

## **EU peer review of Taiwanese nuclear stress tests:**

**Confirmation of existing high safety standards, however full implementation and transparent verification of additional actions will help nuclear power plants to cope better with extreme external events and severe accidents**

### **Background – European Stress Tests:**

Following the Fukushima accident in March 2011<sup>1</sup> the European Council called for comprehensive and transparent risk and safety assessments ("stress tests") of all EU nuclear power plants (NPPs).

The main aim of the stress tests was to assess the safety and robustness of NPPs in case of extreme natural events, especially flooding and earthquakes. The technical scope has specifically been defined considering the issues that have been highlighted by the events that occurred at Fukushima, including combination of initiating events due to extreme external hazards and consequential failures. More generic issues, such as material degradation due to ageing or human factors, have not explicitly been considered.

These 2011/12 European stress tests consisted of three phases: In phase one the NPP operators (the "licensee") carried out a self-assessment, in phase two the national regulators evaluated these self-assessments and prepared national reports. 17 countries fully participated in the stress tests<sup>2</sup>. In phase three, these reports were analysed by multinational teams in a peer review process with participation of experts from nuclear and non-nuclear EU Member States, Switzerland, Ukraine, and the European Commission's own services<sup>3</sup>. The final European Commission Communication on the stress tests was published in October 2012<sup>4</sup>.

In parallel to Europe, ***stress tests based upon the EU concept were performed by a number of other regulators worldwide, among others in Taiwan.***

### **Taiwanese Stress Tests and EU Peer Review:**

In April 2013, the Taiwanese nuclear safety regulator, the Atomic Energy Council (AEC), invited the European Commission to set up an independent peer review of the stress tests of the Taiwanese NPPs as conducted in 2012 by the licensee, the Taiwan Power Company (TPC), and by AEC.

On this basis, the European Commission together with the EU nuclear regulatory authorities organised a multinational EU peer review team with participation of independent experts from several nuclear and non-nuclear EU Member States, Switzerland and its own services.

The EU team started its in-depth review immediately after receipt of the final Taiwanese stress tests report from AEC on May 31, 2013.

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<sup>1</sup> A heavy seaquake and an ensuing tsunami initiated a severe accident at the Fukushima Dai-ichi NPP in Japan, resulting in three partial reactor core melts, loss of containment and widespread dispersion of radioactive nuclides.

<sup>2</sup> <http://www.ensreg.eu/EU-Stress-Tests>

<sup>3</sup> <http://www.ensreg.eu/node/407>

<sup>4</sup> [http://ec.europa.eu/energy/nuclear/safety/doc/com\\_2012\\_0571\\_en.pdf](http://ec.europa.eu/energy/nuclear/safety/doc/com_2012_0571_en.pdf)

The intensive desktop analysis of this report was followed-up by a review mission to Taiwan<sup>5</sup>.

### **EU Peer Review – Transparency and Stakeholders Engagement:**

Taiwan started to use nuclear power in 1977, and has developed considerable experience in the operation of NPPs. There are currently three NPPs on three different sites in operation<sup>6</sup> and one NPP<sup>7</sup> on one site under construction. All these plants are owned and operated by the Taiwanese electricity company TPC. Both the operating NPPs and the NPP under construction have been subject to the Taiwanese stress tests and consequently the EU peer review.

Following the March 2011 series of core melt accidents in Fukushima, Japan, nuclear energy has emerged as a contentious issue among stakeholders also in Taiwan. Therefore, the review team put particular emphasis on the transparency of the entire process, involving all stakeholders – regulator, licensee and Taiwanese non-governmental organisations (NGOs)<sup>8</sup> – throughout the entire review in a participatory approach. This resulted in the peer review being recognised by interested stakeholders, particularly by the public, as a trustworthy reference to better understand the status and prospects of nuclear safety.

All key documents provided by AEC, TPC and NGOs were shared on a publicly accessible website<sup>9</sup>. Further, a web-based public consultation was organised before and during the review visit to Taiwan which allowed NGOs as well as individuals to express their point of view and provide information.

The final version of the EU peer review report was established on the basis of inputs from all stakeholders: AEC, TPC and NGOs.

### **Key Objective – Assurance of High Levels of Severe Accident Prevention and Mitigation:**

The Fukushima accident has shown that lessons learned from incidents and accidents in the past have not been fully addressed. In Fukushima's aftermath came a vigorous reassessment of the safe use of nuclear energy worldwide, firstly because it was a severe accident, and secondly because it occurred in a nation that was previously assumed to have a high standard of nuclear safety.

The potential costs of a severe nuclear accident, especially when it would occur in a densely populated region, could have a substantial impact on the national economy. It is therefore of the utmost importance to avoid such accident scenarios by ensuring the highest possible standards of safety in terms of both prevention and mitigation, and of quality of regulatory oversight<sup>10</sup>.

This applies of course also to Taiwan which is both a highly technologically developed and very densely populated region of the world. Furthermore, like Japan,

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<sup>5</sup> Lasting from September 29 to October 3, 2013, and including visits to two nuclear sites (*Maanshan* and *Lungmen* NPPs)

<sup>6</sup> *Chinshan*, *Kuosheng* and *Maanshan* NPPs (2 reactors each)

<sup>7</sup> *Lungmen* NPP (2 reactors)

<sup>8</sup> NGOs were assembled on the basis of the kind assistance by Greenpeace.

<sup>9</sup> <http://www.ensreg.eu/EU%20Stress%20Tests/International%20outreach>

<sup>10</sup> From discussions held with the different stakeholders during the visit to Taiwan, it is understood that reform processes would aim at strengthening the effectiveness and independence of the regulator in accordance with international standards, e.g. by ensuring sufficient workforce and funding.

due to its geophysical position, Taiwan is prone to large scale earthquakes, and although historically rare, Taiwan also faces the danger of tsunamis.

### **Overall Conclusions:**

In summary, the EU peer review concludes that ***the stress tests in Taiwan were carried out by essentially following the specifications of the 2011/12 European stress tests*** and can thus be considered comparable with regard to the relevance of their results.

Strong commitment of both regulator and licensee to further improve nuclear safety has been observed by the peer review team throughout the entire review.

The EU peer review acknowledges that – building on the results of the European stress tests and on insights from post-Fukushima actions being taken in other regions of the world, particularly in the USA<sup>11</sup>, Europe and Japan – the AEC has developed a comprehensive approach to safety review and identification of actions for further safety enhancements in order to better prepare all NPPs in Taiwan against extreme external events and severe accidents.

***Assuming the proper implementation of these actions and based on the review against the set of Fukushima-type hazards considered within the scope of the stress tests, the EU peer review takes note that AEC has not identified any safety-related weaknesses in Taiwanese NPPs which would require their immediate shutdown.***

***Moreover, the standards of safety applied to Taiwanese NPPs seem to be generally high and to conform in most areas to international state-of-the-art practices.***

***Nevertheless, tangible further improvements in some specific safety related areas are recommended.*** These improvements are justified on the basis of the fact that the risk to be hit by extreme natural hazards, such as earthquakes, flooding including tsunamis, extreme weather conditions and volcanism, is much higher in Taiwan than in many other geographical environments of the world and especially much higher than in the European countries which subjected their NPPs to the European stress tests.

### **Recommendations for Further Safety Enhancements:**

In addition to recommending various *plant specific* technical improvements<sup>12</sup>, the EU peer review resulted in the following key *generic* recommendations:

- **Further measures to ensure an adequate NPP design basis:**
  - As the exposure of Taiwan to natural hazards, such as earthquakes, tsunamis, flooding and typhoons, is generally quite high, the reliable assessment of the severity of these hazards and the implementation of suitable measures to protect against them is of crucial importance. It is recommended to update the design basis events for all natural hazards,

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<sup>11</sup> Taiwanese nuclear requirements and safety assessment practices are based on the applicable technical standards, guides and regulations from the US Nuclear Regulatory Commission (USNRC) and the International Atomic Energy Agency (IAEA).

<sup>12</sup> See: "EU Peer Review Report of the Taiwanese Stress Tests", November 2013.

particularly for earthquakes and tsunamis, and for all NPPs for exceedance probabilities not higher than  $10^{-4}$  per year:

- As the NPP sites are in close vicinity to active faults, an adequate assessment of seismic hazards shall use the most advanced geological and seismological techniques to update the design basis events and identify other earthquake-related hazards.
  - The assessment of tsunami design basis flood levels should be extended to use geological records of past events and the latest state-of-the-art techniques.
  - Whereas prior to Fukushima only one NPP had a hardened venting system installed, now all NPPs are ordered by AEC to install a filtered containment venting system, thus allowing the operators to keep the pressure build-up of the containments below critical levels and to limit radioactive releases in case of a severe accident.
  - The ordered installation of passive autocatalytic hydrogen recombiners will significantly improve the capability of the operators to avoid critical hydrogen build up in the containment and thus reduce risk of explosions. Further evaluations are, however, considered necessary to check whether these systems are of sufficient capacity to cope with beyond design basis accident scenarios.
- **Further measures to maintain NPP robustness under beyond design basis conditions and to ensure availability of adequate severe accident countermeasures:**
    - Since some NPPs are located in close vicinity, combinations of events, including multi-unit and multi-site effects, should be assessed in order to identify potential cliff edge effects and related safety enhancements.
    - In case of an extensive external event, some aggravating circumstances could be expected regarding emergency staff's arrival to the site. As roads/bridges represent weak points to access sites, infrastructure improvements could be considered together with ensuring availability of heavy road-clearing equipment.
    - Fukushima has shown that the treatment of large volumes of contaminated water can be challenging under post-accident conditions. The development of strategies to minimize the quantities of contaminated water produced under accident conditions and evaluating options to create closed cooling circuits could greatly improve plant preparedness.
    - Apart from local operating consoles and remote shutdown panels, no alternative emergency control rooms exist that would represent an additional hardened alternative to the main control room.
    - The foreseen construction of seismically isolated technical support centres is considered a significant improvement based on lessons learned from Fukushima. However, the design target of these centres should correspond at least to an earthquake level beyond present design basis.
    - The accident management provisions rely to a large extent on external support and on the use of mobile equipment. Adequately trained personnel has thus always to be available in sufficient numbers on the sites, or, alternatively, fixed installation of some of the mobile equipment should be considered.
  - **Further measures to ensure transparency on status of nuclear safety:**

- Adequate public information on AEC's decision making process could become an essential trust-building element. New ways of communication could be developed including the use of web-based technologies.
- AEC is encouraged to further develop the generic model of stakeholders involvement adopted for this peer review and transform it into a participatory process specifically adapted to local culture, conditions and needs in line with international best practices.
- Integrating the views of the different stakeholders – legislator, regulator, licensee, scientific community, representatives of the local population, NGOs – in such a process could form the basis of a future broad energy dialogue in Taiwan.

### **Follow up:**

In the light of the lessons learned from Fukushima, it is recommended to increase the robustness of NPPs well beyond their existing safety margins as soon as possible if reactors are to continue in commercial operation<sup>13</sup>.

Consideration of the recommendations made by the EU peer review team for further improvements to the safety of the Taiwanese NPPs is the responsibility of Taiwan itself. It was out of the scope of both the Taiwanese and the European stress tests and thus of their respective peer reviews to verify if sufficiently strong instruments are already available for the proper enforcement of safety enhancement actions resulting from a peer review.

Despite the fact that nuclear safety is a global issue, Taiwan currently remains, however, somewhat isolated from the international debate on it<sup>14</sup> and would need to attain greater involvement. In the light of Fukushima, the international nuclear safety community is encouraged to consider more effective ways of cooperation with both the Taiwanese regulator and the licensee, particularly on issues where their integration in international efforts has the potential to significantly reduce risks to human health and the environment on regional and global scales.

The EU peer review team understands and greatly appreciates that AEC considers taking up recommendations of the EU peer review in its action plan for further post-Fukushima improvements. To ensure that sufficiently strong instruments are available for the proper enforcement of these actions, or are made available in the course of governmental reforms, an international regulatory review could be recommended as a follow-up to this peer review.

### **Acknowledgements:**

The peer review team wishes to express its sincere gratitude to all Taiwanese counterparts – AEC, TPC and NGOs – for actively contributing to this peer review in a spirit of great openness and transparency. Stakeholders were willing to learn from each other and to share insights and concerns about relevant nuclear safety related issues.

Last not least, it shall be noted that the actions set in the course of this peer review on transparency and consideration of independent scientific input clearly demonstrate the great usefulness of the Taiwan peer review for the further

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<sup>13</sup> See: "The Fukushima Daiichi Nuclear Power Plant Accident: OECD/NEA Nuclear Safety Response and Lessons Learnt", OECD 2013, NEA No. 7161.

<sup>14</sup> Interview of AEC's Chairman, His Excellency Minister Chuen-Horng Tsai, with the Nuclear Communications Network, June 25, 2013.

improvement of the stress tests process as such. The fact that AEC and NGOs agreed to these actions and committed to them throughout the peer review is acknowledged with great appreciation.

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