Overview of PRA Methodology Development and RIDM in Japan

Nuclear Risk Research Center
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CRIEPI Central Research Institute of Electric Power Industry

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Overview of Nuclear Risk Research Center (NRRC)

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NRRC Background

Fukushima Daiichi Accident Lessons

- Lack of recognition and mechanisms for proactively addressing nuclear risks
- Insufficient preparedness for massive earthquakes, tsunami, and other low-frequency, high-consequence events

Recognition and mechanisms needed for squarely facing risks and pursuing safety beyond just regulatory compliance

Utilities' Enhancement of Risk Management

- Establish Internal Framework
- Enhance Risk Assessment (PRA Utilization)
- Actively Promote Utilization of Risk & Other Information

Company Publications "RIDM Action Plan"[1] in Feb. 2018

Utilities' Continuing Efforts

Plan Updated in Jun. 2020 [2]
Plan Updated in Dec. 2023 [3]

Reduction of Low-Frequency Event Risks

- Resolve Technical Challenges
- Effectively Combine Deterministic and Probabilistic Approaches
- Establish Integrated R&D Framework

→ Promote Practical Implementation, Feedback, etc.

NRRC established at CRIEPI (Oct. 2014)

Jul. 2016 RIDM Promotion Team established

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NRRC: Vision, Mission & Organization

【Vision】
To become an international center of excellence in PRA methodology and risk management method, thereby gaining the trust of all the stakeholders.

【Mission】
To assist nuclear operators and the nuclear industry in their continuous effort to improve the safety of nuclear facilities, that is, to manage the relevant risks, by developing and employing modern methods of Probabilistic Risk Assessment (PRA), risk-informed decision making and risk communication.

<External Advisory Framework>

Executive Advisor
Dr. R. A. Meserve



Technical Advisory Committee
(Chair: Mr. John W. Stetkar)

<Internal Organization Structure>

Director
Dr. G. Apostolakis



Planning and Administrative Team (21 members)

RIDM Promotion Team (10 members)

Risk Assessment Research Team (34 members)

External Natural Hazard Research Team (58 members)

<Conference Framework>
(Including utilities)

CEO Dialogue

CEO = Chief Executive Officer

CNO Conference

CNO = Chief Nuclear Officer

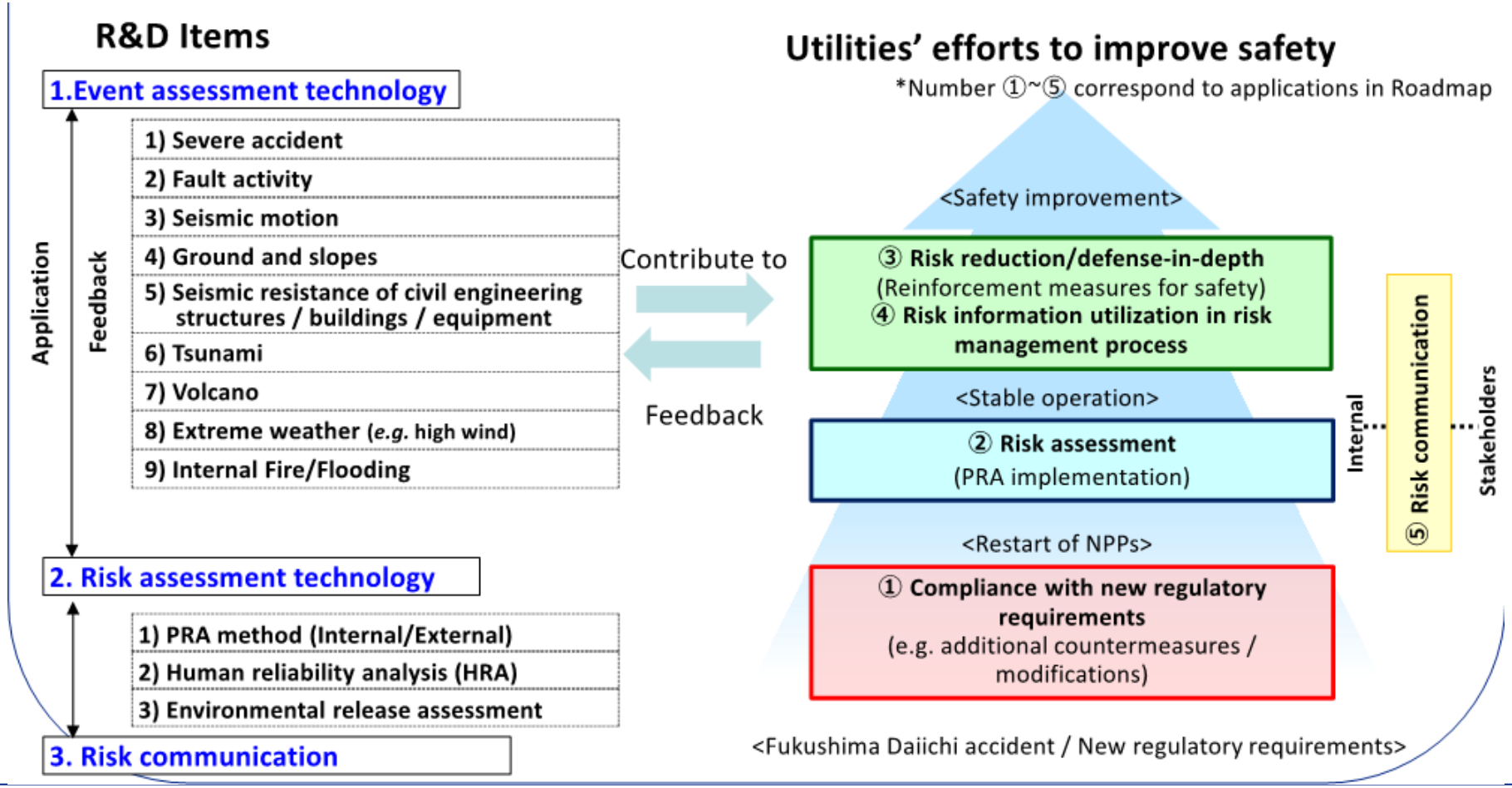
Technical Conference
・Working Groupe 1 (Risk Assessment Field)
・ Working Groupe 2 (External Natural Event Field)

As of July 1, 2026

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NRRC Risk Research & Development Supporting Utilities' Safety Management

- Since its establishment in 2014, NRRC has advanced the development of state-of-the-art methodologies for PRA, RIDM, and risk communication to support efforts by utilities and the industry to pursue the safety of nuclear facilities.



Overview of PRA Technical Foundation in Japan

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What Is PRA?

■What is Risk? – Provide Answers to the Following Three Questions

1. **What can go wrong?** ･･･Scenario
2. **How likely is it?** ･･･Likelihood
3. **What are the consequences?** ･･･Consequences

Risk assessment is the process of identifying combinations of answers to these three questions (risk triplet).

■Nuclear Power Plant PRA (Probabilistic Risk Assessment)

Methodology that comprehensively identifies and evaluates accident scenarios in which the mitigation functions designed to prevent events that could have significant consequences for the public and the environment fail following an event that disrupts the stable operation of a nuclear reactor, as well as the likelihood (frequency) of such scenarios. These mitigation functions include: (1) shutting down the nuclear fission reaction, (2) cooling the reactor core, and (3) confining radioactive materials

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PRA Levels (Level 1–3)

- PRA is divided into three assessment levels: Level 1 (core damage), Level 1.5 (containment failure), Level 2 (containment failure & radioactive release), and Level 3 (off-site consequences including public exposure and environmental impact).

◆ PRA Levels

- Level 1 PRA :

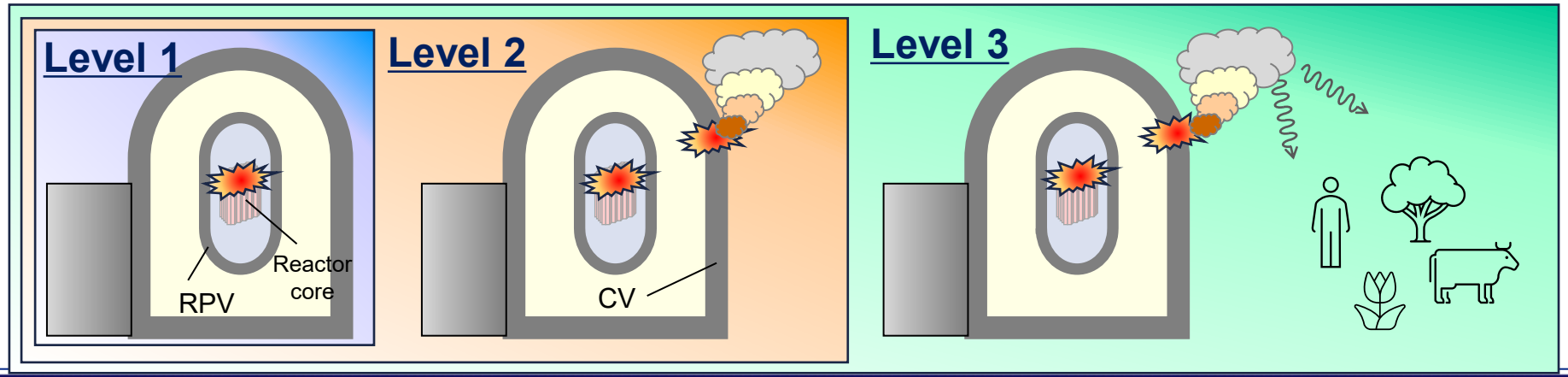
  Identify accident sequences leading to core damage and evaluate their frequencies.

- Level 2 PRA :

  Identify accident sequences leading to containment failure and evaluate their frequencies. ⇒ Level 1.5 PRA
  Assess the characteristics of radioactive material releases to the environment, including the magnitude of releases from fuel.

- Level 3 PRA :

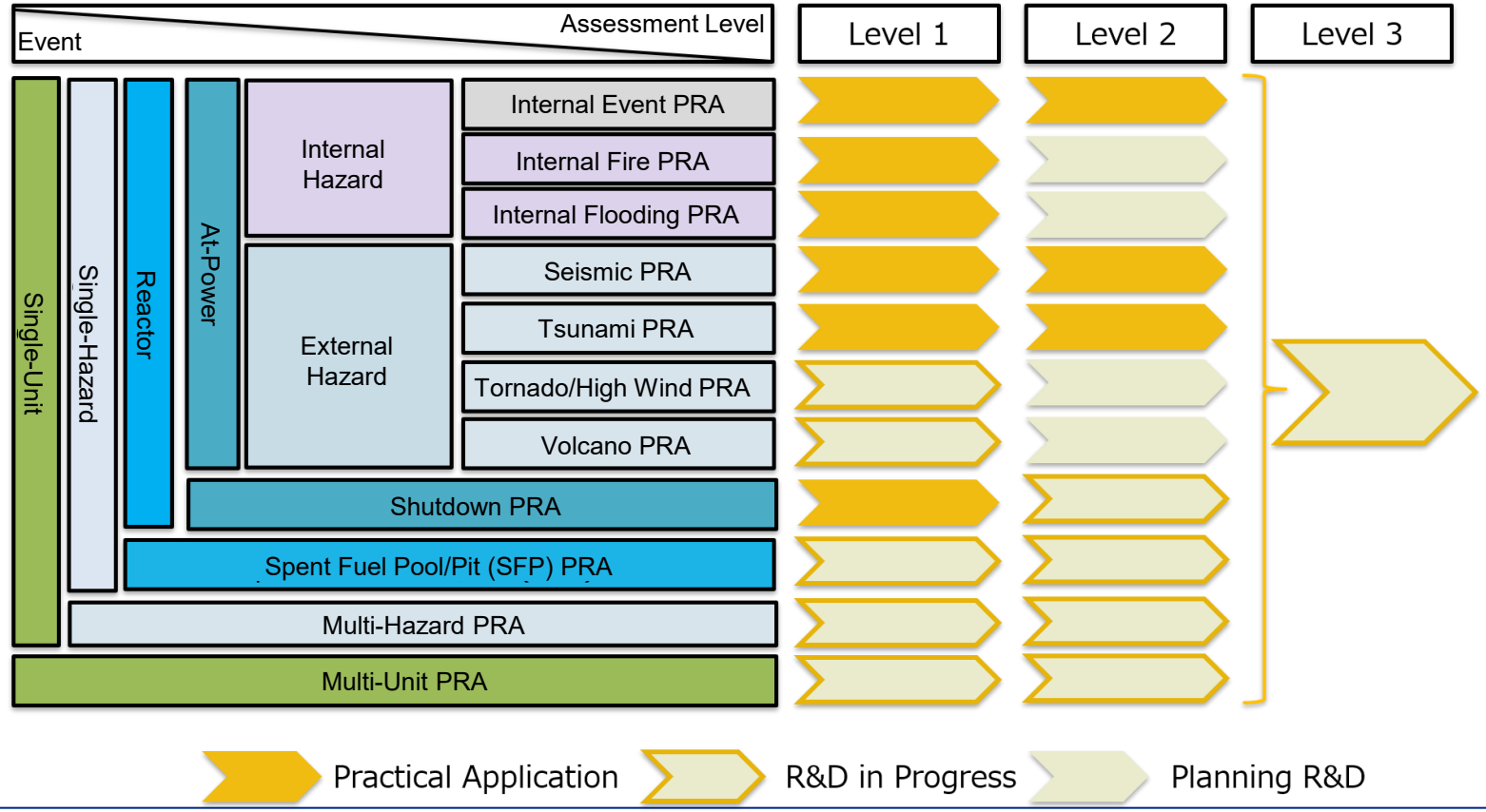
  Assess the impact on public health resulting from transport and dispersion of radioactive materials released into the environment.



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Status of NRRC's Development of PRA Technology

- NRRC has researched and developed PRA technologies applicable to a broad range of single-hazards posing risks to nuclear reactors. In addition, it has advanced the development of technologies for spent fuel pool/pit (SFP) PRA, multi-hazard PRA addressing combined effects of multiple hazards, and multi-unit PRA for sites with multiple nuclear power station units.
- NRRC has strived to develop PRA methodologies whose priority and detail are commensurate with hazard impacts on plants.



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Status of Japanese Utilities' Development of PRA Models

- Utilities have implemented PRA models for Level 1 and Level 2 at-power internal event, seismic, and tsunami PRAs during power operation as well as Level 1 shutdown internal event PRA for plants that have submitted Safety Analysis Reports (SARs) following restart. Utilities continue to enhance these models as appropriate, taking into account plant-specific risk profiles and other relevant factors.
- Utilities are currently developing PRA models for internal fire and internal flooding events. Kansai Electric Power published its evaluation results for Level 1 Internal Flooding PRA in May 2026 as part of the SAR for Takahama Nuclear Power Station Units 3 & 4.
- NRRC is currently developing methodologies for High Wind/Tornado PRA and Volcano PRA.

At-Power PRA			Level 1	Level 1.5	Level 2	Level 3
Internal Event PRA			**Implemented**	**Implemented**	**Implemented**	Not Implemented
External Events	Internal Hazards	Internal Fire PRA	Not Implemented	Not Implemented	Not Implemented	
		Internal Flooding PRA	**Implemented (Takahama 3 & 4 only)**	Not Implemented	Not Implemented	
	External Hazards	Seismic PRA	**Implemented**	**Implemented**	**Implemented**	
		Tsunami PRA	**Implemented**	**Implemented**	**Implemented**	
		High Wind/Tornado PRA	Not Implemented	Not Implemented	Not Implemented	
		Volcano PRA	Not Implemented	Not Implemented	Not Implemented	

Note: In this table, "Implemented" indicates that the evaluation results have been presented in SARs.

Level 1 Shutdown Internal Event PRA is implemented.
SFP PRA、Multi-Hazard PRA、and Multi-Unit PRA are not implemented.

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Overview of RIDM in Japan

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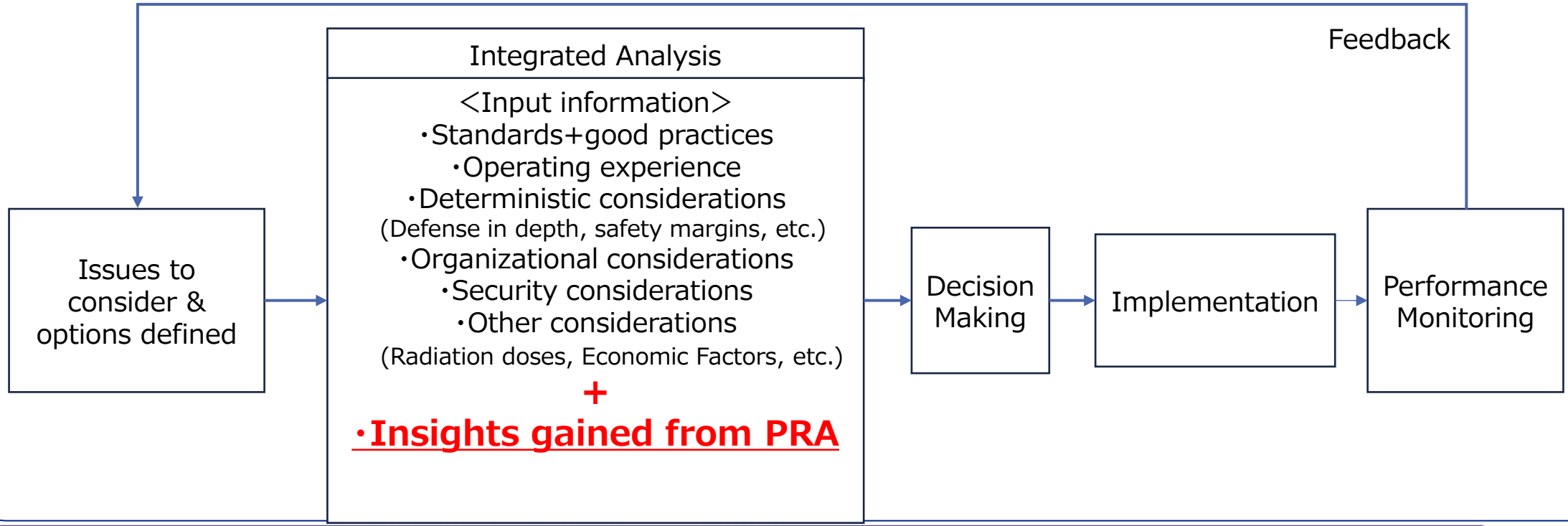
What Is RIDM?

■ **RIDM: Risk-Informed Decision-Making**

Approach to decision-making that integrates insights gained from PRA with those derived from conventional deterministic analyses. RIDM enables organizations to focus on safety-significant issues, thereby promoting more effective and appropriate safety management.

■ **Key Benefits of Utilizing PRA Insights**

- ✓ Comprehensively and realistically identifying how accidents may progress allows PRA to reveal plant vulnerabilities.
- ✓ Quantitative results enable effective prioritization of resources and safety improvements.



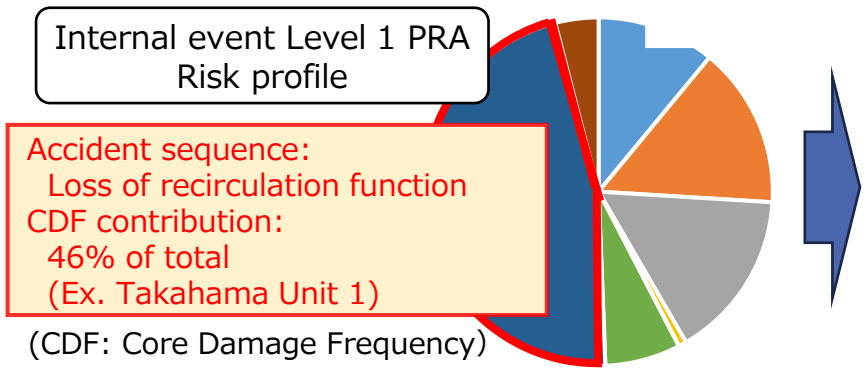
Status of Utilities' RIDM Initiatives

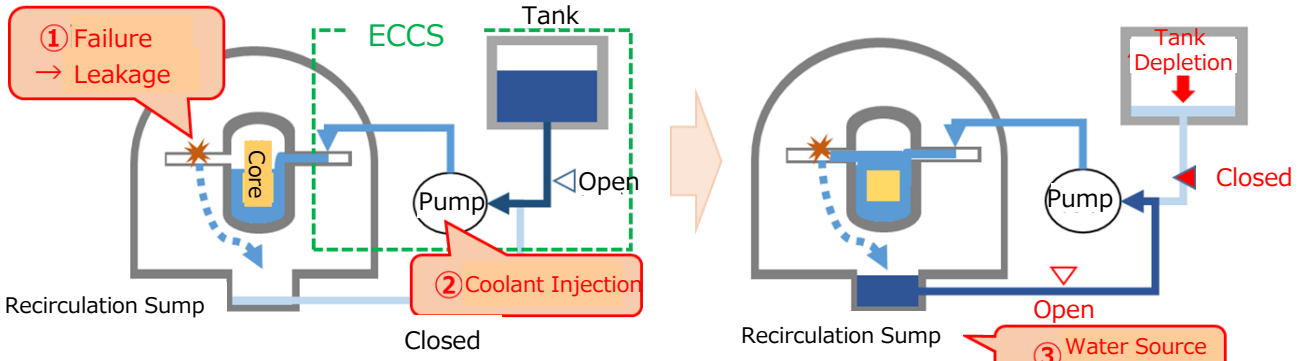
- Utilities established the RIDM Action Plan[1] in February 2018 and revised it two times since in June 2020 [2] and December 2023 [3]. Based on this Action Plan, they have promoted RIDM implementation across a wide range of nuclear power plant operational processes, including work management, plant modification, maintenance management, operations, safety assessments, corrective actions, and education & training.

Example of Kansai Electric Power's Initiative (SARs)

- Based on risk profiles identified through PRA, measures were evaluated to reduce risks associated with high-significance accident sequences.
- Risk reduction has been achieved by automating ECCS water-source switchover to recirculation during LOCA. Measures were implemented after a comprehensive evaluation that also considered benefits of reducing operator workload.

・Takahama 3, 4 and Ohi 3, 4 ⇒ **Automatic operation**
・Mihama 3, Takahama 1, 2 ⇒ **Manual operation ⇒ Identified automated recirculation switchover operation as a risk reduction measure**

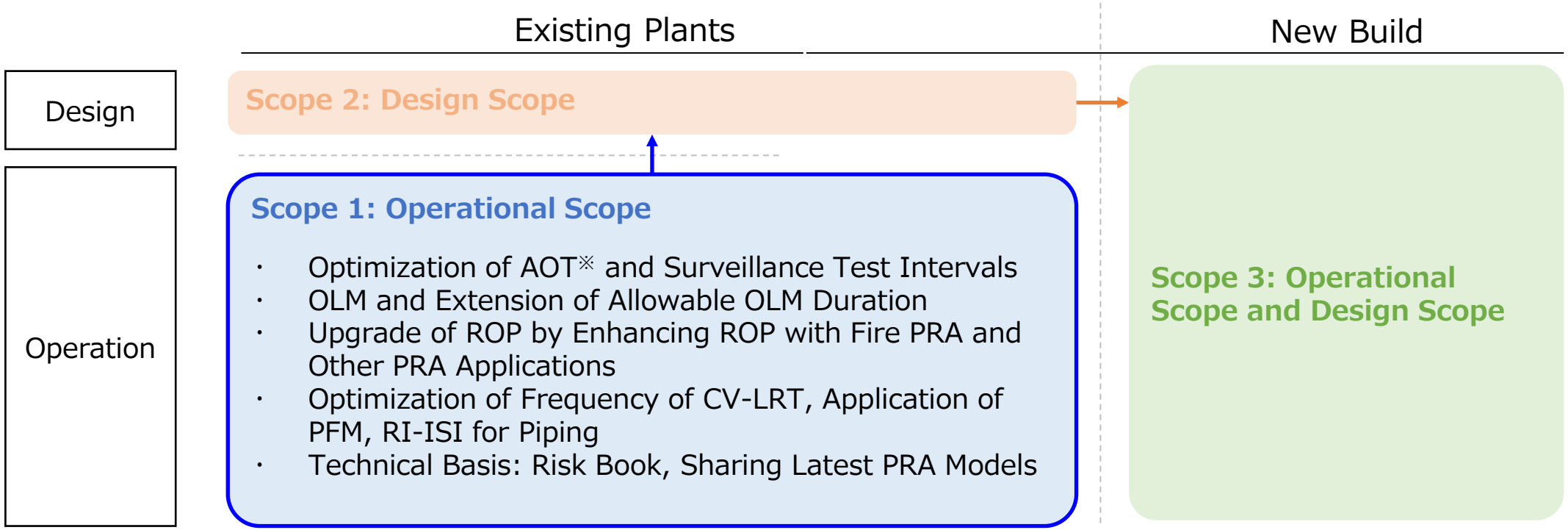




(Partially revised based on "Second Technical Exchange Meeting with Utilities on Risk-Informed Decision-Making: Document 3 (ATENA) [4]")

Status of Open Discussions on RIDM Between NRA and Utilities

- The nuclear industry proposed establishing meetings to exchange views on the use of risk information and this was endorsed by the NRA. With the aim of enhancing on-site plant operations and promptly translating the outcomes into safety improvements, discussions have initially focused on the operational scope of existing plants.
- NRA has approved implementation of OLM by utilities following on-site trials conducted at operating nuclear power plants (Shikoku Electric Power's Ikata Nuclear Power Station and Kansai Electric Power's Ohi Nuclear Power Station), and the necessary procedures are currently underway.



※AOT (Allowed Outage Time): Time allowed to complete required actions specified in the Technical Specifications following failure to meet the Limiting Condition for Operation (LCO).

(Diagram adapted from ATENA presentation material at 3rd Working-Level Open Discussion Meeting[5])

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NRRC Guides for PRA and RIDM

- NRRC has compiled results of its PRA and RIDM research into guides and technical reports, which are provided to utilities.

Published NRRC Guides for PRA and RIDM

Area		NRRC Guide (Abbreviations)
PRA	General	PRA Peer Review Guide[6]
	Internal Events, etc.	Equipment Reliability Data Collection Guide[7]
		Human Reliability Analysis Guide[8]
	Internal Flooding	Internal Flooding PRA Guide[9]
	Internal Fire	Internal Fire PRA Guide[10]
RIDM		OLM Guide[11]
		CV-LRT Interval Extension Guide[12]

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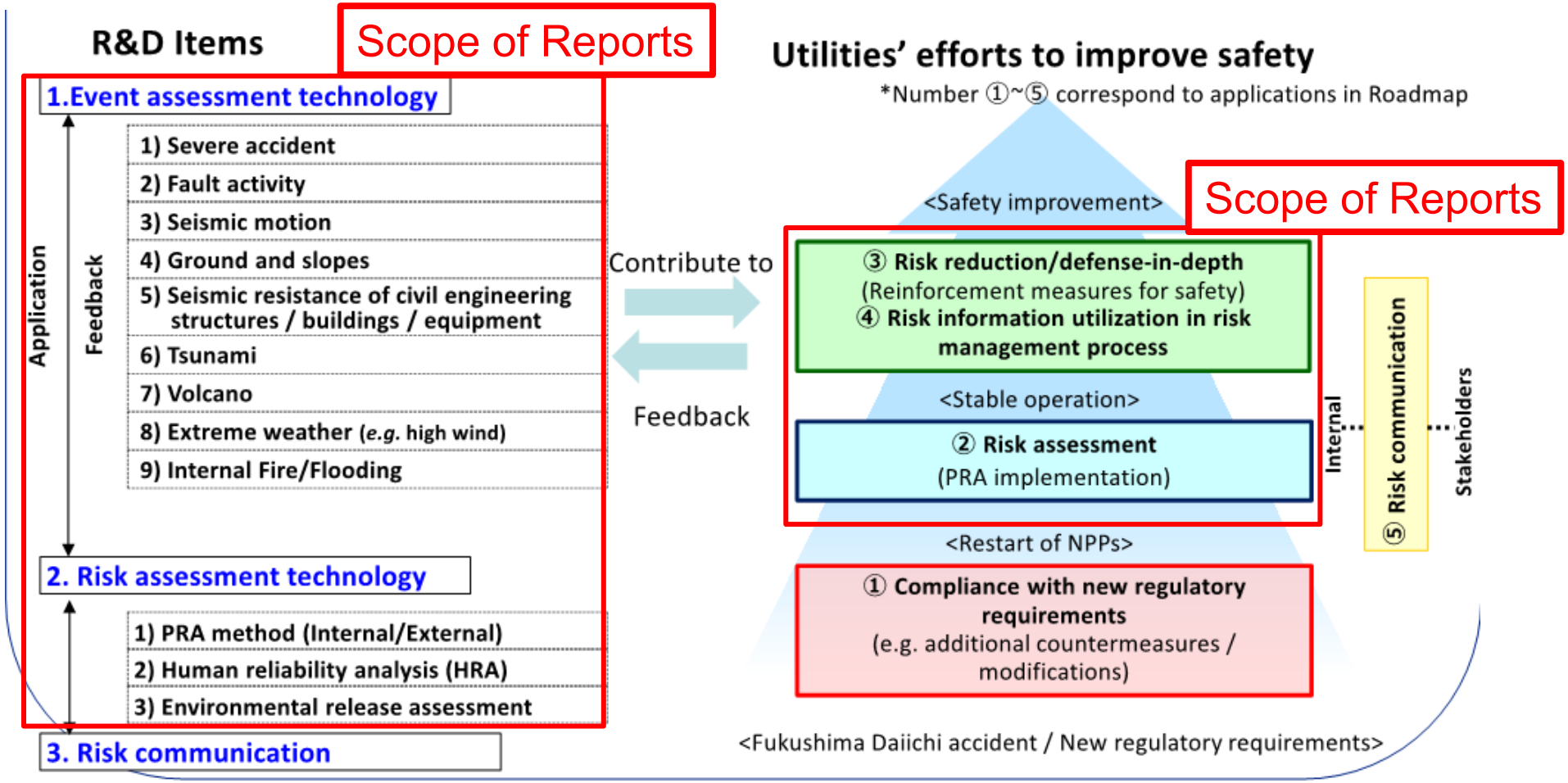
Symposium Reports

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Symposium Reports (1/2)

- Reports to be presented on present stage of achievement and future R&D on PRA technologies and risk-informed applications.



Symposium Reports (2/2)

- Symposium reports to be divided into two parts: “Present stage of achievement” and “Future R&D.”
- For “Present stage of achievement,” presentations will cover areas evaluated by utilities in their SARs (internal events, seismic events, tsunami, and Level 2) and areas for which NRRC has developed methodologies (internal fire and flooding). NRRC efforts to promote the use of risk information will also be included.
- For “Future R&D,” presentations will focus on areas where methodologies have yet to be developed.

■ Present Stage of Achievement
- ➢ Support Improving the Quality of Internal Event PRA Models
- ➢ Seismic PRA Methodology Development and Plant Applications
- ➢ Tsunami PRA Methodology Development and Plant Applications
- ➢ Internal Fire PRA Methodology and Internal Flooding PRA Methodology Development and Plant Applications
- ➢ Level 2 PRA Methodology Development and Plant Applications
- ➢ Development and Utilization of RIDM Guide

■ Future Development
- ➢ Development of Tornado PRA Methodology and Volcano PRA Methodology
- ➢ Development of Methodologies for Full-Scope PRA

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References and Sources

[1] Strategic and Action Plans for the Establishment of a Risk-Informed Decision-Making Process at Nuclear Power Plants (https://criepi.denken.or.jp/jp/nrrc/event/pdf/2018_source.pdf)

[2] Strategic and Action Plans for the Establishment of a Risk-Informed Decision-Making Process at Nuclear Power Plants (updated in 2020) (https://www.fepc.or.jp/pr/news/oshirase/__icsFiles/afieldfile/2020/06/19/press_20200619_b.pdf)

[3] Strategic and Action Plans for the Establishment of a Risk-Informed Decision-Making Process at Nuclear Power Plants (updated in 2023) (https://www.fepc.or.jp/pr/news/oshirase/__icsFiles/afieldfile/2023/12/14/press_20231214_3.pdf)

[4] Second Technical Exchange Meeting with Utilities on Risk-Informed Decision-Making: Document 3 Utilities' Initiatives to Advance PRA and Use Risk Information (Atomic Energy Association) (https://www.da.nra.go.jp/view/NRA100011770?contents=NRA100011770-002-009#pdf=NRA100011770-002-009)

[5] Third Technical Exchange Meeting with Utilities on Risk-Informed Decision-Making: Document 3 – Approach to Discussions on Risk-Informed Applications (Atomic Energy Association) (https://www.da.nra.go.jp/view/NRA100013139?contents=NRA100013139-002-005#pdf=NRA100013139-002-005)

[6] CRIEPI Report NR25001 "PRA Peer Review Guide"

[7] CRIEPI Report NR22006 "Component reliability data collection guide for probabilistic risk assessment"

[8] CRIEPI Report O18011 "The Human Reliability Analysis (HRA) guide with emphasis on the narrative (2018) -Development of qualitative analysis methods and analysis models for tasks on extreme conditions-"／ CRIEPI Report O20003 "Guide for Qualitative Analysis in the Human Reliability Analysis (HRA) with Emphasis on Narratives (FY 2020 Edition)"／ CRIEPI Report NR23005 "Guide for Qualitative Analysis in The Human Reliability Analysis (HRA) with Emphasis on Narratives (FY 2023 Edition)"

[9] CRIEPI Report NR25002 "Development of the Internal Flooding PRA Guide for Japanese Nuclear Power Plants"

[10] CRIEPI Report O20001 "Development of Fire PRA Guide for Japanese Nuclear Power Plants"

[11] CRIEPI Report NR26002 "On-Line Maintenance Guideline (rev.2026) - Enhancement of risk management for external events -"

[12] CRIEPI Report NR24002 "Feasibility study of the risk-informed approach to the Containment Vessel Leak Rate Test interval extension in Japan"

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