[PUBLIC]

European Union Agency for the Cooperation of Energy Regulators

ACER POLICY PAPER

on the revision of the network code on requirements for grid connection of generators and the network code on demand connection

26 September 2022

1. Executive summary

1 Decarbonisation efforts, most recent technological advancements and changes in the electric power and transport sectors require amendments to the European Grid Connection Network Codes (GC NCs). The purpose of this Policy Paper is to inform stakeholders about the areas in which amendments to the concerned network codes are to be expected.

2 The main topics covered by this Policy Paper are the following:

- technical requirements for electrical charging points and electric vehicles (EVs),
- determination of power generating modules' (PGMs') significance,
- requirements for mixed customer sites (MCSs), active customers and energy communities,
- significant modernisation,
- capabilities for grids with high penetration of distributed energy resources (DER) as well as converter-based technologies, and
- generators' resilience to weather hazards.

3 These topics are analysed in terms of possible options to address the identified problems or challenges. Furthermore, the paper draws on the alternative policy options and provides recommendations and proposed actions for the amendment process.

4 The indicative areas of the GC NCs amendment presented in this Policy Paper, address also the necessary improvements determined during the implementation of existing requirements. The Policy Paper aims at respecting the general considerations and the objectives of the GC NCs.

2. Introduction

5 Harmonisation of rules on grid connection of system users helps to ensure fair competition and system security, facilitate the integration of renewable electricity sources and Union-wide trade in electricity. This allows more efficient use of the network and resources, for the benefit of consumers, and provides a level playing field throughout the Union.

6 System security depends, inter alia, on the technical capabilities of power-generating modules, demand facilities, distribution systems and storage units. Therefore, fundamental prerequisites include:

- regular coordination at the level of the transmission and distribution networks and adequate performance of the equipment connected to the grid with sufficient robustness to cope with disturbances, and
- to help prevent any major disruption or to facilitate the restoration of the system after a collapse.

7 Moreover, the proliferation of EVs, displacing traditional internal combustion engine vehicles, is pivotal to enabling the decarbonisation of the transport sector. Therefore, an efficient and sustainable mobility plays a central role in the agenda of the European Union (EU). This is recognised by the Clean Energy Package[1] and the European Green Deal[2].

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[1] https://ec.europa.eu/commission/presscorner/detail/en/fs_19_6726

[2] E.g., Article 33 of Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity (OJ L 158, 14.6.2019, p. 125) concerning the integration of electromobility into the electricity networks.

8 In the context of system security, the networks and the system users should be considered as one entity from a system engineering point of view, given that those parts are interdependent. Therefore, as a prerequisite for grid connection, appropriate technical requirements should be in place for all system users.

9 In the framework of the Grid Connection European Stakeholder Committee (GC ESC), the European Commission proposed for ACER to initiate the process towards the amendment of the existing GC NCs in September 2022.

10 The Policy Paper, planned to be published by September 2022, aims to transparently indicate to stakeholders the areas in which amendments to the concerned network codes are to be expected.

11 Stakeholders could use the Policy Paper to inform their proposals for amendments, which stakeholders will be invited to submit in the course of ACER's public consultation. ACER intends to launch a public consultation on the amendments to the GC NCs in September 2022.

3. Objectives

12 Important developments in the policies of decarbonisation of the EU energy and transport sectors have taken place since the inception of the development of the first GC NCs in 2012.

13 Therefore, besides the necessary improvements identified in the course of the implementation of the GC NCs[3], the Policy Paper aims at addressing the impacts of new developments in the electric power and transport sectors.

14 The Policy Paper aims at respecting the general considerations and the objectives of the GC NCs.

4. Problem definition

15 *Requirements for pump-storage hydro PGMs*

Technical capabilities of pump-storage hydro PGMs[4] vary by type of the installed unit and the operation mode (generating, pumping, synchronous compensation). Yet, at the present time, pump-storage hydro PGMs shall, in principle, fulfil all the relevant requirements laid down in the Network Code on Requirements for Grid Connection of Generators (NC RfG)[5] in both (injecting into the network) and (withdrawing from the network). This may lead, in turn, to an inherent inability to comply with relevant rules by some of the PGMs, as demonstrated by the final report of the Requirements for pump-storage hydro power generation modules Expert Group created by the GC ESC.[6]

Applicable requirements for generators have not addressed constraints arising from structural and operational particularities of pump-hydro storage PGMs. Similar treatment of all types of units and operating modes may hinder the implementation of NC RfG provisions as a consequence.

16 *Determination of significance of PGMs*

The significance of PGMs is based on their size and effect on the overall system. According to Article 5 of NC RfG, PGMs are categorised as type A, B, C or D depending on both the installed capacity and the voltage level at the connection point. Paragraph 2 of the same article specifies a voltage-related criterion and sets out limits for capacity thresholds that are defined at national level.

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[3] Refer to the work of the Grid Connection European Stakeholder Committee and its Expert Groups.
[4] As defined in Article 2 (21) of NC RfG.
[5] Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators, OJ L 112, 27.4.2016, p. 1.
[6] https://www.entsoe.eu/Documents/Network%20codes%20documents/GC%20ESC/PSH/Final_Report_PSH__+supporting_material__-_phase_1_2_results.zip

However, the correlation between maximum capacity and voltage level at the connection point can be affected by various factors, including geographical location or PGM's operation within a larger (e.g., mixed customer) site.[7] Hence, it may be concluded that the cumulative character of the capacity and voltage criteria in their present form can lead to some disproportionate technical requirements for PGMs compared to their actual impact on the system.

17 *Technical requirements for mixed customer sites with generation, demand and storage*

Mixed customer sites are usually a combination of generation, demand and/or storage units. MCSs connected to the distribution network (including sites with a connection point at 110 kV or above) often include smaller PGMs (e.g., type A or B according to national capacity criteria) which generate energy for the sites' own needs. Also, in many instances, sites resorting to renewable generation, employ storage systems that help to ensure continuous electrical energy supply.

Currently, the provisions of the NC RfG and NC DC deal with the connection of industrial sites and do not sufficiently reflect particularities of MCSs. These need to be explored in detail so as to avoid a disproportionate treatment of system users. In relation to this, the voltage criteria used to determine the type of a PGM seems in particular problematic because even small PGMs embedded in MCSs are being treated as type D PGMs if the connection point of the MCS is at 110 kV or above, as discussed in the second part of the final report of the dedicated expert group created by the GC ESC.[8] An enduring solution of this issue should be implemented since possible derogations to remedy such situations are time-limited.

18 *Requirements for type A PGMs*

The technical capabilities of power-generating modules have a massive impact on system security. All connected equipment must be sufficiently robust to withstand disturbances and help prevent major interruptions or support the reconstruction of the grid after a collapse. The EU Member States set different classifications for the threshold values. This results in a range for the threshold between type A and type B, which amounts to between 0.011 MW and 1.5 MW. In view of this wide range, the question arises as to whether the requirements applicable to type B (as per Articles 14, 17 and 20 of NC RfG) should also be specified for type A. The final report produced by the GC ESC Baseline for type A power-generating modules Expert Group also elaborates on this topic.[9] Above all, it is expected that many small plants will be connected to the grid. It is particularly crucial in the context of the joint EU efforts to fight the climate changes and decarbonise the electric power and transport sectors by shifting to variable and distributed generation and implementing low-carbon technologies (e.g., electromobility).

19 *Significant modernisation*

According to Article 4(1) of NC RfG and Article 4(1) of Network Code on Demand Connection (NC DC), [10] existing PGMs as well as existing transmission-connected demand facilities, existing transmission-connected distribution facilities, existing distribution systems and existing demand units that are or can be used by a demand facility or a closed distribution system to provide demand response services to a relevant system operator or relevant TSO are not subject to the requirements of the NCs, except where they have been modified to such an extent that its connection agreement must be substantially revised (currently, this provision only applies to type C and D PGMs). However, the GC NCs are not prescriptive as to the criteria for which a modification must be considered as requiring a substantial revision of the connection agreement, nor what is regarded as a substantial revision. Therefore, the NCs leave room for interpretation which can lead to legal uncertainty and significantly different requirements among Member States.

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[7] https://eepublicdownloads.entsoe.eu/clean-documents/Network%20codes%20documents/GC%20ESC/MSC/GC_ESC_EG_Mixed_Customer_Sites_final_report.pdf

[8] https://eepublicdownloads.entsoe.eu/clean-documents/Network%20codes%20documents/GC%20ESC/MSC/GC_ESC_EG_Mixed_Customer_Sites_part_2_final_report.pdf

[9] https://eepublicdownloads.entsoe.eu/clean-documents/Network%20codes%20documents/GC%20ESC/BftA/EG_BftA_Final_Report_210922.pdf

[10] Commission Regulation (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection, OJ L 223, 18.8.2016, p. 10.

20 *Technical requirements for storage*

Grid connection network codes do not elaborate on specific requirements for storage units[11] in their current version. Following the technological advancement, mature storage solutions are set to gain more significance for the system operation, both for transmission system operators (TSOs) and distribution system operators (DSOs). Therefore, harmonisation prospects for storage grid connection requirements should be explored.

In establishing specific provisions, relevant characteristics and constraints of storage technologies shall be duly recognised, since they may impact feasibility of technical requirements, but also ensure that the system users are treated equitably. Moreover, storage units may be divided into two types (synchronous modules and non-synchronous modules), as identified in the final report of the Storage Expert Group working under the GC ESC, which may lead to pertinent differentiation in established requirements.[12] Finally, depending on the storage units' connection configuration, applicability issues pertaining to the provisions of the NC RfG and NC DC must be considered, including establishment of appropriate non-exhaustive requirements.

21 *Electromobility*

The increasing role of rapidly expanding electromobility and some tools for its further integration have been highlighted in the existing legal framework.[13] As EVs proliferate, the number of electrical charging points grows too. Their interaction with the network depends on the implemented technologies since some electrical charging points are able to operate in both injection and withdrawal operational mode, while others act as demand units only. Moreover, electrical charging points may function in various configurations that affect their significance to the network.

The charging points' operational modes can vary depending on the use of the underlying technology (unidirectional (V1G), bidirectional (V2G)).[14] This necessitates an appropriate consideration of the needed technical connection requirements, operational notification procedures and compliance regimes, as already laid down in both the NC DC and NC RfG.

V1G technologies (as well as some other kinds of demand units, e.g., heat pumps) will expectedly reach significant penetration levels, which will impact all other system users (existing and new). In order to establish the equitable treatment of all system users, it is necessary to determine the contribution to the system stability (system defence strategies) by these "new" technologies.

22 *Simulation models and compliance monitoring*

Power-generating facility owners, transmission-connected demand facility owners and transmission-connected distribution system operators shall ensure that each concerned unit that is a part of the facility (or system) complies with requirements applicable under NC RfG or NC DC. To demonstrate compliance of the unit with applicable provisions, responsible entities shall produce and provide a validated simulation model to the relevant system operator. Existing model requirements are outlined in Article 15(6)(c) of NC RfG[15] and Article 21 of NC DC.

Employment of simulation models is essential in demonstrating compliance. However, it also brings issues linked to the confidentiality and accuracy of simulation models, as presented in the final report of the GC ESC Interaction Studies and Simulation Models Expert Group.[16] Moreover, greater clarity of the applicable requirements and processes (especially the model validation process, including the future recommendations expected to be provided by Expert Group for Certification) could be considered as a vehicle for increased certainty and efficiency. The handling of the already obtained models,

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[11] As defined in Article 2 (60) of Directive (EU) 2019/944.

[12] https://www.entsoe.eu/Documents/Network%20codes%20documents/GC%20ESC/STORAGE/Final_Report_STORAGE__supporting_material_phase_1.zip

[13] See Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (OJ L 158, 14.6.2019, p. 54) and the Directive (EU) 2019/944.

[14] Notions of V1G (unidirectional) and V2G (bidirectional) technologies for electrical charging points are being used widely

[15] Although Article 15 of NC RfG stipulates general requirements for type C PGMs, the same rules on simulation models apply to type D PGMs (Article 16(1)).

[16] https://eepublicdownloads.azureedge.net/clean-documents/Network%20codes%20documents/GC%20ESC/ISSM/EG_ISSM_Final_Report.pdf

necessary in future studies, shall also be addressed. Overall, discussed improvements may contribute to enhancing security and efficient producing models that correspond to their purpose outlined in the GC NCs.

23 *Advanced capabilities for grids with high penetration of DER as well as converter-based technologies*

The rapid increase of the penetration of dispersed generation and converter-based technologies due to the decarbonisation targets have been posing new challenges in ensuring the overall system security for both TSOs and DSOs.

On the network side, electricity system has been developed for years to connect large, centralised plants with the different loads across the country. This means that electricity has been assumed flowing from transmission network to medium voltage distribution networks and to low voltage distribution networks, with limited production connected to medium and low voltage infrastructures. Distribution networks were thus developed according to the so called fit-and-forget approach,[17] with the infrastructure dimensioned to bear the maximum expected load in a given area. Dispersed generation, along with the converter-based technologies, bring about significant changes in power flow patterns and stability challenges in both distribution and transmission systems. In addition, the demand response and energy storage at the distribution level increase the complexity of the issues at stake. New requirements for connection and operation of the distribution networks while ensuring proper interfaces with transmission networks are thus needed.

On the resources side, new technical requirements such as, for example, grid forming can no longer be left aside: relevant discussions should take place in the process of amending the network codes.

24 *Requirements for weather hazards resilience of generators*

Safe generation is one of the building blocks of a well-functioning energy system. However, it may be hampered by emerging or increased environmental risks, including changing weather patterns that could result in weather hazards. As power-generating facilities resort to increasingly diverse technologies, the issue of generators' uninterrupted ability to produce electricity gains importance. Furthermore, greater resilience of generators may allow relevant operators to ensure that the system can safely accommodate reasonable demand.

In essence, NC RfG does not provide for the requirements that could mitigate the risk of unusual weather events compromising generation.

25 *Technical requirements for active customers/energy communities*

The development of renewables and dispersed generation led to new roles in the electricity system: active customers (called also prosumers) consuming or storing electricity generated within their or neighbouring premises are becoming more and more frequent, while other forms of aggregation as energy communities were introduced by the Directive 2019/944.[18]

In the past, the connection rules were conceived for a reality where producers and consumers had defined boundaries, but the current situation is no longer able to capture the complexity of the new roles. In particular whether an active consumer shall comply with NC RfG, NC DC or both should be clearly identified. Moreover, the treatment of new forms of aggregation (such as active customers and energy communities) shall be non-discriminatory to other system users subject to the NC RfG and NC DC. To this end, the technical requirements for the new forms of aggregation shall be clearly specified.

26 *Requirements for units providing demand response services*

According to the current legal framework, demand response services provided to the system operator by demand units are enumerated in a catalogue of Article 27(1) of NC DC. Technical requirements concerning the connection of units providing these services are laid down in Articles 28-30 of NC DC, should the unit fall under the scope of the NC DC.

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[17] CIGRE Working Group C6.19, 2014. Planning and Optimization Methods for Distribution Systems, Technical Brochure 591, CIGRE, Paris

[18] See n. 2.

Whether these requirements should remain a part of the NC DC would have to be reviewed since the demand response is a matter covered by Framework Guidelines to be developed pursuant to Article 59(1)(e) of Regulation (EU) 2019/943[19] and Article 1(b) of Commission Implementing Decision (EU) 2020/1479.[20]

27 *Harmonisation of types B, C and D PGMs requirements*

Technical requirements for types B, C and D PGMs are set out in the NC RfG and are divided by two criteria: exhaustiveness (exhaustive and non-exhaustive) and compulsoriness (mandatory or non-mandatory). Depending on their kind, requirements could be further specified at the national level in the course of implementation to accommodate system needs in particular countries. However, at the national level, sometimes requirements for larger units permeate down to smaller units, additional requirements are introduced or requirements are outside of the prescribed ranges.[21]

Current level of discretion resulted in the introduction of diverse national rules and, consequently, broadening the range of technical requirements across the Member States. An insufficiently harmonised regulatory framework for types B, C and D PGMs may limit the level-playing field, hamper the economies of scale, and impede other benefits of the common connection rules.

28 *Improvements to the applicable rules and procedures*

Application of the NC RfG and NC DC entails the consideration of substantive and formal rules laid down in the regulations and specified further at the national level. In other words, concerned parties should comply with technical requirements and demonstrate compliance according to particular procedures.

This regulatory framework, varying among the Member States, can prove intricate for the system users, manufacturers and other stakeholders present in different markets across the EU. As a result, this acts as a barrier in the efficient functioning of the internal market. Moreover, it may lead to inefficient allocation of resources or compliance issues.

29 *Demonstration of compliance*

In the existing regulatory framework, power-generating facility owners may use equipment certificates in the operational notification procedure. Additionally, Title IV of the NC RfG stipulates that power-generating facility owners may use equipment certificates to demonstrate compliance with the relevant requirement. In both cases, equipment certificates should be issued by an authorised certifier established in accordance with Regulation (EC) No 765/2008.[22]

As it may be used instead of certain steps/parts of the compliance process, the certification may streamline connection and compliance processes. Nevertheless, current rules do not provide sufficient clarity on using certificates and do not reflect the potential for simplifying the demonstration of compliance.

5. Options to address the problems

30 *Requirements for pump-storage hydro PGMs*

Current requirements for pump-storage hydro PGMs do not entirely reflect constraints related to various types of those units and specific modes of operation. Article 6(2) of NC RfG stipulates that pump-storage PGMs shall fulfil all the relevant requirements in both generating and pumping operation mode. Synchronous compensation operation of pump-storage PGMs shall not be limited in time by the

[19] See n. 11.

[20] Commission Implementing Decision (EU) 2020/1479 of 14 October 2020 establishing priority lists for the development of network codes and guidelines for electricity for the period from 2020 to 2023 and for gas in 2020: https://eur-lex.europa.eu/eli/dec_impl/2020/1479/oj.

[21] https://op.europa.eu/en/publication-detail/-/publication/7ff90e84-dae0-11eb-895a-01aa75ed71a1/

[22] Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products, OJ L 218, 13.8.2008, p. 30.

technical design of PGMs. Furthermore, pump-storage variable speed PGMs shall fulfil the requirements applicable to synchronous PGMs as well as those set out in Article 20(2)(b), if they qualify as type B, C or D.

Since some types of pump-storage hydro PGMs are not able to comply with those requirements due to their inherent technology, rules concerning units in question shall be reviewed in terms of operation modes and types of pump-storage hydro PGMs subject to the rules. Notably, constraints varying by:

a) generation and pumping mode, and

b) ability to adjust the motor/generator speed

shall be considered. The outcome of this revision shall render the technical requirements feasible whilst remaining non-discriminatory and transparent.

31 *Determination of significance of PGMs*

The proportionality of technical requirements for PGMs is dependent on the appropriate determination of significance. It may be achieved by applying criteria that accurately reflect PGMs size and their effect on the system. Therefore, the following policy options could be considered:

a) Removal of the voltage criteria – as a result, significance determination for types A, B, C and D of PGMs or for some of them would be based on the maximum capacity only; it may be followed by the amendment of capacity thresholds or introduction of other criteria;

b) Amendment of the voltage criteria – possible range of amendments span from the application of voltage criteria only above specific capacity threshold (also referred to as 'removal of the voltage criteria up to a capacity threshold')[23] to subjecting the final value to national decisions;

c) Hybrid solution encompassing selected elements of discussed alternatives.

Furthermore, the feasibility of harmonisation and possible adaptation of the new criteria at national level shall be assessed.

32 *Technical requirements for mixed customer sites with generation, demand and storage*

To address the issues mentioned in paragraph 17, one has to analyse several alternative options:

a) continue to use derogation mechanism stipulated in the NC RfG and NC DC. Specific small-size PGMs can be exempted from type D requirements, provided that they fall into this category based on voltage criteria;

b) taking into consideration voltage level at connection points to a MCS, if there is such a situation, and not voltage level at connection point where MCS is connected with transmission or distribution network;

c) remove or amend the voltage criteria as discussed in paragraph 31.

It should also be assessed whether the current provisions regarding industrial sites defined in Article 6 of NC RfG are sufficient and whether they need to be amended to better take into account the constraints of these sites (in particular, the exemptions listed in Article 6(4) could also apply to type D PGMs).

33 *Requirements for type A PGMs*

Since there is a wide range of thresholds between type A and B PGMs throughout Europe, harmonising the thresholds could help, e.g. manufacturers, who want to sell their products through the EU, gain an easier access to the common market. However, due account needs to be taken of the fact that the

[23] https://eepublicdownloads.entsoe.eu/clean-documents/Network%20codes%20documents/GC%20ESC/MSC/GC_ESC_EG_Mixed_Customer_Sites_part_2_final_report.pdf

setting of the thresholds was the explicit wish of Member States during the comitology process for the adoption of the GC NCs.

A review of the requirements for type A PGMs is in any case required. In this regard, it is necessary to determine which requirements applicable to type B PGMs may also be necessary for type A PGMs in terms of system security. The following candidate requirements were identified by the Expert Group "Baseline for Type A PGMs" [24]:

a) Fault Ride Through (FRT),

b) Post Fault Active Power Recovery (PFAPR), and

c) Active Power Control (APC).

An additional candidate requirement could be the Limited Frequency Sensitive Mode – Underfrequency (LFSM-U). As the relevant European standard recommends LFSM-U capability for smaller PGMs, its potential inclusion in the NC RfG might be considered accordingly.

However, it should be noted that not all these requirements can be met by each and every technology and/or are likely costly to implement.

34 *Significant modernisation*

Any modification resulting from an investment from the owner of the PGM, the distribution system or demand facility and leading to a significant change in its electrical and grid-dynamic characteristics could present a reason as to why to apply, totally or partially, the GC NCs on the concerned system user/distribution system.[25]

The following key electrical characteristics of the system user/distribution system should be considered when defining the criteria for significant modernisation:

a) the maximum capacity of the PGM/demand facility;

b) the frequency stability and active power management of the PGM/demand unit

c) the reactive power capability of the PGM/demand facility;

d) the short-circuit current of the demand facility/distribution facility; and

e) change of components/assets of a PGM/demand facility/distribution system.

Other key electrical characteristics could be considered as appropriate.

The criteria, for example in terms of difference between the final and the initial value of the key parameter, and the requirements of the NCs to be applied for significant modification could either be defined exhaustively in the NCs, or the NCs could define general principles regarding the key electrical characteristics to consider with the exact criteria to be specified at national level by the TSOs and approved by the competent authority.

Without prejudice to the previous paragraph, as a general principle, any new parts or components which satisfy the criteria established in terms of key electric characteristics and thresholds should, as far as possible, meet the requirements of the NCs so as not to prevent compliance with the NCs in the event of subsequent additional modifications.

Regarding the significant modernisation of types A and B PGMs, the applicability of efficient rules could also be considered since modifications to these PGMs can significantly increase their impact on the system.

35 *Technical requirements for storage*

Provisions concerning grid connection of storage units could be included in the existing GC NCs and linked to the relevant rules for PGMs. In the process of establishing requirements for storage units,

[24] https://eepublicdownloads.entsoe.eu/clean-documents/Network%20codes%20documents/GC%20ESC/BftA/EG_BftA_Final_Report_210922.pdf

[25] For avoidance of doubt, the use of spare parts or maintenance activities having no influence on electrical characteristics are out of scope.

national experiences (e.g., pilot projects), relevant standards and work of dedicated expert groups may be of help. In that context, particular attention shall be given to:

a) Definitions relating to the existing and prospective storage technologies, including grouping (based on specific facility typology or synchronisation criterion), if purposeful for setting out the requirements;

b) Possible interrelations between characteristics and constraints of storage units and current GC NC provisions;

c) Appropriate consideration of the significance criteria of storage units and the scope of the concerned technical requirements. This is also linked to other topics considered in this paper (especially, the determination of significance);

d) Transitional provisions, concerning: i) the indication of storage units falling under the scope of established rules, and ii) rules applicable to other units connected to a network at the same connection point.

36 *Electromobility*

Electrical charging points connected to a network may be subject to technical requirements for demand units or for both demand units and generators, depending, inter alia, on the modes of their operation. The legal framework could differentiate between different types of charging points:

a) electrical charging points that are connected to the network unidirectionally, capable only to withdrawing energy from the network to charge EVs (demand mode);

b) electrical charging points that are connected to the network bidirectionally, capable to both withdrawing and injecting energy to the network as they charge and/or discharge EVs (both demand and generator modes, similar to storage units).

Similar considerations as for the electrical charging points also need to be made for EVs with on-board unidirectional or bidirectional AC/DC converters.

Moreover, technical requirements for electrical charging points may reflect various configuration of the sites connected to a network at one or more connection points (e.g., including both types of electrical charging points), particularities of charging points that provide demand response, and specific differences between electrical charging points and storage units in general (e.g., charging point operating only while connected to one or more EVs).

EVs with on-board unidirectional AC/DC converters as well as unidirectional electrical charging points could also be subject to providing stability related response (e.g. be capable of (remote and/or local) disconnection and/or provide an appropriate limited frequency sensitive mode (LFSM) response in certain system conditions).

37 *Simulation models and compliance monitoring*

General rules on simulation models may address confidentiality and privacy concerns by prescribing the use of particular formats, ensuring necessary requirements and referring to legitimate rights of third parties. These means may also mitigate some deficiencies concerning, inter alia, efficiency and accuracy. Hence, having regard to present national particularities, a few further considerations are necessary:

a) Exploring possible use of contractual arrangements to address deficiencies in the area of confidentiality, protection of legitimate rights and maintaining of the models;

b) Clustering requirements as per broader purposes, which may foster common understanding of the data types analysed by different simulations and converge decisions regarding applicable methods, format and encryption;

c) Defining a range of admissible methods, formats and encryption settings would limit uncertainty over requirements and create a more integrated approach;

d) Defining necessary sub-models, depending on the existence of the individual components;

e) Identifying harmonised rules setting out a common approach towards methods, format and encryption, without prejudice to the Member State's rights to introduce additional requirements.

Robustness and accuracy of simulation models might also be improved by specifying in greater detail the requirements laid down in Article 15(6)(c) of NC RfG and Article 21 of NC DC. Appropriate adjustments could be based on methodologies recognised and used by TSOs.

38 *Advanced capabilities for grids with high penetration of DER as well as converter-based technologies*

It is necessary to assess the operational needs of the future distribution systems and to ensure that an optimisation of investments made in distribution networks as well as in the underlying users' system takes place at the system design phase. This will bring socio-economic benefits to all system users. Standard operating rules and planning criteria developed for an environment where flow used to enter into distribution networks from transmission networks are no longer valid and need to be adapted to the new setup characterised by flows that can come out of distribution networks into transmission network.

A review of the operating rules and planning criteria is thus needed. Two possible approaches could be followed:

a) Strengthening the current infrastructures by increasing the overall transmission/distribution capability while keeping the fit-and-forget approach; this would mean considering in the dimensioning criteria not only the maximum expected load, but the maximum expected flow given the potential combination of local load and generation resources.

b) Moving to a smarter operation of the network, introducing specific congestion management services and installing intelligent protection devices aimed to improve the controllability of flows in the distribution network in the different scenarios. Also, an active participation of system users in voltage regulation at distribution level might be needed is some cases.

New requirements are also needed at the system user level. Reduced inertia and short circuit power will need to be addressed while grid forming capability is a key feature to be considered for generators connected to MV and LV networks. Moreover, all the resources shall be capable of maintaining communication with the DSOs control centres in order to allow smarter monitoring of the system and coordination where needed.

39 *Requirements for weather hazards resilience of generators*

Weather hazards are not considered under existing requirements for generators. As economic costs of preparedness for future and uncertain events and degrees of uncertainty vary across the Union, three main approaches may be considered to address this problem:

a) Inclusion of weather hazard-related mitigation measures as a facultative requirement that TSO may trigger *in concreto* (site-specific requirements);

b) Freeze or heatwave protection measures and/or information on PGMs' operating limitation for specific weather (at least, PGMs' minimum and maximum design temperature) being a requirement applicable as a general rule which may be altered by the TSO; and

c) Harmonisation of the connection requirements concerning freeze or heatwave protection measures and information on PGMs' operating limitations for specific weather (at least, PGMs' minimum and maximum design temperature).

The definition of specific requirements shall take into account the historical record of temperatures under which PGMs continued operation or currently determined performance temperature limits.

40 *Technical requirements for active customers/energy communities*

Active customers may either withdraw from or inject energy into the electricity system. They should thus comply both with the NC RfG and the NC DC. Active customers can be treated in the same manner as mixed customers sites with application of the rules already adopted for those installations.

For energy communities and similar forms of aggregation, it is important to consider whether the community uses the distribution or transmission network or not.

If a distribution or transmission network is used (or if a closed distribution system is involved), the technical requirements applicable to the units participating in an energy community shall be the same as for the other units. This rule is fundamental to ensuring a level playing field across the system and equitable treatment of system users. In other terms, each system user determined as significant should comply with the NC RfG or NC DC or both at its connection point: demand units only with the NC DC (if applicable), generators only with the NC RfG and active customers with both.

If the energy community, instead, is connected to a network without a synchronous connection with the distribution or transmission systems, it shall not be subject to the NC RfG requirements, unless their operation in parallel with the distribution or transmission system exceeds five minutes per calendar month while the system is in normal system state. Parallel operation during the relevant maintenance or commissioning tests shall not count towards the five-minute limit.

41 *Requirements for units providing demand response services*

Should the relevant Framework Guidelines address the subject of current technical requirements for units providing demand response services, existing rules shall be amended accordingly, reflecting relevant process.

It may be considered to cover verification of compliance with the requirements related to demand-side response in the Guideline on Electricity Transmission System Operation (SO GL)[26] to ensure the implementation of the rules across all system users.

42 *Harmonisation of types B, C and D PGMs requirements*

Relevant provisions of the NC RfG should capture system needs adequately. For this purpose, it is necessary to understand the scale of national frameworks' divergence and the underlying reasons for specific rules. Further steps could lead to explicitly loosening some NC RfG requirements or restricting them. Changes might involve adjustment of values or ranges, reversing a character of requirement (e.g., from exhaustive to non-exhaustive), introducing provisions on broader coordination (e.g., regional cooperation on frequency control topics) in setting connection rules, or other measures.

Concerning additional requirements applied in some Member States but not stipulated in the NC RfG, these should be discussed and either included in the regulation or left out of the scope.

Revision of monitoring and transparency provisions could also be considered as they might contribute to improving the overall compliance of national frameworks with the NC RfG. Further policy options on transparency and accessibility are outlined in subsection "Improvements to the applicable rules and procedures".

43 *Improvements to the applicable rules and procedures*

Procedural improvements and enhancements to information accessibility might address identified deficiencies in the national implementation of the NC RfG and NC DC. The potential improvement of rules could take the perspective of parties choosing the most suitable connection conditions in different Member States. First, concerning the accessibility of information, it could be facilitated, inter alia, by a frequently updated, intelligible repository at the EU level collecting all information on technical requirements and stages of the connection process. Additionally, translations of applicable rules could be considered.

Second, further simplification and unification of processes should be explored as regards relevant procedures linked to the NC RfG and NC DC. Besides, the establishment of a single point of contact might also be considered to streamline procedures and assist relevant parties. Detailed policy options for improving compliance demonstration are outlined in the appropriate subsection.

44 *Demonstration of compliance*

The compliance process could be streamlined by the broader use of equipment certificates and clarification of the existing procedures. Concerning certification, respective regimes might be developed at the European, regional, or national levels. Further amendments covering certification principles, product families and missing definitions should also be analysed.

[26] Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation, OJ L 220, 25.8.2017, p. 1.

As regards the compliance process, possible changes could more explicitly delineate different stages of the process, assigned roles, responsibilities, and formal requirements. Specific definitions relevant to the compliance process could be introduced into the NC RfG. Other measures to remove the ambiguity of rules should be explored. In addition to amendments clarifying existing rules, proposals aimed at further unification of procedures might be examined.

6. Analysis and recommendations

45 *Requirements for pump-storage hydro PGMs*

Amendments to the existing rules would allow full implementation of the NC RfG as regards to pump-storage hydro PGMs. However, a detailed assessment of the units' capabilities and constraints is necessary. It appears that, in principle, pump-storage hydro PGMs can meet technical requirements in generation mode, while operating in pumping mode results in more limitations. Those limitations are specifically inherent to the units with fixed-speed motors, which cannot fulfil some requirements related to frequency stability.

Compliance issues or derogation requests which may result from an innate inability of pump-storage hydro PGMs to meet general requirements may be addressed with a more detailed definition of applicability rules together with appropriate transitory provisions. Yet, it has to be ensured that each type of pump-storage hydro PGMs should meet all the feasible technical requirements per operation mode.

46 *Determination of significance of PGMs*

Different levels of technical requirements reflect different types of PGMs, according to their size and their effect on the system. Hence, more onerous technical requirements shall apply to PGMs with a certain impact on the control and operation of the entire system. It shall be considered whether small-size PGMs connected to a network at the connection point at a higher voltage level may efficiently fulfil the requirements defined for type D PGMs. At the same time, changes to classification of PGMs should not result in evading rules designed to ensure stable operation of the interconnected system.

Therefore, the complete removal of voltage criteria for all types of PGMs does not seem to be a viable solution. Yet, in the existing framework, proportionate adjustment of provisions for significance determination shall be examined, particularly for small-size PGMs.

47 *Technical requirements for mixed customer sites with generation, demand and storage*

Derogation mechanisms, according to their nature, are time-limited and conditional. Therefore, relying on a derogation cannot be seen as a viable and enduring solution for the identified problems. The application of voltage criteria only above a specific capacity threshold as discussed in paragraph 31 may be an enduring solution to identified disproportionate significance determination for PGMs operating in the MCSs.

Taking into consideration the voltage level at connection points to a MCS and not voltage level at connection point where the MCS is connected to TSO/DSO represents another solution. The voltage criterion refers to the voltage level at the connection point with the relevant system operator, which in this case might also be a CDSO. This approach may be deemed a non-discriminatory treatment of PGMs within CDS versus non-CDS industrial grids. However, from a legal point of view, this solution may be difficult to implement uniformly because of different MCS arrangements. Furthermore, from a legal and practical point of view, it seems sensible to stick to the concept of determining compliance with the NC RfG and the subsequent national connection rules at the MCS connection point to the distribution or transmission system. It is both, legally and practically nearly impossible for the DSO/TSO and for the NRA to control the NC RfG-compliance of the PGMs within a MCS network. This is because the DSO/TSO are not responsible for the connection points within a MCS network.

In order to better take into account the constraints of industrial sites, it should also be assessed whether the current provisions defined in Article 6 of NC RfG are sufficient.

48 *Requirements for type A PGMs*

Without a defined harmonised level on the low end of the A/B-threshold, manufacturers which are active in several European countries, are forced to include various type B capabilities due to different selected

A/B-thresholds which make their products too expensive and reduces their market significantly. System safety would also be ensured by the FRT capability of type A equipment, especially for PGMs on the high end of the current A/B-threshold.

Moreover, it should be assessed whether smaller types of PGMs (type A and B) and associated requirements are sufficiently robust in their current form. In the course of the amendment process, the introduction of an intermediate PGM type with relevant technical requirements could be looked into as a possible way to improve operational security and accommodate the specificities of the national networks.

49 *Significant modernisation*

The clarification of the exact scope of the provisions of Article 4(1) of NC RfG and Article 4(1) of NC DC concerning significant modernisation and the requirements laid down in the GC NCs which must apply in these cases will allow the definition of coherent principles across Member States. In addition, the definition of these principles will ensure that the facilities connected before the entry into force of the GC NCs, do not jeopardise the security of the system. Therefore, it seems necessary to clarify when the modification would result in the application of the requirements of the GC NCs. Furthermore, it shall be considered in which cases the significantly modified unit has to apply all requirements of the GC NCs and when the applicability is limited to selected provisions.

Given the different requirements of general application defined among Member States, defining strict criteria for significant modernisation in the GC NCs may not be appropriate for some Member States. Conversely, it seems more relevant to define general principles regarding the electrical characteristics to be considered and/or ranges of possible values of the thresholds concerning the significant modernisation criteria, which will have to be specified at national level by the TSOs and approved by the competent authority. Nevertheless, GC NCs shall provide for specific limits capping the values of significance modernisation criteria in order to ensure a level playing field.

Similarly, TSOs and the competent authority should define at the national level the requirements of the GC NCs that must apply for each significant modernisation criterion as well as the scope of application of those requirements (only modified parts or entire unit/installation) according to the general principles laid down in the GC NCs. The decision on significant modernisation criteria and decisions on GC NCs requirements applicable for each significant modernisation shall be without prejudice to a possible revision of the determination of significance as per relevant provisions of the NC RfG.

Regarding types A and B PGMs, amended rules on significant modernisation should apply to them as well, contrary to what is currently written in the NC RfG since modifications to these PGMs can significantly increase their impact on the system. However, the requirements on the small generators should be kept lean and simple in order to retain the efficiency of the applicable rules.

So as not to prevent compliance with the GC NCs in the event of subsequent additional modifications, it seems necessary to clarify in the GC NCs that any new parts or components of a facility should, as far as possible, comply with the requirements laid down in the GC NCs. For example, a replacement of a component/part of a PGM could still lead to a partial compliance of the PGM because of the limitations of the unit which is not affected by the replacement of the component/part.

For avoidance of doubt, spare parts which a PGM owner holds in their inventory and are served as a replacement during any maintenance do not count towards significant modernisation.

50 *Technical requirements for storage*

The inclusion of technical requirements for storage units in the existing GC NCs may be seen as a transparent and robust solution that would lead to a more secure system operation and better integration of generation and demand across the network. Nevertheless, specific characteristics and constraints of particular storage units shall be considered, which may possibly result in necessary exceptions. Similarly, technical requirements shall correspond to specific limitations arising from facilities' configuration (e.g., standalone sites or sites where electricity storage occurs along with generation or demand), operating in synchronism or as an asynchronous unit, and applicability of GC NCs to other units connected to a network at the same connection point.

Current capabilities of storage units in injection mode could translate into classifying them similarly as PGMs as far as the capacity and appropriate voltage criteria are concerned. Hence, it shall be assessed whether storage units should be subject to the same requirements as the PGMs or any specific requirements for ensuring the system stability are needed as well. Especially, a potential cumulative effect of multiple storage units may be addressed.

As regards the applicability of discussed prospective rules, it seems purposeful to explore possible options that recognise both a need for legal certainty and system security. In the case of MCSs where electricity storage occurs along with generation or demand, the application of existing technical requirements laid down in the NC RfG and NC DC may be reviewed. Additionally, technical requirements for storage units used in auxiliary systems of the system user only shall be analysed.

51 *Electromobility*

Compared to other emerging technologies, the rapid expansion of the converter-based technologies such as electromobility is set to shape future system behaviour significantly. In order to ensure operational security during fast transients (e.g. following large system disturbances) a certain level of participation would enable a robust system design in a cost efficient manner.

Requirements applicable to the electrical charging points could reflect the use of the underlying technology and inherent features to promote further integration of these units to the network. Appropriate application of the NC DC to the transmission-connected facilities consisting of electrical charging points (likely comprised of mostly external AC/DC converters) is a feasible option, which follows the existing framework. Possible provisions shall also address the issues raised in the section on MCSs in this paper. Moreover, it is desired that the NC DC would also apply to electrical charging points providing demand response without prejudice to the views on demand response services presented in this paper.

Facilities involving charging points may also be included in the scope of the NC RfG. However, the following considerations are necessary. First, reflections regarding determination of significance, requirements for type A PGMs and technical requirements for storage covered in this paper shall be considered. Second, possible solutions shall take into account that properties innate to charging technologies (i.e., operation based on charging/discharging removable storage unit) significantly reduce response and control capabilities.

Concerning the capacity threshold (banding values) between Type A and Type B for electrical charging points, ACER identifies vast differences among Members States hampering the harmonisation of the underlying technologies for charging points. Three possible policy options are analysed in Figure 1 below.

	Description	Pros	Cons
Option 1	Ad hoc capacity threshold for electrical charging parks	Harmonised solution, reduced barriers to a greater electromobility at EU level	Need for a political compromise
Option 2	Two thresholds for exporting and importing capacities, matched with current thresholds at national level	Minor amendment to the RfG and partial solution to the issue	• Limitations to charging parks' flexibility • Interoperability issues/ reducing economies of scale
Option 3	Do nothing i.e., extend PGMs' current capacity thresholds to electrical charging parks	No changes to the regulation	• Problem unsolved • Expected large number of requests for derogations

Figure 1. Assessment of possible policy options for electrical charging points

Option 1, proposing a distinct capacity threshold for electrical charging points (similar to a threshold between type A and B for PGMs), seems the most efficient to be pursued in the amendments to the GC NCs compared to Options 2 and 3. The introduction of separate capacity thresholds for injecting and withdrawing (Option 2) could result in the asymmetry between large withdrawing capacity (that accommodates fast charging) and relatively low injecting capacity (likely, classifying electrical charging points as type A PGMs). As banding values differ between the Member States, asymmetry would result in reduced economies of scale in the Union. Option 3 (applying current significance criteria) leaves the identified problem unresolved and may lead to a large number of derogation requests from facility owners.

Concerning only the capabilities of EVs and not the electrical charging points, the following applications need to be distinguished:

Case 1 – V1G application: The on-board (and off-board) AC/DC unidirectional converters, able to withdraw power from the network, could be capable of providing stability related response (e.g. be capable of (remote and/or local) disconnection and/or provide an LFSM response in certain system conditions, e.g. during fast transients).[27]

Case 2 – V2G application: An EV with an on-board bidirectional converter is able to withdraw/inject power from/to the network even if connected via an electricity socket.[28] In this regard, the EV can act in the same way as any other electricity storage device and thus could be treated as one as well.Furthermore, it seems that providing these capabilities would be proportional and not result in an unreasonable increase in the final price of the unit product. In this regard, the associated manufacturing costs and the cumulative system users' positive effects on the system behaviour (during transients) should also be considered. Also, following the appropriate network codes specifications (requirements necessary to ensure a robust system design, e.g. related to frequency stability) the underlying detailed technical requirements would best be facilitated via a proper standardisation.

52 *Simulation models and compliance monitoring*

Applicable rules regarding simulation models shall ensure the balance between robust compliance monitoring, information security, national particularities, and protection of legitimate interests. Thus, the option to cluster requirements as per their purposes, which may be put in place regardless of the implementation of other options, seems to be a feasible way forward. Similarly, the introduction of contractual arrangements could easily be accomplished. However, further details on conditions regarding contract conclusion must be considered.

As regards a catalogue of admissible methods, formats and encryption, it could be purposeful to create certainty over simulation models' requirements. Nevertheless, it should be noted that shortlisting admissible methods, including for small generating units, may be more likely to deliver valuable results, as opposed to providing an extensive list. Concerning the last described alternative, possible ways and benefits of achieving a common approach towards methods, format and encryption shall be explored. However, this goal does not seem attainable due to the nature of simulation models and national particularities.

Finally, the usage of detailed models may be deemed as a more advantageous choice compared to inaccurate or excessively limited models. Hence, the plausible granularity level of requirements shall be evaluated in coordination with relevant parties.

53 *Advanced capabilities for grids with high penetration of DER as well as converter-based technologies*

Keeping the fit-and-forget approach and strengthening the network infrastructures induce an increase of capital cost and expenditures in the electricity system without any particular benefit in terms of controllability. The security of the system will be ensured by the proper dimensioning criteria, but no "smartness" will be exploited.

Moving to a smarter approach would indeed improve the overall controllability of the system with particular focus on distribution network. This would mean a stronger cooperation between TSOs and DSOs, but also more flexibility in dimensioning, potential savings in a long term and lower capital costs.

A smarter approach may also benefit from the new requirements, as for example grid forming, which can be introduced for MV and LV generators and may facilitate the procurement of flexibility services. To this extent, the connection codes are not the right place to address how a service shall be designed for the overall system security (this is mainly covered by the SO GL), but they are relevant in addressing the new technical requirements each resource shall comply with in order to be allowed to provide these services. A holistic view shall be pursued; the NC RfG and NC DC being the first to be reviewed,

[27] Application of the relevant requirements to other new system users considerably impacting the overall consumption (e.g., heat pumps) could also be discussed within the Grid Connection Network Codes amendment process.
[28] Thus, without the need for an electrical charging point.

followed by the revisions of the HVDC NC, SO GL, EB GL and, if developed, the dedicated network code on flexibility.

54 *Requirements for weather hazards resilience of generators*

The introduction of requirements pertaining to resilience to weather hazards is foreseen to emphasise the significance of this emerging risk and the need to address it. Moreover, it will enable TSOs to request relevant information or even require certain protection measures.

The first and second presented options translate into a fit-for-purpose approach, where the TSO adjusts requirements at national level to accommodate geographical and technological specificities. The third approach, which aims at harmonisation, ensures a minimum level of preparedness to weather hazards across the Union, yet may prove too burdensome with regard to the related costs vis-à-vis anticipated benefits of the enhanced resilience to weather hazards.

Nevertheless, it has to be reiterated that, in all cases, TSOs defining specific requirements shall take into account for example the historical record of temperatures under which PGMs continued operation or currently determined performance temperature limits, which may contribute to the proportionality of the undertaken actions.

55 *Technical requirements for active customers/energy communities*

The regulation should be as simple as possible to avoid misunderstandings and different interpretation. For this reason, equating active customers with mixed customers sites is fundamental in order to ensure consistency in applying the connection codes in equivalent situations.

Energy communities are relevant for the commercial point of view, while, from a technical point of view, what really matters is the connection point to the distribution or transmission systems. To this extent, there should be no difference between resources involved in an energy community and resources that act standalone. If energy community's members use distribution or transmission networks, they should meet the connection requirements as any other system user, without any general derogations.

The market aspects are out of scope of the connection codes and thus shall not be considered. Nevertheless, the connection codes shall clarify the applicable connection requirements for active customers/energy communities introduced as new forms of aggregation by the Directive (EU) 2019/944.

56 *Requirements for units providing demand response services*

The requirements outlined in Articles 28-30 of NC DC currently apply to units identified in accordance with Articles 3 and 4 of NC DC. The necessary revision of applicable technical requirements for connection would follow the adopted Framework Guidelines on Demand Side Flexibility to achieve consistency and provide stakeholders with the appropriate time to implement the changes.

Inclusion of the relevant rules in the SO GL may support better integration of concerned system users providing demand response to the system, because they would apply to all system users and not only to the 'new' units as per the grid connection network codes.

57 *Harmonisation of types B, C and D PGMs requirements*

Provisions of the NC RfG cannot exhaustively specify all the technical requirements for types B, C and D PGMs since specificities of national electric power systems need to be addressed in the implementation. Applicable rules should provide sufficient flexibility for further specifications by the relevant operators to ensure system security. However, monitoring the implementation of the current provisions for the mentioned PGM types indicated that the Member States apply a wide range of values and requirements. As a result, the burden of PGMs' compliance also varies across the EU, limiting the level-playing field and economies of scale.

The NC RfG should provide a comprehensive reference for the regulatory frameworks in the Member States. Given the network code development and amendment procedures that engage the industry, system operators and NRAs, the EU regulations are best placed to introduce adequately harmonised requirements and/or banding values. Therefore, in principle, technical requirements for generators shall stem from the provisions of the NC RfG.

In the course of developing amendments proposals, particular attention should be paid to the proportionality of the harmonisation vis-a-vis underlying system characteristics.

58 *Improvements to the applicable rules and procedures*

Regulatory frameworks laid down in the NC RfG and NC DC should be straightforward and clear to ensure reasonably predictable and efficient application of the rules. To this end, appropriate terms should be well defined. Similarly, the ambiguity of the scopes and stages of procedures (e.g., applicable operational notification procedures for connection of type A, B, C and D PGMs) set in the regulation should be avoided. In addition, improvements in the accessibility of information on requirements and related processes could be considered insofar as such amendments bring about a more level-playing field and adequately assist system users in making informed decisions.

It should also be encouraged that connection-seeking parties, relevant system operators and NRAs cooperate closely and inquire into good practices to streamline the processes nationally.

59 *Demonstration of compliance*

Equipment certification demonstrating PGMs' technical compliance could simplify the processes related to the grid connection. Therefore, the regulation ought to facilitate the use of certificates by providing a coherent and robust framework. For the efficiency of evaluation, it should promote convergence of assessment schemes applied by certification bodies. The introduction of necessary definitions and further clarifications regarding the use of certificates, compliance tests and related processes could contribute to harmonising practices in the Member States and, consequently, more complete market integration.

Improvements to efficiency and clarity in compliance demonstration should consider relevant national systems' particularities and deliver adequate flexibility. Furthermore, any amendments to the compliance rules should foster effective implementation of compliance demonstration without jeopardising operational security.

7. Conclusions and proposed actions

60 *Requirements for pump-storage hydro PGMs*

The technical requirements of the NC RfG applicable to pump-storage hydro PGMs shall reflect their inherent constraints and capabilities. The examination of current technologies and their limitations shall be followed by rendering the applicable rules feasible to the units in question.

61 *Determination of significance of PGMs*

Amendment of the existing rules shall address identified disproportions between technical requirements and actual PGMs' effect on the overall system while ensuring its stable operation. Moreover, potential changes shall be linked with the appropriate transitory rules.

62 *Technical requirements for mixed customer sites with generation, demand and storage*

A possible amendment of the NC RfG shall take into account:

a) Relevant features of the MCSs, including properties of installed units, operating modes, provided services and topology;

b) Proper balance between the requirements for the connection of the MCSs and the system needs as well as the impact on the implementation of the NC RfG in the different Member States;

c) Examination of the reference to connection point, considering situation when MCS is connected to CDS;

d) Possible application of voltage criteria only above specific maximum capacity threshold.

63 *Requirements for type A PGMs*

A harmonisation of thresholds between type A and type B PGMs in order to give manufacturers security and save them from keeping a large catalogue of units of similar size is recommended, taking into account power system needs. In addition, with the ramp-up of renewable generation and the possible fulfilment of expanded requirements, such as FRT and LFSM-U capability, system security could be further enhanced.

64 *Significant modernisation*

The GC NCs should clarify the general principles concerning the criteria for significant modernisation in order to avoid any doubt on the correct interpretation of the GC NCs and to ensure that existing units/facilities do not put the system at risk. These general principles should list the ranges of modification of the relevant technical characteristics which could be considered as significant modernisations and the minimum requirements of the GC NCs which should apply in these cases. The exact modification criteria and the requirements of the GC NCs applying in the case of significant modernisation will have to be defined at national level in the same way as the requirements of general application.

65 *Technical requirements for storage*

The amended NC RfG could provide for technical requirements for energy storage units respecting the determination of their significance, particular facilities' configuration (e.g., standalone sites or sites where electricity storage occurs along with generation or demand) and differentiating between synchronous and asynchronous units. Certain forms of electricity storage devices may be exempted from the requirements (e.g., synchronous flywheels, synchronous compensators, regenerative braking systems, batteries used for internal services, etc.) without prejudice to the Member States' right to establish specific requirements at national level.

66 *Electromobility*

It is recommended that the technical requirements are set at the connection point of the electrical charging park. The scope of application of GC NCs could be extended to the EVs and their on-board devices, in particular, to their on-board V2G bidirectional converter used to inject power into distribution or transmission networks and V1G so as to provide frequency support in system defence strategies. Also, the electrical charging facility owners shall have the right to choose the EV or equivalent technology to employ for compliance testing.

Modalities of electrical charging park with regard the employment of the on-site technologies (stationary batteries, V1G and/or V2G) will need to be reflected in the application of the GC NCs.

Due to its very positive implications on the integration of electromobility, ACER recommends the introduction of a harmonised capacity threshold (a single banding value) for the classification of electrical charging parks.

67 *Simulation models and compliance monitoring*

Possible amendment of the NC RfG and NC DC could introduce common requirements for simulation models requested by system operators, considering the confidentiality and encrypted level (including cross-border network stability studies), validation of the models, and future maintenance if needed.

68 *Advanced capabilities for grids with high penetration of DER as well as converter-based technologies*

Moving to a smarter approach seems the more efficient solution in the long term. Some investments are needed at the beginning to install new intelligent and control devices both for networks and for the generators and demand response units but in the long term the benefits in terms of flexibility and less costly infrastructures would overcome the initial costs.

The connection codes are a foundation based on which the entire complex system design is eventually built. These codes set, in fact, the technical requirements for both networks and system users, while criteria for operating the network in a smarter approach may be covered in the review of the SO GL and the procurement of the services in the review of the EB GL and, if developed, in the dedicated network code on flexibility.

69 *Requirements for weather hazards resilience of generators*

Proportionate requirements could deliver enhanced system resilience to unusual weather events capable of compromising generation at a reasonable cost. The probability of risks and cost-effectiveness of the adopted measures shall be analysed based on the experience of interested parties and available historical records or performance studies.

70 *Technical requirements for active customers/energy communities*

All resources shall comply with the NC RfG or NC DC or both according to their own nature. Active customers and mixed customers sites are equivalent and thus the same rules and requirements should apply.

Members within energy communities should be not given any specific advantage: they should comply with the connection codes at the connection point to the distribution or transmission systems, as all the other resources.

71 *Requirements for units providing demand response services*

Provisions of the NC DC apply to the connection of defined demand units. Applicability of the requirements for units providing demand response services to relevant system operators and the possibility of their inclusion in the SO GL shall be revised to reflect the Framework Guidelines on Demand Side Flexibility referred to in paragraph 56.

72 *Harmonisation of types B, C and D PGMs requirements*

Harmonisation of the technical requirements to the extent possible is necessary to ensure full market integration. National implementations of these requirements need to appropriately reflect varying system needs while remaining in line with the relevant provisions of the NC RfG. However, closer alignment of the regulatory frameworks between the Member States might require amendments to the existing rules.

73 *Improvements to the applicable rules and procedures*

The clarity over technical requirements and procedural rules is paramount to a robust, non-discriminatory grid connection legal framework. Potential amendments should focus on streamlining existing processes while balancing the costs for involved parties and overall efficiency. In particular, improvements to the accessibility of information could be explored.

74 *Demonstration of compliance*

Appropriate regulation could foster the use of equipment certificates for the demonstration of compliance. Changes in the existing rules need to optimise between the reasonable flexibility for national systems and adequate harmonisation, ensuring a level-playing field. Further improvements to the compliance processes should be thoroughly investigated.