The Need For Standards In An Emerging Market - The Case Of The Electric Vehicle

P. Van den Bossche
CITELEC
VUB-ETEC
Pleinlaan 2
B-1050 Brussels
pvdbos@vub.ac.be

Abstract
In urban traffic, due to their beneficial effect on environment, electric vehicles are an important factor for improvement of traffic and more particularly for a healthier living environment. As it is the case with every product, the electric vehicle needs standards. Standards are on one hand necessary for regulatory reasons, to allow the electric vehicle to be safely presented to the public. The utility of standards however goes beyond mere safety regulations. The initial introduction of industrial standards was aimed to promote standardisation and interchangeability of components. These considerations are still of utmost importance when one looks upon the electric vehicle to be used in a flexible way, particularly when considering its access to recharging infrastructure. This paper will discuss general issues on standardisation, as well as their application on the electric vehicle as a product.

Standardisation issues
What are Standards?
Standards are omnipresent in our technological world. But their essence is often not well understood. For the general public, a standard is a model to which objects or actions may be compared. The official definition is not unsimilar: according to the International Electrotechnical Commission (IEC), a "standard" is *"a document, established by consensus and approved by a recognised body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievements of the optimum degree of order in a given context."* The word "consensus" is important. An international standard represents a common viewpoint of those parties concerned, both manufacturers and users. Furthermore, the standard should be *"aimed at the promotion of optimum community benefits"*. A standard is there to aid industry, government agencies and the general user.

An important point when considering standards, is the fact that the adoption of a standard on one hand, and collaboration to its definition on the other hand, are entirely voluntary. International standardisation is wholly based on a voluntary consensus in the technical working groups that prepare the standards. This means that an international standard is to some degree a compromise between the various interests involved, but it is a way to ensure that every standard published is authoritative.

There is an important difference between standards and regulations. While standards are voluntary, and are adopted in order to gain a mutual benefit for manufacturers, suppliers and users, regulations are like laws, and are imposed by national governments. A set of harmonised regulations is however adopted by the countries of the European Union. These regulations are called directives.

Vehicles are subject to a number of regulations in order to be allowed to circulation. Most of these regulations are safety-related: braking, lights, seat-belts,...; there are also environmental regulations, for example relating to emissions. In some cases, regulations may contain refer to national or international standards. In this way, standards may obtain force of law.

Why Standardisation?

Standardisation results from consensus agreements between all players in a certain economic sector, e.g. electric vehicle manufacturing and use. The standards relate to specifications and criteria to be applied in the provision of materials, products and services. The consistent application of standards may have the following benefits:

- the definition of an acceptable level of safety and environmental protection to be achieved with the product
- the compatibility and interoperability of goods and services
- the improvement of quality and reliability through the introduction of agreed performance criteria
- the improvement of distribution and maintenance efficiency through simplification and reduction in the number of different components.

The international character of the standardisation is essential in order to avoid the existence of non-harmonised standards for similar technologies in different countries, which leads to the formation of so-called “technical barriers to trade”. The importance of world-wide co-ordination of standardisation activities becomes even more critical when considering fields like new technological developments involving several technical or economic sectors (the electric vehicle being an excellent example of this).

How Standards Come to Being

International standards are drafted by international standards organisations, the most important of which are the International Electrotechnical Committee (IEC) and the International Organisation for Standardisation (ISO). National standardisation committees are members of IEC and/or ISO.

The development of a new standard follows a procedure which is common to IEC and ISO, and which, in a simplified way, can be presented as follows:

- in a first phase, if the need for standardisation in a certain field is expressed in a “new work item proposal” which is voted upon by the relevant National Committees;

- if this is accepted, the technical scope and the specifications of the standard are drafted by committees of experts which are delegated by National Committees. It should be stressed upon that this work done by experts in the technical committees and working groups is performed on an complimentary basis;

- the draft standard thus prepared is voted upon by the National Committees, for acceptance and/or comments;

- when finally accepted, a new International Standard is born.

Electric vehicles and standardisation

The past decennia have seen an unprecedented development of electric vehicle technology all over the world, up to the point where only market forces impede the breakthrough of the electric vehicle as a clean and efficient mode of transport. Electric (and hybrid) vehicles are in fact more and more being considered as a positive solution for today's traffic and pollution problems; their deployment can be an important factor for improvement of traffic and more particularly for a healthier living environment. Electric vehicles however represent a complete different technology compared with internal combustion engines. This means that new safety hazards, mainly related to the characteristics of high-power electric equipment, may be present.

To ensure that the electric vehicle, considered as a system together with its charging infrastructure, be designed to operate safely in all conditions, standardisation and regulations work must be performed. These standards will be mainly based on the existing regulations for road vehicles. The use of high-power electric equipment on board the vehicles however creates the need for new regulations and standards. This does not signify at all that the electric vehicle may be a “dangerous” product, but these standards are also needed to gain the confidence of the potential user who might at first be frightened by the presence of high

voltage equipment inside a motor vehicle (even if he uses the same voltage levels in his home).

Legislation and the awareness of people have created a pressure for the zero emission vehicles which is driving the requirements for electric vehicle standards. These are focused particularly on interfacing, safety, definitions and methods of measurements and will be developed, where appropriate, by joint working groups with other standard bodies.

The technologies involved in electric vehicles are moving very quickly, particularly in the field of batteries, power electronics and drive systems. Generic standards to assure safety of persons, to measure performances and to ensure compatibility will continue to be developed as the technology advances.

With standardisation of the electric road vehicle becoming an important issue, the question arises which body would be responsible for these standards. This problem is less straightforward then it looks: the electric vehicle, which introduces electric traction technology in a road vehicle environment, represents in fact a mixed technology.

- on one hand, the electric vehicle is a road vehicle, the standardisation competence for which is the province of ISO;
- on the other hand, the electric vehicle is a piece of electrical equipment, the standardisation competence for which falls under the wings of the IEC.

This difference is even more stressed by the constitution of the technical committees working groups in the two organisations: in ISO, there is a strong input from vehicle manufacturers, whileas in IEC many of the delegated experts are electricians. Furthermore, there is a fundamentally different approach taken towards the concept of standardisation in the automotive and the Electrotechnical world. There is a different "standard culture", the origin of which can be traced back to historical reasons:

- In the car manufacturing world, standardisation is not so widespread: every manufacturer desires to develop his own technical solutions, which in fact make his product unique. Standardisation for road vehicles is limited to issues covered by regulations (safety, environmental impact), and to areas where interchangeability of components is important. For components like combustion engines for example there are very few standards.

  In the automotive industry in fact, most manufacturers were (and to a certain extent still are) responsible for the manufacturing of all components (e.g. the combustion engine) for a certain vehicle. This made the need for overall standardisation much less stringent. Also, the individual customer is unlikely to require strict compliance to standards; safety regulations however may be enforced by governments.

- In the electric world, there is a much longer tradition for standardisation (the IEC was founded as early as 1906, when the Electrotechnical industry was at its very beginning) and a stronger tendency to standardise all and everything; furthermore, standards are more looked upon as being legally binding documents. Electric motors are covered by extensive standards covering their construction and testing. Even the colour code of wires is standardised (e.g. green and yellow for the protective or earth conductor).

  In the Electrotechnical industry in fact, the role of specialist component manufacturers acting as suppliers to equipment manufacturers has always been more important. Furthermore, the customers of the Electrotechnical industry are more likely to be powerful corporations (e.g. railway companies) who tend to enforce very strict specifications on the equipment they order or purchase, hence the need for more elaborate standards to ensure the compliance of the equipment.

To allow for an efficient solution to this problem and to avoid the duplication of work between ISO and IEC, which would lead to redundant or even contradictory documents, discussions are now going on between the relevant bodies inside IEC and ISO to come to a division of work on electric vehicles, in order to come to an agreement.

The main philosophy behind this is the following:

- the electric vehicle as a whole is considered by ISO: standards for performance measurement, etc...
- the electric components of the vehicle are considered by IEC
- the vehicle, being connected to the network for charging, is considered an electric device subject to IEC
- non-traction equipment on the vehicle is considered by ISO, except when it is operated above certain voltages
- in all cases, collaboration between ISO and IEC will be sought on relevant matters.

Standardisation Bodies Active in the Field

The organisations involved with electric vehicle standardisation work are, on a world-wide basis:

- The International Electrotechnical Commission (IEC).
  Inside IEC, the Technical Committee 69 (TC69) is dedicated to electric vehicles.
  IEC TC 69 (Electric Road Vehicles and Electric Industrial Trucks) was established in the 1970's, at a time when environmental concerns, potential oil shortages and available technology made the prospect of electric vehicles attractive. After a slow start, a number of standards and reports were published in the 1980's dealing with chargers, wiring and electric drive systems. More recently, the increasing awareness of environmental matters, coupled with direct legislation to promote zero emission vehicles, has prompted direct involvement at all levels by the vehicle industry.
  At this moment, the following working groups are active inside TC 69:
  - WG2: Motors and Controllers
  - WG3: Batteries
  - WG4: Infrastructure
  All these working groups are constituted of experts who are designated by their national committees.

- The International Organisation for Standardisation (ISO),
  Inside ISO, Technical Committee 22 is responsible for road vehicles; its Sub-Committee 21 (ISO TC22 SC21) is dedicated to electric road vehicles. The following working groups are active:
  - WG 1 Vehicle operation conditions, vehicle safety and energy storage installation
  - WG 2 Terminology. Definitions and methods of measurement of vehicle performance and of energy consumption

  The committee is constituted also by experts designated by national standardisation organisations.

On a regional level, following organisations are also active in the field:

- in the European Union, harmonised standards on an European level are being developed by:
  - CEN, the European Commission for Standardisation.
    Inside CEN, TC 301 is responsible for electric road vehicles.
    Its active working groups are the following:
    - WG1: Measurement of performances
    - WG4: Liaison and dialogue between vehicle and charging station
    - WG5: Safety - Other aspects

  - CENELEC, the European Commission for Standardisation in the field of electrotechnics.
    Inside CENELEC, TC69X is responsible for electric vehicles.
    Its working groups are the following:
    - WG1: Charging-Design and operation
    - WG2:Charging-Environmental aspect
    - WG3: Safety

On a national level, activities are performed by the national standardisation or Electrotechnical committees, for example:

- in the United States, the Society of Automotive Engineers (SAE) has issued a number of technical documents concerning electric vehicles

- in Japan, the Japanese Electric Vehicle Association (JEVA) is concerned with electric vehicle standardisation

Standardisation of vehicle components

In the field of standardisation of traction components like motors and controllers, the clear opposition between the electrotechnical and the automotive industries mentioned above is obvious. The division of standardisation labour between the two main concerned bodies, IEC and ISO, is the central issue in this field.

Inside IEC TC69, this subject is the responsibility of Working Group 2. This WG has been active in the 1980's, producing several documents regarding cables, instrumentation, motors and controllers. It has been dormant for a number of years, but is now revitalised. Its first commitment is the preparation of a standard considering electric vehicle motors and controllers. This document is a merge and a revision of the documents IEC 785 and IEC 786. The rapid evolution of electric vehicle technology makes it desirable to consider a revision taking into account the latest developments. The concept of integrated electric drives makes a merge of the motor and controller parts of the document desirable. The “new work item proposal” regarding this document has been approved; however, there was a strong opposition from a number of car manufacturers, who, according to their traditions, deemed this standardisation work unnecessary.

The new document should be an answer however to the needs of ISO who have requested clear standards including characteristics, specifications and testing procedures for electric vehicle components. Activities on this document will resume with the outcome of the IEC/ISO agreement.

Standardisation of charging infrastructure

The standardisation of charging infrastructure and of the connection of the vehicle to charging station is now exclusively dealt with by the Electrotechnical committee (IEC TC69 WG4). The activities of this working group, where both energy suppliers, car manufacturers, component manufacturers and users are present, may be considered as exemplary for a fruitful mutual collaboration between different parties in the view of electric vehicle standardisation.

This WG has been able to reach a considerable progress, with several new documents being prepared covering the different modes of charge which may be considered for specific applications.

IEC TC69 WG4 has defined a specific structure for the development of new standards which are due to replace the old standard IEC718(1992): “Electrical equipment for the supply of energy to battery powered road vehicles”. The scope of this structure is to accommodate the different kinds of charging which can be taken into account, namely conductive and inductive charging.

A first standard will be devoted to conductive charging systems:

- Part 1 of the standard covers general requirements for electric vehicle conductive charging systems

- Part 2 of the standard covers the physical, electrical and performance requirements concerning new devices for an electric vehicle manual conductive coupling, when devices are not already standardised.

  Part 2 is further subdivided into parts which are published as international standards in their own right:
  - Part 2.1: Electric vehicle requirements for conductive connection to an AC supply network

- Part 2.2: AC electric vehicle charging station
- Part 2.3: DC electric vehicle charging station
- Part 2.4 Communication protocol between DC electric vehicle charging station and electric vehicle.

For the other technique of electric vehicle charging, inductive charging, a similar structure of document has been proposed.

- Part 1 of the standard covers general requirements for electric vehicle inductive charging systems; at this moment, only a very general approach of the safety requirements, akin to the conductive charging, has been proposed.

- Part 2 of the standard covers the physical, electrical and performance requirements concerning new devices for an electric vehicle inductive coupling, when devices are not already standardised.
  Part 2 will be further subdivided into parts which describe the several technological approaches which can be followed concerning inductive charging:
  - mains frequency, automatic coupling
  - middle frequency, automatic coupling
  - high frequency, manual coupling
  - high frequency, automatic coupling,
  - ...

The standardisation aims primarily at electric road vehicles being charged at standard AC supply voltages. The aspects covered include characteristics and operating conditions of the supply device and the connection of the vehicle, operators and third party electrical safety and the characteristics to be complied with by the vehicle with respect to the electricity supply equipment. The standard does not apply to heavy duty vehicles (e.g. buses), industrial vehicles (e.g. off-road trucks), or off-road vehicles (e.g. wheelchairs).

Conclusions: Electric vehicle standardisation and the user

The activities of all these committees will lead to a structured set of documents describing the different aspects of the electric vehicle technology. However, taking into account the rapid evolution of the technology in the field, these documents are in no case to be considered as definitive, and they will be in constant evolution and revision. A too narrow definition of a standard may reflect a momentary state-of-the-art, which is due to change anyway, so that strict adherence to it may impede further technological evolution. This is extremely important when considering fields such as inductive charging, where different technologies co-exist.

Furthermore, the standardisation of electric vehicles must take into account the particular characteristics of these vehicles, and not merely mimic existing regulations for internal-combustion engined vehicles. An example of such ill-adapted document is the proposed ECE regulation for determining the power of electric vehicle drive trains, where is even spoken about the “crankshaft” of an electric motor...

Safety of the vehicle and of its associated infrastructure may of course not be compromised. Standardisation and regulation authorities have an important responsibility in this field. The electric vehicle being a "new" product however, the safety aspects and potential hazards associated with its operation are often unknown or wrongly assessed, which may lead to an over-restrictive regulation policy. A well-designed electric vehicle does not present any more potential safety hazards than any other properly designed electrical device. It has no reservoir of highly flammable fuel on board like a gasoline-powered vehicle, which, when invented today, would probably never be allowed on the public road.

The availability of accepted standards and technical documents is an important factor to allow the user, and more in particular the fleet user, to assess the value of the electric vehicle products which are made available to him or her. Validated standard procedures for performance measurement will undo performance claims which are given on an arbitrary basis, for publicity reasons.

For the vehicle manufacturer, and more in particular for the small and medium sized enterprise which heavily relies on external component suppliers, well-defined component standards will enable a better view on the market in order to make the best design choices.

The availability of widely recognised standards, and the adherence to these, will also allow vehicle manufacturers to present their products on a global market. The compliance to known and accepted standards will allow to gain user confidence in the product and to develop a wide market for the electric vehicle, which will then confirm its position as the safe, reliable, energetically and economically sound transportation means of the future. There is clearly an important task in this field for the standardisation bodies, which, in their tradition of voluntary mutual collaboration in an atmosphere of consensus, may contribute to world-wide acceptance of the electric vehicle.