Storage Expert Group:

PHASE II FINAL REPORT

Purpose: The Grid Connection ESC Expert Group was established to consider the way in which Storage plants are dealt with by the three European Connection Network Codes (RfG, HVDC and DCC) and, where applicable, to make recommendations on how such equipment should be treated. This is on the basis that Storage equipment (other than Pumped Storage Plant) is explicitly excluded from the Connection Network Codes and against a background of a significant growth in this area over the last few years.

In part 1 of their work, the group came up with a number of options to resolve the issues identified, particularly in respect of topology, definitions and capability. As a continuation, in part 2 of the group's work, they were tasked with considering the options produced in part 1 in addition to considering the behaviour of storage technologies during low frequency conditions, the requirements (as applicable to Electric Vehicles), the interaction with other European Codes and consider how the legal text for RfG, HVDC and DCC Network codes could be updated to include storage.

Rather than repeating in full the material in the 'part 1' report, this document is designed to be read in conjunction with and following on from this.

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ABOUT THIS DOCUMENT

This is the Phase II report of the Identification of Storage Devices Expert Group (EG STORAGE). The first Phase (Phase I (see Reference [1]) was established by the Grid Connection European Stakeholder Committee (GC ESC) in the autumn of 2018 to consider the suitability of the three Connection Network Codes (RfG, DCC and HVDC) for storage. It is acknowledged that when the CNCs were drafted the requirements applicable to storage (other than Pumped Storage[1]) were explicitly excluded from these three Codes. The aim of phase I of the report was therefore to identify the need for technical requirements for storage and how these requirements would coincide with the existing Network Codes for connection. In particular, phase I concentrated on (i) identification of storage technologies, applications and topologies, (ii) definitions and (iii) different storage categories. Phase II of this report complements Phase I and it is not intended to replicate the detail of Phase I although elements which were discussed in Phase I and which have resulted in changes, are documented in this Phase II report.

Phase II of the work, established in the Autumn of 2019 aimed to build on the experience of Phase I in addition to i) Revise any relevant Articles of the Connection Network Codes according to the results and observations of the technical assessment from phase 1.

In particular Phase II had the following objectives:-

i) List and briefly assess any possible implications to other Network Codes or Guide Lines that revisions to the Connection Network Codes may have;
ii) List any possible questions to be addressed by other Network Codes Guidelines (market, operation);
iii) Include some information related to the specific case of Electric Vehicles;
iv) Identify the possible configurations for grid connection, and the different modes of operation;
v) Asses the consequences on connection requirements; and
vi) List any possible questions to be addressed by other NCs/GLs

DOCUMENT CONTROL

Version	Date	Change Reference
Initial draft	25 February 2020	First draft incorporating discussions from the EG and material shared by the members
Second Initial Draft	24 April 2020	Second draft incorporating discussions and comments from Expert Group members.
Final Draft	28 May 2020	Final draft incorporating final discussions from Expert Group members and ENTSO-E.

[1] Defined in RfG Article 2(21).

Any Questions?

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INTRODUCTION

On 11 June 2018, the Grid Connection European Stakeholder Committee (GC ESC) decided to establish three Expert Groups (EG) to consider and clarify the requirements on particular groups of users as applicable under the three European Connection Codes (CNCs); namely, Requirements for Generators[2] (RfG), HVDC[3] and Demand Connection[4] (DCC).
The areas to be considered by the three EGs were:

- Pumped Storage (hydro);
- Storage (non-Pumped Storage); and
- Mixed Customer Sites (MCS).

The creation of these EGs was proposed by ENTSO-E to elaborate on the three CNCs issues which had been raised by stakeholders during the national implementation of the CNCs; including as a result of a stakeholder survey to identify priority topics for which future revisions to the CNCs could be considered.

The full terms of reference for the EG STORAGE[5] was approved by the 14 Sept 2018 GC ESC and subsequently with a minor amendment by the 13 Dec 2018 GC ESC. Phase II of the Storage Expert Group Terms of Reference was approved on 11 September 2019 at the GC ESC meeting.

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[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:JOL_2016_112_R_0001

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32016R1447

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2016.223.01.0010.01.ENG&toc=OJ:L:2016:223:TOC

[5] https://www.entsoe.eu/Documents/Network%20codes%20documents/GC%20ESC/STORAGE/Annex_EG_STORAGE_final.pdf

PURPOSE

Objectives

The objectives of Phase I of the Expert Group on Storage were:

- Identify storage technologies, applications and topologies;
- Investigate the possibility of a useful definition of storage devices which could lead to the definition of connection requirements at EU level (due to cross-border relevance); and
- Categorize storage devices (if reasonable).

The objectives of Phase II of the Expert Group on Storage are:-

- Revise any relevant Articles of the Connection Network Codes (RfG, HVDC and DCC) according to the results and observations of the technical assessment from phase I.
- List and briefly assess any possible implications to other Network Codes and Guidelines that these revisions may have.
- List any possible questions to be addressed by other Network Codes / Guide Lines (market, operation).
- Include some information related to the specific case of Electric Vehicles.
- Identify the possible configurations for grid connection, and the different modes of operation.
- Asses the consequences on connection requirements.
- List any possible question to be addressed by other Network Codes / Guide Lines.

Task description

The three European Connection Network Codes (RfG, HVDC and DCC) explicitly exclude Storage technologies other than in respect of Pumped Storage.

In recent years, there has been a substantial increase in the use of electrical system connected storage applications to the extent that some form of connection requirements are necessary. This need is to ensure that relevant system operators can continue to operate safe, secure and economic networks, the requirements upon developers are reasonable, proportionate and non-discriminatory and the definitions are clear. These EU wide requirements are all fundamental pre-requisites which are necessary to facilitate Union wide trade in electricity, ensure security of supply, facilitate the integration of renewable energy sources, increase competition and allow the more efficient use of the network and resources for the benefit of consumers.

Discussion with stakeholders have revealed some questions related to storage devices, especially regarding the connection requirements for such units, in addition to wider issues such as the treatment of storage when in an importing mode of operation during low frequency conditions, the treatment of electric vehicles and the interaction with other network codes. In addition, the wider issue of preparing draft text for implementation into the European Connection Network Codes (RfG, HVDC and DCC), which has built on the foundation of Phase I of this work has been a key part of this work. The Storage Expert Group has therefore prepared the following:-

- Proposed updates and recommendations as to how storage technologies can be integrated into the RfG, HVDC and DCC Connection Network Codes.
- Ensure the applicable technical capabilities as identified in Phase I of the report are reflected in the updates to RfG, HVDC and DCC Connection Network Codes.
- Ensure the definitions as identified as part of the recommendations of this Expert Group are factored into the updates to RfG, HVDC and DCC Connection Network Codes.

In addition, the EG Storage also sought to achieve the following additional objectives:

- Consider the performance of storage equipment when in an importing mode of operation during low system frequencies. In this respect, the group were guided by Article 15(3) of the Emergency and Restoration Code and the experience from Member states, most notably Germany and GB.
- The treatment of electric vehicles was acknowledged by the Workgroup as a significant growth area for which an EU wide unique set of requirements was preferred.
- ACER have undertaken substantial work in considering the development of electric vehicles (see Reference [2] of this report) and this has been taken into account as part of this work.
- The impact on other European codes has also been taken into account, most notably the interaction with the Emergency and Restoration Code and System Operator Guideline (SOGL) which are believed to have the greatest overlap with storage equipment.
- The interaction between the other Expert Groups (namely Pumped Storage Hydro and Mixed Customer Sites) together with the work being developed by ENTSO-E.

To meet these objectives, the Expert Group Storage has considered the experience from Member States at a National level and more widely.

As part of the discussions, it was noted that there are some forms of storage technologies (eg – Synchronous Flywheels, Synchronous Compensators and Regenerative braking systems) which cannot control their injected power in time or magnitude. Whilst it is acknowledged that these technologies can store energy, they can only supply or absorb energy under specific conditions (for example under changing frequency conditions or when a train is braking or simply in terms that some of these technologies are only capable of importing or exporting reactive power with no capability of supplying or absorbing active power). As these technologies either do not contribute to Active Power, or their contribution is limited to specific system events (in other words they are not controllable) they would struggle to satisfy the proposed technical requirements and hence fall outside the scope of this work. As such, they would fall outside the definition of an "Electricity Storage Module" and the technical requirements proposed by this Expert Group. That said, it is down the TSO to define the technical requirements applicable to technologies which fall outside the definition of an

Electricity Storage Module. A section has been added to the "Recitals" ("Whereas") section of RfG to address this issue whilst also acknowledging that TSOs need to ensure that all forms of equipment connecting to the network have the appropriate level of robustness.

Deliverables

The preparation of a report outlining the findings of the group including recommendations in addition to suggestions of how the connection network codes could be updated.

TIMETABLE

The set-up of this Expert Group by the GC ESC was on the basis of delivery of a final report and legal text by June 2020. A timeline of events is given below.

Approval of the Phase I report by GC ESC	June 2019
First Phase II Meeting – Recap / Terms of Reference - Webinar	8 November 2019
Second Meeting – Physical Meeting – ENTSO-E Offices	19th November 2019
Third Meeting – Special meeting on Electric Vehicles - Webinar	10th December 2019
Fourth Meeting - Webinar	16th December 2019
Emilie Milin (RTE) hands chair to Antony Johnson (National Grid ESO)	January 2020
Fifth Meeting - Webinar	28th January 2020
Sixth Meeting Physical Meeting – ENTSO-G Offices – Discussion of draft report and draft connection network codes	4th March 2020
Seventh Meeting - Webinar	13th March 2020
Eighth Meeting - Webinar	2 April 2020
Ninth Meeting – Webinar	7 May 2020
Several bilateral meetings where held with particular Expert Group Members and others who has expressed particular comments on the report	May 2020
Submission of final report and draft legal text	June 2020

CLEAN ENERGY PACKAGE

EU Directive (EU) 2019/944 which is part of the Clean Energy Package and published on 5 June 2019 defines common rules for the internal market for electricity and amends Directive 2012/27/EU. Article 2 of this Regulation defines 'energy storage' as:-

"Energy Storage means, in the electricity system, deferring the final use of electricity to a moment later than when it was generated, or the conversion of electrical energy into a form of energy which can be stored, the storing of such energy, and the subsequent reconversion of such energy into electrical energy or use as another energy carrier".

As part of the Expert Group, the requirements and proposals relate to "Electricity Storage" rather than "Energy Storage". The Expert Group discussed this issue and developed the definition of "Electricity Storage" as follows:-

"electricity storage" means the conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy.

Whilst this issue has developed some debate, we do not believe that the definition of "Energy Storage" as defined in EU Directive (EU) 2019/944 is in conflict with the proposed definition of "Electricity Storage" which is proposed in the revised definition of RfG.

In the "Recitals" section of RfG, it is recommended that the definition of "electricity storage" is clarified stating that electric vehicles are included within the scope of energy storage.

TECHNOLOGIES, APPLICATIONS, TOPOLOGIES AND IMPLEMENTATION IN THE CONNECTION NETWORK CODES

As discussed in Phase I of the Report (see Reference [1]), there is a huge array of different storage technologies and topologies. It is beyond the scope of Phase II of this report to repeat these discussion points, however the key conclusions drawn and the thinking developed in Phase I of the work has been fundamental to the approach used in developing the thinking and recommendations of this report. The key conclusions, are summarised below.

- The scope of this work is only to consider "electricity storage" and the context of the technical requirements which apply. As such, "energy storage" falls outside the remit of this work.
- "Electricity Storage" has been considered to be where electrical energy is taken from the network, is converted into any other form of energy which is stored and then subsequently re-converted back into electrical energy.
- Electricity Storage is simply considered to be equipment which has a generation and demand capability. Therefore, the technical requirements applicable to electricity storage needs to be consistent with that already defined for Generation and Demand.
- The Expert Group believe that a simple approach should be adopted in so far that an electricity storage module is the same as a power generating module. Therefore an electricity storage module will have to meet the same requirements as a power generating module when operating in both a generating mode and consumption mode with specific additional requirements added where necessary (for example charging the storage device during low system frequencies which would equally apply to Type A, B, C and D B Electricity Storage Modules).
- The conversion of electrical energy to or from the network can only take place through two general technologies - these being either via a synchronous machine or a non-synchronous / power electronic equipment. For example, in the case of an air storage system with a turbine, the conversion of mechanical energy (via the turbine) to electrical energy could take place through a synchronous machine operating as a generator when in an generating mode of operation and as a motor when in an consuming mode of operation. In the case of a battery, the interface between the energy storage system and network is achieved through a power electronic converter. This classification is important as it enables the technical requirements applicable to storage to be centred around the same requirements for synchronous and non-synchronous equipment used in RfG. This has the further advantage of simplifying the definitions used in the connection network codes.
- From a definition and legal drafting perspective, the similarities with RfG therefore make it appropriate to treat storage in the same way as generation with additional requirements introduced when the storage plant is operating in a demand (consumption) mode. This is the basis which has been used in suggesting changes to the connection network codes and has the added advantage of limiting the number of legal text changes.
- A key recommendation is that three new definitions are introduced, these being electricity storage", "electricity storage module" and "maximum consumption capacity". In summary, an electricity storage module is a power generating module which can

import and export active power from and to the network. In this way, an electricity storage module is treated in the same way as a power generating module as required by the connection network codes with additional requirements added where necessary. These concepts are covered in more detail in later sections of this report.

- The Expert Group also noted that some electricity storage devices, such as synchronous compensators, synchronous flywheels and regenerative braking systems do not fall within the strict definition of a electricity storage module as they cannot be controlled (ie they will release or absorb electrical energy only under certain conditions) and hence would fall outside the scope of these requirements. This point has been covered above but in summary equipment which falls into this category such as synchronous compensators or flywheels would have to satisfy requirements specified by the TSO.
- Where electrical energy is converted into another form of energy, for example an electrolysis plant producing hydrogen for a low carbon vehicle and the low carbon vehicle uses that hydrogen for transport purposes only, then this would be treated solely as demand. The workgroup agreed that this is no different in concept to flexible load such as heat pumps or refrigeration equipment behind a connection point and hence they should be treated in the same way. Likewise this would equally apply to electric vehicles which only consume electrical energy for the purposes of transport. Since this would be treated as pure demand, it would be able to participate in demand response services as provided for in Articles 27 – 30 of the Demand Connection Code respecting Art.15(3) of the Emergency and Restoration Code (EU 2017/2196). On the other hand, the requirements for bi-directional storage are covered in RfG which need to ensure consistency with Article 15(3) of the Emergency and Restoration Code (EU 2017/2196).
- For the avoidance of doubt, the requirements for Pumped Storage Hydro are being considered by the Pumped Storage Hydro Expert Group and therefore fall outside the scope of this work.Consideration was also given to the requirements applicable to electricity storage modules based on their size and connection point. Given that electricity storage modules are being treated in the same way as generation with additional requirements when operating in the consumption mode, the group considered it appropriate to also apply the same banding thresholds (ie Type A, Type B, Type C and Type D) as defined in Article 4 of RfG to electricity storage modules. The group did not believe there was any requirement for banding of demand, and in any case, this would fall outside the scope of the Expert Group.

In addition to the above points, the issue of connection topologies was discussed extensively during Phase I (see Reference [1]) of the expert group. These issues were discussed again in detail, especially towards the end of Phase II of the Expert Group. The intention here is to provide clarity so it is clear what requirements apply when a storage plant is located at a new or existing site with generation, demand or a combination of both.

Although it is clear what requirements would apply to an electricity storage module (ie a synchronous electricity storage module would have to meet the SPGM and an asynchronous electricity storage module would have to meet the same requirements as a PPM) there was some confusion how the requirements would apply where storage is combined with new and/or existing generation or demand. To this end, it has been suggested that as a future piece of work, an Implementation Guidance Document (IGD) is prepared which covers these requirements in more detail and complements the legal text. This would give examples to developers how the requirements should be interpreted.

In summary, the bullet points below detail at a high level, how the requirements should be applied for a bi directional electricity storage device. Note in the descriptions below, Annex I refers to the additional requirements placed on electricity storage modules as provided for in the updated legal text (Appendix A of this report). The reader is therefore encouraged to look at the legal text section of this report (Appendix A) when assessing the examples below.

- A new battery storage installation is connected with its own designated connection point. Satisfy the requirements of RfG in respect of Power Park Modules plus the additional requirements proposed in the RfG legal Text (Annex I) – see Legal Text section of this report (Appendix A of this report).
- A new compressed air installation using a synchronous machine is connected with its own designated connection point. In this case there is a requirement to satisfy the requirements of RfG in respect of Synchronous Power Generating Modules plus the additional requirements proposed in the RfG legal Text (Annex I) – see Legal Text section of this report (Appendix A of this report).
- A new solar park and battery storage installation are connected with one connection point. The developer proposes to run the solar park and battery storage as one (ie the solar park and battery storage installation are *not* run independently). In this case the new solar park and battery installation (combined) would be treated as one Power Park Module. In this case, the requirements of RfG apply in respect of the maximum capacity of the complete installation (as declared by the developer) plus the additional requirements proposed in the RfG legal Text (Annex I) – see Legal Text section (Appendix A of this report). In other words the requirements of RfG would apply to the complete Power Park Module.
- A new solar park and battery storage installation are connected with one connection point. The developer proposes to run the solar park and battery storage installation *independently* . In this case, the installation would still be treated as one Power Park Module. From a compliance perspective the solar park would have to meet the requirements of RfG based on the maximum capacity of the solar park without the presence of the battery storage installation and visa versa. When the battery storage installation is assessed for compliance purposes, the battery storage installation would have to meet the requirements of RfG as applicable to a power park module (without the presence of the solar park) plus the additional storage elements (Annex I) – see Legal Text Appendix A of this report.
- A new battery installation is integrated into an existing wind farm behind the connection point. The Developer wishes to run both the storage and wind farm as a combined project. The existing wind farm would either meet the current RfG requirements or its existing pre RfG requirements. From a compliance perspective the battery installation would have to meet the requirements of RfG as a Power Park Module together with the additional storage requirements (Annex I) – see legal text section (Appendix A of this report) without the wind farm operating. As to how the developer then chooses to run the combined installation in operational timescales is then its choice.
- A new battery is installed within an existing synchronous generator. The developer wishes to run the installation as a combined unit. The existing synchronous generator has to meet the current requirements of RfG or pre RfG. From a compliance perspective, the battery would have to meet the requirements of RfG as applicable to a power park module with the additional storage requirements (Annex I) without the synchronous generator running. As to how the developer then chooses to run the combined installation in operational timescales is then its choice.
- A new flywheel is connected to an existing synchronous plant. The existing synchronous plant has to meet the RfG or Pre RfG requirements. Flywheels are not caught by RfG and therefore it is down to the TSO to define what technical requirements apply to the flywheel and the compliance tests necessary.

- A new compressed air energy storage system is connected to an existing synchronous plant. The existing synchronous plant has to meet the requirements of RfG or pre RfG. From a compliance perspective the compressed air energy storage system has to meet the RfG requirements applicable to a synchronous power generating module in addition to the storage requirements (Annex I) – see Appendix A of this report without the synchronous plant running.
- A new battery is installed with a new synchronous generator. The developer wishes to run the plant as a combined unit and the battery is not to be operated independently from the generator. Compliance is assessed against the RfG requirements for a synchronous generator based on the maximum capacity declared by the developer.
- A car park which has a maximum capacity of 10MW comprising V2G Electric Vehicles. A V2G electric vehicle is one which can import and export active power to the network. In this case the site would have to meet the requirements of RfG Power Park Modules plus the additional storage requirements (Annex I) – see Appendix A of this report.
- A new demand site of 100MW is integrated with a battery with a maximum capacity of 20MW with one connection point. The developer intends to operate the storage with demand only and there is no expectation for the site to export active power. The connection site would be managed as Demand under DCC and participation in demand response services can take place if requested.

As noted above, it is recommended that ENTSO-E consider the development of an Implementation Guidance Document (IGD) so it is clear what requirements apply to storage and integrated with other equipment at the same site.

So far as implementation is concerned, it is assumed that the requirements applicable to electricity storage modules would apply based i) the date from when any revised regulation is published, ii) the date when a developer places its contract for major plant items and iii) the date when the electricity storage module is connected to the system.

Since changes to the connection network codes are expected to include other technical requirements other than just storage the suggested legal text has not been amended in this respect. This is included in the “Assumptions” section of this report.

ELECTRIC VEHICLES/ELECTROMOBILITY

Under Phase II of the Terms of Reference, the Expert Group was tasked with considering the requirements applicable to Electric Vehicles. The Expert Group considered this in some detail with presentations held at the physical meeting in Brussels on 19th November, a specific webinar held on the 10th December 2019 and a further presentation held at the physical meeting on 4th March 2020.

The group acknowledged the significant growth of Electric Vehicles and the impact and benefits on the network. It is also grateful to the work completed by ACER who have prepared a technical position paper (see Reference [2]) on the integration of electromobility in the scope of application of the Network Codes RfG and DCC. The Expert Group are grateful to ACER for the thinking they have shared on Electromobility.

The Expert Group acknowledges the findings and policy recommendations of the technical position paper prepared by ACER (see Reference [2]) and has incorporated them as part of the proposed Expert Group Report. The Expert Group recognises the high level approach developed by the Expert Group is complementary to the detail developed by ACER.

The Expert Group also acknowledges the definitions introduced in Section 3.1 in the ACER technical position paper (see Reference [2]) which distinguishes the different configurations and implementations in the context of electromobility.

The Expert Group noted the helpful classification of Electric Vehicles, these being either i) V1G – ie where an electric vehicle only takes electricity from the network for the purposes of transport alone; and ii) V2G is an electric vehicle which can both import and export electricity.

Whilst it is not proposed to adopt the key definitions developed in the ACER position paper within the Connection Network Code Legal text, the key definitions used in the ACER report are repeated here for convenience:

*‘**Electrical charging point**’ means an interface between a connection point and one electrical vehicle that allows the charging of the electrical vehicle’s batteries, by absorbing energy from a network, or both the charging and discharging of the electrical vehicle’s batteries, by absorbing and injecting energy from and into a network, respectively.*

*‘**Electrical charging park**’ means the ensemble of electrical charging points that has a single connection point to the relevant network.*

*‘**V1G Electrical charging park**’ means the ensemble of V1G electrical charging points that has a single connection point to the relevant network.*

*‘**V2G Electrical charging park**’ means the ensemble of electrical charging points, also including V2G electrical charging points, that has a single connection point to the relevant network.*

*‘**Electrical charging facility**’ means a facility that consists of one or more electrical charging parks connected to a network at one or more connection points.*

*‘**Electrical charging facility owner**’ means a natural or legal entity owning an electrical charging facility.*

Practical V2G installations can be stand alone and consist of any mix of V1G and V2G arrangements and are also likely to form part of larger installations (including those with other forms of generation). As such the import and export quantities associated with the installation will be determined by the equipment installed behind each network connection point.

Policy Recommendations:

The Expert Group recognises the following policy recommendations included in the ACER technical position paper to promote greater electromobility, ensure compliance with the EU Grid Connection Network Codes and minimise market barriers and distortions in the EU:

1. *Setting the applicable requirements at the connection point of the electrical charging park.*

2. *Ensuring the demonstration of full compliance of the electromobility entities with the relevant GC NCs.*

3. *The Connection Network Codes do not need to recognise the on-board technologies of EV’s from the scope of application of GC NCs, and should only focus on the connection point.*

4. *The application of requirements should be based on the technical capabilities and means of interaction with the system and no differences should exist whether an electrical charging park is located at residential level or in a business facility.*

5. *Setting the criteria to define electrical charging parks as ‘existing’ or ‘new’ and applying a transitional period for the application/development of appropriate certificates and certification processes.*

   For the time being it is recognised that as Storage is “new” this issue is relevant only as the connection network codes develop in future.

6. *Defining the list of the electrical charging parks under the scope of application of the DCC.*

   So far as Electric Vehicles are concerned, a charging park (in particular V1G) would be treated as demand under DCC.

7. *Removing barriers and limitations for the classification of small electrical charging parks concerning the RfG.*

   Under RfG, the Expert Group consider electric vehicles (V2G) would be considered as a storage and hence treated in the same way as any other electricity storage module.

An initial approach discussed within the group was to have detailed requirements for electric vehicles embodied within the connection network codes similar to the level of detail in the ACER position paper.

It was however subsequently agreed that it would be discriminatory to treat V1G differently to any other form of load (for example heat pumps or flexible refrigeration equipment), and therefore with the requirements applicable at the connection point falling under the requirements of the DCC.

Similarly it was agreed that it would be discriminatory to treat V2G differently to any other type of electricity storage module and hence the requirements at the connection point would fall under the provisions of the RfG. Since Electric Vehicles are battery based, they would be treated in the same way as any other Battery based system and hence similar to a power park module.

It was noted that Art.15(3) of the Emergency and Restoration Code (EU 2017/2196) imposes disconnection of storage units at low frequencies, as implemented by the relevant TSO, and the Expert Group note this requirement has to be respected by V2G installations.

As part of the discussion on electric vehicles a presentation was also given on the quality of supply impacts. This issue is discussed in the “Quality of Supply” section of this report.

To finalise, the Expert Group agreed that a high level approach should be adopted in the connection network codes with electric vehicles (V2G) falling under the general definition of an electricity storage module and V1G falling under the definition of Demand under DCC. It is believed this high level approach appropriately complements that of the ACER position paper.

Electric Vehicles and Overview from the European Commission

As part of the Expert Group, there was one meeting (4th March 2020) which was attended by representatives of the European Commission. It was confirmed that Electricity Regulation 2019/943 and the recast electricity Directive 2019/944 contain several provisions to support smart charging of electric vehicles and so-called vehicle-to-grid services (V2G). For smart charging, these are provisions granting the consumer the right to request a smart meter and a dynamic price contract, providing for the possibility of time-differentiated network tariffs and providing the legal framework for demand response service providers to have non-discriminatory access to the markets. For V2G, these are the provisions granting the consumers the right to participate in the electricity market by providing flexibility services through storage using electric vehicles, enabling DSOs to actively manage their networks and purchase flexibility. The provisions also require the elimination of any double charges/taxes, including network charges, on storage for flexibility services provided to system operators.

It was noted that the issue of electric vehicles is also being addressed in the upcoming revision of the directive for the deployment of alternative fuels infrastructure (2014/94/EU). This work will also look into possible measures to enable V2G, with a focus on the charging point and the communication between the charging point and the vehicle. This work would need to be consistent with the connection network codes but also the requirements on cyber security. It was noted that many of these issues were beyond the terms of reference of the Expert Storage group.

Practical examples of electric vehicle charging and trading were discussed for example in the case of a fuelling station (fast charging station) which would effectively be used for recharging a vehicle quickly for the vehicles onward journey as compared to something like a car park at a railway station, hotel or airport where vehicle parking and electricity trading go hand in hand. At this stage it was noted that under current law, the process of charging an electric vehicle was seen as a service not a product which would be quite different if a vehicle was charged at home. The Expert Group noted this and consider further clarification is required in this area where there is a requirement for a non-paid service in Article 15(3) of the EU Emergency and Restoration Code (EU Regulation 2017/2196) to reduce the volume of charging if system frequency were to fall.

The issue of information / data sharing was also considered by the group in addition to some of the more local issues that would need to be agreed between the electric vehicle manufacturers and site owner – for example the standards applicable to connections, data and communication protocols. It was acknowledged that these were issues that were very relevant but fell outside the scope of the terms of reference of the Expert Group which was principally looking at the requirements at the connection point. It is not believed that the work of the Expert Group Storage will be in conflict with these wider issues and it will rather be complementary.

It was agreed that further liaison should continue with the European Commission.

DEFINITIONS

Aside from the definitions discussed as part of the ACER position paper on Electric Vehicles the Expert Group discussed the general issues associated with the definitions relating to Storage. As noted, an electricity storage module is treated in the same way as generation and demand which has the added advantage that it reduces the number of definitions and the subsequent overlap with other EU Codes. A summary of the definitions proposed for the EU Connection Network Codes are Summarised below:-

Requirements for Generators (RfG)

'electricity storage' *means the conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy.*

'electricity storage module' *is a power generating module which can inject and consume active power to and from the network.*

'maximum consumption capacity' *means the maximum continuous active power which an electricity storage module can import from the network.*

Amended Definitions

generating module' *means either a synchronous power-generating module or a power park module. A power generating module includes an electricity storage module.*

HVDC Code (HVDC)

There are no changes to the definitions in the HVDC Code. Based on RfG, electricity storage is included within the definition of a Power Park Module and hence a DC Connected Power Park Module.

Demand Connection Code (DCC)

There are no changes to the definitions in the DCC

INTERACTIONS WITH OTHER EU CODES

The workgroup discussed this in detail and two principle EU Codes where identified to overlap with Storage. The first is Article 15(3) of the EU Emergency and Restoration Code (EU 2017/2196) with regard to its treatment of Energy Storage Units and the second is in relation to some aspects of the System Operator Guideline (EU 2017/1485 SOGL) in particular the ACE (Automatic Control Error) Control. Both of these aspects are covered in detail below.

Emergency and Restoration Code – Article 15(3)

Article 15(3) of the EU Emergency and Restoration Code States:-

3. Prior to the activation of the automatic low frequency demand disconnection scheme, each TSO and DSO identified pursuant to Article 11(4) shall foresee that energy storage units acting as load connected to its system:

(a) automatically switch to generation mode within the time limit and at an active power set-point established by the TSO in the system defence plan; or

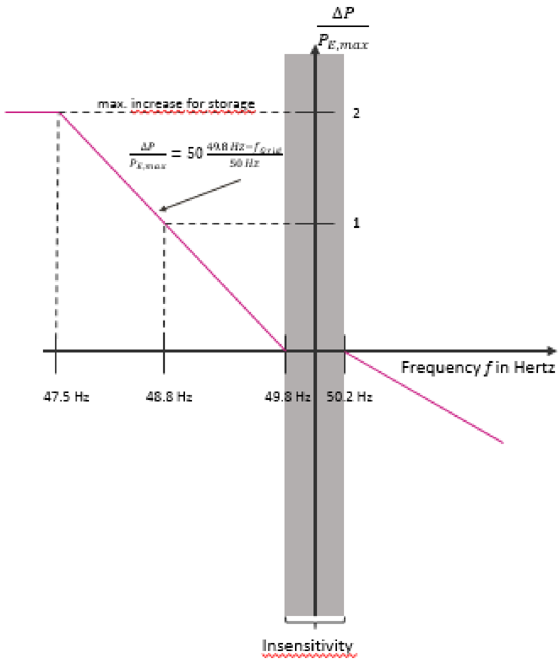
(b) when the energy storage unit is not capable of switching within the time limit established by the TSO in the system defence plan, automatically disconnect the energy storage unit acting as load.

In Phase I of the Expert Group, the view was taken that due to the vast range of storage technologies and their different response times it may be better to specify a short switching time and permit tripping rather than a more detailed characteristic. The requirements of Article 15(3) of the Emergency and Restoration Code was discussed, and it was agreed that this should be a further issue which is taken forward during Phase II of the Expert Group.

In addressing this concern, the Expert Group requested workgroup members to provide any experience of this capability. From these discussions, some work had been completed in Germany and GB but the overall view was that in general a droop type control should be adopted so as to avoid sudden shocks to the system.

In Germany the characteristic shown in Figure 1.0 was suggested. It was noted that in Germany this requirement applies to Type A Storage Units and above.

At under-frequency below 49.8 Hz all storage units shall support the system's frequency



- At frequencies below 49.8 Hz, all storage units shall increase their power with a gradient of 100 % per Hertz
- Storage units will move up and down the frequency characteristic
- Below 49.8 Hz, all storage units in charging mode shall reduce their charging power to their technically possible minimum power.
- If possible, storage shall change into feeding mode.

Figure 1.0

In GB, as part of the implementation of the Emergency and Restoration Code, the characteristic shown in Figure 2.0 was suggested. In introducing this requirement in GB it was proposed that this requirement would apply to those parties bound by the requirements of the Grid Code. Under the EU Emergency and Restoration Code, (2017/2196) the requirements applicable to storage units are unclear as they are undefined, but is it taken to mean that storage Unit which is a Significant Grid Users (SGU) would apply to any electricity storage module of Type B and above.

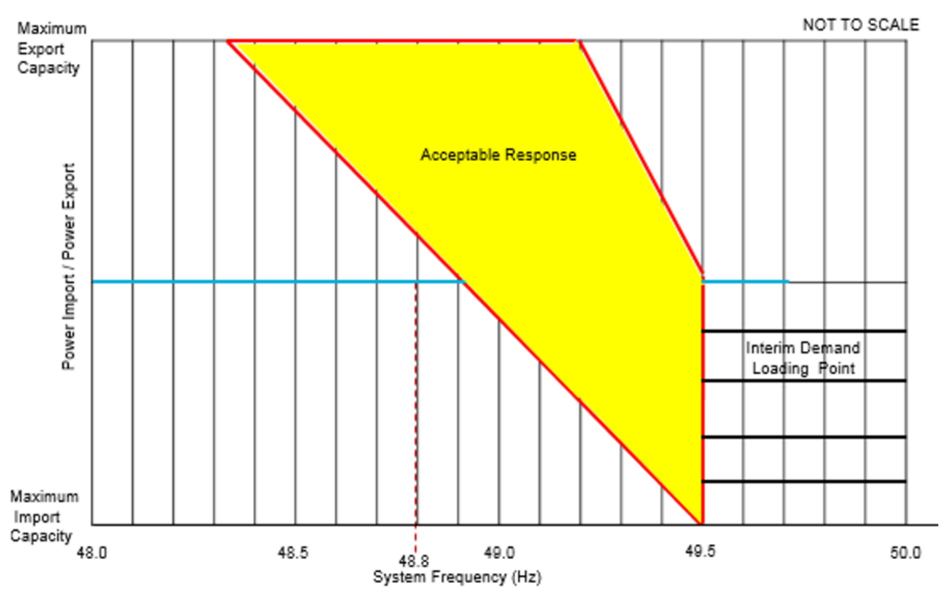


Figure 2.0

In the GB case, the requirement was based on the proposal that an Electricity Storage Module should be capable of transitioning from an import mode of operation to an export mode of operation within 20 seconds. This transition time of 20s is unique to GB based on its system characteristics and the historic time under which the system frequency has fallen during extreme events. At a European level, it is proposed that all parameters would be specified by the TSO. Returning back to GB, if this capability could not be achieved, then the electricity storage module would be required to be tripped at 49.2Hz though there has been some concern expressed within the Expert Group with regard to the risk of tripping plant at defined frequencies. Additionally, as drafted in GB, if the electricity storage module has the capability to satisfy this requirement but is still in an importing mode of operation at 48.9Hz then automatic tripping should be initiated, though it was noted this may cause a conflict with the proposals of the pumped storage hydro Expert Group.

Both the German and GB approaches were considered and discussed by the Expert Group together with individual Expert Group Members. The view taken was that the best option would be to combine both suggestions with a set of flexible parameters which would be decided at National Level or TSO level. This would then enable the correct characteristic to be achieved and provide for an appropriate level of flexibility. The approach suggested and that included within Annex I of RfG is shown in Figure 3.0 below.

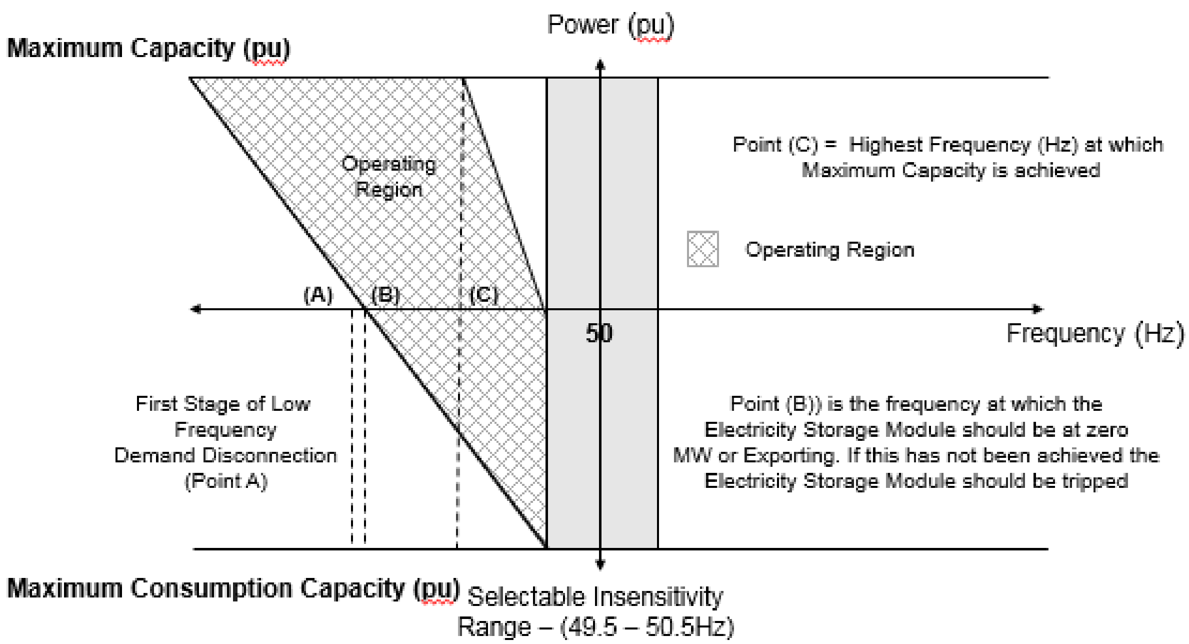


Figure 3.0

Together with a TSO defined set of parameters shown in Table 1.0 below, this enables a fully flexible characteristic to be obtained whilst also permitting plant tripping if the storage device is unable to meet these requirements. These requirements would also equally apply to sites comprising of V2G electric vehicles.

TSO defined Parameter	Unit	Range
Insensitivity	Hz	49.5 – 50.5
Power Gradient	MW/Hz or pu/Hz	Within operating range of Figure 1
Point A - First Stage of Low Frequency Demand Disconnection	Hz	TSO defined according to the E&R (EU 2017/2196) code
Point B – Frequency at which the Power generating module should be at zero MW or Exporting when capable of meeting the capability of Figure 10	Hz	TSO defined according to the E&R (EU 2017/2196) code
Point C – Frequency at which Maximum Export Capability can be reached	Hz	49.6 – 49.0Hz
Time t1 – Maximum Operating time for complete characteristic	s	TSO defined in the range 1 - 25
Time t2 – Initiation time from inception of frequency fall	s	TSO defined in the range 0 - 5
Final Loading Point following frequency fall	MW or pu	0 – Maximum Capacity

Table 1.0

The Expert Group were comfortable with the suggest approach however they highlighted two issues:-

- The need to prevent the risk of transients and unacceptable voltage levels (ie the need to retain voltage levels within the limits specified in the CNC's) and temporary overvoltage transients following the transition from import to export; and
- Power transients causing frequency oscillations or inter-area oscillations; and
- A potential concern over the need for a safety margin prior to the reduction of demand during low system frequencies.

With regard to this second point, the Expert Group agreed that as the characteristic has an insensitivity band there is no requirement for a safety margin. The requirement for preventing transients including unacceptable voltage levels, TOV's and frequency oscillations has been included within RfG as a proposed requirement.

A further point was also raised regarding the impact of Article 15.3 of the Emergency and Restoration Code (EU 2017/2196) on storage which is only capable of importing (for example an electric vehicle charging station (V1G) - such as a motorway service station). The expert group sees two solutions :

1. Impose the Emergency & Restoration Code requirement on pure charging stations by stating that this requirement is not considered as a Demand Response Service according to Art.27-30 of the DCC code; or
2. Exclude the Emergency & Restoration Code requirement for pure charging stations by considering disconnection at low frequencies as a Demand Response Service according

to Art. 27 – 30 of the DCC code but also adding a modification of the Emergency & Restoration code.

The expert group prefers the first solution due to the limitation of the scope of this expert group to the connection codes.

Interaction with System Operator Guideline (SOGL)

As part of the discussion, the issue of the interaction with the System Operator Guideline was discussed, largely around correct dimensioning of the parameters of electricity storage modules to ensure consistency with their power generating module and demand facility counterparts so as to not cause oscillations to the power system in particular between control areas.

The main issue discussed related to the droop control for all Electricity Storage Modules (including Type A) in particular for LFSM-O and LFSM-U. This requirement has been included as the storage plant transitions from import to export during low system frequencies. As an alternative for Type A Electricity Storage Modules operating in charging mode, randomised disconnection can be used in the same way as power generating modules described in Article 13(2)(b) of RfG with regard to LFSM-O operation.

INTERACTIONS WITH OTHER EXPERT GROUPS

As noted above in the section entitled "Interaction with other EU Codes" the parameters for operation of an electricity storage module during low frequency conditions are detailed in Table 1.0. It was noted by one member of the Expert Group that under the Pumped Storage Hydro Expert Group that it is proposed to stop pumping at frequencies of 49.0 Hz. or at a high frequency if required by the TSO and it has been suggested a similar approach should be adopted for storage.

As a general comment, it is recommended that upon completion of all the Expert Groups in June 2020, a co-ordination meeting is held to ensure consistency of the findings.

It is further noted that ENTSO-E are also working on the next iteration of the Connection Network Codes (RfG, HVDC and DCC). It is therefore recognised that the recommendations from this Expert Group and the other Expert Groups (Mixed Customer Sites and Pumped Storage Hydro) will need to feed into the wider work of ENTSO-E to enable updates to the next iteration of the Connection Network Codes.

TECHNICAL REQUIREMENTS

The technical requirements are an essential ingredient to this work, but the general approach adopted by EG Storage is that the technical requirements applicable to storage should be equitable and consistent with the requirements for Generation or Demand. In general, the requirements apply at the connection point as provided for in RfG and DCC. In addition, these technical requirements would apply irrespective of whether the storage plant operates in an importing or exporting mode of operation.

Requirement	Synchronous	Non-Synchronous
Frequency Range	Y	Y
Voltage Range	Y	Y
General Requirements	Y	Y
Simulation Models	Y	Y
Reactive Capability	Y	Y
Output Power with falling frequency	Y	Y
Black Start (Not Mandatory)	Y	Y
Island Operation	Y	Y
Frequency Response	Y	Y
Voltage Control	Y	Y
Neutral Earthing	Y	Y
Frequency and Voltage Deviations	Y	Y
Frequency, rate of change of frequency and voltage protection setting arrangements	Y	Y
Fault Ride Through	Y	Y
Fast Fault Current Injection	Y	Y
Frequency Sensitive Relays and load shedding or switching from import to export under low frequency conditions	Y	Y
Operational Metering	Y	Y
Data Communication and Instructor Facilities	Y	Y
Monitoring	Y	Y
Operation from import to export during low System Frequency Conditions	Y	Y
Electricity Storage Modules integrated within a Demand Facility and their ability to provide demand response services	Y	Y

Table 2.0

As part of the discussions, it was noted that P_{ref} used in RfG for frequency response calculation purposes (for example LFSM-O - RfG Art 13 (2), LFSM-U and FSM - RfG Art 15(2)) may be specified differently between synchronous power generating modules and power park modules. As storage is treated in the same way as generation, a synchronous electricity storage module would be treated in the same way as a synchronous power generating module and a non-synchronous electricity storage module would be treated in the same way as a power park module. On this basis storage would be treated in the same way as generation as specified in RfG.

Towards the end of the Expert Group, one member noted that due to the Generator Banding levels (Type A, B, C and D) across different member states, the threshold between Type B and C in some European countries is quite high being in the region of 10's of MW. As the current storage technologies are generally of lower magnitudes (ie 10MW and less) it is likely that the majority of them would fall into the Type A and B Band for which there are very limited requirements in respect of issues such as LFSM-U, FSM and reactive capability. The view was therefore raised as to whether additional requirements should be raised specifically with regard to storage alone. In other words, should LFSM-U, FSM and reactive capability, for example, be applied to storage alone. In the ACER report on the integration of electromobility (reference [2]) of this document there is no reference to this additional requirement.

This issue requires some further debate, but the argument is no different to that from other generation technologies – for example residential solar where there are very significant uptakes at low generator banding levels. As storage is the same as generation with a demand capability (in much the same way as pumped storage) the recommendation of the Expert Group is to treat these issues in the same way as generation. It is therefore suggested that the application of technical requirements to lower bands of storage for example the requirements for Type A and Type B to meet requirements for LFSM-U, FSM or reactive capability should be considered together with generation. As storage is treated in the same way as generation it is therefore believed that it is appropriate for this issue to be addressed by a future "Baseline type A" Expert Group with appropriate input from ENTSO-E.

Technical Requirements Spreadsheet

The Expert Group in developing the initial technical requirements prepared a spreadsheet outlining the technical requirements. A copy of this spread sheet is attached in Appendix B of this Report. These initial technical requirements include comments from the European Association for the Storage of Energy (EASE). As the dialogue within the Expert Group has progressed, the issues raised have been considered which has then resulted in suggested legal text shown in Appendix A of this report.

Models and Data Submission

With regard to models and data submission, these would be expected to the consistent with those required for power generating modules and demand facilities. The functionality of the plant to operate from an import mode of operation to an export mode of operation during low system frequency conditions would also be required.

Quality of Supply

The issue of quality of supply was also discussed by the Expert Group. An example in the Netherlands was citied in which there is growing concern over the rapid up take of fast electric vehicle chargers and batteries which is starting to have a significant impact on quality of supply issues, in particular, high frequency harmonics. It was noted within the RfG Code there is no requirement for quality of supply requirements as it is not considered as a cross border trade issue. There are however quality of supply provisions in Article 20 of DCC but these largely refer to requirements defined by the TSO. As such, it is proposed to leave the legal text of the RfG and DCC codes as they are, which would enable TSO's to have the flexibility to specify the quality of supply requirements at a local level.

The group did however discuss and consider the impact of fast electric vehicle chargers on the network (see Reference [3]). Whilst quality of supply issues (harmoincs, flicker etc) are not considered to have a cross border impact, it is very important that network owners and operators are aware of these issues, especially in view of the very significant growth of electric vehicles.

Derogations and Emerging Technologies

During the discussions, an expert group member raised the issue of derogations and emerging technologies, on the basis that there may be some storage technologies which may be unable to satisfy the proposed requirements. As noted above, the proposed requirements only relate to controllable electricity storage modules. That said, in the event of a new storage technology emerging in the future which is unable to meet the proposed requirements, then a derogation route is open to that developer. The suggestion of adopting an exemption for emerging storage technologies was discussed but was felt not to be appropriate on the basis that the emerging technology clauses covered in Articles 66 – 70 were introduced before RfG was approved and therefore there was nothing to derogate against. As a result, now that RfG is in place and storage is being treated as a subset of generation, the workgroup agreed that the need for special measures or emerging technology would not be necessary.

Treatment of Flexible Load

The Expert Group discussed the performance requirements for V1G Electric Vehicles during low system frequencies. The initial view was for a specific requirement to be included within DCC for V1G Electric vehicles, however the work group suggested that not only should this requirement apply to V1G electric vehicles but also other forms of flexible load such as heat pumps or refrigeration equipment.

The advantage of this approach is that demand is automatically reduced via a droop characteristic as the frequency starts to fall which will improve the overall robustness of the system during periods of stress.

The Expert Group initially considered the droop characteristic shown in Figure 4.0 below for the behaviour of V1G electric vehicles during times of low system frequencies which adopts a similar approach to that for all forms of storage shown in Figure 3.0 above.

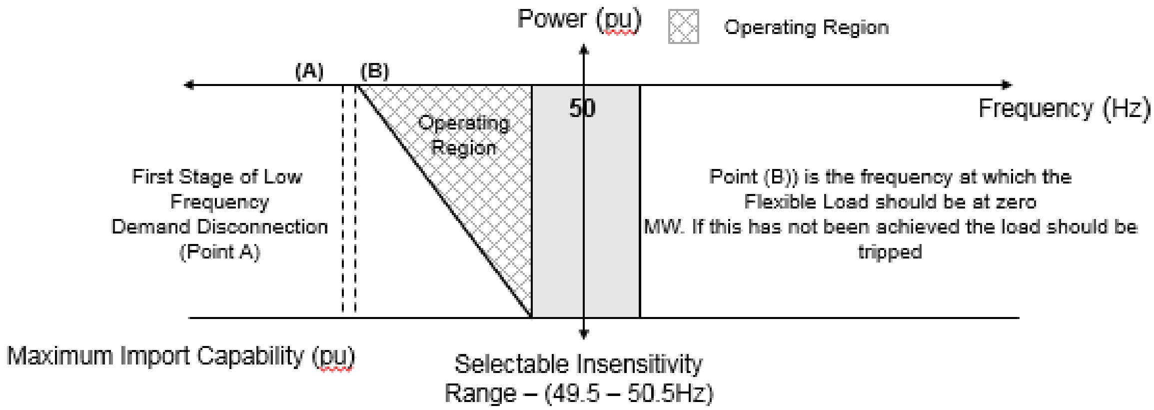


Figure 4.0

TSO defined Parameter	Unit	Range
Insensitivity	Hz	49.5 - 50.5
Power Gradient	MW/Hz or pu/Hz	Within operating range of Figure 1
Point A - First Stage of Low Frequency Demand Disconnection	Hz	TSO defined
Point B - Frequency at which the Flexible load should be at zero MW	Hz	TSO defined
Frequency setting at which the flexible load should be tripped if it is unable to meet the operating characteristic of Figure 1 within time t1.	Hz	49.8 - 48.8Hz
Time t1 - Maximum Operating time for complete characteristic	s	1 - 25
Time t2 - Initiation time from inception of frequency fall	s	0 - 5

Table 3.0

The Expert Group fully supported this approach but acknowledged that as the requirement applied equally to other flexible loads and that a V1G electric vehicle(s) would be included under the general definition of demand, then this requirement would fall outside the scope of the terms of reference of the Expert Group. It is therefore recommended this proposed requirement is highlighted to the ENTSO-E Steering Group for future action, though members of the Expert Group acknowledged that any delay would be a missed opportunity, especially at a time when there is rapid uptake in the volume of flexible loads not least V1G electric vehicles.

It should be noted that for any flexible load, the above characteristic would be applied before the operation of low frequency demand connection scheme which would apply to all non-critical loads but for which there would still be a noticeable customer impact. For the avoidance of doubt, a flexible load is one in which an interruption to supply would have no noticeable effect in the short term, whereas a non-critical load has a noticeable affect – for example loss of supply at domestic residences, shops, offices, industrial premises etc where as a critical load would be something like a hospital, airport or traction supply.

STANDARDS APPLICABLE TO STORAGE

The Expert Group discussed the standards applicable to storage. These include:

- EN50549-1 and -2
  - applicable for LV and MV connection
  - based on RfG requirements (+other requirements based on the needs regarding DSO connections
  - storage included (ESS) Synchronous and Non-Synchronous Categories - implicitly applicable for storage
  - It has however been noted by the Expert Group that IEC50549-1 and -2 is in need of further updating.
- IEC Standards IEC 62933 / 62786
  - define requirements for connection of storage devices, state of approval IEC 62933 is currently under preparation - linkage between IEC 62933 / 62786
- IEC 62933-1 standard gives the following definitions:
  - Electrical Energy Storage (EES): The installation can absorb electrical energy, to store it for a certain amount of time and to release electrical energy during which the energy conversion processes may be included.
  - Electrical Energy Storage System (EES system or EESS): A Grid-connected installation with defined electrical boundaries, comprising at least one electrical energy storage unit, which extracts electrical energy from an electric power system, stores this energy internally in some manner and injects electrical energy into an electrical power system and which includes civil engineering works, energy conversion equipment and related ancillary equipment
- IEC 61851 - Is an international standard for electric vehicle conductive charging systems, parts of which are currently still under development.

COMPLIANCE

The compliance provisions applicable to storage would be expected to be consistent with those for Generation, HVDC and Demand, as set out in the respective three European Connection Codes.

In the case of storage, it is assumed that compliance would be with respect to the Module in the same way as generation. Thus, for a new Power Generating Module, it would take into account the capacity of the complete module. For example, in the case of an installation comprising a new power generating module and a new storage module (eg the storage module is used to improve the performance of the generating plant – such as by providing enhanced FSM capability or reactive power capability) compliance would be assessed on the total Maximum Capacity of the installation (eg if the Maximum Capacity of the Power Generating Module is 100MW and the Maximum Capacity and Maximum Consumption Capacity of the Storage Module is 20MW (ie 20MW import and 20MW export), then compliance would be assessed on a total Maximum Capacity declared by the owner which would be 120MW and a Maximum Consumption Capacity of 20MW. On the other hand, it is likely that the plant owner may wish to declare the maximum capacity of the installation (Storage and Power Generating Module) to be 100MW in which case compliance would be assessed on a Maximum Capacity of 100MW. There is also the situation where the owner may wish to operate the two plants (storage plant and generating plant) independently. This however is a decision for the owner and reflects the fact that it may wish to utilise the capability of the storage plant to supplement the capability of the power generating module in which case it would be registered as one plant. Ultimately how the developer wishes to operate the plant is a decision of the developer but it is important the codes are sufficiently flexible to permit this form of operation without diluting the necessary technical requirements. Examples of different configurations and the requirements expected are covered in the technologies, applications, topologies and implementation section of this report.

On another hand, if the objective is to install a storage plant on an existing facility (generation or demand), which the developer chooses to independently control from the main generating or demand plant, then compliance would be assessed independently on the storage plant and separately on the generation/demand unit.

The majority of the updates have been added to RfG. Very minor updates have been added to DCC and no changes have been added to the HVDC Code. The compliance requirements would be expected to be the same as the original requirements in the current draft of the EU Connection Network Codes (RfG, HVDC and DCC) with additions added where new requirements have been added – for example the transition from import to export during low system frequencies).

It is acknowledged by the Expert Group that an Implementation Guidance Document (IGD) would be a helpful addition to those developers who wish to understand how the Connection Network Codes apply to storage which is installed at the same site with either or both Generation / Demand. Naturally interpretation of these requirements would have a bearing on compliance.

NATIONAL IMPLEMENTATION APPROACHES

As part of the Expert Group discussions, a number of Member States have been developing their own requirements and approaches to storage. Some of them summarized below.

Great Britain

In GB, the issue of how storage is proposed to be implemented into the national Grid Code has been well documented in Phase I of the report. These proposals were approved by the GB Regulator (Ofgem) on 20th May 2020 and will be implemented into the GB Grid Code on 4th June 2020. A link to this work is attached for information.

https://www.nationalgrideso.com/codes/grid-code/modifications/gc0096-energy-storage

In addition to this work, GB has also been implementing the EU Emergency and Restoration Code which has given some consideration to the behaviour of electricity storage units during low system frequencies whilst under an importing mode of operation. Due to the implication on existing storage units, this approach has not been taken forward, but it is certainly something for future consideration. A link to this workgroup is attached for information.

https://www.nationalgrideso.com/codes/grid-code/modifications/gc0127-eu-code-emergency-restoration-requirements-resulting-system

Germany

In Germany, VDE|FNN defines in the technical connection rules requirements for connection and parallel operation with the electrical grid, that fulfil both the EU specifications and the specifics for the German electric power system. Users that comply with these national codes of practice will also adhere to the European Network Codes. The following technical rules are applicable for storage as a part of the National Standardization Document Set: VDE-AR-N 4100, VDE-AR-N 4105, VDE-AR- N 4110, VDE-AR-N 4120, VDE-AR-N 4130 (available also in English).

The German technical connection rules distinguish between voltage levels since the requirements for grid connection depend on them. Storage / storage systems are explicitly included into the scope of these technical rules. Moreover, they have separate paragraphs with specific requirements.

France

In France the work on connection requirements for storage technologies is just starting.

The main technology identified is electrochemical storage (battery) connected to the electrical network through power electronics. As this technology could be comparable to PV plant regarding grid connection, the approach would be to start from RfG requirements (PPM) and to work on similar requirements. The work would then be extended to other technologies.

Belgium

In Belgium technical requirements for storage have been discussed on 2 levels.

The first level is that of the transmission system, for which there is a Federal Technical Grid Code. This code has been amended thoroughly due to e.g. the requirements stemming from the network codes and guidelines. The text of the Federal Technical Grid Code has been published as a Royal Decree of 22 April 2019, available through: http://www.ejustice.just.fgov.be/mopdf/2019/04/29_1.pdf#Page16

This Federal Technical Grid Code contains technical connection requirements for connection of storage modules from type A to type D and which are very similar and some identical to the NC RfG requirements.

The second level is that of the distribution systems, for which the requirements for the connection of storage devices are included in the C10/11 prescriptions of the DSOs (C10/11 = specific technical requirements for decentralized generation working in parallel on the distribution grid). This C10/11 prescription has equally gone through a very important review, mainly due to the new standards EN 50549-1 and -2 on which the C10/11 is based and also due to the new requirements in the NC RfG. Since EN 50549-1 and -2 cover storage requirements, the new C10/11 also covers in the same way requirements for storage devices. The new version of the C10/11 document was published on 1 September 2019 and is available here:

http://www.synergrid.be/download.cfm?fileId=Technical_prescription_C10-11_ed2-1_20190901_tekst_EN.pdf

Netherlands

In the Netherlands, the work on connection requirements for storage technologies hasn't been started yet. Till now, the technical connection rules are still projected with respect to the connection point. For generators or demand behind the connection point (at the customers side), compliance is with respect to RfG and DCC.If there is storage on the customer side, then there is asked for compliance to the grid codes on the connection point, compared to the behavior of the storage component.

Italy

In Italy the technical requirements for connecting to the network are described in three main documents: CEI 0-21 for LV system, CEI 0-16 for MV system and TERNA Grid Code for HV system.

The technical requirements for storage system are already described in such documents, including their definition and testing procedure. The approach used in the Italian standards is unit based rather and the requirements that applies to the storage system must be considered as for the single unit, exception made when they are connected on the DC side of the inverter. In this case the inverter will be the focus point of the requirements.

It has to be said that, as described in the definitions of the CEI standards, the storage definition ("Sistema di Accumulo") is related to chemical storage (batteries) connected to the grid using a dedicated inverter. The testing procedure is basically structured in a similar format of the other technologies and permits the certification of family products. The standards are continuously evolving and CT316 committee very active. The links to the CEI website where the CEI can be downloaded:

https://www.ceinorme.it/it/norme-cei-0-16-e-0-21.html

Link to TERNA Grid Code (English):

https://www.terna.it/en-gb/sistemaelettrico/codicedirete.aspx

ASSUMPTIONS

So far as the legal text is concerned, it is assumed that any changes to the Connection Network Codes (RfG, HVDC and DCC) which are necessary to accommodate storage technologies, will be integrated with other measures, for example mixed customer sites, pumped storage hydro and application of other requirements at a lower banding level. It is assumed that these measures will initiate a new version of the Connection Network Codes and therefore the date from when they will apply. As such, the changes suggested to the legal text does not include the date from when the requirements would be expected to apply.

RECOMMENDATIONS

The recommendations of the Expert Group Storage based on the evidence presented are as follows:

1) The Expert Group Storage considers that Electricity Storage is best defined as “the conversion of electrical energy into a form of energy which can be stored, the storing of that energy and the subsequent reconversion of that energy back into electrical energy. This definition is harmonious with the definition of Energy Storage in the Clean Energy Package.
2) Electricity Storage Modules effectively can be treated as two types, these being Synchronous Electricity Storage Modules or Non- Synchronous Electricity Storage Modules. A Synchronous Electricity Storage Module would be treated in the same way as a Synchronous Power Generating Module and a Non-Synchronous Electricity Storage Module would be treated in the same way as a Power Park Module. Where Energy Storage plants exist (ie they simply convert electricity into any other energy medium for onward conversion without re-converting that energy into electrical energy at that connection point) then this would be treated as demand or a demand response service(s).
3) The Expert Group agreed that two broad connection configurations exist, these being a standalone site or a site where storage is integrated or operated with generation or demand. It is recognised that there are many different permutations and combinations of different plant topologies. In order to provide developers with a better understanding of the applicable requirements for different storage configurations it is recommended a Implementation Guidance Document (IGD) is prepared.
4) The Expert Group believe that it is appropriate for certain forms of electricity storage devices to be excluded from the requirements- for example Synchronous Flywheels, Synchronous Compensators and Regenerative braking systems. These technologies are either are incapable of controlling active power or solely control reactive power. As they do not fall within the definition of an Electricity Storage Module or Power Generating Module it is down to the TSO to define the applicable requirements necessary to protect the integrity of the System.
5) The Expert Group agreed that operational data requirements applicable to storage fall outside the scope of this CNCs related work (as operational and data matters fall within the other, non-connection related, European Network Codes - eg SOGL).
6) The Expert Group agreed that technical capabilities should be included into the connection network codes with operational requirements defined in the operational network codes. This approach substantially minimises the amount of alteration required to the other EU Codes.
7) This report and the connection network codes assume that electric vehicles (V1G’s and V2G’s) fall within the scope of the connection network codes but do not require special treatment. A V1G would fall within the scope of demand (as codified under DCC) and a V2G would fall under the scope of generation (codified under RfG). This approach is consistent with the findings of the ACER position paper (see reference [2]) but it is noted the ACER position paper goes into a greater level of detail.
8) The Expert Group discussed the capability of storage units from changing mode from import to export or to stop operation in the import mode under low frequency conditions

which is a requirement of Article 15(3) of the Emergency and Restoration Code. This issue has now been addressed and included in this report and RfG. The approach adopted is flexible enabling a great selection of values to be adopted at a member state / TSO level. The requirement applies to all Type A, Type B, Type C and Type D Electricity Storage Modules.

9) The Expert Group considered the technical requirements for V1G electric vehicles during periods of low system frequencies. It was initially suggested to include a specific requirement in DCC for this purpose but it was agreed that a V1G was no different to any other form of site containing flexible load – for example heat pumps or refrigeration equipment. The Expert Group believed this requirement should not be delayed as it is important requirement, but it was agreed that it was outside the terms of reference of the group. The Expert Group sees a potential contradiction with the requirement of Art. 15.3 of the Emergency and Restoration code and believes the E&R code has to be respected. This issue in particular needs to be assessed by the European Stakeholder Committee.It is recommended that following submission of the final reports, the Expert Groups (Storage, Mixed Customer Sites and Pumped Storage Hydro) compare the findings so there is consistency in the requirements going forward.

10) Whilst Quality of Supply issues are not considered to have an impact on cross border trade, the Expert Group was made aware of the very significant challenges that fast electric vehicle chargers could have on the network. This is likely to be an increasing problem as the volume of electric vehicles is expected to grow significantly in the future. Network Owners and Operators need to be aware of this issue. In this respect readers are encouraged to look at the issues presented in Reference [3] of this report.

11) The Expert Group noted that as many storage applications are limited in size, many of them will fall into the Type A or Type B Power Generating Module category. There is concern that whilst many of them are quite small on an individual basis, the cumulative effect on the network is more significant. There was some discussion as to whether requirements such as LFSM-U, FSM and Reactive Capability should be applied to storage at lower levels. As storage is treated in the same way as generation and the issue is no different to some other forms of generation technology (eg residential solar) it is recommended that this issue is addressed by the future “Baseline type A” Expert Group with appropriate input from ENTSO-E.

LIST OF PARTICIPANTS

Name	Organisation	Representation at GC ESC
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REFERENCES

[1] Phase I Storage Expert Group Report

[2] ACER - Technical position paper concerning the integration of electromobility in the scope of amendments of the Network Codes Requirements for Generators and Demand Connection Code - May 2020

[3] Electric Vehicle Charging and Power Quality – Supraharmonic effects and impact – presentation by Tim Slangen and Thijs van Wilk – Elaadnl.

All the above references are available from the ENTSO which are available from ENTSO-E upon request.

All the agenda's, meeting material, minutes and discussions are also available on the ENTSO which are available from ENTSO-E upon request.

Appendix A - Extracts of proposed Legal Text

HVDC Code

There are no proposed legal text changes proposed for the HVDC Code.

Demand Connection Code (DCC)

Article 3(2)(b)

~~(b) storage devices except for pump-storage power generating modules in accordance with Article 5(2).~~

Article 27(4)

3. Electricity storage modules are required to satisfy the requirements of section 15.3. of EU 2017/2196. For the avoidance of doubt this requirement is not considered to be a demand response service.

Requirements for Generators (RfG)

Title

Establishing a network code on requirements for grid connection of generators and electricity storage

Whereas

(3) The requirements on electricity storage are considered to be the same as those on power generation modules unless explicitly stated otherwise in this Regulation. In the case of electrical equipment such as synchronous compensators, flywheels and regenerative braking systems which do not fall onto the definition of a power generating module or electricity storage module, it is down to the relevant TSO to define the technical requirements that apply*.

(4) For the purpose of this regulation, electricity storage is defined as "The conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy". For the avoidance of doubt this definition includes electric vehicles*.

(32) An electricity storage module connected to a network by a synchronous generator has to meet the same requirements as a synchronous power generating module and an electricity storage module connected to a network by a non-synchronous generator or through power electronics has to meet the same requirements as a power park module (which could include electric vehicles).

* Note the additional recitals number (3) and (4) would appear after recital (2) to ensure consistency with recitals (1) and (2). Recital (66) is a new recital which can be added to the end of the "Whereas" section.

Article 1 – Subject Matter

This Regulation establishes a network code which lays down the requirements for grid connection of power-generating facilities (which includes electricity storage which can inject and consume electrical energy to and from the network), namely synchronous power-generating modules, power park modules, , offshore power park modules, to the interconnected system. 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.

Article 2 - Definitions

(5) power-generating module' means either a synchronous power-generating module or a power park module. A power generating module includes an electricity storage module.

(66) 'electricity storage' means the conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy.

(67) 'electricity storage module' is a power generating module which can inject and consume active power to and from the network.

(68) 'maximum consumption capacity' means the maximum continuous active power which an electricity storage module can import from the network,

Note:- Definitions (66), (67) and (68) are new definitions to be added to RfG. Definition (5) is an existing definition with an amendment.

Article 3 - Scope of Application

Article 3(2)(d)

~~(d) storage devices except for pump-storage power-generating modules in accordance with Article 6(2).~~

Article 6 - Application to power generating modules, pump-storage power generating modules, combined heat and power facilities and industrial sites

5. An electricity storage module shall be capable of satisfying the requirements of this Regulation irrespective of whether the electricity storage module injects and consumes active power to and from the network.

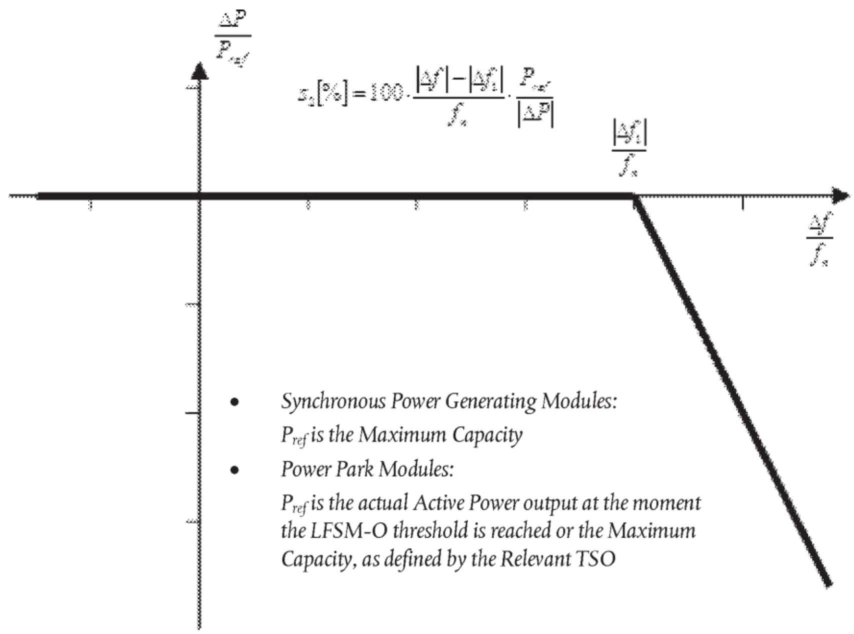
Article 13 - General Requirements for Type A power-generating modules

Article 13(2)

(h) An electricity storage module which is absorbing active power during an overfrequency event shall increase the level of active power absorbed according to the LFSM-O characteristic which shall be considered in terms of the power variation rather than the absolute value. The electricity storage module will absorb power up to filling the maximum energy that it is able to store, then it will cease consumption The TSO can define a different characteristic or establish that the electricity storage module when absorbing active power will maintain the absorption level even during the overfrequency event.

Figure 1

active power frequency response capability of power-generating modules in LFSM-O



P_{ref} is the reference active power to which ΔP is related and may be specified differently for synchronous power- generating modules and power park modules. ΔP is the change in active power output from the power-generating module. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network. At overfrequencies where Δf is above Δf_1, the power-generating module has to provide a negative active power output change according to the droop S_2. In the case of electricity storage modules, Pref could be the maximum capacity or the maximum consumption capacity at the moment the LFSM-O threshold is reached or the maximum capacity or maximum consumption capacity as agreed with the relevant system operator.

Article 13(6)

6. The power-generating module shall be equipped with a logic interface (input port) in order to cease active power output or active power input within five seconds following an instruction being received at the input port. The relevant system operator shall have the right to specify requirements for equipment to make this facility operable remotely. Each electricity storage module shall also be equipped with an input port to cease active power import upon instruction of the relevant system operator.

Article 13(8)

8. With regard to the limited frequency sensitive mode — underfrequency (LFSM-U) an electricity storage module operating in a consumption mode, the requirements of Annex I of this regulation apply.

Article 14 - General requirements for type B power-generating modules

Article 14(2)(a)

(a) to control active power output, the power-generating module shall be equipped with an interface (input port) in order to be able to reduce active power output following an instruction at the input port. In the case of an electricity storage module consuming active power, the electricity storage module shall be capable of modulating the import of active power following an instruction at the input port; and

Article 15 - General requirements for type C power-generating modules

Article 15(2)(c)(vi)

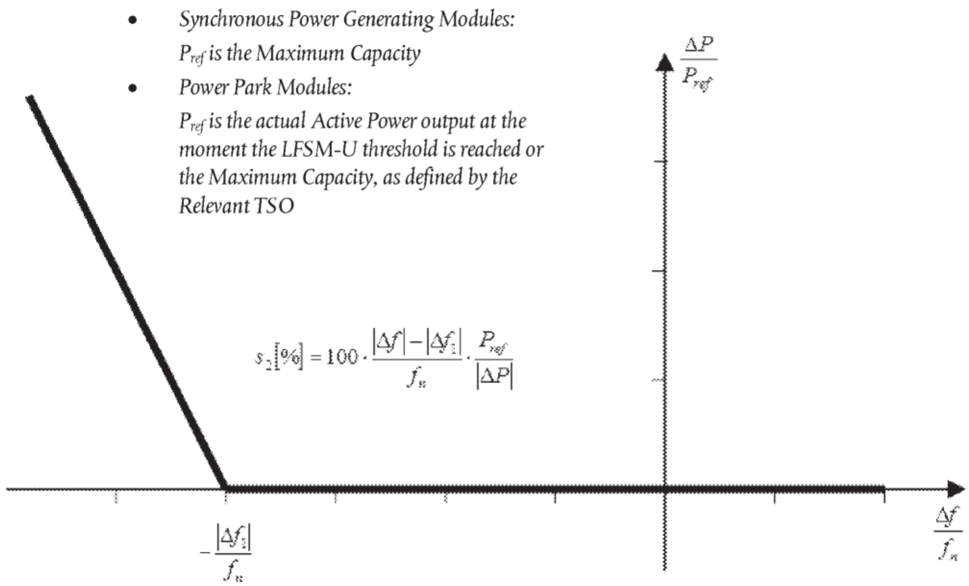
(vi) For an electricity storage module, these requirements shall apply when the electricity storage module is in an injecting mode of operation. Where the electricity storage module is in an importing mode of operation the requirements of Annex I shall apply.

Article 15(2)(d)

(vi) For an electricity storage module, these requirements shall apply when the electricity storage module is in an injecting mode of operation. Where the electricity storage module is in an importing mode of operation the requirements of Annex I shall apply.

Figure 4

ACTIVE POWER FREQUENCY RESPONSE CAPABILITY OF POWER-GENERATING MODULES IN LFSM-U



P_{ref} is the reference active power to which ΔP is related and may be specified differently for synchronous power-generating modules and power park modules. ΔP is the change in active power output from the power- generating module. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network. At underfrequencies where Δf is below Δf_1 the power-generating module has to provide a positive active power output change according to the droop S_2

In the case of electricity storage modules, Pref could be the maximum capacity or the maximum consumption capacity at the moment the LFSM-U threshold is reached or the maximum capacity or maximum consumption capacity as agreed with the relevant system operator.

Article 15(2)(d)(i)

(i) the power-generating module shall be capable of providing active power frequency response in accordance with the parameters specified by each relevant TSO within the ranges shown in Table 4. In specifying those parameters, the relevant TSO shall take account of the following facts:

— in case of overfrequency, the active power frequency response is limited by the minimum regulating level. For electricity storage modules, the active power frequency response may be limited by the minimum regulating level or maximum consumption capacity, or the maximum energy content that the electricity storage module can store or as agreed between the power generating facility and the TSO.

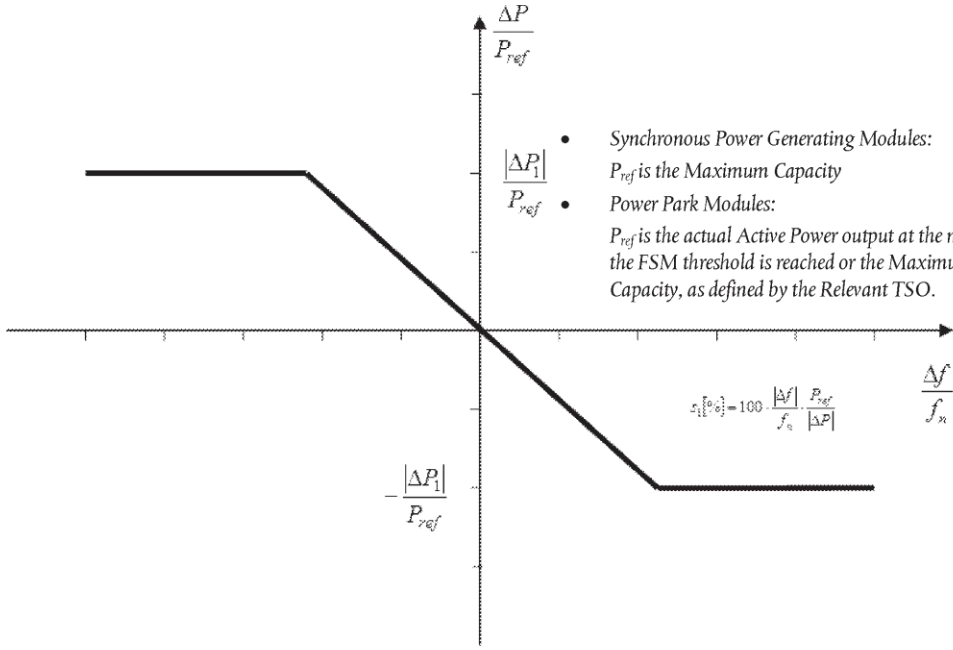
— in case of underfrequency, the active power frequency response is limited by maximum capacity, and, in case of electricity storage modules, also by the maximum consumption capacity or maximum energy content of the electricity storage module or as agreed between the power generating facility and the TSO.

— the actual delivery of active power frequency response depends on the operating and ambient conditions of the power-generating module when this response is triggered, in particular limitations on operation near maximum capacity at low frequencies according to paragraphs 4 and 5 of Article 13 and available primary energy sources;

— The TSO shall take into account the time needed for some technologies of electricity storage modules to switch from consumption mode to generating mode or vice versa and also the fact that the droop in consumption and generating mode could be different.

Article 15(2)(d) – Figure 5

Active power frequency response capability of power-generating modules in FSM illustrating the case of zero deadband and insensitivity



P_{ref} is the reference active power to which ΔP is related. ΔP is the change in active power output from the power-generating module. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network.

In the case of electricity storage modules, Pref could be the maximum capacity or the maximum consumption capacity at the moment the FSM threshold is reached or the maximum capacity or maximum consumption capacity as agreed with the relevant system operator.

Article 15(2)(f)

(f) with regard to disconnection due to underfrequency, power-generating facilities capable of acting as a load, including hydro pump-storage power-generating facilities and electricity storage modules, shall be capable of disconnecting their load in case of underfre-quency. The requirement referred to in this point does not extend to auxiliary supply;

Article 21(3)(vi)

(vi) for the purpose of power factor control mode, the power park module shall be capable of controlling the power factor at the connection point within the required reactive power range, specified by the relevant system operator according to point (a) of Article 20(2) or specified by points (a) and (b) of Article 21(3), with a target power factor in steps no greater than 0,01. The relevant system operator shall specify the target power factor value, its tolerance and the period of time to achieve the target power factor following a sudden change of active power output. The tolerance of the target power factor shall be expressed through the tolerance of its corresponding reactive power. This reactive power tolerance shall be expressed by either an absolute value or by a percentage of the maximum reactive power of the power park module; The relevant system operator shall consider the appropriate requirements for electricity storage modules when specifying power factor control at operation near zero active power;

Article 48(4)(a)

(a) the power park module's technical capability to continuously modulate active power over the full operating range between maximum capacity and minimum regulating level to contribute to frequency control shall be demonstrated. The steady-state parameters of regulations, such as insensitivity, droop, deadband and range of regulation, as well as dynamic parameters, including frequency step change response shall be verified. In the case of an electricity storage module, the full operating range is between maximum consumption capacity and maximum capacity;

Annex I - This is a new Annex for RfG specifically for Electricity Storage Modules

ANNEX I

Additional Requirements applicable to Electricity Storage Modules

Scope

The requirements of Annex I of this Regulation (EU) 2016/631 only apply to electricity storage modules.

Section I1 -Capability at low system frequency

1. When an electricity storage module is operating in a consumption mode (absorbing power) and prior to the activation of the automatic low frequency demand disconnection scheme, each electricity storage module shall be capable of automatically switching to a generation mode (generating power) in accordance Figure 10. The parameters for this capability shall be specified by the TSO within the range specified in Table 12.

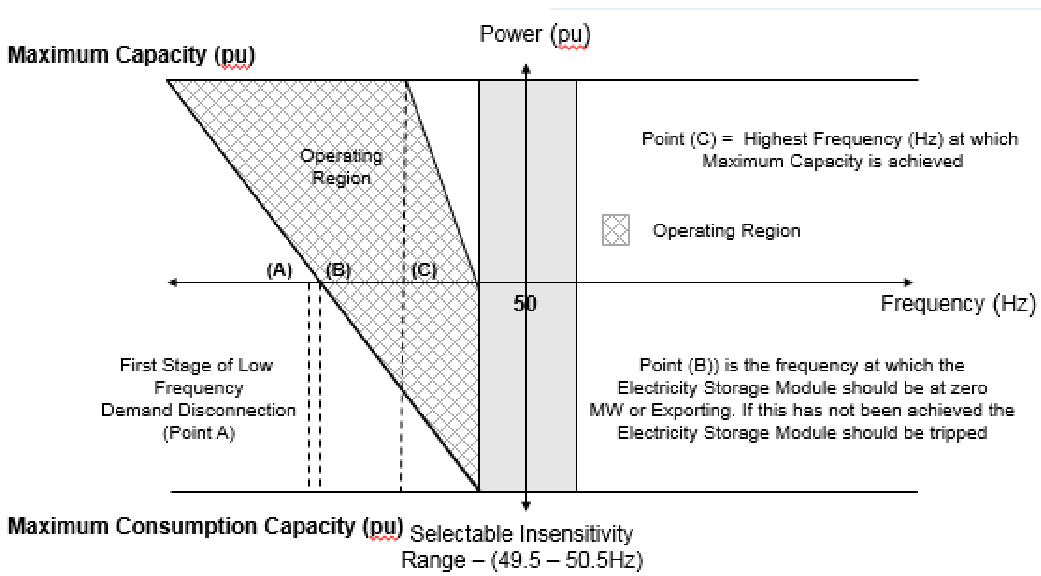


Figure 10

2. The TSO shall specify the time limit for which the electricity storage module shall automatically switch from a consumption mode (absorbing power) to an injection mode (generating power).

3. If the electricity storage module is not capable of switching from a consumption mode (absorbing power) to an injection mode (generating power) within a time limit specified by the TSO, it shall be tripped at a system frequency to be defined by the TSO. The TSO shall ensure that in setting a time limit, it does not result in unacceptable transients (including but not limited to voltages or temporary overvoltage transients (TOV's) or frequency transients)) on the network.

4. The TSO can specify the value of the power gradient anywhere in the shaded operating region of Figure 10. This requirement only applies to electricity storage modules transitioning from a consumption mode of operation (absorbing power) to an injecting mode of operation (generating power).

5. The TSO shall specify the frequency insensitivity range.

6. Instead of the capability referred to in Section I1 above, the relevant TSO may choose to allow within its control area automatic disconnection of Type A electricity storage modules at randomised frequencies ideally uniformly distributed above a frequency threshold as determined by the relevant TSO where it is able to demonstrate to the relevant regulatory authority and with co-operation of power generating facility owners that this has limited cross border impact and maintains the same level of operational security in all system states.

TSO defined Parameter	Unit	Range
Insensitivity	Hz	49.5 – 50.5 Hz
Power Gradient	MW/Hz or pu/Hz	Within operating range of Figure 10
Point A - First Stage of Low Frequency Demand Disconnection	Hz	TSO defined according to the E&R (EU 2017/2196) code
Point B – Frequency at which the Electricity Storage Module should be at zero	Hz	TSO defined according to the E&R (EU 2017/2196) code
Point C – Frequency at which Maximum Export Capability can be reached	Hz	49.6 – 49.0Hz
Time t1 – Maximum Operating time for complete characteristic	s	TSO defined in the range 1 – 25s
Time t2 – Initiation time from inception of frequency fall	s	TSO defined in the range 0 – 5s
Final Loading Point following frequency fall	MW	0 – Maximum Capacity

Table 12

Section I2 - Additional Data, Compliance Tests and Simulations for Power Generating Modules which incorporate electricity storage

1 . Power Generating Facility Owners who own a Type B, C and Type D electricity storage module and which are capable of switching from a consumption mode (absorbing power) to an injection mode (generating power) as detailed above shall:-

i) Submit a true and accurate dynamic model of the plant as built and the associated data to demonstrate the ability of the plant to satisfy the requirements in Section I1.

ii) Electriity storage modules shall be assessed through the injection of frequency signals into the power generating modules control system to demonstrate the ability of the plant to change from a consumption mode to a generating mode during low system frequencies.

Appendix B
Initial Technical requirements and Comments

Copy of 2020.05.14
- EG STORAGE draft