Annex 2 – Reasons for the proposed amendments to the HVDC Regulation

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1. INTRODUCTION

(1) By Recommendation No 03/2023 (hereinafter: '**ACER Recommendation 2023'**)[1], ACER issued reasoned proposals for amendments to Commission Regulation (EU) 2016/631 of 24 April 2016 establishing a network code on requirements for grid connection of generators (hereinafter: the '**RfG Regulation'**) and Commission Regulation (EU) 2016/1388 of 17 August 2016 establishing a network code on demand connection (hereinafter: the '**DC Regulation'**).

(2) Both Regulations are closely linked to Commission Regulation (EU) 2016/1447 of 26 August 2016 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules (hereinafter: the '**HVDC Regulation**'), as they contain technical requirements and capabilities for alternating current-connected power park modules (PPMs).

(3) ACER also proposes amendments to the HVDC Regulation, in order to align it with recent technological advancements and changes in the electric power system within the framework of the effort toward decarbonisation mandating such review of the relevant provisions.

(4) More specifically, while the current structure of the HVDC Regulation remains, profound amendments as well as new provisions were introduced in the attempt, on the one hand, to address the impact of new developments on the stable operation of the power systems as the percentage of the non-synchronous generation is significantly increasing and, on the other hand, to align the relevant provisions with the proposed amendments of the RfG Regulation (hereinafter: the **'RfG 2.0'**) and DC Regulation (hereinafter: the **'DC 2.0'**) as reflected in ACER Recommendation 2023.

(5) In this regard, the proposed amendments mainly aim to:

- expand the scope of the HVDC Regulation to cover offshore demand facilities, power-to-gas (mainly electrolysis) facilities and electricity storage modules connected to remote end HVDC converters stations;
- regulate HVDC systems that are connecting isolated AC networks;
- introduce grid forming requirements for HVDC systems;
- introduce technical requirements to cover offshore demand facilities, power-to-gas (mainly electrolysis) facilities and electricity storage modules connected to remote end HVDC converters stations.

(6) The proposed amendments to the HVDC Regulation are assessed against the objectives of the network codes as set out in Article 59(4) of the Regulation (EU) 2019/943 of the European Parliament and of the Council on the internal market for electricity (hereinafter: the **'Electricity Regulation'**).

[1] https://www.acer.europa.eu/sites/default/files/documents/Recommendations/ACER_Recommendation_03-2023_NC_RfG_DC.pdf

2. TITLE I – GENERAL PROVISIONS

(7) Following Protocol 1 to the EEA Agreement[2] (No 8 and 9), it is agreed that references to territories and to nationals of Member States for the purposes of the Agreement is to be understood as references also to the territories of the Contracting Parties (EU and EEA countries) and the nationals of the EFTA States.

(8) The changes recommended to the HVDC Regulation subsequently imply changes in the definitions (isolated AC network, isolated interface point, remote-end HVDC converter station, the replacement of the term 'DC connected power park module' with the term 'asynchronously connected power park module', asynchronously connected power-to-gas demand unit, asynchronously connected electricity storage module, asynchronously connected demand facility, asynchronously connected power park module owner, asynchronously connected power-to-gas demand unit owner, asynchronously connected electricity storage module owner, asynchronously connected demand facility owner, static synchronous compensator).

(9) As currently the HVDC Regulation includes requirements only for AC-collected and DC connected to a synchronous area PPMs, the scope of application of the HVDC Regulation (Article 3) is extended to include (apart from asynchronously connected power park modules), asynchronously connected demand facilities, asynchronously connected power-to-gas demand units, asynchronously connected electricity storage modules and HVDC systems connecting isolated AC networks. The expansion of the scope of the HVDC Regulation is further related to: a) the anticipated growth in generation capacity of isolated offshore AC networks (AC hubs) that are expected in the near future to connect large scale (GW or tens of GW) offshore wind power generation and large-scale industrial demand (electrolysis), b) the need to provide support to the grid through technical requirements of system users (e.g. power park modules, electricity storage modules, demand facilities) connected to the offshore AC network and HVDC systems, and c) the need to maintain system security and reliability and provide the means for cost-effective system design and secure system operation. The relevant definitions were included in the HVDC Regulation. Further, the development of isolated AC networks is already envisaged on islands of Member States, implying the necessity for harmonisation of certain requirements. ACER considers as important that the Member States have the flexibility to apply some or all of the requirements of the HVDC Regulation (Article 3(7)). More specifically, national rules may provide that the requirements of the HVDC Regulation should apply to HVDC systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units or asynchronously connected electricity storage modules, connected to the transmission system and distribution systems or to parts of the transmission system, or distribution systems, of islands of Member States the systems of which are not operated synchronously with either the Continental Europe, Nordic, Ireland and Northern Ireland or Baltic synchronous area. ACER proposes appropriate adjustments in Article 3(7)(b) due to the withdrawal of the United Kingdom from the European Union.

(10) According to Article 4(1) of the HVDC Regulation, existing HVDC systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules are not subject to the requirements of the HVDC Regulation, except where their electrical and grid-dynamic characteristics have been significantly modified (currently, this provision only applies to DC connected PPMs). However, the HVDC Regulation is not prescriptive as to the criteria for which a modification must be considered significant. With the amended Article 4

[2] https://www.efta.int/sites/default/files/documents/legal-texts/eea/the-eeaagreement/Protocols%20to%20the%20Agreement/protocol1.pdf

significant modernisation is based on specified criteria that the relevant system operators should take into account when defining significant modernisation. The newly introduced provisions aim at harmonizing as much as possible the parameters for all components within the scope of the HVDC Regulation as the latter could be connected to multiple system operators and better align with ACER Recommendation 2023.

(11) In Article 5(1) of the HVDC Regulation, the possibility to include different topology dependent requirements of general application for HVDC systems with more than two alternating current (AC) buses and more than two HVDC converter stations where HVDC converter stations are connected to different voltage levels or geographical locations is provided to allow for a more efficient use of the network and resources for these topologies. Furthermore, in order to allow for a swift implementation of the requirements of the HVDC Regulation, ACER proposes that the Member States may set a shorter time period for system operators to submit a proposal for part or all of the relevant requirements and/or methodologies, communicating their decision to ACER. Further, ACER proposes the amendment of paragraphs 3 and 8 of Article 5 for consistency with the RfG 2.0 and the DC 2.0 and as a result of the expansion of the scope of the HVDC Regulation (see Section 2(9)).

(12) In Article 8 ACER proposes amendments as a result of the expansion of the scope of the HVDC Regulation (see Section 2(9)).

(13) In Article 9 of the HVDC Regulation, and in order for stakeholders' engagement to be extended during consultation, ACER proposes an amendment so as to require ACER in co-operation with ENTSO-E and EU DSO Entity to organise shareholders involvement regarding the requirements for grid connection of HVDC systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules.

3. TITLE II – GENERAL REQUIREMENTS FOR HVDC CONNECTIONS

3.1 Requirements for active power control and frequency support

(14) It is crucial, in the context of the efforts to decarbonise the electric power sector, to shift to variable and distributed generation and implementing low-carbon technologies. In this respect, the appropriate design and management of a power system with high levels of variable generation and HVDC systems is critical for the secure operation of the power system. The HVDC converters/systems as part of the core infrastructure need to allow for the coordination of generators and demand facilities while avoiding unwanted tripping and help prevent major interruptions or support the resynchronisation/restoration of the grid after a large system disturbance such as for example a system split or a black-out. With the high penetration of non-synchronous generation, power electronic devices and HVDC links connected to the grid, system inertia tends to reduce, resulting in larger frequency excursions and higher rate-of-change-of-frequency. To safeguard the stability of the system, ACER proposes in Article 12 of the HVDC Regulation to extend the rate-of-change-of-frequency withstand capability at the connection point for an HVDC system (in line with requirements of Type A power generating modules of the RfG 2.0 as proposed in ACER Recommendation 2023). These new requirements would significantly contribute to the security of supply and sustainability at EU level by reducing the risk of loss of HVDC systems during large system incidents. It is also important to consider new needs for the HVDC system so that they continue to contribute to frequency stability and voltage support. The proposed new provisions introduce voltage phase angle jump withstand capability (Article 12b)

and grid forming capabilities (Article 14) (for the latter see also the final report of the *'Advanced Capabilities for Grids with High Shares of Power Park Modules'* Expert Group under the umbrella of the GC ESC).

(15) Having regard to the introduction of grid forming capabilities for power park modules in ACER's amendment proposal for the RfG 2.0, ACER proposes that grid-forming capability is also introduced in Article 14 of the HVDC Regulation for HVDC systems in order for the aligned requirements' availability throughout Member States (MS) to be facilitated for the purpose of initiation and acceleration of the process of grid-forming implementation. Further specifications in national implementations of the Grid Connection Network Codes' (GC NC) requirements may depend on the location of each Member State and the urgency of the roll out of the grid forming capabilities. Further, the requirement for fast frequency control capability is proposed (Article 14b) in order to accommodate the needs for damping of frequency oscillations if the grid forming capability is not specified by the relevant system operator.

(16) As regards frequency control in Article 16 of the HVDC Regulation, ACER proposes the utilization of the available power at the AC connection point of the HVDC system, if specified by the TSO, in order to contribute to stabilization of the system frequencies. In Article 17 of the HVDC Regulation, for the maximum loss of active power in addition to injection in a synchronous area, ACER proposes that the withdrawal of active power from a synchronous is also included.

3.2 Requirements for reactive power and voltage support

(17) In Article 19 of the HVDC Regulation, ACER proposes that if grid forming capability as prescribed in Article 14 of the HVDC Regulation is not requested and if specified by the relevant system operator, in coordination with the relevant TSO, an HVDC system should have the capability to provide fast fault current at a connection point in case of symmetrical (3-phase) faults. Further, in case an HVDC system is required to have the fast fault current provision, it is proposed that the TSO should specify apart from how and when a voltage deviation is to be determined, the end of the voltage deviation and the characteristics of the fast fault current, the timing and accuracy of the response during fault, which may include several stages.

(18) Further in Article 22 of the HVDC Regulation, additional controls modes shall be specified by the relevant system operator in coordination with the relevant TSO and the HVDC system owner. In addition, ACER proposes that the specified reactive power control mode should not interfere with the initial grid forming response when grid forming capability according to Article 14 of the HVDC Regulation is requested.

3.3 Requirements for fault ride through capability

(19) In Article 25 of the HVDC Regulation, ACER proposes to include non-exhaustive overvoltage ride through capability of the HVDC system in line with the RfG 2.0 with reference to the requirements for power park modules of the RfG 2.0.

3.4 Requirements for control

(20) ACER proposes the introduction of a new Article 30a on passivity of HVDC systems. With regard to this requirement, the HVDC system should be capable of providing passivity at its connection point which requires that the resistive part of the frequency dependent complex impedance of the HVDC converter station at the connection point should not be negative between two frequency thresholds. This new requirement would further contribute to the security of supply and sustainability at EU level by enhancing the harmonic stability and resonance stability of HVDC

systems. Thus, along with grid forming and voltage phase jump capabilities, it will ensure the secure operation of the European interconnected system by reducing the risk of loss of HVDC systems during large system incidents.

3.5 HVDC system robustness

(21) In Article 33 of the HVDC Regulation a new requirement is introduced. ACER proposes that an HVDC converter station being part of an HVDC system be capable of stably operating in the static synchronous compensator (STATCOM) operation mode when disconnected from DC transmission lines or cables following a DC disturbance, if specified by the relevant transmission system operator (TSO).

3.6 Priority ranking of protection and control

(22) In Article 35 of the HVDC Regulation, ACER proposes amendments with regard to priority ranking of protection and control. More specifically, it is recommended that the HVDC system owner organise its protections and control devices in compliance with the following priority ranking, listed in decreasing order of importance, unless otherwise specified by the relevant TSOs, in coordination with the relevant system operator: (a) network system and HVDC system protection; (b) grid forming capability as defined in Article 14(1) to (3), if applicable; (c) synthetic inertia as specified in Article 14(4), if applicable, or fast frequency control capability as specified in Article 14b; (d) active power control for emergency assistance; (e) automatic remedial actions as specified in Article 13(3); (f) FSM and LFSM-O/U, and (g) power gradient constraint.

3.7 Changes to protection and control schemes and settings

(23) ACER proposes the amendment of paragraph 2 of Article 36 of the HVDC Regulation so that any change to the schemes or settings of parameters of the different control modes and protection of the HVDC system, including the procedure, be coordinated and agreed between the relevant system operator, the relevant TSO and the HVDC system owner, and in particular if the schemes and settings of the different control devices are necessary for transmission system stability and for taking emergency action.

4. TITLE III – REQUIREMENTS FOR ASYNCHRONOUSLY CONNECTED POWER PARK MODULES[3], ASYNCHRONOUSLY CONNECTED DEMAND FACILITIES, ASYNCHRONOUSLY CONNECTED POWER-TO-GAS DEMAND UNITS, ASYNCHRONOUSLY CONNECTED ELECTRICITY STORAGE MODULES AND REMOTE-END HVDC CONVERTER STATIONS[4]

4.1 Requirements for asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules

(24) ACER considers that it is important to refer to the requirements applicable to offshore generation under the RfG 2.0 and the requirements applicable to transmission connected demand facilities

[3] Previously referred to as DC connected power part modules.
[4] TITLE III as such was amended to include also asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules.

and power-to-gas demand units under the DC 2.0, for asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules under the HVDC Regulation.

(25) As the scope of the HVDC Regulation is proposed to be extended and aligned with ACER Recommendation 2023, ACER proposes the following amendments in Article 38 of the HVDC Regulation:

(i) to apply the requirements applicable to offshore power park modules under Articles 13 to 22, (with the exception of Articles 13a and 14a) as included in the RfG 2.0, to asynchronously connected power park modules and asynchronously connected electricity storage modules subject to specific requirements provided for in Articles 39 to 45 of the HVDC Regulation and to the newly introduced Articles 40a and 40b;

(ii) to apply the requirements applicable to offshore power park modules under Article 26(2) of the RfG 2.0 – inclusion of requirements for power park modules for forced oscillations – to asynchronously connected power park modules;

(iii) to apply the categorisation in Article 5 of the RfG 2.0 to asynchronously connected power park modules and asynchronously connected electricity storage modules, as well as the requirements applicable to transmission connected demand facilities, under Articles 14, 16, 17, 19, 21, 39, 40 and 44 of the DC 2.0, to asynchronously connected demand facilities;

(iv) to introduce the requirements applicable to power-to-gas demand units, under Articles XX, XX+1, XX+2 and XX+3 of the DC 2.0 for asynchronously connected power-to-gas demand units subject to specific requirements provided for in Article 39, Article 40, Article 40a (newly introduced), Article 40 b (newly introduced), Article 40c (newly introduced), Article 41, Article 42, Article 43, Article 44 and Article 45 of the HVDC Regulation;

(v) to apply these requirements at the isolated interface points of the asynchronously connected power park module, asynchronously connected demand facility, asynchronously connected power-to-gas demand unit, asynchronously connected electricity storage module and the remote-end HVDC converter station.

(26) In Article 39 of the HVDC Regulation on frequency stability requirements ACER proposes the necessary amendments so as the requirements of the Article be extended to asynchronously connected power-to-gas demand unit, asynchronously connected electricity storage module and asynchronously connected demand facility and the references to the relevant provisions to align with the RfG 2.0, where appropriate. Further, ACER proposes the introduction of new provisions entailing requirements regarding a capability for limited frequency sensitive mode - underfrequency consumption (LFSM-UC) for an asynchronously connected power-to-gas demand unit based either on the measured frequency at the power-to-gas demand unit interface point or on a fast signal response as specified in paragraph (1) for the 50 Hz nominal system. More specifically, ACER considers that it is the necessary to align the capabilities for frequency sensitive mode and frequency restoration of an asynchronously connected power park module and asynchronously connected electricity storage module with the RfG 2.0.

(27) In Article 40 of the HVDC Regulation on reactive power and voltage requirements, ACER proposes that the requirements on voltage ranges should apply also to an asynchronously connected power-to-gas demand unit, an asynchronously connected demand facility and an

asynchronously connected electricity storage module and to the asynchronously connected power-to-gas demand unit owner, the asynchronously connected demand facility owner and the asynchronously connected electricity storage module owner. The recommended provisions also ensure that the relevant provisons are aligned with the RfG 2.0 and the DC 2.0 and applicable EU legislation.

(28) Following the need to introduce fault-ride-through capability of asynchronously connected power-to-gas demand units, ACER proposed the introduction of a new Article 40a according to which the asynchronously connected power-to-gas demand unit, when operating above the minimum operating level, should be capable of staying connected to the network and continuing to operate stably after the power system has been disturbed by faults in the isolated AC network according to a voltage-against-time-profile in line with the relevant Tables and Figure provided in the HVDC Regulation.

(29) As regards grid forming capability, ACER introduces a new Article 40b, according to which, if grid forming is requested (as set out in Article 14(4) of the HVDC Regulation), the asynchronously connected power park modules and the asynchronously connected electricity storage modules should aditionally be capable of providing synthetic inertia in accordance with Article 22 of the RfG 2.0, if requested by the relevant system operator.

(30) As regards overvoltage ride through capability of asynchronously connected power-to-gas demand units, ACER introduces a new Article 40c, according to which the asynchronously connected power-to-gas demand unit should be capable of operating stably without disconnecting from the network, if none of the phase-to-phase voltages exceeds the voltage-against-time-profile at the isolated interface point in line with the relevant Figure provided in the HVDC Regulation.

(31) In Article 41 (control requirements), Article 42 (network characteristics), Article 43 (protection requirements), Article 44 (power quality) and Article 45 (general system management requirements applicable to asynchronously connected power park modules, asynchronously connected electricity storage modules, asynchronously connected power-to-gas demand units and asynchronously connected demand facilities), the scope of these provisions is extended to cover asynchronously connected power-to-gas demand units, asynchronously connected demand facilities and asynchronously connected electricity storage modules and their respective owners, as appropriate and that the relevant references are aligned with the RfG 2.0 and the DC 2.0, as appropriate.

4.2 Requirements for remote-end HVDC converter stations

(32) In Article 47 of the HVDC Regulation (frequency stability requirements), the scope of these provisions is extended to cover asynchronously connected power-to-gas demand unit, asynchronously connected demand facility and an asynchronously connected electricity storage module. Further, ACER proposes the introduction of three new paragraphs to cover the case where two or more remote-end HVDC converter stations are connected to one or more interface points of the same isolated AC network. In such case the remote-end HVDC converter stations and their respective HVDC systems should be capable of continuously operating stably over the full operating range between the maximum and the minimum HVDC system active power transmission capacity and contributing to the frequency control of the remote-end HVDC system isolated AC network they are connected to. Further, ACER proposes that the relevant TSO in coordination with adjacent TSOs should specify that a study is required, in order to define coordinated frequency droop slope parameters of the remote-end HVDC converter stations including power sharing ratio between the remote-end HVDC stations and their respective HVDC

system. Finally, ACER recommends that where grid forming is requested, the remote-end HVDC converter station be capable of adjusting at its interface point the isolated AC network frequency and voltage phase angle to use the synthetic inertia from asynchronously connected power park modules and asynchronously connected electricity storage modules, if it is requested by the relevant TSO.

(33) In Article 48 of the HVDC Regulation (reactive power and voltage requirements), as regards voltage ranges, ACER proposes that a remote-end HVDC converter station be capable of staying connected to the remote-end HVDC converter station isolated AC network and operating within the voltage ranges (per unit) and time periods specified in Table 11, Annex VIII, or for voltage level below 110kV as specified by the relevant system operator. The applicable voltage range and time periods specified are selected based on the reference 1 pu voltage. ACER also proposes that wider voltage ranges or longer minimum times for operation may be agreed between the relevant system operator, the relevant TSO, and the asynchronously connected power park module owner, the asynchronously connected demand facility owner, the asynchronously connected power-to-gas demand unit owner and the asynchronously connected electricity storage module owner to ensure the best use of the technical capabilities of a remote-end HVDC converter station if needed to preserve or to restore system security. If wider voltage ranges or longer minimum times for operation are economically and technically feasible, the remote-end HVDC converter station owner should not unreasonably withhold consent. Finally, ACER recommends the introduction of two new paragraphs in Article 48 requiring the remote-end HVDC converter stations and their respective HVDC systems in cases where two or more remote-end HVDC converter stations are connected to one or more interface points of the same isolated AC network to be capable of continuously operating stably over the full operating range between maximum and minimum HVDC system active power transmission capacity and contributing to the voltage stability of the remote-end HVDC system isolated AC network they are connected to; in such a case, the relevant TSO in coordination with adjacent TSOs, should specify that a study is required in order to define coordinated voltage stability control parameters of the remote-end HVDC converter stations including reactive power sharing ratio between the remote-end HVDC stations and their respective HVDC system.

(34) As regards network characteristics in Article 49 of the HVDC Regulation, ACER's proposal ensures that the relevant provisions apply also to asynchronously connected demand facility owners, asynchronously connected power-to-gas demand unit owners and asynchronously connected electricity storage module owners.

(35) As regards power quality in Article 50 of the HVDC Regulation, ACER recommendation ensures that the relevant provisions apply also to asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules.

5. TITLE IV – INFORMATION EXCHANGE AND COORDINATION

(36) In Article 51 of the HVDC Regulation (operation of HVDC systems), ACER proposes that in paragraph 3 the active power flow direction signal is moved to the list of operational signals instead of alarm signals.

(37) In Article 52 of the HVDC Regulation (parameters and settings), ACER proposes the amendment of the main control functions so as to include also grid forming capability, if applicable as referred to in Article 14 and Article 35, fast frequency control, if applicable as referred to in Article 14b

and Article 35 of the HVDC Regulation, and short circuit contribution during faults as referred to in Article 19 and in Article 35 of the HVDC Regulation.

(38) As regards simulation models in Article 54 of the HVDC Regulation, ACER proposes amendments by introducing also new provisions concerning root mean square (RMS) and electromagnetic transient (EMT) simulations as well as the risk assessment of the resonance stability of the HVDC converter station, without prejudice of the Member State's rights to introduce additional requirements. More specifically:

- For the purpose of RMS simulations used in network studies, the relevant TSO should have the right to specify the model requirements so as the HVDC models at lease a) be valid for the specified operating range and all control modes of the HVDC system; b) include representation of HVDC converter unit, HVDC lines/cables and control systems that influence the dynamic behaviour of the HVDC transmission system in the specified time frame; c) include the relevant protection function models as agreed between the relevant TSO and the HVDC system owner; and d) be open source generic model, or encrypted detailed model if applicable, for RMS simulations delivered for cross-border network stability studies.

- As far as EMT simulations are concerned, the relevant TSO should have the right to specify the model requirements. The HVDC system models are proposed to a) be valid at least in the frequency range 0,2Hz to 2500 Hz for relevant studies; b) be valid for the specified operating range and all operation modes of the HVDC system in both the positive and in the negative phase sequence; c) be able to reproduce the detailed transient response of the HVDC system and its control blocks (including synchronisation) during balanced and unbalanced AC and DC network faults in the valid frequency range; d) include, for the respective HVDC system model and study purpose, an accurate representation of the semiconductor valves, the frequency dependency of the HVDC system lines and, where deemed necessary, sufficient representation of communication systems instruments; e) represent at least transformers models (including saturation), resistors, filters, breakers, AC and DC arresters in the valid frequency range; f) include all the control and protection models as agreed between the relevant TSO and the HVDC system owner (under/overvoltage, overcurrent, chopper and frequency sensitive control functions); and g) be capable to be used for the numerical calculation of the frequency dependent impedance of the HVDC converter station (impedance magnitude and impedance phase angle) from the AC and DC side in the frequency range that the model is valid.

- Finally, ACER proposes the introduction of new paragraph concerning the risk assessment of the resonance stability of the HVDC convert station, where the TSO should have the right to request from the HVDC system owner the frequency dependent impedance model of the HVDC converter station at the AC and the DC side. The following requirements are proposed to be applied: a) the impedance model of the HVDC converter station should be requested in the frequency range 5 Hz till 2500 Hz; the relevant system operator may extend the required applicability of the model up to 9000 Hz, in agreement with the HVDC system owner; b) the relevant system operator in coordination with the relevant TSO together with the HVDC owner should agree if the calculation of the impedance model of the HVDC converter station will be either numerically (using the EMT model) or analytically (using transfer function) or both. In the case of numerical calculation, the TSO should specify the frequency steps where the impedance is provided. The number of different frequency steps should be reasonably limited to provide acceptable results and at the same time limit the simulation effort and data storage to an acceptable amount); c) the relevant system operator in coordination with the relevant TSO should have the right to request the impedance model of the HVDC station

through the specified operating range and all control modes of operation; d) the impedance model of the HVDC converter station should be provided for both the positive and for the negative phase sequence; e) the HVDC system owner should take into account the influence of the whole HVDC unit control and measurement system as well as other parts of the HVDC unit which influences the output impedance in the specified frequency range; if coupling between different frequencies exists in a given frequency range, this should be sufficiently represented; and f) the HVDC system owner should specify and justify simplifications made in the calculation of the impedance model.

6. TITLE V – OPERATIONAL NOTIFICATION PROCEDURE FOR CONNECTION

6.1 Connection of new asynchronously connected power park modules, new asynchronously connected demand facilities, new asynchronously connected power-to-gas demand units and new asynchronously connected electricity storage modules

(39) As the scope of application of the HVDC Regulation (Article 3) is extended (see Section 2(9)), ACER proposes relevant amendments to Articles 60, 61, 62, 63 and 64 of the HVDC Regulation so that those provisions apply also to new asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules, and asynchronously connected demand facility owners, asynchronously connected power-to-gas demand unit owners or asynchronously connected electricity storage module owners, as appropriate.

6.2 Cost benefit analysis

(40) As the scope of application of the HVDC Regulation is extended (see Section 2(9)), ACER proposes relevant amendments to Article 65 (identification of costs and benefits of application of requirements to existing HVDC systems or DC connected PPMs) and Article 66 (principles of cost-benefit analysis) of the HVDC Regulation, so that those provisions apply also to asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules, and asynchronously connected demand facility owners, asynchronously connected power-to-gas demand unit owners or asynchronously connected electricity storage module owners, as appropriate.

7. TITLE VI – COMPLIANCE

7.1 Compliance monitoring

(41) As the scope of application of the HVDC Regulation (Article 3) is extended (see Section 2(9)), ACER proposes relevant amendments to Article 67 (common provisions for compliance testing), Article 68 (common provisions on compliance simulation), Article 69 (responsibility of the HVDC system owner and DC connected PPM owner) and Article 70 (tasks of the relevant system operator) of the HVDC Regulation so that those provisions apply also to asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules, and asynchronously connected demand facility owners, asynchronously connected power-to-gas demand unit owners or asynchronously connected electricity storage module owners, as appropriate.

7.2 Compliance testing

(42) As the scope of application of the HVDC Regulation (Article 3) is extended (see Section 2(9)), ACER proposes relevant amendments to Article 72 (compliance testing for DC connected PPMs and remote-end HVDC converter units) of the HVDC Regulation so that this article applies also to asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules, and asynchronously connected demand facility owners, asynchronously connected power-to-gas demand unit owners or asynchronously connected electricity storage module owners, as appropriate.

(43) Further, a new paragraph 15 in Article 72 is proposed to cover compliance testing with regard to Limited Frequency Sensitive Mode - Underfrequency Consumption (LFSM-UC) of an asynchronously connected power-to-gas demand unit.

7.3 Compliance simulations

(44) In Article 73 of the HVDC Regulation, ACER introduces new paragraphs 9-14 to cover compliance simulations with regard to grid forming capability, fast frequency control capability, rate-of-change-of-frequency withstand capability, fast recovery from DC faults, voltage phase angle jump capability and HVDC system passivity.

(45) As the scope of application of the HVDC Regulation is extended (see Section 2(9)), ACER proposes relevant amendments to Article 74 (compliance simulations for DC connected PPMs and remote-end HVDC converter units) of the HVDC Regulation so that this article applies also to asynchronously connected electricity storage modules and asynchronously connected power-to-gas demand units, and asynchronously connected electricity storage module owner and asynchronously connected power-to-gas demand unit owner, as appropriate. ACER also proposes adjustments to Article 74 to align with the RfG 2.0. Further, new paragraphs 8, 9 and 10 are introduced to cover compliance simulations with regard to post fault active power recovery and fault-ride-through capability of an asynchronously connected power-to-gas demand unit and grid forming capability of an asynchronously connected power park module and asynchronously connected electricity storage module.

7.4 Non-binding guidance and monitoring of implementation

(46) In Article 76 of the HVDC Regulation, ACER introduces amendments to update the monitoring process in accordance with Articles 30(5), 32(1) and 55(2)(a) of the Electricity Regulation. Further, it is proposed that ACER in co-operation with ENTSO for Electricity should maintain a public online repository where relevant national information regarding the progress of implementation of the HVDC Regulation should be made available (Article 76(3)). Such information should at least include legal texts, implementation monitoring files, summaries of all the proposals for non-exhaustive requirements, TSO and DSO requirements and compliance tests and process to be performed and links to the national implementation websites. Those amendments are also in line with the RfG 2.0 and the DC 2.0.

8. TITLE VII – DEROGATIONS

(47) As the scope of application of the HVDC Regulation is extended (see Section 2(9)), ACER proposes relevant amendments to Article 77 (power to grant derogations), Article 78 (general provisions), Article 79 (request for derogation by an HVDC system owner or DC connected PPM

owner), Article 80 (request for a derogation by a relevant system operator or relevant TSO) and Article 81 (request for derogations from the provisions of Title III by DC connected PPM owner) of the HVDC Regulation so that those provisions apply also to asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules, and to asynchronously connected demand facility owners, asynchronously connected power-to-gas demand unit owners or asynchronously connected electricity storage module owners, as appropriate.

(48) Under Article 82 of the HVDC Regulation, regulatory authorities maintain a register of all derogations they have granted or refused and provide ACER with an updated and consolidated register at least once every six months, copying also ENTSO for Electricity. For the purposes of transparency, ACER recommends an amendment according to which the register of all derogations granted or refused, kept by the regulatory authorities, is publicly available, also in line with the RfG 2.0 and the DC 2.0.

9. TITLE VIII – FINAL PROVISIONS

(49) As the scope of application of the HVDC Regulation is extended (see Section 2(9)), ACER proposes the relevant amendments to Article 84 (amendment of contracts and general terms and conditions) and Article 85 (HVDC System or DC connected PPMs connecting with synchronous areas or control areas not bound by EU legislation) of the HVDC Regulation so that those provisions apply also to asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules.

(50) ACER proposes to introduce a new Article 85a, in order to provide legal certainty and clarity regarding the repeal of the HVDC Regulation.

(51) In paragraph 2 of the newly introduced Article 85a, ACER proposes that Regulation (EU) 2016/1447 should continue to apply to HVDC systems and asynchronously connected power park modules which fall within its scope of application at the entry into force of HVDC 2.0 and which are not subject to the requirements of HVDC 2.0 according to Article 4(1).

10. ANNEXES

(52) ACER proposes that Annex I of the HVDC Regulation on frequency ranges referred to in Article 11 of the HVDC Regulation under the same title, be amended to include asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules according to Article 39 of the HVDC Regulation. Further, the frequency range 51,5 Hz-52,0 Hz is proposed to be extended to 51,5 Hz-52,5 Hz, in line with the RfG 2.0.

(53) ACER proposes that Annex II of the HVDC Regulation on requirements applying to frequency sensitive mode, limited frequency sensitive mode overfrequency and limited frequency sensitive mode underfrequency, be amended. As regards the frequency sensitive mode, Table 2 is amended for clarity. Further, it is proposed that the initial activation of active power frequency response required should be as short as possible. As regards the limited frequency sensitive mode overfrequency, a new table is introduced to define the default frequency thresholds. As regards the limited frequency sensitive mode underfrequency, the default frequency threshold is introduced based on the new table proposed in the limited frequency sensitive mode overfrequency.

(54) ACER proposes that Annex III of the HVDC Regulation on voltage ranges referred to Article 18 of the HVDC Regulation under the same title, be amended in line with the RfG 2.0. Further, ACER proposes appropriate adjustments in Annex III due to the withdrawal of the United Kingdom from the European Union.

(55) ACER proposes appropriate adjustments in Annex IV due to the withdrawal of the United Kingdom from the European Union.

(56) ACER proposes that Annex V of the HVDC Regulation on voltage-against-time-profile referred to in Article 25 of the HVDC Regulation under the same title, be amended for clarity. Further, the range for the time parameter t_{rec1} is extended from 1,5-2,5 seconds to 1,5-3,0 seconds.

(57) ACER proposes that Annex VI of the HVDC Regulation on frequency ranges and time periods referred to in Article 39(2)(a) of the HVDC Regulation under the same title, be amended to include asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules. Further, the time period for operation in the frequency range 47,0 Hz-47,5 Hz is proposed to be amended to 60 seconds in line with Annex I of the HVDC Regulation.

(58) ACER proposes that Annex VII of the HVDC Regulation on voltage ranges and time periods referred to in Article 40 of the HVDC Regulation on reactive power and voltage requirements be amended to include asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules and to be in line with the RfG 2.0. Further, additional flexibility for the relevant system operator in coordination with the relevant TSO to specify the time period for operation for certain voltage ranges is proposed. Voltage ranges for 275kV rated voltage are introduced as this voltage range is expected to play an important role for future cost-effective isolated AC networks.

(59) ACER proposes that Annex VIII of the HVDC Regulation on reactive power and voltage requirements referred to in Article 48 under the same title, be amended to provide additional flexibility for the relevant system operator in coordination with the relevant TSO to specify the time period for operation for certain voltage ranges. Voltage ranges for 275kV rated voltage are introduced as this voltage range is expected to play an important role for future cost-effective isolated AC networks.