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# Standardisation of Electric Road Systems –

## An Inventory of Standards for Vehicles, Electric Power Supply, and Infrastructure

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**Summary**

The main objective of this study was to identify, analyse and point out areas where standards are missing, or there is need for adaptation of existing standards to ERS. A qualitative method employing document analysis, and e-mail correspondence with a reference group was used for identifying and analysing standards. The study's main result is an inventory list of more than 230 standards considered as useful for ERS, presented as an Excel file with three main categories; vehicle, electric power supply, and infrastructure. An initial analysis of the list points out more than 80 standards as potentially applicable to ERS.

## 1 Research Questions

Sweden intends to become one of the world's first fossil-free welfare states and plans to have net-zero greenhouse gas emissions by the year 2045. An important interim target is a 70 percent reduction in emissions from domestic transport by 2030. Both targets will require a radical transformation of the transport system, and the implementation of Electric Road Systems (ERS) at national and international levels is likely to work together with the use of other solutions for achieving cleaner transportation goals, especially within the heavy and long-distance road transport segment.

There are several ongoing studies and demonstration projects on ERS in Sweden, Germany, and around the world to explore different techniques for energy transfer as well as different use cases. Various ERS technologies with diverse degrees of maturity exist, and each ERS solution has its own advantages and disadvantages. One important area which could have a great impact on the development of ERS is standardisation. Standardisation is particularly important since there are different technologies for ERS developing simultaneously. A seamless European transport system necessitates compatibility between these technologies. So far, there are no dedicated published standards covering ERS. However, several published standards and standards under development could be useful in the context of ERS.

The main objective of this study [1] was to identify, analyse and point out areas where standards are missing, or there is need for adaptation of existing standards to ERS. To this end, the study was set to answer: *Which published standards and standards under development directly or indirectly cover ERS, or could be adapted to apply to ERS?* And, *which standardisation organisations are responsible for these standards?*

## 2 Methodology

To identify and analyse published standards and standards under development that directly or indirectly cover ERS, or could be adapted to apply to ERS, the study [1] forming the basis of this abstract mainly used a qualitative method, yet with some quantitative elements.

The gathering of qualitative data was performed via two main methods: document analysis and e-mail correspondence with experts on different aspects of ERS. This combination of methods offered a first step of mapping the field of standards by the experts at the Swedish Standards Institute (SIS), and then a second step of review, comments and additions by a reference group of experts to the preliminary mapping results. The function of the reference group was to supplement the initial identification of standards by SIS with further expert knowledge from persons working more practically with standards that could be relevant for ERS.

More specifically, SIS first performed a document analysis to locate relevant standards by examining working documents of committees of standardisation organisations on different levels (e.g. ISO/IEC, CEN/CENELEC, SIS/SEK) with subjects related to electric vehicles, infrastructure of electric roads, and electric power supply. Additionally, the document analysis included a review of published standards and work programs of standard committees, and in some cases reviews of current reports and in-depth project information like preliminary work items and early working drafts. As regards the e-mail correspondence, data collection was performed via e-mail sent to members of a reference group consisting of stakeholders with expertise in different thematic areas of ERS. The e-mail included a preliminary list of identified standards from SIS in an Excel file and a request to review and complete a certain category of standards depending on the expertise of the reference person. If needed, the reference person also had the possibility to add additional comments on the other categories.

An analysis was performed by SIS based on the initial mapping of standards and the feedback from the experts in the reference group. The results where presented in a report accompanied by an Excel file with a list of standards, including a macro for filtering standards according to categories and application.

An overarching principle that provided a structure both for the qualitative document analysis, e-mail correspondence, and later, the analysis of data and presentation of results, was that SIS was requested to map standards into three different categories: vehicle, infrastructure, and electric power supply. These categories were used to identify and examine standards in view of ERS as a system of systems [2]. Thereafter, the standards where mapped and examined according to four different applications (general application, conductive transmission by rail in road, conductive transmission overhead, and inductive power transmission). Thus, the standard categories and the possible different standard applications provided a threefold purpose methodological lens: 1) for locating standards, 2) for analysis, and 3) for the structuring, presentation, and possible filtering of results, as well as a quantification of identified standards applicable to ERS.

As regards delimitations, the identification and examination of standards potentially relevant for ERS belonging to the area of telecommunication and the work of respective standardisation organisations at the global, European and Swedish levels (i.e. ITU, ETSI, ITS) were left out of the study.

## 3 Results

This study's main result is an inventory list of more than 230 standards considered as useful for ERS presented in an Excel file with three main categories; vehicle, electric power supply, and infrastructure. An initial analysis of this Excel file points out more than 80 standards (international, European and Swedish) as potentially applicable to ERS. The standards compiled in the Excel file can be filtered according to the three main thematic categories, but also according to four different applications (general application, conductive transmission by rail in road, conductive transmission overhead, inductive power transmission). Additionally, filtering of standards can also be done according to other headings (e.g. Applicable to ERS, Technical Committee, SE mirror committee). The list of standards marked as applicable to ERS is varied, but some examples that can be mentioned are found in the IEC 61851-series, sorted under the category 'electric power supply' with a 'conductive/rail in road application'. Yet other examples can be found in the ISO 6469-series regarding safety specifications for electrically propelled road vehicles, sorted under 'vehicle' with a 'general application'.

All in all, the inventory list of standards in the Excel file is a useful tool when looking further for relevant standards, as well as for identification of missing standards for ERS. Further analysis is however required, and the next step of work is therefore under planning. Besides, information gained from the standard inventory list could also be used to recommend new important areas for standardisation and for taking decisions when prioritising future standardisation work in the developing field of ERS. For instance, two work items which are dedicated to ERS have recently been added within CENELEC TC9X. The first was initiated in 2018 by France on Current Collectors for ground-level feeding system on Commercial Road Vehicles. The second work item is on Current collectors on commercial road vehicles for overhead contact line operation.

As regards uncertainties of the results, it is not always obvious that a listed standard belongs to a single thematic ERS architecture category. In the Excel list, standards are therefore put in the category that they have the closest relation to. It should further be recalled that the identification and listing of standards as applicable in this study is preliminary; there are still no dedicated published or draft ERS standards, only standards that have relevant substance to potentially be adapted to and be used for ERS. The Excel file of compiled standards is therefore a starting point and a work in progress, subsequently to be updated and refined, for instance via a deepened and broadened further analysis of standards.

More precisely, this could be done by involving further expertise from standardisation organisations within the electrotechnical area and continued stakeholder dialogue, but also by examining further aspects and links of ERS as a system of systems. The latter is important considering the potential relevance of telecommunication standards, which were not examined in this study, for payment technologies in ERS, but likewise for other foreseen 'megatrends' besides electrification of transport like autonomous/automated and shared vehicles [3].

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