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European Utility Requirements for New Light Water Reactors

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ABSTRACT

The development of existing nuclear fleet in Europe since its beginning in sixties until recently has been done on a national basis without important collaboration between countries. In 1991, 5 major European electricity producers established an organisation to develop a common set of technical requirements, i.e., European Utility Requirements (EUR) for Light Water Nuclear Power Plants (LWR NPPs) in Europe [1]. The main objectives of the EUR organisation are the development of standard designs, reducing licensing risks, establishing high safety harmonised objectives, and promoting cost-effective design features.

The EUR organization was established in 1991, while the first EUR document was issued a year later. At that time, the EUR requirements were developed mainly on collaboration of aforementioned founders together with the Electric Power Research Institute (EPRI) Utility Requirements Document (URD) in USA. The organization is changing all the time, currently (as of May 2021) there are 14 European Utilities that are members of the EUR organization.

The EUR organization with its EUR requirements has several benefits for the development of the nuclear industry, especially Generation III NPPs, in Europe and worldwide. The first one is to share the knowledge, experience and lessons learned of the main European nuclear utilities and based on that, developing the EUR document with regular revisions. The EUR requirements represent the basis for all technical specifications used in bidding documentation in last 20 years. The second one is their applicability for Vendors and Designers willing to sell and build their NPPs in Europe. The Vendors and Designers take the EUR requirements as one of the most important documents when developing their designs. The third important outcome is an EUR design assessment process of all those reactor designs which are in interest for European utilities. Practically all Vendors with large LWR designs were already assessed by EUR Utility members or are in the process of the assessment. When the assessment process is successfully completed, the Vendors are awarded by the EUR certificate.

The paper will present the EUR organization, EUR document, EUR design assessment process and other activities going on.

1 INTRODUCTION

The European electricity producers Nuclear Electric from United Kingdom, Tractebel from Belgium, EDF from France, Unitad Electrica SA from Spain and Vereinigung Deutscher Elektrizitätwerke from Germany founded an EUR Organisation in 1991. Knowledge and

experience of different electricity producers were gathered and harmonized in one common set of technical requirements for new nuclear designs to be built in Europe. First revision of EUR document was issued in 1992 in a coordinated manner with the Electric Power Research Institute (EPRI) Utility Requirements Document (URD) in USA. The EUR Organisation has grown through the years and currently associates 14 Utilities from Europe. The members of EUR Organisation are shown in Figure 1.

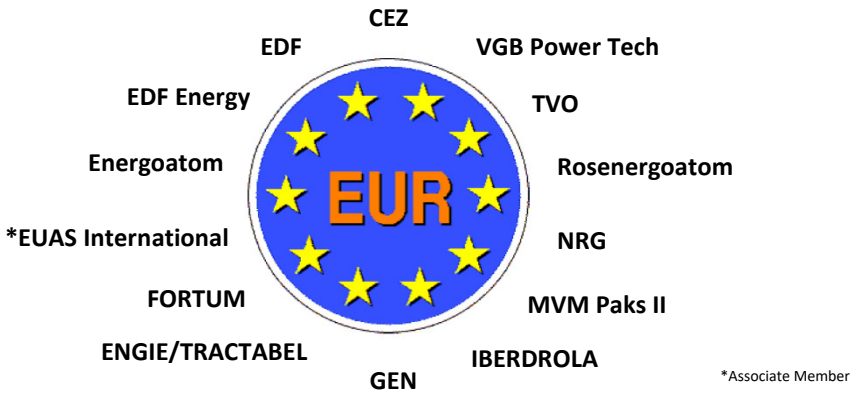

Figure 1: Members of EUR Organisation in 2021.

The members of EUR Organisation involved in the development of the EUR Document aim at harmonisation and stabilisation of the requirements to which LWR NPPs to be built in Europe will be designed, built, commissioned, operated and maintained. Harmonisation of the requirements and standardisation of designs are of benefit to the safety and performance of Nuclear Power Plants (NPPs). A major objective of the EUR Utilities through the EUR Document is to provide the basis for designing standard Nuclear Islands (NI) which can be licensed, built and operated in most European countries. This will lead to increased competitiveness by allowing the development of the Standard Design. Standardisation is cost effective since it allows the developing and launching costs of new design to be spread-over several plants. In addition, series ordering and manufacture of plant and equipment should result in significant cost savings.

The aim of the EUR requirements is to promote the harmonisation of:

- Safety approaches, targets, criteria and assessment methods;
- Design conditions;
- Design objectives and criteria for the main systems and equipment;
- Equipment specifications and standards; and
- The information required for the assessment of safety, reliability and cost, and some of the corresponding criteria.

This will allow the development of a Standard Design that can be built and licensed in several European countries with only minor variations through standardisation of:

- The basic design and layout;
- The safety case; and
- The functional requirements for systems and equipment.

In addition to the safety requirements, an economic competitiveness of NPP Generation III designs in comparison to other means of electricity generation is a primary goal. Overnight capital cost and construction time are the key factors for the design of any new Generation III LWR NPP to be built in Europe.

2 EUR DOCUMENT

The EUR Document [1] covers the subjects of the Nuclear Island (NI) and Power Generation Plant (PGP). It emphasises the most important objectives of the Generation III NPP which are safety, performance, constructability and economics. The requirements apply to the Light Water Reactor designs, i.e. PWR and Boiling Water Reactor (BWR). The EUR Document is structured into four volumes as seen in Figure 2. Volume 1 - Main policies and objectives involves Introduction to EUR describing the EUR organisation and products, EUR policies, EUR synopsis describing the structure of the document and EUR Key Issues used for design pre-assessment. Volume 2 - Generic and Nuclear Island requirements contains all the generic requirements and expectations of the EUR Utilities for the NI or for both NI and PGP. It contains more than 4000 requirements in different areas:

- The general safety approach,
- Design objectives: performance and safety targets,
- General design requirements: design basis, grid requirements, Codes and Standards, layout rules,
- Functional requirements: systems, containment, Instrumentation and Control (I&C),
- Requirements relating to equipment: components, materials, I&C,
- Requirements relating to the design process and construction: design process, Quality Assurance, constructability, Decommissioning and
- Requirements relating to assessment methodologies: Deterministic and Probabilistic approaches, performance, costs and Environmental Impact Assessment (EIA).

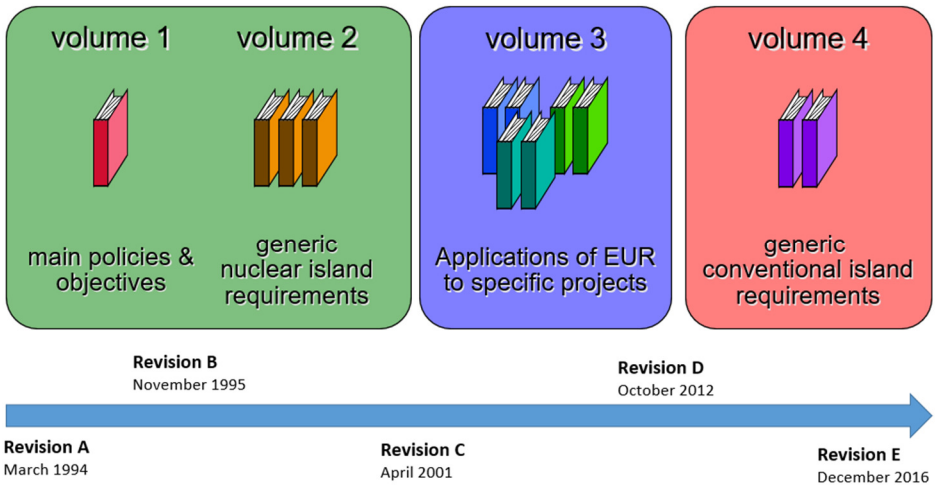

Figure 2: The structure of EUR document and historical evolution of revisions.

Volume 3 - Application of EUR to specific designs consists of several subsets. Each subset is dedicated to a specific design that is of interest to the participating Utilities. It contains a

description of a standard NI, a summary of the analysis of compliance against EUR Volume 2 and, where needed, design dependent requirements and preferences of the EUR Utilities. It also includes information related to that design called for in certain requirements of Volume 2. This information is proprietary and only available subject to vendor agreement and signature of a Non-Disclosure Agreement. Volume 4 - Specific PGP requirements contains more than 1000 generic requirements related to the PGP. As mentioned above, these requirements are not subject of EUR design assessment.

Five revisions have been published since the EUR was founded. The current Revision E was released at the end of 2016. Revision E is aimed at delivering significant updates of the EUR Document mainly in the following fields:

- Safety requirements in line with the newest international safety standards, specifically the recent versions of IAEA and WENRA documents, and considering Lessons Learned from the Fukushima accident. This has led to an in-depth restructuring and rewriting of Chapter 2.1;
- Safety Categorisation and Classification following a new approach based on the IAEA and IEC standards;
- Criteria for Limited Impact for Severe Accidents which are aligned with the objectives defined by WENRA;
- External Hazards with two distinct levels to be considered: Design Basis External Hazards and Rare andSevere External Hazards;
- Seismic Approach which reflects the best practice approaches to determine the seismic input for nuclear power facilities;
- Instrumentation & Control and Human Machine Interface requirements in line with IEC Standard 61513;
- Generic EUR requirements with regard to pipe break prevention and mitigation (i.e. Leak Before Break and Pipe Break Preclusion concepts);
- Layout requirements updated with new regulations, references to standards and industry guidelines, as well as lessons learnt from studies and current designs;
- Grid Connection requirements consistent with the European Network Code on Grid Connection Requirements applicable to generators (RfG); and
- Probabilistic Safety Assessment Methodology requirements reflecting the world-wide best available practices to provide a state-of-the art position on PSA methodology and its application.

It is expected that the next Revision will be published in a couple of years. In addition to the above-mentioned technical updates, the structure of the EUR Document has been modified significantly during the production of Revision E regarding the organisation of requirements applicable to NI and PGP parts in Volumes 2 and 4 to simplify the use of the EUR Document during the bidding process. In Volume 1, two new chapters “EUR Policies” and “EUR key issues” have been added.

Figure 3 shows more detailed structure for each of the Volumes. The main emphasis is given to the Volume 2 which contains the requirements for nuclear island. Volume 2 includes approximately 4000 requirements, meanwhile Volume 4 approximately 1000 requirements. All together there are more than 5000 requirements describing Nuclear Island and Power Generation Plant.

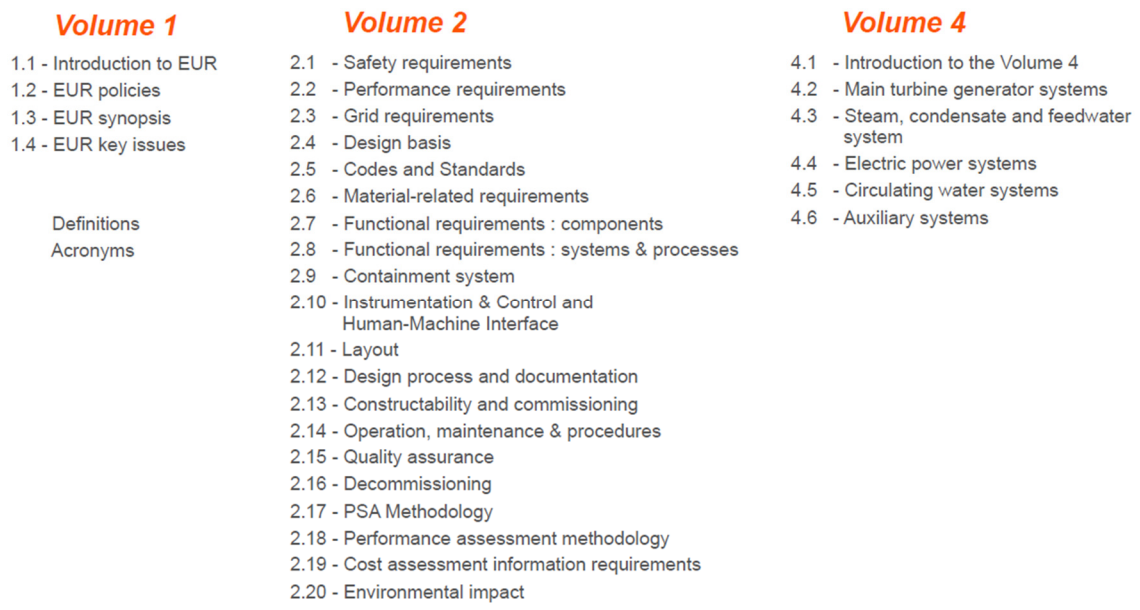

Figure 3: The chapters of EUR Volumes.

It should be also highlighted that European Commission launched the project "Benchmarking of nuclear technical requirements against WENRA safety reference levels, EU regulatory framework and IAEA standards" [3] that was completed in 2019. One of the tasks was also benchmarking of the European Utility Requirements against the requirements of the IAEA, WENRA and the amended Nuclear Safety Directive of the EU. The comprehensive compliance analysis demonstrated that the overall benchmarking of European Utility Requirements against above mentioned international standards has resulted in the conclusion that the European Utility Requirements are in full compliance with the international standards. This certainly increased the credibility of the EUR requirements and pave the path for the future work of EUR Organisation.

Volume 3 involves the results of completed design assessments. Since 1990, 12 design assessments (EUR volume 3 subsets) of various designs have been performed against the EUR requirements:

- 5 designs assessed against rev B: BWR90, EPP, EPR, ABWR, SWR1000
- 3 designs assessed against rev C: AP1000, AES-92, EPR
- 3 designs assessed against rev D: EU-APWR, EU-APR1400, VVER TOI
- 1 design assessed against rev E: EU HPR1000
- 1 design assessed against rev E in progress: APR1000

Volume 1 is publicly accessible [2], meanwhile full EUR document is accessible only to EUR members. Special organisation, e.g. nuclear Regulators and Vendors can apply for the full EUR document. For any commercial use (e.g. preparing bid specifications), the full document can be obtained against fee. The Requester has to sign the Non-Disclosure Agreement with EUR Organisation, which defines the scope of the rights of use, constrains the distribution to any third party and specifies the EUR organisation disclaimer concerning the liability exemption.

Figure 4 shows different applicability of the requirements, i.e. N, C or T. The requirements of Volume 2 can be tagged either with the applicability identifier [N] which is for requirements that are applicable to the Nuclear Island, or by applicability identifier [C] for those which are applicable to the entire plant.

The requirements of Volume 4 are tagged with the applicability identifier [T] since Volume 4 contains requirements which are exclusive to the Power Generation Plant.

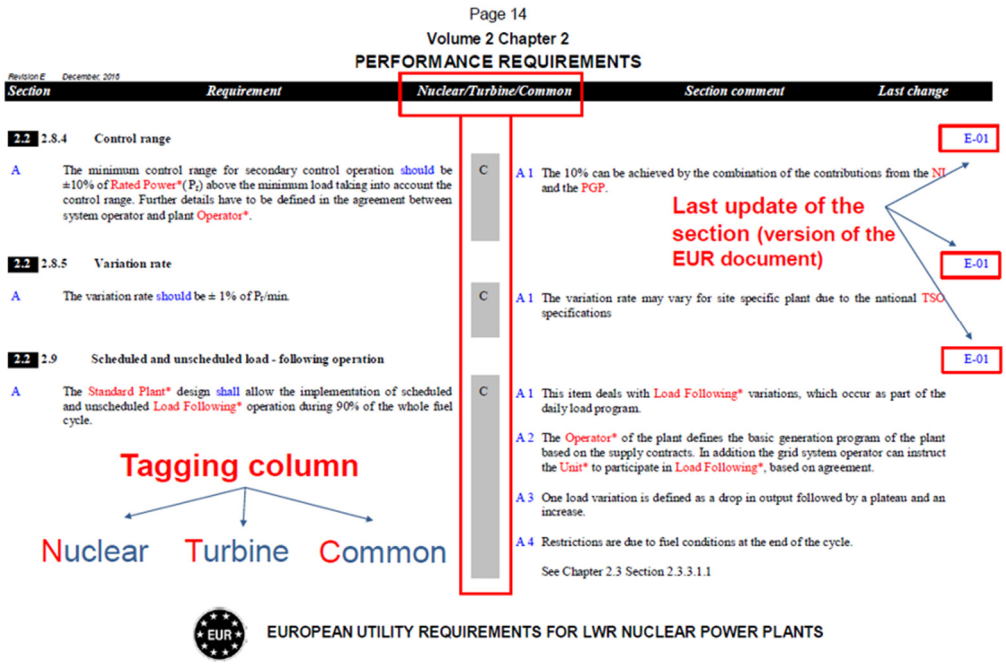

Figure 4: Example of EUR requirement.

In principle, there are two different kinds of requirements, i.e. shall or should requirements. The “shall” requirement is mandatory, which means that the requirement has to be fulfilled exactly as required. The “should” requirement is more flexible since also other technical solutions can be accepted than the one specified, but the Plant Designer needs to demonstrate that they are equivalent or better than specified in EUR requirements.

3 ASSESSMENT OF LWR DESIGNS

The EUR design assessment of Vendor’s design starts with the application to the EUR Steering Committee (SC). If there is enough interest among EUR Utilities for that particular design, then the SC approves a beginning of the project. As shown in Figure 5, the project starts with the Vendor self-assessment of 53 key issues which are part of the Volume 1 of EUR requirements. This part of the process is relatively short and without significant human resource effort on EUR side. The group of EUR reviewers is set that is responsible to assess the Vendor self-assessment and give a green light if the self-assessment gives a confidence that the project of full assessment which follows will be also successful. There are more aspects that are followed in this pre-assessment process: (1) the result of self-assessment and the level of compliancy with EUR requirements, (2) a mature design with well-prepared documentation, (3) enough human resources within EUR. It follows the Vendor preparation of the Design

Description Documents and self-assessment sheets based on the EUR Volume 2 requirements. The most extensive phase of the project from the EUR perspective is the assessment of the design towards each requirement in Volume 2 by Coordination Group (CG), Administration Group (AG) and Steering Group (SG). This part takes approximately 18 months, depends on the maturity of the design, the quality of the Vendor's documentation and effectiveness of the Vendor response on numerous questions (additional clarifications) which are issued during the EUR assessment phase. After the assessment phase is completed, the standardised subset for the Volume 3 is prepared by Vendor and reviewed and approved by EUR. The total time of the entire project usually takes between 2 and 3 years.

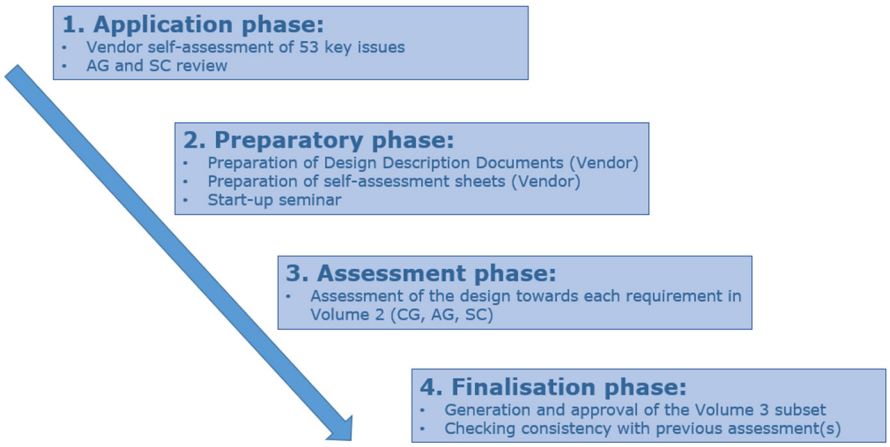

Figure 5: Project organisation of the EUR design assessment.

Figure 6 shows typical project organisation of the EUR design assessment. The project is managed by Coordination Group, Administration Group and Steering Committee.

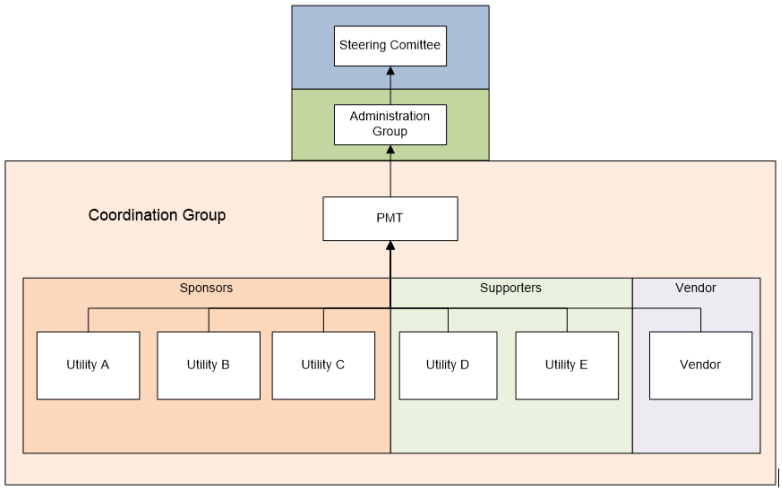

Figure 6: Project organisation of the EUR design assessment.

The Coordination Group is set up for each of the design assessment project separately and consists of the representatives from the Sponsors, Supporters and Vendor. Its main tasks are managing and administrating the design assessment project, mainly the assessment phase and

partially also finalisation phase. The Sponsors are EUR utilities that participate in the project and are responsible for the assessment of the EUR chapters in Volume 2, meanwhile the Supporters are those EUR utilities that perform the review of the assessment done by Sponsors. Very important member of the project organisation is also the Vendor who is responsible for the design of the plant that is subject of the assessment. The Vendor also takes part in all project meetings where one of the main tasks is given to review and discussion of the items which are not fully compliance to the EUR requirements. The Project Management Team (PMT) manages the project and consists of the representatives of Sponsors and Supporters. It is led by the project manager from the leading Sponsor. The Administration Group and Steering Committee are permanent EUR organisations that take a review and approval roles in the project.

4 FUTURE GOALS

There is an increasing interest for Small Modular Reactor (SMR) in the last 10 years. As a reflection to this trend, the EUR members decided to develop EUR Key positions focused on Small Modular Light Water Reactor (SMLWR). These EUR Key Positions should be considered for designing SMLWRs to be built in Europe, complementary with the EUR Document Revision E issued in December 2016 [1]. They are intended to support interactions with the EUR members' stakeholders. They will be considered in the frame of the next revision of the EUR Document (Revision F) which will be applicable to both, large LWRs and SMLWRs. When the specific requirements for SMLWRs will be integrated into the EUR document, the EUR will be also prepared for design assessment of the SMLWRs. Some of the SMR Vendors already indicated an interest in EUR assessment.

The EUR document is a living document. One of the most important goals of the EUR is to have up to date requirements. EUR follows the state of the art in the nuclear industry, lessons learned, activities in other nuclear organisations (e.g. IAEA, WENRA, ENISS …) etc. When there is enough basis for updating the EUR document, the EUR starts organizing all activities that are needed for EUR revision project. The project of EUR Revision F will be certainly very important in the near future.

Promoting of EUR organisation is also one of the important tasks of EUR activities. EUR requirements are very well recognised and respected by Utilities and Vendors not only in Europe but also in other parts of the world. EUR document is the most important and credible document used in the preparation of the Bid Invitation specifications (BIS). EUR will continue with the promotion of its work to attract new utilities to join the EUR. But not only Utilities, also Vendors with their new designs will be encouraged to be assessed against EUR requirements. This approach will certainly bring to the highest safe and economical efficient designs which can, later when in operation compete with other electrical production units.

The nuclear regulators can also benefit from EUR work, especially from the projects of different design assessments. Nuclear licensing is still matter of national authorities but with the work done by EUR, it can be done more thoroughly, faster and less risky of not fulfilling the national and international nuclear regulations.

REFERENCES

[1] European Utility Requirements for LWR Nuclear Power Plants, Revision E, December 2016.

[2] EUR website, https://www.europeanutilityrequirements.eu/Welcome.aspx (as of August 2021)

[3] Benchmarking of nuclear technical requirements against WENRA safety reference levels, EU regulatory framework and IAEA standards, ENER/D2/2016-677, prepared for European Commission DG ENER, ENCO, 2019.