

# Fukushima Daiichi Nuclear Power Plant Accident, Ten Years On

Progress, Lessons and Challenges



# The NEA Report

- Based on the contributions of many from across the world
  - Senior experts and leaders from around the world providing views to the drafting team
  - The NEA team of experts
  - Fellow consultants: Len Creswell, Randy Gauntt and Vic McCree
  - All under the guidance of NEA Director-General, William D. Magwood, IV
- Aimed at providing knowledge, understanding and opportunities principally to policymakers and leaders, but aid the general public and others
- To assist in providing clean energy and environment, and a healthy and safe society
- Third publication by the NEA on the accident
- May be viewed as the last such report by providing more comprehensive information on the effects of the accident and future perspectives
- Complements the work of other international and national organisations, including IAEA and WANO

# Areas covered in the Report

- The accident
- The aftermath - Status of decommissioning, remediation of surrounding areas and policy responses
- Safety and other lessons at international level
- Global impact of lessons
- Further challenges/opportunities
- Some perspectives and conclusions
- Suggestions for further actions

# The Accident

# The Great East Japan Earthquake 11/3/11

## Initiation of the Sequence of Events Leading to the Accident

- Magnitude 9 earthquake
- Subsequent tsunami had tremendous impact
- ~20 000 dead or missing
- Massive destruction
- Impaired infrastructure

# Nuclear power plants affected

Affected all nuclear plants on the east coast with greatest consequences at Fukushima Daiichi

# Fukushima Daiichi - Earthquake

- Units 1-3 automatically shutdown in response to the earthquake
- Units 4-6 were already in outage
- The 12 (of 13 – one in maintenance) available Emergency Diesel Generators all started up
- The earthquake caused the loss of all 6 off-site power lines

# Consequences of Tsunami site inundation

- Loss of all normal power
- Only 1 of 13 EDGs available – Reactor 5 & 6
- Ultimate heat sink lost
- Unprecedented devastation
- Impaired infrastructure – little hope of short- term help
- Long-term, developing scenario
- No AC power, little instrumentation, dark, access problems, 6 reactors etc, normal shift
- Attempts to use various means to provide cooling, operate valves, read instruments, etc



# Loss of cooling and containment – Hydrogen explosions, fuel melt, further site devastation



Reactor Building 1



Reactor Building 2



Reactor Building 3



Common ventilation stack of RB3 and RB4



Reactor Building 4

# The response and initial aftermath

- Heroic efforts on the site to try to deal with accident but off-site release of radioactivity
- Off-site emergency arrangements initiated
- As a result of earthquake, tsunami and nuclear accident around 150 000 people were evacuated
- Large area of land contaminated from deposition of radioactive releases
- Radiation from the accident not considered to have any direct impact on human health but evacuation reported to have resulted in early deaths
- Events impacted the well-being of people and communities
- All nuclear power reactors in Japan shut down
- Large amounts of contaminated water generated on the site

# Status of decommissioning and remediation

- Immense and complex task
- Japanese government put in place a flexible Mid-and Long-Term Roadmap
- Impressive progress both on and off the site, but more to do
- Very large amount of contaminated water treated, and arisings reduced
- Spent fuel retrieval from reactor buildings well in progress
- Plans for fuel debris retrieval advanced
- Safety and working conditions on site much enhanced
- Environmental remediation off-site progressed to allow wherever possible safe return of population
- Decontamination in Special Decontamination Area finished in March 2017 and planned work in Intensive Contamination Survey Area completed in March 2018

# Japan's policy responses

- Established a new strategic decommissioning body (NDF)
- Redesigned approach to nuclear regulation with new independent body – the Nuclear Regulation Authority (NRA)
- NRA quickly established new nuclear regulatory requirements, and is adopting new approaches including risk-informed oversight processes
- Adapted/supplemented legislation to enhance safety, emergency preparedness and the nuclear liability framework to better enable compensation

# International improvements and lessons learnt

- International institutions and nations working together - good understanding of the accident and implemented lessons to further improve safety
- Greatly facilitated by the openness, transparency and support of the Japanese government
- The report notes in particular the work of the IAEA, WHO, UNSCEAR, ICRP, WANO

# International improvements and lessons learnt

- NEA efforts have delivered:
  - cross-cutting research;
  - improved tools to support decommissioning;
  - greater understanding and quantification of plant safety margins;
  - potential improvements in such areas as accident tolerant fuels, more robust electrical power systems, complex waste characterisation/categorisation processes
- NEA has also focused on:
  - lessons for post accident recovery management including balanced decision making in radiological protection;
  - human aspects of nuclear safety including regulatory safety culture and stakeholder engagement

# Global impact

- Different impacts on nuclear power strategies in different countries
- Enhanced interest in new NPP technologies (e.g. SMRs, Advanced reactors)
- National/industry programmes to increasing resilience of the 3Cs (Cooling, Containment, Control) and avoiding cliff-edges
- Increased recognition of human & organisational factors
  - Earning public trust in nuclear policies
  - Robustness of nuclear safety institutional systems
  - National cultures and safety cultures
- Risk benefits and detriments in policy decisions
  - Holistic approaches to optimisation
  - Better balancing of risks in emergencies

# Further challenges (1)

- Technical challenges
  - Fuel debris removal
  - Decontamination methods, remediation, waste management
- Regulation
  - under uncertainty/unknowns
  - regulatory effectiveness in a post accident environment
- Rebuilding and revitalising communities and local economies
- Public and stakeholder engagement
- Optimised holistic decision making – wider than health benefits and detriments



## Further challenges (2)

- Institutional systems for ensuring nuclear safety – adopting a whole system approach
- Ethics for leaders and participants – earning trust through commitment to common ethical principles
- Intergenerational knowledge and experience – passing on the hard won lessons
- A global system of international organisations working together – building on the success of the response to the Fukushima Daiichi accident
- Legal preparedness – being better able to respond timely and effectively to needs for compensation

# Conclusions and perspectives (1)

- Japanese government and industrial organisations have responded well especially in:
  - Containing the accidents effects
  - Being open and transparent with information
- Decommissioning effort being pursued with vigour, in structured way focused on risk reduction with priority of safety of workers, public & environment
- Off-site remediation progressed well
- Need to rebuild and revitalise communities
- Globally lessons learnt with further enhancement of safety
- Lessons learnt in earning public trust
- Need enhanced system for managing unconventional radioactive wastes arising
- Technical understanding sufficient to give firm basis for nuclear safety into the future
- Opportunities for scientific knowledge on specific aspects as decommissioning advances

# Conclusions and perspectives (2)

- NDF made tremendous strides in effective public engagement
- Lessons on more effective approaches to stakeholder engagement in policy decisions processes, especially in recovery, and in off-site emergency planning decisions
- A more holistic approach to risk assessment in emergency preparedness, response and recovery required
- Building on its guiding principles, the NRA could enhance its effectiveness further by open and constructive dialogue with industry
- Damage compensation arrangements need to be prompt, and understood by all - the world could learn from Japanese experience
- Vital that hard-won knowledge and experience is captured in a knowledge management system to aid development of expertise and for future generations

# Recommendations (1)

- NRA to enhance further its open interaction with licensees while maintaining its independence and integrity
- Japan should adopt, and thereby lead all nuclear power countries, a system approach to institutional nuclear safety - covering the three pillars of industry, regulators and stakeholders, and interactions among them, noting the benefit of nuclear ethical principles
- Enhance participation in international efforts on decommissioning technologies in difficult radiological environments
- Intensify focus on securing disposal of radioactive waste and managing fuel debris
- Seek to continuously improve the arrangements for and the processing of compensation claims

## Recommendations (2)

- Seek to continuously improve the arrangements for and the processing of compensation claims
- Encourage multi-stakeholder engagement in policy decision making and risk communication on complex decommissioning matters
- Additional consideration be given on how to take into account in recovery decisions a wider range of impacts, including on the mental health and well-being of people
- Build on the opportunities afforded by the long term and complex nature of Fukushima Daiichi decommissioning to help economic redevelopment, including consideration of a local university based research centre and international conferences
- Pursue national and international knowledge management frameworks to preserve and make available the hard won lessons, knowledge and experience from the Fukushima Daiichi accident and the decommissioning