG30: Standardization Roadmap for Electromobility
- DKE steering group on e-energy/smart grids
- DKE/K 353: Electric road vehicles (review of the IEC 61851 series: Electric vehicle conductive charging systems)
- DKE/AK 353.0.1: Inductive charging of electric vehicles
- DKE/AK 353.0.2: DC charging of electric vehicles
- DKE/AK 542.4.1: Connector system for conductive connection of vehicles to the grid (review of IEC 62196-1 and -2)
- DKE/AK 542.4.3: DC connector system for conductive connection of vehicles to the grid
- DKE/K 371: Accumulator batteries (development of standards for batteries and their safety requirements)
- DKE/UK 411.2: Insulated high-voltage cables (standardization of requirements and the types of cable used for the charging cable of electric vehicles)
- DKE/AK 221.1.11: System approach to electric vehicle connectors (protection against electric shock)
- DKE/K 116: Graphic symbols for man-machine interaction; safety markings
- DKE/AK 541.3.6: Protective devices for e-mobility
- DKE/GUK 767.13 (NA 052-01-03-03 GAK): Electromagnetic compatibility, vehicles (joint working group of the DKE and NAAutomobil)
- DKE/GUK 767.14 : Radio interference suppression of vehicles, of vehicle equipment and of internal combustion engines

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