THE IAEA REPORT ON THE FUKUSHIMA DAIICHI ACCIDENT AND THE IAEA ACTION PLAN ON NUCLEAR SAFETY

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IACA International Atomic Energy Agency



- Background
- The IAEA Report on the Fukushima Daiichi accident
- The IAEA Action Plan on Nuclear Safety
- Observations and lessons
- The way forward



THE REPORT - KEY FACTS

GENERAL

- September 2012 announcement by DG Amano
- 3 years work
- September 2015 report released
- DG Report + 5 Technical Volumes
- What happened + why

REPORT BY THE DIRECTOR GENERAL

- Executive Summary + Summary Report
- ~200 pages drawn from Technical Volumes
- 45 key observations and lessons
- Most not new
- IAEA activities + CNS Review Meetings

5 TECHNICAL VOLUMES

- 5 Working Groups
- 180 Experts 40 Member States
- Geographical representation
- ~1000 Pages + Annexes
- 104 observations and lessons
- IAEA website

WORKING METHODS

- 6 rounds of 5 Working Group meetings
- Consultancy meetings
- Expert missions to Japan
- Bilateral meetings in Japan
- Information received from Japan
- Independent advice
- Safety standards extant in 2011

PARTICIPATION



Approximately 180 experts from over 40 Member States and various international organizations (including IAEA staff).

THE REPORT

- Report by the Director General
- Technical Volume 1
 Description and Context of the Accident
- Technical Volume 2 Safety Assessment
- Technical Volume 3
 Emergency Preparedness and Response
- Technical Volume 4
 Radiological Consequences
- Technical Volume 5





REPORT BY THE DIRECTOR GENERAL

• Executive Summary

Summary Report

- Key messages
- Observations and lessons

Uses safety standards in place <u>at the</u> <u>time</u> of the accident as a reference.





The Fukushima Daiichi Accident

Report by the Director General

WHAT HAPPENED

Description of the events presented in chronological order to highlight the integrated response to a multi-unit accident





Alternative measure

Perspective





SAFETY ASSESSMENT WHY IT HAPPENED

- Vulnerability to external events
- The defence in depth concept
- The fundamental safety functions
- Beyond design basis accidents and severe accident management
- Regulatory effectiveness
- Human and organizational factors
- Operating Experience



VULNERABILITY TO EXTERNAL EVENTS

FINDINGS

- No apparent damage to SSC's from earthquake
- Tsunami far exceeded design basis causing major damage
- External hazards not in line with international practice

- Appropriate conservatism to account for uncertainties
- Predictions that challenge current assumptions need prompt corrective actions
- Multi-unit and multi-site accidents need to be assessed
- Importance of national and/or international independent peer reviews needs to be emphasized



Section 1-1





THE FUNDAMENTAL SAFETY FUNCTIONS

FINDINGS

- Following the earthquake control of reactivity was fulfilled in all six units
- Removal of heat could not be maintained as the operators were deprived of almost all means of control over Units 1, 2 and 3
- The confinement function was lost as a result of the loss of AC and DC power

- Robust and reliable cooling needed to remove residual heat
- Need to ensure a reliable confinement function to prevent significant release of radioactive material to the environment
- Operators need to be trained to manage severe plant conditions



SEVERE ACCIDENT MANAGEMENT

FINDINGS

- Deterministic and probabilistic treatment was not in line with international best practices
- PSA results much lower than NPPs in other Member States
- Limited scope deterministic analyses led to weaknesses in accident management procedures

- Training in the use of emergency equipment under extreme environmental conditions insufficient to allow for its timely use
- Latest guidance from the BWROG not implemented and hampered operators response
- Regulatory bodies need to ensure that adequate accident management provisions are in place



REGULATORY EFFECTIVENESS

FINDINGS

- Complex regulatory system several different organizations
- Distribution of regulatory body decision making was unclear
- Some activities not in line with international best practices
- Inspection program was overly limited in scope and influence
- Periodic safety reviews lacked effective regulatory oversight

- Government coordination
- Clear lines of authority and decision making
- Regulatory independence, competence, strong legislative authority and adequate resources, including qualified personnel, are essential

HUMAN AND ORGANIZATIONAL FACTORS

FINDINGS

- Basic assumption that plants were safe
- All stakeholders shared and mutually reinforced this belief

- Individuals + organizations need to continuously question basic assumptions + implications for safety
- The need to be prepared for the unexpected
- Regulatory authorities should provide oversight and independent review of safety culture programs



EMERGENCY PREPAREDNESS AND RESPONSE

- Initial response in Japan to the accident
- Protecting emergency workers
- Protecting the public
- Transition from the emergency phase
- International response







INITIAL RESPONSE IN JAPAN TO THE ACCIDENT

FINDINGS

- Separate arrangements were in place to respond to nuclear emergencies and natural disasters at national and local levels
- The earthquake and tsunami and radiation levels made the onsite response extremely difficult

- Need to consider emergencies that could involve severe damage to nuclear fuel including those involving several units
- Need clearly defined roles and responsibilities for the operator and local and national authorities



PROTECTING EMERGENCY WORKERS

FINDINGS

- Legislation and guidance in Japan addressed measures for the protection of emergency workers but not in sufficient detail.
- No arrangements to integrate those emergency workers not designated prior to the accident

- Emergency workers need to be designated, assigned clearly specified duties, be trained and properly protected
- Arrangements to integrate those emergency workers not designated prior to the emergency, and helpers/volunteers
- Need to involve non-governmental organizations in establishing adequate emergency arrangements and provide training IAEA

PROTECTING THE PUBLIC

FINDINGS

- Criteria for protective actions not expressed in measurable quantities
- No predetermined criteria for relocation
- Evacuees relocated several times during the first 24 hours

- Decisions on urgent protective actions based on predefined plant conditions or monitoring results
- Protective actions need to do more good than harm
- Medical staff need to be trained in basic medical response to a nuclear emergency
- Arrangements for decision makers, the public and others to understand radiological health hazards in a nuclear emergency to make informed decisions on protective actions
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INTERNATIONAL RESPONSE

FINDINGS

- Assistance Convention was not invoked and RANET not used
- Different States recommended different protective actions for their nationals in Japan in response to the accident
- These differences were generally not well explained to the public and occasionally caused confusion and concern

- The implementation of international arrangements for notification and assistance needs to be strengthened by enhanced training and exercises
- There is a need to improve consultation and sharing of information among States on response actions.
- IAEA process of assessment and prognosis



RADIOLOGICAL CONSEQUENCES

- Radioactivity in the environment
- Protecting people against radiation exposure
- Radiation exposure
- Health effects
- Radiological consequences for non-human biota







RADIOACTIVITY IN THE ENVIRONMENT

FINDINGS

- Most of the atmospheric releases were blown eastward , depositing onto the Pacific Ocean.
- Releases and discharges directly into the sea
- 1311, 134Cs and 137Cs were found in drinking water, food and in drinking water, food and in doing 2011
 some non-edible items

OBSERVATIONS AND LESSONS

- Prompt quantification and characterization of releases is needed
- Comprehensive and coordinated programme of long term environmental monitoring is necessary
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Fukushima Daiichi NPP

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RADIATION EXPOSURE

FINDINGS

- The significant contributors to the exposure of the public were:
 - External exposure from the plume and the ground; and
 - Internal exposure from 1311, 134Cs and 137Cs
- Public doses comparable to levels of natural background
- 23 000 emergency workers, most below occupational dose limit
 - 174 exceeded the original dose criterion for emergency workers
 - 6 emergency workers exceeded the revised criterion

- Education and training in radiation protection should be continuous for all stakeholders and should be regularly updated
- Personal radiation monitoring invaluable for dose estimates
- A robust system is necessary for monitoring and recording occupational radiation doses



PUBLIC AND WORKER DOSES



Measured Dose

Estimated Dose





Occupational Dose

HEALTH EFFECTS

FINDINGS

- No early health effects were observed among workers or the public that could be attributed to the accident
- UNSCEAR "no discernible increased incidence of radiationrelated health effects are expected among exposed members of the public and their descendants"

- The risks of radiation exposure and attribution of health effects need to be clearly presented to stakeholders
- Need for radiological protection guidance to address the psychological consequences to members of the affected populations in the aftermath of radiological accidents
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POST-ACCIDENT RECOVERY

- Off-site remediation
- On-site stabilization and preparations for decommissioning
- Management of contaminated material and radioactive waste
- Community revitalization and stakeholder engagement







OFF-SITE REMEDIATION

000 000

FINDINGS

- Policies and strategies for post-accident remediation were not in place
- The remediation strategy focused on activities to reduce radiocaesium
- Two categories of contaminated areas were defined
 - Special Decontamination Area
 - Intensive Contamination Survey Area

- Strategies and measures for post-accident recovery need to be prepared in advance
- Further international guidance is needed on for postaccident recovery situations.



ON-SITE STABILIZATION AND PREPARATIONS FOR DECOMMISSIONING

FINDINGS

- A comprehensive, high level strategic plan for stabilization and decommissioning was developed
- Safety functions had been re-established and SSC's were in place to reliably maintain stable conditions
- Completion of decommissioning ~ 30–40 years

- A strategic plan for maintaining long term stable conditions and decommissioning of accident damaged facilities is essential
- Establishing and maintaining long term knowledge and technical expertise is essential for successful decommissioning.
- Decommissioning will take decades and arrangements for maintaining the necessary expertise are needed.



MANAGEMENT OF CONTAMINATED MATERIAL AND RADIOACTIVE WASTE

FINDINGS

- On-site decontamination and remediation efforts result in large quantities of contaminated material and of radioactive waste
- Several hundred temporary storage facilities had been established in local communities

- Strategies for post-accident recovery need generic strategies for managing contaminated liquid and solid material and radioactive waste
- Generic safety assessments for discharge, storage and disposal



COMMUNITY REVITALIZATION AND STAKEHOLDER ENGAGEMENT

FINDINGS

- Evacuation and relocation measures and restrictions on food involved hardships for the people affected.
- The revitalization and reconstruction projects were developed from understanding the socioeconomic consequences of the accident.

- Need to recognize the socioeconomic consequences of an accident and the protective actions to develop revitalization and reconstruction projects
- Support by stakeholders is essential for all aspects of post-accident recovery



THE IAEA ACTION PLAN ON NUCLEAR SAFETY

KEY FACTS

- 12 key actions, 39 sub-actions
- Unanimously adopted in September 2011
- EBP funded projects:
 - 52 from Japan
 - 10 from USA
 - 7 from Russia

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- Over 900 activities completed
- ~ 40 Million euro since September 2011

TRANSPARENCY

- Mission calendar of peer reviews
- International experts missions reports
- International Experts Meetings reports







NUCLEAR SAFETY ACTION PLAN AREAS OF WORK













Safety Assessments

IAEA Peer Reviews

Emergency Preparedness and Response

National Regulatory Bodies

Operating Organizations

IAEA Safety Standards



International Legal Framework



Member States Embarking on Nuclear Power



Capacity Building



Protection from Ionizing Radiation



Communication



Research & Development



CAPACITY BUILDING

ACTION : Strengthen and maintain capacity building

 Member States with nuclear power programmesto strengthen, develop, maintain and implement their capacity building programs.....to continuously ensure sufficient and competent human resources necessary to assume their responsibility for safe, responsible and sustainable use of nuclear technologies

• The IAEA to assist as requested.

 Such programmes to cover safe operation, emergency preparedness and response and regulatory effectiveness and to build upon existing capacity building infrastructures.





IAEA REPORTS - LESSONS LEARNED

IAEA Report on **IAEA Report on IAEA Report on** IAEA Report on **IAEA Report on IAEA Report on** Enhancing Transparency and **Reactor and Spent Fuel Safety Protection against Extreme Decommissioning and** Preparedness and Response Strengthening Nuclear Regulatory in the Light of the Accident Communication Effectiveness Remediation after a Earthquakes and Tsunamis in the for a Nuclear or Radiological Effectiveness in the Light of the in the Event of a Nuclear or **Nuclear Accident** at the Fukushima Dailchi Light of the Accident Accident at the Fukushima Daiichi Emergency in the Light of the Nuclear Power Plant **Radiological Emergency** at the Fukushima Dalichi **Nuclear Power Plant** Accident at the Fukushima Daiichi Nuclear Power Plant Nuclear Power Plant International Experts Meeting 19–22 March 2012, Vienna, Austri International Experts Meeting 18-23 June 2012, Vienna, Austria International Experts Meeting 28 January–1 February 2013, Vienna, Austria International Experts Meeting A-7 September 2012, Vienna, Austria () IAEA (A) IAEA () IAEA (A) IAEA (A) IAEA () IAEA **Protection Against Preparedness and** Decommissioning **Transparency & Strengthening Nuclear Reactor and Spent** External Events Response and Remediation **Regular Effectiveness** Communication **Fuel Safety** 2013 2012 2013 2013 2012 2012 IAEA Report on IAEA Report on **IAEA Report on IAEA Report on** IAEA Report on **IAEA Report on** Human and Organizational **Radiation Protection after the** Assessment and Prognosis **Capacity Building for** Severe Accident Management Strengthening Research and Factors in Nuclear Safety in Fukushima Daiichi Accident: in the Light of the Accident at the Development Effectiveness in in Response to a Nuclear or **Nuclear Safety** the Light of the Accident at the Promoting Confidence and Radiological Emergency Fukushima Daiichi Nuclear the Light of the Accident at the Fukushima Dalichi Nuclear Understanding **Power Plant** Fukushima Daiichi Nuclear **Power Plant** Power Plant International Experts Meeting 21-24 May 2013, Vienna, Austria International Experts Meeting 17-21 February 2014, Vienna, Austria International Experts Meeting 12–70 March 2014, Vienna, Austria International Experts Meeting 16–20 February 2015, Vienna, Austria International Experts Meeting 20-24 April 2015, Vienna, Austri (A) IAEA (IAEA () IAEA () IAEA ()IAEA (A)IAEA Radiation Human & Organizational Severe accident Research & Assessment & Capacity protection Development management Prognosis Building AEA 2014 2015 2015 2015 2015

CAPACITY BUILDING REPORT LESSONS LEARNED

INSIGHTS FROM

- The 2014 conference on Human resource Development
- The IAEA peer review services
 - The Education and Training Review Service (ETReS)
 - The Integrated Regulatory Review Service (IRRS)
 - The Operational Safety Review Team (OSART) programme
 - The emergency preparedness review (EPREV)
- Other IEM reports

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- Decommissioning
- Human Factors
- Radiation Protection
- Severe Accident Management
- Emergency Preparedness



International Conference on Human Resource Development for Nuclear Power Programmes: Building and Sustaining Capacity

Strategies for Education and Training, Networking and Knowledge Management



IAEA Report on Capacity Building for

Nuclear Safety

LESSONS LEARNED

- Capacity building needs to be supported by governments through a national strategy to ensure that all stakeholders are involved
- Increased emphasis needs to be placed on medium and long term planning of capacity building and human resource development
- An integrated national HRD plan to be developed and updated.
- R&D activities can be used to identify the needs for capacity building activities at the national, regional or international levels.



LESSONS LEARNED

- All Member States would benefit from a programme of capacity building in radiation protection.
- Importance of human and organizational factors for nuclear training nuclear plant operators
- Need better understand of the systemic approach to safety to ensure proper training for dealing with an unexpected nuclear or radiological event.
- IAEA Peer review services are an important mechanism for exchanging information and experience at the organizational and national levels



IAEA ACTIVITIES TO SUPPORT MEMBER STATES CAPACITY BUILDING

- Strategic Approach to Education and Training in Nuclear Safety (2013-2020)
- Safety Education and Training Peer Review Service (ETPRES)
- Cyber Learning Platform (CLP4NET)
- New version of the Education & Training Catalogue
- Self-assessment methodology for capacity building activities in Member States
- Global Nuclear Safety and Security Network Strategic Plan was published in 2014 aimed at supporting capacity building activities
- GNSSN promotes knowledge safety networks and sharing lessons learned
- Publications
 - Methodology for the Systematic Assessment of the Regulatory Competence Needs (SARCoN) for Regulatory Bodies of Nuclear Installations (IAEA TECDOC 1757; 2015)
 - The IAEA Report on Capacity Building for Nuclear Safety (2015)
 - Regulatory Control of Nuclear Power Plants



IAEA FUTURE ACTIVITIES IN CAPACITY BUILDING

- Respond to requests from Member States for assistance in self-assessments for capacity building programmes, including human resources, education and training, knowledge management and networks.
- Encourage Member States to share their measures to develop, maintain and strengthen cooperation for capacity building at the regional and international levels.
- Respond to requests from Member States for assistance in identifying and implementing necessary improvements in their capacity building programmes in the areas of
 - Regulatory frameworks,
 - Operating organizations and
 - National nuclear power infrastructure, with a view to incorporating lessons learned from the Fukushima Daiichi accident.



THE WAY FORWARD

MEMBER STATES RESPONSE

- Board of Governors + 2015 General Conference
- Wide support for the Action Plan activities the publication of the IAEA Fukushima Report

"Important to follow up to ensure the Action Plan and IAEA Report contribute to a continuous improvement in nuclear safety worldwide"

"It is essential that the IAEA ensure that the momentum to improve global nuclear safety is improved and further increased building on the Fukushima report"





IAEA GENERAL CONFERENCE 2015

Resolution GC(59)/RES/9 September 2015

- Welcomes the publication of the IAEA Report on the Fukushima Daiichi accident, consisting of the Director General's Report and five technical volumes
- Requests the Secretariat, in close consultation with Member States, to integrate actions arising from the Observations and Lessons in the Report into the Agency's regular programme;
- Requests the Secretariat to continue follow-up on the projects/activities arising from the Action Plan and to build upon the findings, lessons learned, and measures implemented from the Fukushima Daiichi accident;
- Requests the Agency to continue to build upon:
 - the Action Plan on Nuclear Safety,
 - the experience of States in implementing the Action Plan,
 - the observations and lessons contained in the IAEA Fukushima Report and
 - the principles of the Vienna Declaration,

and use them for defining its nuclear safety strategy and its programme of work.



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IMPLEMENTATION

- The Agency is developing an implementation plan to facilitate the transition of the relevant activities into its regular work programme
- The aim of the implementation plan is to establish the framework for the work of the relevant Departments and Divisions of the Agency for the coming years

"I believe that this IAEA report will provide a solid knowledge base for the future and will help to improve nuclear safety throughout the world. I hope that governments, regulators and nuclear power plant operators in all countries will continue to act on the lessons learned from the Fukushima Daiichi accident." Director General Amano September 2015





DIRECTOR GENERA

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