Requirements for Grid Connection of Generators : Ideas for improvements of the code.

Presented at Brainstorming Session 31/1/2018

Content

This presentation describes a number of items detected by Eurelectric and VGB susceptible for improvements in the RfG NC. Also interactions with the IGDs and with provisions in other codes are included.

The aim is to start a discussion to solve those issues in close collaboration with ALL stakeholders of the GC ESC.

The solution proposed in this presentation is one of the potential solutions and the position of Eurelectric and VGB can change due to the exchanges formulated at the brainstorming session.

A priori, Eurelectric and VGB will provide a formal input for next GC&SO-ESCs (March, 2018), following their presentation in Dec. 2017 and the exchanges.

If a consensus would be reached, what will be the procedure to insert the solution in the legal documents?

Topic 1: information on amendment process

- For several issues, one of the possible solutions for **medium/long term** is an amendment in the codes => this is why we propose an exchange on the corresponding process
- How can one stakeholder make some proposal for amendment?
  - Directly to the Commission?
  - In the ESC who will decide or not to transmit the proposal to the Commission?
- ACER informed the GC-ESC that the ACER Guidance on amendment process would be updated (the last version was written in 2013) by about 1 year => more detailed deadline?
- How long will the ‘fast procedure’ take to achieve amendment?

Topic 2: Classification of PGMs (1/2)

IN RfG:

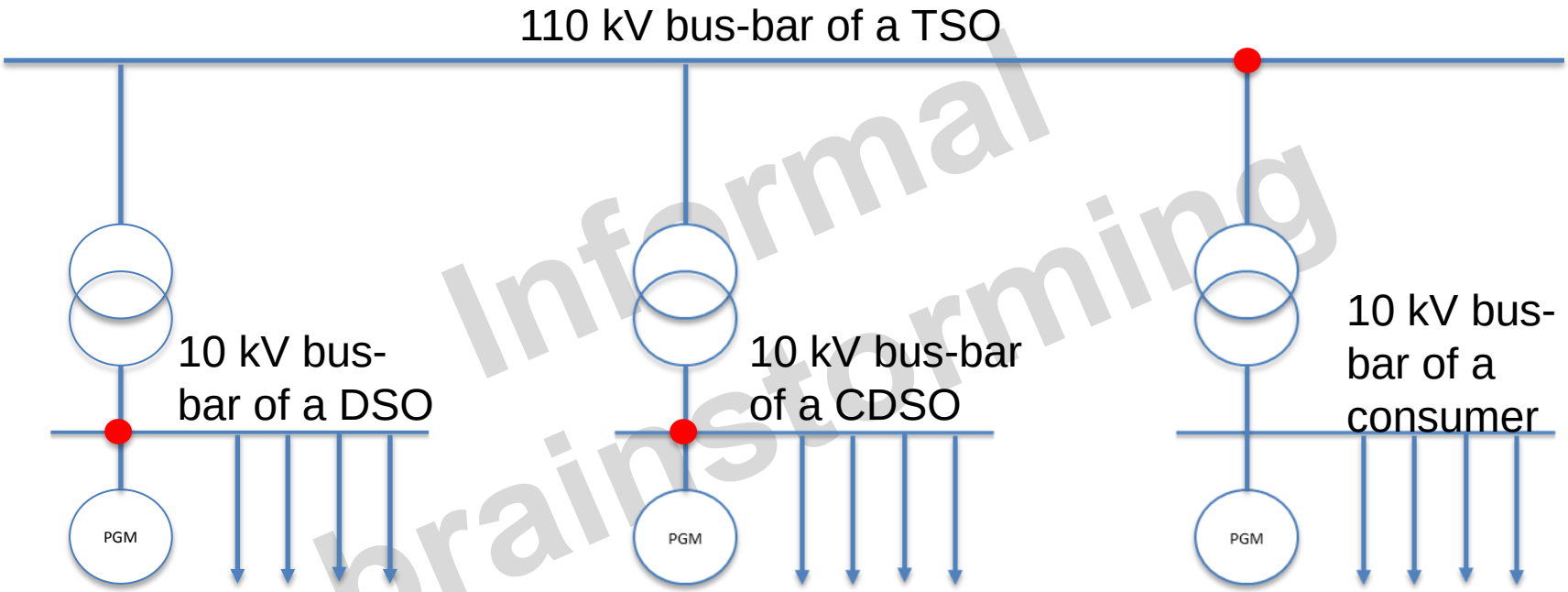
- Art. 5 defines a classification of power generating modules (PGM) depending on their capacity and on the voltage at the connection point.
- Each PGM connected at 110 kV or above is defined as a type D, meaning that a photo-voltaic panel of 800 W at an industrial consumer, connected at 110 kV or above, is a PGM of type D and is treated identically as a nuclear PGM of 1000 MW.
- Some countries expect a class derogation for not using this voltage criterion.

This classification is also used **in the GLSO**:

- The GLSO imposes operational planning procedures in Part III for relevant PGMs type B,C and D without a definition of the notion “relevant” creating also uncertainty.
- The procedures are justified for a nuclear PGM but NOT for smaller PGMs at industrial sites.
- Those procedures will reduce the interest of large industrial consumers to install RES and cogeneration units at their site.

Topic 2: Classification of PGMs (2/2)

The connection of a 10 MW PGM can be realised as follows:



PGM = Type B

PGM = Type B

PGM = Type D

● = connection point

Technically, all PGMs and their effect on the grid are identical.
Why the discrimination at the site of an industrial consumer ?

SOLUTIONS?

Topic 3: Measurement precision of the frequency

In the NC RfG, Art. 14 table 4 imposes

- a frequency response insensitivity between 10 mHz and 30 mHz
- a dead band between 0 mHz and 500 mHz

for PGMs supplying FSM.

In the GLSO, Art.154 and the table in Annex V require a “Maximum combined effect of inherent frequency response insensitivity and possible intentional frequency response dead band of the governor of the FCR providing units or FCR providing groups” of 10 mHz for CE.

SOLUTIONS?

Topic 4: Max. voltage in 400 kV grids (1/2)

In the NC RfG, table 6.2 imposes for Continental Europe that equipment has to withstand a voltage of 1.05 pu to 1.1 pu during a period of time not less than 20 minutes and not more than 60 minutes. The value of 1 pu is 400 kV (Art.6.2.iv).

In the GLSO, Art. 27 and Annex II table 2 limit the voltage in the normal state of the 400kV grid at the level of 1.05 pu or 420 kV, supposing 1 pu equal to 400 kV.

We are convinced that the requirement to withstand 440 kV during 20 minutes or more is a violation of Art. 1 of NC RfG requiring that system operators make appropriate use of the power generating facilities capabilities because the voltage will never be above 420 kV during more than 20 minutes.

Notes :

- The value of 420 kV is also the upper limit specified in the IEC established technical standard to be taken into particular consideration according to the NC RfG recital 27.
- A similar requirement for the installations of the grid operators does not exist.

Topic 4: Max. voltage in 400 kV grids (2/2)

The table below visualises characteristics of GIS switchgear according to IEC.
The power frequency withstand voltage can be applied during only 1 min.

ELK-3 C, 420 kV	Product ID	1HC0071250M0080
Rated voltage	kV	420
Power-frequency withstand voltage, 1 min.	kV	650
Power-frequency withstand voltage, 1 min. across open contacts	kV	815
Lightning impulse withstand voltage	kV	1425
Lightning impulse withstand voltage across open contacts	kV	1425 + 240
Switching impulse withstand voltage	kV	1050
Switching impulse withstand voltage across open contacts	kV	900 + 345
Rated frequency	Hz	50/60
Rated continuous current	A	4000/5000
Rated short-time withstand current	kA	63
Rated withstand impulse current	kA	170

SOLUTIONS?

Topic 5: Battery storage devices (1/2)

IN RfG:

- Art.3.2.d indicates that battery storage devices are not subjected to the code.
- But given the respective definitions of SPGM and PPM, it seems that:
  - Batteries can be used to merge capabilities for PPM
  - But not for SPGM because of '***indivisible*** *set of installations*'
- If the interpretation is confirmed, this constitutes to a discrimination

IN GLSO:

- The scope of this code (Art. 2) doesn't mention batteries (neither to include them, nor to exclude them)
- Some people consider they are included in application of (d) & (e) as a **demand facility** providing demand response
- Can we consider this interpretation is correct?
- If 'yes', shouldn't there be some adaptation of requirements?

Topic 5: Battery storage devices (2/2)

Why the issue is important?

- Since the drafting of the NC RfG, batteries have become a common, mature equipment for storage
- We believe that this technology will have an increasing impact on the electrical system
- Up-to-date batteries have characteristics even more performing than synchronous generators, especially in the domain of responds times

- ➢ Some adaptation of the requirements would permit to benefit plainly from this technology in near future!
- ➢ Are requirements for batteries at European level justified?

More information in the presentation of EASE

SOLUTIONS?

Topic 6: Pump-storage devices (1/4)

Pump-storage devices have to fulfil the requirements in both generating and pumping mode.

As stated in Art.14.3 a unique fault-ride-through requirement applies for both operating modes.

Due to the hydraulic phenomena in the penstock, it is technically justified to allow different characteristics, one for the generating mode and another one for the pumping mode.

Topic 6:

Pump-storage devices (2/4)

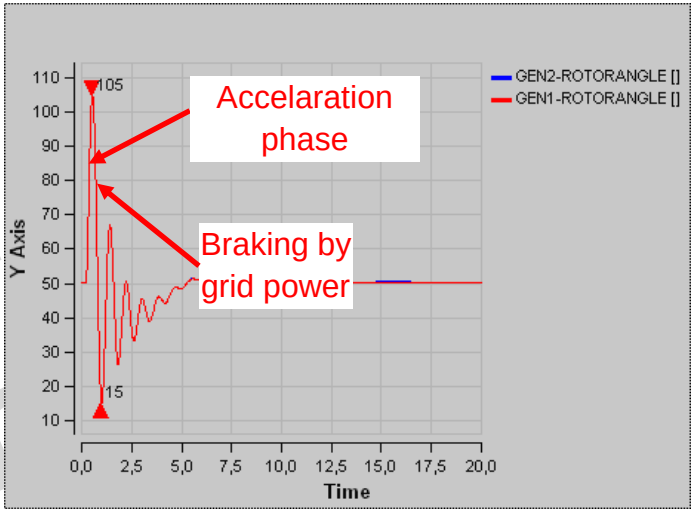
Generating mode

- During FRT the power of the turbine ($P_{Turbine}$) is used to cover bearing losses, generator losses and to accelerate the rotor ($P_{accelerate}$)
- $P_{accelerate} = P_{Turbine} - P_{Losses}$
- After voltage recovery, the rotor is forced to original rotor angle position by the grid.

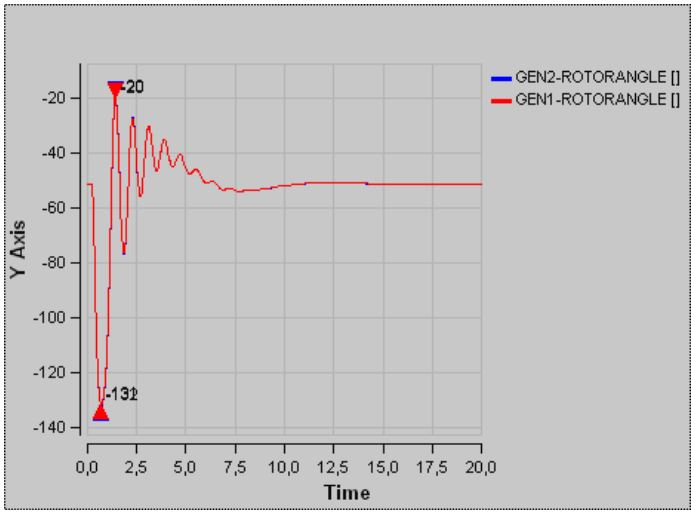
Pump mode

- FRT in pump-mode is more difficult to achieve, since the rotor slows down ($P_{slowdown}$) by water pressure + bearing losses + generator losses leading to a larger rotor angle.
- $P_{slowdown} = P_{Pump} + P_{losses}$
- After voltage recovery, the rotor is forced from more far rotor angle to the original rotor angle position by the grid.
- Close to stability limit this process is highly non linear

Typical simulation result of rotor angle



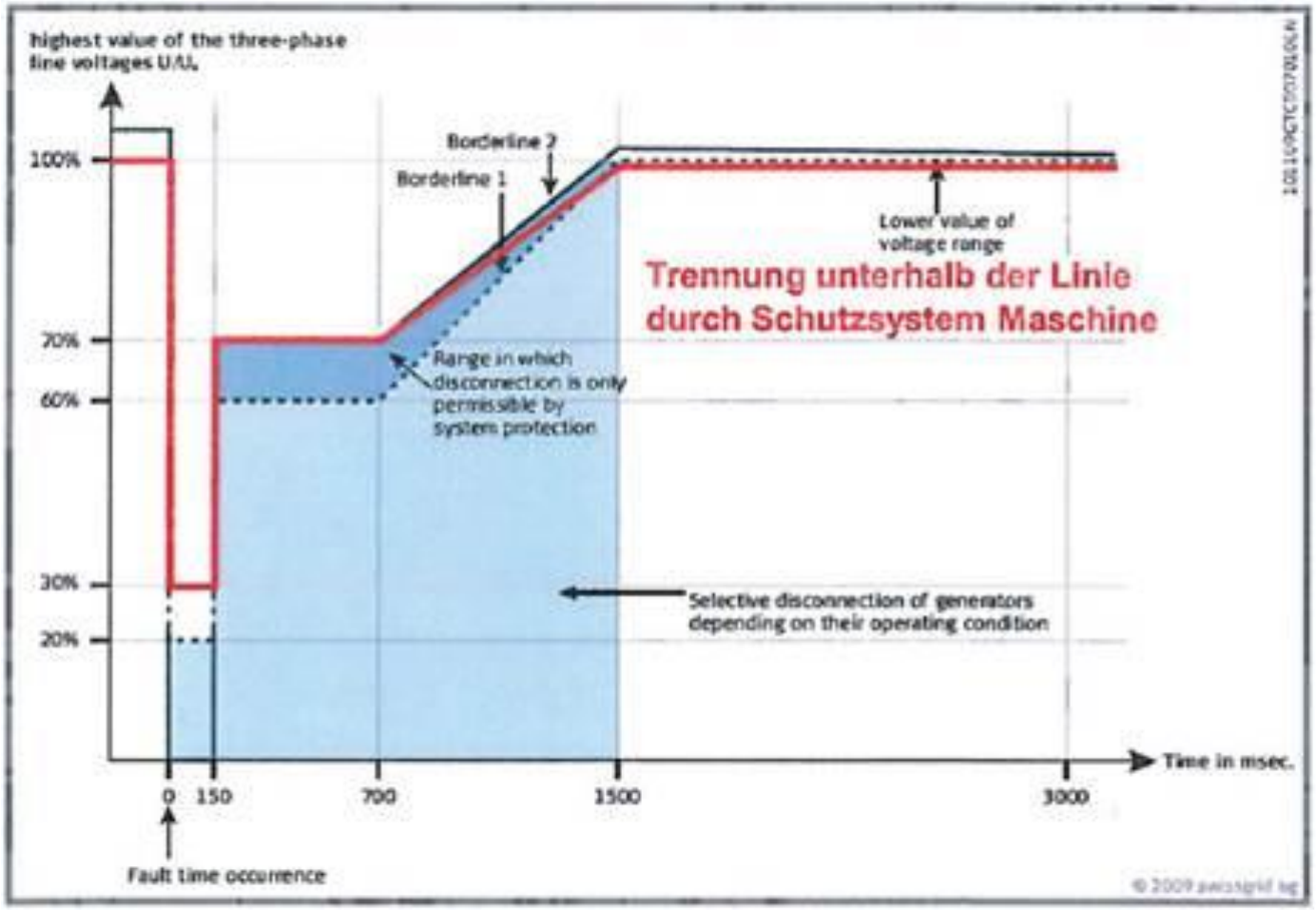
Rotor angle in generating mode +105°



Rotor angle in pump mode -132°

Topic 6: Pump-storage devices (3/4)

This graph shows the FRT capability of a recent plant in pump mode (build now) :
At a voltage dip below 30%, the plant will trip (RfG table 7 imposes 0%)



Topic 6: Synchronous compensation of pump-storage (4/4)

Art. 6.2 imposes that the synchronous compensation mode of pump-storage PGMs shall not be limited in time. But :

- To avoid the waste of water, the water supply from the penstock is blocked during such operating mode.
- All losses e.g. bearing losses, generator losses have to be supplied by the electrical grid.
- The turbine blades (Pelton & Francis) now rotate in air instead of water.
- Therefore the turbine blades do not get cooled by the water, but instead get heat up by air friction.
- If such a turbine has to be operated for unlimited time in synchronous operation, an additional blade cooling system is necessary.

More globally, what is the interpretation of the whole Art. 6.2?

SOLUTIONS?

Topic 7: Regarding CENELEC's / new standards (1/2)

- A standardization of equipments (units Types A&B, in this instance) would benefit to the whole community, mainly because:
  - Economic interest (manufacturers => producers & system operators => consumers)
  - It permits to avoid very numerous and heavy 'compliance checking' (testing and/or monitoring)
- CELENEC's new standard is a good opportunity to approach the interests above. In this objective, some requirements have to be treated carefully:
  - Good choices **while applying CENELEC's** standard (because some requirements are also 'non-exhaustive' in this standard), ex.: f_1 threshold for LFSM-O (50,2 – 52 Hz in the standard/50,2-50,5 Hz in RfG)
  - Good choices **while implementing RfG** code, ex.: tclear for FRT/Type B (0,14 – 0,25s in RfG / min. 0,2s in the standard)

Topic 7: Regarding CENELEC's / new standards (2/2)

- CENELEC's standard also contains some additional requirements (not in the scope of RfG) => not a problem, as long as they do not lead to substantial overcosts

- Presentation by CENELEC

SOLUTIONS?

Topic 8: Entering into force of the RfG requirements

Art. 4.2.b specifies :
For the purposes of this Regulation, a power-generating module shall be considered existing if the power-generating facility owner has concluded a final and binding contract for the purchase of the main generating plant by two years after the entry into force of the Regulation. => 17/5/2018.

Art.7.4 specifies :
The relevant system operator or TSO shall submit a proposal for requirements of general application, or the methodology used to calculate or establish them, for approval by the competent entity within two years of entry into force of this Regulation.
=> A proposal on 17/5/2018. => No approved requirements available on this date.

Art.72 specifies :
Without prejudice to Articles 4(2)(b), 7, 58, 59, 61 and Title VI, the requirements of this Regulation shall apply from three years after publication. => 27/4/2019

Which requirements apply at a purchase between both dates?

Topic 9: Specifications in the IGDs (1/2)

The IGD on FSM proposes following activation times for UK and IE / NI

Initial delay t1	≤ 2s for SPGM ≤ 500 ms for PPM	
Response activation (full activation) t_2 default value	CE, Nordic :	30s
	GB	10s
	IE/NI	15s

Art.15.2.d of the RfG NC specifies :
"Max. admissible choice of full activation time t_2, unless longer activation times are allowed by the relevant TSO …. = 30 seconds"

Our interpretation of Art.15.2.d is that :

- The PGM can choose any activation time with a max of 30 sec
- The TSO can impose longer activation times, no shorter ones.

SOLUTIONS?

Topic 9: Specifications in the IGDs (2/2)

The IGD on Limited Frequency Sensitive Mode (LFSM) mentions

- A recommendation for the thresholds for LFSM-U and LFSM-O

Synchronous area	LFSM-U threshold	LFSM-O threshold
Continental Europe	49.8 Hz	50.2 Hz
Nordic	49.5 Hz	50.5 Hz
Great Britain	49.5 Hz	50.4 Hz
Ireland	49.5 Hz	50.2 Hz
Baltic	49.8 Hz	50.2 Hz

- A default droop for LFSM-O

Synchronous area	LFSM-O default droop settings of PGMs
Continental Europe	5%
Nordic	4%
Great Britain	3-5%
Ireland	4%
Baltic	5%

- No figures for LFSM-U.

Are those settings a subject for an IGD of the RfG NC or for the GL SO in the Synchronous Area Operational Agreement?

Next steps

We propose to create a dedicated “ad-hoc stakeholder group” as specified in Art. 11 of the NC RfG

- Chaired by ACER or ENTSO-E or Eurelectric/VGB?
- To discuss the items proposed in this presentation
- To add the items proposed by other stakeholders
- To propose a solution for each item
- According to the Terms of Reference of this GC ESC

in order to establish a common proposal.