GEN ENERGIJA
KRŠKO NUCLEAR POWER PLANT

ENGINEERING SERVICES SPECIFICATION

PROBABILISTIC SEISMIC HAZARD ANALYSIS FOR KRŠKO NUCLEAR POWER PLANT (NEK) AND KRŠKO NUCLEAR POWER PLANT 2 (JEK2)

Non-Nuclear Safety Related

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Content

Abbreviations

AF	Amplification Factor
AI	Authorized Institution
EUR	European utility requirements
ESV	Extended Site Vicinity
FCA	Fault Capability Assessment
FIER	Final Independent Evaluation Report
FNGMM	Fully Non-ergodic Ground Motion Model
GMM	Ground Motion Model
IAEA	International Atomic Energy Agency
IR	Independent Review
HID	Hazard Input Document
JEK2	Nuclear Power Plant Krško Unit 2 - Jedrska elektrarna Krško 2
MAFE	Mean Annual Frequency of Exceedance
NEK	Nuclear Power Plant Krško – Nuklearna elektrarna Krško
NPP	Nuclear Power Plant
PGA	Peak Ground Acceleration
PIER	Preliminary Independent Evaluation Report
PNGMM	Partially Non-ergodic Ground Motion Model
PSHA	Probabilistic Seismic Hazard Analysis
SAF	Site Adjustment Factor
SHA	Seismic Hazard Analysis
SNSA	Slovenian Nuclear Safety Administration
SRA	Site Response Analysis
SSC	Seismic Source Characterization
SSCM	Seismic Source Characterization Model
SSE	Safe Shutdown earthquake
SSG	Specific Safety Guide (IAEA)
SSI	Soil-structure interaction
STM	Seismotectonic Model
SV	Site Vicinity
UHS	Uniform Hazard Spectrum
UHRS	Uniform Hazard Response Spectrum
USAR	Updated Safety Analysis Report

1 BACKGROUND AND DESCRIPTION OF THE CHALLENGE

1.1 Sites description

The NPP Krško and potential JEK2 sites are located in the southeastern part of Slovenia on the northern bank of the Sava River. NEK and proposed site for JEK2 are situated at an average elevation of 155.20 meters above sea level (a.s.l.). Site's west part extends a few kilometers, and gradually transitions into hilly and mountainous terrain, while it is open in the east part. The width of the Krško valley along the Sava River is about 10 km. To the north and west, the valley is replaced by a zone representing a karstified plateau gradually lifted from 350 to more than 700 m. To the south, the mountain range elevates to above 1000 m and is oriented north-east.

The closest settlements to the sites include Vrbina, Spodnja Libna, and Spodnji Stari Grad. Krško town lies to the northwest, approximately 3 kilometers upstream from the sites, while Brežice town is positioned to the southeast, approximately 7 kilometers downstream.

1.2 PSHA for NEK site from 2004

The currently valid probabilistic seismic hazard analysis for the Krško site was conducted in 2002–2004 (Revised PSHA PSR – NEK – 2.7.2, 2004 [1]), considering up-to-date geological, seismological, geophysical and geodetic investigations. It was concluded that: (1) 10.000 years return period free-surface median peak ground acceleration was 0.56 g, (2) no direct evidence indicating there is a potential for surface fault rupture has been identified, (3) there was insufficient geological and geophysical data to preclude the potential for surface faulting, (4) since the uncertainty have been adequately incorporated into PSHA, plant evaluations based on vibratory ground motions could proceed independently of the investigations to resolve surface faulting issue. The results of the revised PSHA in 2004 proved to be more severe than the hazard estimated in the original PSHA. The frequency of occurrence of the PGA has increased by a factor of about two, but was partly offset by a lower amplification in the ground-motion spectrum. It has been concluded that there are some active faults near the Krško basin, but no capable faults that could extend up to distance of 5 km from the NPP Krško site. More details are documented in the NPP Krško Updated Safety Analysis Report (USAR) (NEK USAR).

Within the last seismic probabilistic safety assessments of NEK, the seismic response and probabilistic floor response spectra were calculated based on Probabilistic Seismic Response Analysis of Krško Nuclear Power Plant using mass-stick model and accounting for the effects of the embedment of the nuclear island (SPSA 2004, [4]). The input motions at the embedment depth (average depth of the foundation) were determined by deconvolving the surface ensemble of the time histories to the average foundation level. US NRC ISG-17 (NRC, 2009, [105]) refers to NEI white paper (2012) [106], where it is defined that in case of site-specific soil-structure interaction (SSI) analyses of embedded structures including the embedment, the foundation input response spectra (FIRS) should be obtained using the soil column outcrop response (SCOR) at the foundation

depth. This means that for embedded structures (when embedment effects are included), the FIRS should be calculated using full height soil column (with consideration of soil layers above the foundation), which is different from the current results in Rev. 1 (2023) and Rev. 2 (2024) working version PSHA, where UHS are defined as free field outcrop response spectrum. If, for the selected control point, outcrop spectra which include the effects of the soil profile above that control point is generated, the effects of the down-coming waves from the profile above the control point will be included in the response at the outcrop (control point) elevation. These effects may reduce the outcrop motions at the selected control point for the existing NEK site.

1.3 Field investigations for JEK2 and NEK sites after 2004

After 2004, extensive additional geological, geotechnical and seismological (GG&S) investigations were carried out in the immediate vicinity of the NEK as part of the site investigations for the JEK2 project (Čarman and Živčić, 2009 [11]; Douglas et al., 2008 [12], Bertil et al. 2010 [10], Douglas and Sinclair 2010 [13], Foerster and Belvaux, 2010 [15], Bazargan-Sabet and Bernardie, 2010a [8]; 2010b [9], Douglas, 2011 [14]; Atanackov et al. 2010 [6]; GeoZS, IRSN, BRGM, and ARSO, 2010a [16], 2010b [17]; GeoZS, 2013 [20]; Petkovšek, 2013 [39]). Investigations have focused on evaluating potential seismic hazards within the near region/site vicinity of Krško NPP and, particularly, in the extended site vicinity of Krško NPP. Investigations also focused on geological structures (seismic sources and faults) with the aim of better understanding the seismotectonic structure of the Krško basin, reducing uncertainties in the input data for determining the seismic hazard of the site and providing a basis for the assessment of capable faults. As part of the preliminary conclusions of these studies, which have been carried out in the wider area of the JEK2 site since 2008, no basis was provided that would suggest the existence of capable fault (i.e., fault structures or geological structures that could permanently deform the surface of the site in the event of an earthquake).

In 2013, a Probabilistic Fault Displacement Hazard Analysis, PFDHA (RIZZO, 2013a [40]; 2013b [41]), was issued, based on the seismo-tectonic model developed in the 2008-2010 timeframe, which indicated that surface fault displacement of engineering significance is highly unlikely at the Krško Sites. The new PSHA project has been launched by GEN in 2014 (RIZZO-GeoZS, 2015a [47]; 2016a [48]; 2016b [49], 2018 [50]; 2018a-f [51] - [59]). The Revision 0 of new PSHA for potential JEK2 site was concluded in 2018 (RIZZO-GeoZS; 2018f [59]). In the project of Evaluation of Probabilistic Seismic Hazard Analysis and Engineering solutions for building new NPP JEK2 (FGG/ARSO; 2020a [71]; 2020b [72]; FGG/NAA, 2020 [83]; 2021 [86]; FGG, 2022a-d [67] - [70]) several changes and improvements were presented. Based also on numerous studies (FGG/ARSO; 2020a [71]; 2020b [72]; FGG/NAA, 2020 [83]; 2021[86]; FGG, 2022a-d [67] - [70]) the PSHA from 2018 was updated and extended to JEK2 and NEK sites, which was received in November 2023 (RIZZO/GeoZS/NAA, PSHA Rev.1, 2023 [56]). Based on it, a Preliminary Independent Evaluation Report (PIER) of authorized institution has been issued in January 2024 (FGG/LCI, 2024 [84]). Extensive supporting documentation was issued in support of PIER (see references FGG, 2022a-d [67] - [70]; FGG/ARSO, 2022a-c [73] - [75]; 2023a-c [76] - [78]; LCI, 2024 [88]; FGG/ARSO, 2024a-c [80] - [82]; FGG/LCI, 2024 [84]; FGG/NAA, 2024 [87]). Following PIER, Rev. 0, agreed upon comment resolutions from the FGG and ARSO independent reviews were

implemented accordingly in Rev. 2 PSHA working version. PIER, Rev. 0, issued in 2024 (FGG/LCI, 2024 [84]), was revised by FGG/LCI based on comment resolutions and work performed by RIZZO as a response to PIER. Revision 1 of PIER was issued in 2025 (FGG/LCI, 2025 [85]).

1.4 Description of the challenges

As a result of draft comment resolutions as a response to PIER, Rev. 0 (FGG/LCI, 2024 [84]) on Revision 1 of PSHA for JEK2 and NEK sites (RIZZO/GeoZS/NAA, PSHA Rev.1, 2023 [56]), the new working version of PSHA, Rev. 2 was prepared. In this process, GEN, NEK and independent reviewers have been witnessing significant changes in several parameters of seismic source characterization model. The changes in PSHA Rev.1, 2023 and working version of PSHA, Rev. 2, have introduced substantial uncertainties and diverge importantly from the previous models (e.g., Revised PSHA PSR – NEK – 2.7.2, 2004 [1]), which applied established models and the result of decades of intensive field investigations, laboratory analyses and supporting field studies (geomorphology, seismic reflection lines, age dating, drilling etc.) in the Krško Basin. Uncertainties should be better constrained with further evaluation/inclusion of available field observational data-based models which may include new data acquired since 2018.

The main open issues related to PSHA for JEK2 and NEK sites (RIZZO/GeoZS/NAA, PSHA Rev.1, 2023 [56]), which need to be resolved within the scope of this specification (in addition to the preparation of final comment resolutions as a response to PIER, Rev. 1, and revised report on FCA) are:

1. Disproportionate increase in estimated rates, e.g.: 0.05–0.08 mm/year for the Orlica fault in PSHA 2004 (Revised PSHA PSR – NEK – 2.7.2, 2004 [1]) to 0.06-0.96 mm/year in working version of PSHA 2024, Rev. 2 as a response to PIER. Estimated rates for Orlica and other faults need to be re-evaluated by consideration of existing data.
2. Disproportionate increase in seismic hazard. In addition, the results are quite sensitive to changes in the models, for example: recommendations for model changes (in the scope of draft comment resolutions as a response to PIER which resulted in working version of PSHA 2024, Rev. 2), may cause increase of estimated mean annual frequency of exceedance of peak ground acceleration of 0.8 g by a factor of 2, which may be biased due to the absence of the sensitivity studies. It is necessary to identify the parameters that have the greatest impact and potentially reduce related uncertainties.
3. There exists a large difference in the results of the site response between 2004 (Revised PSHA PSR – NEK – 2.7.2, 2004 [1]) and 2023 (RIZZO/GeoZS/NAA, PSHA Rev.1, 2023 [56]). The new results (RIZZO/GeoZS/NAA, PSHA Rev.1, 2023 [56]) show almost identical results for different depths below the ground surface, while in 2004, it was estimated that spectral accelerations significantly decreased with depth. This, however, is also supported by observational data of real recorded earthquakes at the NEK site, measured at the free surface and foundation level (-20 m). Note that real recorded earthquakes were measured away from main island enough so that the effects of structural responses on measurements are excluded. Other measurement's locations (i.e., on the foundation) are available as well. The differences between PSHA 2023 and PSHA 2004 results could be a consequence of using different spectra definitions. Specifically, UHS spectra calculated in PSHA 2023 and 2024 represent free-field (truncated) soil column outcrop motions, where the soil layers above the elevation of interest (CP2-CP6) are removed during the site response analysis. On the other hand,

based on the description provided in the PSHA 2004 report, it appears that the 2004 UHS at the selected control point (-20 m) below ground was calculated through the SHAKE deconvolution process, considering full soil columns, which is sometimes referred to as "within" soil layers motions. However, SHAKE software can produce both types of spectra as output, as well as so-called full soil column outcrop motions, in which the soil layers above the elevation of interest are not removed during the site response analysis. It is important for NEK to clarify the differences in CP1/CP3 (and other) spectral acceleration ratios resulting from the different site response analysis methodologies used in PSHA 2004 and the one that will be used in the revised PSHA. Since the description in the PSHA 2004 report suggests that the UHS at the selected control point (-20 m) below ground was calculated using the SHAKE deconvolution process—contrasting with the methods applied in newer PSHAs—new PSHA in the scope of this specification should be expanded with additional analyses and results as defined in Section 2.4.

2 SCOPE OF WORK

This specification defines the scope of work needed to re-evaluate the PSHA 2023, Rev.1 (RIZZO/GeoZS/NAA, PSHA Rev.1, 2023 [56]) based on the requirements from PIER Rev.1 (FGG/LCI, 2025 [85]), and with consideration of field observational data (i.e., changing to data-driven approaches, which were used in selected parts of the PSHA 2023, while the model-driven approaches should be less acceptable), as well as open issues listed in Section 1.4 of this specification. References, such as the new IAEA TECDOC 2067 (IAEA, 2024) [94] may be used as a background to perform re-evaluation. Issues addressed in Chapter 1.4 shall be addressed and resolved.

The response to PIER Rev. 1 shall not be prepared in the form of a separate delivery. Requirements reported in PIER, Rev. 1 shall be directly reflected in the revised (Rev. 2) PSHA.

With consideration of the requirements described in the paragraphs/sections above (e.g., (1) requirements stated in Sections 7.0, 7.1, 7.4 and 7.5 of PIER, Rev. 1; (2) requirements to address three open challenges listed in Section 1.4 of this TS; and (3) a general requirement is to consider field observational data, and not model-driven approaches), the scope of work per this specification consists of the following tasks (which are in more detail described in sub-sections 2.1 to 2.5):

1. Preparation of revised seismotectonic models (STM) and SSCM in accordance with IAEA SSG-9 Rev. 1 (IAEA, 2022) [95]. In order to ensure continuity/consistency across the models applied in different past and recent PSHAs, the model applied in PSHA 2023 Rev.1 (RIZZO/GeoZS/NAA, PSHA Rev.1, 2023 [56]) and working draft version of PSHA 2024, Rev. 2, shall be critically assessed based on the models developed back in PSHA 2004 (Revised PSHA PSR – NEK-2.7.2,2004 [1]). Where applicable, seismotectonic models and seismic source characterization models shall be changed to data driven models. In doing this, recommendations for future SSCM improvements, given in Section 7.3 of PIER, Rev. 1, should be considered if they are in line with PPRP (see Section 2.6 for PPRP) recommendations, will result in decrease of uncertainties of the results, and will provide realistic

(best estimated) assessments. Open issues (1st item of the second paragraph), described in Section 1.4 of this specification shall be considered.

2. Preparation of revision of fault capability assessment (RIZZO-GeoZS, 2018e [58]) for the new JEK2 site.
3. Preparation of proposed NEK USAR update (revised report from 2004 (NEK USAR) [3]). Editable copy of the last USAR update will be available for use.
4. Preparation of PSHA, Rev. 2, for JEK2 and NEK sites based on re-evaluation of PSHA dated 2023, Rev.1 (RIZZO/GeoZS/NAA, PSHA Rev.1, 2023 [56]) and revised seismotectonic model (STM). In this effort, requirements from different Sections of the preliminary independent evaluation report (PIER, Rev. 1, Sections 7.0, 7.1, 7.4 and 7.5) (FGG/LCI, 2025 [85]), should be taken into consideration. In addition to the comments from the PIER report, AI commented that the host profile for SRA in the FNGMM case needs to be corrected (see details in Section 2.4). Open issues (2nd and 3rd bullet of the second paragraphs), described in Section 1.4 of this specification, shall be considered.
5. Recommendations for determining seismic design parameters for seismic analysis and the design of potential second unit of Krško NPP (JEK2).

For performing the tasks described beforehand purchaser will provide revised Earthquake Catalogue, which will include earthquakes until the end of 2024. In addition, the purchaser will provide additional input on the M_{min} (ARSO, 2025 [55]). Revised deliverables (seismic catalogue and consideration of M_{min}) will be provided as an input to the project.

2.1 Revised Seismotectonic model of the Krško Basin

Revised Seismotectonic model of the Krško Basin shall be prepared based on Revised STM PSR – NEK – 2.7.1 Part 1 & 2, 2004 ([2],[3]) with consideration of results of field observational data from 2004 referenced in Section 4.2 (Atanackov et al., 2010 [6], 2020 [7] ; Bazargan et al. 2010 [8][9] ; Čarman et al. 2009 [11] ; Douglas et al. 2008 – 2011 [12] - [14] ; Foerster et al., 2010 [15]; GeoZS, IRSN, BRGM and ARSO, Phase 1&2, 2010 [16] - [19]; Geozs, 2013 [20], 2023a-p [21] - [36]; ARSO-GeoZS, 2023 [5]; GeoZS, OGS, Geostern, ARSO, 2023 [37], [38]; RIZZO, 2013a-e [42] - [46], RIZZO/GeoZS 2015 [47], 2016a-b [48], [49], 2018a-c [51] - [53]). In doing this, recommendations for future SSCM improvements, given in Section 7.3 of PIER, Rev. 1, should be considered if they are in line with PPRP (see Section 2.6 for PPRP) recommendations, will result in decrease of uncertainties of the results, and will provide realistic (best estimated) assessments. In this effort applicable open questions/issues listed in Section 1.4 shall be addressed (1st item of the second paragraph).

The revised seismotectonic model of Krško basin per this item will be the base for the completion of the work described in task 2.4 below.

2.2 Fault capability assessment – FCA

The revision of the existing Fault capability assessment for the proposed Krško 2 nuclear power plant Slovenia, 2018 (RIZZO-GeoZS, 2018e [58]), shall be prepared for new JEK2 site by integration of all the past/existing assessments and related independent reviews ([33],[89],[90],[91],[92]) concluding that the given faults are "capable" or "not capable". The integration of current assessments shall be performed in accordance with applicable and valid international nuclear standards (e.g., IAEA SSG.9 Rev. 1 (IAEA, 2022) [95], US NRC Part 100 [97], IAEA SSR-1 (IAEA, 2019) [98]). For JEK2 the methodology for new nuclear facilities shall be taken into account.

The assessment must be performed for site vicinity (SV) and extended site vicinity (ESV) (+3 km) area for a radius of not less than 5 (+3) km (following the IAEA SSG.9 Rev. 1 (IAEA, 2022) [95], IAEA, SSR-1 (IAEA, 2019) [98], US NRC Part 100 [97]) JEK2 and NEK site taking into consideration site-near region (SNR).

Note that NEK site should not be included in Fault Capability Assessment as it is not required for existing sites. Note also that update of Probabilistic Faults Displacement Hazard Analysis is not needed and not required per standards, guidelines or Slovenian regulatory requirements and is therefore outside the scope of work per this specification.

2.3 Proposed NEK USAR update

Proposed revised affected USAR Chapter 2 sections shall be prepared based on tasks 2.1 and 2.2 above, references listed in Chapter 4 of this specifications and NEK procedure ESP 2.302. As an example, format of revised affected USAR Chapter 2 sections made in 2004 may be followed (Revised STM PSR – NEK – 2.7.1 Part 1 & 2, 2004 [2][3]).

2.4 PSHA for JEK2 and NEK sites, Rev. 2

PSHA report for JEK2 and NEK sites, Rev.2, shall be prepared by re-evaluating revision 1 of PSHA for JEK2 and NEK sites (RIZZO/GeoZS/NAA, PSHA Rev.1, 2023 [56]) with consideration of Task 1 (presented in Section 2.1). In this effort, requirements from the preliminary independent evaluation report (PIER Rev.1, Sections 7.0, 7.1, 7.4 and 7.5) (FGG/LCI, 2025 [85]) should be taken into consideration in new revision (Rev. 2) of PSHA. Open issues described in 2nd and 3rd bullet of the second paragraph of Section 1.4 of this specification shall be considered, with special attention to identifying the parameters that have the greatest impact on the hazard and potential reduction of the related uncertainties.

In addition to the comments from the PIER report [56], AI commented that the host profile for SRA in the FNGMM case should be site-specific and thus consistent with the FNGMM that is developed for the JEK2 and NEK site considering V_{S30}=760 m/s. This means that the host shear wave velocity profile for the FNGMM case

should not be the same as for the PNGMM case (i.e., the "host profile" for the CY14 model), as the FNGMM has been adjusted for the location of JEK2 and NEK. Because in rev. 1 of PSHA [56] only one "host profile" was used in the SRA, it is required to assess the "host profile" for the FNGMM, which will correspond to V_{S30}=760 m/s and use it in the SRA for the assessment of the site amplification factors. Please note, that currently also the Revision 3 of FNGMM for Krško site is in development. The findings of study shall be incorporated in this update of PSHA.

In order to include appropriate local and regional knowledge about the site/near site geology and seismicity, it is requested to expand the PSHA team of geologists/seismologists with competent individuals to ensure PSHA project team can fully cover the issues with seismotectonic and seismic source characterization models - with the support of potential subcontractors, where the knowledge of local geology, data and models is crucial. Where possible, all changes to seismotectonic models and seismic source characterization models should be data driven (untested models and hypotheses should not be used). Hypotheses and models supported by available information should be integrated into a representation of uncertainty in which the center, body, and range of technically defensible interpretations is determined by the support in the data for each interpretation.

As an alternative option, the organization of work for completing this task (PSHA for JEK2 and NEK sites, Rev. 2) using the SSHAC level 3 methodology [108] shall be presented. This option shall include a project work organization, project costs, and a timeline, both with and without the use of this methodology.

The scope of work of new revision of PSHA for JEK2 and NEK site includes also generation/preparation of all information/data need to define conditional spectra (CS) (i.e., where CS is conditioned on selected PGA). Conditional Mean Spectra (CMS) conditioned on selected peak ground acceleration is expected to be reduced compared to UHS, which would potentially reduce seismic demand in probabilistic safety assessment of NEK (or JEK2). In addition, it would build basis to estimate aleatory uncertainties related to spectral acceleration dispersion for the selected PGA acceleration. Note that CS is intended to use primarily for SPSA of NEK.

The result of this task shall be the PSHA report, Revision 2, with calculated seismic hazard curves and uniform hazard spectra (UHS) for selected control points at different depths and for several selected Mean Annual Frequencies of Exceedance (MAFE). The estimated uniform hazard spectra should at least be calculated for six control points (CP): CP1 (Surface - depth 0 m), CP2 (depth 12 m), CP3 (depth 20 m), CP4 (depth 80 m), CP5 (depth 120 m), CP6 (depth 200 m). The UHS of all CPs must be estimated for at least Mean Annual Frequencies of Exceedance (MAFE) corresponding to the following return periods (TR) 100 years, 760 years, 1 000 years, 10 000 years and 100 000 years. For the defined control points and return periods, the percentile (5^{th}, 16^{th}, 50^{th}, 84^{th}, 95^{th}) and mean uniform hazard spectra shall be calculated. Also, the Cumulative Distribution Function (CDF) for spectral accelerations for (at least) vibration frequencies 1 Hz, 2.5 Hz, 5 Hz, 10 Hz and 100 Hz shall be graphically presented for all calculated spectra.

Regarding the 3rd bullet of the second paragraph of Section 1.4, new PSHA should be expanded to include an additional appendix that contains the following analyses:

1. The real recorded time histories (supplied by NEK) shall be analyzed and spectra calculated to confirm high spectral ratios between on-site measurements taken in the free field and 20 m below grade.
2. For the control point CP3:
    - calculate CP3 full soil column outcrop motion UHS,
    - calculate CP3 "within" column motion UHS (by deconvolving free-field UHS to 20 m below grade).
    - Calculate and compare the CP3 free-field (truncated) soil column outcrop motion UHS with the two CP3 UHSs above.
3. For further use in NEK, the definitions UHS for control points below ground that will be used in new PSHA should be consistent with those applied in PSHA 2004. Therefore, if based on the comparison in item #2 above it can be assumed that the 2004 foundation UHS represents either (a) "within" soil motion or (b) full soil column outcrop motion, then the revised PSHA results (hazard curves and UHS for CP1-CP6) shall be calculated and presented using the same (a or b) UHS definition as that in PSHA 2004 (this should be presented in the additional appendix).

2.5 Recommendations for seismic design parameters for JEK2

This task includes the definition/development of seismic design parameters for JEK 2 based on the results of Task 2.4 above. Recommendations shall be given based on the review of requirements of Slovenian regulation [101], European Utility Requirements (EUR) [107], international standards (e.g., IAEA [95], [96] [98], [103], [104]) and a comparison with US applicable standards and requirements for analysis and design of nuclear facilities ([99], [100]) (see Section 6).

2.6 Contractor's response on PIER and FIER

It is required that Contractor forms and engages a participatory peer review panel (PPRP) throughout the STM and SSCM update process, site response analyses, and hazard calculations, aiming at following the SSHAC level 3 methodology requirements. The PPRP members would review the technical approach, observe working group meetings and review updated inputs to the PSHA and site response analyses as calculations are performed.

In addition to that, for the revised reports presented under scope in sections 2.1–2.5, purchaser will seek a new independent evaluation by Authorized Institution (AI) as this is required by Slovenian Nuclear Safety Administration legal requirements. In this evaluation, the contractor shall participate and technically defend the work. The contractors/authors of the PSHA shall remain a proponent of the work, while the AI shall act

as an independent reviewer. However, any accepted resolution, given by the AI, should be documented in the revision log of the document.

PSHA for JEK2 and NEK sites, Rev. 2, as well as all deliverables (as defined in Section 7) will be subject to final independent review by Authorized Institution (AI) in accordance with applicable Slovenian legislation listed in Section 6. The scope of Contractor's work includes activities for preparing final comment resolutions in accordance with comment of AI and, accordingly, preparation of final PSHA report, Rev. 2.

3 SAFETY CLASSIFICATION

Work per this specification is classified as NOT SAFETY RELATED.

4 ANALYSIS INPUT

4.1 PSHA for Krško site and NEK USAR

[1] Revised PSHA for NPP Krško site, PSR – NEK- 2.7.2. Revision 1, University of Ljubljana, Faculty of Civil and Geodetic Engineering Institute of Structural Engineering, Earthquake Engineering and Construction IT, January 2004.

[2] Revised Seismotectonic model of the Krško Basin, Part 1, PSR-NEK-2.7.1 (Rev. 1), Krško Slovenia, Geomatrix Consultants, January 2004.

[3] Revised Seismotectonic model of the Krško Basin, Part 2, Proposed USAR update PSR-NEK-2.7.1 (rev 1), Krško Slovenia, Geomatrix Consultants, February 2004.

[4] EQE International, Probabilistic Seismic Response Analysis for Krško Nuclear Power Plant", Report 52177-R-001, August 1995.

4.2 Site investigations and related documents

[5] ARSO-GeoZS, 2023, Task C Final Report: Spatial analysis of historic and instrumental seismicity and earthquake fault plane solutions in the broader area of the Gorjanci structure. Project: Characterization of the Drnovo Anomaly and the Gorjanci Structure. Ljubljana, Geološki zavod Slovenije.

[6] Atanackov, J., et al., 2010, Geotechnical, geological, and seismological (GG&S) evaluations for the new nuclear power plant at the Krško site (NPP Krško II): Geology, phase 1 report.

[7] Atanackov, J., Jamšek Rupnik, P., Celarc, B., Jež, J., Novak, M., Milanič, B., Markelj, A. 2020. Izdelava seizmotektonskih kart za leto 2020 – Strukturno geološka in seizmotektonska parametrizacija

Posavskih gub [Production of seismotectonic maps for 2020 - Structural-geological and seismotectonic parameterization of the Posavina folds], 2. del (2/2), rev 0. Geološki zavod Slovenije, 86 p.

[8] Bazargan-Sabet, B, and S Bernardie, 2010a, Geotechnical, geological and seismological (GG&S) evaluation of the new nuclear power plant at the Krško site: Phase 1 summary report. Intermediary Report BRGM/RC-58777-FR.

[9] Bazargan-Sabet, B, and S Bernardie, 2010b, Geotechnical, Geological, and Seismological (GG&S) Evaluations for the New Nuclear Power Plant at the Krško Site: Phase 1 Summary Report, BRGM/RC-59096-FR, 164 pp., October 2010.

[10] Bertil, D with the collaboration of O. Scotti and C. Clément, 2010, NPP Krško II (Slovenia): computation of seismic activity parameters for area sources models, BRGM/RC-58253-FR, 124 p., 43 ill., 7 appendices.

[11] Čarman, M., and M. Živčić, (2009). Double-difference hypocenter relocation of earthquakes in the area of Krško II NPP proposed site. Manuscript, Seismology and Geology Office, ARSO, Ljubljana.

[12] Douglas, J, and S Auclair with collaboration of D. Baumont, C. Berge-Thierry, L.F. Bonilla, P. Fajfar, and O. Scotti, 2008, Selection of ground-motion prediction equations and determination of weights for logic tree for NPP Krško II, Final Report, BRGM/RC-56092-FR, 91 pp, 31 ill, 2 appendices.

[13] Douglas, J, and S Auclair 2010, Addendum to Selection of ground-motion prediction equations and determination of weights for logic tree for NPP Krško II, Final Report, BRGM/RC-56092-FR, June 2010.

[14] Douglas, J., 2011. Ground-motion predication equations 1964-2010. Final Report, RP-59356-FR, BRGM.

[15] Foerster, E., and Belvaux, M., 2010, "Site Effect Estimation for NPP Krško II, Using 2D Numerical Simulations," BRGM/RC-58722-FR.

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4.3 Analysis, reports and related documents

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[74] FGG/ARSO (Faculty of Civil and Geodetic Engineering, Institute of Structural Engineering, Earthquake Engineering, and Construction IT, University of Ljubljana/Slovenian Environment Agency), 2022b, Independent Review of Reports on JEK2 PSHA: Hazard Input Document for Fully Non-ergodic Ground Motion Model, Preliminary Independent Review Report, Revision 4, J2P-1-IRR-Rev. 4-HID-NGMM, prepared by M. Dolšek and Anže Babič, (comments provided in mark-up of Word document), 13 October 2022.

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[92] PRP Final Letter, 12. October, 2018 (SHA project).

Other reports may be submitted as applicable.

5 CONTRACTOR'S DESIGN CONTROL PROGRAM

All services shall be provided according to Contractor's quality management program, which complies with the requirements of ISO-9001 (or a comparable standard), or 10 CFR 50, Appendix B.

[93] ESP 2.302, Administration of changes to the updated safety analysis report (USAR), Nuclear Power Plant Krško, May, 2020.

6 APPLICABLE CODES STANDARDS AND LEGISLATION

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NOTE: Codes, standards and legislation referenced in PSHA 2023 also apply as applicable.

7 DELIVERABLES

All deliverables (document packages) shall be first delivered as preliminary documents and after NEK, GEN and authorized institutions review and consequential comment resolutions also in a final form. In addition to electronic version, all deliverables shall be provided in two hard copies.

The deliverables required are:

7.1 Project Management Manual (PMM)

7.2 Document with revised seismotectonic model of the Krško basin (part 1) and proposed revised affected USAR Chapter 2 sections (part 2). Part 1 and 2 shall be presented in separate reports.

7.3 Final fault capability assessment for the proposed Krško 2 Nuclear Power Plant and NEK.

7.4 Probabilistic seismic hazard analysis for Krško nuclear power plant (NEK) and Krško nuclear power plant 2 (JEK2), Revision 2.

7.5 Document with Recommendations for seismic design parameters for Krško nuclear power plant 2 (JEK2).

8 SCHEDULE REQUIREMENTS

The detailed project schedule shall be prepared within the contractor's approach plan. Work should be organized to plan in parallel in all Tasks and Subtasks as much as possible to ensure work is performed in the allocated timeframe. The Contractor shall present the best-case schedule plan and its duration without jeopardizing any aspect of these Technical Specifications.

Deliverable shall be issued within the following time frame:

Activity	Version	Time frame
Contract Signature		T0
Deliverable 1 (part 1)	Preliminary Final	T0 + 3 months T0 + 5 months
Deliverable 2	Preliminary Final	T0 + 5 months T0 + 7 months
Deliverable 1 (part 2)	Preliminary Final	T0 + 8 months T0 + 10 months
Deliverable 3	Preliminary Final	T0 + 9 months T0 + 11 months
Deliverable 4	Preliminary Final	T0 + 11 months T0 + 13 months

9 STATUS REPORTS

The Contractor is required to submit Intermediate Reports for each task monthly.

Intermediate Report(s) shall include project overview and progress, issues, risk and change management (open issues - identification of any key issues requiring resolution, open risks, open change requests) and action plan. The Contractor shall submit Intermediate reports to GEN Project Team members. The Intermediate Reports shall be numerated from 1 to N and send by email every last Friday of each month.

10 TECHNICAL APPORACH TO THE WORK

Within the proposal bidder shall submit a DRAFT Project Management Plan, which outlines the process of work to be performed. Also, bidder shall confirm understanding of the scope of work. In the case that the bidder intends to use any subcontractor(s), the latter shall be listed and the scope of work subcontracted to them shall be clearly reported.

The Contractor and GEN could propose and organize working meetings and/or conference calls after the Intermediate Report is submitted or at any other need during the project. Meetings shall be held at regular intervals or if justified by special agenda issue and shall be occurring online.

The Contractor is obliged to prepare and transmit the minutes of each meeting (draft minutes during the meeting and final minutes within three (3) working days after the meeting).

The Contractor is obliged to keep records of open issues (notes, questions, and answers) during the project. A record of open / closed issues must be attached to the Intermediate Report.

11 CHANGES IN THE SCOPE OF WORK

The Contractor shall identify any scope changes that could cause an impact on the Contractor's cost or schedule of the project by the issuance of a Contractor Request for Change of Work Scope. The Contractor shall not proceed with the change of Work Scope until written approval has been authorized by GEN and NEK. It is the Contractor's obligation to notify the GEN and NEK Responsible Project Manager(s), Project Engineer(s) and Deputy Project Engineer(s) in writing of the noted scope changes and it is the responsibility of the GEN and NEK Responsible Project Manager(s)/Project Engineer(s) to respond within ten (10) working days from the receipt of the Contractor's request for work scope change. Changes in the scope of work are possible based on a written annex to the basic contract, which must be agreed between both parties.

12 ORGANIZATIONAL CONTACT

Project organization is as follows:

Responsible Project Managers	[redacted]
	[redacted]
E:	[redacted]
T:	[redacted]
	[redacted]
	[redacted]
E:	[redacted]
T:	[redacted]

Project Engineers	[redacted]
	[redacted]
	[redacted]
	[redacted]
	[redacted]
	[redacted]
E:	[redacted]
T:	[redacted]

13 DELIVERABLE DOCUMENTATION TECHNICAL REQUIREMENTS

The Contractor is obliged to deliver all documents in Preliminary form and after GEN/NEK approval, as final documents.

Documentation	Quantity	Media/Transfer	File type
Preliminary Reports	1	electronic: ftp	doc(x) & pdf
Final Reports	2	electronic: ftp	doc(x) & pdf
Presentations	1	electronic: ftp	ppt(x)
Figure, photo, scan		electronic: ftp	png, tiff, jpg, jpeg, pdf
Table		electronic: ftp	xsl(x)
Spatial data		electronic: ftp	shp
Calculation		electronic: ftp	source file

The text should be written and delivered in MS Office Word format. Figures and tables included in the reports shall be inserted as objects. Figures shall be delivered also as original source files or in other formats in high-resolution size. Tables shall be delivered as original source MS Office Excel format files. Scanned text, figures and tables of reference documentation should be in MS Office compatible format or other formats which are widely used.

The documentation has to be written in programs: MS Word, MS Excel, MS Office PowerPoint, with the following features:

Paper size:	A4
Margins:	top, bottom, left, right – 2,54cm
Font style:	MS Office Word, use Calibri
Font size:	text 10 pt, titles 14 pt bold, subtitles 12pt bold
Language:	English

Delivery of the documentation:
The Contractor is obliged to deliver all additional documentation, which was used as a reference for the Final Report: Regulations and industry guidelines, Analyses and calculations results, Figures, graphs and tables, and other reference documents important for the implementation of the study.

14 ACCESS TO INFORMATION

The Contractor shall provide access to all the information used for purposes of consulting services. The access will be provided for Purchaser and/or its Sub-Contractor's personnel who are engaged in the work per this specification for the purpose of reviewing the quality and the amount of the work being performed.

15 CONTRACT AND SUBCONTRACT WORK

When the Bid is accepted, the Contractor shall not subcontract any portion of the work without the written approval of GEN and NEK. Only Subcontractors already specified in the bid are considered to be approved directly. Appropriate contractors QA program shall be applied for selection of subcontractors (sub-contractors will be required to the satisfaction of the Contractor and NEK criteria).

16 PROPRIETARY INFORMATION

GEN and NEK have a proprietary interest in all drawings, design, specifications, documents, information and know-how that may be furnished pursuant contract execution. Also, GEN and NEK have a proprietary interest in any know-how, improvement, discovery, and invention which may be made, developed, or conceived in the performance of work hereunder or which may arise or result therefrom (hereinafter collectively referred to as the "Information"). All such information shall be considered to be proprietary of GEN and NEK.

The right to use any such Information shall be restricted to the Contractor only, for its internal use, and shall be entirely tied to the performance of the Contract. All such Information is subject to the confidentially provision.

17 TRANSFER OF COPYRIGHT

Receiving all payments defined in the project work performance contract, the Contractor shall exclusively transfer for an indefinite period and all cases documentation copyright to GEN and NEK.