European Network of
Transmission System Operators
for Electricity

NETWORK CODE FOR REQUIREMENTS FOR GRID CONNECTION APPLICABLE TO ALL GENERATORS

FREQUENTLY ASKED QUESTIONS

24 JANUARY 2012

Disclaimer: This document is not legally binding. It only aims at clarifying the content of the draft network code for requirements for grid connection applicable to all generators. This document is not supplementing the final network code nor can be used as a substitute to it.

Foreword:

ENTSO-E has been instructed by Regulation (EC) N°714/2009 with the responsibility to draft network codes for providing and managing effective and transparent access to the transmission networks across borders, and to ensure coordinated and sufficiently forward-looking planning and sound technical evolution of the transmission system in the European Union, with due regards to the environment.

The elaboration process of the network codes is entirely a new legal tool which has not been experienced before. It should allow the European Commission to adopt a piece of legislation which will reflect the sound technical expertise and know-how of the European Transmission System Operators. ENTSO-E is in charge of drafting network codes upon request of the European Commission and in line with the framework guidelines specified by the Agency for the Cooperation of Energy Regulators (ACER). These network codes will then be submitted to ACER who will, if satisfied, recommend them to the European Commission for adoption via Comitology. A more detailed description of the network Code development process is provided in response to FAQ 2.

ENTSO-E is committed to ensure thorough public consultation on its draft network codes before submission to ACER and is seeking for your expert views. Since the development process of the network codes is quite complex and has been a learning experience for all involved parties, ENTSO-E has therefore prepared this FAQ document to clarify the network code for requirements for grid connection which is applicable to all generators and explains the reasoning supporting the proposed requirements.

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Frequently Asked Questions

As used in this paper, the capitalized words and terms shall have the meaning ascribed to them in the draft network code.

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Answer to FAQ 1:

What are the "cross-border network issues and market integration issues"?

Regulation (EC) 714/2009 Article 8 (7) defines that "*the network codes shall be developed for cross-border network issues and market integration issues and shall be without prejudice to the Member States' right to establish national network codes which do not affect cross-border trade*".

The terms "cross-border network issues and market integration issues" are not defined by the Regulation. However, ENTSO-E's understanding of the terms has been derived from the targets of the EC 3rd legislative package for the internal electricity market:

- supporting the completion and functioning of the internal market in electricity and cross-border trade
- facilitating the targets for penetration of renewable generation
- maintaining security of supply

Based on these targets and in the context of the network codes for grid connection, the following interpretation of the terms "cross-border network issues and market integration issues" has been taken as a guiding principle:

The interconnected transmission system establishes the physical backbone of the internal electricity market. TSOs are responsible for maintaining, preserving and restoring security of the interconnected system with a high level of reliability and quality, which in this context is the essence of facilitating cross-border trading.

The technical capabilities of the users play a critical part in system security. TSOs therefore need to establish a minimum set of performance requirements for generators connected to their network. The performance requirements include robustness to face disturbances and to help to prevent any large disturbance and to facilitate restoration of the system after a collapse.

Secure system operation is only possible by close cooperation of power generating facilities connected at all voltage levels with the network operators in an appropriate way, because the system behavior especially in disturbed operating conditions largely depends on the response of Generating Units in such situations. With respect to system security the transmission system and the Generating Units need to be considered as one entity. It is therefore of crucial importance that Generating Units are able to meet the requirements and to provide the technical capabilities with relevance to system security.

Moreover, harmonization of requirements and standards at a pan-European level (although not an objective in itself) is an important factor that contributes to supply-chain cost benefits and efficient markets for equipment, placing downwards pressure on the cost of the overall system.

To ensure system security within the interconnected transmission system and to provide an adequate security level, a common understanding of these requirements to power generating facilities is essential. All requirements that contribute to maintaining, preserving and restoring system security in order to facilitate proper functioning of the internal electricity market within and between synchronous areas and to achieving cost efficiencies through technical standardisation shall be regarded as "cross-border network issues and market integration issues".

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Answer to FAQ 2:

What is the relationship between the framework guidelines and network codes – what are the responsibilities of both and what is the process of network code development?

The relationship between framework guidelines and network codes as well as the process for the establishment of network codes are defined by Article 6 of Regulation (EC) 714/2009.

The Agency for the Cooperation of Energy Regulators (ACER), on request of the European Commission (EC), shall submit to EC, within a reasonable period of time not exceeding six months, a non-binding framework guideline. This framework guideline will set out clear and objective principles for the development of network codes, covering cross-border network issues and market integration issues relating to the following areas and taking into account, if appropriate, regional specificities:

- network security and reliability rules including rules for technical transmission reserve capacity for operational network security;
- network connection rules;
- third-party access rules;
- data exchange and settlement rules;
- interoperability rules;
- operational procedures in an emergency;
- capacity-allocation and congestion-management rules;
- rules for trading related to technical and operational provision of network access services and system balancing;
- transparency rules;
- balancing rules including network-related reserve power rules;
- rules regarding harmonized transmission tariff structures including locational signals and inter-transmission system operator compensation rules; and
- energy efficiency regarding electricity networks.

Each framework guideline shall facilitate non-discrimination, effective competition and the efficient functioning of the market.

Based on such a framework guideline the EC shall request ENTSO-E to submit a network code which is in line with the relevant framework guideline to ACER within a reasonable period of time not exceeding 12 months.

If ACER assesses that the network code is in line with the relevant framework guideline, ACER shall submit the network code to the EC. The EC will then initiate the comitology process to give the network codes binding legal effect. It is likely that the network codes through the commitology process will become European Union (EU) regulations making the provisions of the network codes applicable in all Member States immediately without further transposition into national legislation.

The main objective of the framework guidelines is to highlight **which** emerging questions/problems should be solved, leaving the approaches on **how** to solve them to the related network code(s). Figure 1 provides an overview on the complete process of framework guideline and network code development.

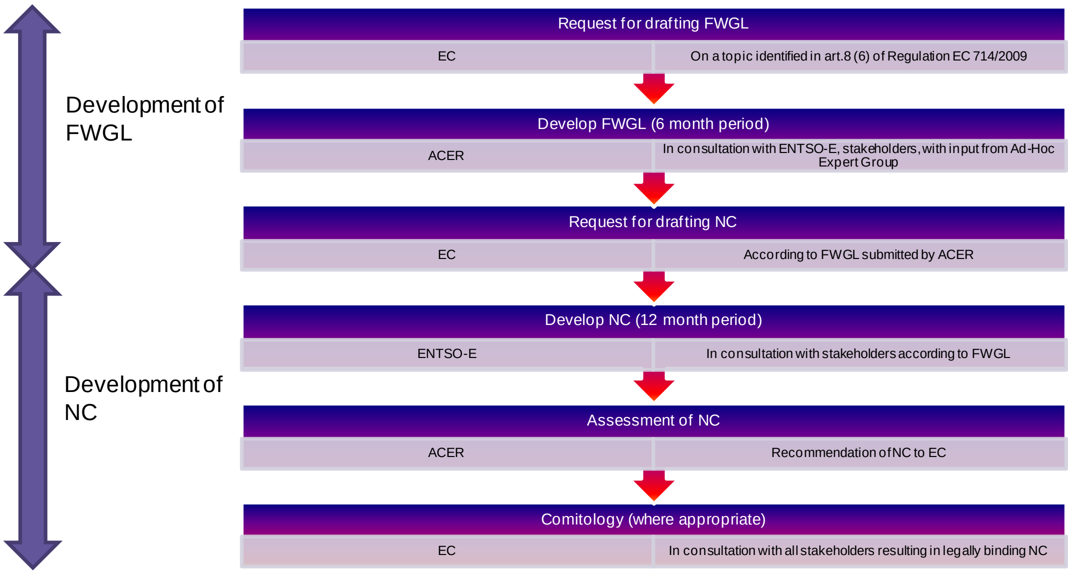

Figure 1: Framework guideline (FWGL) and network code (NC) development process

As reflected in the public consultation[1] launched by the EC "Establishment of the priority list for the development of network codes for 2012 and beyond" that ended on 10th of April 2011, one or more network code(s) may correspond to a single framework guideline. The ACER framework guidelines on grid connections[2] were published on 20 July 2011. In total, four codes are anticipated in the next three years: connection of generation, connection of demand, connection of HVDC circuits and connection procedures. For the last two topics, no starting date for the formal network code development process has yet been given.

In accordance with Article 10 of Regulation (EC) 714/2009, ENTSO-E shall conduct an extensive consultation process while preparing the network codes, at an early stage and in an open and transparent manner, involving all relevant market participants, and, in particular, the organisations representing all stakeholders. That consultation shall also involve national regulatory authorities and other national authorities, supply and generation undertakings, system users including customers, distribution system operators, including relevant industry associations, technical bodies and stakeholder platforms. It shall aim at identifying the views and proposals of all relevant parties during the decision-making process.

In addition to this legal obligation, ENTSO-E has conducted an extensive dialogue with stakeholders in a pilot project before starting the official development of the network code on grid connection requirements for generators. This cooperation with stakeholders has been managed by means of two public workshops on 16th of April 2010 and 05th of November 2011, that attracted around 100 participants each, and about 15 bilateral meetings with European associations that addressed in depth technical issues. The response of this open approach has been overwhelming: more than 1500 comments from stakeholders were registered and thoroughly considered, the network code was updated extensively and individual responses were provided to all the comments. Since the completion of the pilot project, stakeholder engagement has continued running up to the start of the formal consultation period by bilateral meetings, national workshops initiated by TSOs and regional workshops initiated by ENTSO-E.

[1] http://ec.europa.eu/energy/international/consultations/20110410_external_dimension_en.htm

[2] http://www.acer.europa.eu/portal/page/portal/ACER_HOME/Public_Docs/Acts%20of%20the%20Agency/Framework%20Guideline/Framework%20Guidelines%20On%20Electricity%20Grid%20Connections/110720_FGC_2011E001_FG_Elec_GrConn_FINAL.pdf

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Answer to FAQ 3:

Does the network code apply in non-EU member states or in respect to cross-border issues between a EU member state and a non-EU member state?

It is foreseen that the Network Codes will be adopted via the Comitology process in the format of an EU regulation.

Therefore, they will become binding vis-à-vis non EU-countries in accordance with the following principles.

1) For the non-EU countries which are parties to the EEA Agreement (the European Economic Area Agreement), the EEA Agreement provides for the inclusion of EU legislation that covers the four freedoms — the free movement of goods, services, persons and capital — throughout the 30 EEA States. The Agreement guarantees equal rights and obligations within the Internal Market for citizens and economic operators in the EEA.
   As a result of the EEA Agreement, EC law on the four freedoms is incorporated into the domestic law of the participating EFTA States. All new relevant Community legislation is also introduced through the EEA Agreement so that it applies throughout the EEA, ensuring a uniform application of laws relating to the internal market.
   As energy legislation covering the functioning of the internal market falls within the scope of the EEA-Agreement, the entire body of future Network Codes will almost certainly be EEA relevant, and hence be applicable and binding after decision by the EEA Committee and national implementation. The regular implementation procedures will apply.

2) As Switzerland is not a party to the EEA Agreement, the enforceability of the NC transformed into EU Regulation will need to be assessed in the context of the pending negotiations between Switzerland and the EU. However, Swiss law is also based on the principle of subsidiary. Under this principle, self-regulating measures can be taken by the parties of the sector if they reach the conclusion that these rules should become common understanding of the sector. Based on the subsidiarity principle it is currently considered by the Swiss authorities to introduce under Swiss law, new rules compliant to relevant EU-regulations by the parties of the sector.

3) For the countries that are parties to the Energy Community Treaty, the Ministerial Council of the Energy Community decided on 6 October 2011 that the Contracting Parties shall implement the Third Package by January 2015, at the latest. Moreover, it decided "to start aligning the region's network codes with those of the European Union without delay". The Network Codes will be adopted by the Energy Community upon proposal of the European Commission. The relevant network codes shall be adopted by the Permanent High Level Group which shall seek the opinion of the Energy Community Regulatory Board before taking a decision.

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Answer to FAQ 4:

How will ENTSO-E efficiently and transparently perform stakeholder consultation?

Over the next few years ENTSO-E will be required to develop and consult on a series of network codes covering most aspects of the electricity market, and the operation and the development of the electricity system. The active involvement of all stakeholders, expected to be reflected through their submission of comments during ENTSO-E public workshops as well as during the formal consultation, is considered to be crucial for the development of the network codes.

Each consultation will be composed of the following steps:

- preparation and announcement;
- stakeholders registration;
- comments gathering assessment and management including some statistical analysis; and
- Archiving.

Once the comments of stakeholders are assessed by ENTSO-E, they will be made publicly available, together with the corresponding answers/justifications. ENTSO-E will indicate how the comments received during the consultation have been taken into consideration and provide reasons where they have not been acted upon. All consultation material will remain publicly accessible for a period (envisaged to be at least one year) after the end of the consultation. Beyond this point, it will be archived by an ENTSO-E administrator so as to be available on request.

To make the consultation process more user-friendly and efficient, ENTSO-E has established a web facility for two-way communication exchanges.

The reader is referred for further information to the ENTSO-E publication "Consultation process"[3].

[3] https://www.entsoe.eu/fileadmin/user_upload/_library/consultations/110628_Consultation_Process_Description.pdf

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Answer to FAQ 5:

What is the role of the subsidiarity and proportionality principle in the NC RfG?

One of the primary drivers for the network code is the aim of harmonisation of requirements for generators across the EU as part of the fulfilment of the 3rd legislative package.

However, complete harmonisation of all requirements for Generating Units is not a pragmatic or cost effective solution due to the geographic dispersion of generation and the variance (due to historical, topographic and geographic effects) of network designs across Europe.

In these cases the principle of subsidiarity is applied, with the high level harmonisation of the requirement, generally in the form of a range specified in the code, and the more specific details and/or parameters specified at a more local level. In this manner, only the harmonisation of aspects of the requirements which can only be achieved at a European level in practice by means of a European legislation (derived from a network code) is included in the network code, whilst maintaining the necessary flexibility in the details to apply these requirements more efficiently at a more local level.

Following this principle, the requirements in the code also apply the subsidiarity principle with the individual requirements in the code being applied to the type, size and connection point and their relevance at a European level. Aspects of this concept are discussed in detail in FAQ 6 and FAQ 18.

In line with the requirements in the Framework Guideline on Grid Connection, the requirements for Significant Grid Users are categorised in the network code as follows:

- general requirements
- specific requirements for Synchronous Generating Units
- specific requirements for Power Park Modules
- specific requirements for Offshore Generation.

Each of these categories is divided into four types with thresholds in terms of installed capacity of the Generating Unit and voltage level, which are set at national level by the relevant TSO and reviewed by the National Regulatory Authority.

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Answer to FAQ 6:

What is the appropriate level of detail of the network code? Is it too broad or too detailed?

The level of detail and the scope of the network code are in line with the scope defined by the corresponding framework guidelines provided by ACER which read as follow: *"Furthermore, the network code(s) shall define the requirements on significant grid users in relation to the relevant system parameters contributing to secure system operation, including:*

- *Frequency and voltage parameters;*
- *Requirements for reactive power;*
- *Load-frequency control related issues;*
- *Short-circuit current;*
- *Requirements for protection devices and settings;*
- *Fault-ride-through capability; and*
- *Provision of ancillary services.*

(…)

The network code(s) shall set out how the TSO defines the technical requirements related to frequency and active power control and to voltage and reactive power management."

All requirements in the network code have a system wide impact; however the appropriate level of detail for each requirement has undergone a case-by-case consideration of its purpose, taking into account the *extent* of the system-wide impact as a guiding principle. The relevant entity from the perspective of system security is predominantly the synchronous area (Continental Europe, Nordic States, Great Britain, Ireland and Baltic States).

For the requirements with immediate relevance to system security on the level of a synchronous area, besides a common level of methods and principles, common parameters and settings (thresholds, limits) are necessary to achieve a harmonized network code, since one of the aims of the network code is to harmonise requirements for Generating Units throughout Europe to a reasonable extent to preserve system security in a non-discriminatory manner by applying the principle of equitable treatment. Other requirements of the network code are limited to the definition of common methods and principles and the details have to be provided by each TSO at national level (e. g. by explicit thresholds or parameter values). This allows consideration of specific regional system conditions (e. g. areas with different system strength, density of demand or concentration of Generating Units). Therefore the level of detail of the requirements varies and the principles of subsidiarity and proportionality are applied.

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Answer to FAQ 7:

Why do we need some requirements to apply even for domestic size of generation? Why are different categories of Generating Units introduced and what are the criteria for specifying the categories?

Meeting the EU energy policy targets regarding integration of renewable sources implies that:

I) Many medium and large scale renewable energy sources (RES) developments (e.g. wind) connect at high voltage and gradually extending to also cover offshore.

II) Domestic level generation, e.g. photovoltaic (PV), in massive numbers (millions) appear within a short timeframe.

The domestic level generation (II), often called micro-generation, covers domestic combined heat and power (CHP) in addition to PV. These developments may arise in new houses or as replacement of gas central heating systems with gas based CHP, often with as little as 1kW or less generation.

Individually these developments (II) are not of significance with regard to maintaining security of supply. However, when a very large number of them respond similarly to a common stimulus (eg frequency changes) they quickly become a threat to security of supply through risk of tripping.

Frequency is shared within each of the five synchronous areas mentioned in FAQ 6. Any change in frequency is experienced immediately by micro-generation just as for large generators. To maintain security of supply, the generation industry is familiar with the requirement for all medium and large generators to remain connected during frequency disturbances, most obviously in the form of the frequency range requirements.

Large simultaneous loss of generation is a threat to frequency stability with potentially widespread consequences. In terms of the impact on the system, loss of a large generator, say 1000MW is no different from 200 000 domestic generators at 5kW each (e.g. from PV). Within a very short period, concentrations of PV units have reached a level where at certain times (sunny days) 15-25% of the total generation within some geographical areas comes from such sources. For example, in Germany more than 2000MW of PV was installed in a single month in 2010.

The consequences of not sufficiently addressing this issue (e.g. too narrow frequency range for some generators based on RES) has unfortunately already been experienced in Europe, which led to large scale customer disconnections.

Examples of this include:

- Greater demand disconnection in Central Europe during the system split 4th November 2006. GWs (millions of kWs) of RES tripped at 49.5Hz resulting in a larger frequency disturbance and consequently in a similarly larger demand disconnection.
- On a smaller scale, but in a similar manner, an inadequate frequency range of smaller scale generation in GB (including RES) contributed to nationwide demand disconnection on 27th May 2008.

The requirements of this network code need to be forward looking. It will enter into force by means of European legislation, which means that it will be applicable for a rather long time and changes/amendments to them can only be implemented by running through extensive European legislative procedures. Therefore the anticipated mid- and long-term developments of the power generating portfolio need to be well considered and anticipated, which are, amongst others, clearly driven by rapidly increasing decentralised generation. Consequently it is undisputed, that smaller Generating Units will need to have capabilities to support the power transmission and distribution system security, which are nowadays provided by bulk generation facilities only.

In order to reflect these developments, the approach has been chosen to introduce four categories of generation units in the network code by following the principle of subsidiarity and proportionality. The criteria for specifying the categories are the voltage level of grid connection and the installed capacity of a Generating Unit. The capacity thresholds are defined as upper limits of the lower threshold leaving the final determination of this

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threshold on the discretion of national TSOs. The upper limits have been chosen from an estimation of having sufficient generation capacity of each category and the corresponding capabilities available for secure system operation.

Type A requirements are the basic level requirements, necessary to ensure capability of generation over operational ranges with limited automated response and minimal system operator control of generation. They ensure there is no wide scale loss of generation over system operational ranges, thereby minimising critical events, and requirements necessary for wide spread intervention during system critical events. Only essential requirements are included for Type A, limited to those aspects with potential system wide implications. For new installations, there is normally little or no additional cost in complying with these requirements once introduced as part of the standard product.

Type B requirements provide a wider level of automated dynamic response (generally with settings by the Relevant Network Operator) with higher resilience to more specific operational events to ensure use of this higher dynamic response and a higher level system operator control and information to utilise these capabilities. They ensure automated response to alleviate and maximise dynamic generation response to system events, greater generator resilience of these events to ensure this dynamic response and better communication and control to leverage these capabilities.

Type C requirements provide refined, stable and highly controllable (real time) dynamic response to provide principle balancing services to ensure security of supply. These requirements cover all operational network states with consequential detailed specification of interactions of requirements, functions, control and information to utilise these capabilities. They ensure real time system response necessary to avoid, manage and respond to system events. These requirements provide sufficient generation functionality to respond to both intact and system disturbed situations, and the need for information and control necessary to utilise this generation over this diversity of situations.

Type D requirements cover a wide area of control and range of operation They ensure specific needs for higher voltage (equal to or greater than 110kV) networks and their operation and stability over wide areas, allowing the use of balancing services from generation Europe wide. For this reason the requirements apply also for large generation connected at a lower voltage, but above a given capacity threshold.

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Answer to FAQ 8:

Why is the option maintained to apply the network code requirements to Existing Generating Units?

The option is maintained to apply the network code requirements to Existing Generating Units because this principle is required by the ACER Framework Guidelines. The ACER Framework Guidelines provides that the network code requirements will apply to Existing Generating Units if the relevant TSO has proposed an application to Existing Generating Units and if this proposal has been approved by the National Regulatory Authority (see FAQ 9).

A network code requirement shall apply to an Existing Generating Unit only if it is demonstrated by a quantitative cost-benefit analysis and that the costs to fulfil this requirement are in an acceptable relation to the benefits to the power system (see FAQ 11).

Currently the European power systems are changing rapidly: the internal market evolves, renewable generation increases, new transmission technologies, like FACTS (Flexible AC Transmission Systems), HVDC (High Voltage Direct Current) lines, etc. are introduced. In this situation there is a high uncertainty in anticipating the needs for power system security for the next 20 years. On the other hand, the requirements of this network code will be entered into force by means of European legislation, which means that they will be applicable for a rather long time and changes/amendments to them can only be implemented by running through extensive European legislative procedures. Hence, it is essential to have the possibility to apply network code requirements to existing plants. Such application will be pursued in very particular and reasonable cases and, with all the necessary safeguards and respecting the provision of ACER's Framework Guidelines.

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Answer to FAQ 9:

Does the network code apply to Existing Generating Units? What is the situation of Existing Generating Units after the entry into force of the network code? Do existing derogations still apply after its enforcement or will they cease?

In the context of the network code, an Existing Generating Unit is a unit which:

- is either physically connected to the Network, or
- under construction, or
- has a confirmation by the Power Generating Facility Owner that a final and binding contract for the construction, assembly or purchase of the main plant, i.e. prime mover, generator, etc., of the Generating Unit exists at the day of the entry into force of the network code.

As requested by the ACER Framework Guidelines, the network code shall apply to New Generating Units. It shall apply to Existing Generating Units as well, if this has been proposed by the relevant TSO on a national level and this proposal has been approved by the National Regulatory Authority. Depending on the proposal by the relevant TSO (and the regulator's approval) there can be a variety of application to Existing Generating Units:

- All Existing Generating Unit shall meet all requirements
- All Existing Generating Units shall meet selected requirements
- Selected Existing Generating Units shall meet all requirements
- Selected Existing Generating Units shall meet selected requirements

Once approved and applied to a certain Existing Generating Unit, this unit shall meet those requirements which are covered by this approval without any exemption, regardless whether it possesses a derogation from this requirement, which was issued on a national level *before* the network code entered in force. In respect of the network codes, such former derogations are invalid. Derogations will have to be sought specifically from the requirements of the network code by applying for them according to the procedure for derogation defined in the network code.

However, Existing Generating Units, which are not covered by the network code, shall continue to be bound by such technical requirements that apply to them pursuant to legislation in force in the respective Member States or contractual arrangements in force. Consequently, existing national/ local derogations may remain in force as well, provided that they refer to a requirement not covered by the EU network code.

Although existing derogations are not suitable evidence of derogation from the network code in case of application to Existing Generating Units, such documentation can however provide useful background information when preparing the derogation application regarding the network code.

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Answer to FAQ 10:

Does the network code deviate from existing requirements?

One of the aims of the network code is to harmonise the requirements for Generating Units throughout Europe to a reasonable extent to preserve system security in a non-discriminatory manner by applying the principle of equitable treatment. Consequently, this network code cannot be in line with all existing requirements in each individual country by nature, because they do not currently provide the necessary level of harmonisation. Deviations mainly result from both horizontal (between TSOs) and vertical (between TSOs and DSOs) harmonisation of requirements to better prepare for the emerging changes to the electricity transmission and distribution systems, in particular with regard to distributed renewable generation.

Harmonising grid connection requirements provides the opportunity to improve system security by learning from experiences due to the diversities in the European countries, e.g. those which already have a high penetration of renewable and distributed generation sources. This will support other countries to have clear and satisfactory grid connection requirements for forthcoming generation facilities. It needs to be understood that, in the case of renewable energy, the higher the level of fulfillment of requirements, the higher the penetration level that can be reached in the European countries.

ENTSO-E believes that there is no significant deviation from existing requirements, because the network code has been developed by taking and improving requirements from different existing national codes and regulations that have proven their efficiency on the respective issue and could be considered as best practice.

The draft network code was challenged against existing requirements by stakeholders during the informal consultations. The huge number of comments received enabled a further cross-check with existing standards and requirements. The stakeholder comments were assessed and have either lead to according amendments to the network code or the original position has been retained and justified.

The network code deviates from existing standards in the following aspects:

1. Number and strictness of requirements: the change is modest for most countries.
2. Generating Units affected by the requirements: A larger number of smaller units has to fulfill the requirements. Therefore one major change of the network code compared to existing national codes and regulations is that requirements which are relevant for system security are established even for units connected to the distribution grid due to a larger proportion of smaller RES generation expected to be connected in the future.
3. Compliance procedures and tests: Intensity of compliance testing and, consequently, the costs attached will increase.
4. The NC RfG will require Distribution System Operators to take a greater role in ensuring compliance of generators connected to their system. This will require greater resource within the DSOs than at present, but will lead to greater levels of network security.

In the following paragraphs an overview of the situation in the different synchronous areas is given:

Continental Europe (former UCTE)

The Continental European Region includes more than 20 TSOs with many grid codes. Already in 2008 UCTE published a “TECHNICAL PAPER – DEFINITION OF A SET OF REQUIREMENTS TO GENERATING UNITS”, which was a big step forward with regards to harmonisation of requirements for generators. This paper was taken into account in the development of the network code resulting in the network code reflecting well the requirements of UCTE. As a consequence, the network code very well reflects the requirements of the former UCTE for Continental Europe. In addition, the network code provides improved specifications and many clarifications for existing requirements, in particular in the field of compliance monitoring.

Nordic States (former NORDEL)

The Nordic states (Denmark, Finland, Norway and Sweden) have their own national generator codes, which do not fully cover all requirements for Generating Units which are considered necessary in future. There is also a

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consolidated Nordic grid code for the Nordic states which does not cover all the details in the national generator codes. The existing Nordic grid code has similar requirements to NC RfG. However, the NC RfG brings new requirements to smaller units and extends compliance monitoring and testing for all units. In addition, the network code provides good specifications and clarifications for existing requirements.

Great Britain

Generally speaking the GB Grid Code is similar to the network code in respect to the number of requirements and in respect of its enforcement. One significant change is that the GB Grid Code only places requirements on Users of the Transmission System (both directly connected or embedded but generally above a certain size threshold). This threshold will vary depending upon geographic location within GB but in general the TSO will have no involvement with Small Generators generally less than 50MW, in England and Wales, less than 30MW in the South of Scotland and 10MW or less in the North of Scotland and Offshore.

New requirements are proposed relating to the provision of frequency response, as the current requirements are not sufficient to ensure that the system can operate without constraints against an anticipated background of large nuclear generation sets and high volumes of wind generation. One factor being considered within the frequency response debate is the need for system inertia. Currently the GB Grid Code does not make any specification of inertia for any type of plant although this issue is currently subject to review and has been discussed at length amongst the GB Grid Code Review Panel and associated working groups.

The NC RfG which extends to Smaller Generating Units is seen as an important requirement to assist in maintaining system security against a rapidly increasing growth of small scale Renewable generation.

The FRT requirements in the network code are less severe than those currently in place, but they are extended to smaller Generating Units connected to distribution systems. The application of FRT requirements to smaller plants, along with the need to remain connected during fast frequency drops, will address system security issues associated with increasing levels of embedded and micro-generation.

In addition, the network code contains a significant change in code implementation: It will require Distribution System Operators to take a greater role in ensuring compliance of generators connected to their system. This will require greater resources within the DSOs than at present, but will lead to greater levels of network security.

Ireland

The Irish Grid Code is either broadly similar to the requirements in the network code and they are within the system operator defined ranges where specified. The biggest area of overall change and benefit is focused on the increasing level of interaction and co-ordination between generator and system operator, particularly for smaller distribution connected generators. This will enable the security and planning of the transmission and distribution systems in a more diverse environment assisting the realisation of European and National development targets (including RES) within Ireland.

Baltic System

The TSOs of the Baltic countries (Estonia, Latvia and Lithuania) have their own national codes, which do not fully cover all requirements for Generating Units which are considered necessary in future. The network code will provide a more complete set of requirements and will lead to harmonization in particular between these countries, and to a certain extent to a stronger link with the other European countries. Connection requirements for wind power parks were implemented recently and are compatible to those included in the network code. They have a high standard, as they were created based on national and international experience. The connection requirements for wind power parks include requirements for FRT, frequency response, remote active power, reactive power and voltage control. Synthetic inertia requirement is not included.

Answer to FAQ 11:

How is cost-benefit analysis going to be applied to address the question of implementation of network codes for Existing Generating Units?

The ACER Framework Guidelines define that "*The applicability of the standards and requirements to pre-existing significant users shall be decided on a national basis by NRA, based on a proposal from the relevant TSO, after a public consultation. The TSO proposal shall be made on the basis of a sound and transparent quantitative cost-benefit analysis that shall demonstrate socio-economic benefit, in particular of retroactive application of the minimum standards and requirements*".

Before any Existing Generating Unit is required to implement requirements of the network code, the relevant TSO will have undertaken a cost-benefit analysis, carried out a public consultation and the National Regulatory Authority (NRA) will have made the final decision based on information obtained from both the cost-benefit analysis and the consultation processes.

A cost-benefit analysis is an intensive process that requires resources from all market participants to collect the required data. To make best use of resources it is important to focus on cases of real merit. Therefore a filtering process is applied initially to identify these cases. This filtering consists of a high level analysis using a traffic light system. This method, applied by each TSO, evaluates if there is a reasonable prospect of justifying application to Existing Generating Units with respect to each requirement defined in the network code.

The marginal cost for implementing each part of the network code to Existing Generating Units is illustrated by the cost traffic lights. The socio-economic benefit of reducing the risk of disconnection of consumers and associated balancing services costs through implementation to Existing Generating Units is evaluated by the benefit traffic lights.

- Costs
  Following engineering review, an outline decision is made about the required modification:
  - Insignificant modification: Green
  - Significant modification: Red

- Benefits
  Following engineering review, the reduction in demand loss and/or cost of balancing services is indicated:
  - No/low impact: Red
  - Significant impact: Green

In respect of requirements for which this filtering process demonstrates that there is no prospect of justifying the application to Existing Generating Units (e.g. "red" on costs & "red" on benefits) for one class of Existing Generating Units (e.g. Type A) or for all classes, then no further action will be taken. As a result, these requirements shall not be under the jurisdiction of this network code for Existing Generating Units. However, the FWGL allows for a review of this significance evaluation at a later date, but not within a period of less than 3 years. This facility to review later is intended to, on the one hand, allow the TSO to avoid excessive application to Existing Generating Units where this may prove unnecessary and, on the other hand, have a safety net for changes in circumstances.

If the filtering process demonstrates that there is a reasonable prospect of justifying application to Existing Generating Units for a requirement for all or one class of Existing Generating Units (e.g. benefit "green" and costs "green") then the TSO can proceed on to a more detailed assessment, being assisted by the Power Generating Facility (PGF) Owners. Below is a high level summary of this:

- Cost-benefit analysis by the TSO for an item of the code on a national basis:
  - The PGF owners are required to co-operate by providing cost of retrofit.

   - The TSO completes the cost-benefit analysis and prepares a report. The cost-benefit analysis is based on methodologies described in the network code.
   - If the outcome of the cost-benefit analysis is negative (application to Existing Generating Units not justified) then there is no need for further action other than informing affected Stakeholders.

- Public Consultation:
   - If the outcome of the cost-benefit analysis is positive then the TSO undertakes public consultations.
   - If the outcome of the consultation is negative (application to Existing Generating Units not justified) then there is no need for further action.
   - Following consultations resulting in "no further action" all affected parties and ENTSO-E are informed.

- NRA decision:
   - If the outcome of the consultation is positive then the TSO sends the report including results of the consultation to the NRA.
   - The NRA decides if the application to Existing Generating Units is justified based upon the report.

- Implementation of application to Existing Generating Units:
   - If the NRA decides to go ahead, the Relevant Network Operator issues a LON (as per Article 27b of the Network Code).
   - The PGF owners carry out retrofit and demonstrate full compliance in respect of the specified issue to the satisfaction of the relevant Network Operator.
   - If the result of the retrofit is satisfactory as evaluated, then the Relevant Network Operator issues a FON (as per Article 27a of the Network Code) to the Power Generating Facility Owner.

The TSO will provide information of the outcomes of the above processes to affected stakeholders in order to assist PGF owners and their associates with the degree of certainty as the process allows. A summary of the national decisions on application of network code requirements to Existing Generating Units will also be shared with ENTSO-E, NRA and ACER.

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Answer to FAQ 12:

Why does the network code not define certain requirements as paid-for ancillary services?

The ACER Framework Guidelines prescribe *"(...) Nothing in the network code(s) shall prevent commercial arrangements being used for the provision of ancillary services. (...)"*

The scope of this network code is to define the requirements for technical capabilities of Generating Units which are needed for secure operation of electricity transmission and distribution systems.

Secure system operation is only possible by close cooperation of power generating facilities connected at all voltage levels with the network operators in an appropriate way, because the system behavior especially in disturbed operating conditions largely depends on the response of Generating Units in such situations. With respect to system security the transmission system and the Generating Units need to be considered as one entity from a system engineering approach. It is therefore of crucial importance that Generating Units are able to meet the requirements and to provide the technical capabilities with relevance to system security.

The requirements of this network code need to be forward looking. Hence, the anticipated mid- and long-term developments of the power generating portfolio need to be well considered, which are, amongst others, clearly driven by rapidly increasing decentralised generation. Consequently it is undisputed, that smaller Generating Units will need to have capabilities to support the power transmission and distribution system security, which are currently provided by bulk generation facilities only.

One objective of the network code is clearly specifying these capabilities in order to enable the industry to consider these features for future Generating Units and to develop corresponding technical solutions. This approach has been expressively endorsed by the industry, because sufficient time for research and development is needed to be able to deliver the functionalities with future generation technologies. Moreover, the claims of other stakeholders to introduce such capabilities once the market demands for them have to be rejected. This inherently bears the risk, that at the time the market requests for these capabilities, they are not available and cannot be introduced at short notice causing a substantial risk to the security of the electricity transmission and distribution systems due to a lack of ancillary services.

It needs to be well distinguished between mandatory requirements of capabilities and the provision of ancillary services based on these capabilities. ENTSO-E agrees with stakeholders, that the provision of ancillary services is basically a market-related issue which needs to be appropriately remunerated. However, the introduction of remuneration provisions shall be subject to market-related network codes. Depending on the outcome of ACER's scoping exercise, this topic could be covered for example in the network code on balancing foreseen for 2013 according to the EC/ACER/ENTSO-E three-year work plan.

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Answer to FAQ 13:

Why does the network code not specify who pays for improvements of existing Power Generating Facilities to become compliant with the requirements? Who bears the costs for demonstrating compliance?

Cost allocation of improvements is not covered specifically by the framework guidelines on electricity grid connection issued by ACER. The ACER Framework Guidelines state that *"The network code(s) shall always require the system operators to optimise between the highest overall efficiency and lowest total cost for all involved stakeholders. In that respect, NRAs shall ensure, that, whatever the cost-sharing scheme is, the cost split follows the principles of non-discrimination, maximum transparency and assignment to the real originator of the costs."*

Improvements of existing Power Generating Facilities and equipment to achieve compliance with the network code based on TSO proposal can only be mandated after a cost-benefit analysis on a socio-economic level (see FAQ 11). Hence, costs of improvements for existing Power Generating Facilities should be borne by the Power Generating Facility Owner.

Nevertheless, in case of replacement/improvements/modernisation of existing Power Generating Facilities, it is required that the replaced/improved/modernised installations are compliant with the requirements of the network code, unless the Power Generating Facility Owner applies for a derogation from this obligation and this derogation is granted by the relevant Network Operator.

The responsibility on demonstrating compliance with the requirements established in the network code relies on the Power Generating Facility Owners. Consequently they shall bear their costs related to compliance tests and simulations. This should be done in alignment with the compliance principle set out in this network code and detailed further at a national level.

Answer to FAQ 14:

Why do TSOs impose requirements for connections to the distribution networks rather than the relevant DSO?

Secure system operation is only possible by close cooperation of Power Generating Facilities connected at all voltage levels with the Network Operators in an appropriate way, because the system behaviour, especially in disturbed operating conditions, largely depends on the response of Generating Units in such situations (FAQ 1). For example, requirements for frequency stability are independent of the voltage level of the grid connection point of a Generating Unit, because system frequency has global impact and the behaviour of Generating Units at all voltage levels are affected equally by frequency.

Recent years are characterized by rapid development of dispersed generation, in particular renewable (wind turbines and photovoltaic panels). In some countries the level of installed capacity of renewable energy sources (RES) is close to the level of power consumption, in other countries where the current level of wind generation is relatively small, a strong growth is expected within the next 2-5 years. The generation portfolio has changed or will change across all countries within Europe. TSOs will not be able to ensure an appropriate level of system security without imposing requirements on Generating Units connected to the distribution grid, that are comparable to those requirements, which Generating Units connected to the transmission grid have to fulfil. The DSOs are responsible for system security as well, but only the TSOs have the ability to assess and control an entire area. It is therefore only the TSO that can comprehensively assess which requirements are needed from a systems engineering perspective and what requirements should be met by Generating Units to maintain system security. It should be noted that some system security issues are dedicated exclusively to the TSOs, e.g. frequency control or system inertia. Experience has shown that the current technical and organisational solutions are inadequate and insufficient to meet future changes. The influence of dispersed generation connected to the distribution grid, due to the scale, is now much higher than in the past and new challenges occur. RES themselves become a source of noise in the system due to the fact that they are difficult to predict and are often sensitive to failures in the system. Besides, the risk of their disconnection due to certain system disturbances, such as frequency deviations or system faults, consideration needs to be given to the characteristics of new generation technologies (e.g. 25 000 MW PV panels installed in Italy and Germany which can automatically disconnect from the grid whenever the system frequency deviation increases about 0.2 - 0.3 Hz).

Therefore, it is crucial that Generating Units connected to the distribution system meet grid connection requirements which are relevant for system security as well. In addition, for some requirements, like those for frequency stability, it is important that the performance of all Generating Units in a TSO's area of responsibility are harmonised when they experience the same incident (e. g. a frequency deviation). TSOs need to define such requirements to be uniformly applied in the area of their responsibility to avoid the risk of varying requirements and performances resulting in a situation where the TSO is not in control of it. Ensuring system security by TSOs solely by technical capabilities of the Generating Units connected to the transmission grid is hardly possible; therefore connection requirements for distributed generation need to be implemented in a coordinated way.

It is evident that DSOs need to be strongly involved in these issues. Therefore, during both the informal and the formal period for developing the network code, several bilateral meetings with experts from the three largest European DSO Associations (Cedec, Eurelectric DSO, Geode) have been taking place and continue to do so.

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Answer to FAQ 15:

Why does the network code not provide for dispute resolutions?

The settlement of dispute provisions is commonly used for contractual types of relationships which are outside the scope of this network code.

Therefore, in case a dispute regarding the application of NC provision arises, it shall be referred to national courts - which are the ordinary courts in matters of European Union law - in accordance with national rules. Nevertheless, to ensure the effective and uniform application of European Union legislation, the national courts may, and sometimes must, refer to the Court of Justice and ask it to clarify a point concerning the interpretation of EU law (in the NC provisions).

The Court of Justice's reply takes a form of a judgment and the national court to which it is addressed is, in deciding the dispute before it, bound by the interpretation given and the Court's judgment likewise binds other national courts before which the same problem is raised. It is thus through references for preliminary rulings that any European citizen/ entity can seek clarification of the European Union rules which affect him.

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Answer to FAQ 16:

Why do you not develop dedicated network codes for each type of generation?

The requirements for grid connection of Generating Units have been developed from the perspective of maintaining, preserving and restoring the security of the interconnected electricity transmission and distribution systems with a high level of reliability and quality in order to facilitate the functioning of the EU-internal electricity market. Secure system operation is only possible by close cooperation of Power Generating Facilities of all types, connected at all voltage levels with the Network Operators in an appropriate way (FAQ 1).

Therefore Power Generating Facilities of all types have to be capable of providing services to the Relevant Network Operator to enable it to satisfy its security of supply obligations.

From a system engineering perspective these capabilities are independent from generation technologies to a large extent and cover:

- provision of information for system management
- system balancing / frequency stability
- voltage stability
- system wide angular stability including robustness of Generating Units against perturbations
- system restoration after a disturbance.

Major differences in the capability requirements of Power Generating Facilities do not result from the primary energy source used (wind, solar, gas, coal, nuclear, hydro, etc.) for conversion into electricity, but from the type of generator connected to the network, in particular whether the generator is synchronously connected to the grid (like for the vast majority of conventional thermal Generating Units) or via a power converter installation (like for wind farms or PV installations).

Therefore it is appropriate to distinguish between three categories of requirements:

- general requirements which shall apply regardless of the type of connection, because they are not influenced by it;
- specific requirements for synchronously connected Generating Units;
- specific requirements for non-synchronously connected Generating Units (so called Power Park Modules).

Keeping all these parts within a single network code aids the aim of the electricity market of equitable treatment for all Users by maintaining a consistent set of requirements for all developers and owners of Power Generating Facilities.

Developing a single code for each type of generation technology, based on the primary energy source, would have been highly inefficient in terms of keeping the network code as simple as possible. It should also be noted that the code needs to be adaptable in the future to address new generation technologies.

However, it should be noted that the requirements have been subject to detailed examinations by a number of leading experts, who have considered the impact on future generation technologies. Following these discussions, adjustments have been made in detail to prevent any technology from unreasonable treatment.

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Answer to FAQ 17:

Why does the network code not consider specific conditions which may apply for some Power Generating Facilities, in particular in industrial sites?

The network code does not exclude the consideration of such specific conditions, but these conditions are of a site-specific or generation type-specific nature and therefore cannot be covered by a general exemption from single or all the requirements of the network code for these Power Generating Facilities. Moreover, it is necessary to have a closer look at these conditions on a case-by-case basis founded on the principle of equitable treatment. In applying this principle, some cases may emerge of well justified derogations.

The basics of this process are covered within this network code. However, it is anticipated that the process for these aspects for new connections may be covered in the planned network code "grid connection procedures" under the grid connection framework guideline. The Power Generating Facility operator can request a derogation from the Network Operator it is connecting to, and this request will then be evaluated in relation to whether it is reasonable and justified. Depending on the result of this assessment, a decision on granting a derogation will be made. The network codes provide a transparent and non-discriminatory derogation procedure, according to the ACER Framework Guidelines.

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Answer to FAQ 18:

Do the requirements have to be considered as "minimum" or "maximum" requirements; what is the understanding of "minimum"/ "maximum" requirements?

"Minimum" relates to the request for defining the minimum set of requirements in the corresponding network code(s) which is necessary in order to achieve the objectives of the framework guideline and consequently of Regulation (EC) 714/2009. The terms "minimum" (and "maximum" respectively) shall not be understood in the sense of defining minimum (or maximum) values for parameters, thresholds, ranges, etc.

The requirements established in the network code prevail over national provisions when implemented via EC Regulation, and if compatible with the provisions in the European network code(s), national codes, standards and regulations which are more detailed or more stringent than the respective European network code(s) should retain their applicability. Nevertheless, additional measures remaining within the scope of the network code can, as a matter of principle, be taken at the national level provided that they do not contradict the provisions of the network code.

The following theoretical examples attempt to clarify this principle:

- Example 1: The network code determines the admissible operational voltage range for the 400 kV network to be limited between 380 kV (lower limit) and 420 kV (upper limit).
  - It is not admissible to define different limits on a national level.

- Example 2: The network code determines that the admissible operational voltage range for the 400 kV network shall be defined by the national TSOs with a minimum lower limit of 380 kV and a maximum upper limit of 420 kV.
  - It is not admissible to define ranges outside the minimum or maximum limit on a national level, but a range within these limits shall be defined by the national (relevant) TSO.

- Example 3: The network code does not determine an admissible operational voltage range for the 400 kV network.
  - It is admissible to define any kind of ranges on a national level, because it is not in conflict with the network code

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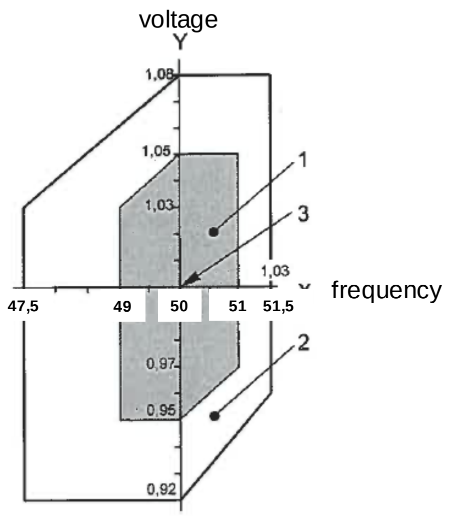
Answer to FAQ 19:

Why do you need the wide frequency ranges for operation and do not comply with the relevant IEC standard 60034 for rotating electrical machines?

The capability of operating Generating Units during deviations of the system frequency from its nominal value is of crucial importance from the perspective of system security. Significant deviations are likely to occur in case of major disturbance to the system, which come along with splits of normally synchronously interconnected areas due to imbalances between generation and demand in the then separated parts of the system. A rise of frequency will occur in case of generation surplus, while lack of generation will result in a drop of frequency. The volume of a frequency deviation not only depends on the amount of imbalance, but also on other conditions / characteristics of the system, such as the generation profile i.e. system inertia, spinning reserve and the frequency response speed. In this sense, the current massive displacement of conventional generation by renewable generation may decrease the system reliability in terms of maintaining a stable frequency. In general, smaller systems will usually be exposed to higher frequency deviations than bigger ones. In the same way, peripheral systems which are part of very large systems, such as the interconnected Continental European area, but are weakly interconnected to the main system will be exposed to substantial frequency deviations in case of disturbances that cause the trip of the interconnections with the main interconnected system. Therefore, the capability of operation of Generating Units under such frequency conditions is a prerequisite to keep the system "alive" in order to be able to continue electricity supply and to restore a secure system state quickly.

During the informal discussions on the pilot code, stakeholders reiterated their concerns on the wide frequency ranges originally requested by the draft requirements of ENTSO-E claiming that they exceeded the provisions of the relevant IEC standard 60034 for rotating electrical machines, according to figures 1 and 2:



Area 1: Operation unlimited in time
Area 2: No specification of time limits

Figure 1: Frequency and voltage ranges for operation of rotating electrical machines according to IEC standard 60034-1

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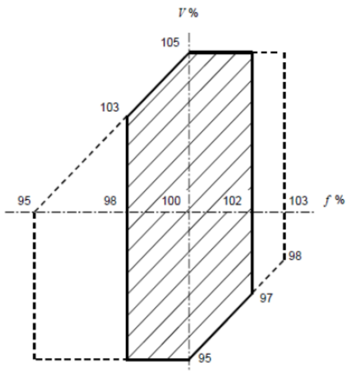

Figure 2: Frequency and voltage ranges for operation of synchronous generators driven by steam turbines or combustion gas turbines according to IEC standard 60034-3

Limited off-frequency operation is tolerated by both the turbine and generator, however the underfrequency limitations on the generator, are usually less restrictive than the limitations on the turbine.

IEC 60034 does not define a specific duration for time-limited operation (Area 2) because operation within an abnormal frequency range is time cumulative before turbine blade damage is probable and these characteristics differ from manufacturer to manufacturer. However, IEEE/ANSI C37.106-2003 Standard "Guide for Abnormal Frequency Protection for Power Generating Plants" provides some examples in which the time accumulated within each frequency range is shown in next figure:

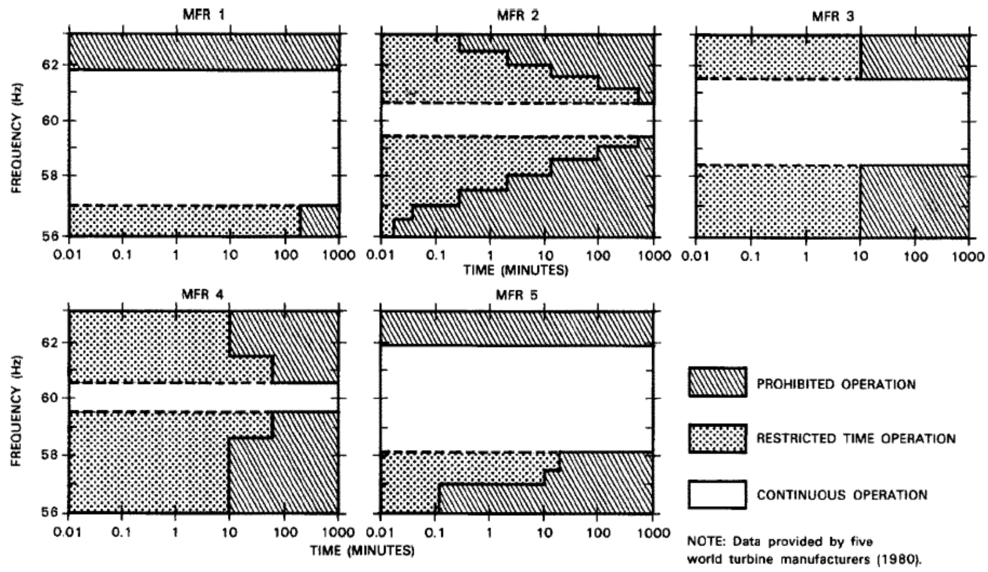

Figure 3: Examples of steam turbine limitations (different manufacturers) during abnormal frequency according ANSI/IEEE C37.106-2003 standard

The network code is in line with IEC-60034 in the sense that unlimited time operation is required within the range (49 - 51 Hz). In the case of time limited operation (area 2 in Fig.1 and non-shaded area in Fig.2), ENTSO-E acknowledges that operation of Generating Units cannot be generally required under these conditions, however situations in which the system frequency has been outside of the time-unlimited operation range have already occurred.

The system security and continuity of supply would be even more endangered if generation units were tripped and consequently would not assist system restoration. In this case, ENTSO-E considers that the time period for operation within 48.5 - 49 Hz will be established by the relevant TSO on a local/national basis, since each system topology has different needs on operation of frequency ranges for the Generating Units. In the case of Continental Europe, and due to the existence of a large number of TSOs with different characteristics, the minimum time period for operation within the range 47.5 – 48.5 Hz, will be determined by each TSO.

ENTSO-E believes that a minimum operation period of 90 minutes is adequate for smaller synchronous areas in the ranges 47.5 – 48.5 Hz and 51.0 – 51.5 Hz, because situations where a frequency deviation to Area 2 of figure 1 may occur (even though countermeasures like low-frequency load shedding are implemented) in particular after severe disturbances which can be accompanied by a loss of communication and remote control infrastructure. Therefore a significant amount of time will be needed to prepare for system restoration under such conditions. In the future, it is expected that larger frequency excursions could take place following a disturbance due to the fact that a large volume of renewable energy (a non provider of system inertia), will be installed in the ENTSO-E synchronous areas.

As a conclusion, the frequency range requirements of the network code reflect the need for maintaining/restoring system security.

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Answer to FAQ 20:

Why do you need the wide voltage ranges for operation?

1. Why is voltage a "cross-border issue"?

A change of voltage in a certain point in a network results in a change of the power flow in an interconnected system towards this point. The voltage may change due to loss of generation, loss of load, loss of transmission lines, or normal variations of connected demand.

If the voltage increases in a certain point, currents towards the point will decrease since demand depends on voltage and current. System losses will also decrease which will further increase system voltage. If the voltage increases over an acceptable value, the isolation of connected equipment is jeopardized.

If the voltage decreases in a certain point, currents towards the point will increase since demand depends on voltage and current. Reactive power losses will also increase, which will further decrease system voltage. This situation can result in loss of voltage stability and subsequently escalate to a large-scale disturbance (voltage collapse), if there is a lack of capacity to regulate voltage by static or synchronous equipment and depending on the proportion of static/ synchronous equipment. The distance between the regulation equipment and the affected point in the system also has an impact on the effectiveness of the compensation. It is therefore of crucial importance for system security that Generating Units are capable of operating in a wide voltage range to be able to control voltage to preserve voltage stability and to prevent the system from voltage collapse. Indeed, most of the large-scale disturbances to electricity transmission system in the recent years were caused by a loss of voltage stability.

2. What do the international standards say about voltage range and duration?

Voltage is one of the basic parameters describing the state of the power system and cannot be omitted in the requirements for generators. According to the EN60034-1 standard (*Electrical machines*) as well as EN60034-3 the permanently permissible range of generator voltage variation is defined from 95% to 105% of rated voltage. For a limited time, generators ought to be capable of operating in a voltage range from 92% to 108% of rated voltage. The operation of a generator outside the permanently permissible range is possible but this operation should be limited in extent and duration due to the effects of temperature increase.

The duration of the time limited operation is not standardised and can be different depending on the type of generator as well as the needs of the local system. Without any additional equipment a generator should stay connected to the grid within the variation of ±8% of its rated voltage. It should be noted that the voltage range defined in standard EN 60034-1 refers to the generator voltage in contrast to this network code where the voltage range is defined at the Connection Point (CP).

3. Possible measures for Power Generating Facility Owners to match different voltage ranges of international standards with ranges defined in this network code

Between the generator terminals and the Connection Point there will be at least one transformer and its parameter has essential influence on the capability of the Generating Unit to operate at voltages below and above rated generator voltage. Therefore, to minimize adverse effects on the generator from operation outside the nominal parameters (e.g. reduction in life of the generator) additional countermeasures can be taken. To meet the voltage range as required by the network code and to increase the permissible range of Generating Unit operation without negative effect on the grid voltage, on-load tap changers can be used. It makes the voltage range requirements compatible for the Generating Unit and this is also the case for auxiliaries, *as auxiliary and standby transformers can also be equipped with on-load tap changers*[4]. Note that according to EN50160 standards under normal operating conditions voltage variations should not exceed ±10%, and for remote users +10%/-15% of nominal voltage (refer to medium voltage) unless otherwise agreed with the grid users. Thus the

[4] feedback received during the stakeholder dialogues.

voltage requirements defined in EN60034-1 standard cannot be treated as binding at the Connection Point for power Generating Units, nor can it restrict the Network Operators to define Generating Unit requirements (as a whole and not only the generator) to ensure system security. From this point of view these voltage range requirements are not in contradiction with IEC standards.

The wide voltage ranges of the Generating Unit operations are very important during "normal" operation to ensure the technical capability of a Generating Unit to retain synchronous operation and support the system when local voltage problems occur (e.g. to avoid voltage collapse). Across Europe, tripping of generation units from the meshed network to protect plant and equipment and to prepare to contribute to the restoration process is permitted if extreme voltage drops occur. In practice, the setting of these under voltage protections in terms of nominal grid voltage and time delay should be agreed with the Network Operators.

A wide voltage range of Generating Units is furthermore highly desired during the system restoration process when extreme voltage conditions may occur, (e.g. during charging of long lines).

Answer to FAQ 21:

How should the combined effect of frequency and voltage ranges be interpreted?

For both frequency and voltage required operating ranges are defined in which immediate disconnection of a Generating Unit is prohibited due to the deviation of the frequency or the voltage from its nominal value. These requirements also define the duration the generators are required to withstand the deviation from the normal value. In the IEC Standard 60034-1 for rotating electrical machines these two dimensions (ranges and times) are combined in a single diagram covering both voltage and frequency (see FAQ 19, Figure 1).

- Why does ENTSO-E not do the same?

  The IEC standard covers requirements at the generator terminals. The network code covers requirements at the Connection Point. Therefore they are very different. The impact of the generator transformer possibly with an on-load tap changer as well the impact of the collection network in the case of a Power Park Module makes up this difference. The network code does not specify the voltage range at the generator terminals.

- If there is no diagram how should the situation of simultaneous deviation in frequency and voltage be interpreted?

  Each requirement applies on its own. If the specified duration withstand capability is exceeded, then the Generator is entitled to trip. If both quantities vary at the same time, the quantity with the shortest duration criterion can initiate the trip.

Example for GB:

If 51.2 Hz (frequency limited time operation) and 1.07 p.u (voltage limited time operation) occurs for 20 min, what will happen?

- It is not allowed to trip on frequency (<90 min), however after 15 min, it would be allowed to trip for voltage (>1.05 for longer than 15 min).
- If the voltage threshold of 1.05 p.u. had not been exceeded until after 80 min of frequency at 51.2 Hz , then it would be allowed to trip on frequency after 80+10 = 90 min (voltage will then have exceeded its limit for 10 min only and therefore it is not allowed to trip on voltage criteria).

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Answer to FAQ 22:

Why do you need the wide reactive power capability range?

The U-Q/P_{max}-profile is representing the reactive power capability of a Power Generating Facility in context of varying voltage at the high-voltage terminals of the step-up transformer to the voltage level of the Connection Point. The U-Q/P_{max}-profile applies to the HV-side of the last step-up transformer before the Connection Point.

Different types of networks (e.g. distribution or transmission purpose), different network topologies (degree of network meshing) and characteristics (ratio of infeed and consumption) need different ranges of reactive power. The provision of reactive power at a certain point in the network strongly depends on the local needs which are described in the sentence before. For instance, highly meshed and/or heavily loaded networks need more lagging reactive power (production), whereas remote networks with modest power flows and low consumption need more leading reactive power (consumption) in order to keep the network voltage within the permitted range.

The size of the Q/P_{max}-Range (fixed green envelope) in the U-Q/P_{max}-profile is determined by the maximum leading reactive power (consumption) and by the maximum lagging reactive power (production) which is defined in today's different network codes of European TSOs. The green envelope is thus only an outer limitation and not a requirement for a reactive power range.

The dimension of the red envelope is defined for each synchronous area in order to harmonize the reactive power capability requirement. The inner red envelope can be moved within the green envelope, but cannot be positioned outside.

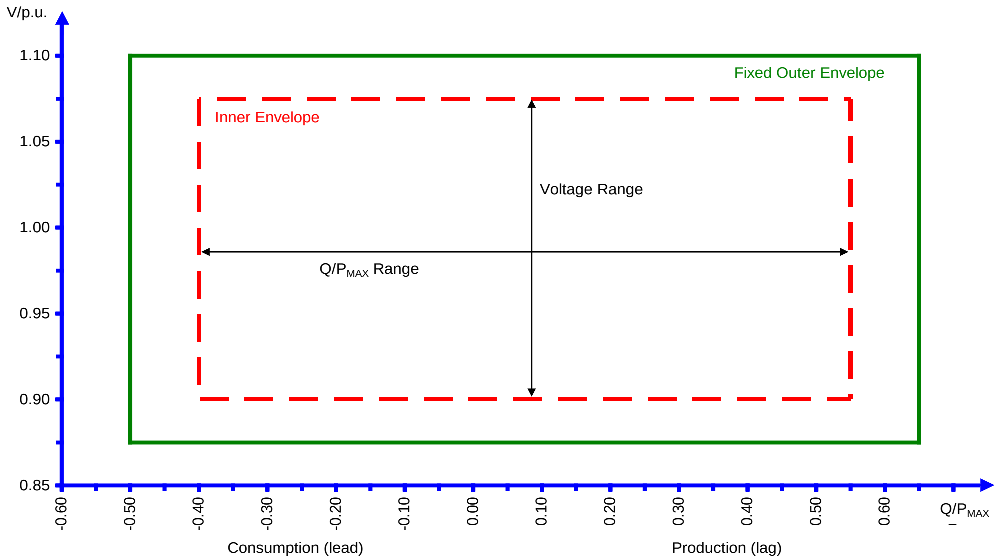

Figure 1 – U-Q/P_{max}-profile of a Synchronous Generating Unit

Each Network Operator defines his particular shape (e.g. rectangle, parallelogram) inside the red envelope of the synchronous area it is connected to with regard to its specific local needs and after approval of the NRA or after consultation.

The importance of wide reactive power capability range is defined by the constantly increasing necessity of effective voltage regulation in the whole network. Voltage regulation becomes more complex because of the continuous change of network topology and characteristics, in particular driven by increasing long-distance power flows due to changes in the generation portfolio and the emerging internal electricity market. Each Generating Unit, must be able to participate in the voltage regulating process.

In the end the specific needs of the TSO are essential parameters for the final design of the generator/converter and Step-Up-Transformer of the Power Generating Facility.

Answer to FAQ 23:

Why do you not refer to primary, secondary and tertiary response?

In the different synchronous areas in Europe different control schemes are implemented with the aim to maintain and restore system frequency to its nominal value. The Continental Europe synchronous area (former UCTE), for example, has established the provision of primary, secondary and tertiary response, which differs from the scheme applied in the Great Britain synchronous area. The different schemes have in common, that they make use of the capability of Generating Units to operate in "Frequency Sensitive Mode" (FSM)[5] and "Limited Frequency Sensitive Mode" (LFSM)[6] respectively which are both included in the network code requirements. These define the capabilities of Generating Units to increase or decrease active power output in response to frequency deviations from the nominal value to improve frequency stability. Therefore on this level the relevant capabilities can be determined for all synchronous areas regardless of the specific implemented control scheme.

[5] Frequency Sensitive Mode (FSM) - a Generating Unit operating mode which will result in Active Power output changing, in response to a change in System Frequency, in a direction which assists in the recovery to Target Frequency, by operating so as to provide Frequency Response.

[6] Limited Frequency Sensitive Mode (LFSM) - a Generating Unit operating mode which will result in Active Power output reduction/increase, in response to a change in System Frequency above/below a certain value.

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Answer to FAQ 24:

What is the technical background for setting the network code's Fault-Ride-Through requirements?

ENTSO-E recognizes the urgent need that both Synchronous Generating Units and Power Park Modules (PPM) should remain stable and connected to the network when faults occur on the transmission network, in particular in order to avoid frequency instability. This is known as fault ride-through capability (FRT) and it is an emerging requirement, in particular for TSOs with a high penetration of distributed generation.

The FRT requirements are based on a voltage-against-time profile at the Connection Point, which reflects the worst voltage variation during a fault and after its clearance (retained voltage during a fault and post-fault voltage recovery) which is to be withstood. Generating Units have to stay connected to the grid for voltages above these worst-case conditions and shall continue stable operation after a Secured Faults on the network unless the protection scheme requires the disconnection of a Generating Unit from the network.

Due to the limited impact of failures at the distribution levels on power system security, both Synchronous Generating Units and PPM have to fulfil less stringent requirements during the voltage drop. They will however have to withstand a voltage drop that results from a fault at the higher (transmission) voltage levels. Different voltage-against-time-profiles for Synchronous Generating Units and PPM are applied in order to make best use of the different technical capabilities of the generation technologies.

A number of reasons justify the FRT capability:

- Security of supply must be ensured. Every power system is designed to withstand a maximum sudden loss of generation capacity after system faults. However, if Generating Units connected to healthy circuits do not remain connected and stable during and after a fault, a considerable amount of generation may be lost even after a secured fault. This results in the potential loss of generation connected to healthy circuits with the consequence of losing the maximum designed infeed loss, the impact being the collapse of system frequency.
- If FRT capability is not applied the ability to connect such generation sources to the system in the future becomes substantially limited.
- It must be ensured that as a result of a voltage drop and during the voltage recovery phase, the auxiliary and control supplies of the Generating Units do not trip.
- A essential requirement is the ability of the generating plant to restore active power on fault clearance. Whilst the ability to remain connected is important it is essential that there is no significant drop in active power output exported to the system once the fault has been cleared.

Large scale wind power and other distributed generation integration into power system operation gives rise to new challenges for the entire system and for TSOs in particular. As certain forms of renewable generation emerges, there is an increased risk that faults on the transmission system (which lead to low voltages spread across large geographical areas around the point of the fault during the period of the fault) may lead to the disconnection of large amounts of generation. The massive loss of generation after a normal fault leads to more severe disturbances, i.e. frequency collapse in a synchronous area causing demand tripping and unexpected power flows resulting in overloads both on internal transmission lines and tie lines with neighbouring systems possibly leading to cascading tripping, system splitting, load shedding, major faults, brown outs and even black outs. It should be noted that power systems have been designed to withstand a maximum loss of generation (usually the largest unit, crucial interconnectors etc). Although, the transformers between the transmission and distribution system will limit the voltage drop seen on the distribution system for a transmission system fault, the effect of increased levels of distributed generation will need to be tolerant to system faults, especially where the total installed volume of embedded generation at a Grid Supply Point exceeds the maximum designed generation loss.

In order to design and assess the FRT capability of the single generating unit each TSO shall define the pre-fault and post-fault conditions for the fault ride through capability in terms of:

- conditions for the calculation of the pre-fault minimum short circuit capacity at the Connection Point;
- conditions for pre-fault active and Reactive Power operating point of the Generating Unit at the Connection Point and voltage at the Connection Point;

and conditions for the calculation of the pre- and post-fault minimum short circuit capacity at the Connection Point and pre-fault active and reactive power of the Generating Unit

The FRT requirements are defined at the Connection Point (CP). Therefore in principle compliance needs to be demonstrated at the CP. For some countries this may contrast with an existing compliance process in which FRT compliance is dealt with through a type testing process. The movement of focus to the CP could therefore lead to significantly more complex and hence costly engineering studies to prove compliance on a project by project basis.

To avoid this wherever possible, it is anticipated that type tests of single Generating Units in a PPM will continue. The challenge is testing against what voltage profile, as none is defined in the network code for PPMs at the individual Generating Unit level. It is possible to determine a worst case voltage withstand curve for an individual Generating Unit in a PPM from the national chosen voltage withstand curve, taking into account the retained voltage across the minimum impedance between the CP and the Generating Unit. All Generating Units in a PPM compliant with this worst case curve can avoid the sometimes complex studies of calculating retained voltage up to the CP for the tested conditions.

As there is a degree of national choice in the withstand curve (the shaded area) it is challenging to define testing at a European level. The details of the compliance process are determined at a national level rather than at a European level. Any manufacturer testing against the most challenging version of the voltage withstand envelope will however be compliant throughout Europe. Failure of a type of Generating Unit in a PPM to achieve this most challenging requirement does not mean that it is not compliant. It only means it has more work to do to demonstrate compliance, maybe even for an individual project. Therefore more studies will have to be undertaken.

Example explaining FRT capability as required by the network code:

The FRT requirement for a Type B PPM is chosen. A TSO can specify a voltage-against-time profile for FRT capability this being any profile on or between the red lines. An example is given in the figure below, in which the green or the blue profile can be defined.

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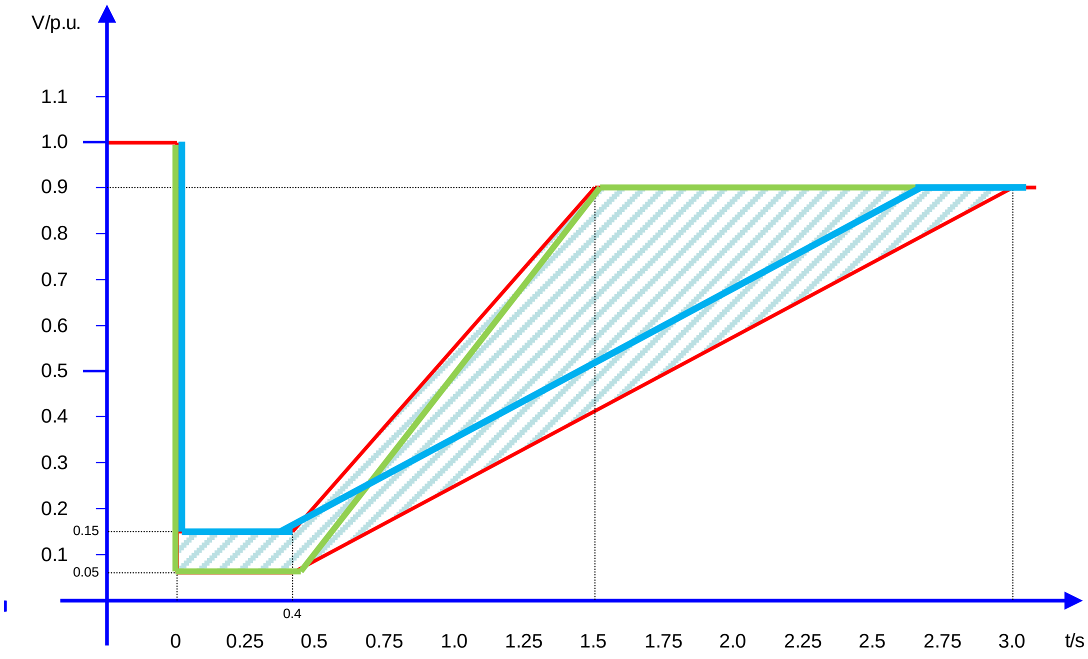
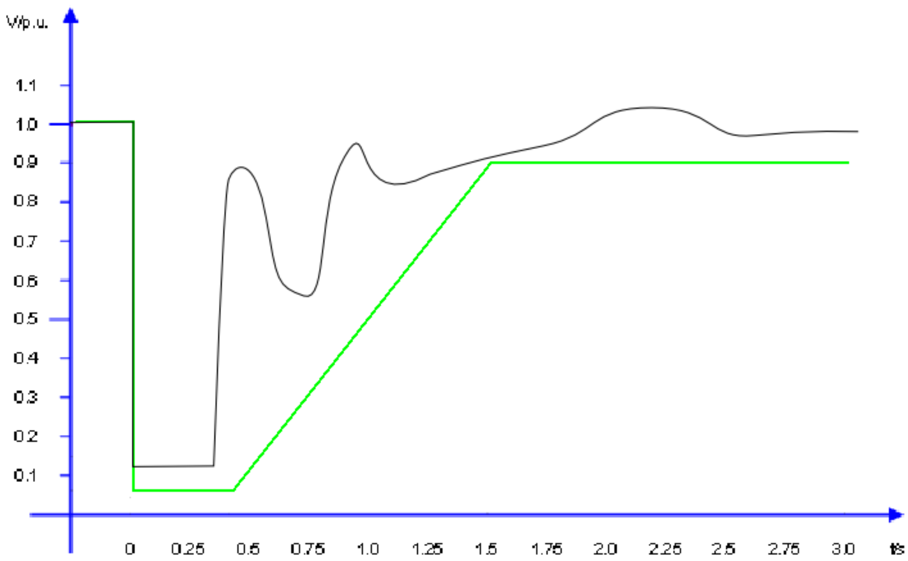
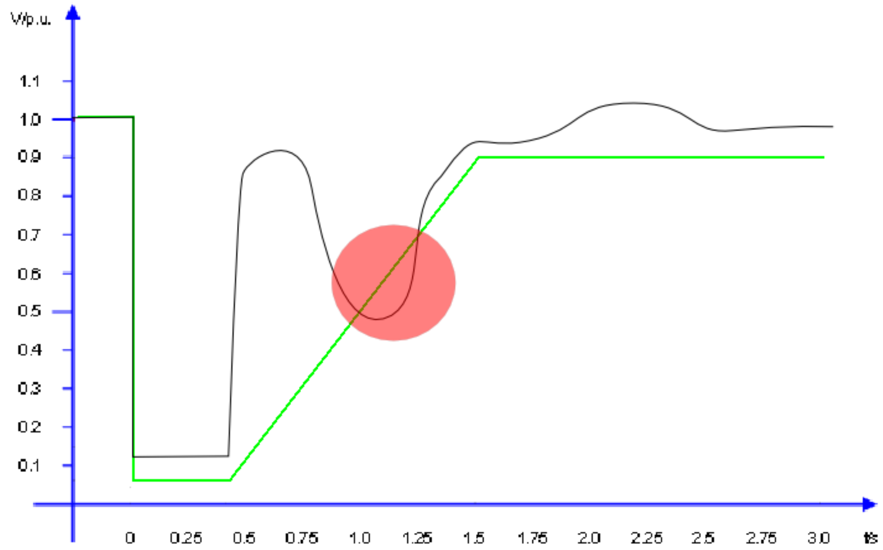


If we consider the green profile, the PPM shall stay connected to the network and continue stable operation when the actual course of one of the three phase-to-phase voltages on the network voltage level at the Connection Point which sustains the lowest retained voltage during a symmetrical or asymmetrical fault (actual voltage recovery curve) remains above the green line.

In case of an actual voltage recovery curve of the shape given in the figure below, the PPM shall not disconnect because the voltage recovery curve remains above the voltage-against-time-profile define by the TSO.



In the second case given in the figure below, the voltage recovery curve in the red zone is below the voltage-against-time-profile. Hence, the PPM is allowed to disconnect from the grid in this case.



It has to be understood that the TSO is **not** requiring the actual voltage recovery curve (black) to be of the shape of the voltage-against-time-profile (green). It needs to be clear that the actual voltage recovery curve will have a free controlled response during the post-disturbance recovery period that will strongly depend on both the PPM technology (e.g. full converter, doubly-fed...) and the short circuit power of the grid connection point. The voltage-against-time-profile (green) just expresses the lower limit for the actual voltage recovery curve (black) for FRT capability.

Answer to FAQ 25:

Why is synthetic inertia needed by some TSOs?

In meeting the EU energy policy targets regarding security of supply, frequency stability is a major topic. Maintaining frequency stability is particularly challenging when the balance between supply and demand is suddenly disturbed, for instance from a large change in available generation to support the demand. This can occur from the loss of a large generator which is reasonably common or a system split which is a lot less common.

In a system where synchronous generators are predominant, at the instance of a large generation trip, the remaining synchronous generation tends to resist the subsequent change in speed (inertia) to restore balance. Wind turbines under the most common configurations, as well as PV generation, do not contribute to this as their mechanical inertia is decoupled from the system. In high wind conditions, particularly when combined with modest demand, some synchronous zones either have already experienced or expect to experience in the foreseeable future based on planned / contracted connections a very high proportion of the total generation to be sourced from generation which is unable to contribute to System Inertia.

A major system study carried out for the Irish System Operator Eirgrid concluded that there is a limit to the instantaneous wind penetration while maintaining frequency stability. It defines this limit to be somewhere between 60 and 70% for the Irish system. As both the Irish and the Great Britain synchronous areas expect to experience conditions when wind generation alone exceeds total demand of the synchronous area on some days in the year, and most European countries are expecting particularly high penetration levels of wind generation in the coming years[7], to maintain the security of the system three alternative options (from an engineering point of view) could be envisaged:

1. Put in place an upper limit for RES penetration (e.g. the capacity likely to give 60% instantaneous non-synchronous generation penetration).
2. During high wind periods, non-synchronous generation (pre-dominantly wind in most systems) should be constrained down/off and replaced through balancing services by synchronous generation constrained on.
3. Require a technical means of replicating the inertia of synchronous plant (fast supply, e.g. in 200ms of a large but short injection of power proportional to the severity of the disturbance). This means is described as synthetic inertia.

The first two options are very costly from a societal and financial point of view. The second one has been employed in some cases and should continue to do so where most economical (including adequate cost representation of greenhouse gas consequences). The TSOs in Ireland and GB have already contracted for connections which at certain times (unless constrained) will exceed 60% penetration. The network code allows for the third option. It is expected that synchronous areas with potential for such high instantaneous non-synchronous generation (e.g. >60%) will require such a solution. Therefore, early action should be taken to add an additional control function for the converters in order to deliver synthetic inertia and/or fast frequency response capability. The requirements have to be carefully balanced to avoid internal wind turbine stability issues. Work has been done with the wind industry towards this goal.

It is not suggested that this added level of complexity is justified for the smallest installations, such as those described in the network code as Type A and Type B.

The technical solution of implementing inertia requirements for those Generating Units which do not naturally provide inertia is still under development. The two main options under consideration are:
- A form of synthetic inertia providing a power increase proportional to the rate of change of frequency
- Delivering a fast frequency response in which the response starts early and in which the full response is delivered in a short time.

[7] See ENTSO-E's Ten-Year Network Development Plan at www.entsoe.eu

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To facilitate the second option, should this become the preferred method of contributing to "inertia", TSOs are allowed to specify reaction and delivery times shorter than what is required for frequency response, taking into consideration generation technologies (see Table 4, t_1 and t_2).

Answer to FAQ 26:

Why is Power Quality out of the scope of this code?

The term power quality is related to the degree of the distortion of the real grid voltage from the ideal sinusoidal wave. If the real grid voltage has the shape of an ideal sinusoidal wave, power quality is best. The more it differs, the worse power quality becomes. Bad power quality means a high degree of harmonics, flicker and voltage dips. These distortions can lead to malfunctioning of some grid users, but do not bear the risk of a wide-spread danger to system security. In contrast to other issues (e.g. voltage or frequency stability), the impact of power quality problems is limited to local customers.

Countermeasures against power quality problems are for example the introduction of filters, grid separation into “dirty” and “proper” parts or the increase of short circuit power by modified topology. For all these countermeasures, local circumstances have to be considered carefully.

Both, the impact of and the countermeasures against power quality problems, can be solved on a local basis and therefore have to be considered as a local issue which is not covered by this code.

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