PRELIMINARY SUMMARY REPORT

IAEA INTERNATIONAL PEER REVIEW MISSION ON MID-AND-LONG-TERM ROADMAP TOWARDS THE DECOMMISSIONING OF TEPCO'S FUKUSHIMA DAIICHI NUCLEAR POWER STATION UNITS 1-4

(Second Mission)

Tokyo and Fukushima Prefecture, Japan
25 November – 4 December 2013

IAEA INTERNATIONAL PEER REVIEW MISSION ON MID-AND-LONG-TERM ROADMAP TOWARDS THE DECOMMISSIONING OF TEPCO'S FUKUSHIMA DAIICHI NUCLEAR POWER STATION UNITS 1-4

(Second Mission)

PRELIMINARY SUMMARY REPORT TO THE GOVERNMENT OF JAPAN

Tokyo and Fukushima Prefecture, Japan

25 November – 4 December 2013

PRELIMINARY SUMMARY REPORT

Mission date: 25 November – 4 December 2013

Location: Tokyo and Fukushima Prefecture, Japan

Organized by: International Atomic Energy Agency

IAEA Review Team:

Lentijo, Juan Carlos	IAEA/NEFW, Team Leader
Hahn, Pil-Soo	IAEA/NSRW, Deputy Team Leader
Holton, David	UK, AMEC
Izumo, Akira	IAEA/NEFW
Ljubenov, Vladan	IAEA/NSRW
Kilic, Nesimi	IAEA/NENP
Michal, Vladimir	IAEA/NEFW
Nies, Hartmut	IAEA/NA Radiometric Laboratory
Pieraccini, Michel	France, EDF/CIDEN
Sagi, Laszlo	IAEA/NSRW
Samanta, Susanta Kumar	IAEA/NEFW
Siemann, Michael	OECD/NEA
Standring, Paul	IAEA/NEFW
Stoyanov, Georgi	Canada, CNSC
Szőke, Larisza	Hungary, NPP Paks
Webb, Greg	IAEA/MTPI

Experts of Working Group 5 (Sub-group 5.3, Decommissioning) in charge of preparing the IAEA Comprehensive Report on TEPCO Fukushima Daiichi Accident:

Belencan, Helen	USA, Consultant
Mele, Irena	IAEA/NEFW
Negin, Chuck	USA, PEC

Issue Date: 4 December 2013

Executive Summary

Following the accident at TEPCO's Fukushima Daiichi Nuclear Power Station on 11 March 2011, the "Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1-4" (hereinafter referred to the "Roadmap") was adopted by the Government of Japan and the TEPCO Council on Mid-to-Long-Term Response for Decommissioning in December 2011. The Roadmap was revised in July 2012 and June 2013. The Roadmap includes a description of the main steps and activities to be implemented for the decommissioning of the Fukushima Daiichi NPS through the combined effort of the Government of Japan and TEPCO.

Within the framework of the IAEA Action Plan on Nuclear Safety, the Government of Japan invited the IAEA to conduct an independent peer review of the Roadmap with two main objectives:

- To improve the decommissioning planning and the implementation of pre-decommissioning activities at TEPCO's Fukushima Daiichi NPS; and
- To share the good practices and lessons learned by the review with the international community.

The review was organized in two steps. The first mission was conducted from15 to 22 April 2013 with the main purpose of undertaking an initial review of the Roadmap, including assessments of decommissioning strategy, planning and timing of decommissioning phases and a review of several specific short-term issues and recent challenges. The mission report is available on the IAEA webpage (http://www.iaea.org/newscenter/focus/fukushima/missionreport230513.pdf).

After the first mission, the Government of Japan and TEPCO took into consideration the advice given through the aforesaid mission report in the course of revising the Roadmap. The revised Roadmap, "Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1-4 revised 27 June 2013" is available on the Ministry for Economy, Trade and Industry (METI) website (http://www.meti.go.jp/english/press/2013/pdf/0627_01.pdf).

The objective of the second mission was a more detailed and holistic review of the revised Roadmap and mid-term challenges, including the review of specific topics agreed and defined in the first mission. These included the removal of spent fuel from storage pools, removal of fuel debris from the reactors, management of contaminated water, management and monitoring of marine water, management of radioactive waste, maintenance and enhancement of stability and reliability of structures, systems and components, and research and development relevant to pre-decommissioning and decommissioning activities.

The mission team involved 16 international experts. Additionally, three experts of the Working Group 5 (Subgroup 5.3, Decommissioning) in charge of preparing the IAEA Comprehensive Report on TEPCO Fukushima Daiichi Accident accompanied the Mission as observers, to obtain first-hand information for the comprehensive report.

The Government of Japan and TEPCO have provided comprehensive information on the decommissioning plan. The mission was conducted through the assessment of the information provided to the team, professional and open discussions with the relevant institutions in Japan, and a visit to TEPCO's Fukushima Daiichi NPS. The mission team also held consultations with the Nuclear Regulation Authority (NRA) to discuss issues concerning marine monitoring.

This preliminary summary report presents an overview of the main findings, acknowledgments and advisory points of the second mission. The final report will be provided to Japan by the end of January 2014.

Main Findings and Conclusions

The decommissioning of TEPCO's Fukushima Daiichi NPS is a very challenging task that requires the allocation of enormous resources, as well as the development and use of innovative technologies to deal with the most difficult activities. The team considers that Japan developed its efforts towards decommissioning the plant promptly after the accident, and since then, Japan has achieved good progress in improving its strategy and the associated plans, as well as in allocating the necessary resources towards the safe decommissioning of TEPCO's Fukushima Daiichi NPS.

Since the IAEA mission in April 2013, the Government of Japan and TEPCO have increasingly adopted a more proactive attitude and approach towards addressing the many difficulties at the site.

The team also notes that the current situation is very complex, and that there are still some very challenging issues (e.g. contaminated water management, nuclear fuel removal, and fuel debris removal) that must be resolved to ensure the long-term sustainability of the plant's stable condition. In light of these challenges, Japan appears to have adopted a well-oriented set of countermeasures.

Acknowledgements and Advisory Points

This report highlights 19 areas of important progress (acknowledgments) to date and offers 19 advisory points where the team felt that current practices could be improved.

1. Holistic review of the revised and updated Roadmap

(1) Revised and updated Roadmap

Acknowledgement 1:

The IAEA mission team acknowledges that the revised Roadmap was developed based on more-realistic assumptions, a reflection of the current knowledge of the condition of each specific unit, and the feedback and opinions from stakeholders. The advice provided by the first IAEA mission in April 2013 was also taken into account. Within the framework of this revised Roadmap, a more proactive organizational structure has been adopted to deal with the most relevant challenging issues, such as the contaminated water management or fuel removal. The revised Roadmap allocates a comprehensive structure of work to engage the national and international expertise and technical capabilities, such as establishing the International Research Institute for Nuclear Decommissioning (IRID), needed for a safe implementation and possible acceleration of the activities towards decommissioning of TEPCO's Fukushima Daiichi NPS.

Advisory point 1:

The IAEA mission team encourages the Government of Japan to continue its on-going leading and promoting of efforts towards the safe implementation of the decommissioning of TEPCO's Fukushima Daiichi NPS. In relation to this, the IAEA mission team recognizes the important role of the NRA in ensuring nuclear and radiation safety. In addition, the IAEA team encourages the regulator to continue its involvement in the oversight of the Implementation Plan activities.

(2) Public relations and communication

Acknowledgement 2:

TEPCO has become more proactive in implementing public information and communication activities. In particular, TEPCO has:

- established the Social Communication Office with communication and risk management experts under the TEPCO President's direct supervision, which is a good basis to enhance the needed competence and capability for timely disseminating accurate information, and
- created comprehensive criteria to define methods and timing of public releases describing the operation, incidents and problems at TEPCO's Fukushima Daiichi NPS, through consultations with the NRA, the Fukushima Prefecture, municipalities and local communities.

Advisory point 2:

Recognizing the efforts by the Government of Japan to communicate with a variety of local stakeholders, the team urges METI to move forward with establishing the Fukushima Advisory Board without delay so that it can begin engaging with stakeholders in a more appropriate manner. A clear definition about the role and competencies of the Board should be developed and agreed on before starting the work.

Advisory point 3:

TEPCO should consider revising its communication strategy by expanding its targeted stakeholders to include on-site staff and contractors. Interactive outreach efforts that are now used for public stakeholders could also be effective for engaging the worker community. As these workers are responsible for safely conducting all activities at the power plant, it is critical that they have a clear understanding of plant conditions and how their work contributes to the plant's recovery.

2. Review of mid-term challenges and specific issues

(1) Spent fuel removal and fuel debris removal

(a) Removal of spent fuel from storage pools and further management

Acknowledgement 3:

The IAEA team recognizes the substantial efforts made by TEPCO in transitioning the Unit 4 operating floor to a state in which the first fuel assemblies could be removed in November 2013, thus completing a major milestone one month ahead of the original plan. A number of good practices have been identified, including: the use of mock-ups in operator training; the introduction of licensed operators with annual renewal; detailed process flow charts; international peer review; and adoption of a post-operations review and continuous improvement process.

Acknowledgement 4:

The IAEA team recognizes that individual plans for the recovery of fuel from Units 1-3 have been developed and that the plans include hold points and contingency options. Additionally, the team

recognizes TEPCO's efforts to meet the milestones identified in these plans, in particular the completion of debris removal from the Unit 3operating floor to enable remote decontamination work to start.

Advisory point 4:

The IAEA team advises TEPCO to consider alternative options to support the on-going fuel storage operations in the Common Spent Fuel Pool and future fuel disposition. This includes: The management of non-irradiated fuel; Collection of data which needs to inform fuel integrity; To prevent cross contamination; The techniques for the removal of rubble from fuel assembly internals; The management of the different categories of spent fuel.

(b) Removal of fuel debris from the reactors and further management

Acknowledgement 5:

The IAEA team recognizes TEPCO's and IRID's efforts to develop remote technology to identify water leakage locations in primary containment vessels (PCVs) and the supporting development work on techniques for fixing these leaks. Applying these devices to identify leak locations can be a significant step towards isolating the PCVs.

(2) Management of Contaminated Water

Acknowledgement 6:

The IAEA team acknowledges the proactive steps taken by the Government of Japan to address the contaminated water issue, including the formulation of policies and the establishment of the Committee on Countermeasures of Contaminated Water Treatment. The team had an opportunity to meet with this Committee and exchange information and views on this topic.

(a) Treatment and storage of contaminated water

Acknowledgement 7:

The IAEA team acknowledges the continued successful use of the caesium removal system to treat contaminated water accumulated in the reactor and turbine buildings, with consistently high system availability and performance. This has made it possible to very efficiently remove caesium isotopes, the major gamma emitters in the contaminated water, thereby enabling the recycling of part of the treated water for cooling of the damaged reactor cores, and the storing of the remaining part in above-ground tanks.

Advisory point 5:

The IAEA team believes that it is necessary to find a sustainable solution to the problem of managing contaminated water at TEPCO's Fukushima Daiichi NPS. This would require considering all options, including the possible resumption of controlled discharges to the sea. TEPCO is advised to perform an assessment of the potential radiological impact to the population and the environment arising from the release of tritium and any other residual radionuclides to the sea in order to evaluate the radiological significance and to have a good scientific basis for taking decisions. It is clear that final decision making will require engaging all stakeholders, including TEPCO, the NRA, the National Government, Fukushima Prefecture Government, local communities and others.

Advisory point 6:

TEPCO's strategy for managing contaminated water stored on-site depends heavily on the consistent and high performance of the Advanced Liquid Processing System (ALPS). The mission team encourages TEPCO to continue, and even accelerate, its efforts to improve the performance and enhance the capacity of ALPS to be able to meet these goals as planned.

(b) Leakage issues including review of root cause analysis and countermeasures

Acknowledgement 8:

TEPCO has taken a more proactive role in identifying and permanently controlling leakages issues instead of a reactive role that has focused on the mitigation of consequences and the treatment of symptoms by provisional countermeasures.

Advisory point 7:

The IAEA team emphasizes the importance of establishing a thorough and structured impact review process. Such a process would identify the effects of the individual countermeasures, which have been taken to address on-site issues, on the overall Roadmap activities and schedule (or vice versa), and would help to ensure compliance with the Implementation Plan.

(3) Management of Radioactive Waste

(a) Management of secondary waste from treatment of contaminated water

Acknowledgement 9:

The on-going treatment of contaminated water is resulting in the generation of large volumes of secondary waste streams that have high levels of radioactivity. The IAEA team was informed that adequate facilities and arrangements are in place for safely storing these wastes on a temporary basis. Efforts are also being made by TEPCO and other Japanese organizations to characterize these wastes and develop options for their processing in preparation for future disposal.

(b) Management of solid waste

Acknowledgement 10:

The IAEA mission team acknowledges that TEPCO is on the way to optimise the classification and handling of the solid waste in order to minimise volumes by waste prevention and recycling of non- or low-contaminated waste.

Advisory point 8:

As radiological characterisation and waste classification are important for developing a waste management strategy, establishing an on-site or near-site facility for radiological characterisation of the waste should be accelerated. Based on a sound radiological characterisation of the waste, it will be possible to establish a useful waste classification scheme, which will enable TEPCO to further develop its strategy for the processing, storage and final disposal of the waste.

Advisory point 9:

As decommissioning activities progress, large amounts of waste will continue to be generated and may require on-site storage for a long period of time. Therefore, careful planning of storage facilities for the whole decommissioning period should be in place. Design life of waste storage facilities should take into consideration the expected long decommissioning period. Due to limited space at the site, appropriate measures for waste minimization and volume reduction should also be implemented.

(c) R&D to support waste management activities

Acknowledgement 11:

The IAEA mission team acknowledges further progress in developing and implementing a comprehensive research and development (R&D) programme to support the management of waste generated during the emergency phase and during pre-decommissioning and decommissioning activities at TEPCO's Fukushima Daiichi NPS site. A clearly demonstrated intention to take into account international experience and to benefit from international cooperation by involving the International Research Institute for Nuclear Decommissioning (IRID) has been recognized.

(4) Measures to stop or reduce ingress of ground water into reactor and turbine buildings

Acknowledgement 12:

TEPCO has provided a comprehensive and multi-barrier approach to control the flow into and out

of the reactor and turbine buildings. This multi-barrier approach to control groundwater flow appears to be underpinned by project planning, information and data gathering, trialling of the proposed methods, and peer review by the Contaminated Water Treatment Measures Committee. TEPCO has demonstrated good progress in beginning to address these issues in preparation for decommissioning. For example, there is a comprehensive plan for the feasibility, design and implementation of a frozen wall around the reactor buildings of Units 1-4. The lead technical role is handled by an expert task group with good planning of test activities that are to establish the feasibility and design parameters of the wall.

Advisory point 10:

The IAEA team encourages TEPCO to progress the implementation and careful monitoring of its measures to reduce the ingress of groundwater into reactor and turbine buildings and to prevent radioactive releases. In preparation for this, TEPCO should continue to evaluate and optimise the selected strategy for reducing water inflow into Units 1-4. The approach using the simultaneous operation of the proposed freeze wall, active sub-drain and water recharge -- in light of the limited space on site and the complex radiological environment -- should be carefully re-evaluated at each stage of the project as more data is collected.

Advisory point 11:

The IAEA team encourages TEPCO to continue to ensure that at the detailed planning stage, an evaluation is performed (as a series of 'what if' scenarios) of the resilience of the overall approach to controlling the flow into and out of the reactor and turbine buildings (and trenches). The IAEA team encourages TEPCO to consider the potential implications and possible mitigation measures arising from these scenarios. For example, such scenarios may include: the presence of higher-than-expected contamination levels observed in the groundwater removed from one or more of the sub-drains; the possibility of continued hydraulic connection between buildings at different elevations; and the incomplete effectiveness of an individual barrier.

(5) Marine monitoring and assessment of potential radiological impact

Acknowledgement 13:

A comprehensive "Sea Area Monitoring Plan" was established with a detailed description of sampling positions, including depth distribution, frequency of sampling, detection limit of the analysis to be performed, and indication of the responsible entity. The plan is kept flexible in space and time for reaction on special events when additional inputs to the marine environment can occur or would be expected. The Plan will ensure a comprehensive overview of the environmental situation in the marine environment and the data will provide sufficient background for dose assessments for radiation exposure from marine pathways.

The analytical centres visited by the IAEA team are accredited according to ISO 17025 and should therefore produce reliable, and thus comparable, data. The marine monitoring results are made public nationwide and internationally by means of information dissemination to international organizations and nuclear regulatory bodies, as well as via websites of the monitoring organizations in a prompt way.

Acknowledgement 14:

Wherever possible, a number of countermeasures were implemented in order to protect further contamination of the marine environment, such as isolating and removing the contamination sources and preventing leakages. Thus it can be stated that initial levels of concentrations in the sea area have dropped significantly since 2011 and are found near the plant outside the port to be around 1 Bq/L for Cs-137. The levels further off-shore between 2 and 20 kilometers away are now mostly below 0.1 Bq/L, and beyond this region, the levels are almost near those prior to the accident of 0.001–0.003 Bq/L for Cs-137. The decrease of activity concentration in seawater is also reflected in the levels in biota and seafood.

Advisory point 12:

Due to the fact that about 10 Japanese institutions are involved in marine monitoring, it is highly advised to perform interlaboratory comparisons to ensure the high quality of the data and to prove the comparability of the results. This can be done by splitting and sharing of samples or by a proficiency test (PT). The IAEA Environment laboratories would be pleased to organise such tests in collaboration with the responsible authorities in Japan.

International partners could be included in the analyses of samples collected by Japanese institutions in order to enhance the credibility of the data. The IAEA would be ready to recommend good laboratories to take part in this exercise based on the recently performed PT in relation to the determination of Cs-134, Cs-137 and Sr-90 in seawater. Other radionuclides, such as tritium, could also be included in these exercises.

Such activities could contribute to more confidence in the produced results and improve the credibility of the results produced by the involved institutions. It will also help to show higher transparency of the monitoring activities.

Advisory point 13:

Interpreting the data and presenting it to the public in an understandable, but scientifically correct, way is extremely important but not always simple. Just to show the concentration of radionuclides in the environment without interpretation is not sufficient to gain trust from the public. One possibility could be to refer these data to doses arising from natural radionuclides or to show the temporal trend since the accident. By this, the improvement of the general situation can be demonstrated.

The IAEA team encourages Japan to continue with public seminars or workshops as done in the past and get relevant stakeholders (in particular fishermen, consumers and market traders) involved in data interpretation.

Advisory point 14:

The IAEA team encourages relevant counterparts to consider installing underwater in-situ measurement detectors close to the Fukushima Daiichi site to measure continuously the concentration of gamma-emitting radionuclides in seawater. This would complement the monitoring strategy with separate sampling from ships and only in a limited time scale due to discontinuous sampling. Based on present concentration in the port and near to the port, the detectors will allow detecting Cs-137 in seawater continuously by gamma-spectrometry. This data could also be made available to the public by Internet. These systems would allow detecting any sudden increase of inflow from unknown sources, such as from contaminated groundwater. However, it needs to be

mentioned that structures must be found to install these systems properly and transmit the data and spectra. The systems also need to be cleaned from biological fouling growing on the containment. Underwater systems are commercially available in the meantime.

(6) Reviewing of the public radiation exposure in the surrounding areas from on-going activities at the site

Advisory point 15:

As advised in the April 2013 mission, the IAEA team reiterates that the Government of Japan and TEPCO should establish constructive discussions with relevant authorities and stakeholders, including the NRA and local authorities, to assess and balance the risks and benefits of the dose limit at the boundaries and its practical implementation, particularly from direct exposures at the site-boundary arising from contaminated solids and accumulated liquids on the site and for the possibility of controlled liquids discharges from the site. The discussions should include an assessment of the balance of off-site and on-site exposure risks, as well as the consideration of the parallel progress of the off-site remediation programme and the roadmap for on-site decommissioning and their mutual interaction. The discussion should also include the definition of representative members of the public to be considered in the assessments of individual doses in different areas, taking into consideration the real and evolving off-site situation.

Advisory point 16:

Providing that controlled water discharges to the sea could be necessary in the future to enhance the long-term sustainability of a stable situation on-site and to reduce risks of accidental leakages as well as exposure to workers, the IAEA team encourages TEPCO to prepare safety and environmental impact assessments of this possible practice based on the limit of 1 mSv/year for the population, and to submit it to the NRA for the necessary regulatory review. In addition, the IAEA team encourages the Government of Japan, TEPCO and NRA to hold constructive discussions with the relevant stakeholders on the implications of such authorized discharges, taking into account that they could involve tritiated water. Because tritium is practically not accumulated by marine biota and shows a very limited dose factor, it therefore has a very limited contribution to radiation exposure to individuals.

For this purpose, the IAEA is ready to offer further advice to Japan on the suitable methodology to conduct the safety and environmental impact assessments associated with controlled discharges, as well as assistance for training experts in the involved parties (namely TEPCO and the NRA).

(7) Specific decommissioning programmes and decommissioning planning

Acknowledgement 15:

The IAEA mission team acknowledges all the Japanese stakeholders for the tremendous work they are performing on Fukushima's activities towards decommissioning and particularly for the beginning reflections about what should be the end state of decommissioning process, even if it involves a several decades schedule.

(8) Preparation for licensing and regulatory requirements

Acknowledgement 16:

Authorization for the fuel removal from the spent fuel storage pool of Unit 4 to the Common Spent Fuel Pool was conducted in an efficient way between TEPCO and the NRA. Modifications to the initially submitted "Implementation Plan on Fuel Removal" were discussed and agreed in a timely manner, which enabled TEPCO to get the authorization to commence the activities with no delay. This is a good example to be followed in the future.

A thorough assessment of risks during the fuel removal operations at Unit 4 and identification of preventive and mitigation measures was performed and was included in the related "Implementation Plan on Fuel Removal". Such an evaluation of safety, and demonstration of the adequacy of the proposed safety measures, contributed to the efficiency of the interaction with the regulator and to the timely completion of the authorization process.

Advisory point 17:

The Roadmap introduces hold points prior to commencement of some of the activities. These hold points were introduced mainly due to the need to make technical decisions and to select and develop technical options for implementing activities. It is suggested that the licensing hold points should be integrated into the Roadmap or its implementing documents in order to include points of important regulatory decisions and to account for the time needed for regulatory reviews and approvals prior to commencement of certain activities or implementation phases.

In addition to its involvement in the review of the official submissions by TEPCO and in the inspections of activities, the NRA should be more actively involved during the planning and preparatory process and should be kept informed about the options considered for the future activities. This will help the NRA to plan its activities and resources more efficiently, and to better respond to public expectations.

(9)Technologies for remote decontamination, technologies for investigation of PCV/RPV interiors, etc.

Acknowledgement 17:

The team visited the remote-control room for operation of robotic equipment that is being used for clearing the rubble from the top floor of Unit 3. This is an excellent beginning for what will be ever-increasing needs for remotely operated equipment for many diverse future tasks. This real-time experience will provide valuable lessons for the expansion of capacity.

Acknowledgement 18:

Establishing a working group for developing remotely operated equipment has resulted in accelerating the time between identification of a specific need and delivery of individual remote technology equipment. For example, after the working group was established, the subsequent devices for leak location within the drywell have taken only 7 to 8 months. The participation of the plant representatives in the working group is a good practice that will contribute to success of development.

(10) Programme and processes to maintain and to enhance stability and reliability of structures, systems and components until decommissioning

Acknowledgement 19:

The IAEA mission team acknowledges the efforts that have been implemented by the focused reliability improvements, quality assurance, countermeasure project, contaminated water treatment organizations and the site personnel as a sign of the utility's progress toward taking a more anticipating role in identifying and controlling equipment issues instead of a reactive role that had "fought problems after they occurred". TEPCO has made proactive and diligent attempts and has demonstrated visible processes and efforts trying to identify areas of concern and measures to maintain and improve performance and reliability of SSCs, and minimizing risk.

Advisory point 18:

The IAEA mission team suggest that TEPCO revisit the assumptions, especially on service lifetimes and other technical specifications, of the SSCs placed as a prompt action immediately following the accident as well as to consider conservative lifetime assumptions in design of new SSCs.

Advisory point 19:

The IAEA mission team suggests that specific measures to control and to sample run-off storm water from each storage facility are taken to minimize the potential dispersing contamination through storm water. This suggestion is in line with good industry practices and with TEPCO's commitment for implementation of preventative measures.