Tutorial Title

Electric Vehicle Charging Systems: Power Quality, Metering Accuracy, and On-Site Verification

Speaker

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Webpage/CV link/short bio	https://orcid.org/0000-0001-6074-8633 Angela Espin-Delgado received the M.Sc. degree in electric power engineering from Los Andes University, Bogotá, Colombia, in 2018, and the Ph.D. degree in electric power engineering from Luleå University of Technology, Luleå, Sweden, in 2022, during which she investigated the propagation of high frequency (2 – 150 kHz) waveform distortion and its impact on low- and medium-voltage grids. Her work experience includes the design of low-voltage installations, power quality studies, measurement technology, signal processing, and machine learning. She is currently working as a researcher at RISE Research Institutes of Sweden where she investigates on measurement data analysis techniques and measurement technologies for power quality in the modern electricity grids.

Abstract

The rapid expansion of electric vehicle charging infrastructure across Europe requires charging systems that operate reliably, efficiently, and with fair, traceable energy metering. However, present metrology and power quality (PQ) assessment methods are still insufficient to evaluate the increasingly complex behaviour of modern electric vehicle charging systems (EVCS). The European Met4EVCS project, that started mid-2024, addresses these challenges by developing a comprehensive, traceable metrology framework for AC and DC charging systems under realistic grid and charging conditions.

This tutorial introduces participants to the latest methods for EVCS from a metrological and PQ perspective. The session begins with an overview of representative on-site operating conditions, including grid disturbances, local grid impedance, and EVCS-emitted distortion up to 150 kHz. These conditions can significantly influence the charging efficiency of the EVCS and the accuracy of incorporated metering devices, yet they are currently not fully reflected in existing standards or test benches. The latter has led to the development of new measurement equipment and methods to capture these phenomena, based on field measurements at multiple AC and DC charging sites across Europe.

The tutorial then focuses on the development of traceable test benches for the laboratory characterisation of EVCS under realistic operating conditions. These include AC systems up to 44 kW and DC systems up to 350 kW, supporting realistic evaluation of metering

accuracy, conducted emissions, and energy transfer efficiency with uncertainties as low as 0.1 %. The development of advanced EV load emulators capable of replicating voltage and impedance dynamics observed in real EV charging processes will be presented as well. Such tools enable more representative and reproducible testing scenarios, supporting both manufacturers and metrology institutes in improving EVCS performance assessment.

A third focus area is the development of on-site verification procedures for EVCS energy metering, targeting a maximum uncertainty of 0.5 %. These procedures respond to the urgent industry need for cost-effective, portable, and standardised tools for legal verification of EVCS energy metering. This contributes directly to the work of OIML TC 12, WELMEC WG 11, and IEC TC 69, and provides input to emerging international standards and regulatory frameworks.

Participants will gain:

- A technical understanding of how EVCS affect the grid and how grid conditions affect EVCS energy metering
- Insight into emerging European test benches and metrology infrastructure for characterisation of EVCS
- Practical guidance on energy metering evaluation of EVCS
- Practical guidance on-site verification of EVCS energy metering

This tutorial is aimed at professionals in power quality, metrology, EV infrastructure, measurement instrumentation, standardisation, and grid operation.