TRAFFIC

# E-vehicle charging

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## Abstract

Demand for electric cars has risen sharply in recent years. From a metrological point of view, a number of questions remain unanswered, such as how electricity meters in charging stations should be conformity assessed and with reference to which requirements. Various organisations, including OIML TC 12 *Instruments for measuring electrical quantities*, are active in this rapidly evolving domain of legal metrology.

## 1 Introduction

The market share of electric cars is growing at an ever faster rate. Electric vehicles (EVs) need charging stations to charge their batteries. The availability of public charging stations is one of the most important success factors for the acceptance of electric cars [1]. Consumers are used to the trustworthy measurement of volumes of petrol (gasoline) or diesel when they refuel their traditional car and so they expect the same level of trustworthiness from the measurement of electrical energy when they recharge their electric car.

However, while legislation for petrol (gasoline) stations is well established, this is not yet the case for regulations for electric vehicle supply equipment (EVSE). To harmonise the approach and use knowledge available in different OIML Member States, OIML TC 12 received a mandate to work on this matter in 2016 and a subgroup was set up within Project Group p 1 working on a revision of R 46 *Active electrical energy meters* [2]. Given the enormously rapid pace at which the EV charging infrastructure is developing worldwide, an increasing number of individual economies is recognising an urgent need to develop national or regional metrology regulations for EV charging. To prevent initiatives from diverging, and to support international harmonisation of metrological requirements, an OIML publication on this topic will be needed very soon.

EVSE at a government office in Zwolle, The Netherlands.

There is an increasing need for electric car charging infrastructures in many places worldwide. The OIML is playing a key role in ensuring trustworthy measurements of electrical energy transferred.

The time pressure made it unpractical for the EV charging subgroup to proceed as part of the R 46 revision project. Notably, the latter is a task of considerable breadth and extent even if EV charging is left out of the equation. Consequently, a new project group p 3 *Electric vehicle charging stations* was set up in 2021 [3] in order to prepare a stand-alone Guide rather than an annex to R 46.

## 2 OIML Guide *Electric vehicle supply equipment*

While the measurand in EVSE is the same as in utility applications, i.e. active electrical energy, the EVSE use case differs from traditional utility measurements. An individual document can account for these differences much better than an annex to a Recommendation for meters used in utility applications. The main differences are:

- EVSE transactions are more similar to direct sales than to utility applications;
- EVSE are designed for very specific operating conditions, e.g. when in use they are always connected to a vehicle using a standardised interface;
- EVSE are usually exposed to the elements, including sunlight, while in many OIML Member States utility meters are usually mounted indoors, often in cellars;
- all utility meters can be verified individually while the metering function in EVSE might be integrated into the electronics of the EVSE;
- EVSE show the measurement result on a purpose-built client interface – even if there is a physical display inside, e.g. on a separately approved meter, it is not visible to the trading parties, whereas a physical display is part of most utility meters; and
- testing can be very efficient when phantom power is used, but manufacturers may not be aware of this design constraint.

R 46 requires the meter to be a multi-purpose meter, suitable for use with any load – heaters, lamps, motors, PCs, etc. – connected to the electricity grid. This implies a large variety of operating conditions to be tested. Since those meters are designed for connection to the electricity grid, they shall withstand disturbances such as overcurrent caused by lightning. Since they are traditionally read once a year only, without remote communication, they must continue to measure correctly after the disturbance.

The interface between the EVSE and the vehicle, in turn, is standardised. For instance, the power factor must be close to unity, either because DC is used or because the vehicle's AC/DC converter is required to operate at unity power factor. The cable between the EVSE and the vehicle is very short compared to the electricity grid, so remote lightning strikes are not possible. Direct lightning strikes on the cable are unlikely, but if they happen, they are unlikely to affect only the measurement and not the control electronics. When such an event renders the EVSE completely dysfunctional, the consumer may be unhappy, but a correct metering function will have become irrelevant. Therefore, the requirements and tests may be adapted without adversely affecting the confidence the trading parties have in the measurement.

This, then, is the prime advantage of having a stand-alone, self-consistent document with 'blueprint' requirements and test procedures aimed at EVSE. It allows TC 12/p 3 to define requirements and associated test procedures that support the trustworthiness of the measurement of energy transferred through an EVSE; and to shed the burden of requirements and test procedures that are only needed in 'classical' utility applications, but that are not appropriate for the EV charging application. At the same time, this project is taking the opportunity to include requirements – albeit in rudimentary form – for the fastest growing side of the EV charging market: 'fast charging' stations delivering energy in DC form.

The OIML TC 12/p 3 Project Group aims to finalise the Guide on EVSE within a few months, to be used as a model for OIML Member States who wish to implement local regulations for measuring energy transferred to and from electric vehicles. Immediately after the publication of the Guide, the same Project Group will start working on the Recommendation that will, once published, replace the Guide.

## 3 Activities in other organisations

### 3.1 IEC

Standards on electrical power and energy transfer systems for electrically propelled road vehicles and industrial trucks with rechargeable batteries are prepared by IEC TC 69. These include the IEC 61851 series for conductive charging, the IEC 61980 series for wireless power transfer (WPT) and the ISO 15118 series for vehicle to grid communication. Standards of the IEC 62051 to IEC 62059 series in the field of electrical energy measurement, also for use in EVSE, are being prepared by IEC TC 13. One of the most recent standards is IEC 62053-41 for DC active electrical energy meters; its first edition was published in 2021 [4].

### 3.2 European Union (EU)

#### 3.2.1 Measuring Instruments Directive, mandate M/541

In the EU, national metrology law for active electrical energy meters is harmonised by the Measuring Instruments Directive (MID) [5]. Since the MID is intended to specify performance requirements rather than detailed technical specifications (Recital 25 MID), the level of abstraction is high. The result is that the MID is technology-independent and does not impede technical progress, but is difficult to apply for manufacturers and conformity assessment bodies. Therefore, the MID allows for harmonised standards that are published in the Official Journal of the EU to give presumption of conformity (Art. 14 MID). Those standards are prepared by the European standardisation organisations in response to a mandate issued by the European Commission, which checks them for compliance before publishing the reference in the Official Journal of the EU. In 2015, the EU Commission requested such standards "containing technical specifications concerning the legal metrological control of delivery to the public of AC and/or DC electricity, also for onboard metering, for use in electrical means of transport" with reference to the MID by 31 December 2017 by means of the standardisation mandate M/541 [6].

#### 3.2.2 Alternative fuels infrastructure: AFID, AFIR

In 2014, the Directive 2014/94/EU on the deployment of alternative fuels infrastructure (AFID) [7] set out a framework of common measures in the EU. Its scope includes all alternative fuels with practical relevance, such as hydrogen, and it also covers means of transport other than road vehicles, e.g. ships. It does not cover metrology. The Directive required Member States to set up national policy frameworks to establish markets for alternative fuels and to ensure that recharging and refuelling stations are publicly available in sufficient number. Relevant to the design and operation of EVSE are restrictions on the types of connectors that are to be used for connecting vehicles to EVSE and requirements on the transparency in communicating the unit price prior to the start of a charging session. However, the implementation lacked "ambition, consistency and coherence" [8]. The lack of interoperable, easy-to-use recharging and refuelling infrastructure risked becoming a barrier to the uptake of low- and zero-emission road vehicles, vessels and stationary aircraft, which is fundamental to the European Green Deal, a major European policy aiming for the reduction of greenhouse gas emissions. Therefore, the European Commission proposes to replace the AFID by a regulation (AFIR) [8]. A *Directive*, on one hand, is addressed to Member States and is binding as to the results to be achieved only; the choice of form and methods is left to the Member States. A *Regulation*, on the other hand, is binding in its entirety and directly applicable in all Member States [9].

### 3.3 DKE

Seeing the need for a standard that can give presumption of conformity with legal metrology requirements, the German Commission for Electrical, Electronic and Information Technologies (DKE) prepared VDE-AR-E 2418-3-100 [10], a standard for measuring systems for EVSE, and published it in November 2020. This standard includes system aspects, mainly related to data processing, storage and communication, as well as metrology aspects such as requirements for the active electrical energy meter, AC or DC, used in the EVSE.

### 3.4 CENELEC

In principle, IEC standards are transformed into CENELEC standards without modification. However, standards are commonly used as a means to show compliance with EU legislation such as the Measuring Instruments Directive (MID) [5]: If a product complies with a standard that is listed in the official journal of the EU, the manufacturer may presume compliance with the relevant EU legislation. Therefore, the relevant standards must be adapted to fulfil the requirements of the relevant regulation. In many cases, this means only that a European Annex ZZ is added. This annex establishes a link between the individual articles of the EU legislation and the clauses and subclauses of the standard. In some cases, however, a dedicated European standard has to be prepared. In the context of active electrical energy meters, the most relevant example is the EN 50470 series. At present, CENELEC TC 13 is preparing a new standard for DC active electrical energy meters, EN 50470-4; work started at the end of 2021. This standard is prepared in response to the European Commission's mandate M/541 [6] and intended for giving presumption of conformity with the requirements of the MID.

The decision of CENELEC TC 13 to start working on EN 50470-4 in response to the European Commission's mandate M/541 was taken after the start of the LegalEVcharge project and the NordCharge activities explained below. Therefore, the LegalEVcharge and

NordCharge consortia jointly prepared a provisional standard. Once EN 50470-4 is published, the provisional standard will become redundant. Since the common basis for both standards is the MID and the consortia are well represented in CENELEC TC 13, EN 50470-4 is expected to be very similar to the provisional standard. Should meters that are compliant with the provisional standard need to be modified to make them compliant with the future EN 50470-4, the modification will most likely be minimal.

### 3.5 EURAMET TCEM: LegalEVcharge

In order to prepare the technical infrastructure for an EVSE legal metrology framework, in December 2020 a number of metrology institutes from different European countries decided to set up the joint project LegalEVcharge (EURAMET TCEM project no 1539) [11].

The European Directive 2014/32/EU (MID) is applicable in all participating countries and is therefore taken as the basis for the work. As a first step, the consortium analysed the existing legal framework and provided guidance; the result is published online [11].

To make sure the proposals are practically viable and pragmatic, systems for laboratory and on-site verification will be set up and tested. The project provides a platform for exchange of ideas and experience, both with technical and legal implementation questions. For instance, the principle of proportionality calls for transitional provisions to be chosen carefully: On the one hand, the regulation to be prepared needs to come into force as soon as possible; on the other hand, previous investment in charging infrastructures must be protected.

The project consortium reached out to e-vehicle charging stakeholders to ensure that the proposed solutions are useful and practical.

### 3.6 NordCharge

NordCharge, the Nordic co-operation on charging stations for electric vehicles working on metrological regulation, started work in early 2021. The consortium closely co-operates with LegalEVcharge; some documents were issued jointly. In addition, NordCharge prepared guidance for making EVSE available on the market. The guidance is based on existing legal requirements such as the MID. Given the principle of mutual recognition, this guidance cannot be enforced as such by legal metrology legislation. However, its content is based on the MID, which is enforceable. The guidance explains the obligations of EVSE manufacturers, importers and charge point operators, which are often new to the legal metrology environment.

### 3.7 WELMEC

To exchange information on metrology regulations for EVSE between WELMEC members, WELMEC WG 11 subgroup electricity set up the Ad Hoc Group 3 (WG11/SGe/ahg3) in March 2021. This group is now working on a common view on which of the MID requirements apply to public EVSE. While waiting for EN 50470-4 in response to the European Commission's mandate M/541 [6], the AHG will also prepare a common view on the use of DC active electrical meters in EVSE. To make regulations easier to find (especially for manufacturers and charge point operators) the group will prepare an overview of regulations in the different Member States. Further, the AHG will provide guidance to test laboratories assessing EVSE in coherence with applicable legal metrology requirements. This guidance is supported by a broad group of WELMEC Member States, including most members of NordCharge and LegalEVcharge. In addition to existing results from the latter two projects, the WELMEC guidance will also take into account the work of the OIML, IEC, CENELEC, and the German standardisation committee DKE.

## 4 Legal framework

### 4.1 European Union (EU)

Free movement of goods is one of the four freedoms of the EU and its single market. In the context of legal metrology, two different mechanisms are relevant: harmonisation and mutual recognition. Harmonisation is achieved through common requirements, for example set out in a European Directive. Since all requirements across the Union are the same, goods can move freely. Mutual recognition (commonly referred to as the "Cassis de Dijon principle"), in turn, requires all Member States to accept goods lawfully marketed in another Member State and applies only in the absence of harmonisation. In this case, the requirements are not identical, but considered equivalent. A short list of legitimate public interest grounds for exceptions from the principle of mutual recognition is defined in Regulation (EU) 2019/515 [12].

In the EU, metrology law is the responsibility of the individual Member States. However, the provisions for

certain measuring instruments are harmonised by the EU's Measuring Instruments Directive (MID) [5]. Countries may prescribe the use of these instruments, in which case they must adopt the provisions of the MID and deviations are not permitted. This Directive thereby removes barriers to trade on the EU market by defining common requirements. It applies to measuring instruments placed on the market or put into service for the first time.

National regulations for the active electrical energy metering function of EVSE are harmonised under the MID, regardless of whether the EVSE contains a conformity-assessed meter or is conformity assessed as a measuring instrument. Any other legal metrology regulation for EVSE is not harmonised and therefore subject to Regulation (EU) 2019/515.

### 4.2 USA

In the United States, to promote the development of uniform laws, regulations and methods of practice, coordination and collaboration is initiated at the national level. Important considerations in legal metrology include traceability to the International System of Units (SI) and harmonisation with international standards. Commercial measurement standards are published in NIST Handbooks once adopted at the national level. The States adopt handbook requirements in part or entirety and enforce them. Multiple states have also enacted legislation to recognise the fact that the sale of electricity dispensed as a vehicle fuel is not subject to regulation as a utility. The method of sale of electricity, by the kilowatt-hour when sold as a vehicle fuel and other fees related to that sale, were published in NIST Handbook 130 in 2014 [13]. The NIST Handbook 44 EVSE requirements are the basis for type evaluation; the first edition was published in 2016, and the current in 2022 [14]. An EVSE submitted for type evaluation must include documentation of the certification of the system's design and construction compliance with relevant current electrical safety standards by nationally recognised testing laboratories.

### 4.3 Canada

In Canada, all trade measurements are governed by federal legislation under the *Weights and Measures Act* and Regulations, and the *Electricity and Gas Inspection Act* and Regulations. National requirements are developed where internationally recognised standards are either not available or not appropriate for the Canadian marketplace. OIML Recommendations are adopted as much as possible. For the electricity measurement discipline, only Canadian standards are currently being used. Canada is developing standards for EVSE. Elements of the US Handbook 44 and the OIML Draft Guide are being used to develop the Canadian requirements. It is expected that Canada will adopt OIML Recommendations for EVSE when they are completed.

## 5 Conclusion

In the context of the ever increasing urgency of the global energy transition, the topic of electric vehicle charging has been steadily gaining interest over the past years. In this article, we summarise ongoing and recent activities in the domain of legal metrology for EVSE. It is in the interest of legislators, manufacturers, users, and customers – and indeed society as a whole – that any requirements defined are as convergent as possible between countries and regions. In terms of international harmonisation of legal metrology requirements for EVSE, the OIML has a special role in the landscape of actors. In an attempt not to be overtaken by the high-speed rollout of charging infrastructures in various places worldwide, the OIML is developing the EVSE Guide at a pace that is untypical in the world of international standardisation. ■

## 6 References


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[3] Working draft OIML EVSE version 020, Reference no TC 12_p3_N008, issued on 22 December 2021

[4] IEC 62053-41:2021 *Electricity metering equipment – Particular requirements - Part 41: Static meters for DC energy (classes 0,5 and 1)*

[5] Directive 2014/32/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of measuring instruments (recast)

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[8] Proposal for a Regulation of the European Parliament and of the Council on the deployment of the alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council, COM(2021) 559, 14 July 2021

[9] Treaty on the Functioning of the European Union, OJ C 326, 26.10.2012, p. 47–390

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[13] NIST Handbook 130 – *Uniform Laws and Regulations in the Areas of Legal Metrology and Fuel Quality* as adopted by the 106th National Conference on Weights and Measures 2021 (version 2022)

[14] NIST Handbook 44 – *Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices* as adopted by the 106th National Conference on Weights and Measures 2021 (version 2022)