Max voltage in 400 kV Networks

ENTSO-E

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Summary

Need to withstand wide voltage range

RfG requirements have been written taking into account power system needs.

Some examples of such needs are reported below (extracts from the final NC RfG package submitted to ACER in July 2012):

- "**120626 - NC RfG - Justification outlines**", p. 35 [1]:

  "Voltage ranges are critical to secure planning and operation of a power system within a synchronous area. These need to be coordinated between adjacent interconnected networks. This can often be a cross border issue."

  Alternative solutions identified was to: ***"Have no defined voltage ranges".***

  but:

  "However, this would lead to widespread uncertainty in planning and operation of the system with respect to operation beyond normal operating conditions."

- "**120626 - NC RfG – Frequently Asked Question**", p. 29 [2]:

  Q: "Why do you need the wide voltage ranges for operation?"

  A: "… Indeed, most of the large-scale disturbances to electricity transmission system in the recent years were caused by a loss of voltage stability "

Existing connection rules

The following table shows existing operational voltage ranges, as used in respective countries, before EU's NC RfG (extracts from the document: "120626 NC RfG - Requirements in the context of present practices" [3]).

- Every voltage range is related to a time period in minutes (∞ = unlimited operating time):

Country	Fig.	1° range	2° range	3° range
Romania	10	0.90 pu ÷ **1.1 pu** = ∞		
Hungary	11	0.925 pu ÷ 0.95 pu = 120'	0.95 pu ÷ 1.05 pu = ∞	1.05 pu ÷ **1.1 pu = 30'**
Poland	12	0.8 pu ÷ 0.85 pu = 30'	0.85 pu ÷ 1 pu = ∞	
Italy	13	0.875 pu ÷ **1.075 pu = ∞**		
Germany	14	0.875 pu ÷ 0.9 pu = 120'	0.9 pu ÷ 1.05 pu = ∞	1.05 pu ÷ **1.1 pu = 30'**
Spain	15	0.90 pu ÷ **1.0875 pu = ∞**		

Such values show the need for the operating voltage range high threshold to be not limited to 1.05 pu

KEMA report on RfG

- The KEMA report on RfG [4] (requested by the EC during comitology) further justified the need to have wide voltage withstand capability for the power system:

  "Drafting should be introduced permitting the reinstatement of the additional overvoltage range of 1.0875 pu – 1.10 pu for the Type D power generating modules in Article 11, Table 6.2 for parts of the networks of individual TSOs in Continental Europe where it is required for network configuration reasons, as approved by the NRA, provided it is neither detrimental to the operation of the power system nor to the operation of the internal market."

- The above proposal (as in the paragraph 5.2.1 of the KEMA report about Voltage Ranges) was the conclusion of the analysis and the reply to the comment from the Stakeholders on the values of the voltage ranges proposed during the drafting phase of the RfG.

Studies about TOV

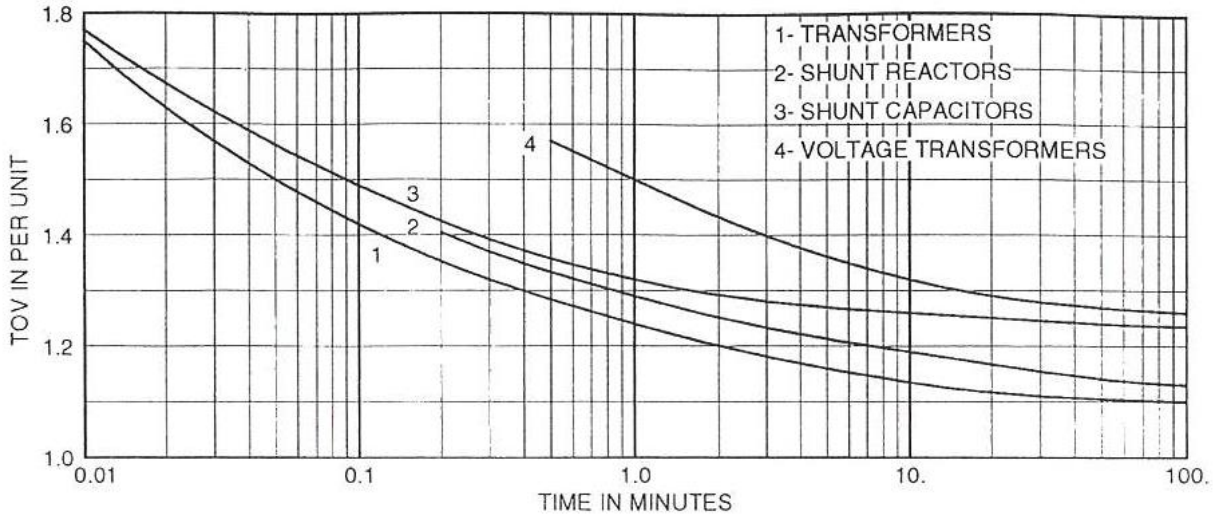
- Several works [5] [6] from Cigrè Working Group 33.10 assess the need for High Voltage equipment to be capable of withstand to Temporary over voltage.

  Temporary over voltage definition (from Cigrè Electra 185-5 [6]):

  "Temporary over voltages (TOV) are undamped or weakly damped oscillatory overvoltages. Frequencies of TOV range from a few Hz to a few hundreds Hz and TOV duration varies from one period of power frequency to hours."

As an example, following figure shows voltage withstand capability related to some HV equipment

(from Cigrè Electra 179-3 [5])



Withstand TOV characteristics for power equipment

Reference to "Voltage Ranges" in EU NCs and GLs

- **Art. 16.2(a)(i) of NC RfG:** ***"power-generating module shall be capable of staying connected to the network and operating within the ranges of the network voltage at the connection point, expressed by the voltage at the connection point related to the reference 1 pu voltage, and for the time periods specified in Tables 6.1 and 6.2;"***

  Table 6.2 applies to networks from 300 kV to 400 kV (for Continental Europe, following ranges are admitted):

Voltage Ranges	*Time period for operation*
0,85 pu – 0,90 pu	60 minutes
0,90 pu - 1,05 pu	Unlimited
1,05 pu – 1,10 pu	20 < time period in minutes <= 60 (to be specified by each TSO)

  Thus, this RfG's article refers to voltage withstand capability in **all operating conditions**.

- **Art. 27.1 of SO GL:** ***"In accordance with Article 18, each TSO shall endeavour to ensure that during the normal state the voltage remains in steady-state at the connection points of the transmission system within the ranges specified in the Tables 1 and 2 of Annex II"***

  Annex II - Table 2 applies to networks from 300 kV to 400 kV (for Continental Europe):

Synchronous area	Voltage Range
Continental Europe	0,90 pu – 1,05 pu

  Thus, this SO-GL's article refers to voltage withstand capability in **normal operating conditions**.

Eurelectric question on violation of RfG's Art.1

- Statement by Eurelectric:

  "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."

- However RfG, Art. 1 states that:

  "This Regulation establishes a network code which lays down the requirements for grid connection of power-generating facilities, namely synchronous power-generating modules, power park modules and offshore power park modules, to the interconnected system. It, therefore, helps to ensure fair conditions of competition in the internal electricity market, to ensure system security and the integration of renewable electricity sources, and to facilitate Union-wide trade in electricity.

  This regulation also lays down the obligations for ensuring that system operators make appropriate use of the power- generating facilities' capabilities ***in a transparent and non-discriminatory manner to provide a level playing field throughout the Union****."*

- The **whole reading** of Art. 1, **clarifies** that the following sentence:

  "system operators make appropriate use of the power- generating facilities' capabilities "

  is **referred** to the "competition for the **European Energy Market**" and not to the technical capabilities of the power generating modules.

Eurelectric question about “technical standards” 1/2

- On the same topic, Eurelectric claims:
  - *“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.”*

  moreover, a table on product specification about a GIS switchgear was also shown:

ELK-3 C, 420 kV		
Rated Voltage	kV	420
Power-frequency withstand voltage, 1min.	kV	650

- To further discuss on this topic, we need to show previous terms as defined on “Electropedia.org” [7]:

Term	Definition	IEV ref
Rated voltage	Rated value of the voltage assigned by the manufacturer to a component, device or equipment and to which operation and performance characteristics are referred	442-09-10
Power-frequency withstand voltage	rms value of sinusoidal power frequency voltage that the insulation of the given equipment can withstand during tests made under specified conditions and for a specified duration	614-03-22

Eurelectric question about “technical standards” 2/2

- According to previous “Electropedia” definitions, these values do not refer to voltage withstand capabilities requirement of the NC RfG, but to:

Rated voltage	• the nominal voltage of the switchgear
Power-frequency withstand voltage	• a compliance test which product should withstand

thus, this **compliance test does not explicitly limit the voltage operational range to a maximum value of 420 kV**.

- About current technical standards on equipment tests, WG-CNC/ENTSO-E agrees with Eurelectric that they do not adequately cover some aspects of RfG requirements.
- This gap, however, should not affect the validity of the connection requirements, which should instead lead to review or update such standards

Conclusions

- There is no violation of Art.1 of RfG because:
  - ✓ Fair use of power generating facilities refers to energy market
  - ✓ The voltage limit of 420 kV from Art. 27(1) GL SO is related to “Normal Operating Conditions”

- Regarding NC RfG recital 27 about Technical Standards:
  - ✓ The voltage limit of 420 kV from IEC standard is a reference to the equipment characteristics
  - ✓ The time limit of 1 minute is related to a specific compliance test which equipment should withstand

- About current technical standards on equipment tests:
  - ✓ They don't adequately cover some aspects of RfG requirements
  - ✓ This shortcoming, however, should not affect the validity of the connection requirements
  - ✓ Equipment testing procedures should be amended according to NC RfG Requirements

- About applying upper compliance standards:
  - ✓ The intent is not to require compliance to 550 kV standard, but to continue using 420 kV standard

References

- [1] 120626 - NC RfG - Justification outlines
  https://www.entsoe.eu/fileadmin/user_upload/_library/consultations/Network_Code_RfG/120626_-_NC_RfG_-_Justification_outlines.pdf
- [2] 120626 - NC RfG – Frequently Asked Question
  https://www.entsoe.eu/fileadmin/user_upload/_library/consultations/Network_Code_RfG/120626_-_NC_RfG_-_Frequently_Asked_Questions.pdf
- [3] 120626 - NC RfG – Requirements in the context of present practice
  https://www.entsoe.eu/fileadmin/user_upload/_library/consultations/Network_Code_RfG/120626_-_NC_RfG_-_Requirements_in_the_context_of_present_practices.pdf
- [4] KEMA final Report of November 2013 on the ENTSO-E Network Code: Requirements for Generators
  https://ec.europa.eu/energy/sites/ener/files/documents/KEMA_Final%20Report_RfG%20NC.pdf
- [5] Temporary overvoltage withstand characteristics of extra high voltage equipment
  https://e-cigre.org/publication/ELT_179_3-temporary-overvoltage-withstand-characteristics-of-extra-high-voltage-equipment
- [6] Temporary overvoltages. System aspects. Part 1
  https://e-cigre.org/publication/ELT_185_5-temporary-overvoltages-system-aspects-part-1
- [7] Electropedia: The World's Online Electrotechnical Vocabulary (by IEC)
  http://www.electropedia.org/