ACER
European Union Agency for the Cooperation of Energy Regulators

ACER Recommendation No 01/2024 on NC HVDC

Annex 1 – Proposed amended HVDC Regulation

NOTE: All relevant references to RfG and DC in the text are consistent with RfG 2.0 and DC 2.0 according to ACER Recommendation No 3/2023 to the European Commission and they are marked as such in the text where necessary.

COMMISSION REGULATION (EU) 20--/---- of ...

establishing a network code on requirements for grid connection of high voltage direct current systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast) ([1]), and in particular Articles 59(2)(a) and 60(1) thereof,

Whereas:

(1) The swift completion of a fully functioning and interconnected internal energy market is crucial to maintaining security of energy supply, increasing competitiveness and ensuring that all consumers can purchase energy at affordable prices.

(2) Regulation (EU) 2019/943 sets out non-discriminatory rules governing access to the network for cross-border exchanges in electricity with a view to ensuring the proper functioning of the internal market in electricity. In addition Article 3 of Directive (EU) 2019/944 of the European Parliament and of the Council ([2]) requires that Member States shall ensure, a level playing field where electricity undertakings are subject to transparent, proportionate and non-discriminatory rules, fees and treatment. Where requirements constitute terms and conditions for connection to national networks, Article 59(7) of the same Directive requires regulatory authorities to be responsible for fixing or approving at least the national methodologies used to calculate or establish them. In order to provide system security within the interconnected transmission system, it is essential to establish a common understanding of the requirements for High-Voltage Direct Current (HVDC) systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules. Those requirements that contribute to maintaining, preserving and restoring system security in order to facilitate proper

[1] OJ L 158, 14.6.2019 p. 54.

[2] 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 and amending Directive 2012/27/EU (recast) (OJ L 158, 14.6.2019, p. 125).

functioning of the internal electricity market within and between synchronous areas, and to achieve cost efficiencies, should be regarded as cross-border network issues and market integration issues.

(3) Harmonised rules for grid connection for HVDC systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules should be set out in order to provide a clear legal framework for grid connections, facilitate Union-wide trade in electricity, ensure system security, facilitate the integration of renewable electricity sources, increase competition and allow more efficient use of the network and resources, for the benefit of consumers.

(4) System security depends partly on the technical capabilities 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. Therefore regular coordination at the level of the transmission and distribution networks and adequate performance of the equipment connected to the transmission and distribution networks with sufficient robustness to cope with disturbances and to help to prevent any major disruption or to facilitate restoration of the system after a collapse are fundamental prerequisites.

(5) Secure system operation is only possible if there is close cooperation between owners 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 and system operators. In particular, the functioning of the system under abnormal operating conditions depends on the response of the HVDC systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules to deviations from the reference 1 per unit (pu) values of voltage and nominal frequency. In the context of system security, the networks and the HVDC systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules 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, relevant technical requirements should be set for HVDC systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules.

(6) Regulatory authorities should consider the reasonable costs effectively incurred by system operators in the implementation of this Regulation when fixing or approving transmission or distribution tariffs or their methodologies or when approving the terms and conditions for connection and access to national networks in accordance with Article 59(1) and (7) of Directive (EU) 2019/944 and with Article 18 of Regulation (EU) 2019/943.

(7) Different synchronous electricity systems in the Union have different characteristics which need to be taken into account when setting the requirements for HVDC systems,

asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules. It is therefore appropriate to consider regional specificities when establishing network connection rules as required by Article 58(1) and (2) of Regulation (EU) 2019/943.

(8) In view of the need to provide regulatory certainty, the requirements of this Regulation should apply to new HVDC systems, 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 but should not apply to HVDC systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules already existing or at an advanced stage of planning but not yet completed unless the relevant regulatory authority or Member State decides otherwise based on evolution of system requirements and a full cost-benefit analysis, or where there has been substantial modernisation of those facilities. Similarly, the requirements under Regulation (EU) 2016/1447 should continue to apply to the HVDC systems and units which exist at the entry into force of this Regulation and fall within the scope of Regulation (EU) 2016/1447.

(9) Due to its cross-border impact, this Regulation should aim at the same frequency-related requirements for all voltage levels, at least within a synchronous area. That is necessary because, within a synchronous area, a change in frequency in one Member State would immediately impact frequency and could damage equipment in all other Member States.

(10) To ensure system security, it should be possible for HVDC systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules in each synchronous area of the interconnected system to remain connected to the system for specified frequency and voltage ranges.

(11) Voltage ranges should be coordinated between interconnected systems because they are crucial to secure planning and operation of a power system within a synchronous area. Disconnections because of voltage disturbances have an impact on neighbouring systems. Failure to specify voltage ranges could lead to widespread uncertainty in planning and operation of the system with respect to operation beyond normal operating conditions.

(12) Appropriate and proportionate compliance testing should be introduced so that system operators can ensure operational security. In accordance with Article 59(1)(b) of Directive (EU) 2019/944, regulatory authorities are responsible for ensuring that system operators are compliant with this Regulation.

(13) The regulatory authorities, Member States and system operators should ensure that, in the process of developing and approving the requirements for network connection, they are harmonised to the extent possible, in order to ensure full market integration.

Established technical standards should be taken into particular consideration in the development of connection requirements.

(14) A process for derogating from the rules should be set out in this Regulation to take into account local circumstances where exceptionally, for example, compliance with those rules could jeopardise the stability of the local network or where the safe operation of an HVDC system, asynchronously connected power park module, asynchronously connected demand facility, asynchronously connected power-to-gas demand unit or asynchronously connected electricity storage module might require operating conditions that are not in line with this Regulation.

(15) In the case of asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules, new modules, facilities and units could, in the future form part of a meshed off-shore grid connecting to more than one synchronous area. In this case, certain technical requirements should be set in order to maintain system security and ensure that future meshed networks can be developed cost- effectively. However, for certain requirements, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units or asynchronously connected electricity storage modules should only be required to fit the equipment needed for system security at the time it becomes necessary.

(16) Therefore, the owners of asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units or asynchronously connected electricity storage modules which are, or will be, connected to one synchronous area with a radial connection should have the possibility to apply, via an expedited process, for derogations to requirements that will only be needed where the asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units or asynchronously connected electricity storage modules become connected to a meshed grid and which take account of case-by-case circumstances. They should also be informed as early as possible whether they qualify for a derogation for the purposes of their investment decision-making.

(17) Subject to approval by the relevant regulatory authority, or other authority where applicable in a Member State, system operators should be allowed to propose derogations for certain classes 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.

(18) This Regulation has been adopted on the basis of Regulation (EU) No 2019/943 which it supplements and of which it forms an integral part. References to Regulation (EU) 2019/943/ in other legal acts should be understood as also referring to this Regulation.

(19) The measures provided for in this Regulation are in accordance with the opinion of the Committee referred to in Article 67(1) of Regulation (EU) 2019/943,

HAS ADOPTED THIS REGULATION:

TITLE I

GENERAL PROVISIONS

Article 1

Subject matter

This Regulation establishes a network code which lays down the requirements for grid connections of high-voltage direct current (HVDC) systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules. It, therefore, helps to ensure fair conditions of competition in the internal electricity market, to ensure system security and the integration of renewable electricity sources, and to facilitate Union-wide trade in electricity.

This Regulation also lays down the obligations for ensuring that system operators make appropriate use 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 capabilities in a transparent and non-discriminatory manner to provide a level playing field throughout the Union.

Article 2

Definitions

For the purposes of this Regulation, the definitions in Article 2 of Regulation (EU) 2019/943, Article 2 of Commission Regulation (EU) 2015/1222 ([3]) , Article 2 of RfG 2.0 ([4]), Article 2 of DC 2.0 ([5]) and Article 2 of Directive (EU) 2019/944 shall apply. In addition, the following definitions shall apply:

(1) 'HVDC system' means an electrical power system which transfers energy in the form of high-voltage direct current between two or more alternating current (AC) buses and

[3] Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (OJ L 197, 25.7.2015, p. 24).
[4] 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).
[5] Commission Regulation (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection (OJ L 223, 18.8.2016, p. 10).

comprises at least two HVDC converter stations with DC transmission lines or cables between the HVDC converter stations;

(2) 'embedded HVDC system' means an HVDC system connected within a control area that is not installed for the purpose of connecting an asynchronously connected power park module or an asynchronously connected electricity storage module at the time of installation, nor installed for the purpose of connecting an asynchronously connected demand facility or an asynchronously connected power-to-gas demand unit;

(3) 'HVDC converter station' means the station which is a part of an HVDC system which consists of one or more HVDC converter units installed in a single location together with buildings, reactors, filters, reactive power devices, control, monitoring, protective, measuring and auxiliary equipment;

(4) 'maximum HVDC active power transmission capacity' (P_{max}) means the maximum continuous active power which an HVDC system can exchange with the network at each connection point as specified in the connection agreement or as agreed between the relevant system operator and the HVDC system owner;

(5) 'minimum HVDC active power transmission capacity' (P_{min}) means the minimum continuous active power which an HVDC system can exchange with the network at each connection point as specified in the connection agreement or as agreed between the relevant system operator and the HVDC system owner;

(6) 'HVDC system maximum current' means the highest phase current, associated with an operating point inside the U-Q/P_{max}-profile of the HVDC converter station at maximum HVDC active power transmission capacity;

(7) 'HVDC converter unit' means a unit comprising one or more converter bridges, together with one or more converter transformers, reactors, converter unit control equipment, essential protective and switching devices and auxiliaries, if any, used for the conversion;

(8) 'isolated AC network' means an AC network which is not part of a synchronous area, which is connected to one or more synchronous areas via one or more HVDC systems. This definition does not include the transmission and distribution systems or their parts, of islands of Member States of which the systems are not operated synchronously with either the Continental Europe, Nordic, Ireland and Northern Ireland or Baltic synchronous area, unless the designated entity, decides to make such systems subject to all or some of the requirements of this Regulation, according to national rules;

(9) 'isolated interface point' means the AC interface of an isolated AC network at which technical specifications affecting the performance of the relevant equipment can be prescribed, as identified in the connection agreement;

(10) 'remote-end HVDC converter station' means an HVDC converter station which is not synchronously connected to any synchronous area but is connected to one or more isolated AC networks;

(11) 'asynchronously connected power park module' or 'A-PPM' means a power park module that is connected via an isolated interface point to one or more remote-end HVDC converter stations;

(12) ‘asynchronously connected power-to-gas demand unit’ or ‘A-PtG-DU’ means a power-to-gas demand unit that is connected via an isolated interface point to one or more remote end HVDC converter stations;

(13) ‘asynchronously connected electricity storage module’ or ‘A-ESM’ means an electricity storage module that is connected via an isolated interface point to one or more remote end HVDC converter stations;

(14) ‘asynchronously connected demand facility’ or ‘A-DF’ means a facility which consumes electrical energy and is connected via an isolated interface point to one or more remote end HVDC converter stations;

(15) ‘asynchronously connected power park module owner’ or ‘A-PPM owner’ means a natural or legal entity owning an asynchronously connected power park module;

(16) ‘asynchronously connected power-to-gas demand unit owner’ or A-PtG-DU owner’ means a natural or legal entity owning an asynchronously connected power-to-gas demand unit;

(17) ‘asynchronously connected electricity storage module owner’ or A-ESM owner’ means a natural or legal entity owning an asynchronously connected electricity storage module;

(18) ‘asynchronously connected demand facility owner’ or ‘A-DF owner’ means a natural or legal entity owning an asynchronously connected demand facility.

(19) ‘static synchronous compensator’ or ‘STATCOM’ means a fast-acting device capable of providing or absorbing reactive current and thereby regulating the voltage at the point of connection to a power grid. It is categorised under Flexible AC transmission system (FACTS) devices. The technology is based on voltage source converters with semi-conductor valves in a modular multi-level configuration.

Article 3

Scope of application

1. The requirements of this Regulation shall apply to the AC side of HVDC systems:

(a) connecting synchronous areas or control areas, including back-to-back schemes;

(b) connecting A-PPMs, A-DFs, A-PtG-DUs and A-ESMs to a transmission network or a distribution network, pursuant to paragraph 2;

(c) embedded within one control area and connected to the transmission network;

(d) embedded within one control area and connected to the distribution network when a cross-border impact is demonstrated by the relevant transmission system operator (TSO). The relevant TSO shall consider the long-term development of the network in this assessment, and;

(e) connecting isolated AC networks.

2. Relevant system operators, in coordination with relevant TSOs, shall propose to competent regulatory authorities the application of this Regulation for A-PPMs, A-DFs, A-PtG-DUs and A-ESMs with a single connection point to a transmission network or distribution network which is not part of a synchronous area for approval in accordance with Article 5. All other power park modules, demand facilities, power-to-gas demand units and electricity storage modules which are AC-collected but are asynchronously connected to a synchronous area are considered A-PPMs, A-DFs, A-PtG-DUs and A-ESMs and fall within the scope of this Regulation.

3. Article 55, Article 56, Article 57, Article 58, Article 59, Article 69, Article 70, Article 71, Article 72, Article 73, Article 74 and Article 84 shall not apply to HVDC systems within one control area referred to in points (c) and (d) of paragraph 1 where:

(a) the HVDC system has at least one HVDC converter station owned by the relevant TSO;

(b) the HVDC system is owned by an entity which exercises control over the relevant TSO;

(c) the HVDC system is owned by an entity directly or indirectly controlled by an entity which also exercises control over the relevant TSO.

4. The connection requirements for HVDC systems provided for in Title II shall apply at the AC connection points of such systems, except the requirements provided for in Article 29(4) and (5) and Article 31(5), which can apply at other connection points, and Article 19(1) which may apply at the terminals of the HVDC converter station.

5. The connection requirements for A-PPMs, A-DFs, A-PtG-DUs, A-ESMs and remote-end HVDC converter stations provided for in Title III shall apply at the isolated interface point of such systems, except the requirements provided for in Article 39(1)(a) and Article 47(2), which apply at the connection point in the synchronous area to which frequency response is being provided.

6. The relevant system operator shall refuse to allow the connection of a new HVDC system, A-PPM, A-DF, A-PtG-DU or A-ESM which does not comply with the requirements set out in this Regulation and which is not covered by a derogation granted by the regulatory authority, or other authority where applicable in a Member State pursuant to Title VII. The relevant system operator shall communicate such refusal, by means of a reasoned statement in writing, to the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner and, unless specified otherwise by the regulatory authority, to the regulatory authority.

7. This Regulation shall not apply to:

(a) HVDC systems whose connection point is below 110 kV unless a cross-border impact is demonstrated by the relevant TSO. The relevant TSO shall consider the long-term development of the network in this assessment;

(b) HVDC systems, A-PPMs, A-DFs, A-PtG-DUs or A-ESMs connected to the transmission system and distribution systems or to parts of the transmission system, or distribution systems, of islands of Member States of which the systems are not operated synchronously with either the Continental Europe, Nordic, Ireland and Northern Ireland or Baltic synchronous area, unless the designated entity, decides to make such systems

subject to all or some of the requirements of this Regulation, according to national rules. The decision of the designated entity shall be published.

Article 4

Application to 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

1. Except for Article 26, Article 31, Article 33 and Article 50, existing HVDC systems and existing A-PPMs, A-DFs, A-PtG-DUs and A-ESMs are not subject to the requirements of this Regulation, unless:

(a) the HVDC system or A-PPM, A-DF, A-PtG-DU, A-ESM has been modified that its electrical and grid-dynamic characteristics, relating to paragraph (1)(c), have significantly altered. In these cases, prior to carrying out a modification:

(i) the HVDC system or A-PPM, A-DF, A-PtG-DU, A-ESM owners who intend to undertake the modernisation of a plant or replacement of equipment affecting the electrical characteristics of the HVDC system or A-PPM, A-DF, A-PtG-DU, A-ESM shall notify their plans to the relevant system operator in advance;

(ii) if the relevant system operator considers that the extent of the modernisation or replacement of equipment is significant, in respect of any of the criteria in paragraph (1)(c) below, the system operator shall notify the relevant regulatory authority or, where applicable, the Member State; and

(iii) the relevant regulatory authority or, where applicable, the Member State shall decide if the existing connection agreement needs to be revised or a new connection agreement is required and which requirements of this Regulation shall apply; or

(b) a regulatory authority or, where applicable, a Member State decides to make an existing HVDC system or existing A-PPM, A-DF, A-PtG-DU, A-ESM subject to all or some of the requirements of this Regulation, following a proposal from the relevant TSO in accordance with paragraphs 3, 4 and 5.

(c) For the purposes of this Article a significant modernisation shall be defined according to at least the following criteria:

(i) an increase above the existing maximum power transmission capability of the HVDC installation, whether this increase results from one modernisation or cumulatively from several successive modernisations, of a minimum percentage to be defined by the relevant system operator in co-ordination with the relevant TSO in the range 5-20 %;

(ii) a deviation from the HVDC system short circuit contribution, whether this deviation results from one modernisation or cumulatively from several successive modernisations, of a minimum percentage to be defined by the relevant system operator in co-ordination with the relevant TSO in the range 25-50 %;

(iii) a deviation from the existing required reactive power capability triggered by the HVDC system, whether this deviation results from one modernisation or cumulatively from several successive modernisations, of a minimum percentage to be defined by the relevant system operator in co-ordination with the relevant TSO in the range 10-20 %;

(iv) a change of components/assets of an HVDC system, apart from maintenance and repair activities and spare parts, whether or not those parts are purchased new at the time of their incorporation in the HVDC system;

(v) a change of the underlying technology of the HVDC system from thyristor-based line commutated HVDC converter technology to voltage source HVDC converter technology;

(vi) as regards an A-PPM or an A-ESM, the criteria of Article 4a of RfG 2.0;

(vii) as regards an A-DF or an A-PtG-DU, the criteria of Article 4a of DC 2.0.

The relevant system operator in co-ordination with the relevant TSO may propose additional criteria defining a significant modernisation.

2. For the purposes of this Regulation, an HVDC system, A-PPM, A-DF, A-PtG-DU or A-ESM shall be considered existing if:

(a) it is already connected to the network on the date of entry into force of this Regulation; or

(b) the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner has concluded a final and binding contract for the purchase of the main generating plant or HVDC equipment by two years after the entry into force of the Regulation. The HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner must notify the relevant system operator and relevant TSO of conclusion of the contract within 30 months after the entry into force of the Regulation.

The notification submitted by the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner to the relevant system operator and to the relevant TSO shall at least indicate the contract title, its date of signature and date of entry into force and the specifications of the main generating plant or HVDC equipment to be constructed, assembled or purchased.

A Member State may provide that in specified circumstances the regulatory authority may determine whether the HVDC system, A-PPM, A-DF, A-PtG-DU or A-ESM is to be considered an existing or new HVDC system, A-PPM, A-DF, A-PtG-DU or A-ESM.

3. Following a public consultation in accordance to Article 8 and in order to address significant factual changes in circumstances, such as the evolution of system requirements including penetration of renewable energy sources, smart grids, distributed generation or demand response, the relevant TSO may propose to the regulatory authority concerned, or where applicable, to the Member State to extend the application of this Regulation to existing HVDC systems and/or A-PPMs, A-DFs, A-PtG-DUs and/or A-ESMs.

For that purpose a sound and transparent quantitative cost-benefit analysis shall be carried out, in accordance with Article 65 and Article 66. The analysis shall indicate:

(a) the costs, in regard to existing HVDC systems, A-PPMs, A-DFs, A-PtG-DUs and A-ESMs, of requiring compliance with this Regulation;

(b) the socioeconomic benefit resulting from applying the requirements set out in this Regulation; and

(c) the potential of alternative measures to achieve the required performance.

4. Before carrying out the quantitative cost-benefit analysis referred to in paragraph 3, the relevant TSO shall:

(a) carry out a preliminary qualitative comparison of costs and benefits;

(b) obtain approval from the relevant regulatory authority or, where applicable, the Member State.

5. The relevant regulatory authority or, where applicable, the Member State shall decide on the extension of the applicability of this Regulation to existing HVDC systems, A-PPMs, A-DFs, A-PtG-DUs or A-ESMs within six months of receipt of the report and the recommendation of the relevant TSO in accordance with paragraph 4 of Article 65. The decision of the regulatory authority or, where applicable, the Member State shall be published.

6. The relevant TSO shall take account of the legitimate expectations of HVDC system owners, A-PPMs owners, A-DFs owners, A-PtG-DUs owners and A-ESMs owners as part of the assessment of the application of this Regulation to existing HVDC systems, A-PPMs, A-DFs, A-PtG-DUs or A-ESMs.

7. The relevant TSO may assess the application of some or all of the provisions of this Regulation to existing HVDC systems, A-PPMs, A-DFs, A-PtG-DUs or A-ESMs every three years in accordance with the criteria and process set out in paragraphs 3 to 5.

Article 5

Regulatory aspects

1. Requirements of general application, including, if necessary, different topology dependent requirements 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, to be established by relevant system operators or TSOs under this Regulation shall be subject to approval by the entity designated by the Member State and be published. The designated entity shall be the regulatory authority unless otherwise provided by the Member State.

2. For site specific requirements to be established by relevant system operators or TSOs under this Regulation, Member States may require approval by a designated entity.

3. System operators shall ensure that system users' equipment shall offer a cyber-protected data exchange interface where relevant.

4. When applying this Regulation, Member States, competent entities and system operators shall:

(a) apply the principles of proportionality and non-discrimination;

(b) ensure transparency;

(c) apply the principle of optimisation between the highest overall efficiency and lowest total costs for all parties involved;

(d) respect the responsibility assigned to the relevant TSO in order to ensure system security, including as required by national legislation;

(e) consult with relevant DSOs and take account of potential impacts on their system;

(f) take into consideration agreed European standards, technical specifications and implementation guidance documents developed by ENTSO-E in accordance with Article 59(15) of Regulation (EU) 2019/943 .

5. The relevant system operator or TSO shall submit a proposal for requirements of general application, or the methodology used to calculate or establish them, for approval by the designated entity within two years of entry into force of this Regulation. The Member State may provide for a shorter time period for all or parts of the requirements or the methodologies. In this case, the Member State shall communicate the shorter time period to the European Union Agency for the Cooperation of Energy Regulators (ACER).

6. Where this Regulation requires the relevant system operator, relevant TSO, HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner, A-ESM owner and/or the distribution system operator to seek agreement, they shall endeavour to do so within six months after a first proposal has been submitted by one party to the other parties. If no agreement has been found within this timeframe, each party may request the relevant regulatory authority to issue a decision within six months.

7. Competent entities shall take decisions on proposals for requirements or methodologies within six months following the receipt of such proposals.

8. If the relevant system operator, TSO or relevant regulatory authority or designated entity deems an amendment to requirements or methodologies as provided for and approved under paragraph 1 and 2 to be necessary, the requirements provided for in paragraphs 4 to 9 shall apply to the proposed amendment. System operators, TSOs or relevant regulatory authority or designated entity proposing an amendment shall take into account the legitimate expectations, if any, of HVDC system owners, A-PPM owners, A-DF

owners, A-PtG-DU owners, A-ESM owner, equipment manufacturers and other stakeholders based on the initially specified or agreed requirements or methodologies.

9. Any party having a complaint against a relevant system operator or TSO in relation to that relevant system operator's or TSO's obligations under this Regulation may refer the complaint to the regulatory authority which, acting as dispute settlement authority, shall issue a decision within two months after receipt of the complaint. That period may be extended by two months where additional information is sought by the regulatory authority. That extended period may be further extended with the agreement of the complainant. The regulatory authority's decision shall have binding effect unless and until overruled on appeal.

10. Where the requirements under this Regulation are to be established by a relevant system operator that is not a TSO, Member States may provide that instead the TSO be responsible for establishing the relevant requirements.

Article 6

Multiple TSOs

1. Where more than one TSO exists in a Member State, this Regulation shall apply to all those TSOs.

2. Member States may, under the national regulatory regime, provide that the responsibility of a TSO to comply with one or some or all obligations under this Regulation is assigned to one or more specific TSOs.

Article 7

Recovery of costs

1. The costs borne by system operators subject to network tariff regulation and stemming from the obligations laid down in this Regulation shall be assessed by the relevant regulatory authorities. Costs assessed as reasonable, efficient and proportionate shall be recovered through network tariffs or other appropriate mechanisms.

2. If requested by the relevant regulatory authorities, system operators referred to in paragraph 1 shall, within three months of the request, provide the information necessary to facilitate assessment of the costs incurred.

Article 8

Public consultation

1. Relevant system operators and relevant TSOs shall carry out consultation with stakeholders, including the competent authorities of each Member State, on proposals to extend the applicability of this Regulation to existing HVDC systems, A-PPMs, A-DFs and A-ESMs, in accordance with Article 4(3), on the report prepared in accordance with Article 65(3), and the cost-benefit analysis undertaken in accordance with Article 80(2). The consultation shall last at least for a period of one month.

2. The relevant system operators or relevant TSOs shall duly take into account the views of the stakeholders resulting from the consultations prior to the submission of the draft proposal or the report or cost benefit analysis for approval by the regulatory authority or, if applicable, the Member State. In all cases, a sound justification for including or not the views of the stakeholders shall be provided and published in a timely manner before, or simultaneously with, the publication of the proposal.

Article 9

Stakeholder involvement

ACER, in close cooperation with the European Network of Transmission System Operators for Electricity (ENTSO for Electricity) and the European entity for distribution system operators (the EU DSO entity), shall organise stakeholder involvement regarding the requirements for grid connection of HVDC systems, A-PPMs, A-DFs, A-PtG-DUs and A-ESMs, and other aspects of the implementation of this Regulation. This shall include regular meetings with stakeholders to identify problems and propose improvements notably related to the requirements for grid connection of HVDC systems, A-PPMs, A-DFs, A-PtG-DUs and A-ESMs.

Article 10

Confidentiality obligations

1. Any confidential information received, exchanged or transmitted pursuant to this Regulation shall be subject to the conditions of professional secrecy laid down in paragraphs 2, 3 and 4.

2. The obligation of professional secrecy shall apply to any persons, regulatory authorities or entities subject to the provisions of this Regulation.

3. Confidential information received by the persons, regulatory authorities or entities referred to in paragraph 2 in the course of their duties may not be divulged to any other person or authority, without prejudice to cases covered by national law, the other provisions of this Regulation or other relevant Union law.

4. Without prejudice to cases covered by national or Union law, regulatory authorities, entities or persons who receive confidential information pursuant to this Regulation may use it only for the purpose of carrying out their duties under this Regulation.

TITLE II

GENERAL REQUIREMENTS FOR HVDC CONNECTIONS

CHAPTER 1

Requirements for active power control and frequency support

Article 11

Frequency ranges

1. An HVDC system shall be capable of staying connected to the network and remaining operable within the frequency ranges and time periods specified in Table 1, Annex I for the short circuit power range as specified in Article 32(2).

2. The relevant TSO and HVDC system owner may agree on wider frequency ranges or longer minimum times for operation if needed to preserve or to restore system security. If wider frequency ranges or longer minimum times for operation are economically and technically feasible, the HVDC system owner shall not unreasonably withhold consent.

3. Without prejudice to paragraph 1, an HVDC system shall be capable of automatic disconnection at frequencies specified by the relevant TSO.

4. The relevant TSO may specify a maximum admissible active power output reduction from its operating point if the system frequency falls below 49 Hz.

Article 12

Rate-of-change-of-frequency withstand capability

With regard to the rate-of-change-of-frequency withstand capability at the connection point:

(a) an HVDC system shall be capable of staying connected to the network and operate at rate-of-change-of-frequency up to the following values (non-consecutive):

- ±5,0 Hz/s over a period of 0,25 s
- ±2,5 Hz/s over a period of 0,5 s
- ±1,25 Hz/s over a period of 2 s

(b) without prejudice to the frequency ranges specified in Annex VI, an HVDC system shall be capable of staying connected to the network and operate at the sequence of rate-of-change-of-frequencies which are defined considering the over frequency against time profiles given in Figure X-a and the underfrequency against time profiles given in Figure X-b;

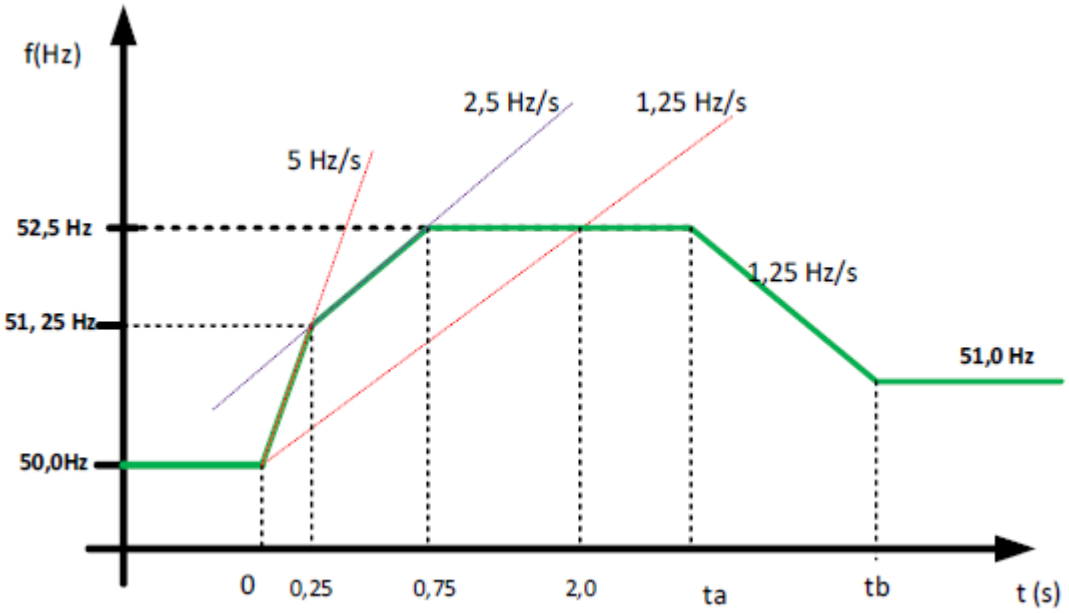

Figure X-a: The frequency ride through profile that an HVDC system shall remain connected to the network for the case of over-frequency. The value ta and tb shall be specified by the relevant TSO, but longer than for A-PPMs according to Article 39.

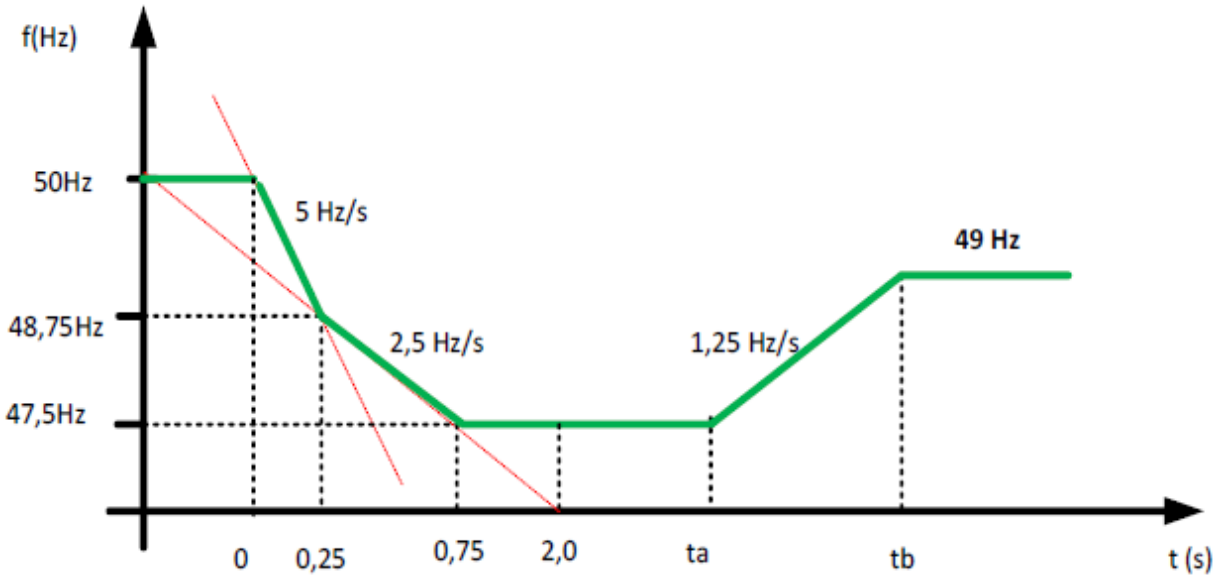

Figure X-b: The frequency ride through profile than an HVDC system shall remain connected to the network for the case of under-frequency. The value ta and tb shall be specified by each relevant TSO, but longer than for A- PPMs according to Article 39.

(c) if the rate-of-change-of-frequency is used for loss of mains protection of the HVDC system, the rate-of-change-of-frequency threshold shall be set at higher values than the ones defined in paragraph (a);

(d) the HVDC system shall be capable of remaining connected to the network and continuing to operate stably when the network frequency remains within the frequency range specified in Annex I. The protection schemes shall not jeopardize frequency-ride-through performance.

Article 12b

Voltage phase angle jump withstand capability

1. Without prejudice to Article 12, the relevant TSO may specify that the HVDC system shall be capable of remaining connected without disconnection during voltage phase angle jumps.

2. If the capability referred to in paragraph 1 is requested, the relevant TSO shall agree with the HVDC system owner, the associated performance parameters and the maximum voltage phase angle jump.

Article 13

Active power controllability, control range and ramping rate

1. With regard to the capability of controlling the transmitted active power:

(a) an HVDC system shall be capable of adjusting the transmitted active power up to its maximum HVDC active power transmission capacity in each direction following an instruction from the relevant system operator.

The relevant system operator:

(i) may specify a maximum and minimum power step size for adjusting the transmitted active power;

(ii) may specify a minimum HVDC active power transmission capacity for each direction, below which active power transmission capability is not requested; and

(iii) shall specify the maximum delay within which the HVDC system shall be capable of adjusting the transmitted active power upon receipt of request from the relevant system operator.

(b) the relevant system operator in coordination with the relevant TSO shall specify how an HVDC system shall be capable of modifying the transmitted active power infeed in case of disturbances into one or more of the AC networks to which it is connected. If the initial delay prior to the start of the change is greater than 10 milliseconds from receiving the triggering signal sent by the relevant system operator, it shall be reasonably justified by the HVDC system owner to the relevant system operator and relevant TSO.

(c) the relevant system operator in coordination with the relevant TSO may specify that an HVDC system be capable of fast active power reversal. The power reversal shall be possible from the maximum active power transmission capacity in one direction to the

maximum active power transmission capacity in the other direction as fast as technically feasible and reasonably justified by the HVDC system owner to the relevant TSOs if greater than 2 seconds.

(d) for HVDC systems linking various control areas or synchronous areas, the HVDC system shall be equipped with control functions enabling the relevant TSOs to modify the transmitted active power for the purpose of cross-border balancing.

2. An HVDC system shall be capable of adjusting the ramping rate of active power variations within its technical capabilities in accordance with instructions sent by relevant TSOs. In case of modification of active power according to points (b) and (c) of paragraph 1, there shall be no adjustment of ramping rate.

3. If specified by a relevant system operator, in coordination with the relevant TSO and adjacent TSOs, the control functions of an HVDC system shall be capable of taking automatic remedial actions including, but not limited to, stopping the ramping and blocking FSM, LFSM-O, LFSM-U and frequency control. The triggering and blocking criteria shall be specified by relevant TSO and subject to notification to the regulatory authority. The modalities of that notification shall be determined in accordance with the applicable national regulatory framework.

Article 14

Grid forming capability

1. If specified by the relevant system operator, in coordination with the relevant TSOs, an HVDC system shall provide grid forming capability at its connection point as defined by the following paragraphs:

(a) within the HVDC system voltage, current and energy limits, the HVDC converter station shall be capable of behaving as a controllable voltage source behind an internal impedance (i.e. a Thevenin source) during both the normal operation and immediately after a grid disturbance. The Thevenin source is characterized by its internal voltage amplitude, voltage phase angle, frequency, and internal impedance. All of these characteristics are a result of a control response which shall ensure stability in the connected electrical power networks.

(b) During the first instance following a grid disturbance:

(i) while the HVDC system voltage, current and energy limits are not exceeded, the instantaneous AC voltage characteristics of the internal Thevenin source of the HVDC converter station shall be capable of maintaining its amplitude and voltage phase angle while voltage phase angle steps or voltage magnitude steps (in positive and in negative sequence) are occurring at the connection point of HVDC converter station (grid side). The positive and the negative sequence current exchanged between the HVDC converter station (converter unit side), and AC grid shall flow naturally according to grid and converter impedances;

(ii) if the HVDC system and individual converter capabilities, voltage, current and energy limits are exceeded, the current, energy and voltage shall be kept within

their admissible limit values. The relevant TSOs shall specify, in agreement with the HVDC system owner where so relevant, additional requirements describing the behaviour of the HVDC system and individual converter when the limitation is reached;

(iii) within the HVDC system voltage, current and energy limits, the relevant TSO shall specify, in agreement with the HVDC system owner where so relevant, time dependent current envelopes with tolerance band, based on the HVDC system capabilities and overall optimization of the dynamic behaviour, for which the capability of the HVDC converter station is required;

(iv) the relevant TSOs, in agreement with the HVDC system owner where so relevant, shall specify the relevant dynamic performance of the HVDC system and its associated performance parameters, including the change of control parameters via remote signals according to Article 51(3).

(c) During the grid disturbance period and after the first instants:

(i) the HVDC converter station active and reactive power adjustment shall always respect the minimum and maximum HVDC transmission capability and current limits (in each direction);

(ii) the relevant TSOs shall specify, in agreement with the HVDC system owner where so relevant, additional requirements describing the behaviour of the HVDC system and individual converter when the current limitation is reached;

(iii) the HVDC system shall be capable of stable and smooth transition when reaching the HVDC system current or converter limits, without interruption, in a continuous manner and returning to the behaviour described in paragraph (1)(b) as soon as the limitations are no longer active;

(iv) the relevant TSOs, in agreement with the HVDC system owner where so relevant, shall specify the relevant dynamic performance of the HVDC system and its associated performance parameters.

2. Where an HVDC system is required to have the capability referred to in paragraph 1, the HVDC system shall be capable of supporting system survival by means of stable and smooth transition towards and from island mode of system operation (islanding), without interruption, in a continuous manner while complying with paragraph (1)(b) and paragraph (1)(c). The energy needed for this function shall be agreed between the HVDC system owner and the relevant TSO, in coordination with adjacent TSOs;

3. Where an HVDC system is required to have the capability referred to in paragraph 1, considering the voltage, current and energy limit as given in points (b) and (c), the capability to provide the inherent usable energy shall be ensured throughout the whole active power operating range of the HVDC system;

4. If grid forming capability as prescribed in paragraph 1 is requested and if specified by the relevant system operator, in coordination with the relevant TSO, the HVDC system shall be capable of contributing to limit the transient frequency deviation by providing a synthetic inertia response both in low and/or high frequency regimes. The synthetic inertial response shall be provided without delay. In that case the contribution to synthetic

inertia shall be specified in accordance with paragraphs (1)(b)(iv) and (1)(c)(iv). The synthetic inertia shall be provided with a damped system response and the energy needed for this function shall be coordinated with sources external to the HVDC system and if applicable within the isolated AC network's design and operational limits;

Article 14b

Fast frequency control capability

The relevant TSO may specify that an HVDC system shall be capable of performing fast frequency control to contribute to limiting the transient frequency deviation by adjusting its active power as a function of the measured frequency, as specified by the relevant TSO. Fast frequency control shall be available in both low and/or high frequency regimes as specified by the relevant TSO. The following shall apply:

(a) the HVDC system shall be capable without intentional delay of adjusting the active power injected to or withdrawn from AC grid within its rated power. The fast frequency control shall be provided with a damped system response and the energy needed for this function shall be coordinated with sources external to the HVDC system and if applicable within the isolated AC network's design and operational limits;

(b) this active power adjustment shall be performed based on the measured frequency, as specified by the relevant TSO. The measurement method shall be agreed between the relevant TSOs and the HVDC system owner;

(c) when the frequency has recovered, the operating point of the HVDC system shall return to its pre-disturbance active power value or an operating point according to the power available for transmission through the HVDC system;

(d) the requirements regarding measurement of frequency and/or rate-of-change-of-frequency as well as the dynamic performance parameters of rapidly adjusted active power injected to or withdrawn from AC grid shall be agreed between the relevant TSOs and the HVDC system owner.

Article 15

Requirements relating to frequency sensitive mode, limited frequency sensitive mode overfrequency and limited frequency sensitive mode underfrequency

Requirements applying to frequency sensitive mode, limited frequency sensitive mode overfrequency and limited frequency sensitive mode underfrequency shall be as set out in Annex II.

Article 16

Frequency control

1. If specified by the relevant TSO, utilizing the available power at the AC connection points of the HVDC system, an HVDC system shall be equipped with an independent control mode to modulate the active power output of the HVDC converter stations depending on the frequencies at all connection points of the HVDC system in order to contribute to the stabilisation of the system frequencies.

2. The relevant TSO shall specify the operating principle, the associated performance parameters and the activation criteria of the frequency control referred to in paragraph 1.

Article 17

Maximum loss of active power

1. An HVDC system shall be configured in such a way that its loss of active power injection in or withdrawal from a synchronous area shall be limited to a value specified by the relevant TSOs for their respective load frequency control area, based on the HVDC system's impact on the power system.

2. Where an HVDC system connects two or more control areas, the relevant TSOs shall consult each other in order to set a coordinated value of the maximum loss of active power injection as referred to in paragraph 1, taking into account common mode failures.

CHAPTER 2

Requirements for reactive power control and voltage support

Article 18

Voltage ranges

1. Without prejudice to Article 25, an HVDC converter station shall be capable of staying connected to the network and capable of operating at HVDC system maximum current, within the ranges of the network voltage at the connection point, expressed by the voltage at the connection point related to reference 1 pu voltage, and the time periods specified in Tables 4 and 5, Annex III. The establishment of the reference 1 pu voltage shall be subject to coordination between the adjacent relevant system operators.

2. The HVDC system owner and the relevant system operator, in coordination with the relevant TSO, may agree on wider voltage ranges or longer minimum times for operation than those specified in paragraph 1 in order to ensure the best use of the technical capabilities of an HVDC system 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 HVDC system owner shall not unreasonably withhold consent.

3. An HVDC converter station shall be capable of automatic disconnection at connection point voltages specified by the relevant system operator, in coordination with

the relevant TSO. The terms and settings for automatic disconnection shall be agreed between the relevant system operator, in coordination with the relevant TSO, and the HVDC system owner.

4. For connection points at reference 1 pu AC voltages not included in the scope set out in Annex III, the relevant system operator, in coordination with relevant TSOs, shall specify applicable requirements at the connection points.

5. Notwithstanding the provisions of paragraph 1, the relevant TSOs in the Baltic synchronous area may, following consultation with relevant neighbouring TSOs, require HVDC converter stations to remain connected to the 400 kV network in the voltage ranges and for time periods that apply in the Continental Europe synchronous area.

Article 19

Short circuit contribution during faults

1. If grid forming capability as prescribed in Article 14 is not requested and if specified by the relevant system operator, in coordination with the relevant TSO, an HVDC system shall have the capability to provide fast fault current at a connection point in case of symmetrical (3-phase) faults.

2. Where an HVDC system is required to have the capability referred to in paragraph 1, the relevant system operator, in coordination with the relevant TSO, shall specify the following:

(a) how and when a voltage deviation is to be determined as well as the end of the voltage deviation;

(b) the characteristics of the fast fault current;

(c) the timing and accuracy of the response during fault, which may include several stages.

3. The relevant system operator, in coordination with the relevant TSO, may specify a requirement for asymmetrical current injection in the case of asymmetrical (1-phase or 2-phase) faults.

Article 20

Reactive power capability

1. The relevant system operator, in coordination with the relevant TSO, shall specify the reactive power capability requirements at the connection points, in the context of varying voltage. The proposal for those requirements shall include a U-Q/P_{max}-profile, within the boundary of which the HVDC converter station shall be capable of providing reactive power at its maximum HVDC active power transmission capacity.

2. The U-Q/P_{max}-profile referred to in paragraph 1 shall comply with the following principles:

(a) the U-Q/P_{max}-profile shall not exceed the U-Q/P_{max}-profile envelope represented by the inner envelope in the figure set out in Annex IV, and does not need to be rectangular;

(b) the dimensions of the U-Q/P_{max}-profile envelope shall respect the values established for each synchronous area in the table set out in Annex IV; and

(c) the position of the U-Q/P_{max}-profile envelope shall lie within the limits of the fixed outer envelope in the figure set out in Annex IV.

3. An HVDC system shall be capable of moving to any operating point within its U-Q/P_{max} profile in timescales specified by the relevant system operator in coordination with the relevant TSO.

4. When operating at an active power output below the maximum HVDC active power transmission capacity ($P < P_{max}$), the HVDC converter station shall be capable of operating in every possible operating point, as specified by the relevant system operator in coordination with the relevant TSO and in accordance with the reactive power capability set out by the U-Q/P_{max} profile specified in paragraphs 1 to 3.

Article 21

Reactive power exchanged with the network

1. The HVDC system owner shall ensure that the reactive power of its HVDC converter station exchanged with the network at the connection point is limited to values specified by the relevant system operator in coordination with the relevant TSO.

2. The reactive power variation caused by the reactive power control mode operation of the HVDC converter Station, referred to in Article 22(1), shall not result in a voltage step exceeding the allowed value at the connection point. The relevant system operator, in coordination with the relevant TSO, shall specify this maximum tolerable voltage step value.

Article 22

Reactive power control mode

1. An HVDC converter station shall be capable of operating in one or more of the three following control modes, as specified by the relevant system operator in coordination with the relevant TSO:

(a) voltage control mode;

(b) reactive power control mode;

(c) power factor control mode.

2. An HVDC converter station shall be capable of operating in additional control modes specified by the relevant system operator in coordination with the relevant TSO and the HVDC system owner.

3. For the purposes of voltage control mode, each HVDC converter station shall be capable of contributing to voltage control at the connection point utilising its capabilities, while respecting Article 20 and Article 21, in accordance with the following control characteristics:

(a) a setpoint voltage at the connection point shall be specified to cover a specific operation range, either continuously or in steps, by the relevant system operator, in coordination with the relevant TSO;

(b) the voltage control may be operated with or without a deadband around the setpoint selectable in a range from zero to +/− 5 % of reference 1 pu network voltage. The deadband shall be adjustable in steps as specified by the relevant system operator in coordination with the relevant TSO;

(c) following a step change in voltage, the HVDC converter station shall be capable of:

(i) achieving 90 % of the change in reactive power output within a time t1 specified by the relevant system operator in coordination with the relevant TSO. The time t1 shall be in the range of 0,1-10 seconds; and

(ii) settling at the value specified by the operating slope within a time t2 specified by the relevant system operator in coordination with the relevant TSO. The time t2 shall be in the range of 1-60 seconds, with a specified steady- state tolerance given in % of the maximum reactive power.

(d) voltage control mode shall include the capability to change reactive power output based on a combination of a modified setpoint voltage and an additional instructed reactive power component. The slope shall be specified by a range and step specified by the relevant system operator in coordination with the relevant TSO.

4. With regard to reactive power control mode, the relevant system operator shall specify a reactive power range in MVAr or in % of maximum reactive power, as well as its associated accuracy at the connection point, using the capabilities of the HVDC system, while respecting Article 20 and Article 21.

5. For the purposes of power factor control mode, the HVDC converter station shall be capable of controlling the power factor to a target at the connection point, while respecting Article 20 and Article 21. The available setpoints shall be available in steps no greater than a maximum allowed step specified by the relevant system operator.

6. The relevant system operator in coordination with the relevant TSO shall specify any equipment needed to enable the remote selection of control modes and relevant setpoints.

7. The specified reactive power control mode shall not interfere with the initial grid forming response when grid forming capability according to Article 14 is requested.

Article 23

Priority to active or reactive power contribution

Taking into account the capabilities of the HVDC system specified in accordance with this Regulation, the relevant TSO shall determine whether active power contribution or reactive power contribution shall have priority during low or high voltage operation and during faults for which fault-ride-through capability is required. If priority is given to active power contribution, its provision shall be established within a time from the fault inception as specified by relevant TSO.

Article 24

Power quality

An HVDC system owner shall ensure that its HVDC system connection to the network does not result in a level of distortion or fluctuation of the supply voltage on the network, at the connection point, exceeding the level specified by the relevant system operator in coordination with the relevant TSO. The process for necessary studies to be conducted and relevant data to be provided by all grid users involved, as well as mitigating actions identified and implemented, shall be in accordance with the process in Article 29.

CHAPTER 3

Requirements for fault ride through capability

Article 25

Fault ride through capability

1. The relevant TSO shall specify, while respecting Article 18, a voltage-against time profile as set out in Annex V and having regard to the voltage-against-time-profile specified for power park modules according to RfG 2.0. This profile shall apply for fault conditions, under which the HVDC converter station shall be capable of staying connected to the network and continuing stable operation after the power system has recovered following fault clearance. The voltage-against-time-profile shall express a lower limit of the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, as a function of time before, during and after the fault. Any ride through period beyond t_{rec2} shall be specified by the relevant TSO consistent with Article 18.

2. On request by the HVDC system owner, the relevant system operator shall provide the pre-fault and post-fault conditions as provided for in Article 32 regarding:

(a) pre-fault minimum short circuit capacity at each connection point expressed in MVA;

(b) pre-fault operating point of the HVDC converter station expressed as active power output and reactive power output at the connection point and voltage at the connection point; and

(c) post-fault minimum short circuit capacity at each connection point expressed in MVA.

Alternatively, generic values for the above conditions derived from typical cases may be provided by the relevant system operator.

3. The HVDC converter station shall be capable of staying connected to the network and continue stable operation when the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, given the pre-fault and post-fault conditions provided for in Article 32, remain above the lower limit set out in the figure in Annex V, unless the protection scheme for internal faults requires the disconnection of the HVDC converter station from the network. The protection schemes and settings for internal faults shall be designed not to jeopardise fault-ride-through performance.

4. The relevant TSO may specify voltages (U_{block}) at the connection points under specific network conditions whereby the HVDC system is allowed to block. Blocking means remaining connected to the network with no active and reactive power contribution for a time frame that shall be as short as technically feasible and which shall be agreed between the relevant TSOs and the HVDC system owner.

5. In accordance Article 34, undervoltage protection shall be set by the HVDC system owner to the widest possible technical capability of the HVDC converter station. The relevant system operator, in coordination with the relevant TSO, may specify narrower settings pursuant to Article 34.

6. The relevant TSO shall specify fault-ride-through capabilities in case of asymmetrical faults.

7. The HVDC converter station shall be capable of operating stably without disconnecting from the network, if none of the phase-to-phase voltages exceed the voltage-against-time-profile as defined by the relevant TSO and having regard to the high voltage-ride-through profile specified for power park modules according to RfG 2.0.

Article 26

Post fault active power recovery

The relevant TSO shall specify the magnitude and time profile of active power recovery that the HVDC system shall be capable of providing, in accordance with Article 25.

Article 27

Fast recovery from DC faults

HVDC systems, including DC overhead lines, shall be capable of fast recovery from transient faults within the HVDC system. Details of this capability shall be subject to coordination and agreements on protection schemes and settings pursuant to Article 34.

CHAPTER 4

Requirements for control

Article 28

Energisation and synchronisation of HVDC converter stations

Unless otherwise instructed by the relevant system operator, during the energisation or synchronisation of an HVDC converter station to the AC network or during the connection of an energised HVDC converter station to an HVDC system, the HVDC converter station shall have the capability to limit any voltage changes to a steady-state level specified by the relevant system operator in coordination with the relevant TSO. The level specified shall not exceed 5 per cent of the pre-synchronisation voltage. The relevant system operator, in coordination with the relevant TSO, shall specify the maximum magnitude, duration and measurement window of the voltage transients.

Article 29

Interaction between HVDC systems or other plants and equipment

1. When several HVDC converter stations or other plants and equipment are within close electrical proximity, the relevant TSO may specify that a study is required, and the scope and extent of that study, to demonstrate that no adverse interaction will occur. If adverse interaction is identified, the studies shall identify possible mitigating actions to be implemented to ensure compliance with the requirements of this Regulation.

2. The studies shall be carried out by the connecting HVDC system owner with the participation of all other parties identified by the TSOs as relevant to each connection point. Member States may provide that the responsibility for undertaking the studies in accordance with this Article lies with the TSO. All parties shall be informed of the results of the studies.

3. All parties identified by the relevant TSO as relevant to each connection point, including the relevant TSO, shall contribute to the studies and shall provide all relevant data and models as reasonably required to meet the purposes of the studies. The relevant TSO shall collect this input and, where applicable, pass it on to the party responsible for the studies in accordance with Article 10.

4. The relevant TSO shall assess the result of the studies based on their scope and extent as specified in accordance with paragraph 1. If necessary for the assessment, the

relevant TSO may request the HVDC system owner to perform further studies in line with the scope and extent specified in accordance with paragraph 1.

5. The relevant TSO may review or replicate some or all of the studies. The HVDC system owner shall provide the relevant TSO all relevant data and models that allow such study to be performed.

6. Any necessary mitigating actions identified by the studies carried out in accordance with paragraphs 2 to 5 and reviewed by the relevant TSO shall be undertaken by the HVDC system owner as part of the connection of the new HVDC converter station.

7. The relevant TSO may specify transient levels of performance associated with events for the individual HVDC system or collectively across commonly impacted HVDC systems. This specification may be provided to protect the integrity of both TSO equipment and that of grid users in a manner consistent with its national code.

Article 30

Power oscillation damping capability

The HVDC system shall be capable of contributing to the damping of power oscillations in connected AC networks. The control system of the HVDC system shall not reduce the damping of power oscillations. The relevant TSO shall specify a frequency range of oscillations that the control scheme shall positively damp and the network conditions when this occurs, at least accounting for any dynamic stability assessment studies undertaken by TSOs to identify the stability limits and potential stability problems in their transmission systems. The selection of the control parameter settings shall be agreed between the relevant TSO and the HVDC system owner.

Article 30a

Passivity of HVDC systems

1. The HVDC system shall be capable of providing passivity at its connection point. With regard to this capability the resistive part of the frequency dependent complex impedance of the HVDC converter station at the connection point shall fulfil the requirement of Figure HZ.

2. The relevant TSO shall specify the frequency thresholds in figure HZ within the ranges provided in Table HZ.

f_threshold_1	100 Hz – 250 Hz, with default value **100 Hz**
f_threshold_2	800 Hz – 2500 Hz, with default value **1000 Hz.** The relevant TSO with the HVDC system owner may agree to extend the upper threshold.

Table HZ: Thresholds of figure HZ with default values.

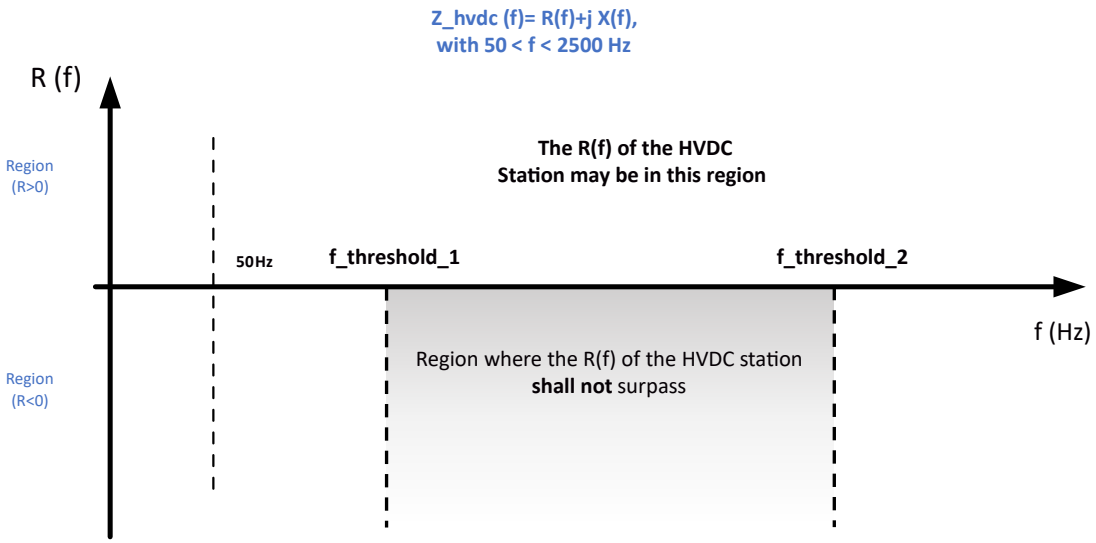

Figure HZ: The figure represents the resistive part of the complex frequency dependent impedance of an HVDC converter station at its connection point for frequencies higher than the nominal value of the frequency of the synchronous area. The variables f_threshold_1 and f_threshold_2, as specified in accordance with paragraph 2, represent thresholds in the frequency band where the capability of passivity is required.

Article 31

Subsynchronous torsional interaction damping capability

1. With regard to subsynchronous torsional interaction (SSTI) damping control, the HVDC system shall be capable of contributing to electrical damping of torsional frequencies.

2. The relevant TSO shall specify the necessary extent of SSTI studies and provide input parameters, to the extent available, related to the equipment and relevant system conditions in its network. The SSTI studies shall be provided by the HVDC system owner. The studies shall identify the conditions, if any, where SSTI exists and propose any necessary mitigation procedure. Member States may provide that the responsibility for undertaking the studies in accordance with this Article lies with the TSO. All parties shall be informed of the results of the studies.

3. All parties identified by the relevant TSO as relevant to each connection point, including the relevant TSO, shall contribute to the studies and shall provide all relevant data and models as reasonably required to meet the purposes of the studies. The relevant TSO shall collect this input and, where applicable, pass it on to the party responsible for the studies in accordance with Article 10.

4. The relevant TSO shall assess the result of the SSTI studies. If necessary for the assessment, the relevant TSO may request that the HVDC system owner perform further SSTI studies in line with this same scope and extent.

5. The relevant TSO may review or replicate the study. The HVDC system owner shall provide the relevant TSO all relevant data and models that allow such study to be performed.

6. Any necessary mitigating actions identified by the studies carried out in accordance with paragraphs 2 or 4, and reviewed by the relevant TSOs, shall be undertaken by the HVDC system owner as part of the connection of the new HVDC converter station.

Article 32

Network characteristics

1. The relevant system operator shall specify and make publicly available the method and the pre-fault and post-fault conditions for the calculation of at least the minimum and maximum short circuit power at the connection points.

2. The HVDC system shall be capable of operating within the range of short circuit power and network characteristics specified by the relevant system operator.

3. Each relevant system operator shall provide the HVDC system owner with network equivalents describing the behaviour of the network at the connection point, enabling the HVDC system owners to design their system with regard to at least, but not limited to, harmonics and dynamic stability over the lifetime of the HVDC system.

Article 33

HVDC system robustness

1. The HVDC system shall be capable of finding stable operation points with a minimum change in active power flow and voltage level, during and after any planned or unplanned change in the HVDC system or AC network to which it is connected. The relevant TSO shall specify the changes in the system conditions for which the HVDC systems shall remain in stable operation.

2. The HVDC system owner shall ensure that the tripping or disconnection of an HVDC converter station does not result in transients at the connection point beyond the limit specified by the relevant TSO.

3. If specified by the relevant TSO, the HVDC system owner shall ensure that an HVDC converter station being part of an HVDC system, shall be capable of stably operating in static synchronous compensator (STATCOM) operation mode when disconnected from DC transmission lines or cables following a DC disturbance.

4. The HVDC system shall withstand transient faults on HVAC lines in the network adjacent or close to the HVDC system, and shall not cause any of the equipment in the HVDC system to disconnect from the network due to auto- reclosure of lines in the network.

5. The HVDC system owner shall provide information to the relevant system operator on the resilience of the HVDC system to AC and DC system disturbances.

CHAPTER 5

Requirements for protection devices and settings

Article 34

Electrical protection schemes and settings

1. The relevant system operator shall specify, in coordination with the relevant TSO, the schemes and settings necessary to protect the network taking into account the characteristics of the HVDC system. Protection schemes relevant for the HVDC system and the network, and settings relevant for the HVDC system, shall be coordinated and agreed between the relevant system operator, the relevant TSO and the HVDC system owner. The protection schemes and settings for internal electrical faults shall be designed so as not to jeopardise the performance of the HVDC system in accordance with this Regulation.

2. Electrical protection of the HVDC system shall take precedence over operational controls taking into account system security, health and safety of staff and the public and mitigation of the damage to the HVDC system.

3. Any change to the protection schemes or their settings relevant to the HVDC system and the network shall be agreed between the relevant system operator, the relevant TSO and the HVDC system owner before being implemented by the HVDC system owner.

Article 35

Priority ranking of protection and control

1. A control scheme, specified by the HVDC system owner consisting of different control modes, including the settings of the specific parameters, shall be coordinated and

agreed between the relevant TSO, the relevant system operator and the HVDC system owner.

2. With regard to priority ranking of protection and control, the HVDC system owner shall 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.

Article 36

Changes to protection and control schemes and settings

1. The parameters of the different control modes and the protection settings of the HVDC system shall be able to be changed, if required by the relevant system operator or the relevant TSO, and in accordance with paragraph 3.

2. Any change to the schemes or settings of parameters of the different control modes and protection of the HVDC system, including the procedure, shall 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.

3. The control modes and associated setpoints of the HVDC system shall be capable of being changed remotely, as specified by the relevant system operator, in coordination with the relevant TSO.

CHAPTER 6

Requirements for power system restoration

Article 37

Black start

1. The relevant TSO may obtain a quote for black start capability from an HVDC system owner.

2. An HVDC system with black start capability shall be able, in case one converter station is energised, to energise the busbar of the AC-substation to which another converter station is connected, within a timeframe after shut down of the HVDC system determined by the relevant TSOs. The HVDC system shall be able to synchronise within the frequency limits set out in Article 11 and within the voltage limits specified by the relevant TSO or as provided for in Article 18, where applicable. Wider frequency and voltage ranges can be specified by the relevant TSO where needed in order to restore system security.

3. The relevant TSO and the HVDC system owner shall agree on the capacity and availability of the black start capability and the operational procedure.

TITLE III

REQUIREMENTS FOR ASYNCHRONOUSLY CONNECTED POWER PARK MODULES, ASYNCHRONOUSLY CONNECTED DEMAND FACILITIES, ASYNCHRONOUSLY CONNECTED POWER-TO-GAS DEMAND UNITS, ASYNCHRONOUSLY CONNECTED ELECTRICITY STORAGE MODULES AND REMOTE-END HVDC CONVERTER STATIONS

CHAPTER 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

Article 38

Scope

The requirements applicable to offshore power park modules under Articles 13 to 22, except Articles 13a and 14a, of RfG 2.0 shall apply to A-PPMs and A-ESMs subject to specific requirements provided for in Article 39, Article 40, Article 40a, Article 40b, Article 41 Article 42, Article 43, Article 44 and Article 45 of this Regulation. The requirements applicable to offshore power park modules under Article 26(2) of RfG 2.0 shall apply to A-PPMs. The categorisation in Article 5 of RfG 2.0 shall apply to A-PPMs and A-ESMs. The requirements applicable to transmission connected demand facilities, under Articles 14, 16, 17, 19, 21, 39, 40 and 44 of DC 2.0 shall apply to A-DFs. The requirements applicable to power-to-gas demand units, under Articles XX, XX+1, XX+2 and XX+3 of DC 2.0 shall apply to A-PtG-DUs subject to specific requirements provided for in Article 39, Article 40, Article 40a, Article 40b, Article 40c, Article 41, Article 42, Article 43, Article 44 and Article 45 of this Regulation. These requirements shall apply at the isolated interface points of the A-PPM, A-DF, A-PtG-DU, A-ESM and the remote-end HVDC converter station.

Article 39

Frequency stability requirements

1. With regards to frequency response:

(a) an A-PPM, A-PtG-DU and A-ESM shall be capable of receiving a fast signal from a connection point in the synchronous area to which frequency response is being provided, and be able to process this signal no later than 0,1 seconds from sending to completion of processing the signal for activation of the response. Frequency shall be measured at the connection point of the HVDC system or a predefined connection point in a synchronous area to which frequency response is being provided;

(b) A-PPMs, A-PtG-DUs and A-ESMs connected via HVDC systems to more than one control area shall be capable of delivering coordinated frequency control as specified by the relevant TSO, in coordination with adjacent TSOs.

2. With regard to frequency ranges and response:

(a) an A-PPM, A-DF, A-PtG-DU and A-ESM shall be capable of staying connected to the remote-end HVDC converter station isolated AC network and operating within the frequency ranges and time periods specified in Annex VI for the 50 Hz nominal system. Where a nominal frequency other than 50 Hz, or a frequency variable by design is used, subject to agreement with the relevant TSO, the applicable frequency ranges and time periods shall be specified by the relevant TSO taking into account specificities of the system and the requirements set out in Annex VI;

(b) wider frequency ranges or longer minimum times for operation can be agreed between the relevant TSO and the A-PPM owner, the A-DF owner, the A-PtG-DU owner and the A-ESM owner to ensure the best use of the technical capabilities needed to preserve or to restore system security. If wider frequency ranges or longer minimum times for operation are economically and technically feasible, the A-PPM owner, the A-DF owner, the A-PtG-DU owner and the A-ESM owner shall not unreasonably withhold consent;

(c) while respecting the provisions of point (a) of paragraph 2, an A-PPM, A-DF, A-PtG-DU and A-ESM shall be capable of automatic disconnection at specified frequencies, if specified by the relevant TSO. Terms and settings for automatic disconnection shall be agreed separately between the relevant TSO and the A-PPM owner, the A-DF owner, the A-PtG-DU owner and the A-ESM owner.

3. With regard to rate-of-change-of-frequency withstand capability, an A-PPM, an A-DF, an A-PtG-DU and an A-ESM shall be capable of staying connected to the remote-end HVDC converter station isolated AC network and operable if the system frequency changes at a rate up to +/– 2 Hz/s (measured over a period of 1 second) at the isolated interface point of the A-PPM, the A-DF, the A-PtG-DU and the A-ESM for the 50 Hz nominal system.

4. A-PPMs and A-ESMs shall have limited frequency sensitive mode — overfrequency (LFSM-O) capability in accordance with Article 13(3) of RfG 2.0 subject to fast signal response as specified in paragraph 1 for the 50 Hz nominal system.

5. A capability for A-PPMs and A-ESMs to maintain constant power shall be determined in accordance with Article 13(4) of RfG 2.0 or the 50 Hz nominal system.

6. A capability for active power controllability of A-PPMs and A-ESMs shall be determined in accordance with Article 15(2)(a) of RfG 2.0 for the 50 Hz nominal system. Manual control shall be possible in the case that remote automatic control devices are out of service.

7. A capability for limited frequency sensitive mode — underfrequency (LFSM-U) for a A-PPM and A-ESM shall be determined in accordance with Article 15(2)(c) of RfG 2.0, subject to fast signal response as specified in paragraph 1 for the 50 Hz nominal system.

8. A capability for limited frequency sensitive mode — underfrequency consumption (LFSM-UC) for an A-PtG-DU shall be based either on the measured frequency at the A-PtG-DU isolated interface point or on a fast signal response as specified in paragraph 1 for the 50 Hz nominal system. More specifically, the following shall apply:

(a) the A-PtG-DU shall be capable of reducing the consumption from the current active power input automatically down to the minimum technical operational level, according to the indicative Figure X-c at a frequency threshold and with a droop setting specified by the relevant TSO;

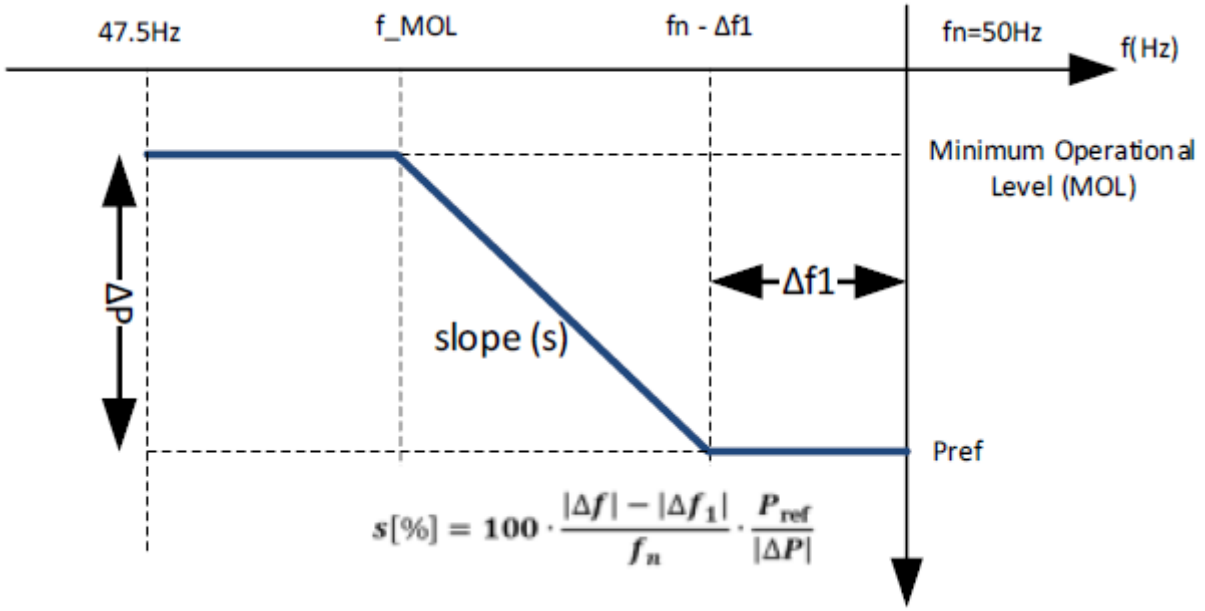

Figure X-c: LFSM-UC curve for an A-PtG-DU

(b) the default setting of the droop slope (%) shall be specified by the relevant TSO;

(c) the frequency threshold shall be 49,8 Hz (inclusive), except for synchronous area Nordic, IE and NI, where the frequency threshold shall be 49,5 Hz (inclusive);

(d) the A-PtG-DU shall stay in this specific mode as long as the frequency is below the frequency threshold. If the frequency recovers, the electrical charging demand unit

shall follow the same power-frequency characteristic until it is back to its prior state of active power input;

(e) if the minimum technical operating level is between 20% and 50% of Pref, the A-PtG-DU shall disconnect when reaching its minimum technical operating level;

(f) if disconnection was performed according to point (e), on return of frequency above the frequency threshold, a random time delay of up to 5 minutes shall be initiated before normal operation resumes;

(g) the requirements for frequency measurement shall be:

(i) maximum measuring time window: 100 ms

(ii) accuracy: ± 30 mHz

(h) stable operation of the A-PtG-DU during LFSM-UC operation shall be ensured;

(i) the response time for LFSM-UC shall be less or equal to 0,5 seconds. The relevant system operator has the right to request the demonstration of technical evidence of the response time.

9. A capability for frequency sensitive mode for an A-PPM and an A-ESM shall be determined in accordance with Article 15(2)(d) of RfG 2.0, subject to a fast signal response as specified in paragraph 1 for the 50 Hz nominal system.

10. A capability for frequency restoration for an A-PPM and an A-ESM shall be determined in accordance with Article 15(2)(e) of RfG 2.0. for the 50 Hz nominal system.

11. Where a constant nominal frequency other than 50 Hz, a frequency variable by design or a DC system voltage is used, subject to the agreement of the relevant TSO, the capabilities listed in paragraphs 3 to 10 and the parameters associated with such capabilities shall be specified by the relevant TSO.

Article 40

Reactive power and voltage requirements

1. With respect to voltage ranges:

(a) an A-PPM, an A-PtG-DU, an A-DF and an A-ESM shall be capable of staying connected to the remote-end HVDC converter station isolated AC network and operating within the voltage ranges (per unit), for the time periods specified in Table 9, Annex VII. The applicable voltage range and time periods specified are selected based on the reference 1 pu voltage;

(b) wider voltage ranges or longer minimum times for operation can be agreed between the relevant system operator, the relevant TSO and the A-PPM owner, the A-PtG-DU owner, the A-DF owner and the A-ESM owner to ensure the best use of the technical capabilities of the A-PPM, the A-PtG-DU, the A-DF and the A-ESM 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 A-PPM owner, the A-PtG-DU owner, the A-DF owner and the A-ESM owner shall not unreasonably withhold consent;

(c) for A-PPM, A-PtG-DU, A-DF and A-ESM which have an isolated interface point to the remote-end HVDC converter station isolated AC network, the relevant system operator, in coordination with the relevant TSO may specify voltages at the isolated interface point at which an A-PPM, an A-PtG-DU, an A-DF and an A-ESM shall be capable of automatic disconnection. The terms and settings for automatic disconnection shall be agreed between the relevant system operator, the relevant TSO and the A-PPM owner, the A-PtG-DU owner, the A-DF owner and the A-ESM owner;

(d) for isolated interface points at AC voltages that are not included in the scope of Annex VII, the relevant system operator, in coordination with the relevant TSO shall specify applicable requirements at the connection point;

(e) where frequencies other than nominal 50 Hz are used, subject to relevant TSO agreement, the voltage ranges and time periods specified by the relevant system operator, in coordination with the relevant TSO, shall be proportional to those in Table9, Annex VII.

2. With respect to reactive power capability for an A-PPM and an A-ESM:

(a) if the A-PPM owner and the A-ESM owner can obtain a bilateral agreement with the owners of the HVDC systems connecting the A-PPM and the A-ESM to a single isolated interface point on an isolated AC network, it shall fulfil all of the following requirements:

(i) it shall have the ability with additional plant or equipment and/or software, to meet the reactive power capabilities prescribed by the relevant system operator, in coordination with the relevant TSO, according to point (b), and it shall either:

— have the reactive power capabilities for some or all of its equipment in accordance with point (b) already installed as part of the connection of the A-PPM and the A-ESM to the isolated AC network at the time of initial connection and commissioning; or

— demonstrate to, and then reach agreement with, the relevant system operator and the relevant TSO on how the reactive power capability will be provided when the A-PPM and the A-ESM is connected to more than a single isolated interface point in the isolated AC network, or the isolated AC network at the remote-end HVDC converter station isolated AC network has either another A-PPM, A-ESM or HVDC system with a different owner connected to it. This agreement shall include a contract by the A-PPM owner and the A-ESM owner (or any subsequent owner), that it will install reactive power capabilities required by this Article for its A-PPM and A-ESM at a point in time specified by the relevant system operator, in coordination with the relevant TSO. The relevant system operator, in coordination with the relevant TSO shall inform the A-PPM owner and the A-ESM owner of the proposed completion date of any committed development which will require the A-PPM owner and the A-ESM owner to install the full reactive power capability.

(ii) the relevant system operator, in coordination with the relevant TSO shall account for the development time schedule of retrofitting the reactive power capability to the A-PPM and A-ESM in specifying the point in time by which this reactive power capability retrofitting is to take place. The development time schedule shall be provided by the A-PPM owner and the A-ESM owner at the time of connection to the AC network.

(b) A-PPMs and A-ESMs shall fulfil the following requirements relating to voltage stability either at the time of connection or subsequently, according to the agreement as referred to in point (a):

(i) with regard to reactive power capability at maximum HVDC active power transmission capacity, A-PPMs and A-ESMs shall meet the reactive power provision capability requirements specified by the relevant system operator, in coordination with the relevant TSO, in the context of varying voltage. The relevant system operator shall specify a U-Q/P_{max}-profile that may take any shape with ranges in accordance with Table 10, Annex VII, within which the A-PPM and the A-ESM shall be capable of providing reactive power at its maximum active power capacity. The relevant system operator, in coordination with the relevant TSO, shall consider the long-term development of the isolated AC network when determining these ranges, as well as the potential costs for A-PPMs and A-ESMs of delivering the capability of providing reactive power production at high voltages and reactive power consumption at low voltages.

If the Ten-Year Network Development Plan developed in accordance with Article 30 of Regulation (EU) 2019/943 or a national plan developed and approved in accordance with Article 51 of Directive (EU) 2019/944 specifies that an A-PPM and an A-ESM will become AC-connected to the synchronous area, the relevant TSO may specify that either:

— the A-PPM and the A-ESM shall have the capabilities prescribed in Article 25(4) of RfG 2.0 for that synchronous area installed at the time of initial connection and commissioning of the A-PPM and the A-ESM to the AC-network; or

— the A-PPM owner and the A-ESM owner shall demonstrate to, and then reach agreement with, the relevant system operator and the relevant TSO on how the reactive power capability prescribed in Article 25(4) of RfG 2.0 for that synchronous area will be provided in the event that the A-PPM and the A-ESM becomes AC-connected to the synchronous area.

(ii) With regard to reactive power capability, the relevant system operator may specify supplementary reactive power to be provided if the isolated interface point of an A-PPM and an A-ESM is neither located at the high-voltage terminals of the step-up transformer to the voltage level of the isolated interface point nor at the asset terminals, if no step-up transformer exists. This supplementary reactive power shall compensate the reactive power exchange of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the A-PPM and the A-ESM or the assets terminals, if no step-up transformer exists, and the isolated interface point and shall be provided by the responsible owner of that line or cable.

3. With regard to priority to active or reactive power contribution for A-PPMs and A-ESMs, the relevant system operator, in coordination with the relevant TSO shall specify whether active power contribution or reactive power contribution has priority during

faults for which fault-ride-through capability is required. If priority is given to active power contribution, its provision shall be established within a time from the fault inception as specified by the relevant system operator, in coordination with the relevant TSO.

4. With respect to reactive power capability for A-DFs and A-PtG-DUs, the actual reactive power range at the isolated interface point shall be specified by the relevant TSO for importing and exporting reactive power prescribed in Article 15(1) of DC 2.0.

Article 40a

Fault-ride-through capability of asynchronously connected power-to-gas demand units

With regard to fault-ride-through capability of A-PtG-DUs:

(a) the A-PtG-DU, when operating above the minimum operating level, shall be capable of remaining connected to the network and continuing to operate stably after the isolated AC network has been disturbed by faults in the isolated AC network according to a voltage-against-time-profile in line with Figure X-d and Tables X.1.1 to X.1.2.

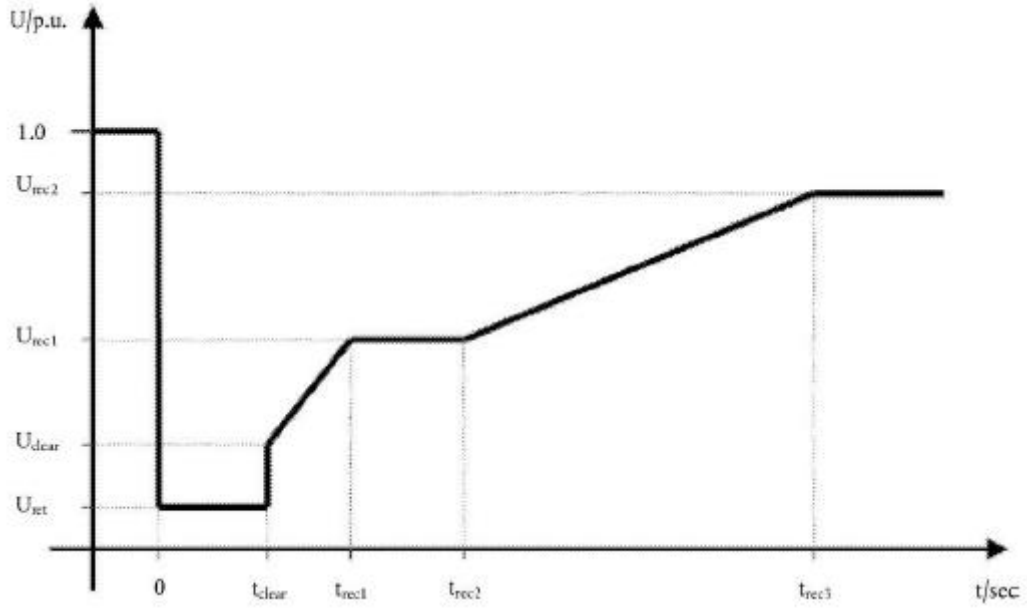

Figure X-d: Fault-ride-through profile of an A-PtG-DU.

Voltage parameters (pu)	
U_{ret}:	0
U_{clear}:	0
U_{rec1}:	0
U_{rec2}:	0,85

Table X.1.1: Voltage parameters of an A-PtG-DU.

Time parameters (seconds)	
t_{clear}:	0,15
T_{rec1}:	0,15
t_{rec2}:	0,15
t_{rec3}:	3,0

Table X.1.2: Time parameters for fault-ride-through capability of an A-PtG-DU.

(b) the voltage-against-time-profile expresses a lower limit of the profile of the phase-to-phase voltages on the network voltage level during a symmetrical fault, as a function of time before, during and after the fault;

(c) when the isolated AC network voltage resumes, after the fault has been cleared, to a value within the voltage range of 0,85 pu – 1,1 pu, an A-PtG-DU shall recover its active power consumption level at the isolated interface point. The relevant TSO shall specify the magnitude and time for post fault active power recovery;

(d) fault-ride-through capabilities in case of asymmetrical faults shall be specified by the relevant system operator, in coordination with the relevant TSO.

Article 40b

Grid forming capability

If grid forming capability as set out in Article 14(4) is requested, the A-PPMs and the A-ESMs shall be capable of providing synthetic inertia in accordance with Article 22 of RfG 2.0, if requested by the relevant system operator.

Article 40c

Overvoltage ride through capability of asynchronously connected power-to-gas demand units

The A-PtG-DU shall be capable of operating stably without disconnecting from the network, if none of the phase -to -phase voltages exceed the voltage-against-time-profile defined in Figure Y-a at the isolated interface point. The relevant system operator, in coordination with the relevant TSO, may define longer times for operation, if it is required to preserve or to restore system security. The A-PtG-DU owner shall not unreasonably withhold consent to apply longer times for operation, taking account of their economic and technical feasibility.

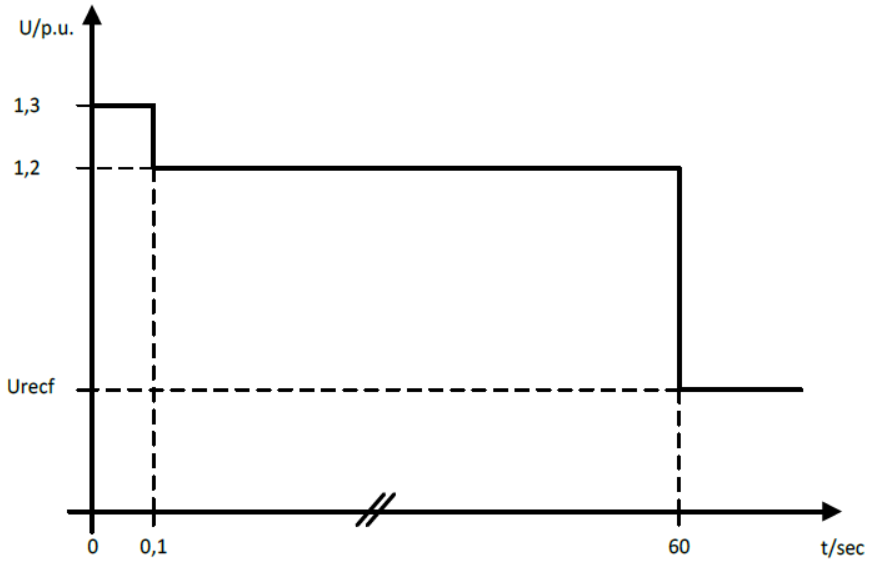

Figure Y-a: Overvoltage against-time profile of an A-PtG-DU. The diagram represents the higher limit of a voltage-against-time profile of the voltage at the isolated interface point, expressed as the ratio of its actual value and its reference 1 pu value, before, during and after a fault. Urecf is the maximum voltage as specified by the relevant TSO.

Article 41

Control requirements

1. During the synchronisation of an A-PPM, A-PtG-DU and an A-ESM to the isolated AC network, the A-PPM, the A-PtG-DU and the A-ESM shall have the capability to limit any voltage changes to a steady-state level specified by the relevant system operator, in coordination with the relevant TSO. The higher permissible voltage change shall not exceed 5 per cent of the pre-synchronisation voltage, as specified by the relevant system operator. The relevant system operator, in coordination with the relevant TSO, shall specify the maximum magnitude, duration and measurement window of the voltage transients.

2. The A-PPM owner, the A-PtG-DU owner and the A-ESM owner shall provide output signals as specified by the relevant system operator, in coordination with the relevant TSO.

Article 42

Network characteristics

With regard to the isolated AC network characteristics, the following shall apply for the A-PPMs, A-DFs, A-PtG-DUs and A-ESMs:

(a) each relevant system operator shall specify and make publicly available the method and the pre-fault and post-fault conditions for the calculation of minimum and maximum short circuit power at the isolated interface point;

(b) the A-PPM, the A-DF, the A-PtG-DU and the A-ESM shall be capable of stable operation within the minimum to maximum range of short circuit power and isolated AC network characteristics of the isolated interface point specified by the relevant system operator, in coordination with the relevant TSO;

(c) each relevant system operator and HVDC system owner shall provide the A-PPM owner, the A-DF owner, the A-PtG-DU owner and the A-ESM owner with isolated AC network equivalents representing the system, enabling the A-PPM owner, the A-DF owner, the A-PtG-DU owner and the A-ESM owner to design their system with regard to harmonics;

Article 43

Protection requirements

1. Electrical protection schemes and settings of A-PPMs and A-ESMs shall be determined in accordance with Article 14(5)(b) of RfG 2.0. Electrical protection schemes and settings of A-DFs shall be determined in accordance with Article 16 of DC 2.0. The protection schemes have to be designed taking into account the system performance, grid specificities as well as technical specificities of the power park module technology and agreed with the relevant system operator, in coordination with the relevant TSO.

2. Priority ranking of protection and control of A-PPMs and A-ESMs shall be determined in accordance with Article 14(5)(c) of RfG 2.0 and in accordance with Article 17(4) of DC 2.0 for A-DFs and agreed with the relevant system operator, in coordination with the relevant TSO.

Article 44

Power quality

A-PPM owners, A-DF owners and A-ESM owners shall ensure that their connection to the isolated AC network does not result in a level of distortion or fluctuation of the supply voltage on the isolated AC network, at the isolated interface point, exceeding the level specified by the relevant system operator, in coordination with the relevant TSO. The necessary contribution from grid users to associated studies, including, but not limited to, existing A-PPMs, A-DFs, A-ESMs and existing HVDC systems, shall not be unreasonably withheld. The process for necessary studies to be conducted and relevant data to be exchanged by all grid users involved, as well as mitigating actions identified and implemented, shall be in accordance with the process in Article 29.

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

With regard to general system management requirements, Articles 14(5), 15(5) and 16(4) of RfG 2.0 shall apply to any A-PPM and A-ESM. With regard to general system management

requirements, Articles 16(1), 17(1) and XX(6) of DC 2.0 shall apply to any A-DFs and A-PtG-DUs.

CHAPTER 2

Requirements for remote-end HVDC converter stations

Article 46

Scope

The requirements of Articles 11 to 39 apply to remote-end HVDC converter stations, subject to specific requirements provided for in Article 47, Article 48, Article 49 and Article 50.

Article 47

Frequency stability requirements

1. Where a nominal frequency other than 50 Hz, or a frequency variable by design is used in the isolated AC network connecting the A-PPMs, A-DFs, A-PtG-DUs and A-ESMs, subject to relevant TSO agreement, Article 11 shall apply to the remote-end HVDC converter station with the applicable frequency ranges and time periods specified by the relevant TSO, taking into account specificities of the system and the requirements laid down in Annex I.

2. With regard to frequency response, the remote-end HVDC converter station owner, the A-PPM owner, the A-DF owner, the A-PtG-DU owner and the A-ESM owner shall agree on the technical modalities of the fast signal communication in accordance with Article 39(1). Where the relevant TSO requires, the HVDC system shall be capable of providing the network frequency at the connection point as a signal to the remote-end HVDC converter station. For an HVDC system connecting an A-PPM, an A-DF, an A-PtG-DU and an A-ESM the adjustment of active power frequency response shall be limited by the capability of the A-PPMs.

3. Where two or more remote-end HVDC converter stations are connected to one or more isolated interface points of the same isolated AC network, the remote-end HVDC converter stations and their respective HVDC systems shall 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.

4. Where paragraph 3 applies, the relevant TSO in coordination with adjacent TSOs, shall 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. This study shall also include robustness against control interactions during frequency changes response. The process for the necessary study to be conducted and relevant data to be provided by all grid users involved, as well as mitigating actions identified and implemented, shall be in accordance with the process in Article 29.

5. If grid forming capability as set out in Article 14(4) is requested, each remote end HVDC converter station shall be capable of adjusting at its isolated interface point the isolated AC network frequency and voltage phase angle in order to use the synthetic inertia from A-PPMs and A-ESMs, if it is requested by the relevant TSO.

Article 48

Reactive power and voltage requirements

1. With respect to voltage ranges:

(a) a remote-end HVDC converter station shall 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;

(b) wider voltage ranges or longer minimum times for operation may be agreed between the relevant system operator, the relevant TSO, and the A-PPM owner, the A-DF owner, the A-PtG-DU owner and the A-ESM 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 shall not unreasonably withhold consent;

(c) for isolated interface points at AC voltages that are not included in the scope of Table 11, Annex VIII, the relevant system operator, in coordination with the relevant TSO shall specify applicable requirements at the connection points;

(d) where frequencies other than nominal 50 Hz are used, subject to agreement by the relevant TSO, the voltage ranges and time periods specified by the relevant system operator, in coordination with the relevant TSO, shall be proportional to those in Annex VIII.

2. A remote-end HVDC converter station shall fulfil the following requirements referring to voltage stability, at the connection points with regard to reactive power capability:

(a) the relevant system operator, in coordination with the relevant TSO shall specify the reactive power provision capability requirements for various voltage levels. In doing so, the relevant system operator, in coordination with the relevant TSO shall specify a U-Q/P_{max}-profile of any shape and within the boundaries of which the remote-end HVDC converter stations shall be capable of providing reactive power at its maximum HVDC active power transmission capacity;

(b) the U-Q/P_{max}-profile shall be specified by each relevant system operator, in coordination with the relevant TSO. The U-Q/P_{max}-profile shall be within the range of Q/P_{max} and steady-state voltage specified in Table 12, Annex VIII, and the position of the U-Q/P_{max}-profile envelope shall lie within the limits of the fixed outer envelope specified in Annex IV. The relevant system operator, in coordination with the relevant TSO, shall consider the long term development of the network when determining these ranges;

(c) where two or more remote-end HVDC converter stations are connected to one or more isolated interface points of the same isolated AC network, the remote-end HVDC

converter stations and their respective HVDC systems shall 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;

(d) where paragraph (c) applies, the relevant TSO in coordination with adjacent TSOs, shall 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. This study shall include robustness against control interactions during voltage disturbances. The process for the necessary study to be conducted and relevant data to be provided by all grid users involved, as well as mitigating actions identified and implemented, shall be in accordance with the process in Article 29.

Article 49

Network characteristics

With regard to the network characteristics, the remote-end HVDC converter station owner shall provide relevant data to any A-PPM owner, A-DF owner, A-PtG-DU owner and A-ESM owner in accordance with Article 42.

Article 50

Power quality

Remote-end HVDC converter station owners shall ensure that their connection to the network does not result in a level of distortion or fluctuation of the supply voltage on the network, at the connection point, exceeding the level allocated to them by the relevant system operator, in coordination with the relevant TSO. The necessary contribution from grid users to the associated studies shall not be unreasonably withheld, including from, but not limited to, existing A-PPMs, A-DFs, A-PtG-DUs, A-ESMs and existing HVDC systems. The process for necessary studies to be conducted and relevant data to be provided by all grid users involved, as well as mitigating actions identified and implemented shall be in accordance with the process provided for in Article 29.

TITLE IV

INFORMATION EXCHANGE AND COORDINATION

Article 51

Operation of HVDC systems

1. With regard to instrumentation for the operation, each HVDC converter unit of an HVDC system shall be equipped with an automatic controller capable of receiving instructions from the relevant system operator and from the relevant TSO. This automatic controller shall be capable of operating the HVDC converter units of the HVDC system in a coordinated way. The relevant system operator shall specify the automatic controller hierarchy per HVDC converter unit.

2. The automatic controller of the HVDC system referred to in paragraph 1 shall be capable of sending the following signal types to the relevant system operator:

(a) operational signals, providing at least the following:

(i) start-up signals;

(ii) AC and DC voltage measurements;

(iii) AC and DC current measurements;

(iv) active and reactive power measurements on the AC side;

(v) DC power measurements;

(vi) HVDC converter unit level operation in a multi-pole type HVDC converter;

(vii) elements and topology status; and

(viii) FSM, LFSM-O and LFSM-U active power ranges.

(b) alarm signals, providing at least the following:

(i) emergency blocking;

(ii) ramp blocking;

(iii) fast active power reversal.

3. The automatic controller referred to in paragraph 1 shall be capable of receiving the following signal types from the relevant system operator:

(a) operational signals, receiving at least the following:

(i) start-up command;

(ii) active power setpoints;

(iii) active power flow direction;

(iv) frequency sensitive mode settings;

(v) reactive power, voltage or similar setpoints;

(vi) reactive power control modes;

(vii) power oscillation damping control; and

(viii) synthetic inertia.

(b) alarm signals, receiving at least the following:

(i) emergency blocking command;

(ii) ramp blocking command; and

(iii) fast active power reversal command.

4. With regards to each signal, the relevant system operator may specify the quality of the supplied signal.

Article 52

Parameters and settings

The parameters and settings of the main control functions of an HVDC system shall be agreed between the HVDC system owner and the relevant system operator, in coordination with the relevant TSO. The parameters and settings shall be implemented within such a control hierarchy that makes their modification possible if necessary. Those main control functions are at least:

(a) grid forming capability, if applicable as referred to in Article 14 and Article 35;

(b) fast frequency control, if applicable as referred to in Article 14b and Article 35;

(c) frequency sensitive modes (FSM, LFSM-O, LFSM-U) referred to in Article 15, Article 16 and Article 17;

(d) frequency control, if applicable, referred to in Article 16;

(e) short circuit contribution during faults as referred to in Article 19 and Article 35;

(f) reactive power control mode, if applicable as referred to in Article 22;

(g) power oscillation damping capability, referred to Article 30;

(h) subsynchronous torsional interaction damping capability, referred to Article 31.

Article 53

Fault recording and monitoring

1. An HVDC system shall be equipped with a facility to provide fault recording and dynamic system behaviour monitoring of the following parameters for each of its HVDC converter stations:

(a) AC and DC voltage;

(b) AC and DC current;

(c) active power;

(d) reactive power; and

(e) frequency.

2. The relevant system operator may specify quality of supply parameters to be complied with by the HVDC system, provided a reasonable prior notice is given.

3. The particulars of the fault recording equipment referred to in paragraph 1, including analogue and digital channels, the settings, including triggering criteria and the sampling rates, shall be agreed between the HVDC system owner, the relevant system operator and the relevant TSO.

4. All dynamic system behaviour monitoring equipment shall include an oscillation trigger, specified by the relevant system operator, in coordination with the relevant TSO, with the purpose of detecting poorly damped power oscillations.

5. The facilities for quality of supply and dynamic system behaviour monitoring shall include arrangements for the HVDC system owner and the relevant system operator to access the information electronically. The communications protocols for recorded data shall be agreed between the HVDC system owner, the relevant system operator and the relevant TSO.

Article 54

Simulation models

1. The relevant system operator in coordination with the relevant TSO may specify that an HVDC system owner deliver simulation models which properly reflect the behaviour of the HVDC system in steady-state, in time domain dynamic simulations (root mean square - RMS) and in electromagnetic transient (EMT) simulations.

The format in which models shall be provided and the provision of documentation of models structure and block diagrams shall be specified by the relevant system operator in coordination with the relevant TSO. In the case that encrypted detailed RMS or EMT models are accepted by the relevant TSO, the relevant TSO together with the HVDC system owner shall specify the requirements of the model encryption (for example, use of source code, the model structure and the signal interfaces to be observable in the network studies). The agreement shall be made on project specific basis according to national regulations.

2. For the purpose of electromechanical dynamic (RMS) simulations used in network studies, the relevant TSO shall have the right to specify the model requirements. Without prejudice to the Member State's rights to introduce additional requirements, the HVDC system models shall at least :

(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;

(d) be open source generic model, or encrypted detailed model if applicable, for RMS simulations delivered for cross-border network stability studies;

The above listed simulation model requirements and information shall not violate manufactures intellectual property.

3. For the purpose of electromagnetic transient (EMT) simulations, the relevant TSO shall have the right to specify the model requirements. Without prejudice to the Member State's rights to introduce additional requirements, the HVDC system models shall:

(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 disturbances in the valid frequency range;

(d) for the respective HVDC system model and study purpose, include 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);

(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 AC and DC side in the frequency range that the model is valid;

The above listed simulation model requirements and information shall not violate manufactures intellectual property.

4. For the purpose of the risk assessment of the resonance stability of the HVDC converter station, the relevant system operator in coordination with the relevant TSO shall 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. Without prejudice to the Member State's rights to introduce additional requirements, the following requirements shall apply:

(a) the impedance model of the HVDC converter station shall be requested in the frequency range 5 Hz till 2500 Hz; the relevant system operator in coordination with the relevant TSO and the HVDC system owner may agree to extend the required applicability of the model up to 9000 Hz;

(b) the relevant system operator in coordination with the relevant TSO together with the HVDC owner shall 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 shall specify the frequency steps where the impedance is provided. The number of different frequency steps shall 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 shall 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 shall be provided for both the positive and for the negative phase sequence;

(e) the HVDC system owner shall 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 shall be sufficiently represented;

(f) the HVDC system owner shall specify and justify simplifications made in the calculation of the impedance model.

5. The HVDC system owner shall verify the models against the results of compliance tests carried out according to Title VI and a report of this verification shall be submitted to the relevant TSO. The models shall then be used for the purpose of verifying compliance with the requirements of this Regulation including, but not limited to, compliance simulations as provided for in Title VI and used in studies for continuous evaluation in system planning and operation.

6. An HVDC system owner shall submit HVDC system recordings to the relevant system operator or relevant TSO if requested in order to compare the response of the models with these recordings.

7. An HVDC system owner shall deliver an equivalent model of the control system when adverse control interactions may result with HVDC converter stations and other connections in close electrical proximity if requested by the relevant system operator or relevant TSO. The equivalent model shall contain all necessary data for the realistic simulation of the adverse control interactions.

TITLE V

OPERATIONAL NOTIFICATION PROCEDURE FOR CONNECTION

CHAPTER 1

Connection of new HVDC systems

Article 55

General provisions

1. The HVDC system owner shall demonstrate to the relevant system operator that it has complied with the requirements set out in Title II to Title IV at the respective connection point by successfully completing the operational notification procedure for connection of the HVDC system as described in Article 56, Article 57, Article 58 and Article 59.

2. The relevant system operator shall specify any detailed provisions of the operational notification procedure and make the details publicly available.

3. The operational notification procedure for connection for each new HVDC system shall comprise:

(a) energisation operational notification (EON);

(b) interim operational notification (ION); and

(c) final operational notification (FON).

Article 56

EON for HVDC systems

1. An EON shall entitle the HVDC system owner to energise its internal network and auxiliaries and connect it to the network at its specified connection points.

2. An EON shall be issued by the relevant system operator, subject to completion of preparation and the fulfilment of the requirements specified by the relevant system operator in the relevant operational procedures. This preparation will include agreement on the protection and control settings relevant to the connection points between the relevant system operator and the HVDC system owner.

Article 57

ION for HVDC systems

1. An ION shall entitle a HVDC system owner or HVDC converter unit owner to operate the HVDC system or HVDC converter unit by using the network connections specified for the connection points for a limited period of time.

2. An ION shall be issued by the relevant system operator subject to the completion of the data and study review process.

3. For the purpose of the completion of data and study review, the HVDC system owner or HVDC converter unit owner shall provide the following upon request from the relevant system operator:

(a) itemised statement of compliance;

(b) detailed technical data of the HVDC system with relevance to the network connection, that is specified with respect to the connection points, as specified by the relevant system operator, in coordination with the relevant TSOs;

(c) equipment certificates of HVDC systems or HVDC converter units where these are relied upon as part of the evidence of compliance;

(d) simulation models or a replica of the exact control system as specified by Article 54 and by the relevant system operator in coordination with the relevant TSOs;

(e) studies demonstrating expected steady-state and dynamic performance as required by Titles II, III and IV;

(f) details of intended compliance tests according to Article 72;

(g) details of intended practical method of completing compliance tests pursuant to Title VI.

4. Except where paragraph 5 applies, the maximum period for the HVDC system owner or HVDC converter unit owner to remain in the ION status shall not exceed twenty four months. The relevant system operator may specify a shorter ION validity period. The ION validity period shall be notified to the regulatory authority in accordance with the applicable national regulatory framework. ION extension shall be granted only if the HVDC system owner demonstrates substantial progress towards full compliance. At the time of ION extension, the outstanding issues shall be explicitly identified.

5. The maximum period for an HVDC system owner or HVDC converter unit owner to remain in the ION status may be extended beyond 24 months upon request for a derogation made to the relevant system operator in accordance with the procedure in Title VII. The request shall be made before the expiry of the twenty four month period.

Article 58

FON for HVDC systems

1. A FON shall entitle an HVDC system owner to operate the HVDC system or HVDC converter units by using the grid connection points.

2. A FON shall be issued by the relevant system operator upon prior removal of all incompatibilities identified for the purpose of the ION status and subject to the completion of the data and study review process.

3. For the purpose of the completion of data and study review, the HVDC system owner shall provide the following upon request from the relevant system operator in coordination with the relevant TSO:

(a) itemised statement of compliance; and

(b) update of applicable technical data, simulation models, a replica of the exact control system and studies as referred to in Article 57, including use of actual measured values during testing.

4. In case of incompatibility identified for the purpose of the granting of the FON, a derogation may be granted upon a request to the relevant system operator, in accordance

with Article 79 and Article 80. A FON shall be issued by the relevant system operator, if the HVDC system is compliant with the provisions of the derogation.

Where a request for a derogation is rejected, the relevant system operator shall have the right to refuse the operation of the HVDC system or HVDC converter units, whose owner's request for a derogation was rejected, until the HVDC system owner and the relevant system operator have resolved the incompatibility and the relevant system operator considers that the HVDC system complies with the provisions of this Regulation.

If the relevant system operator and the HVDC system owner do not resolve the incompatibility within a reasonable timeframe, but in any case not later than six months after the notification of the rejection of the request for a derogation, each party may refer the issue for decision to the regulatory authority.

Article 59

Limited operational notification for HVDC systems/derogations

1. HVDC system owners to whom a FON has been granted shall inform the relevant system operator immediately in the following circumstances:

(a) the HVDC system is temporarily subject to either a significant modification or loss of capability, due to implementation of one or more modifications of significance to its performance; or

(b) in case of equipment failures leading to non-compliance with some relevant requirements.

2. The HVDC system owner shall apply to the relevant system operator for a limited operational notification (LON) if the HVDC system owner reasonably expects the circumstances detailed in paragraph 1 to persist for more than three months.

3. A LON shall be issued by the relevant system operator with a clear identification of:

(a) the unresolved issues justifying the granting of the LON;

(b) the responsibilities and timescales for expected solution; and

(c) a maximum period of validity which shall not exceed 12 months. The initial period granted may be shorter with the possibility for extension if evidence to the satisfaction of the relevant system operator demonstrates that substantial progress has been made towards achieving full compliance.

4. The FON shall be suspended during the period of validity of the LON with regard to the subjects for which the LON has been issued.

5. A further prolongation of the period of validity of the LON may be granted upon request for a derogation made to the relevant system operator before the expiry of that period, in accordance with Article 79 and Article 80.

6. The relevant system operator may refuse the operation of the HVDC system if the LON terminates and the circumstance which caused it to be issued remains. In such a case the FON shall automatically be invalid.

7. If the relevant system operator does not grant an extension of the period of validity of the LON in accordance with paragraph 5 or if it refuses to allow the operation of the HVDC system once the LON is no longer valid in accordance with paragraph 6, the HVDC system owner may refer the issue for decision to the regulatory authority within six months after the notification of the decision of the relevant system operator.

CHAPTER 2

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

Article 60

General provisions

1. The provisions of this Chapter shall apply to new A-PPMs, new A-DFs, new A-PtG-DUs and new A-ESMs only.

2. The A-PPM owner, A-DF owner, A-PtG-DU owner and A-ESM owner shall demonstrate to the relevant system operator its compliance with the requirements referred to in Title III at the respective connection points by successfully completing the operational notification procedure for connection of the A-PPM, A-DF, A-PtG-DU or A-ESM in accordance with Article 61, Article 62, Article 63, Article 64, Article 65 and Article 66.

3. The relevant system operator shall specify further details of the operational notification procedure and make those details publicly available.

4. The operational notification procedure for connection for each new A-PPM, A-DF, A-PtG-DU and A-ESM shall comprise:

(a) energisation operational notification (EON);

(b) interim operational notification (ION); and

(c) final operational notification (FON).

Article 61

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

1. An EON shall entitle the owner of an A-PPM, an A-DF, an A-PtG-DU or an A-ESM to energise its internal network and auxiliaries by using the grid connection that is specified by the connection points.

2. An EON shall be issued by the relevant system operator, subject to completion of preparation including agreement on the protection and control settings relevant to the connection points between the relevant system operator and the A-PPM, A-DF, A-PtG-DU or A-ESM.

Article 62

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

1. An ION shall entitle the A-PPM owner, the A-DF owner, the A-PtG-DU owner and the A-ESM owner to operate the A-PPM, the A-DF, the A-PtG-DU and the A-ESM by using the grid connection for a limited period of time.

2. An ION shall be issued by the relevant system operator, subject to the completion of the data and study review process.

3. With respect to data and study review, the A-PPM owner, the A-DF owner, the A-PtG-DU owner and the A-ESM owner shall provide the following upon request from the relevant system operator:

(a) itemised statement of compliance;

(b) detailed technical data of the A-PPM, A-DF, A-PtG-DU and A-ESM with relevance to the grid connection, that is specified by the connection points, as specified by the relevant system operator in coordination with the relevant TSO;

(c) equipment certificates of A-PPM, A-DF, A-PtG-DU and A-ESM, where these are relied upon as part of the evidence of compliance;

(d) simulation models as specified in Article 15(5)(c) of RfG 2.0 and Article 21 of DC 2.0 and as required by the relevant system operator in coordination with the relevant TSO;

(e) studies demonstrating expected steady-state and dynamic performance as required by Title III; and

(f) details of intended compliance tests in accordance with Article 73.

4. Except where paragraph 5 applies, the maximum period for the A-PPM owner, the A-DF owner, the A-PtG-DU owner or the A-ESM owner to remain in the ION status shall not exceed twenty-four months. The relevant system operator may specify shorter ION validity.

The ION validity period shall be notified to the regulatory authority in accordance with the applicable national regulatory framework. ION extensions shall be granted only if the A-PPM owner, the A-DF owner, the A-PtG-DU owner or the A-ESM owner demonstrates substantial progress towards full compliance. At the time of ION extension, any outstanding issues shall be explicitly identified.

5. The maximum period for an A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner to remain in the ION status may be extended beyond 24 months upon request for a derogation made to the relevant system operator in accordance with the procedure in Title VII.

Article 63

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

1. A FON shall entitle the A-PPM owner, the A-DF owner, the A-PtG-DU owner or the A-ESM owner to operate the A-PPM, the A-DF, the A-PtG-DU or the A-ESM by using the grid connection that is specified by the connection point.

2. A FON shall be issued by the relevant system operator, upon prior removal of all incompatibilities identified for the purpose of the ION status and subject to the completion of the data and study review process as required by this Regulation.

3. For the purpose of the completion of data and study review, the A-PPM owner, the A-DF owner, the A-PtG-DU owner and the A-ESM owner shall provide the following upon request from the relevant system operator:

(a) itemised statement of compliance; and

(b) update of applicable technical data, simulation models and studies as referred to in Article 62(3), including use of actual measured values during testing.

4. In case of incompatibility identified for the purpose of the granting of the FON, a derogation may be granted upon request made to the relevant system operator, in accordance with the derogation procedure according to Title VII. A FON shall be issued by the relevant system operator, if the A-PPM, the A-DF, the A-PtG-DU and the A-ESM is compliant with the provisions of the derogation. The relevant system operator shall have the right to refuse the operation of the A-PPM, the A-DF, the A-PtG-DU or the A-ESM, whose owner's request for a derogation was rejected, until the A-PPM owner, the A-DF owner, the A-PtG-DU owner or the A-ESM owner and the relevant system operator have resolved the incompatibility and the A-PPM, the A-DF, the A-PtG-DU or the A-ESM is considered to be compliant by the relevant system operator.

Article 64

Limited operational notification for asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units and asynchronously connected electricity storage modules

1. A-PPM owners, A-DF owners, A-PtG-DU owners and A-ESM owners to whom a FON has been granted shall inform the relevant system operator immediately in the following circumstances:

(a) the A-PPM, the A-DF, the A-PtG-DU or the A-ESM is temporarily subject to either a significant modification or loss of capability, due to implementation of one or more modifications of significance to its performance; or

(b) in case of equipment failures leading to non-compliance with some relevant requirements.

2. The A-PPM owner, the A-DF owner, the A-PtG-DU owner or the A-ESM owner shall apply to the relevant system operator for a limited operational notification (LON), if the A-PPM owner, the A-DF owner, the A-PtG-DU owner or the A-ESM owner reasonably expects the circumstances detailed in paragraph 1 to persist for more than three months.

3. A LON shall be issued by the relevant TSO with a clear identification of:

(a) the unresolved issues justifying the granting of the LON;

(b) the responsibilities and timescales for expected solution; and

(c) a maximum period of validity which shall not exceed 12 months. The initial period granted may be shorter with the possibility for extension if evidence to the satisfaction of the relevant system operator demonstrating that substantial progress has been made towards achieving full compliance.

4. The FON shall be suspended during the period of validity of the LON with regard to the subjects for which the LON has been issued.

5. A further prolongation of the period of validity of the LON may be granted upon request for a derogation made to the relevant system operator, before the expiry of that period, in accordance with the derogation procedure described in Title VII.

6. The relevant system operator may refuse the operation of the A-PPM, the A-DF, the A-PtG-DU or the A-ESM if the LON terminates and the circumstance which caused it to be issued remains. In such a case the FON shall automatically be invalid.

CHAPTER 3

Cost benefit analysis

Article 65

Identification of costs and benefits of application of requirements to existing HVDC systems, asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units or asynchronously connected electricity storage modules

1. Prior to the application of any requirement set out in this Regulation to existing HVDC systems, A-PPMs, A-DFs, A-PtG-DUs or A-ESMs in accordance with paragraph 3 of Article 4, the relevant TSO shall undertake a qualitative comparison of costs and benefits related to the requirement under consideration. This comparison shall take into account available network-based or market-based alternatives. The relevant TSO may only proceed to undertake a quantitative cost-benefit analysis in accordance with paragraphs 2 to 5, if the qualitative comparison indicates that the likely benefits exceed the likely costs. If, however, the cost is deemed high or the benefit is deemed low, then the relevant TSO shall not proceed further.

2. Following a preparatory stage undertaken in accordance with paragraph 1, the relevant TSO shall carry out a quantitative cost-benefit analysis of any requirement under consideration for application to existing HVDC systems, A-PPMs, A-DFs, A-PtG-DUs or A-ESMs that have demonstrated potential benefits as a result of the preparatory stage according to paragraph 1.

3. Within three months of concluding the cost-benefit analysis, the relevant TSO shall summarise the findings in a report which shall:

(a) include the cost-benefit analysis and a recommendation on how to proceed;

(b) include a proposal for a transitional period for applying the requirement to existing HVDC systems, A-PPMs, A-DFs, A-PtG-DUs or A-ESMs. That transitional period shall not be more than two years from the date of the decision of the regulatory authority or where applicable the Member State on the requirement's applicability;

(c) be subject to public consultation in accordance with Article 8.

4. No later than six months after the end of the public consultation, the relevant TSO shall prepare a report explaining the outcome of the consultation and making a proposal on the applicability of the requirement under consideration to existing HVDC systems, A-PPMs, A-DFs, A-PtG-DUs or A-ESMs. The report and proposal shall be notified to the regulatory authority or, where applicable, the Member State, and the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner or, where applicable, third party shall be informed on its content.

5. The proposal made by the relevant TSO to the regulatory authority or, where applicable, the Member State pursuant to paragraph 4 shall include the following:

(a) an operational notification procedure for demonstrating the implementation of the requirements by the owner of the existing HVDC system, A-PPM, A-DF, A-PtG-DU or A-ESM;

(b) a transitional period for implementing the requirements which shall take into account the category of HVDC system, A-PPM, A-DF, A-PtG-DU or A-ESM and any underlying obstacles to the efficient implementation of the equipment modification/refitting.

Article 66

Principles of cost-benefit analysis

1. HVDC system owners, A-PPM owners, A-DF owners, A-PtG-DU owners, A-ESM owners and DSOs, including CDSOs, shall assist and contribute to the cost-benefit analysis undertaken according to Article 65 and Article 80 and provide the necessary data as requested by the relevant system operator or relevant TSO within three months of receiving a request, unless agreed otherwise by the relevant TSO. For the preparation of a cost-benefit-analysis by a HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner, or their prospective owner, assessing a potential derogation pursuant to Article 79, the relevant TSO and DSO, including CDSO, shall assist and contribute to the cost-benefit analysis and provide the necessary data as requested by the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner, or their prospective owner, within three months of receiving a request, unless agreed otherwise by the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner, or their prospective owner.

2. A cost-benefit analysis shall be in line with the following principles:

(a) the relevant TSO, or HVDC system owner or A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner, or their prospective owner, shall base its cost-benefit analysis on one or more of the following calculating principles:

  (i) the net present value;

  (ii) the return on investment;

  (iii) the rate of return;

  (iv) the time needed to break even.

(b) the relevant TSO, or HVDC system owner or A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner, or their prospective owner, shall also quantify socioeconomic benefits in terms of improvement in security of supply and shall include at least:

  (i) the associated reduction in probability of loss of supply over the lifetime of the modification;

  (ii) the probable extent and duration of such loss of supply;

  (iii) the societal cost per hour of such loss of supply.

(c) the relevant TSO, or HVDC system owner or A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner, or their prospective owner, shall quantify the benefits to the internal

market in electricity, cross-border trade and integration of renewable energies, including at least:

(i) the active power frequency response;

(ii) the balancing reserves;

(iii) the reactive power provision;

(iv) congestion management;

(v) defence measures.

(d) the relevant TSO shall quantify the costs of applying the necessary rules to existing HVDC systems, A-PPMs, A-DFs, A-PtG-DUs or A-ESMs, including at least:

(i) the direct costs incurred in implementing a requirement;

(ii) the costs associated with attributable loss of opportunity;

(iii) the costs associated with resulting changes in maintenance and operation.

TITLE VI

COMPLIANCE

CHAPTER 1

Compliance monitoring

Article 67

Common provisions for compliance testing

1. Testing of the performance of HVDC systems, A-PPMs, A-DFs, A-PtG-DUs and A-ESMs shall aim at demonstrating that the requirements of this Regulation have been complied with.

2. Notwithstanding the minimum requirements for compliance testing set out in this Regulation, the relevant system operator is entitled to:

(a) Allow the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner to carry out an alternative set of tests, provided that those tests are efficient and suffice to demonstrate that a HVDC system, A-PPM, A-DF, A-PtG-DU or A-ESM complies with the requirements of this Regulation; and

(b) require the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner to carry out additional or alternative sets of tests in those cases where the information supplied to the relevant system operator in relation to compliance testing

under the provisions of Chapter 2 of Title VI, is not sufficient to demonstrate compliance with the requirements of this Regulation.

3. The HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner is responsible for carrying out the tests in accordance with the conditions laid down in Chapter 2 of Title VI. The relevant system operator shall cooperate and not unduly delay the performance of the tests.

4. The relevant system operator may participate in the compliance testing either on site or remotely from the system operator's control centre. For that purpose, the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner shall provide the monitoring equipment necessary to record all relevant test signals and measurements as well as ensure that the necessary representatives of the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner are available on site for the entire testing period. Signals specified by the relevant system operator shall be provided if, for selected tests, the system operator wishes to use its own equipment to record performance. The relevant system operator has sole discretion to decide about its participation.

Article 68

Common provisions on compliance simulation

1. Simulation of the performance of HVDC systems, A-PPMs, A-DFs, A-PtG-DUs and A-ESMs shall aim at demonstrating that the requirements of this Regulation have been fulfilled.

2. Notwithstanding the minimum requirements set out in this Regulation for compliance simulation, the relevant system operator may:

(a) allow the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner to carry out an alternative set of simulations, provided that those simulations are efficient and suffice to demonstrate that a HVDC system, A-PPM, A-DF, A-PtG-DU or A-ESM complies with the requirements of this Regulation or with national legislation; and

(b) require the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner to carry out additional or alternative sets of simulations in those cases where the information supplied to the relevant system operator in relation to compliance simulation under the provisions of Chapter 3 of Title VI, is not sufficient to demonstrate compliance with the requirements of this Regulation.

3. To demonstrate compliance with the requirements of this Regulation, the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner and A-ESM owner shall provide a report with the simulation results. The HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner and A-ESM owner shall produce and provide a validated simulation model for a given HVDC system, A-PPM, A-DF, A-PtG-DU or A-ESM. The scope of the simulation models is set out in Article 38 and Article 54.

4. The relevant system operator shall have the right to check that a HVDC system, A-PPM, A-DF, A-PtG-DU and A-ESM complies with the requirements of this Regulation by

carrying out its own compliance simulations based on the provided simulation reports, simulation models and compliance test measurements.

5. The relevant system operator shall provide the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner with technical data and a simulation model of the network, to the extent necessary to carry out the requested simulations in accordance with Chapter 3 of Title VI.

Article 69

Responsibility of the HVDC system owner, asynchronously connected power park module owner, asynchronously connected demand facility owner, asynchronously connected power-to-gas demand unit owner and asynchronously connected electricity storage module owner

1. The HVDC system owner shall ensure that the HVDC system and HVDC converter stations are compliant with the requirements provided for by this Regulation. This compliance shall be maintained throughout the lifetime of the facility.

2. The A-PPM owner, A-DF owner, A-PtG-DU owner and A-ESM owner shall ensure that the A-PPM, A-DF, A-PtG-DU and A-ESM is compliant with the requirements under this Regulation. This compliance shall be maintained throughout the lifetime of the facility.

3. Planned modifications of the technical capabilities of the HVDC system, HVDC converter station, A-PPM, A-DF, A-PtG-DU or A-ESM with possible impact on its compliance to the requirements under this Regulation shall be notified to the relevant system operator by the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner before initiating such modification.

4. Any operational incidents or failures of an HVDC system, HVDC converter station, A-PPM, A-DF, A-PtG-DU or A-ESM that have impact on its compliance to the requirements of this Regulation shall be notified to the relevant system operator by the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner as soon as possible without any delay after the occurrence of such an incident.

5. Any foreseen test schedules and procedures to verify compliance of an HVDC system, HVDC converter station, A-PPM, A-DF, A-PtG-DU or A-ESM with the requirements of this Regulation shall be notified to the relevant system operator by the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner in due time and prior to their launch and shall be approved by the relevant system operator.

6. The relevant system operator shall be facilitated to participate in such tests and may record the performance of the HVDC systems, HVDC converter stations, A-PPMs, A-DFs, A-PtG-DUs or A-ESMs.

Article 70

Tasks of the relevant system operator

1. The relevant system operator shall assess the compliance of an HVDC system, HVDC converter station, A-PPM, A-DF, A-PtG-DU and A-ESM with the requirements under this Regulation throughout the lifetime of the HVDC system, HVDC converter station, A-PPM, A-DF, A-PtG-DU or A-ESM. The HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner shall be informed of the outcome of this assessment.

2. Where requested by the relevant system operator, the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner shall carry out compliance tests and simulations, not only during the operational notification procedures according to Title V, but repeatedly throughout the lifetime of the HVDC system, HVDC converter station, A-PPM, A-DF, A-PtG-DU or A-ESM according to a plan or general scheme for repeated tests and specified simulations or after any failure, modification or replacement of any equipment that may have impact on the compliance with the requirements under this Regulation. The HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner shall be informed of the outcome of these compliance tests and simulations.

3. The relevant system operator shall make publicly available the list of information and documents to be provided as well as the requirements to be fulfilled by the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner in the frame of the compliance process. Such list shall cover at least the following information, documents and requirements:

(a) all documentation and certificates to be provided by the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner;

(b) details of the technical data of the HVDC system, HVDC converter station, A-PPM, A-DF, A-PtG-DU or A-ESM with relevance to the grid connection;

(c) requirements for models for steady-state and dynamic system studies;

(d) timeline for the provision of system data required to perform the studies;

(e) studies by the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner to demonstrate the expected steady-state and dynamic performance in accordance with the requirements set out in Titles II, III and IV;

(f) conditions and procedures including the scope for registering equipment certificates; and

(g) conditions and procedures for use of relevant equipment certificates, issued by an authorised certifier, by the A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner.

4. The relevant system operator shall make publicly available the allocation of responsibilities to the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner and to the system operator for compliance testing, simulation and monitoring.

5. The relevant system operator may partially or totally assign the performance of its compliance monitoring to third parties. In this case, the relevant system operator shall ensure compliance with Article 10 by appropriate confidentiality commitments with the assignee.

6. The relevant system operator shall not unreasonably withhold any operational notification in accordance with Title V, if compliance tests or simulations cannot be performed as agreed between the relevant system operator and the HVDC system owner, A-PPM owner, A-DF owner, A-PtG-DU owner or A-ESM owner due to reasons which are in the sole control of the relevant system operator.

7. The relevant system operator shall provide the relevant TSO when requested the compliance test and simulation results referred to in this Chapter.

CHAPTER 2

Compliance testing

Article 71

Compliance testing for HVDC systems

1. Equipment certificates may be used instead of part of the tests below, on the condition that they are provided to the relevant system operator.

2. With regard to the reactive power capability test:

(a) the HVDC converter unit or the HVDC converter station shall demonstrate its technical capability to provide leading and lagging reactive power capability according to Article 20;

(b) the reactive power capability test shall be carried out at maximum reactive power, both leading and lagging, and concerning the verification of the following parameters:

  (i) Operation at minimum HVDC active power transmission capacity;

  (ii) Operation at maximum HVDC active power transmission capacity;

  (iii) Operation at active power setpoint between those minimum and maximum HVDC active power transmission capacity.

(c) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

  (i) the HVDC converter unit or the HVDC converter station has been operating no shorter than 1 hour at maximum reactive power, both leading and lagging, for each parameter as referred to in point (b);

  (ii) the HVDC converter unit or the HVDC converter station demonstrates its capability to change to any reactive power setpoint within the applicable reactive power range

within the specified performance targets of the relevant reactive power control scheme; and

(iii) no action of any protection within the operation limits specified by reactive power capacity diagram occurs.

3. With regard to the voltage control mode test:

(a) the HVDC converter unit or the HVDC converter station shall demonstrate its capability to operate in voltage control mode in the conditions set forth in Article 22(3);

(b) the voltage control mode test shall apply concerning the verification of the following parameters:

(i) the implemented slope and deadband of the static characteristic;

(ii) the accuracy of the regulation;

(iii) the insensitivity of the regulation;

(iv) the time of reactive power activation.

(c) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the range of regulation and adjustable droop and deadband is compliant with agreed or decided characteristic parameters, according to Article 22(3);

(ii) the insensitivity of voltage control is not higher than 0,01 pu;

(iii) following a step change in voltage, 90 % of the change in reactive power output has been achieved within the times and tolerances according to Article 22(3).

4. With regard to the reactive power control mode test:

(a) the HVDC converter unit or the HVDC converter station shall demonstrate its capability to operate in reactive power control mode, according to the conditions referred to in Article 22 (4);

(b) the reactive power control mode test shall be complementary to the reactive power capability test;

(c) the reactive power control mode test shall apply concerning the verification of the following parameters:

(i) the reactive power setpoint range and step;

(ii) the accuracy of the regulation; and

(iii) the time of reactive power activation.

(d) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the reactive power setpoint range and step is ensured according to Article 22(4);

(ii) the accuracy of the regulation is compliant with the conditions as referred to in Article 22(3).

5. With regard to the power factor control mode test:

(a) the HVDC converter unit or the HVDC converter station shall demonstrate its capability to operate in power factor control mode according to the conditions referred to in Article 22(5);

(b) the power factor control mode test shall apply concerning the verification of the following parameters:

(i) the power factor setpoint range;

(ii) the accuracy of the regulation;

(iii) the response of reactive power due to step change of active power.

(c) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the power factor setpoint range and step is ensured according to Article 22(5);

(ii) the time of reactive power activation as result of step active power change does not exceed the requirements specified in accordance with Article 22(5);

(iii) the accuracy of the regulation is compliant with the value, as referred to in Article 22(5).

6. With regard to the FSM response test:

(a) the HVDC system shall demonstrate its technical capability to continuously modulate active power over the full operating range between maximum HVDC active power transmission capacity and minimum HVDC active power transmission capacity to contribute to frequency control and shall verify the steady-state parameters of regulations, such as droop and deadband and dynamic parameters, including robustness during frequency step change response and large, fast frequency changes;

(b) the test shall be carried out by simulating frequency steps and ramps big enough to activate at least 10 % of the full active power frequency response range in each direction, taking into account the droop settings and the deadband. Simulated frequency deviation signals shall be injected into the controller of the HVDC converter unit or the HVDC converter station;

(c) the test shall be deemed to be passed, provided that the following conditions are all fulfilled:

(i) activation time of full active power frequency response range as result of a step frequency change has been no longer than required by Annex II;

(ii) undamped oscillations do not occur after the step change response;

(iii) the initial delay time has been according to Annex II;

(iv) the droop settings are available within the range provided for in Annex II and deadband (thresholds) is not more than the value in Annex II;

(v) insensitivity of active power frequency response at any relevant operating point does not exceed the requirements set forth in Annex II.

7. With regard to the LFSM-O response test:

(a) the HVDC system shall demonstrate its technical capability to continuously modulate active power to contribute to frequency control in case of large increase of frequency in the system and shall verify the steady-state parameters of regulations, such as droop and deadband, and dynamic parameters, including frequency step change response;

(b) the test shall be carried out by simulating frequency steps and ramps big enough to activate at least 10 % of the full operating range for active power, taking into account the droop settings and the deadband. Simulated frequency deviation signals shall be injected into the controller of the HVDC converter unit or the HVDC converter station;

(c) the test shall be deemed passed, provided that the following conditions are both fulfilled:

(i) the test results, for both dynamic and static parameters, are in line with the requirements as referred to in Annex II;

(ii) undamped oscillations do not occur after the step change response.

8. With regard to the LFSM-U response test:

(a) the HVDC system shall demonstrate its technical capability to continuously modulate active power at operating points below maximum HVDC active power transmission capacity to contribute to frequency control in case of large drop of frequency in the system;

(b) the test shall be carried out by simulating at appropriate active power load points with low frequency steps and ramps big enough to activate at least 10 % of the full operating range for active power, taking into account the droop settings and the deadband. Simulated frequency deviation signals shall be injected into the controller of the HVDC converter unit or the HVDC converter station;

(c) the test shall be deemed passed, provided that the following conditions are both fulfilled:

(i) the test results, for both dynamic and static parameters, are in line with the requirements as referred to in Annex II;

(ii) undamped oscillations do not occur after the step change response.

9. With regard to the active power controllability test:

(a) the HVDC system shall demonstrate its technical capability to continuously modulate active power over the full operating range according to Article 13(1)(a) and (d);

(b) the test shall be carried out by sending manual and automatic instructions by the relevant TSO;

(c) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the HVDC system has demonstrated stable operation;

(ii) the time of adjustment of the active power is shorter than the delay specified pursuant to Article 13(1)(a);

(iii) the dynamic response of the HVDC system when receiving instructions for the purposes of exchange or sharing of reserves, or for participating in imbalance netting processes, if capable of fulfilling the requirements for these products, as specified by the relevant TSO, has been demonstrated.

10. With regard to the ramping rate modification test:

(a) the HVDC system shall demonstrate its technical capability to adjust the ramping rate according to Article 13(2);

(b) the test shall be carried out by relevant TSO sending instructions of ramping modifications;

(c) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) ramping rate is adjustable;

(ii) the HVDC system has demonstrated stable operation during ramping periods.

11. With regard to the black start test, if applicable:

(a) the HVDC system shall demonstrate its technical capability to energise the busbar of the remote AC substation to which it is connected, within a time frame specified by the relevant TSO, according to Article 37(2);

(b) the test shall be carried out while the HVDC system starts from shut down;

(c) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the HVDC system has demonstrated being able to energise the busbar of the remote AC-substation to which it is connected;

(ii) the HVDC system operates from a stable operating point at agreed capacity, according to the procedure of Article 37(3).

Article 72

Compliance testing for asynchronously connected power park modules, asynchronously connected demand facilities, asynchronously connected power-to-gas demand units, asynchronously connected electricity storage modules and remote-end HVDC converter units

1. Equipment certificates may be used instead of part of the tests below, on the condition that they are provided to the relevant system operator.

2. With regard to the reactive power capability test of A-PPMs and A-ESMs:

(a) the A-PPM and the A-ESM shall demonstrate its technical capability to provide leading and lagging reactive power capability according to Article 40(2);

(b) the reactive power capability test shall be carried out at maximum reactive power, both leading and lagging, and concerning the verification of the following parameters:

(i) operation in excess of 60 % of maximum capacity for 30 minutes;

(ii) operation within the range of 30-50 % of maximum capacity for 30 minutes; and

(iii) operation within the range of 10-20 % of maximum capacity for 60 minutes.

(c) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the A-PPM and the A-ESM has been operating no shorter than requested duration at maximum reactive power, both leading and lagging, in each parameter as referred to in point (b);

(ii) the A-PPM and the A-ESM has demonstrated its capability to change to any reactive power setpoint within the agreed or decided reactive power range within the specified performance targets of the relevant reactive power control scheme; and

(iii) no action of any protection within the operation limits specified by reactive power capacity diagram occurs.

3. With regard to the reactive power capability test of remote-end HVDC converter units:

(a) the HVDC converter unit or the HVDC converter station shall demonstrate its technical capability to provide leading and lagging reactive power capability according to Article 48(2);

(b) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the HVDC converter unit or the HVDC converter station has been operating no shorter than 1 hour at maximum reactive power, both leading and lagging, at:

— minimum HVDC active power transmission capacity;

— maximum HVDC active power transmission capacity; and

— an active power operating point between those maximum and minimum ranges.

(ii) the HVDC converter unit or the HVDC converter station demonstrates its capability to change to any reactive power setpoint within the agreed or decided reactive power range within the specified performance targets of the relevant reactive power control scheme; and

(iii) no action of any protection within the operation limits specified by reactive power capacity diagram occurs.

4. With regard to the voltage control mode test:

(a) the A-PPM and the A-ESM shall demonstrate its capability to operate in voltage control mode in the conditions set forth in Article 21 of RfG 2.0;

(b) the voltage control mode test shall apply concerning the verification of the following parameters:

(i) the implemented slope and deadband of the static characteristic;

(ii) the accuracy of the regulation;

(iii) the insensitivity of the regulation;

(iv) the time of reactive power activation.

(c) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the range of regulation and adjustable droop and deadband is compliant with agreed or decided characteristic parameters, according to Article 21(2)(d) of RfG 2.0;

(ii) the insensitivity of voltage control is not higher than 0,01 pu, according to Article 21(2)(d) of RfG 2.0;

(iii) following a step change in voltage, 90 % of the change in reactive power output has been achieved within the times and tolerances according to Article 21(2)(d) of RfG 2.0.

5. With regard to the reactive power control mode test:

(a) the A-PPM and the A-ESM shall demonstrate its capability to operate in reactive power control mode, according to the conditions referred to in Article 21(2)(d)(v) of RfG 2.0;

(b) the reactive power control mode test shall be complementary to the reactive power capability test;

(c) the reactive power control mode test shall apply concerning the verification of the following parameters:

(i) the reactive power setpoint range and step;

(ii) the accuracy of the regulation;

(iii) the time of reactive power activation.

(d) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the reactive power setpoint range and step is ensured according to Article 21(2)(d) of RfG 2.0;

(ii) the accuracy of the regulation is compliant with the conditions as referred to in Article 21(2)(d) of RfG 2.0.

6. With regard to the power factor control mode test:

(a) the A-PPM and the A-ESM shall demonstrate its capability to operate in power factor control mode according to the conditions referred to in Article 21(2)(d)(vi) of RfG 2.0;

(b) the power factor control mode test shall apply concerning the verification of the following parameters:

(i) the power factor setpoint range;

(ii) the accuracy of the regulation;

(iii) the response of reactive power due to step change of active power.

(c) the test shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the power factor setpoint range and step is ensured according to Article 21(2)(d) of RfG 2.0;

(ii) the time of reactive power activation as result of step active power change does not exceed the requirement according to Article 21(2)(d) of RfG 2.0;

(iii) the accuracy of the regulation is compliant with the value, as referred to in Article 21(2)(d) of RfG 2.0.

7. With regard to the tests identified in paragraphs 4, 5 and 6 the relevant TSO may select only two of the three control options for testing.

8. With regard to LFSM-O response of A-PPM and A-ESM, the tests shall be carried out in accordance with Article 47(3) of RfG 2.0.

9. With regard to LFSM-U response of A-PPM, the tests shall be carried out in accordance with Article 48(3) of RfG 2.0. With regard to limited frequency sensitive mode – underfrequency – electricity storage module (LFSM-U-ESM) response of A-ESM, the tests shall be carried out in accordance with Article 47(3) of RfG 2.0.

10. With regard to active power controllability of A-PPM and A-ESM, the tests shall be carried out in accordance with 48(2) of RfG 2.0.

11. With regard to FSM response of A-PPM and A-ESM, the tests shall be carried out in accordance with Article 48(4) ofRfG 2.0.

12. With regard to frequency restoration control of A-PPM and A-ESM, the tests shall be carried out in accordance with Article 45(4) of RfG 2.0.

13. With regard to fast signal response of A-PPM, A-PtG-DU and A-ESM, the test shall be deemed passed if the A-PPM, the A-PtG-DU or the A-ESM can demonstrate its response within the time specified in Article 39(1)(a).

14. With regard to tests for A-PPMs, A-DFs and A-ESMs where the AC collection network is not at nominal 50 Hz frequency, the relevant system operator, in coordination with the relevant TSO, shall agree with the A-PPM owner, the A-DF owner and the A-ESM owner the compliance tests required.

15. With regard to LFSM-UC of an A-PtG-DU, the A-PtG-DU owner shall demonstrate its technical capability to provide LFSM-UC according to the conditions of Article 39(8). The following requirements with regard to the test shall apply:

(a) the A-PtG-DU technical capability to continuously modulate active power to contribute to frequency control in case of any large increase of frequency in the system shall be demonstrated. The steady-state parameters of regulations, such as droop and deadband, and dynamic parameters, including frequency step change response shall be verified;

(b) the test shall be carried out by simulating frequency steps and ramps big enough to trigger at least 10 % of maximum capacity change in active power, taking into account the droop settings and the deadband. If required, simulated frequency deviation signals shall be injected simultaneously at both the speed governor and load controller of the control systems, taking into account the scheme of those control systems;

(c) the test shall be deemed successful if the following conditions are fulfilled:

(i) the test results, for both dynamic and static parameters, meet the requirements set out in Article 39(8) and

(ii) undamped oscillations do not occur after the step change response.

CHAPTER 3

Compliance simulations

Article 73

Compliance simulations for HVDC systems

1. Equipment certificates may be used instead of part of the simulations below, on the condition that they are provided to the relevant system operator.

2. With regard to the fast fault current injection simulation:

(a) the HVDC converter unit owner or the HVDC converter station owner shall simulate fast fault current injection in the conditions set forth in Article 19;

(b) the simulation is deemed passed, provided that compliance with the requirements specified in accordance with Article 19 is demonstrated.

3. With regard to the fault-ride-through capability simulation:

(a) the HVDC system owner shall simulate the capability for fault-ride-through in the conditions set forth in Article 25; and

(b) the simulation is deemed passed, provided that compliance with the requirements specified in accordance with Article 25 is demonstrated.

4. With regard to the post fault active power recovery simulation:

(a) the HVDC system owner shall simulate the capability for post fault active power recovery in the conditions set forth in Article 26;

(b) the simulation is deemed passed, provided that compliance with the requirements specified in accordance with Article 26 is demonstrated.

5. With regard to the reactive power capability simulation:

(a) the HVDC converter unit owner or the HVDC converter station owner shall simulate the capability for leading and lagging reactive power capability in the conditions referred to in Article 20(2) to (4);

(b) the simulation shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the simulation model of the HVDC converter unit or the HVDC converter station is validated against the compliance tests for reactive power capability as referred to in Article 71;

(ii) compliance with the requirements as referred to in Article 20(2) to (4) is demonstrated.

6. With regard to the power oscillations damping control simulation:

(a) the HVDC system owner shall demonstrate the performance of its control system (POD function) to damp power oscillations in the conditions set forth in Article 30;

(b) the tuning shall result in improved damping of corresponding active power response of the HVDC system in combination with the POD function compared to the active power response of the HVDC system without POD;

(c) the simulation shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the POD function damps the existing power oscillations of the HVDC system within a frequency range specified by the relevant TSO. This frequency range shall include the local mode frequency of the HVDC system and the expected network oscillations; and

(ii) a change of active power transfer of the HVDC system as specified by the relevant TSO does not lead to undamped oscillations in active or reactive power of the HVDC system.

7. With regard to the simulation of active power modification in case of disturbance:

(a) the HVDC system owner shall simulate the capability to quickly modify active power according to Article 13(1)(b); and

(b) the simulation shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the HVDC system has demonstrated stable operation when following the pre-specified sequence of active power variation;

(ii) the initial delay of the adjustment of the active power is shorter than the value specified in Article 13(1)(b) or reasonably justified if greater.

8. With regard to the fast active power reversal simulation, as applicable:

(a) the HVDC system owner shall simulate the capability to quickly reverse active power according to Article 13(1)(c);

(b) the simulation shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the HVDC system has demonstrated stable operation;

(ii) the time of adjustment of the active power is shorter than the value specified in Article 13(1)(c) or reasonably justified if greater.

9. With regard to the grid forming capability simulation:

(a) the HVDC system owner shall simulate its technical capability to provide grid forming capability according to Article 14, if applicable;

(b) in case that Article 47(5) is applicable, the remote-end HVDC converter station owner shall simulate its capability to modulate the isolated AC network frequency and voltage phase angle;

(c) the simulation shall be deemed passed, provided that compliance with the requirements specified in accordance with Article 14 is demonstrated.

10. With regard to fast frequency control capability simulation:

(a) the HVDC system shall demonstrate its technical capability to provide fast frequency control according to Article 14b;

(b) the simulation shall be deemed passed, provided that compliance with the requirements specified in accordance with Article 14b is demonstrated.

11. With regard to the rate-of-change-of-frequency simulation:

(a) the HVDC system shall demonstrate its technical capability to provide rate-of-change-of-frequency immunity according to Article 12;

(b) the simulation shall be deemed passed, provided that compliance with the requirements specified in accordance with Article 12 is demonstrated.

12. With regard to the fast recovery from DC faults:

(a) the HVDC system owner shall simulate the capability of the HVDC system to fast recover from transient faults within the HVDC system (including DC network) according to Article 27;

(b) the simulation shall be deemed passed, provided that compliance with the requirements specified in accordance with Article 12 is demonstrated.

13. With regard to the voltage phase angle jump capability simulation:

(a) the HVDC system shall demonstrate its technical capability to provide voltage phase angle jump immunity according to Article 12b.

(b) the simulation shall be deemed passed, provided that compliance with the requirements specified in accordance with Article 12b is demonstrated.

14. With regard to HVDC system passivity simulation:

(a) the HVDC system shall simulate its technical capability to provide passivity according to Article 30a.

(b) The simulation shall be deemed passed, provided that compliance with the requirements specified in accordance with Article 30a is demonstrated.

Article 74

Compliance simulations for asynchronously connected power park modules, asynchronously connected electricity storage modules, asynchronously connected power-to-gas demand units and remote-end HVDC converter units

1. A-PPMs and A-ESMs are subject to the compliance simulations detailed in this Article. Equipment certificates may be used instead of part of the simulations described below, on the condition that they are provided to the relevant system operator.

2. With regard to the fast fault current injection simulation:

(a) the A-PPM owner and the A-ESM owner shall simulate the capability for fast fault current injection in the conditions set forth in Article 20(2)(b) of RfG 2.0; and

(b) the simulation shall be deemed passed, provided that compliance with the requirement according to Article 20(2)(b) of RfG 2.0 is demonstrated.

3. With regard to the post fault active power recovery simulation:

(a) the A-PPM owner and the A-ESM owner shall simulate the capability for post fault active power recovery in the conditions set forth in Article 20(3)(a) of RfG 2.0; and

(b) the simulation shall be deemed passed, provided that compliance with the requirement according to Article 20(3)(a) of RfG 2.0 is demonstrated.

4. With regard to the reactive power capability simulation of A-PPMs and A-ESMs:

(a) the A-PPM owner and the A-ESM owner shall simulate the capability for leading and lagging reactive power capability in the conditions referred to in Article 40(2); and

(b) the simulation shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the simulation model of the A-PPM and the A-ESM is validated against the compliance tests for reactive power capability as referred to in Article 72(2);

(ii) compliance with the requirements as referred to in Article 40(2) is demonstrated.

5. With regard to the reactive power capability simulation of remote-end HVDC converter units:

(a) the remote-end HVDC converter unit owner or the remote-end HVDC converter station owner shall simulate the capability for leading and lagging reactive power capability in the conditions referred to in Article 48(2); and

(b) the simulation shall be deemed passed, provided that the following conditions are cumulatively fulfilled:

(i) the simulation model of the remote-end HVDC converter unit or the remote-end HVDC converter station is validated against the compliance tests for reactive power capability at the as referred to in Article 72(3);

(ii) compliance with the requirements as referred to in Article 48(2) is demonstrated.

6. With regard to the power oscillations damping control simulation:

(a) the A-PPM owner and the A-ESM owner shall simulate the capability for power oscillations damping under the conditions as referred to in Article 21(2)(f) of RfG 2.0; and

(b) the simulation shall be deemed passed, provided that the model demonstrates compliance with the conditions of Article 21(2)(f) of RfG 2.0.

7. With regard to fault-ride-through capability simulation of an A-PPM and A-ESM:

(a) the A-PPM owner and the A-ESM owner shall simulate the capability for fault-ride-through under the conditions as referred to in Article 16(3)(a) of RfG 2.0;

(b) the simulation shall be deemed passed, provided that the model demonstrates compliance with the conditions of Article 16(3)(a) of RfG 2.0.

8. With regard to the post fault active power recovery simulation of an A-PtG-DU:

(a) the A-PtG-DU owner shall simulate the capability for post fault active power recovery in the conditions set forth in Article 40a(c);

(b) the simulation shall be deemed passed, provided that compliance with the requirement according to Article 40a(c) is demonstrated.

9. With regard to fault-ride-through capability simulation of an A-PtG-DU:

(a) the A-PtG-DU owner shall simulate the capability for fault-ride-through under the conditions as referred to in Article 40a;

(b) the simulation shall be deemed passed, provided that compliance with the requirement according to Article 40a is demonstrated.

10. With regard to grid forming capability of an A-PPM and A-ESM:

(a) the A-PPM and the A-ESM shall simulate its technical capability to provide grid forming control according to the conditions of Article 22 of RfG 2.0, and if applicable Article 40b;

(b) the simulation shall be deemed passed, provided that compliance with the requirement according to Article 22 of RfG 2.0 and if applicable Article 40b is demonstrated.

CHAPTER 4

Non-binding guidance and monitoring of implementation

Article 75

Non-binding guidance on implementation

1. No later than six months after the entry into force of this Regulation, the ENTSO for Electricity shall prepare and thereafter every two years provide non-binding written guidance to its members and other system operators concerning the elements of this Regulation requiring national decisions. The ENTSO for Electricity shall publish this guidance on its website.

2. ENTSO for Electricity shall consult stakeholders when providing non-binding guidance.

3. The non-binding guidance shall explain the technical issues, conditions and interdependencies which need to be considered when complying with the requirements of this Regulation at national level.

Article 76

Monitoring

1. ACER shall monitor the implementation of this Regulation in accordance with Article 32(1) of Regulation (EU) 2019/943. Monitoring shall cover in particular the following matters:

(a) identification of any divergences in the national implementation of this Regulation;

(b) assessment of whether the choice of values and ranges in the requirements applicable to HVDC systems, A-PPMs, A-DFs, A-PtG-DUs and A-ESMs under this Regulation continues to be valid.

ACER shall involve the European Stakeholder Committee in the monitoring, where relevant.

2. ACER, in cooperation with ENTSO for Electricity, shall maintain a list of the relevant information to be communicated by ENTSO for Electricity to ACER in accordance with Articles 30(5) and 32(1) of Regulation (EU) 2019/943. The list of relevant information may be subject to updates and shall be in line with the information contained in the implementation monitoring files to be published in accordance with paragraph 3. ENTSO for Electricity shall maintain a comprehensive, standardised format, digital data archive of the information required by ACER.

3. Relevant TSOs shall submit to ENTSO for Electricity the information required for ACER to perform the tasks referred to in paragraphs 1 and 2.

TSOs shall ensure that the information is provided without undue delay and is up to date.

The EU DSO entity shall cooperate with ENTSO for Electricity on the monitoring of implementation of this Regulation in accordance with Article 55(2)(a) of Regulation (EU) 2019/943, among other activities, on the provision of information necessary for monitoring the implementation of this Regulation.

Based on a request of the regulatory authority, DSOs shall provide TSOs with information under paragraph 2 unless the information has already been obtained by the regulatory authorities, ACER or the ENTSO for Electricity in relation to their respective implementation monitoring tasks, with the objective of avoiding duplication of information. DSOs shall ensure that the information is provided without undue delay and is up to date.

ACER, in cooperation with ENTSO for Electricity, shall maintain a public online repository where relevant national information regarding the progress of implementation of this Regulation shall be made available. The information to be made available shall 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.

4. Where ENTSO for Electricity or ACER identify areas in which, based on market developments or experience gathered in the application of this Regulation, further harmonisation of the requirements under this Regulation is advisable to promote market integration, they shall propose draft amendments to this Regulation pursuant to Article 60(2) of Regulation (EU) 2019/943.

TITLE VII

DEROGATIONS

Article 77

Power to grant derogations

1. Regulatory authorities may, at the request of a HVDC system owner, an A-PPM owner, an A-DF owner, an A-PtG-DU owner or an A-ESM owner, or their prospective owner, relevant system operator or relevant TSO, grant HVDC system owners, A-PPM owners, A-DF owners, A-PtG-DU owners or A-ESM owners, or their prospective owner, relevant system operators or relevant TSOs derogations from one or more provisions of this Regulation for new and existing HVDC system and/or A-PPMs, A-DFs, A-PtG-DUs and/or A-ESMs in accordance with Article 78, Article 79, Article 80, Article 81 and Article 82.

2. Where applicable in a Member State, derogations may be granted and revoked in accordance with Article 78, Article 79, Article 80 and Article 81 by other authorities than the regulatory authority.

Article 78

General provisions

1. Each regulatory authority shall specify, after consulting relevant system operators, HVDC system owners, A-PPM owners, A-DF owners and A-ESM owners and other stakeholders whom it deems affected by this Regulation, the criteria for granting derogations pursuant to Article 79, Article 80 and Article 81. It shall publish those criteria on its website and notify them to the Commission within nine months of the entry into force of this Regulation. The Commission may require a regulatory authority to amend the criteria if it considers that they are not in line with this Regulation. This possibility to review and amend the criteria for granting derogations shall not affect the derogations already granted which shall continue to apply until the scheduled expiry date as detailed in the decision granting the exemption.

2. If the regulatory authority deems that it is necessary due to a change in circumstances relating to the evolution of system requirements, it may review and amend at most once every year the criteria for granting derogations in accordance with paragraph 1. Any changes to the criteria shall not apply to derogations for which a request has already been made.

3. The regulatory authority may decide that HVDC systems, A-PPMs, A-DFs or A-ESMs for which a request for a derogation has been filed pursuant to Article 79, Article 80 and Article 81 do not need to comply with the requirements of this Regulation from which a derogation has been sought from the day of filing the request until the regulatory authority's decision is issued.

Article 79

Request for derogations by an HVDC system owner, asynchronously connected power park module owner, asynchronously connected demand facility owner or asynchronously connected electricity storage module owner

1. HVDC system owners, A-PPM owners, A-DF owners and A-ESM owners, or their prospective owner, may request a derogation to one or several requirements of this Regulation.

2. A request for a derogation shall be filed with the relevant system operator and include:

(a) an identification of the HVDC system owner, A-PPM owner, A-DF owner or A-ESM owner, or their prospective owner, and a contact person for any communications;

(b) a description of the HVDC system, A-PPM, A-DF or A-ESM for which a derogation is requested;

(c) a reference to the provisions of this Regulation from which a derogation is requested and a detailed description of the requested derogation;

(d) detailed reasoning, with relevant supporting documents, and cost-benefit analysis pursuant to the requirements of Article 66;

(e) demonstration that the requested derogation would have no adverse effect on cross-border trade;

(f) in the case of an A-PPM, an A-DF or an A-ESM connected to one or more remote-end HVDC converter stations, evidence that the converter station will not be affected by the derogation or, alternatively, agreement from the converter station owner to the proposed derogation.

3. Within two weeks of receipt of a request for a derogation, the relevant system operator shall confirm to the HVDC system owner, A-PPM owner, A-DF owner or A-ESM owner, or their prospective owner, whether the request is complete. If the relevant system operator considers that the request is incomplete, the HVDC system owner, A-PPM owner, A-DF owner or A-ESM owner, or their prospective owner, shall submit the additional required information within one month from the receipt of the request for additional information. If the HVDC system owner, A-PPM owner, A-DF owner or A-ESM owner, or their prospective owner, does not supply the requested information within that time limit, the request for a derogation shall be deemed withdrawn.

4. The relevant system operator shall, in coordination with the relevant TSO and any affected adjacent DSO or DSOs, assess the request for a derogation and the provided cost-benefit analysis, taking into account the criteria determined by the regulatory authority pursuant to Article 78.

5. If a request for a derogation concerns a HVDC system, A-PPM, A-DF or A-ESM connected to a distribution system, including a closed distribution system, the relevant system operator's assessment shall be accompanied by an assessment of the request for a derogation by the relevant TSO. The relevant TSO shall provide its assessment within two months of being requested to do so by the relevant system operator.

6. Within six months of receipt of a request for a derogation, the relevant system operator shall forward the request to the regulatory authority and submit the assessment(s) prepared in accordance with paragraphs 4 and 5. That period may be extended by one month where the relevant system operator seeks further information from the HVDC system owner, A-PPM owner, A-DF owner or A-ESM owner, or their prospective owner, and by two months where the relevant system operator requests the relevant TSO to submit an assessment of the request for a derogation.

7. The regulatory authority shall adopt a decision concerning any request for a derogation within six months from the day after it receives the request. That time limit may be extended by three months before its expiry where the regulatory authority requires further information from the HVDC system owner, A-PPM owner, A-DF owner or A-ESM owner, or their prospective owner, or from any other interested parties. The additional period shall begin when the complete information has been received.

8. The HVDC system owner, A-PPM owner, A-DF owner or A-ESM owner, or their prospective owner, shall submit any additional information requested by the regulatory authority within two months of such request. If the HVDC system owner, A-PPM owner, A-DF owner or A-ESM owner, or the prospective owner, does not supply the requested information within that time limit, the request for a derogation shall be deemed withdrawn unless, before its expiry:

(a) the regulatory authority decides to provide an extension; or

(b) the HVDC system owner, A-PPM owner, A-DF owner or A-ESM owner, or their prospective owner, informs the regulatory authority by means of a reasoned submission that the request for a derogation is complete.

9. The regulatory authority shall issue a reasoned decision concerning a request for a derogation. Where the regulatory authority grants a derogation, it shall specify its duration.

10. The regulatory authority shall notify its decision to the HVDC system owner, A-PPM owner, A-DF owner or A-ESM owner, or their prospective owner, the relevant system operator and the relevant TSO.

11. A regulatory authority may revoke a decision granting a derogation if the circumstances and underlying reasons no longer apply or upon a reasoned

recommendation of the Commission or reasoned recommendation by ACER pursuant to Article 83(2).

Article 80

Request for a derogation by a relevant system operator or relevant TSO

1. Relevant system operators or relevant TSOs may request a derogation for classes of HVDC systems, A-PPMs, A-DFs or A-ESMs connected or to be connected to their network.

2. Relevant system operators or relevant TSOs shall submit their requests for a derogation to the regulatory authority. Each request for a derogation shall include:

(a) identification of the relevant system operator or relevant TSO, and a contact person for any communications;

(b) a description of the HVDC systems, A-PPMs, A-DFs or A-ESMs for which a derogation is requested and the total installed capacity and number of HVDC systems, A-PPMs, A-DFs or A-ESMs;

(c) the requirement or requirements of this Regulation for which a derogation is requested, with a detailed description of the requested derogation;

(d) detailed reasoning, with all relevant supporting documents;

(e) demonstration that the requested derogation would have no adverse effect on cross-border trade;

(f) a cost-benefit analysis pursuant to the requirements of Article 66. If applicable, the cost-benefit analysis shall be carried out in coordination with the relevant TSO and any adjacent DSOs.

3. Where the request for a derogation is submitted by a relevant DSO or CDSO, the regulatory authority shall, within two weeks from the day after receipt of that request, ask the relevant TSO to assess the request for a derogation in the light of the criteria determined by the regulatory authority pursuant to Article 78.

4. Within two weeks from the day after the receipt of such request for assessment, the relevant TSO shall confirm to the relevant DSO or CDSO whether the request for a derogation is complete. If the relevant TSO considers that it is incomplete, the relevant DSO or CDSO shall submit the required additional information within one month from the receipt of the request for additional information.

5. Within six months of receipt of a request for a derogation, the relevant TSO shall submit to the regulatory authority its assessment, including any relevant documentation. The six-month time limit may be extended by one month where the relevant TSO seeks further information from the relevant DSO or from the relevant CDSO.

6. The regulatory authority shall adopt a decision concerning a request for a derogation within six months from the day after it receives the request. Where the request for a derogation is submitted by the relevant DSO or CDSO, the six- month time limit runs from the day following receipt of the relevant TSO's assessment pursuant to paragraph 5.

7. The six-month time limit referred to in paragraph 6 may, before its expiry, be extended by an additional three months where the regulatory authority requests further information from the relevant system operator requesting the derogation or from any other interested parties. That additional period shall run from the day following the date of receipt of the complete information.

The relevant system operator shall provide any additional information requested by the regulatory authority within two months from the date of the request. If the relevant system operator does not provide the requested additional information within that time limit, the request for a derogation shall be deemed withdrawn unless, before expiry of the time limit:

(a) the regulatory authority decides to provide an extension; or

(b) the relevant system operator informs the regulatory authority by means of a reasoned submission that the request for a derogation is complete.

8. The regulatory authority shall issue a reasoned decision concerning a request for a derogation. Where the regulatory authority grants a derogation, it shall specify its duration.

9. The regulatory authority shall notify its decision to the relevant system operator requesting the derogation, the relevant TSO and ACER.

10. Regulatory authorities may lay down further requirements concerning the preparation of requests for derogations by relevant system operators. In doing so, regulatory authorities shall take into account the delineation between the transmission system and the distribution system at the national level and shall consult with system operators, HVDC system owners, A-PPM owners, A-DF owners, A-ESM owners and stakeholders, including manufacturers.

11. A regulatory authority may revoke a decision granting a derogation if the circumstances and underlying reasons no longer apply or upon a reasoned recommendation of the Commission or reasoned recommendation by ACER pursuant to Article 83(2).

Article 81

Request for derogations from the provisions of Title III by an asynchronously connected power park module owner, asynchronously connected demand facility owner or asynchronously connected electricity storage module owner

1. A request for a derogation to the provisions of Article 40(1)(b) and (c), Article 40(2)(a) and (b), and Article 41, Article 42, Article 43, Article 44 and Article 45 shall not be subject to Article 79(2)(d) and (e) where it relates to an A-PPM, A-DF or A-ESM that has, or will have, a single connection to a single synchronous area.

2. The regulatory authority may attach any conditions to a decision concerning request for a derogation referred to in paragraph 1. This may include a condition that the development of the connection into a multi-terminal network, or that connection of a further power park module at the same point, will cause the derogation to be evaluated by the regulatory authority or to expire. The regulatory authority shall take into account the need to optimise the configuration between the A-PPM, A-DF or A-ESM and the remote-end HVDC converter station, as well as the legitimate expectations of the A-PPM owner, A-DF owner or A-ESM owner when adopting a decision concerning a request for a derogation.

Article 82

Register of derogations from the requirements of this Regulation

1. Regulatory authorities shall maintain a register of all derogations they have granted or refused and shall provide ACER with an updated and consolidated register at least once every six months. This register shall be publicly available.

2. The register shall contain, in particular:

(a) the requirement or requirements for which the derogation is granted or refused;

(b) the content of the derogation;

(c) the reasons for granting or refusing the derogation;

(d) the consequences resulting from granting the derogation.

Article 83

Monitoring of derogations

1. ACER shall monitor the procedure of granting derogations with the cooperation of the regulatory authorities or relevant authorities of the Member State. Those authorities or relevant authorities of the Member State shall provide ACER with all the information necessary for that purpose.

2. ACER may issue a reasoned recommendation to a regulatory authority to revoke a derogation due to a lack of justification. The Commission may issue a reasoned recommendation to a regulatory authority or relevant authority of the Member State to revoke a derogation due to a lack of justification.

3. The Commission may request ACER to report on the application of paragraphs 1 and 2 and to provide reasons for requesting or not requesting derogations to be revoked.

TITLE VIII

FINAL PROVISIONS

Article 84

Amendment of contracts and general terms and conditions

1. Regulatory authorities shall ensure that all relevant clauses in contracts and general terms and conditions relating to the grid connection of new HVDC systems, new A-PPMs, new A-DFs, new A-PtG-DUs or new A-ESMs are brought into compliance with the requirements of this Regulation.

2. All relevant clauses in contracts and relevant clauses of general terms and conditions relating to the grid connection of existing HVDC systems, existing A-PPMs, existing A-DFs, existing A-PtG-DUs or existing A-ESMs subject to all or some of the requirements of this Regulation in accordance with paragraph 1 of Article 4 shall be amended in order to comply with the requirements of this Regulation. The relevant clauses shall be amended within three years following the decision of the regulatory authority or Member State as referred to in Article 4(1).

3. Regulatory authorities shall ensure that national agreements between system operators and owners of new or existing HVDC systems, A-PPMs, A-DFs, A-PtG-DUs and A-ESMs subject to this Regulation and relating to grid connection requirements for HVDC systems, A-PPMs, A-DFs, A-PtG-DUs and A-ESMs, in particular in national network codes, reflect the requirements set out in this Regulation.

Article 85

HVDC System, asynchronously connected power park modules, asynchronously connected demand facilities or asynchronously connected electricity storage modules connecting with synchronous areas or control areas not bound by EU legislation

1. Where an HVDC system to which the requirements of this Regulation apply is connecting synchronous areas or control areas, with at least one synchronous area or one control area not falling under the scope of application of Union legislation, the relevant TSO or, where applicable, the HVDC system owner shall endeavour to implement an agreement to ensure that the owners of HVDC systems with no legal obligation to comply with this Regulation also cooperate to fulfil the requirements.

2. If an agreement as referred to in paragraph 1 cannot be implemented, the relevant TSO or, as the case may be, the HVDC system owner concerned shall use all available means to comply with the requirements of this Regulation.

Article 85a

Repeal

1. Regulation (EU) 2016/1447 is repealed. References to the repealed Regulation shall be construed as references to this Regulation and shall be read in accordance with the correlation table set out in Annex [].

2. Notwithstanding paragraph 1, Regulation (EU) 2016/1447 shall continue to apply to HVDC systems and A-PPMs which fall within its scope of application at the entry into force of this Regulation and which are not subject to the requirements of this Regulation according to Article 4(1).

Article 86

Entry into force

This Regulation shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

Without prejudice to Article 4(2)(b) and Article 5, Article 75, Article 76 and Article 78 the requirements of this Regulation shall apply from three years after publication.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels,.

For the Commission

The President

ANNEX I

Frequency ranges referred to in Article 11

Frequency range	Time period for operation
47,0 Hz-47,5 Hz	60 seconds
47,5 Hz-48,5 Hz	To be specified by each relevant TSO, but longer than established times for generation and demand according to RfG 2.0 and DC 2.0 respectively, and longer than for A-PPMs, A-PtG-DUs, A-ESMs and A-DFs according to Article 39
48,5 Hz-49,0 Hz	To be specified by each relevant TSO, but longer than established times for generation and demand according to RfG 2.0 and DC 2.0 respectively, and longer than for A-PPMs, A-PtG-DUs, A-ESMs and A-DFs according to Article 39
49,0 Hz-51,0 Hz	Unlimited
51,0 Hz-51,5 Hz	To be specified by each relevant TSO, but longer than established times for generation and demand according to RfG 2.0 and DC 2.0 respectively, and longer than for A-PPMs, A-PtG-DUs, A-ESMs and A-DFs according to Article 39
51,5 Hz-52,5 Hz	To be specified by each relevant TSO, but longer than for A-PPMs, A-PtG-DUs, A-ESMs and A-DFs according to Article 39

Table 1: Minimum time periods an HVDC system shall be able to operate for different frequencies deviating from a nominal value without disconnecting from the network.

ANNEX II

Requirements applying to frequency sensitive mode, limited frequency sensitive mode overfrequency and limited frequency sensitive mode underfrequency

A. Frequency sensitive mode

1. When operating in frequency sensitive mode (FSM):

(a) the HVDC system shall be capable of responding to frequency deviations in each connected AC network by adjusting the active power transmission as indicated in Figure 1 and in accordance with the parameters specified by each TSO within the ranges shown in Table 2. This specification shall be subject to notification to the regulatory authority. The modalities of that notification shall be determined in accordance with the applicable national regulatory framework;

(b) the adjustment of active power frequency response shall be limited by the minimum HVDC active power transmission capacity and maximum HVDC active power transmission capacity of the HVDC system (in each direction);

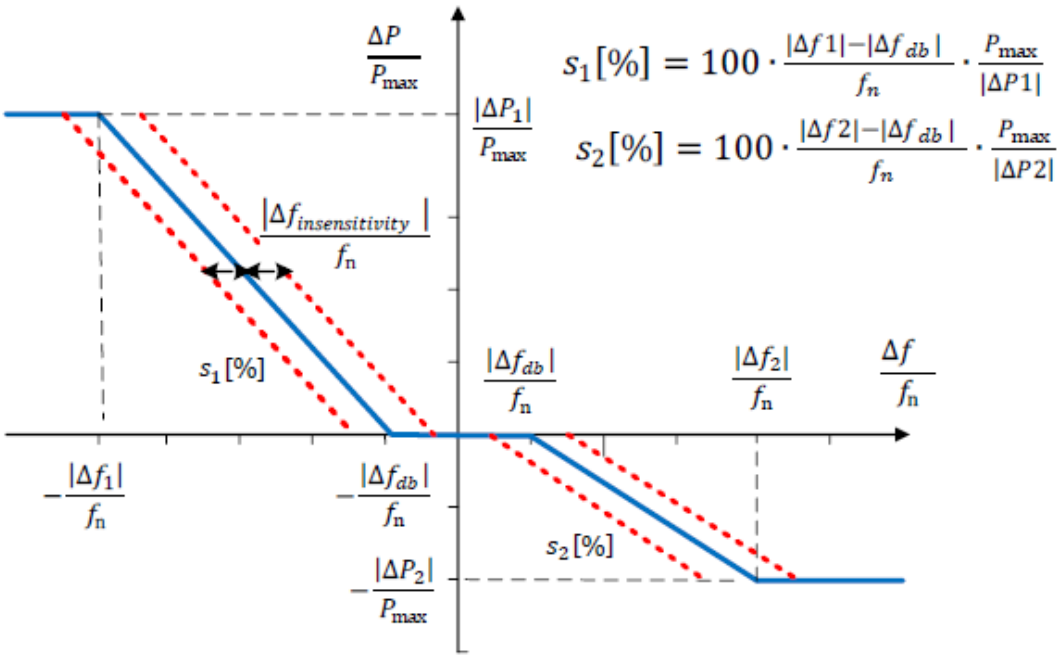

Figure 1: Active power frequency response capability of an HVDC system in FSM illustrating the case with deadband and insensitivity. In this figure, ΔP is the active power change by an HVDC system with the network at its connection point based on its actual operating point, P_{max} is maximum transmission capacity of the HVDC system, f_n is the target frequency in the AC network where the FSM service is provided, Δf is the frequency deviation in the AC network where the FSM service is provided, ΔP1 is the agreed power change for the FSM at reaching the frequency threshold value Δf1, ΔP2 is the agreed power change at reaching the frequency threshold value Δf2, Δf_{db} is the deadband of the power frequency response, $\Delta f_{insensitivity}$ is the frequency response insensitivity (or else the permissible tolerance allowed), s1 is the droop value for the given ΔP1 and s2 is the droop for the given ΔP2.

Parameters	Ranges
Deadband of the FSM, Δf_{db}	0-±500 mHz
Range of the droop s_1	≥0,1 %
Range of the droop s_2	≥0,1 %
Frequency response insensitivity, $\Delta f_{insensitivity}$	≤30 mHz

Table 2: Parameters for active power frequency response in FSM (range values of the Figure 1)

(c) the HVDC system shall be capable, following an instruction from the relevant TSO, of adjusting the droops for upward and downward regulation, the frequency response deadband and the operational range of variation within the active power range available for FSM, set out in Figure 1 and more generally within the limits set by points (a) and (b). These values shall be subject to notification to the regulatory authority. The modalities of that notification shall be determined in accordance with the applicable national regulatory framework;

(d) as a result of a frequency step change, the HVDC system shall be capable of adjusting active power to the active power frequency response defined in Figure 1, in such a way that the response is:

(i) as fast as inherently technically feasible; and

(ii) at or above the solid line according to Figure 2 in accordance with the parameters specified by each relevant TSO within the ranges according to Table 3:

— the HVDC system shall be able to adjust active power output ΔP up to the limit of the active power range requested by the relevant TSO in accordance with the times t_1 and t_2 according to the ranges in Table 3, where t_1 is the initial delay and t_2 is the time for full activation. The value of t_2 shall be specified by the relevant TSO;

— the initial activation of active power frequency response (the value of t_1) required shall be as short as possible; if the initial delay of activation is greater than 0,5 seconds, the HVDC system owner shall reasonably justify it to the relevant TSO.

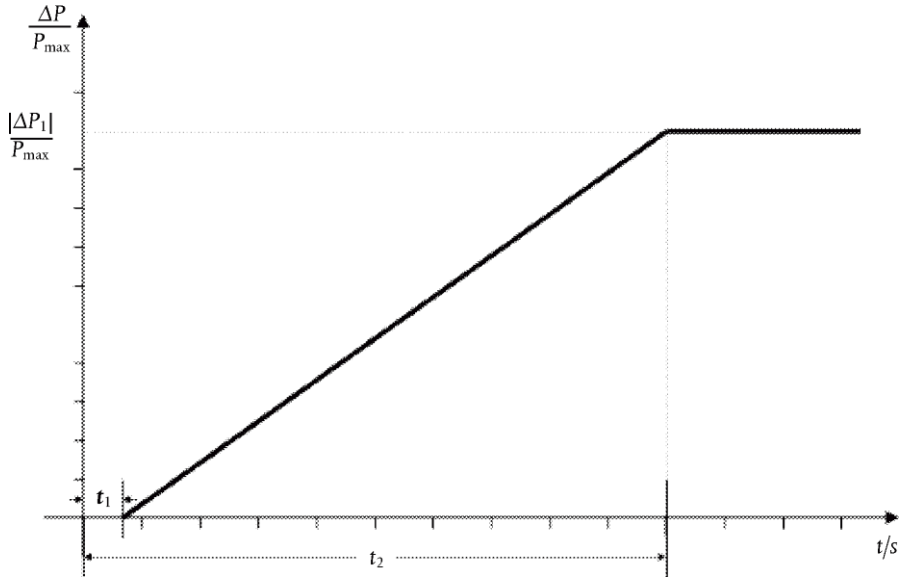

Figure 2: Active power frequency response capability of an HVDC system. ΔP is the change in active power triggered by the step change in frequency.

Parameters	Time
Maximum admissible initial delay t_1	0,5 seconds
Maximum admissible time for full activation t_2, unless longer activation times are specified by the relevant TSO	30 seconds

Table 3: Parameters for full activation of active power frequency response resulting from frequency step change.

(e) for HVDC systems linking various control areas or synchronous areas, in frequency sensitive mode operation the HVDC system shall be capable of adjusting full active power frequency response at any time and for a continuous time period;

(f) as long as a frequency deviation continues active power control shall not have any adverse impact on the active power frequency response.

B. Limited frequency sensitive mode overfrequency

1. In addition to the requirements of Article 11 the following shall apply with regard to limited frequency sensitive mode — overfrequency (LFSM-O):

(a) the HVDC system shall be capable of adjusting active power frequency response to the AC network or networks, during both import and export, according to Figure 3 at a frequency threshold f_1 adjustable between and including 50,2 Hz and 50,5 Hz with a droop S_3 adjustable from 0,1 % upwards; the default frequency threshold f_1 shall be 50 Hz + Δf_1, where Δf_1 is defined in Table X.

Synchronous area	Δf_1 and Δf_2 thresholds
Continental Europe	0,2 Hz
Nordic	0,5 Hz
Ireland	0,2 Hz (for LFSM-O and FSM), 0,5 Hz (LFSM-U)
Baltic	0,2 Hz

Table X: Definition of Δf_1, Δf_2 used for LFSM-O and LFSM-U

(b) the HVDC system shall be capable of adjusting active power down to its minimum HVDC active power transmission capacity;

(c) the HVDC system shall be capable of adjusting active power frequency response as fast as inherently technically feasible, with an initial delay and time for full activation determined by the relevant TSO and notified to the regulatory authority in accordance with the applicable national regulatory framework;

(d) the HVDC system shall be capable of stable operation during LFSM-O operation. When LFSM-O is active, hierarchy of control functions shall be organised in accordance with Article 35.

2. The frequency threshold and droop settings referred to in point (a) of paragraph 1 shall be determined by the relevant TSO and be notified to the regulatory authority in accordance with the applicable national regulatory framework.

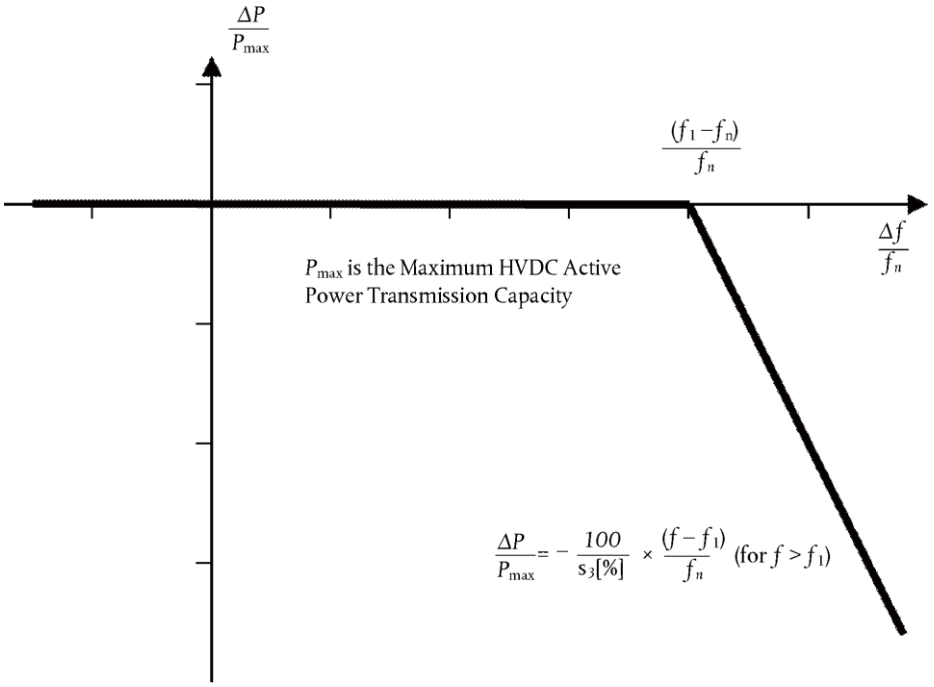

Figure 3: Active power frequency response capability of HVDC systems in LFSM-O. ΔP is the change in active power output from the HVDC system and, depending on the operational conditions, either a decrease of import power or an increase of export power. f_n is the nominal frequency of the AC network or networks the HVDC system is connected to and Δf is the frequency change in the AC network or networks the HVDC is connected

to. At overfrequencies where f is above f_1 the HVDC system shall reduce active power according to the droop setting.

C. Limited frequency sensitive mode underfrequency

1. In addition to the requirements of Article 11, the following shall apply with regard to limited frequency sensitive mode — underfrequency (LFSM-U):

   (a) the HVDC system shall be capable of adjusting active power frequency response to the AC network or networks, during both import and export, according to Figure 4 at a frequency threshold f2 adjustable between and including 49,8 Hz and 49,5 Hz with a droop S4 adjustable from 0,1 % upwards; the default frequency threshold f2 shall be 50 Hz – Δf2, where Δf2 is defined in Table X;

   (b) in the LFSM-U mode the HVDC system shall be capable of adjusting active power up to its maximum HVDC active power transmission capacity;

   (c) the active power frequency response shall be activated as fast as inherently technically feasible, with an initial delay and time for full activation determined by the relevant TSO and notified to regulatory authority in accordance with the applicable national regulatory framework;

   (d) the HVDC system shall be capable of stable operation during LFSM-U operation. When LFSM-U is active, hierarchy of control functions shall be organised in accordance with Article 35.

2. The frequency threshold and droop settings referred to in point (a) of paragraph 1 shall be determined by the relevant TSO and be notified to the regulatory authority in accordance with the applicable national regulatory framework.

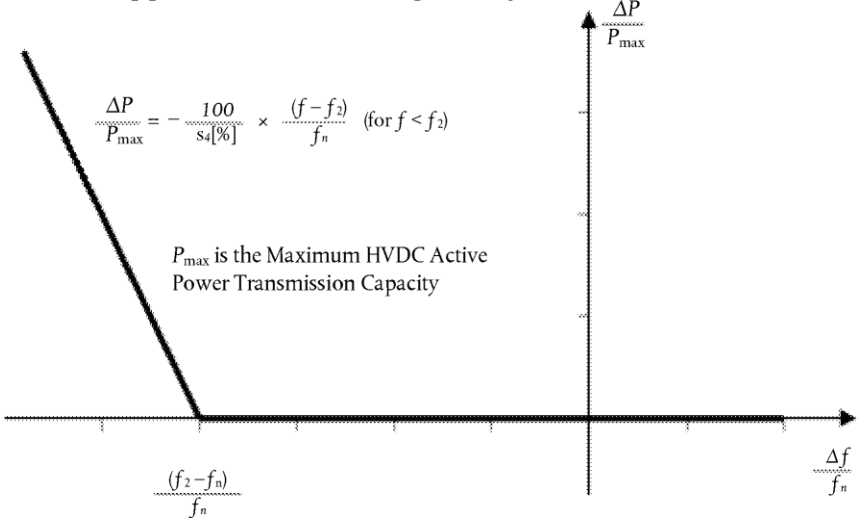

Figure 4: Active power frequency response capability of HVDC systems in LFSM-U. ΔP is the change in active power output from the HVDC system, depending on the operation condition a decrease of import power or an increase of export power. f_n is the nominal frequency in the AC network or networks the HVDC system is connected and Δf is the frequency change in the AC network or networks the HVDC is connected. At underfrequencies where f is below f_2, the HVDC system has to increase active power output according to the droop s_4.

ANNEX III

Voltage ranges referred to in Article 18

Synchronous Area	Rated Voltage	Voltage Range	Time period for operation
Continental Europe	110 kV	0,85 pu-1,118 pu	Unlimited
		1,118 pu-1,15 pu	To be established by each relevant system operator, in coordination with the relevant TSO but not less than 20 minutes
	132 kV	0,85 pu-1,098 pu	Unlimited
		1,098 pu-1,15 pu	To be established by each relevant system operator, in coordination with the relevant TSO but not less than 20 minutes
	150 kV	0,85 pu-1,118 pu	Unlimited
		1,118 pu-1,15 pu	To be established by each relevant system operator, in coordination with the relevant TSO but not less than 20 minutes
	220 kV	0,85 pu-1,113 pu	Unlimited
		1,113 pu-1,15 pu	To be established by each relevant system operator, in coordination with the relevant TSO but not less than 20 minutes
Nordic	110 kV	0,90 pu-1,05 pu	Unlimited
		1,05 pu-1,10 pu	60 minutes
	132 kV	0,90 pu-1,05 pu	Unlimited
		1,05 pu-1,10 pu	60 minutes
	220 kV	0,90 pu-1,05 pu	Unlimited
		1,05 pu-1,10 pu	60 minutes
	110 kV	0,90 pu-1,118 pu	Unlimited

Ireland and Northern Ireland	220 kV	0,90 pu-1,113 pu	Unlimited
	275 kV	0,90 pu-1,09 pu	Unlimited
Baltic	110 kV	0,85 pu-1,118 pu	Unlimited
		1,118 pu-1,15 pu	20 minutes
	220 kV	0,85 pu-1,113 pu	Unlimited
		1,113 pu-1.15 pu	20 minutes

Table 4: Minimum time periods an HVDC system shall be capable of operating for voltages deviating from the reference 1 pu value at the connection points without disconnecting from the network. This table applies in case of pu voltage base values at or above 110 kV and up to (not including) 300 kV.

Synchronous Area	Rated Voltage	Voltage Range	Time period for operation
Continental Europe	330 kV	0,85 pu-1,05 pu	Unlimited
		1,05 pu-1,0875 pu	To be specified by each TSO, but not less than 60 minutes
		1,0875 pu-1,10 pu	60 minutes
	400 kV	0,85 pu-1,05 pu	Unlimited
		1,05 pu-1,0875 pu	To be specified by each TSO, but not less than 60 minutes
		1,0875 pu-1,10 pu	60 minutes
Nordic	330 kV	0,90 pu-1,05 pu	Unlimited
		1,05 pu-1,10 pu	To be specified by each TSO, but not more than 60 minutes
	400 kV	0,90 pu-1,05 pu	Unlimited
		1,05 pu-1,10 pu	To be specified by each TSO, but not more than 60 minutes
Ireland and Northern Ireland	400 kV	0,90 pu-1,05 pu	Unlimited
Baltic	330 kV	0,88 pu-1,097 pu	Unlimited
		1,097 pu-1,15 pu	20 minutes

	400 kV	0,88 pu-1,05 pu	unlimited
		1,05 pu-1,15 pu	20 minutes

Table 5: Minimum time periods an HVDC system shall be capable of operating for voltages deviating from the reference 1 pu value at the connection points without disconnecting from the network. This table applies in case of pu voltage base values from 300 kV to 400 kV (included).

ANNEX IV

Requirements for U-Q/Pmax-profile referred to in Article 20

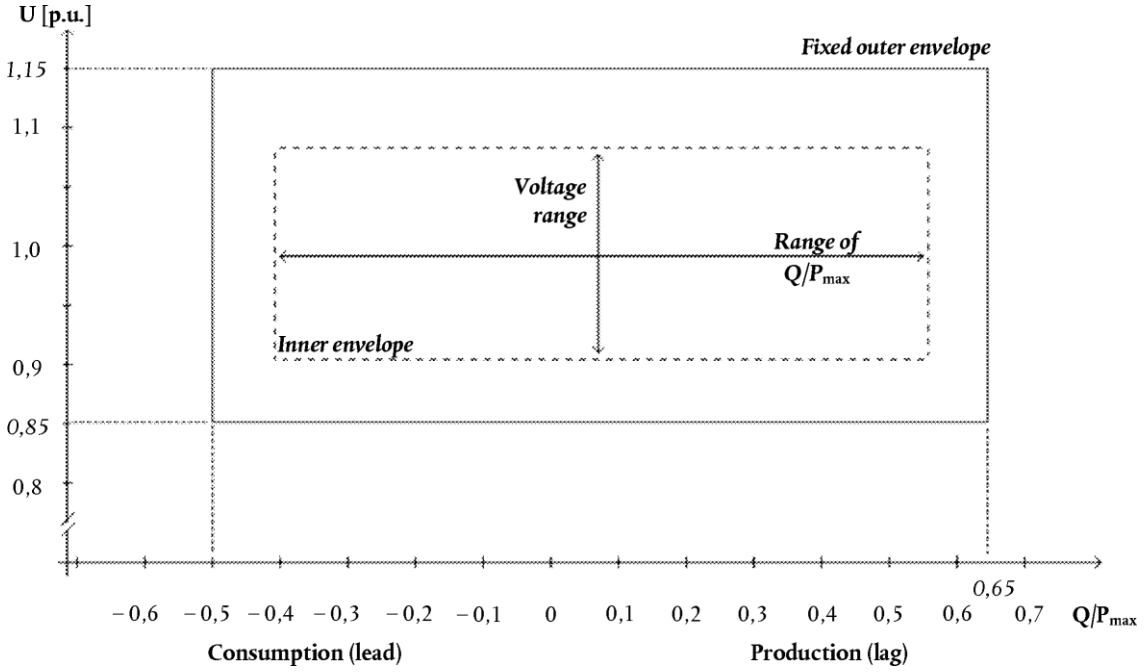

Figure 5: The diagram represents boundaries of a U-Q/Pmax-profile with U being the voltage at the connection points expressed by the ratio of its actual value to its reference 1 pu value in per unit, and Q/Pmax the ratio of the reactive power to the maximum HVDC active power transmission capacity. The position, size and shape of the inner envelope are indicative and shapes other than rectangular may be used within the inner envelope. For profile shapes other than rectangular, the voltage range represents the highest and lowest voltage points in this shape. Such a profile would not give rise to the full reactive power range being available across the range of steady-state voltages.

Synchronous Area	Maximum range of Q/Pmax	Maximum range of steady-state Voltage level in PU
Continental Europe	0,95	0,225
Nordic	0,95	0,15
Ireland and Northern Ireland	1,08	0,218
Baltic States	1,0	0,220

Table 6: Parameters for the Inner Envelope in the Figure.

ANNEX V

Voltage-against-time-profile referred to in Article 25

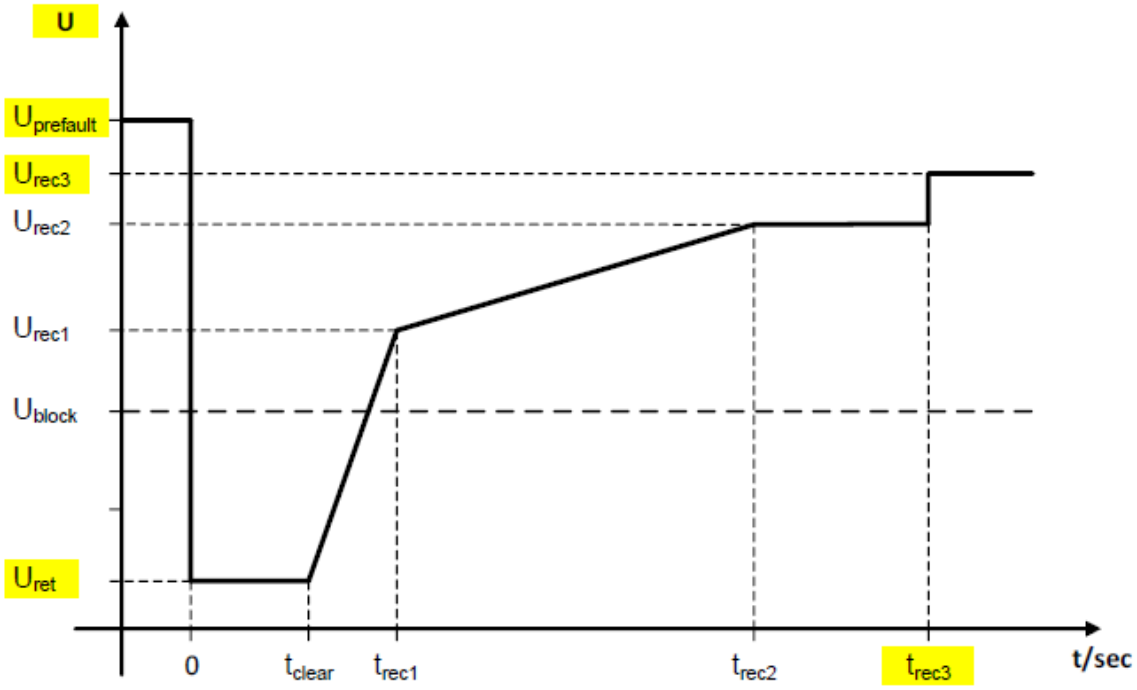

Figure 6: Voltage-against-time profile of an HVDC converter station. The diagram represents the lower limit of a voltage- against-time profile at the connection point, before, during and after a fault. $U_{prefault}$ is the prefault voltage, U_{ret} is the retained voltage at the connection point during a fault, t_{clear} is the instant when the fault has been cleared, U_{rec1} and t_{rec1} specify a point of lower limits of voltage recovery following fault clearance. U_{block} is the blocking voltage at the connection point. The time values referred to are measured from t_{fault}.

Voltage parameters [pu]	
U_{ret}	0,00-0,30
U_{rec1}	0,25-0,85
U_{rec2}	0,85-0,90
U_{rec3}	Minimum voltage specified in Article 40

Table 7.1: Voltage parameters for Figure 6 for the fault-ride-through capability of an HVDC converter station.

Time parameters [seconds]

t_{clear}	0,14-0,25
t_{rec1}	1,5-3.0
t_{rec2}	t_{rec1}-10,0
t_{rec3}	To be specified by each TSO and ≥ t_{rec2}

Table 7.2: Time parameters for Figure 6 for the fault-ride-through capability of an HVDC converter station.

ANNEX VI

Frequency ranges and time periods referred to in Article 39(2)(a)

Frequency range	Time period for operation
47,0 Hz-47,5 Hz	60 seconds
47,5 Hz-49,0 Hz	90 minutes
49,0 Hz-51,0 Hz	Unlimited
51,0 Hz-51,5 Hz	90 minutes
51,5 Hz-52,0 Hz	15 minutes

Table 8: Minimum time periods for the 50 Hz nominal system for which an A-PPM, A-ESM, A-DF and A-PtG-DU shall be capable of operating for different frequencies deviating from a nominal value without disconnecting from the network.

ANNEX VII

Voltage ranges and time periods referred to in Article 40

Rated Voltage	Voltage Range	Time period for operation
110 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,118 pu	Unlimited
	1,118 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO
132 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,098 pu	Unlimited
	1,098 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
150 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,118 pu	Unlimited
	1,118 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the

		relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
220 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,1136 pu	Unlimited
	1,1136 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
275 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,05 pu	Unlimited
	1,05 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability can be specified.
330 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,05 pu	Unlimited
	1,05 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of

		voltage withstand capability can be specified.
400 kV	0,85 pu-0,90 pu	60 minutes
	0,90 pu-1,05 pu	Unlimited
	1,05 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability can be specified.

Table 9: Minimum time periods for which an A-PPM, an A-ESM, an A-PtG-DU and an A-DF shall be capable of operating for different voltages deviating from a reference 1 pu value without disconnecting from the network.

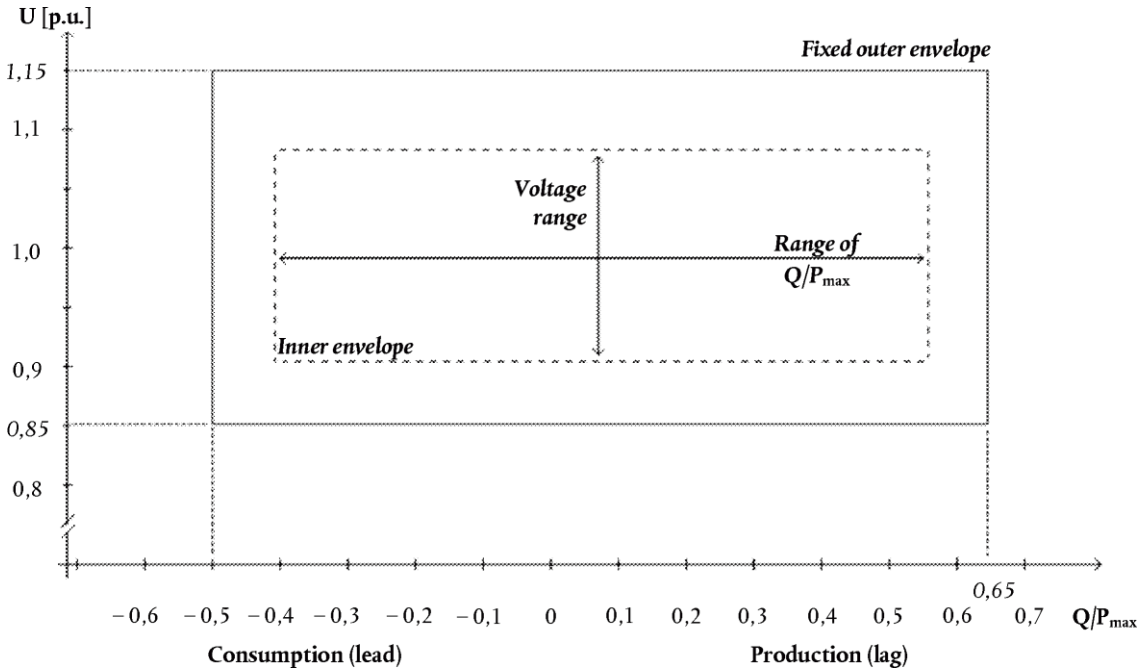

Figure 7: U-Q/Pmax-profile of an A-PPM and A-ESM at the connection point. The diagram represents boundaries of a U-Q/Pmax-profile of the voltage at the connection point[s], expressed by the ratio of its actual value to its reference 1 pu value in per unit, against the ratio of the reactive power (Q) to the maximum capacity (Pmax). The position, size and shape of the inner envelope are indicative and other than rectangular may be used within the fixed outer envelope. For profile shapes other than rectangular, the voltage range represents the highest and lowest voltage points. Such a profile would not give rise to the full reactive power range being available across the range of steady-state voltages.

Range of width of Q/Pmax profile	Range of steady-state Voltage level in pu
0-0,95	0,1-0,225

Table 10: Maximum and minimum range of both Q/Pmax and steady-state voltage for an A-PPM and an A-ESM

ANNEX VIII

Reactive power and voltage requirements referred to in Article 48

Rated Voltage	Voltage range	Time period for operation
110 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,118 pu	Unlimited
	1,118 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
132 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,098 pu	Unlimited
	1,098 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
150 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,118 pu	Unlimited
	1,118 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of

		voltage withstand capability may be specified by the relevant TSO.
220 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,1136 pu	Unlimited
	1,1136 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
275 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,05 pu	Unlimited
	1,05 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
330 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,05 pu	Unlimited
	1,05 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified.

400 kV	0,85 pu-0,90 pu	60 minutes, unless specified otherwise by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified by the relevant TSO.
	0,90 pu-1,05 pu	Unlimited
	1,05 pu-1,15 pu	To be specified by the relevant system operator, in coordination with the relevant TSO. Various sub-ranges of voltage withstand capability may be specified.

Table 11: Minimum time periods for which a remote-end HVDC converter station shall be capable of operating for different voltages deviating from a reference 1 pu value without disconnecting from the network.

Maximum range of Q/Pmax	Maximum range of steady-state voltage level in PU
0,95	0,225

Table 12: Maximum range of both Q/Pmax and steady-state voltage for a remote-end HVDC converter station.