**AEC Response to Preliminary Questions for TOPIC-1b**

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| **Questions and Responses** | **Referring page in National report** |
| 1. Chapter 2.1.2.1 Key SSCs required to achieve safe shutdown:   a) How is the seismic resilience of the SSCs verified?  b) Which technical rules or guides have been applied?  c) Has besides the plant vendor or the licensee an independent body (regulator or Technical support organization) verified the calculations?  d) Who was this independent body?  a) The seismic resilience of key SSCs is warranted following USNRC Standard Review Plan (SRP), which requires dynamic analysis and/or seismic shake table testing qualification.  b) USNRC Regulations, associated Regulatory Guides and SRP.  c) The seismic calculations have been thoroughly reviewed by independent experts invited by Atomic Energy Council, but very few confirmatory calculations were done.  d) Atomic Energy Council. | **21** |
| 1. Chapter 2.1.2.1 Key SSCs required to achieve safe shutdown: Are the answers to the question above valid for the NPPs of all 4 sites? If not , please specify for all sites or plants.   Yes, the answers to the question above are valid for all 4 NPPs. | **21** |
| 1. Chapter 2.1.2.3 Indirect effects of the earthquake taken into account: Did you take into account for all sites and plants all items as:   (1) induced in plant flooding,  (2) induced fire event,  (3) loss of off-site power  (4) excavation and backfill  5) personnel and equipment?  If yes, why wasn't it mentioned?  CS:  Items including earthquake induced plant flooding, fire event, loss of off-site power and delay of personnel & equipment’s arrival at plant site, are taken into account and discussed in Section 2.1.2.3 “Indirect effects of the earthquake taken into account” in stress test report.  As to excavation and backfill, CSNPP has procedure 1361 delineating requirements for excavation and backfill work. CSNPP excavation and backfill contracts all require the contractors to include price for transporting the leftover excavated soil to licensed deposit area. CSNPP compound disaster accident prevention and mitigation facilities and adjacent areas currently have no excavation work. The ongoing pipe trench excavation work for the addition of redundant raw water piping is on the slope of the small hill on the other side of Chien-Hwa Creek away from the plant. The excavation and refill will not affect the plant safety.  KS:  Items have been mentioned in stress test report Section 2.1.2.3 “Indirect effects of the earthquake taken into account,” including flooding impact to building, loss of off-site power, the required manpower and facilities and earthquake induced fire event. Excavation and backfill has been discussed in Section 2.2.3.1 page 40.  MS:  Items have been mentioned in Stress Test Report Section 2.1.2.3. “Indirect effects of the earthquake taken into account,” including flooding impact to building, loss of off-site power, the required manpower and facilities and earthquake induced fire event, excavation and backfill has been evaluated.  LM:  Items including earthquake induced plant flooding, fire event, loss of off-site power and delay of personnel & equipment’s arrival at plant site, are taken into account and discussed in Section 2.1.2.3 “Indirect effects of the earthquake taken into account” in stress test report. Excavation and backfill has also been discussed in Section 2.1.2.3. No construction of this plant is built on an excavation-and- backfill land. Since all safety related equipment and structure sit on a solid rock base, there exists no possibility of soil liquefaction. The earthquake wouldn’t affect the plant safety due to soil liquefaction. An operating procedure 1208 “Excavation and Back-fill Engineering” was issued to instruct and control quality of all excavation and back-fill constructions. This procedure is to assure that any excavation and back-fill construction won’t affect plant building structure and seismic resistance of the pipes. |  |
| 1. LM, Chapter 2.1.3.2: How is the present status in respect to the general rescue equipment?   The general rescue equipment as per procedure 186.01 “Focuses of disaster prevention and Rescue” are being prepared. The present status of general rescue equipment is shown in chart 3.3 of “EU Stress Test for LMNPP Licensee report”. Several rescue equipment have been procured, including 4.16 kV 1500 kW power vehicle, fire trucks, mobile pumps, etc. And some other rescue equipment is being procured. Presently LMNPP has not carried out fuel loading. Parts of rescue equipment are being used in Post-Construction Test (PCT) or Pre-Operational Test (Pre-Op Test). We will set up all the general rescue equipment as per procedure 186.01 “Focuses of disaster prevention and Rescue” before commercial operation. | **32** |
| 1. CS, Chapter 2.1.3.3: If there are deviations "the station shall follow relevant procedures to carry out safety evaluation and take corrective actions: .... ".   (a) Do the other sites have the same requirements?  (b) How often since the Fukushima-Daiichi accident cases of non-conformance have been reported to AEC?  (c) Are non-conformance information processes with information of AEC also in force for other aspects of nuclear safety and are they laid down (e.g. operation manual)?  (d) And for which plants?  (a) Yes, all of the Nuclear power plants follow the same requirements.  (b) There has one non-conformance item, regarding to the unprotected ECW system from the specified tsunami run-up height, been reported to AEC by KSNPP, since the Fukushima-Daiichi accident cases.  (c) Yes, it is carried out in accordance with SOP 1115.01 (The control procedure for the case which does not meet the quality requirement.), all the non-conformance information will be clearly submitted to the AEC in all aspects.  (d) All NPPs are required to follow. | **32** |
| 1. MS: What is the elevation above sea level?   The elevation of the entire plant is about 4.5 to 35 meters above sea level. | **2** |
| 1. All sites: What is the soil / rock type below the site?   CS:  The structure geologic maps at the site area which present bedrock contours are shown in Figures 2.5-7 to 2.5-11 of FSAR. The geological profiles presenting the relationship of the foundations of nuclear power plant to subsurface materials are shown in Figures 2.5-7 to 2.5-13 of FSAR.    KS:  In the power block area approximately 10 meters of terrace deposits covered the foundation rocks. The rocks consist of sedimentary deposits belonging to the middle portion of the Mushan Formation. The foundation rocks consist of a sequence of estuarine and near shore deposits. These deposits include sandstone, shale, siltstone, and mudstone.  MS:  During construction period, surface accumulation layer and weathered mudrock were excavated and plant structure building is located directly on fresh mudrock layer (FSAR Appendix 2B, Fig 2B-1, 2B-7, 2B-8, 2B-9).  LM:  Unit 1: Ground level at EL. 12 m, overburden: EL. 12 m~7.3 m, weathered rock: EL. 7.3 m~5.3 m, intact rock below EL. 5.3 m. | **16** |
| 1. All sites: Have site effects resulting from soil / rock type been accounted for in the determination of peak ground acceleration?   For CS, KS, and MS NPPs, the specific generic design response spectrum (e.g. RG 1.60 response spectrum) were adopted. While the design response spectrum for LMNPP, the plant specific spectrum was used. And since the location is specified at free surface of the rock foundation level, so in the determination of pga, the overlaid soil is accounted in the soil column as well as soil-structure interaction analysis. | **16** |
| 1. All sites: Seismic hazard assessment uses a deterministic approach. Have the results been benchmarked against probabilistic methods?   During the design stage, deterministic approach was used to determine the design earthquake for all existing 4 sites. All the NPPs have performed probabilistic safety assessment, the design pga was checked against the annual frequency of exceedance (or return period). | **16** |
| 1. All sites: Are any hazard studies available that constrain ground motion values for low expedience probabilities such as 10-4?   RG 1.165 or 1.208 requires the design ground motion to be low frequency of exceedance (such as 10-4). But since the deterministic approach was adopted for the design, we did not use such value as a design requirement, and based on the PRA result, none of the four NPPs is with such low exceedance as 10-4. | **16** |
| 1. CS, KS and LM: Deterministic hazard assessment uses the strongest historical earthquake (M=7.3) recorded in a 100 years period instead of the MCE (Maximum Credible Earthquake)?   The deterministic hazard assessment used the strongest historical recorded earthquake. Still, the MCE, based on the strongest earthquake magnitude, was evaluated and was used for the final determination of the design. | **16** |
| 1. CS, KS and LM: Conservative deterministic hazard assessment would add some safety margin to the strongest historical earthquake. What is the justification for not applying such an approach to the three sites?   As answered in the previous question, safety margin has been added by given a delta M from 0.0~0.3 or from total energy theory, and again in the final decision for the value. | **16** |
| 1. MS: A maximum potential magnitude of M=7.5 is assumed for the SE Taiwan-W Philippine Sea tectonic province. How is this value justified?   Regarding the importance of this seismic zone to the plant, we assumed that the largest earthquake magnitude is 7.5 (actual data is 7.1) and the distance from the seismic zone boundary to the plant is 20 km (actual distance is 20~35 km).(page 4 of MSNPP report) | **16** |
| 1. LM: What is the justification to draw a tectonic province boundary 5 km from the site?   The 5 km distance is believed to be the shortest distance for an earthquake to occur provided the site is a good site as far as geology and seismicity are concerned. | **16** |
| 1. KS: What correlations have been used to compute intensity and horizontal ground acceleration from magnitude?   Four attenuation equations (including Campbell’s form, Joyner & Boore’s form, Kanai’s form and Japan Rock site’s form) were combined by different weighting factors (0.32, 0.24, 0.22, 0.22 in order, for example) to compute PGA from magnitude. | **16** |
| 1. All sites: Which attenuation law/laws have been used for determining local ground accelerations?   In the seismic re-evaluation chapter of 10-year periodic safety review, four attenuation equations (including Campbell’s form, Joyner & Boore’s form, Kanai’s form and Japan Rock site’s form) were combined by different weighting factors (0.32, 0.24, 0.22, 0.22 in order, for example) to compute PGA from magnitude. | **16** |
| 1. All sites: Some ground motion prediction equations (attenuation functions) predict significantly higher values for PGAh for M=7 than those listed in the National Report (e.g., Joyner and Boore, 1981: M=7 / PGAh ~0.5g for the epicentral area). Could that difference be explained?   For the ground motion prediction equation, not only one was adopted, for example, four attenuation models used for LMNPP site to determine local ground accelerations were: (1) Kanai's form; (2) Joyner and Boore's form; (3) Campbell's form; and (4) Japan Rock Site's. All the parameters have been best fitted to suitable earthquake measurement data including Taiwan data. It’s natural to see the difference caused by the different equations. However, different weighting factors were assigned to the individual equations by a team of experts. | **16** |
| 1. CS and LM: Deterministic assessments for both plants use an M=7.3 event occurring at a source at distances of 5 and 8 km from the NPP, respectively. For CS this results in PGAh=0.3g, for LM in PGAh=0.4g. What is the reason for these different results?   Attenuation formulas are different.  CS:  CS PGAh was obtained almost 40 years ago. Attenuation formulas of Kanai, Guterberg & Richter, Guterberg & Richter-Benioff, Modified Estava & Rosenblueth, Seed, Blume and Wiggins were used to calculate the design basis earthquake. DBE of 0.3g was recommended which is higher than the average value of maximum acceleration to be expected at the site by the above formulas.  LM:  Four attenuation models used for LMNPP site to determine local ground accelerations were: (1) kanai's form; (2) Joyner and Boore's form; (3) Campbell's form; and (4) Japan Rock Site's. The highest value 0.4g taken from the result of the four attenuation models with different weighting factors was adopted as the SSE value of LMNPP site. | **16** |
| 1. All sites: Which methods have been used to assess seismicity related to the subduction zones?   Point source is used to assess the seismicity related to the subduction zones. | **17** |
| 1. All sites: Which methods have been used to map "active faults" in the large areas extending to a radius of 320km from the sites?   The inland active faults were investigated, defined, and issued by Central Geological Survey. Basically, historical earthquake records, reconnaissance of faults, boring, geophysical investigation, geodetic measurement, LiDAR, etc. are used to map active faults. As to the sea area, only seismicity was considered. But in light of 2007 Japan NCO and 2011 Great East Japan earthquakes experiences, at the request of AEC, TPC now re-investigates the active faults using Multi-beam Scan and Multichannel Seismic Reflection System in the sea area. | **17** |
| 1. All sites, active fault assessment: "The historical maximum magnitude or a higher value was used to evaluate ground motion": What is the justification to use either one or the other value?   Please refer to the response provided in Q11 and Q12. | **17** |
| 1. CS and KS: What methods have been used to re-classify and assess the Shanchiao Fault? Has a systematic paleoseismological investigation been carried out?   Boring, geodetic measurement, LiDAR, surface deformation, offshore and onshore geophysical investigation, etc. are used to re-classify and assess the Shanchiao Fault | **19** |
| 1. CS and KS: What type of fault is the Shanchiao Fault? Is it a reverse fault that dips below the KS site?   Shanchiao fault is a normal fault and KS site is on the side of hanging wall, therefore, the fault dips toward KS site. | **19** |
| 1. What correlations have been used to calculate the maximum magnitude of an earthquake that can be produced by the Shanchiao and Hengchun fault?   Based on the relationship between fault length (L) and magnitude (M). M-L Equations proposed by Wells & Coppersmith (1994) and local expert Ma and Yen (2011) were used. | **18.19** |
| 1. MS: What methods have been used to re-classify and assess the Hengchun Fault? Has a systematic paleoseismological investigation been carried out? Why is a southern continuation of the fault into the ocean excluded?   Boring, geodetic, LiDAR, surface deformation, etc.  Offshore geophysical investigation results show that fault extended to somewhere in the ocean only. | **20** |
| 1. MS: What type of fault is the Hengchun Fault? Is it a reverse fault that dips below the MS site?   Hengchun fault is a reverse fault which dips toward east. MSNPP site located at the west side of Hengchun fault. | **20** |
| 1. All sites: Are control rooms qualified for DBE? Are emergency control rooms available and seismically qualified?   Yes, the main control room of all sites are seismically qualified for DBE.  Each unit has another remote shutdown panel. It is seismically qualified for DBE, also. | **21** |
| 1. CS: Are the following SSCs seismically qualified for the DBE level: control room / control building, EDG buildings, depressurisation system, hydrogen recombiners (if available)?   Yes, they are all seismically qualified for the DBE level. | **21** |
| 1. KS and MS: Are the following SSCs seismically qualified for the DBE level: depressurisation system, hydrogen recombiners (if available)?   Both depressurization system and hydrogen recombiners at KS and MS are seismic categoryⅠdesign. | **22** |
| 1. LM: Are the following SSCs seismically qualified for the DBE level: EDG buildings, hydrogen recombiners (if available)?   Yes, both EDG building and hydrogen recombiners are seismically qualified for the DBE level. | **23** |
| 1. All sites: Can secondary earthquake effects such as liquefaction, lateral spreading, ground settlement etc. be ruled out for the four sites?   Structures in nuclear power block have been designed appropriately and could rule out the effects mentioned in the question. | **26~30** |
| 1. All sites, earthquake induced fire: Are fire brigade buildings and equipment storages seismically qualified to ensure functionality after an earthquake?   CS,KS, and MS:  Currently the seismic evaluation and reinforcement work according to local seismic requirements or building code (modified after 1999 Chi-Chi earthquake) is in progress. The goal of this activity is to ensure functionality after an earthquake.  LM:  The LMNPP fire brigade (has not been constructed yet) has already been designed for the seismic loads as specified by local Building Code. However, we are now planning to upgrade this building to assure it could retain its structural integrity during and after the Design Basis Earthquake (SSE Level) event.  All sites:  In the future, all the fire brigade buildings will be upgraded to provide necessary support in terms of personnel and equipment during a beyond design basis accident. | **26~30** |
| 1. All sites: Do the extremely high values such as >3g only refer to the fragility of a specific component (e.g., RCIC pump) or do they also apply to all SSCs at the periphery of these components (e.g., pipe connections, power supply etc.)?   A successful operation of a safety function must rely on the operation of various components (e.g. power supply, cooling, piping, valves, heat exchangers, pumps). So, basically, components which were picked-up to perform its fragility calculation were based on the system event tree and fault tree analysis. Besides, the surrounding connection and interaction, etc., will be checked during the plant walkdown. So, the periphery of these components is considered. | **36~44** |
| 1. All sites: The tables on p. 36-44 partly show extremely high values for some SSCs. A more detailed explanation of the fragility analysis would be appreciated.   In general, the fragility value come up with a product of several safety factors extract from the design analysis report. The SSCs of extremely high values are those with high margin of capacity factor in the fragility analysis. | **36~44** |
| 1. CS: What is the fragility of EDG 1-4? Is the 5th DG sufficient for the emergency supply of two units?   1. The fragility of EDG 1-4 is >3g  2. The 5th EDG can supply power to the safety 4.16KV essential bus of both units simultaneously with load shedding. | **37** |
| 1. MS: The success path 1 (p. 41) speaks of using a gas turbine to drive AFWP. According to the table (p. 42) the fragility of the gas turbine is 0.3g. Why is 0.3g not the limiting values for success path 1?   “→…gas turbine…→” is a typo error. It should be “→…steam turbine…→”. | **42** |
| 1. LM: The sentence is not understood: "HCLPF = 0.9g was selected conservatively as the screening value to be used in the seismic cliff edge effects event tree."   As suggested in EPRI-1002988, a HCLPF value of 0.57g can be used as a screen value to screen out high seismic capacity SSCs which will not have significant impact to the risk. For LMNPP, we use the HCLPF value of 0.9g to screen out high seismic capacity SSCs when developing cliff edge effects event tree. | **43** |