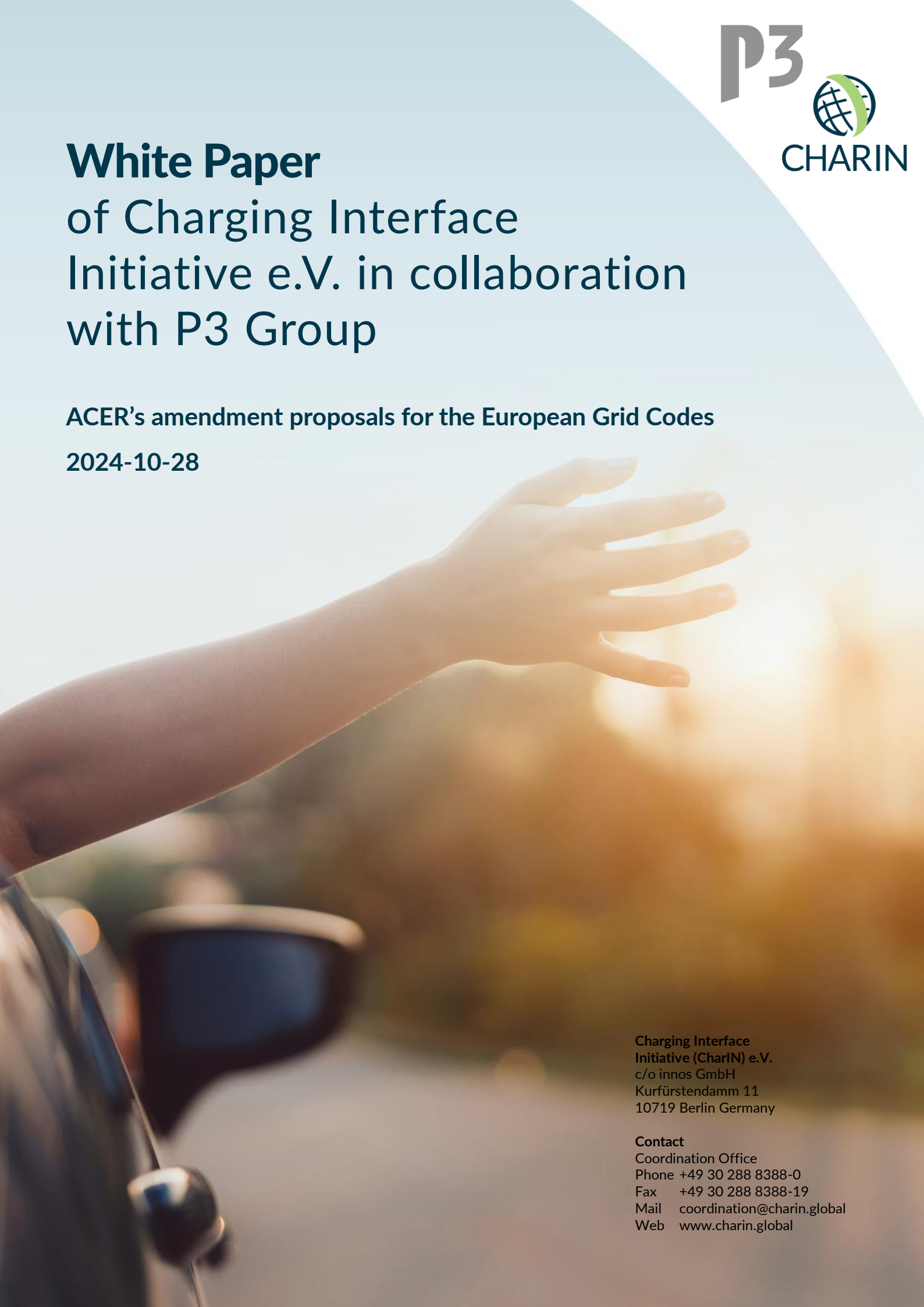
White Paper
of Charging Interface Initiative e.V. in collaboration with P3 Group

ACER's amendment proposals for the European Grid Codes

2024-10-28



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Content

1. Executive Summary

The role of electric vehicles in Europe's electricity grids is becoming increasingly important. The increasing number of electric vehicles represents a challenge for electricity grids, particularly in the context of the energy transition, but also an opportunity. Load peaks and thus grid instabilities can be induced by the charging electric vehicles, but can also be compensated for example in the case of volatile electricity generation from renewables.

The European legislator has recognized the need for uniform grid connection requirements for electric vehicles (EVs) and electric vehicle supply equipment (EVSE) and has commissioned the Agency for the Cooperation of Energy Regulators (ACER) to expand the existing set of European Grid Codes to include the connection of EVs and EVSE. At the end of 2023, ACER submitted amendment proposals of the Grid Codes to the European Commission.

The drafts contain several changes that are intended to harmonize the requirements for the integration of EVs into the electricity grid across Europe and improve the stability and resilience of the electricity grid in view of the increasing number of vehicle-to-grid (V2G) electric vehicles. They will also help to ensure that V2G EVs can provide valuable ancillary services to the grid, such as frequency regulation and reactive power compensation. These support services are essential for maintaining the balance between electricity supply and demand in real-time. If the European Commission follows ACER's proposals, the updated grid connection requirements can be expected to be applied by the end of this decade.

This whitepaper aims to clarify ACER's proposed requirements for EVs and electric vehicle supply equipment (EVSE) in the V2G context, outline the necessary actions for affected stakeholders and detail the forthcoming steps in the legislative process.

2. Status quo of European Grid Connection Requirements

The framework of national grid connection conditions in Europe is defined by EU regulations 2016/631 (Requirements for Generators) and 2016/1388 (Network code on Demand Connection). Until now, neither of these regulations explicitly applied to the connection of EV and EVSE. The proposed amendments developed by ACER aim to ensure that both Grid Codes will apply to EVs and EVSEs in the future and that there are exhaustive requirements for EVs and EVSE throughout Europe. The requirements for V2G bidirectional power transfer will be described in EU 2016/631, while the requirements for unidirectional charging will be outlined in EU 2016/1388. This document focuses on the upcoming Requirements for Generators.

European Grid Codes in transition

EU 2016/631
Requirements for Generators

EU 2016/1388
Network code on Demand Connection

3. The path to the proposed amendments to the EU Grid Codes

In September 2022, the European Commission proposed that ACER initiates the process to prepare reasoned proposals for amendments to the grid connection network codes.[1] Until the final publication of the amendment proposals in December 2023, ACER gathered input from 66 stakeholders through public consultations (Sep-Nov 2022[2] and Jul-Sep 2023[3]) as well as workshops (Apr & May 2023[4]). The energy industry was the most represented, with a total of 50 stakeholders (e.g. Eurelectric, ENTSO-E, and various grid operators), followed by the mobility sector with 10 stakeholders, including OEMs (VW, Porsche, Mercedes-Benz, Renault and Volvo) and CharIN e.V.

4. Requirements for Generators (EU 2016/631)

Introduction

Grid connection requirements for generators have been codified in EU 2016/631 since 2016. In the future, V2G-capable EVs and EVSEs will also be covered under the successor of EU 2016/631 due to their power feeding function. The proposed amendment to EU 2016/631 categorizes the combination of V2G-capable EVs and EVSEs into three types based on their maximum capacity[5]:

Type EV1: 0,8kW – 2,4KW

Type EV2: 2,4kW – 50KW

Type EV3: 50kW – 1MW

Analogous to conventional generators, the proposed amendment to EU 2016/631 specifies the following sets of requirements for each of the three types:

- Technical requirements (esp. Art. 13a & 14a)
- Requirements for operational notification (esp. Art. 30a & 31a)
- Requirements for conformity (esp. Art. 42.5)

[1] Recommendation No 03/2023 of the European Union Agency for the Cooperation of Energy Regulators (19 December 2023), I (1)
[2] https://www.acer.europa.eu/documents/public-consultations/pc2022e08-public-consultation-amendments-grid-connection-network
[3] https://www.acer.europa.eu/documents/public-consultations/pc2023e07-public-consultation-amendments-electricity-grid-connection-network-codes
[4] https://www.acer.europa.eu/public-events/acer-workshop-electromobility-power-gas-demand-units-and-heat-pumps
https://www.acer.europa.eu/public-events/acer-workshop-rate-change-frequency-and-grid-forming-capabilities
https://www.acer.europa.eu/public-events/acer-workshop-electricity-storage
[5] EU 2016/631amd Art. 5(6)

Technical requirements

For each type, the proposed amendment to EU 2016/631 describes technical requirements for nominal operation, fault behavior, protection and control systems, and active power provision (see Table 1). Additionally, for EV3, specific requirements for system restoration and grid-supporting services are defined, including reactive power, dynamic reactive current support, asymmetric current, and grid-forming capabilities. In the case of the EV3 requirements, the draft legislation obligates grid operators to specify the individual grid connection conditions (see positions marked with a * in Table 1).

Table 1 – Grid connection requirements for EV1, EV2, and EV3 according to EU 2016/631 amendment, Articles 13a & 14a

Subject	Comment		EV1	EV2	EV3
Frequency	Nominal operation	Frequency & time ranges (47,5@30min-52,5 Hz@10s)	13a(1a)		14a(1)
		Rate of change of frequency (±1,25@2s - ±4 Hz/s@0,25s)	13a(1b)		
	Protection systems must not jeopardize nominal operation		13a(1c)		
Communication	Cyber-secure interface for control by the system operator		13a(2)		
Autonomy	Autonomous establishment or restoration of grid connection		13a(3) & (4)		
Active Power	Limited frequency sensitive mode – underfrequency		13a(5)		
	Limited frequency sensitive mode – overfrequency		13a(6)		
	Provision of active power under nominal conditions		13a(7)		
Voltage	Nominal operation	Voltage range (0,85-1,1 pu)	13a(8)		
	Fault-ride-through capability (FRT)		13a(9) - (12)		
	Nominal operation	at 1-110kV (*)	-		14a(2)
		at ≥ 110kV (*)	-		
	Fault-ride-through Capability		-		14a(3)
System Restoration	Reconnecting to the network after an incidental disconnection		-		14a(4)
Network Management	Control schemes and settings (*)		-		14a(5)
	Electrical protection schemes and settings (*)		-		
	Prioritization of protection and control devices		-		
	Real time information exchange (general*, metering, fault recording*, quality of supply*, dynamic system behavior*)		-		
Additional Capabilities	supply and absorb reactive power (*)		-		14a(6)
	Provision of fast fault current (*)		-		
	Asymmetrical current injection (*)		-		
	Post-fault active power recovery (*)		-		14a(7)
	Grid forming capability (*)		-		14a(8)

Requirements for operational notification of EVSE

The operational notification procedure for connection of each new type EV2 associated V2G EVSE shall consist of submitting an installation document containing at least information on location and date of the connection, maximum capacity of the installation and equipment certificates.[6] For the purpose of operational notification for connection of each new type EV3 V2G EVSE, a supply equipment document (SED) shall be provided. For the EV3 SED, a system operator shall have the right to request that the

[6] EU 2016/631amd Art. 30a

electrical charging park owner includes specific information such as compliance test reports demonstrating steady-state and dynamic performance.[7] An operational notification of type EV1 is not mentioned and is therefore not required.

Requirements for conformity

Art. 5(6) states that EV2 V2G EV and EV1 V2G and V2G EVSE shall possess equipment certificates, proving compliance.[8] In contrast, Art. 42(5) states that the compliance of V2G EV and V2G EVSE, shall be based on individual type-test certificates.[9] It remains unclear how equipment certificates differ from type test certificates.

As mentioned, for the purpose of operational notification of EV3 V2G EVSE a system operator shall have the right to request information on compliance test reports demonstrating steady-state and dynamic performance. For these test reports the draft legislation refers to provisions for synchronous power generating units (sPGU) and power park modules (PPM) summarized in Table 2.[10] It remains unclear how to determine which of the different types of sPGU and PPM apply to EV3 V2G EVSE.

Table 2 – Compliance requirements for sPGM and PPM according to EU 2016/631 amendment, Art. 44-49 and Art. 51-56

	Synchronous Power Generating Unit (sPGM)		Power Park Modules (PPM)	
Scope	Type B	Type C	Type B	Type C
LFSM-O	x	x	x	x
LFSM-U	-	x	x	x
FSM	-	x	-	x
Frequency restoration	-	x	-	x
Black start capability	-	x	-	-
Tripping to houseload	-	x	-	-
Reactive power capability	-	x	-	x
Active power output	-	-	-	x
Voltage control	-	-	-	x
Reactive power control	-	-	-	x
Power factor control	-	-	-	x

[7] EU 2016/631amd Art. 30b
[8] EU 2016/631amd Art. 2(47): 'equipment certificate' means a document issued by an authorised certifier for equipment […]. The equipment certificate defines the scope of its validity at a national or other level […]. For the purpose of replacing specific parts of the compliance process, the equipment certificate may include models that have been verified against actual test results.
[9] EU 2016/631amd Art. 42(5): The compliance of V2G electric vehicle and V2G electric vehicle supply equipment, shall be based on individual type-test certificates issued according to Regulation (EC) No 765/2008 regarding the V2G EVSE on one side and the V2G EV homologated platform (in case of AC connection of V2G electric vehicle) on the other side."
[10] EU 2016/631amd Art. 30b(e):" compliance test reports demonstrating steady-state and dynamic performance as required by Chapters 2, 3 and 4 of Title IV" and EU 2016/631amd Art. Article 44-50

5. Need for action

As mentioned above, some topics are not clearly specified in the proposed amendment of the European Network Codes, which are addressed in this chapter.

Aggregation of capacity

Proposed amendment to EU 2016/631 recommends not to require an aggregation of capacities when determining the significance of power generating units.[11] The industry urges national authorities to follow this reasoning to avoid different requirements across Europe.

Response time

With regard to the limited frequency sensitive mode (underfrequency) Art. 13a(5e) states that "the response time [...] shall be less or equal to 0,5 s for an active power setpoint change of 100% of Pmax". For AC-charging the frequency measurement has to take place in the EV in order to support such a short response time. This requirement poses a huge challenge for vehicle architectures which are currently under development. A longer transition period needs to be granted in order to prepare vehicle architectures accordingly. Otherwise, electric vehicles would not be able to connect to the grid legally.

Revision of local grid connection requirements

The European grid connection conditions define the framework within which the locally applicable grid connection conditions ("requirements of general application") have to comply. Hence, the currently applicable local grid connection conditions must be checked for required adaptation (e.g. VDE-AR-N 4100 and 4105 for Germany). The proposed amendment of EU 2016/631 requires that updates of "requirements of general application" must be submitted within two years after entry into force.[12] In addition, the draft legislation of EU 2016/631 explicitly points out that the requirements applicable to EV3 must be specified by the grid operators (see with * marked positions in Table 1). From an industry perspective authorities and system operators should ensure that requirements of general application are harmonized throughout Europe and finalized as soon as possible to ensure that manufactures have sufficient time to incorporate requirements in their product design.

[11] 2016/631amd (11):" To ensure an appropriate harmonisation or rules for mass-market products, capacities of units of different underlying technology, [] should not necessarily be aggregated for the purpose of the determination of significance"
[12] EU 2016/631amd Art. 7(5):" The relevant system operator or TSO shall submit a proposal for requirements of general application [...] for approval by the designated entity within two years of entry into force of this Regulation.

Conformity requirements

Unambiguous requirements: As already mentioned, the draft regulation requires equipment certificates and type test certificates respectively as proof of conformity. It is necessary to explain how the two conformity documents differ and for which case which proof is required.

Homologation: The amendment proposal of EU 2016/631 requires EVs to demonstrate compliance via test-type certificates. To avoid that grid operators must request type-test certificates each time a vehicle connects it is recommended that the type-test certificate is incorporated in EV homologation documentation.

Compliance test reports for EV3: As mentioned, the amendment proposal of EU 2016/631 grants the system operator to request compliance test reports which are related to synchronous power generating units (sPGM) and power park modules (PPM). If this provision remains, the legislator must clarify how to determine which of the mentioned sPGM and PPM related compliance requirements apply to EV3.

Cyber Security

Art. 13a(2) states that a V2G EV or V2G EVSE, as relevant, shall be equipped with a data exchange interface. During the public consultation, ACER referred to the Network Code on Cybersecurity[13] which according to ACER will apply to data exchange per se.[14] Hence, in addition to meet with RfG-requirements, EV and EVSE manufacturer must take provisions by the Network Code on Cybersecurity into consideration when designing their products.

Interoperability

To guarantee interoperability EV and EVSE manufacturers shall follow the relevant product standards (ISO 5474 series, IEC 61851 series, ISO 15118-20) that also define configuration and communication processes. For ISO 15118-20 an update is in progress and is expected to contain relevant grid code parameters. Also, stakeholders must agree whether the data exchange interface is located in the EVSE or EV as well as which protocol will be used for communication (e.g. OpenADR).

[13] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401366

[14] https://www.acer.europa.eu/sites/default/files/documents/Recommendations_annex/ACER_Recommendation_03-2023_Annex_7_Evaluation_PC_2023_E_07.pdf (p. 71, row 4)
Stakeholder's perspective: The stakeholders propose to define the cyber protection for the data exchange interface. They also propose to use a more generic definition, such as "communication interface".
ACER view: As the Network Code on Cybersecurity will apply to data exchange per se, the grid connection network codes do not need to include any specific definition. The Network Code on Cybersecurity will define its own scope.

Grid modernization

In the event that grid stability is jeopardized, EU 2016/631 intends to enable grid operators to regulate the power generated by electricity-generating units.[15] Accordingly, grid operators are required to check their IT infrastructure and digitalization strategies for the need for adaptation, such as the implementation of coordinated control logics and monitoring systems to monitor and control the feed-in power of EVSE and EVs.

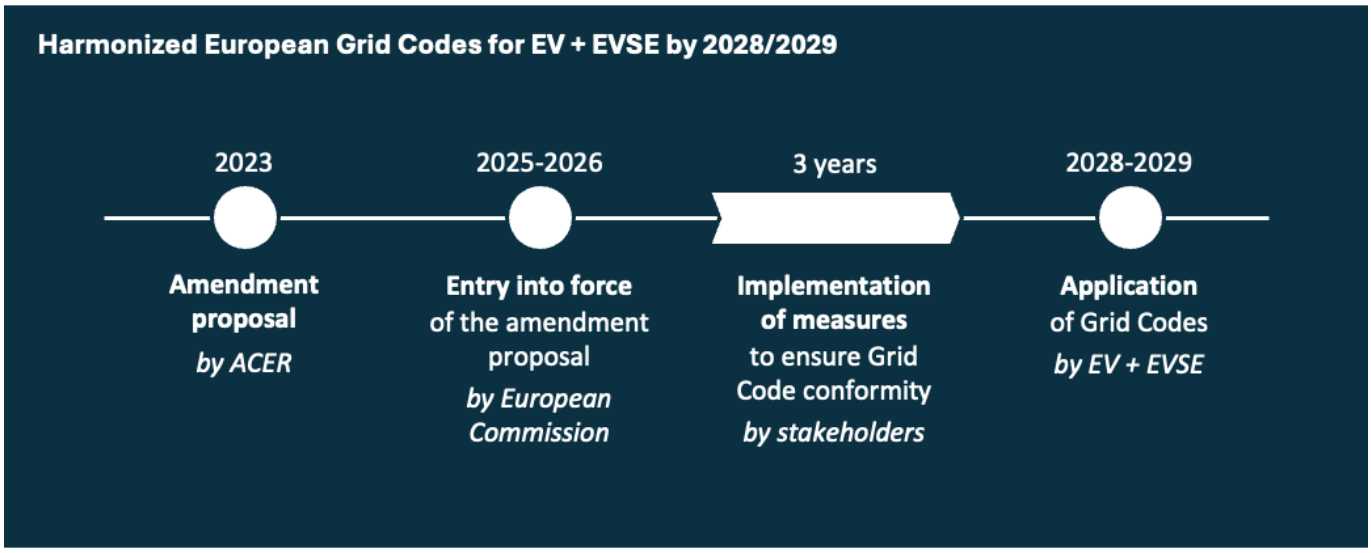
Funding programs and cooperations

The implementation of the updated grid connection requirements will pose economic challenges for some stakeholders. For example, smaller distribution system operators (DSOs) may not be able to upgrade their IT infrastructure on their own. It is necessary to examine whether funding programs and/or consortia can reduce the financial burden on individual stakeholders and thus accelerate the development of V2G potential.

[15] see. EU 2016/631amd Preamble Nr. 24: "In emergency situations which could endanger system stability and security, system operators should have the possibility to instruct that the output of power-generating modules be adjusted in a way which allows system operators to meet their responsibilities for system security." or EU 2016/631 Art. 13a(2): "A V2G electric vehicle or V2G electric vehicle supply equipment, as relevant, shall be equipped with a data exchange interface in order to modulate, without undue delay, active power output and input following an instruction being received at the input port."

6. Outlook

After ACER has provided the draft legislation for the grid codes to the European Commission at the end of 2023, the legislative process will follow via readings in the European Parliament and the European Council. According to the current proposal the fulfilment of the requirement should apply 3 years after entry into force.[16] Within this period, affected stakeholders must implement measures to ensure conformity with the network code requirements by the deadline. It can be assumed that the network code requirements will have to be met by the end of the decade.



[16] EU 2016/631amd Art. 72

7. Glossary

European Grid Codes: Regulations that define the requirements for connecting various types of electricity generators and consumers to the grid to ensure stability, security, and efficiency of the power supply.

ACER: Agency for the Cooperation of Energy Regulators, responsible for coordinating and regulating energy markets at the European level. ACER has been tasked with proposing amendments to existing Grid Codes to include electric vehicles (EVs) and electric vehicle supply equipment (EVSE).

V2G electric vehicle supply equipment means the infrastructure necessary to conduct electrical energy safely from the electricity supply grid to the electric vehicle and from the electric vehicle to the electricity supply network with both generation and demand behaviour. Electrical wirings are not deemed part of an electric vehicle supply equipment. This definition takes into account all solutions, regardless of whether the V2G electric vehicle supply equipment contains the inverter or not.

V2G electric vehicle means the vehicle that is powered, fully or in part, with electricity and is equipped with technology enabling the vehicle to inject electricity to the network over a V2G electric vehicle supply equipment. This definition takes into account all solutions, regardless of whether the V2G electric vehicle contains the inverter or not.

Synchronous power-generating module or 'SPGM' means a set of machines which cannot be operated independently from each other and can generate electrical energy such that the frequency of the generated voltage, the generator speed and the frequency of network voltage are in a constant ratio and thus in synchronism.

Active power means the real component of the apparent power at fundamental frequency, expressed in watts or multiples thereof such as kilowatts ('kW') or megawatts ('MW'). Active Power in the context of generators and Vehicle-to-Grid (V2G) systems is the portion of electrical power that is converted into useful work. This includes powering electrical devices, driving motors, and charging batteries in electric vehicles. For generators, active power represents the electricity that is actually supplied to the grid and consumed by end users. In V2G systems, it is the power that electric vehicles can either consume from or supply to the grid, contributing to the overall energy balance and grid stability. Active power is measured in watts (W).

Reactive power means the imaginary component of the apparent power at fundamental frequency, usually expressed in kilovar ('kVAr') or megavar ('MVAr'); Reactive Power in generators and V2G systems refers to the component of electrical power that supports the voltage levels necessary for the effective transmission of active power. It is crucial for maintaining the voltage stability of the grid, especially in systems with significant inductive or capacitive loads. Reactive power does not contribute to the actual energy consumed but is essential for the functioning of the grid. In V2G systems, electric vehicles can provide reactive power support, enhancing grid stability and reliability. Reactive power is measured in volt-amperes reactive (VAR).

Rate of change of frequency (RoCoF) withstand capability refers to the ability of electrical equipment, such as generators, inverters, and other grid-connected devices, to continue operating correctly and without damage when subjected to rapid changes in the grid's frequency. This capability is crucial for

maintaining grid stability, especially in scenarios involving significant fluctuations in power supply or demand.

Limited frequency sensitive mode - overfrequency or 'LFSM-O' means a power-generating module or HVDC system operating mode which will result in active power output reduction in response to a change in system frequency above a certain value.

Limited frequency sensitive mode - underfrequency or 'LFSM-U' means a power-generating module or HVDC system operating mode which will result in active power output increase in response to a change in system frequency below a certain value.

Frequency sensitive mode or 'FSM' means the operating mode of a power-generating module or HVDC system in which the active power output changes in response to a change in system frequency, in such a way that it assists with the recovery to target frequency.

Fault-ride-through means the capability of electrical devices to be able to remain connected to the network and operate through periods of low voltage at the connection point caused by secured faults.

Fast fault current means a current injected by a power park module or HVDC system during and after a voltage deviation caused by an electrical fault with the aim of identifying a fault by network protection systems at the initial stage of the fault, supporting system voltage retention at a later stage of the fault and system voltage restoration after fault clearance.

Asymmetrical Current Injection is a condition where the current injected into the grid is not balanced across all phases. This can occur during certain fault conditions or due to the presence of unbalanced loads. Asymmetrical current injection can cause voltage imbalances and affect the quality of power in the grid, necessitating specific measures to manage and mitigate its impact.

Grid Forming Capability is the ability of a power source to establish and control the voltage and frequency of an electrical grid. This capability is essential for integrating renewable energy sources and distributed generation into the grid. Grid-forming units can operate independently of the grid and support the grid by providing stability, especially in scenarios with high penetration of intermittent renewable energy sources.

Equipment certificate means a document issued by an authorised certifier for equipment used by a power-generating module, demand unit, distribution system, demand facility or HVDC system. The equipment certificate defines the scope of its validity at a national or other level at which a specific value is selected from the range allowed at a European level. For the purpose of replacing specific parts of the compliance process, the equipment certificate may include models that have been verified against actual test results.

Certification scheme means conformity assessment system according to internationally recognized standards, that the relevant system operator may include in the compliance scheme, which shall be related to the power-generating module, PGU or components, and their fulfilment with specific rules and procedures to demonstrate compliance.

8. Reference

European Union Agency for the Cooperation of Energy Regulators (ACER). 2023. "NC RfG DC Recommendation - Annex 1 - Amended RfG Regulation." 12 19. Accessed 05 06, 2024. https://www.acer.europa.eu/sites/default/files/documents/Recommendations_annex/ACER_Recommendation_03-2023_Annex_1_NC_RfG_clean.pdf.

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This document was created with a collaboration of P3 Group and the Focus Group Grid Integration & Energy of the CharIN association.

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