Electrification of Transport

Power Quality Guidelines

ENEDIS
L'ELECTRICITE EN RESEAU

Elaadnl

Due to committed attitude towards supporting clean transportation, French grid operator Enedis and Dutch e-mobility foundation Elaad, collaborate on charging infrastructure, aiming to drive electric mobility integration within the distribution grid.

To achieve this, innovative work on power disturbance testing between EVs and the grid has been undertaken to anticipate and avoid malfunctions. Six recommendations are offered to share awareness of power quality impacts and improve e-mobility grid integration for EV stakeholders.

#1 - Raise awareness on Power Quality issues among e-mobility players

OBSERVATION: The increased diffusion of Power Electronic equipment in the energy grid, including the influx of EVs, brings new challenges in the domain of Power Quality (PQ). Despite these changes and the fact that PQ is a core business component for distribution grid operators, it remains a relatively unknown area. Moreover, EV charging has some specificities which can lead to concerns about PQ: the very large variety of electric environments where EVs are charging; the conception of charger by vehicle manufacturers aiming primarily at compactness, weight and cost; the controllability of charging power.

RECOMMENDATION: It is essential to raise awareness and educate a wide variety of e-mobility stakeholders on the topic of Power Quality. To reach a broad range of stakeholders, information should be communicated through multiple channels. ElaadNL and Enedis have already created animated movies and presented findings at a Power Quality webinar. Future dissemination efforts can be directed towards events such as the Electric Vehicle Summit or a European conference.

#2 - Integrate Smart Charging in the research and standardization of harmonic emissions

OBSERVATION: The IEC 61000-3-2 standard defines the harmonic current limits for electronic equipment rated up to 16A operating in the mode expected to produce the maximum total harmonic current. The IEC 61000-3-12 standard defines the harmonic current limits for equipment rated 16A - 75A operating at its rated current. In both cases, a single operating point is used for compliance testing. However, the charging power of EVs can be controlled which can significantly alter the behaviour of the equipment emissions, especially when lowering the charging power. Consequently, low power operation points can generate much higher total harmonic distortion than the rated operation point.

RECOMMENDATION: For both standards, a new category of controllable loads can be created which include electric vehicles. In addition to the harmonic limits already defined in the standards, harmonic limits at different operating points can be set as a percentage of the drawn current. The tests of standard compliance would also be adapted to address several operating points.

#3 - Integrate Smart Charging in the research and standardization of supraharmonic emissions

OBSERVATION: Electric vehicles can emit supraharmonic distortions which could cause overheating and malfunctioning of electronic components, devices, and distribution grid assets. Little is known about the propagation of these emissions and no formal emission, immunity and testing standards have been defined yet. Furthermore, although grid impedance is related to frequency, how supraharmonic frequency affects the grid is under-researched.

Research in this area is essential to determine how supraharmonic currents propagate through the grid and if these currents have negative effects on grid components or other electronic devices.

RECOMMENDATION: When testing electric vehicles, gathering data on: 1) the supraharmonic behaviour during smart charging; 2) the interaction effects and 3) the time-varying distortions. Then use these data to create a category of controllable loads in the 61000-2-2 standard future evolutions. To better understand the impact of these supraharmonic distortions, measurements of supraharmonic impedance in typical grids should be performed. This can include:

- Execute supraharmonic impedance measurements in typical electricity grids in the Netherlands and France.
- Share research data with the different research institutes and standardization committees working on supraharmonic distortions.
- Conduct further research regarding instability phenomena and supraharmonic interaction between electric vehicles.

#4 - Define criteria for laboratory assessment of EV charging quality

OBSERVATION: With no existing standard testing procedure for charging quality, there is a need to define criteria to generate a representative characterization of an EV charger in terms of harmonic and supraharmonic behaviours. This applies mainly to onboard chargers but could apply to direct current chargers as well.

RECOMMENDATION: To fully understand how an electric vehicle charger functions with regards to emissions of PQ distortions and sensitivity to distortions emitted from other appliances, new laboratory test scenarios can be administered. These include:

- Assessing charger operating points to determine an electric vehicle's ability to perform efficient smart charging.
- Measuring EV charger harmonic and supraharmonic emissions for each operating point in ideal and deteriorated voltage conditions.
- Sensitivity/Immunity measurements of electric vehicle charging for different scenarios of harmonic and supraharmonic voltage injections.

#5 - Define "Power Quality proven" and "Smart charging ready" labels for EVs

OBSERVATION: With the increasing manufacture and market presence of EVs, it is safe to say that the prevalence of EVs on our roads will continue to grow over the coming years. Despite this, existing legislation relates solely to vehicle safety and driving characteristics and there is a lack of consideration towards factors related to EVs and charging.

RECOMMENDATION: A government-approved assessment of the charging quality of EVs. This assessment could be realised through "Power Quality Proven" and "Smart Charging Ready" labels.

To qualify as "Power Quality Proven", EVs would be subject to rigorous laboratory testing and fulfil a designated number of Power Quality indicators that ensure harmonic and supraharmonic emissions do not exceed a defined limit based on IEC standards across a variety of measurement conditions.

To qualify as a "Smart Charging Ready" vehicle, their EV charger behaviour can be assessed in terms of:

- EV time responsiveness to station instructions (charging delays and pauses, change of charging speed, etc.),
- EV capability to follow charging speeds transmitted by a charging station.
- Ability to maintain charging efficiency (reasonable power factor, reasonable total harmonic distortion, etc.) when charging at low speeds.

#6 - Adapt charging power to voltage levels

OBSERVATION: Electric vehicle testing in the ElaadNL testlab revealed that some vehicles continued charging when the voltage drops as low as 100 volts. It has also been observed that some vehicles even increase their current intake when the voltage drops, to keep the amount of power (current x voltage) at the same level.

RECOMMENDATION: To avoid electrical vehicle charging during voltage drops, standards must be defined at (inter)national level that addresses critical threshold values. The following standards are recommended:

- Charging stations and/or electric vehicles should measure voltage and reduce the maximum charging speed if the voltage falls outside the specified threshold values.
- Utilizing threshold values of voltage limits defined in the IEC 50160. When the voltage drops by 10% (from 230V to 207V) the current should be reduced, and when it drops by over 15% (to 195.5V or less) charging should be stopped until the voltage level is returned to within optimal limits.
- Vehicles and direct-current charging stations should be able to detect malfunctions in the energy supply, such as high sudden voltage drops, and immediately stop charging.

To know more about power quality and e-mobility watch the videos below:

From France

International PQ webinar

From Holland

For more about e-mobility and electric network management go to:

www.enedis.fr **www.elaad.nl**

Graphic Design: GECO Global