



Guide on New Generator-Grid Interaction Requirements

Panel Session 1: Vision and Drivers for Electric Power Systems

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Introduction

- **As early as in 2004, generator-grid interaction issues attracted the attention of Cigre Study Committee A1: a panel session took place in the Cigre Biannual Session.**
- **Concerns were raised on the lack of consistency between generator standards and grid code requirements around the world.**
- **Working Group A1.29 on “Guide on New Generator-Grid Interaction Requirements” was launched in 2010 within Cigre SC A1.**
- **The outcome of the WG is a Technical Brochure that has just been completed and it is under approval procedures.**

Introduction

■ Scope of WG A1.19

- **Compile grid code requirements worldwide**
- **Identify extra requirements imposed by grid codes with respect to IEC and IEEE standards**
- **Discuss the consistency of extra requirements imposed by grid codes**
- **Elaborate recommendations of consistent requirements**

Review of standards

■ **Standards**

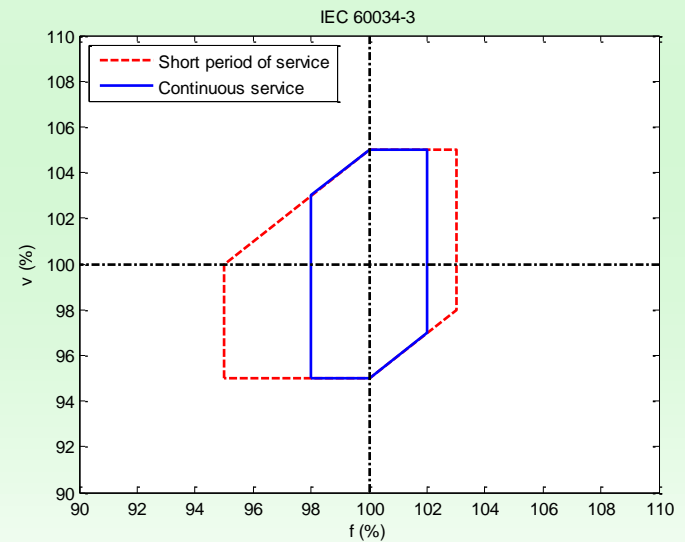
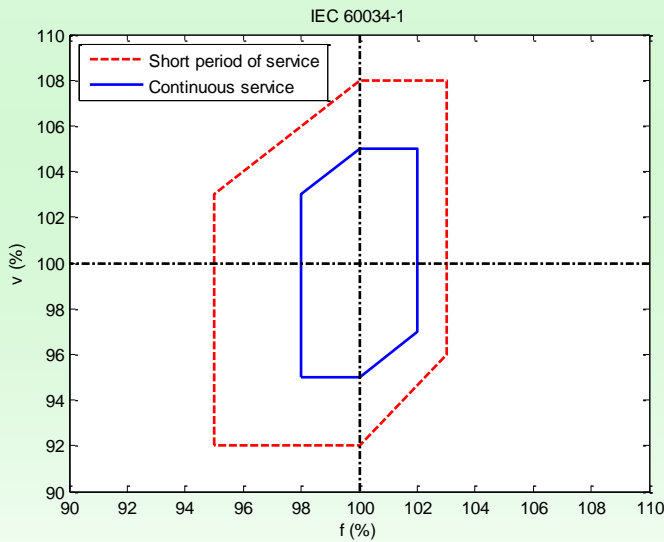
- **Standards are the usual instrument for interaction between suppliers and customers.**
- **Standards play an important role in product specifications.**
- **For turbogenerators IEC 60034-3 and IEEE C50.13 are the most recognized standards and are usually taken as a basis for specifications, both for the development of standard products, as well as for customer-specific products.**
- **As these standards are internationally well accepted, compliance with them gives manufacturers the confidence of developing products, which are acceptable for a wide range of customers.**
- **Such standards do not have legal value, unless they are incorporated to the legal framework of a region or country**

Review of standards

- **Items reviewed**
 - **Voltage-frequency**
 - **Reactive power capability diagram**
 - **Short-circuit ratio**
 - **Ceiling factor**

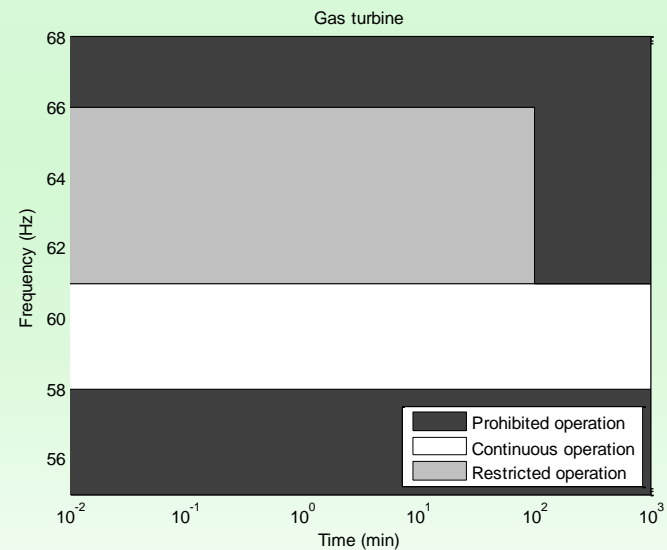
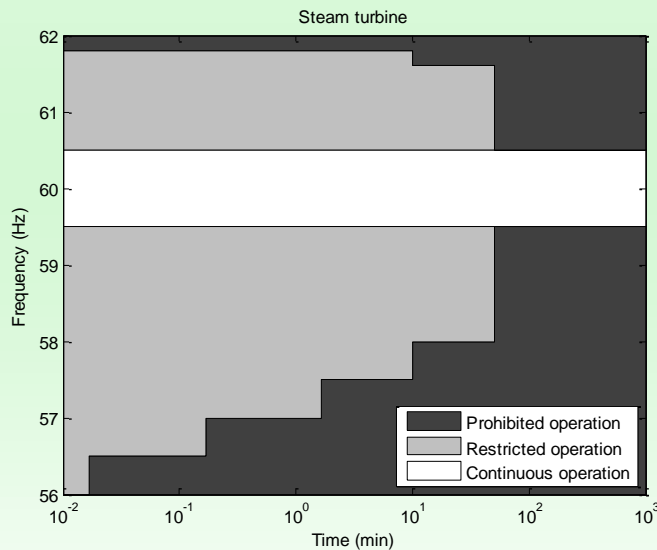
Review of standards

- Voltage-frequency limits as IEC 60034 standard



Review of standards

- Frequency limits of typical steam and gas turbines shown in IEEE Standard C37.106-2003



Review of grid codes

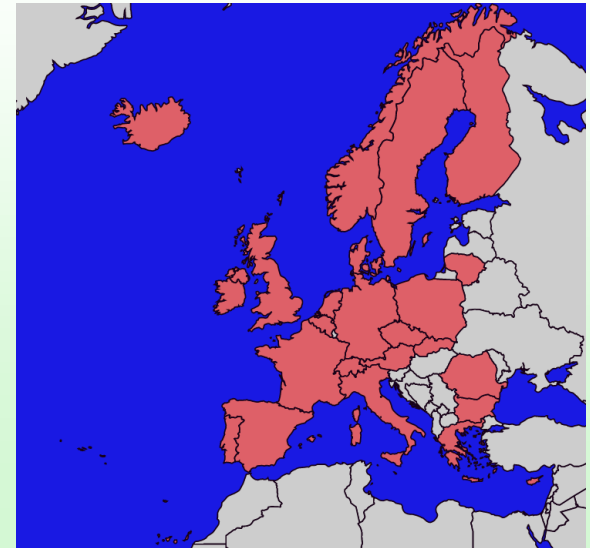
■ Grid Codes

- The de-regulation of electricity markets has resulted in the unbundling of vertically integrated utilities into generation, transmission and distribution companies.**
- As a consequence, grid codes have been developed by Transmission System Operators (TSOs) to formalize their obligations and to establish the framework of their technical relationships with generation and distribution companies.**
- Grid codes have legal value in the region or country they apply.**

Review of grid codes

■ Reviewed European grid codes (22):

- Austria
- Belgium
- Bulgaria
- Czech Republic
- Cyprus
- France
- Germany
- Ireland
- Iceland
- Italy
- Lithuania
- Malta
- Netherlands
- Poland
- Portugal
- Romania
- Slovakia
- Scandinavia
- Spain
- Switzerland
- UK

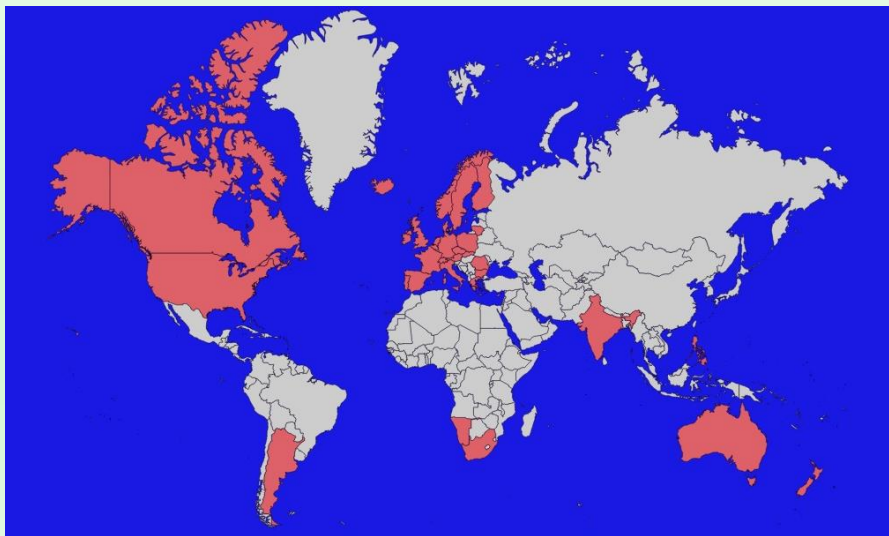


ENTSO-E has elaborated a harmonized code which has been approved as European Directive

Review of grid codes

■ Rest-of-the-World grid codes (12):

- Alberta
- Argentina
- Australia
- India
- Namibia
- New Zeland
- North America
- Ontario
- Philippines
- Quebec
- South Africa



35 grid codes have been reviewed !

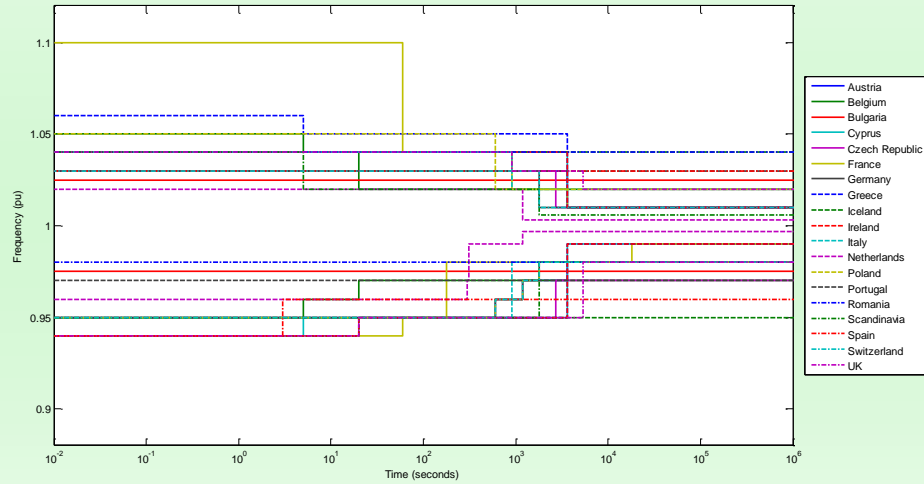
Review of grid codes

- **Items (related to generator-grid requirements) reviewed**
 - **Frequency variation**
 - **Voltage variation**
 - **Reactive power capability**
 - **Fault ride through capability**

Review of grid codes

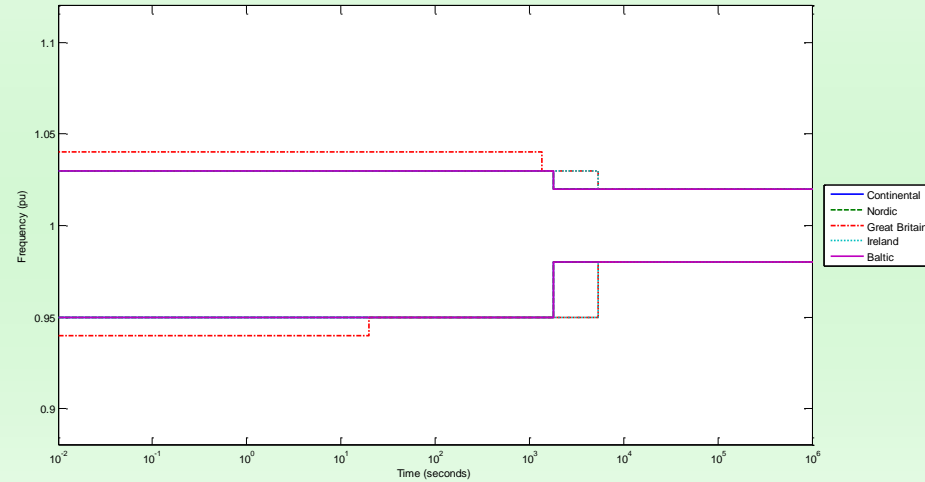
■ Frequency variation

European grid codes



European grid codes

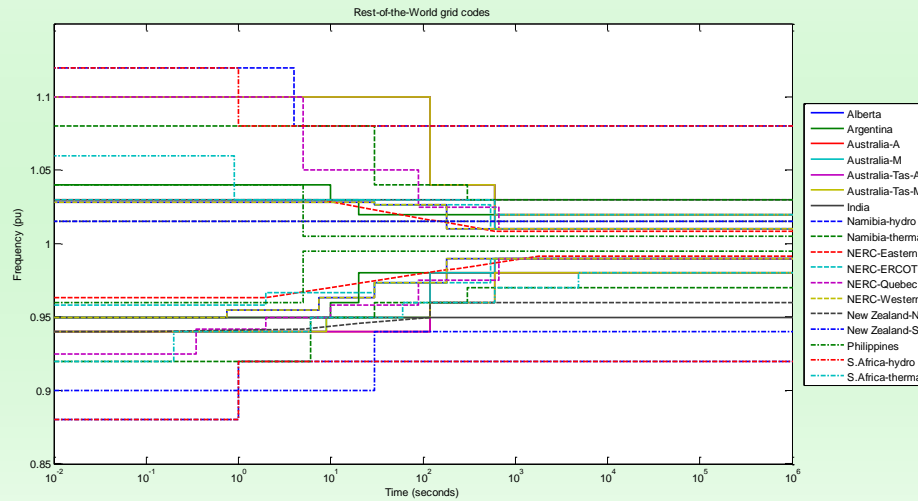
ENTSO-E grid code



ENTSO-E grid code

Review of grid codes

■ Frequency variation



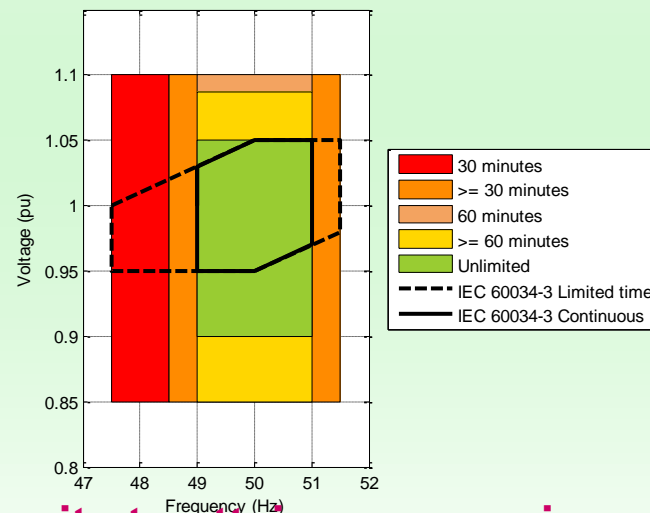
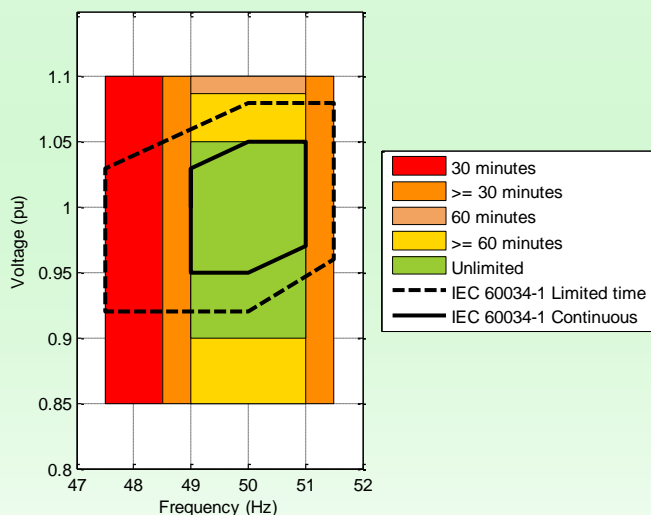
Rest-of-the-world

Discussion of extra requirements imposed by grid codes with respect to standards

- **The ENTSO-E grid code is taken as reference since it is the outcome of a harmonization effort within the European Union**

Discussion of extra requirements imposed by grid codes with respect to standards

- Voltage-frequency variation (generating units connected to the 400 kV grid in continental Europe)



It might be a challenge for generating units to attain some regions of the voltage-frequency required region
 Even machines with OLTC step-up transformers may be subject to over/under fluxing

Conclusions

■ General conclusions:

- Grid code requirements imposed not merely to the synchronous machine but to the generating unit itself**

 - Diversity of grid code requirements compared to coherency of IEC and IEEE standards**
 - ◆ The diversity of power system features could explain this fact.**
 - ◆ Weaker power systems would experience broader frequency and voltage variations than stronger systems.**

 - Grid code requirements could go beyond what standard synchronous machine can provide**
 - ◆ One solution to such problem could be to make use of a bigger (more costly) machine.**
 - ◆ We believe that requirements should be result of an economic trade off between generation and transmission.**
 - ◆ ENTSO-E in Europe has already recognized that the implementation of grid code requirements to existing generators should involve a cost-benefit analysis.**
 - ◆ Such approach should be also considered for new generators.**
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Conclusions

■ Specific conclusions:

- IEC and IEEE standards define a limit for continuous operation and a limit for limited time operation. However, grid codes define duration of the frequency and voltage excursions.
- Translation of reactive power requirement at the high voltage bus to the low voltage bus might either result in overloaded machine or require an on load tap changer transformer.
- Fault ride through capability requirement could not be met in some cases.
- Machine short circuit ratio has little impact on fault ride through capability.

Recommendations

- **Elaboration of grid codes is a great challenge for TSOs:**
 - As the grid is constantly evolving and new technologies are incorporated to it, grid codes will have to evolve as well.
 - Implications of any grid code parameter should be carefully studied. Analytical studies are greatly recommended.
- **CENELEC is working in Europe with ENTSO-E in matching grid codes with standards.**
 - Some results of this work could be useful to such effort.