The European Utility Requirements (EUR)

Position from EUR Working Group for “ENTSO-E Network Code for Requirements for Grid Connection Applicable to all Generators”

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Agenda

- The organization EUR
- Nuclear power in Europe
- Position of EUR
- Summary

EUR: a mature co-operative organization of European utilities

- EUR represents a large majority of the 185 nuclear power plants in operation in Europe, the majority of these are from the 70th and 80th.
- 16 units are under construction, 2 in western Europe
- New units has 1000 < P < 1800 MWe.

Nuclear Power in Europe

- **Nuclear Power generates approximately 25% of the electricity within the European Union**
- **Developing a new NPP requires a lot of time (5-10 years) and is a large investment for the vendor**
- **New NPPs have extremely long lead times (10-15 years) and are huge and very risky investments for the utilities**
- **Design of auxiliary power is a very important part of the design**
- **One of the most important methods to reduce investments and risks are to:**
  - Standardize the design, made possible by harmonizing the requirements within larger geographical areas

Description of the code

- **The ENTSO-E Network Code:**
  - Frequency and voltage ranges are wider than today; longer duration time for extreme events
  - No frequency of occurrence is given
  - Reactive power demands from generators will be higher than today Nuclear power plants are normally designed for a power factor of 0.90, in some cases 0.85 for new plants
  - The Fault-Ride Through curve requires novel and unproven technology in many plants
  - There must be possibility to reduce produced power depending on the grid voltage and the frequency
  - Nuclear Safety aspects especially on existing plants must be considered when defining the voltage and frequency domain

Consequences on nuclear safety

- **Safety systems have very stringent capacity requirements. If these not are fulfilled the plant is regarded as not operable**
- **The grid is the most reliable source of auxiliary power**
- **Operation in the lower frequency and voltage domain specified by ENTSO-E will change the safety systems performance**
  - A solution could be to disconnect the safety systems from the grid and energies them from the on-site diesel generators
    - Would drastically increase the core damage frequency and not to be allowed by Nuclear Safety Regulators
  - Frequent operation in this domain would not be accepted by Nuclear Safety Regulators
- **Changes in safety classified auxiliary power to permit operation in this domain will be very costly and require long lead times (5-6 years) and long outages**
- **Changes necessary to fulfil the new requirement could be so costly that it can result in premature shutdown of existing nuclear power plants**

Frequency control and load following

- **Frequency control**
  - **Nuclear power plants normally has frequency control capabilities**
  - **Despite this they are mainly designed for base load operation**
  - **Nuclear power plants are designed for a limited number of cycles**
    - Frequency control rapidly accumulate these cycles
    - An increase above this will decrease the lifetime on the existing fleet of NPPs and drive cost for new NPPs
  - **Frequency control is often prohibited by Nuclear Safety Regulators**
    - The operator shall be in control of the thermal output of the plant
- **Load following**
  - **Nuclear power plants has the ability to load follow within certain limits**
  - **Impossible to accommodate power variations at the end of fuel cycle**
- **Load following and frequency control could challenge the business case for new plants**

Pumps and tap-changers

- Nuclear Safety aspects especially on existing plants must be considered when defining the voltage and frequency domains
- Frequency converters can and are already used for some applications in Nuclear Power Plants. To use frequency converters in applications like Reactor Coolant Pumps, only to handle new grid requirement, is unsuitable
- Extensive use of frequency converters in existing plants is not realistic
- The reliability/availability is less with new pumps including frequency converters and software, compared to direct driven pumps
- Changes including frequency converters:
  - Not allowed in safety systems
  - Not included in existing design. Likely not to fit in existing layouts
- Larger voltage variations increase the need for tap-changers.
  - Many existing plants will need costly backfittings
  - Increase of failure risk because of On-Load Tap Changer is remarkable

Conventional island

- **Existing plants are designed:**
  - In accordance with the existing codes.
  - Many plants are uprated. Utilizing the original design margins.
  - Generator are designed for a limited number of under voltage and frequency. New requirements will shorten lifetime of the components
  - New equipment represents a large investments, long lead times (5-6 years) and long outages
  - Too stringent requirements could result in premature shutdown of parts of the existing fleet
- **New Plants**
  - Will drive cost for new plants

Frequency and Voltage ranges

- Voltage and frequency should be shown combined in one diagram
- Frequency of occurrence should be given. If the frequency of occurrence of these events is less than every 10 year it is included in existing designs
- Is power reduction allowed for the different domains?
- The voltage level (0.85 < U < 0.90) should only long for a maximum of 30 minutes in Continental Europe
- The 1.10 p.u. voltage is not harmonized with standards
- The safety systems are not designed for frequent changes in grid frequency as indicated in the ENTSO-E Network Code

Summary

- Voltage requirements
  - The frequency of over and under voltages could in the short run be challenging
  - After replacing (in many power plants) with tap changers the requirement could be handled
- Frequent under-frequency. The new requirement will result in large replacements of electrical safety equipment. It will also require new generators in many plants
- Frequent frequency control will shorten the lifetime of the plant. It is also prohibited in many countries
- Frequency control and load following will make the business case for new plants more challenging

Summary

- The use of frequency converters, only to fulfill the grid code, is unsuitable
- Improvement of the ENTSO-E Network Code:
  - Keep frequency of occurrence as it is today
  - Set reactive power demands as they are today
  - Set the Fault-Ride Through curve as it is recommended in the EUR Grid Requirement (150 ms critical fault clearing time)
  - Give possibility to reduce power depending on the grid voltage and the frequency
  - Nuclear Safety aspects especially on existing plants must be considered when defining the voltage and frequency domain
- To fulfill the code will be very costly for existing plants and sometimes result in a premature shutdown
- The code will drive cost for new plants

Thank you for your attention!

European Utility Requirements for future LWR plants

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