February 18, 2015

Roadmap on R&D and Human Resource for Light Water Reactors Safety in Japan

\- Nuclear Safety Visions and Technical Basis Reconstruction -
after the Fukushima Accident

Prof. Naoto Sekimura,

Department of Nuclear Engineering and Management,

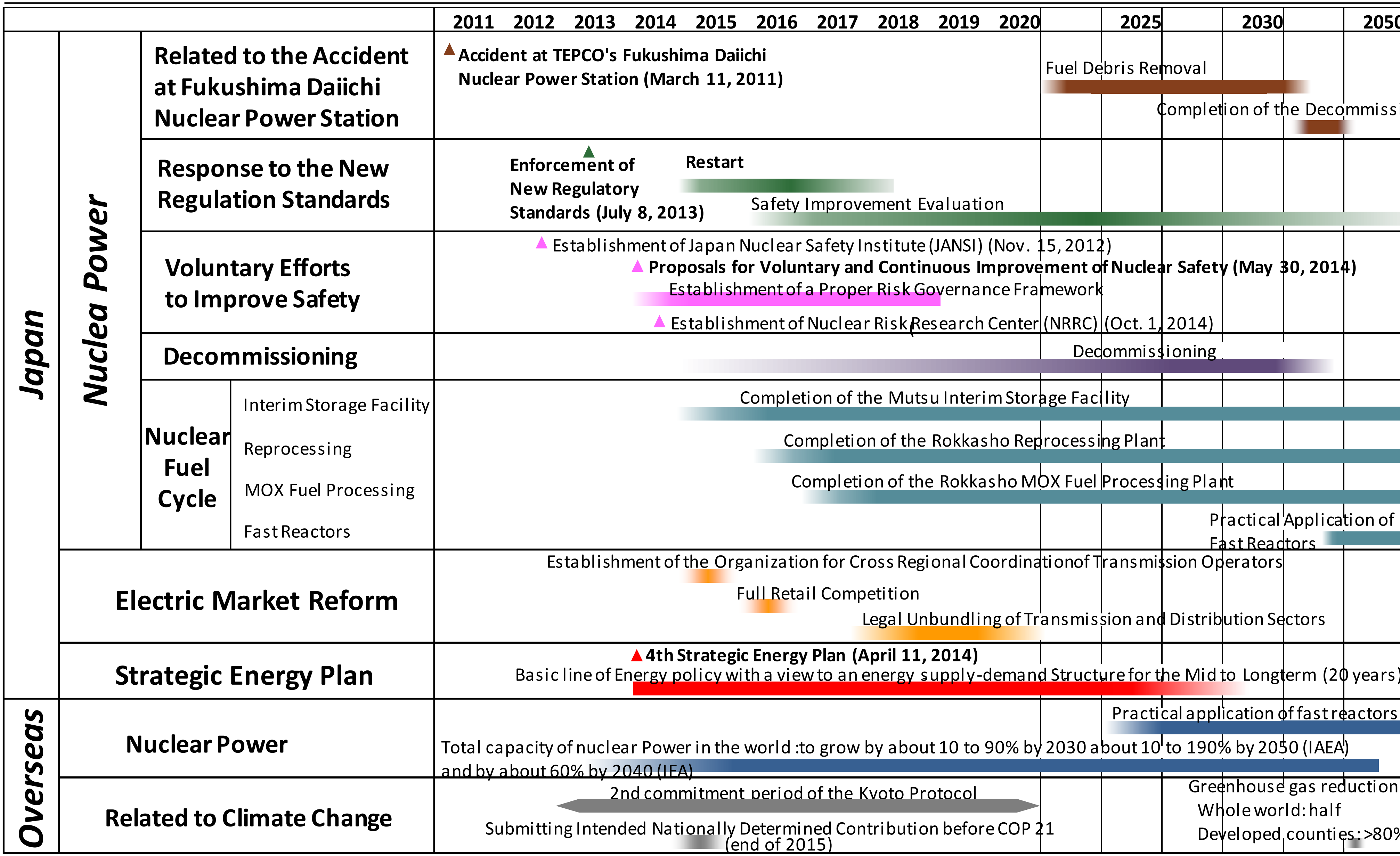
The University of Tokyo

Chairperson of the Special Committee on Nuclear Safety Research Roadmap,

Atomic Energy Society of Japan

Contents

Situations Surrounding the Use of Nuclear Power in Japan



Current Status of Strategic Energy Plan in Japan

- **4th Strategic Energy Plan has been determined by the Government on April 11, 2014 to provide basic lines of energy policy with a view to an energy supply-demand structure for the mid to longterm for these 20 years.**

  ✓ **"Nuclear power is an important baseload electricity source."**

28 Items from the Lessons Learned from the Fukushima Accident

Report of the Japanese Government to the IAEA

The Accident at TEPCO's Fukushima Daiichi NPS -Second Report (September 2011)

（Category 1; Prevention of SAs）

(1) Strengthen measures against earthquakes and tsunamis
(2) Ensure power supplies
(3) Ensure reliable cooling function of reactors and PCVs
(4) Ensure reliable cooling functions of spent fuel pools
(5) Thorough accident management (AM) measures
(6) Responses to multi-unit site issues
(7) Consideration of NPS arrangement in basic design
(8) Ensuring the water tightness of essential equipment and facilities

（Category 2 ; Countermeasures against SAs）

(9) Enhancement of measures to prevent hydrogen explosions
(10) Enhancement of the containment venting systems
(11) Improvements to the accident response environment
(12) Enhancement of the radiation exposure management system at the time of the accident
(13) Enhancement of training for responding to severe accidents
(14) Enhancement of instrumentation for reactors and PCVs
(15) Central control of emergency supplies and setting up of rescue teams

（Category 3 ; Responses to nuclear emergencies）

(16) Response to a combined situation of massive natural disaster and nuclear emergency
(17) Reinforcement of environmental monitoring
(18) Clarification of the allotment of roles between central and local organizations
(19) Enhancement of communication regarding the accident
(20) Enhancement of responses to assistance from other countries and communication to the international community
(21) Accurate understanding and prediction of the effect of released radioactive materials
(22) Clear definition of the criteria for wide-area evacuations and radiological protection standards in nuclear emergencies

（Category 4 ; Enhancement of safety infrastructure）

(23) Enhancement of safety regulatory and administrative systems
(24) Establishment and reinforcement of legal frameworks, standards and guidelines
(25) Human resources for nuclear safety and nuclear emergency preparedness and Responses
(26) Ensuring the independence and diversity of safety systems
(27) Effective use of probabilistic safety assessment (PSA) in risk management

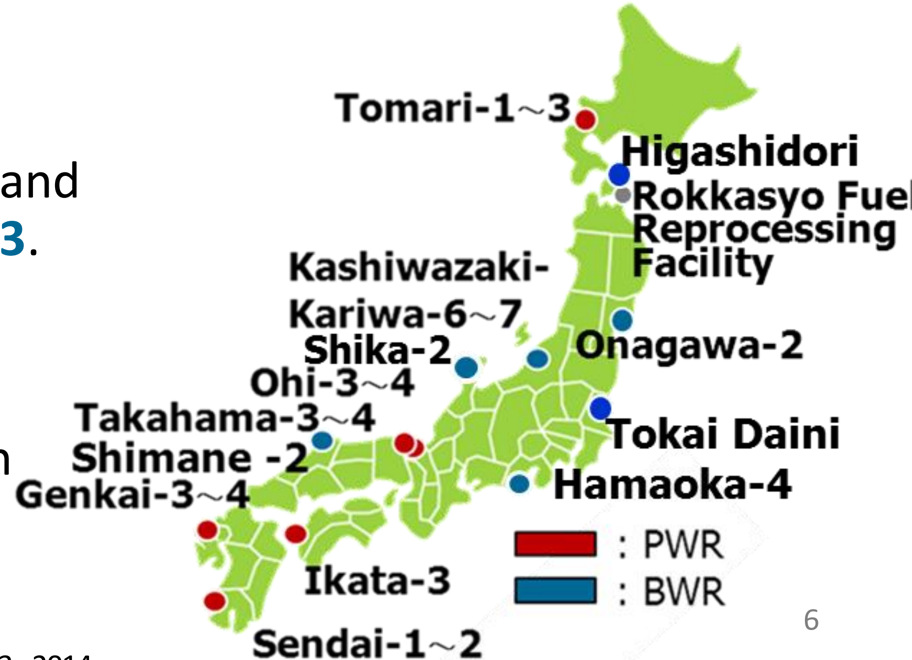
（Category 5 ; Thoroughly instill a safety culture）

(28) Thoroughly instill a safety culture

Current Status of Safety Regulation

- **Nuclear Regulatory Authority (NRA) was established in Sep. 2012 and developed the new regulatory requirements for NPPs which came into force in July 2013.**
  - **All the 48 units** have been shut down **since Sep. 2013**.
  - So far, a total of **20 units**, 12 PWRs and 8 BWRs, have applied for **conformance review** for restart.
  - In **Sep. 2014**, NRA first approved the applications from **Sendai Units 1 and 2**.
  - In **Feb. 2015**, NRA approved the applications from **Takahama Units 3 and 4.**

- The new requirements for fuel cycle facilities and research reactors came into force in **Dec. 2013**.
- The former **JNES was merged with NRA** on **Mar. 1, 2014.**
- NRA invited the **IAEA IRRS mission** to be taken place in **late 2015**.



Dr. Masashi HIRANO (NRA),
U.S. NRC Regulatory Information Conference, Washington, March 11-13, 2014

Basic Policies Set out in Major Acts Amended in June, 2012

Basic Act for Atomic Energy

IAEA SF-1

- Safety objective was stipulated in Article 2:

  To protect people's lives, health and property, and the environment, and to contribute to security ...,

  taking into account established **international standards**

IAEA Safety Standards, etc.

Nuclear Regulation Act

- Mandatory **severe accidents measures**
- **Back-fitting** to existing plants
- **Licensee's primary responsibility for safety**
- **Limit of operation of 40 years** for NPPs with possible extension up to 20 years just once
- Special regulation applied to **disaster-experienced plant** (Fukushima Daiichi), etc.

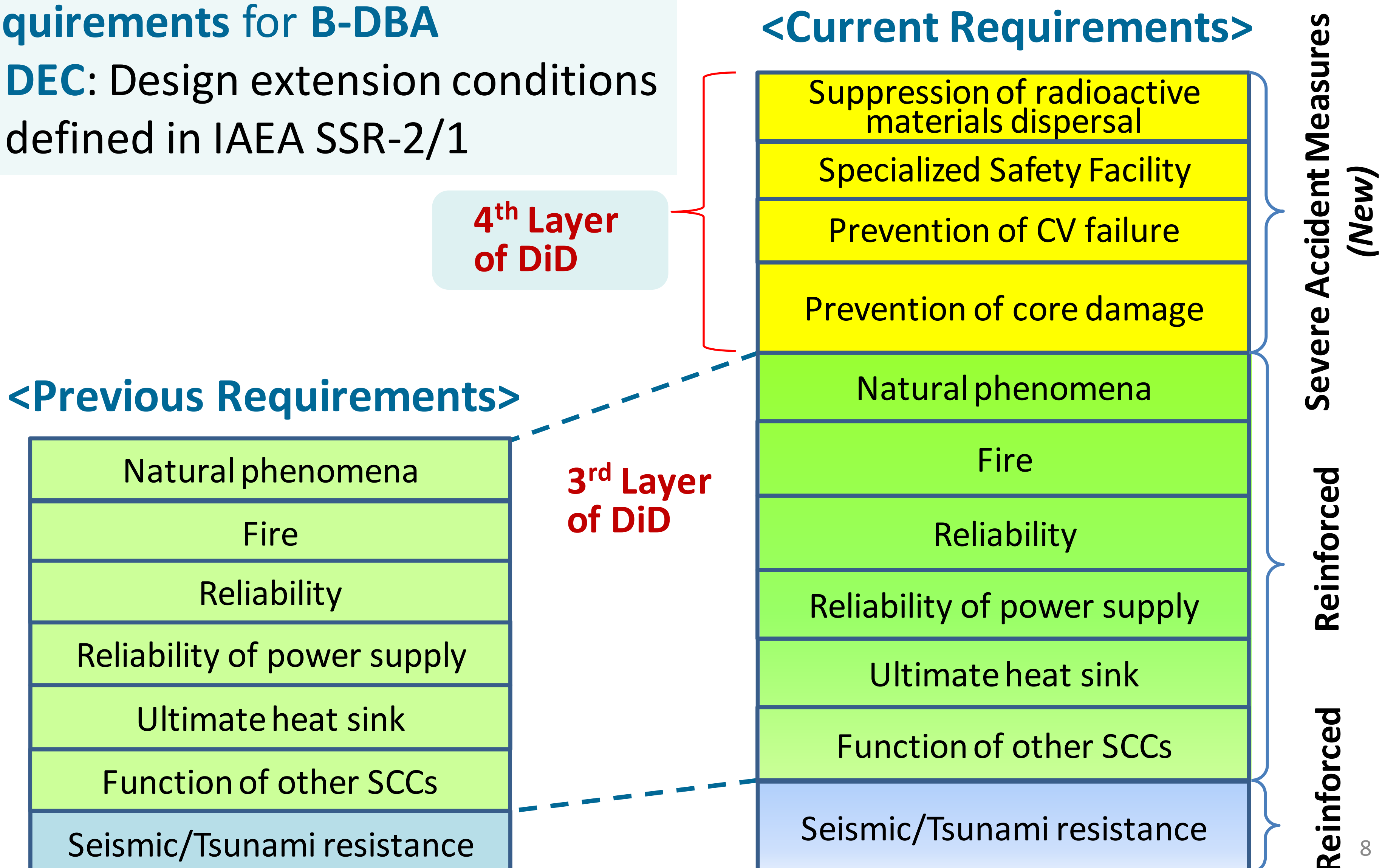
Dr. Masashi HIRANO (NRA),
U.S. NRC Regulatory Information Conference, Washington, March 11-13, 2014

http://www.nsr.go.jp/english/library/data/related_act_140301-02.pdf

New Regulatory Requirements: Basic Structure

Requirements for **B-DBA**

- **DEC**: Design extension conditions defined in IAEA SSR-2/1



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Proposals for Voluntary and Continuous Improvement of Nuclear Safety（2014.5.30）

Report by the WG on Voluntary Efforts and Continuous Improvement of Nuclear Safety,
Nuclear Energy Subcommittee, the Advisory Committee for Natural Resources and Energy（2013.7-）

Recommendations on Desirable Efforts for the Future Activities and Research and Development

- ✓ **Implementation of risk management under an appropriate risk governance framework**
- ✓ **Activities required to be implemented with lessons learned from the accident at TEPCO's Fukushima Daiichi NPS as the starting point**
  - Implementation of exhaustive and comprehensive risk assessments including low-frequency events
  - Reduction of residual risk through strengthening "defense in depth"
  - Identifying the accident sequences and cliff edges at each plant, focusing on external events, and improving resilience
  - Reorganization of research for improving the safety of light water reactors and reinforcement of research coordination

Proposals for Voluntary and Continuous Improvement of Nuclear Safety（2014.5.30）

Report by the WG on Voluntary Efforts and Continuous Improvement of Nuclear Safety, Nuclear Energy Subcommittee, the Advisory Committee for Natural Resources and Energy（2013.7-）

Previous Research Activities on Safety of Light Water Reactors

- Activities on basic research and safety research on light water reactors by research institutions have been reduced since 1990s, because of the matured light water reactor technologies .
- Countermeasures against severe accidents have been implemented voluntarily by electric utilities from early 2000s, research and development activities related to severe accidents of light water reactors have decreased significantly by both industries and government.
- Collaboration among the industry, academia and government was not sufficient.
- Joint research activities by the promoting side and the regulating side of the government, have not been implemented effectively, even though these are common in other countries.

Construction of Future Research Roadmap

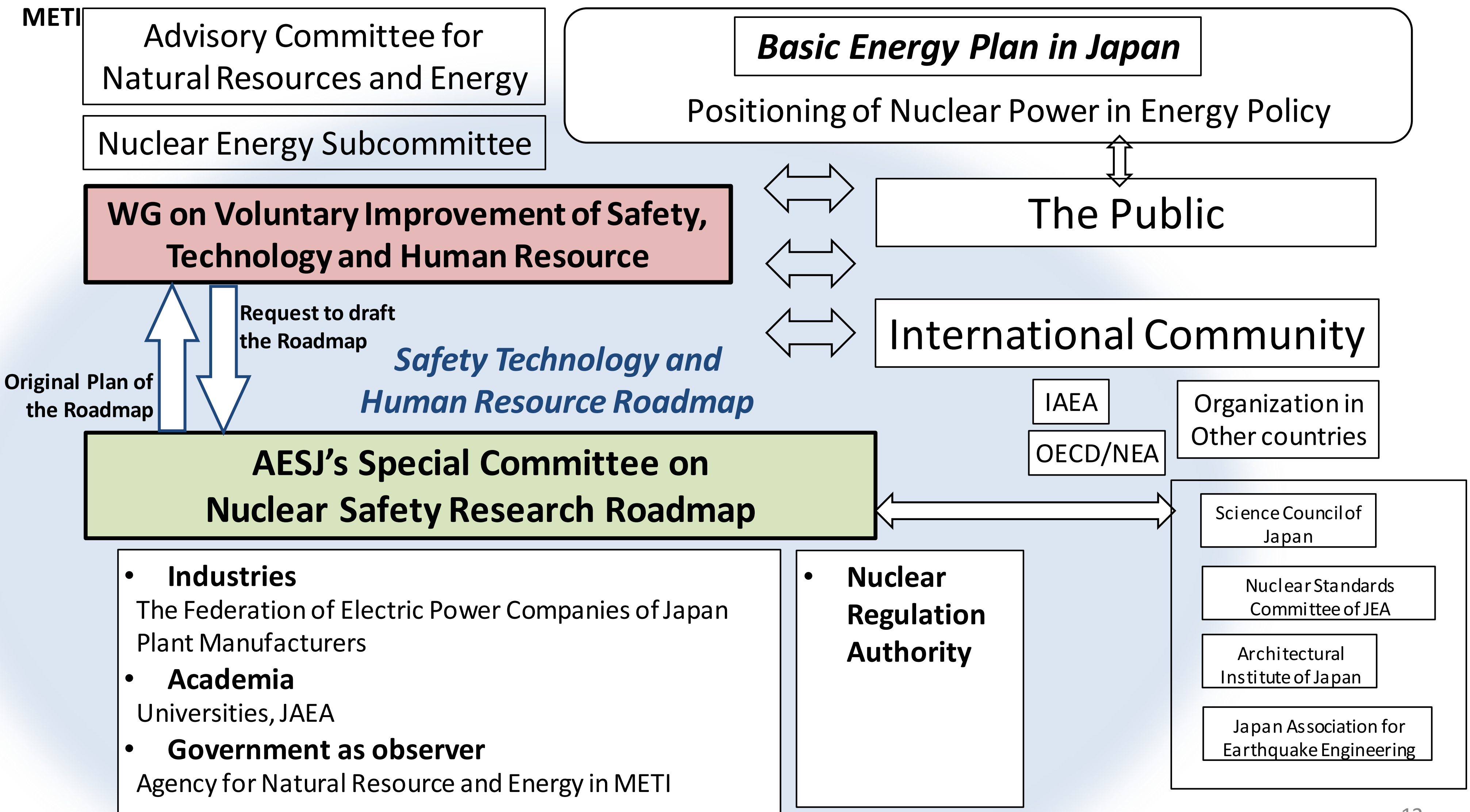
- **The Roadmap for Light Water Reactor Safety Research and Human Resources** is considered as an tools for effective safety improvement in the future and communication tool which can share the consensus between the stakeholders including the public.
- Clear roles are decided among the related organizations to promote research and development activities effectively without duplication.

Basic Policy to Construct The Roadmap for Light Water Reactor Safety Technology and Human Resource

- **"WG on Voluntary Improvement of Safety, Technology and Human Resource"** was established in August, 2014 under the Nuclear Energy Subcommittee of Advisory Committee for Natural Resources and Energy in METI.

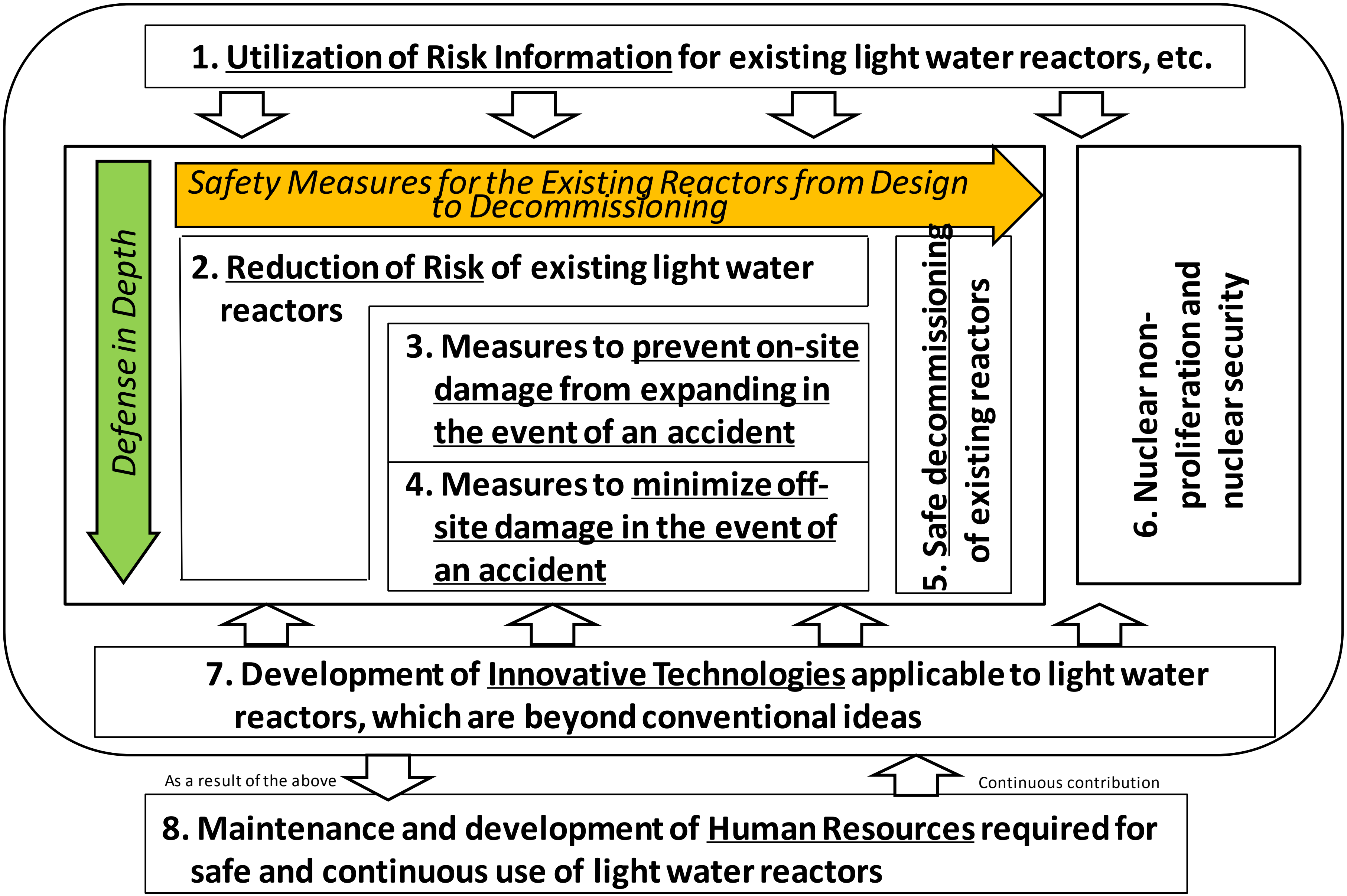
- **The WG provided the Basic Policy to construct the Roadmap for Light Water Reactor Safety Technology and Human Resource**
  - ✓ The Roadmap should be formulated in full consideration of the lessons learnt from the experiences of the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, so that the public can feel confident of safety of light water reactors.
  - ✓ In order to define items of technology development and to maintain and develop human resources to support these items, firstly we need to present challenges in realizing enhancement of the public confidence in the safety of the light water reactors and safe and continuous use of the reactors; then we need to reconstruct the roadmap by reviewing the priority of the existing technology development and schedule, with considering whether they can contribute to resolve the challenges.
  - ✓ Roadmap for Light Water Reactor Safety Technology and Human Resource should be able to realize the optimal approach, by clarifying roles among the parties concerned such as academic societies, the government, operators, manufacturers, and research institutes; and by eliminating overlapping of roles in Japan as a whole. Furthermore, in order to obtain the highest level of outcomes with eliminating overlapping of the roles in research and development, elements of necessary international collaborative researches should be actively incorporated into the roadmap, in full consideration of the trend of the global research and development and human resource development.

Construction of the Roadmap for Light Water Reactor Safety Technology and Human Resource



AESJ : Atomic Energy Society of Japan

Eight Categories of Challenges provided by the WG on Voluntary Improvement of Safety, Technology and Human Resource

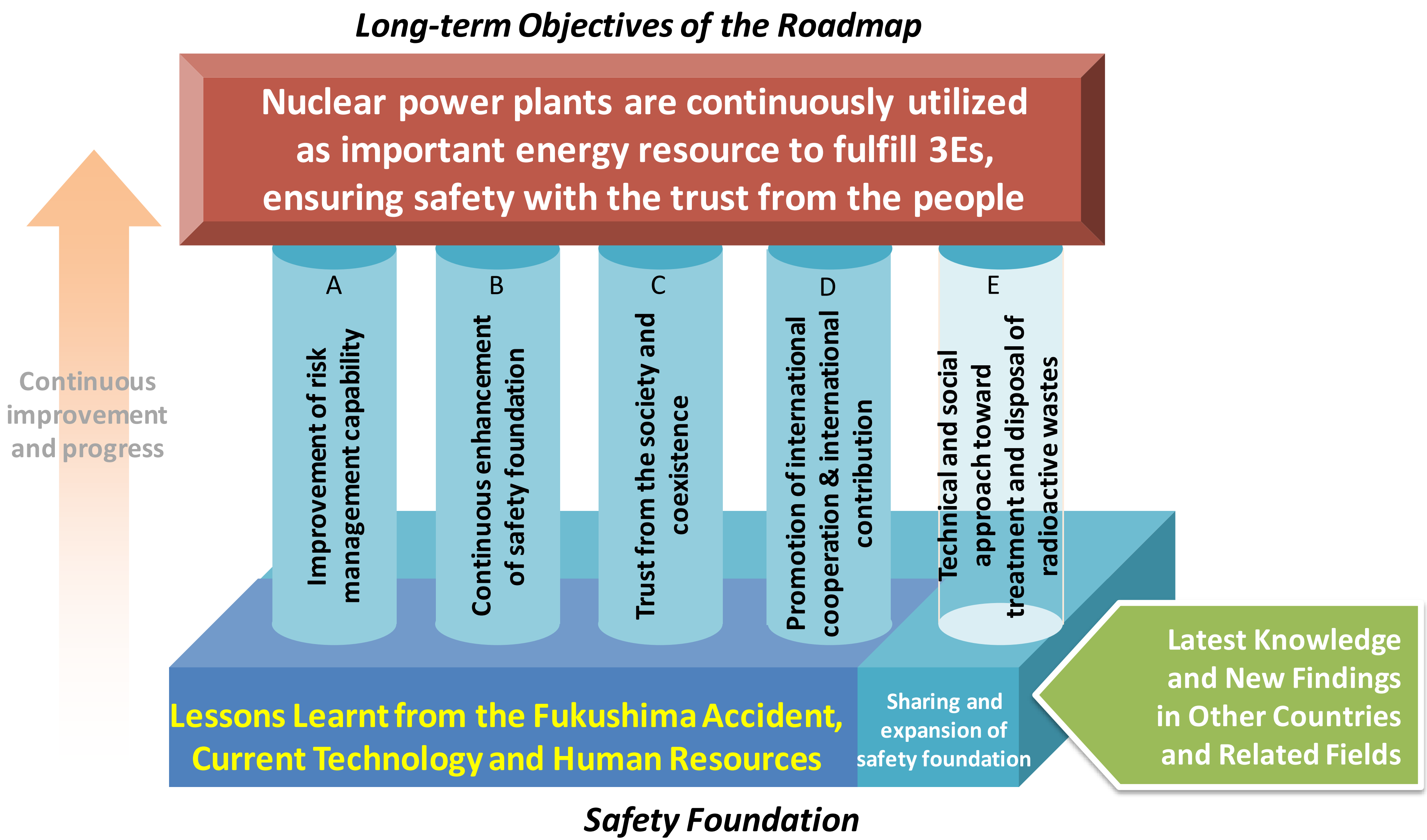


Sub-Committees in AESJ's Special Committee on Nuclear Safety Research Roadmap

Sub-Committee	Maintenance and Plant Life Management	Review countermeasures against facility ageing based on operational experiences and plant maintenance as well as the challenges related to safe operation.
	Safety Improvement through Design	Review the challenges related to safety improvement through design activities for fuels, materials, thermal hydraulics, etc.
	Accident Management	Review the challenges related to accident management.
	Earthquake Resistance and External Events	Review the challenges related to long-term durability of buildings and structures with taking into account external events such as earthquakes tsunamis and external events.
	Decommissioning (*)	Review the challenges related to the processes of safe decommissioning of the existing reactors and handling of large wastes, etc.
	Nuclear Security	Review the challenges related to nuclear non-proliferation and nuclear security as nuclear energy is widely used in international community.

* Technology Development related to Decommissioning of TEPCO's Fukushima Daiichi NPS is not included in this Roadmap.

Five Pillars in the Light Water Reactor Safety Technology and Human Resource Roadmap



Categorization of Social Requirements and Needs to Construct the Roadmap

Social requirements and needs	Category
✓ Sincere dialogue and information disclosure based on the assumption that risks exist ✓ In order to reduce accident risk as low as possible, continuous review of challenges through a series of discussions with grasping a total picture of matters from diversified viewpoints, which leads to elimination of unexpected matters ✓ Retention of flexible systems and organizations capable of utilizing the latest knowledge and technology succession	**Improvement of Risk Management Capability**
✓ Sharing of the experience and lessons learned from the accidents and decommissioning work at Fukushima Daiichi ✓ Sharing and utilization of best practice based on abundant operational experience ✓ Long-term forecast for acquisition of the latest knowledge and findings through continuous basic and advanced researches ✓ Realization of reactors with a minimized risk of severe accident by employing innovative technology	**Continuous Advancement of Safety Foundation**
✓ Completion of responses to the 1F accident and strong determination of the people in nuclear energy field never to recur an accident ✓ Sincere attitude and approach by the people in nuclear industry that can be trusted ✓ Sincere dialogue and information disclosure based on the assumption that risks exist ✓ Operation under an indispensable prerequisite of ensuring safety as well as establishment of systems for nuclear disaster prevention and continuous improvement ✓ Contribution to stable supply of energy ✓ Contribution to suppression of greenhouse gas emissions	**Trust from the Society and Coexistence**
✓ Provision of experience and knowledge for the purpose of creating international codes and standards based on the 1F accident as well as contribution to international diffusion of safety measures that satisfy such codes and standards ✓ Contribution to nuclear non-proliferation and nuclear security ✓ Contribution to suppression of greenhouse gas emissions	**International Cooperation and Contribution**
✓ Reduction of risks for future generations by reducing volume and toxicity of radioactive wastes	**Technological and Social Approach toward Radioactive Wastes Management**

Concerns by Researchers and Engineers who participated in the Roadmap

Awareness for challenges pointed out by the researchers and engineers		Category
• Reflection of knowledge and findings from the 1F accident into the existing reactors • Improvement of organizational strength and optimization of organizational formation and division of functions • Advancement of method for safety management education	• Reduction of maintenance and operation workloads (including response to exposure reduction) • Improvement of communication capability in various situations • Continuous development of human resources for maintenance, operation and management	**Improvement of Risk Management Capability**
• Retention of technological base (basic research, experiment facilities, etc.) • Production of database based on the knowledge of operational experience and creation of a system for continuous maintenance and utilization	• Enhancement of reliability of facilities and equipment through advancement in methods and measures to evaluate ageing deterioration • Reflection of the outcome of technology development into regulatory guidelines and standards	**Continuous Advancement of Safety Foundation**
• Completion of decommissioning work at 1F • Electric utilities' involvement in and support for regional disaster prevention	• Contribution to reduction in greenhouse gas emissions through safe and stable operation with a high availability factor • Realization of the plants that do not require evacuation of the local residents concerned	**Trust from the Society and Coexistence**
• Technical and managerial support for countries that newly introduce nuclear power generation • Establishment of challenges that are common to the needs in other countries (development of advanced technology, etc.)	• Contribution to formulation of international technical standards • Contribution to international organizations through provision of human resources and various activities, in addition to financial support	**International Cooperation and Contribution**
• Development of innovative technology to suppress generation of radioactive wastes • Development of technologies to shorten lives or reduce volume of radioactive wastes by nuclear transformation	• Study of optimum process for selection of repository sites and approach to sharing social awareness and understanding	**Technological and Social Approach toward Radioactive Wastes Management**

Milestones : Steps to Complete Long-term Objectives in the Roadmap

(Draft Version)

2050

Stage 3 (Long Term)

1. As innovative technology to reduce risks associated with radioactivity release into the environment or radioactivity exposure due to accidents or troubles has been developed progressively, many countries would utilize nuclear energy as a safe and stable generation resource with no greenhouse gas emissions under international safety standards that incorporate the latest knowledge and findings and advanced technology. [A, B, C, D]
2. As technology to reduce the volume and toxicity of radioactive wastes has been developed progressively, a positive perspective for reduction of such volume and toxicity is obtained for future generations. [A, B, C, D, E]
3. Amid the level of technology and knowledge on nuclear safety rises worldwide and the latest knowledge is always shared and used internationally, our country takes a leadership role in the field of nuclear safety in the world. [A, B, C, D]

2030

Stage 2 (Medium term)

1. With continuous and effective reduction of accident risk and the trust from the people created through good communication, nuclear power generation is used as a stable energy source in consideration of cost balance with other generation resources. [A, C]
2. Through incorporation of technology for further safety improvement and some of requirements for management response into plant design, the knowledge to substantially reduce accident risk is obtained and efforts for development of innovative technology are continuously made. [B, C]
3. As the number of countries with nuclear power plants increases, our country contributes to nuclear safety through various activities under an international framework for cooperation with providing a high level of human resources and technology to lead other countries in international organizations. [B, D]

2020

Stage 1 (Short term)

1. Voluntary efforts for improvement of safety and reliability based on defense in depth have been made and risk disclosure with taking account of the people's concerns and dialogue are smoothly conducted on such efforts. [A, C]
2. As electric utilities complete their efforts and activities to satisfy new regulatory standards and voluntary efforts for safety improvement take root, a more positive relationship between regulatory authorities and electric utilities is established for promoting safety improvement further. [A]
3. A system for disaster prevention becomes enhanced and sophisticated, resulting in harmonization with efforts for prevention of natural disasters as well as protection of the humans and the environment from radiation. [C]
4. As nuclear power generation is widely used in the world, our country contributes to improvement of nuclear safety in countries with nuclear power plants through provision of technology and information, based on abundant operational experience and knowledge in Japan. [B, D]

Examples of the AESJ Roadmap : Risk Information and Management

(Draft Version)

Category		Short-Term (S)	Medium-Term (M)	Long-Term (L)
Use risk information for assessments		Improvement of earthquake risk assessment strategies (SI15) Improvement of tsunami risk assessment strategies (SI14) Develop risk assessments for accidents other than earthquakes and tsunamis (SI13)	Develop strategies for assessment of large-scale, low-frequency disasters and share them with regulatory authorities and society (MI01,MI02,MI04,MIV01)	Constantly update assessment strategies for large-scale disasters and emergency situations (LIII01)
		Re-awareness of nuclear risks based on 1F accident experiences, and set risk reduction goals (SIII03,SIII02,SIV08)	Continuous improvement of risk assessments of power plants in operation (MII02,LI07)	
Use risk information for countermeasures	Hardware	Reflect the latest knowledge on large-scale, low-frequency disasters onto hardware (SII12,MI02)		Continue developing hardware capable of responding to large-scale disasters and emergency situations (LII06,LI07)
		Reflect risk reduction measures based on lessons learned from the 1F accident onto hardware (SIV04,SV08,SIV02)	Reduce operator risks through automation and other measures (LI04)	
	Organization	Entrench risk culture (SII04,SII09) Consider systems to make use of risk information (SIV09,SIII04,SI12,SII06)	Operate systems that make use of risk information (MIV04,MI03,MI01)	Create a resilient organization capable of responding to large-scale disasters and emergency situations (LI05,LI08)
Use risk information to collaborate with society		Engage in sincere dialogs with society on risk reduction goals based on risk information (SIII03) Share risk reduction goals with society (SIII03,MIV02)	Constantly share risk information with society and continually update risk reduction goals (MIV01,LIII03)	
		Provide risk information for more effective disaster prevention, strengthen collaboration with external assistance organizations to contribute to community disaster prevention (SII10,SII07)		Contribute to wide-area disaster prevention (MIV05,LII03)
		Share the lessons learned from the 1F accident internationally (SVI01)	Inform the international community of the assessment and organizational structure that reflect the lessons of the 1F accident, thus contributing to improved worldwide nuclear safety (MV01,LIV01)	
Human resources development		Develop human resources in Japan capable of making use of risk information (SII11,SIII04,MIV04)	Accept human resources training regarding the use of risk information from abroad (MV02) Develop human resources capable of providing on-site direction in nuclear newcomer countries (MV02)	Maintain a pool of human resources who can play active role internationally in risk information utilization (LI02)

Examples of the AESJ Roadmap : External Risk Assessment and Severe Accident Management

(Draft Version)

	Short-Term (S)	Medium-Term (M)	Long-Term (L)
Assessment of External Event Risk	Development of monitoring & observation framework for natural hazards (SI16)	Updating and enhancement of monitoring & observation framework for natural hazards	
	Comprehensive risk identification and assessment methodology for external events (SI02,SI03,SI13)	Continued efforts on research and development of risk assessment framework for rare natural events for uncertainty reduction of predicted risk (including unidentified events) (SI02,MI02,LI07)	
	Development of systematic earthquake risk assessment framework including ground motion, tsunami, fault displacement and slope failure (SI02,SI14,SI15)		
Prevention of Accident Progression – Risk identification	Development of advanced analysis codes and evaluation tools for severe accident (SI06,SIV06)	Application of advanced analysis codes and evaluation tools for risk reduction of existing power plant (including large-scale disaster) (MI01, MIV01)	Development of concept of nuclear power plant system with enhanced accident tolerance (LI06, LI08,LII06, LIII01)
Prevention of Accident Progression – Management	Development of nuclear reactor instrumentation ability under severe accident conditions (SI04,SV01,SII02)	Development of advanced nuclear reactor instrumentation system under any conditions including severe accident conditions (MIII07,MIV03)	
	Countermeasures for severe accident (application of risk assessment, mobile equipment, training, etc.) (SI01,SI05, SII01, SIII02, SIV08, SV03)	Application of countermeasures against severe accident for existing plant to advanced power plant design (MIII11,MIII12, MIV02)	
Prevention of Accident Progression – Organizat-ion etc.	Development of advanced drill for nuclear accident & disaster (SII01)	Review and reconstruction of organizational structure to cope with critical accident condition (MII03)	
Building Disaster Resilient Society	...	...	...
Human Resources Development	Development of better leader and human resources for accident management (SII01)	Development of human resources to lead a cross-organizational role for accident and disaster management (MI03)	Development of human resources to fulfill an international role in the area of accident and disaster management (LI08)
	Increase of the number of human resources who can apply scientific knowledge (e.g. natural hazard) to enhancement of safety of nuclear power plant (SII12)	Development and continuous attraction of human resources who conduct researches on rare event (e.g., large scale disaster etc.) and have a motivation to make a contribution for safety enhancement of nuclear power plant (MI02,LI07)	

Evaluation of Prioritization of Each Technical Issues to Formulate the Roadmap

(Draft Version)

Effectiveness for safety improvement (based on defense in depth concept)

①Is it highly helpful for safety verification or safety improvement? (Is it relatively effective in risk reduction if the challenges are solved?)

② Is it highly helpful for improvement of reliability on risk evaluation? (Is the clarification or the projection and evaluation level of unclear or unidentified phenomena highly improved?)

③Is the challenge related to a solution with less effective alternatives? (Dose the solution of the challenge lead to an increase in safety measures or evaluation methods?)

④Is early application possible? (Is it a solution based on highly matured technology or is introduction without modification of the existing plants possible?)

Retention and development of technology and human resource including breakthrough idea, knowledge-base accumulation, and systems engineering viewpoints

①Are the scopes of application and contribution in nuclear safety field large?

②Is it highly helpful for improvement and verification of safety if practically applied?

③Is it highly helpful for international contribution based on our accident experience?

④Does it result in breakthrough to solve nuclear safety challenges?

Safety Research in NRA

（Safety Research in Nuclear Regulation Authority, Sep. 2013）

Research for acquisition of technical knowledge necessary for developing regulatory requirements and those application, technical basis for decision making

① Research to Develop of Regulatory Requirements and Acceptance Criteria

Research for the development of regulatory requirement, acceptance criteria in the regulatory review and inspection, review manual, as well as development and verification of analysis code

② Technical Basis for Decision Making in Regulatory Activities

Research for obtaining data to ensure the technical adequacy in regulatory activities such as review, inspection, evaluation of plant integrity and supervising licensees

③ Maintaining Technical Competence/Expertise

Research for maintaining technical competence / expertise to fulfill the NRA obligation

Merger of JNES with NRA

- **JNES was merged with NRA** on **March 1, 2014**.
  - The major objective of the merger is to enhance the **technical competence and capabilities of NRA**.

- "Regulatory Standard and Research Department" consisting of mostly research engineers was created for "**development of technical standards**" and "**conduct of safety research**".
  - Four technical branches: **Reactor System Safety**, **Severe Accident**, **Earthquake and Tsunami** and **Nuclear Fuel Cycle/Waste.**
- All the **research activities** having being done in NRA/JNES are continued or even enhanced, including all the **international cooperative research activities**, either bilateral or multi-lateral.
- Cooperation with **NSRC** (Nuclear Safety Research Center) in **JAEA** and **NIRS** (National Institute for Radiological Sciences) will be strengthened as external TSOs for NRA.

Safety Research Implementation System in NRA

Nuclear Regulation Authority, Japan

The Secretariat of Nuclear Regulation Authority

- Regulatory Standard and Research Department
  (JNES was merged into NRA in March, 2014)
  【Staff : 196, including 149 researchers 】*
  - Regulatory Standard and Research Division
  - Reactor System Safety
  - Severe Accident
  - Nuclear Fuel Cycle and Radioactive Waste
  - Earthquake and Tsunami
- ⋮

Safety research by NRA researchers

Partial jurisdiction →

Research Contract →

- Evaluation of Fuel Debris Criticality
- Data Acquisition for Nuclear Fuel Failure Threshold
- Prediction of Radiation Embrittlement of Pressure Vessel
- Data Collection for IASCC of core internals

etc.

Japan Atomic Energy Agency

JAEA

Sector of Nuclear Safety Research and Emergency Preparedness

Nuclear Safety Research Center

- **Permanent staff: 63 (except temporary staff)**
- **Temporary staff: 28**
- **Part-time staff: 17**

↑

Management expenses grants (MEXT)

＊As of April, 2014

Research Contract ↓

Universities, Research Institutes, Venders, etc.

✓ Prevention of conflict of interest

Dr. Masashi HIRANO (NRA),
U.S. NRC Regulatory Information Conference, Washington, March 11-13, 2014

Focus in Safety Research in NRA

- Special emphasis on **external / internal hazards** leading to large scale **common cause failure**:
  - **Extreme natural phenomena**:
    - **Hazard curves** of earthquake/tsunami, **fragilities** of SSCs
    - Monitoring of **volcanic unrests**, …
  - **PRA** methods and models: External/internal **fire** and **floods**, multi-hazards, **multi-units**, application of **level 3 PRA**
- Research on **Severe Accidents** (SAs):
  - **Code development** for SA progression / source terms, …
  - Experiments on **scrubbing**, **seawater injection**, **SFP LOCA**
- Research on **Fukushima Daiichi**:
  - Management of wastes/contaminated water, **risk assessment**
  - **Criticality of fuel debris**, etc.
- Other areas:
  - **Decommissioning/waste Disposal**, fuel cycle facilities, …

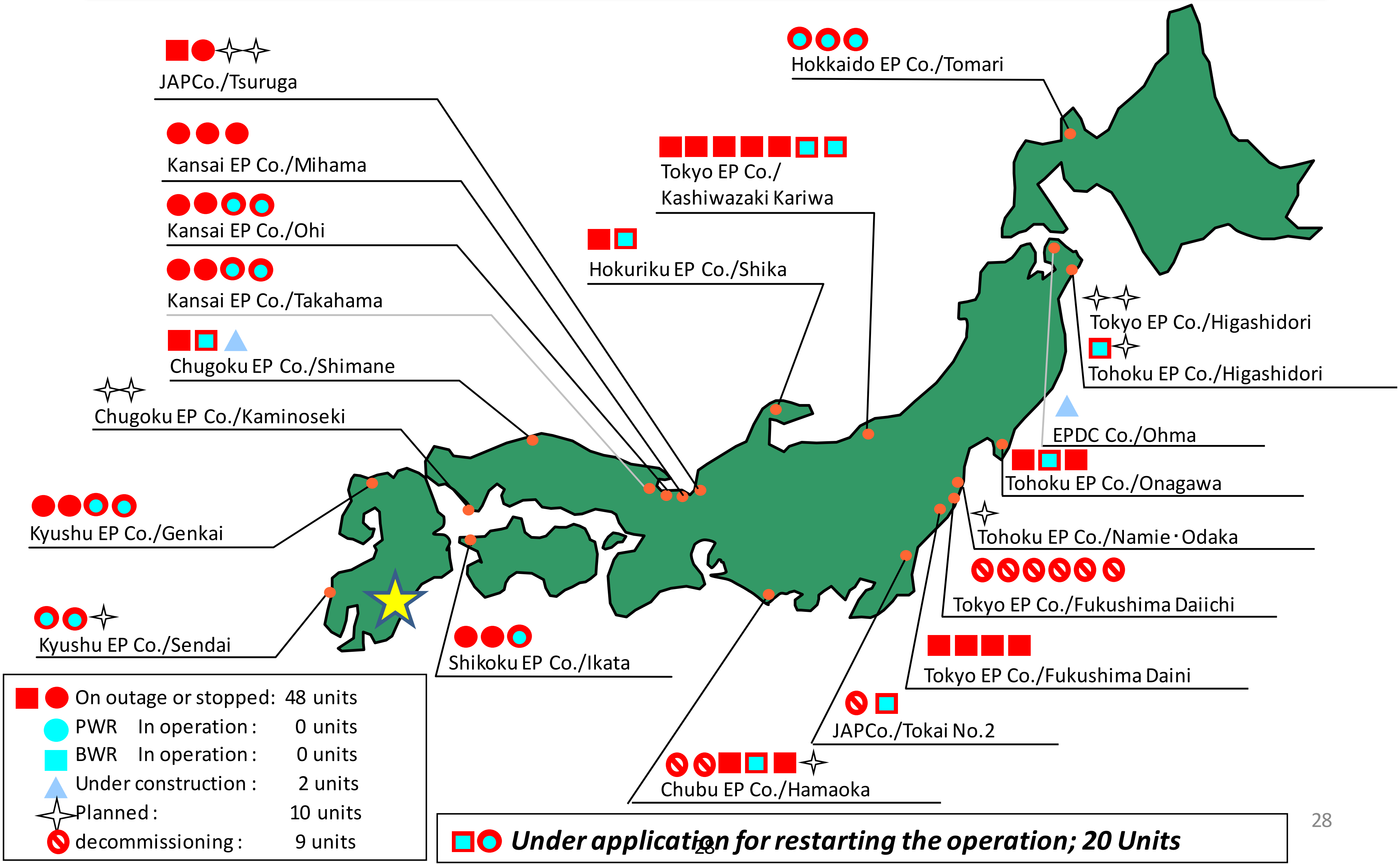
Summary on for Light Water Reactor Safety Technology and Human Resource

- The Roadmap for Light Water Reactor Safety Technology and Human Resource has been under construction by the Special Committee on Nuclear Safety Research Roadmap in the AESJ.
- Intensive work has been conducted to cover future research activities which cover analysis of social requirements and needs, extraction of the challenges to be solved, establishment of pillars to review challenges and milestones, clarification and sharing of the goals (requisites for achievement) to be pursued at each milestone, and a concept of evaluation axes to determine the priority in the Roadmap.
- Efforts should be exerted to make responses to and coordination with a technology map showing structurally the challenges and milestones extracted. Then, a roadmap based on evaluation axes should be produced to present a final report.
- The roadmap to be formulated should be reviewed and improved continuously based on the outcome and external evaluations. Organized efforts and communication with all the stakeholders should also be carried out.

Research Activities

related to Decommissioning Reactors

Nuclear Power Plants in Japan as of February, 2015

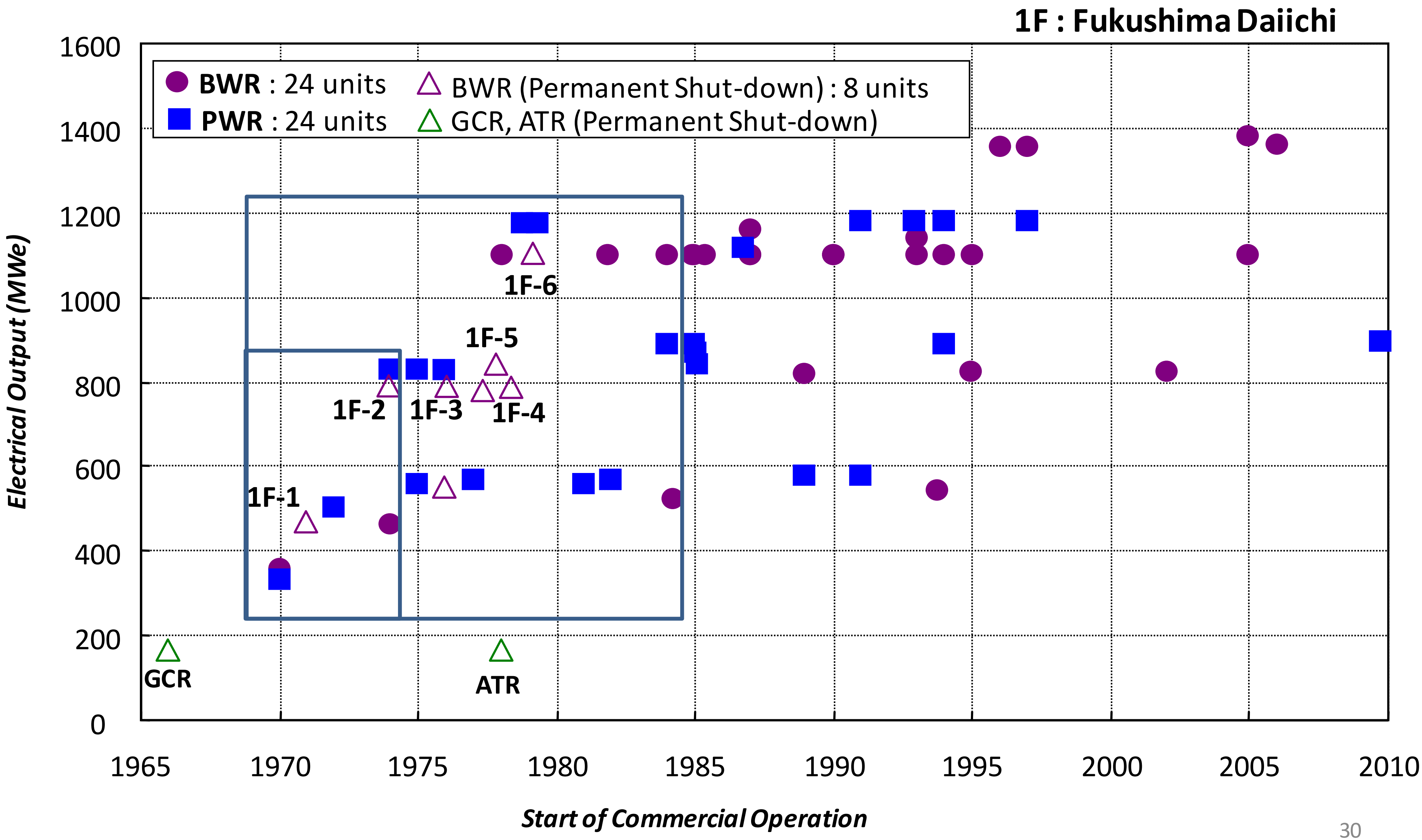


The NRA has received 20 Applications for Restarting Reactors

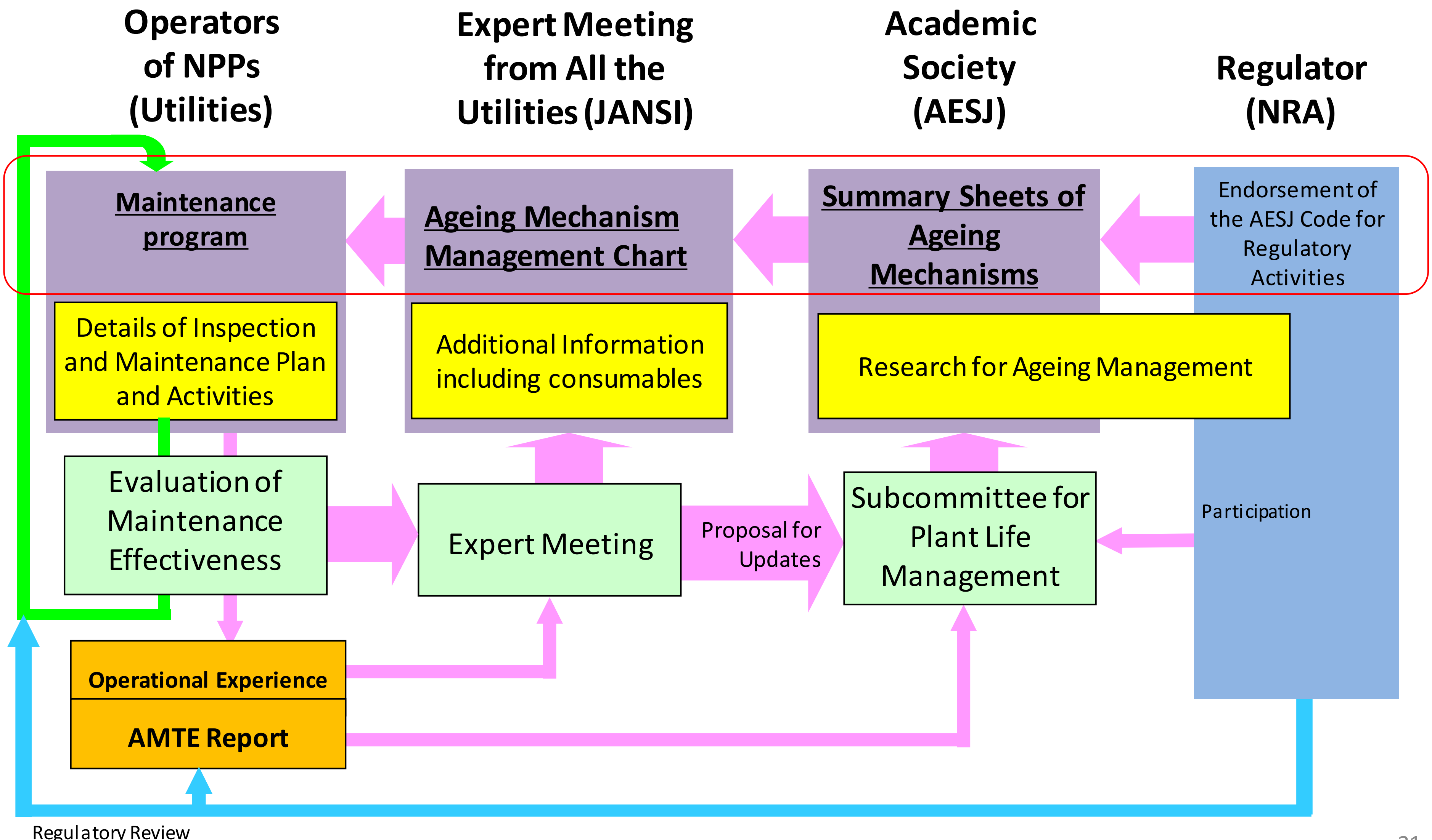
Applicants (Electric Utility Company)	Nuclear Power Plant and Unit #	Start of Operation (Age)	Date of Application	Completion of NRA Review
Hokkaido	Tomari #1, #2	1989/1991 (25/23)	July 8, 2013	
	Tomari #3	2009 (4)	July 8, 2013	
Kansai	Ohi #3,#4	1991/1993 (22/21)	July 8, 2013	
	Takahama #3,#4	1985/1985 (29/29)	July 8, 2013	**Feb. 12, 2015**
Shikoku	Ikata #3	1994 (19)	July 8, 2013	
Kyushu	**Sendai #1,#2**	1984/1985 (30/28)	July 8, 2013	**July 16, 2014**
	Genkai #3, 4	1994/1997 (20/17)	July 12, 2013	
Tokyo	Kashiwazaki-Kariwa #6,#7	1996/1997 (17/17)	Sep. 27, 2013	
Chugoku	Shimane #2	1989 (25)	Dec. 25, 2013	
Tohoku	Onagawa #2	1995 (19)	Dec. 27, 2013	
Chubu	Hamaoka #4	1993 (21)	Feb. 14, 2014	
Japan Atomic Power Company	Tokai-Daini	1978 (35)	May 20, 2014	
Tohoku	Higashidori #1	2005 (8)	June 10, 2014	
Hokuriku	Shika #2	2006 (8)	Aug. 12,2014	
total	20 Units		-	4 Units

https://www.nsr.go.jp/activity/regulation/tekigousei/power_plants.html

Nuclear Power Plants in Japan



Sharing and Updating Knowledge for Ageing Management with Summary Sheets of Ageing Mechanisms



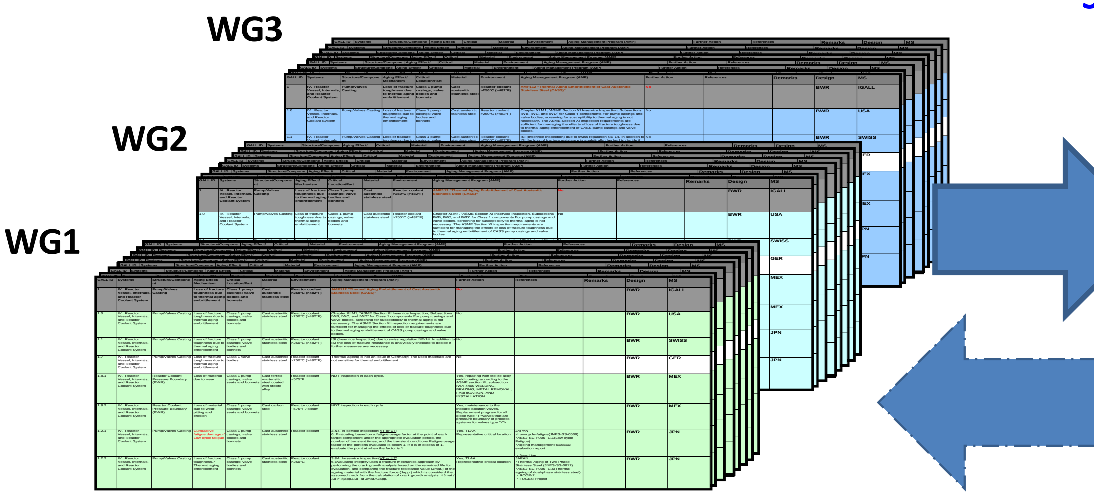
(JANSI : Japan Nuclear Safety Institute)

Knowledge Transfer between IAEA/IGALL and the AESJ Code

- ***The combinations of intended and required safety functions, portion of SSCs and the ageing mechanism/effect are summarized in the summary sheet in the Attachment A of the AESJ code, based on the experience from the 17 AMTEs in Japan.***
- ***Knowledge-base from IAEA IGALL is currently under review by AESJ members be reflected in the next major revision, including the lessons learned from the Fukushima accident.***

IGALL (Spread sheets)

Attachment A of the AESJ code
Summary Sheets of Ageing Mechanisms



No.	機能達成に必要な項目	部位	材料	経年劣化事象	高経年化技術評価不要の条件	耐震安全上の 静的機能	耐震安全上の 動的機能	耐震上の影響
1	ポンプの容量・揚程確保	主軸	ステンレス鋼	摩耗				▼
2				疲労割れ（高サイクル疲労割れ）	②		☆	
3		羽根車	ステンレス鋼鋳鋼，銅合金鋳物	腐食（キャビテーション）	②			
4		羽根車リング	―	（消耗品・定期取替品）	―			
5	伝熱性能の確保	伝熱管	インコネル690合金	疲労割れ（フレッティング疲労割れ）		★		▼
6				管板クレビス部応力腐食割れ	②			
7				デンティング				▼
8				スケール付着				▼
9		振止め金具	ステンレス鋼	摩耗		★		▼
10	バウンダリの維持	冷却材出入口管台セーフエンド（ステンレス鋼）	ステンレス鋼（インコネル肉盛）	応力腐食割れ		★		◎
12		1次側マンホール	低合金鋼（インサートプレートはステンレス鋼）	（想定されず）	―	★		
13		管板	低合金鋼（インコネル肉盛）	疲労割れ		★		◎
14				肉盛部応力腐食割れ				▼
15				肉盛下層部のき裂	②			
16		ガスケット	―	（消耗品・定期取替品）	―	★		
17		仕切板	インコネル600合金	応力腐食割れ		★		▼
18			インコネル690合金	応力腐食割れ	①			

1,000 pages for PWR and BWR

Special Inspections to Extend Operational Period

Regulatory Requirements of Special Additional Inspections for Long Term Operation beyond 40 years up to 60 years

Components	Current Inspection	Additional Inspection
Reactor Pressure Vessel	Ultrasonic Tests of Welded Zone	100% UT Examination of Base Metal in addition to Welded Zone
Primary Containment Vessel (Steel)	Leak Rate Tests	Visual Test (Appearance of coating film)
Civil Concrete Structure	Visual Tests & NDT	Core Sampling (Strength, Neutralization, Salt intrusion, etc.)

- **Special Inspections are requirements to extend the operational period beyond 40 years by up to 20 years (60 years maximum) in addition to;**
  - **Ageing Management Technical Evaluation (AMTE) for every 10 years**
  - **Maintenance Program**

IAEA New Coordinated Research Project

"The Evaluation of Properties of Structure and Component Materials Utilizing Actual Aged Materials from Decommissioned Reactors"

The first Meeting of the CRP on June 11 – 13, 2014 in Vienna

New IAEA Coordinated Research Project

Title of the CRP

Evaluation of structure's and component's material properties utilizing actual aged materials removed from decommissioned reactors for safe LTO

Project Preparation

- *Initial proposal to IAEA prepared by Japan in 2012*
- *Approved in IAEA in November 2012 for 2014 -2015 biannual plan*
- *Coordination Meetings*
  - ✓ *February 2013 – Vienna*
  - ✓ *July 2013 – Tokyo*
- *Draft of "Proposal for a New Coordinated Research Project" prepared*

Official Meetings

- *First Meeting of the CRP in Vienna in June, 2014*
  (participants from 12 countries and 2 international institutes)
- *Second Meeting in Spain (Madrid and Zorita) in January 13-15, 2015*

Purpose of the New IAEA CRP

To establish international collaboration aimed to collecting, measuring, recording and analysis of properties of sample materials removed from SSCs of decommissioned NPPs or replaced components, which are subject to physical ageing,

- ***addressing synergetic effects of combination of different degradation mechanisms in real operational conditions,***
- ***providing basis for comparison with results of laboratory tests and calculations; and***
- ***providing possibility for removing of unnecessary conservatism.***

New IAEA Coordinated Research Project

The specific objective of the CRP will address degradation mechanisms of mechanical, electrical and I&C components and also structures,

CRP Phase 1 (2014-2017)

1. ***RPV***
2. ***Core internals***
3. ***Concrete structures, and other non-metallic materials***

Additional Topics in CRP Phase 2 beyond 2017

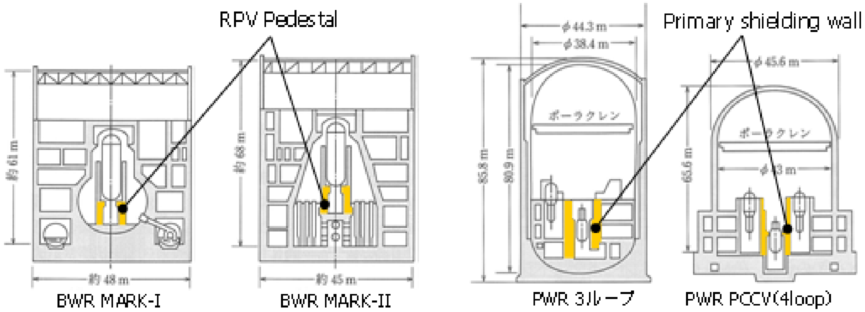
(can be initiated in 2015 or later)

1. ***Low-cycle fatigue including environmentally assisted fatigue***
2. ***Degradation of cable insulation and electrical and I&C penetrations***

Research Project funded by NRA on Concrete

Targeted member

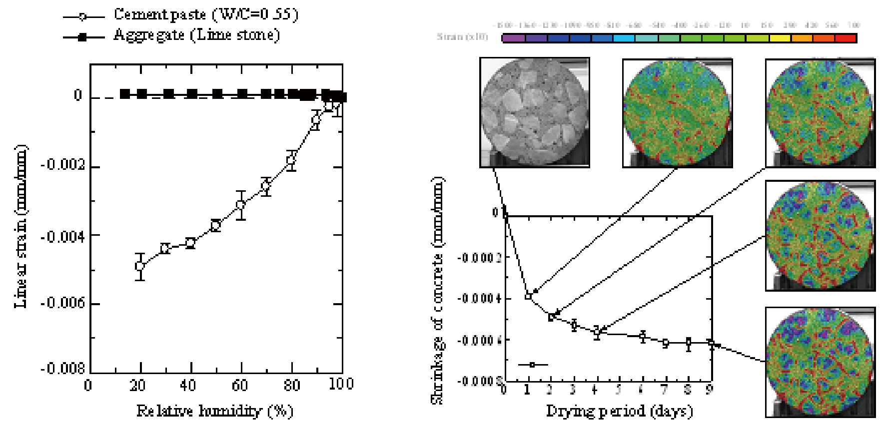
- RPV pedestal in BWR and First shielding wall in PWR are targeted mambers.



Targeted reinforced concrete member in BWR (after nuclear power plant handbook)

Targeted reinforced concrete member in PWR (after nuclear power plant handbook)

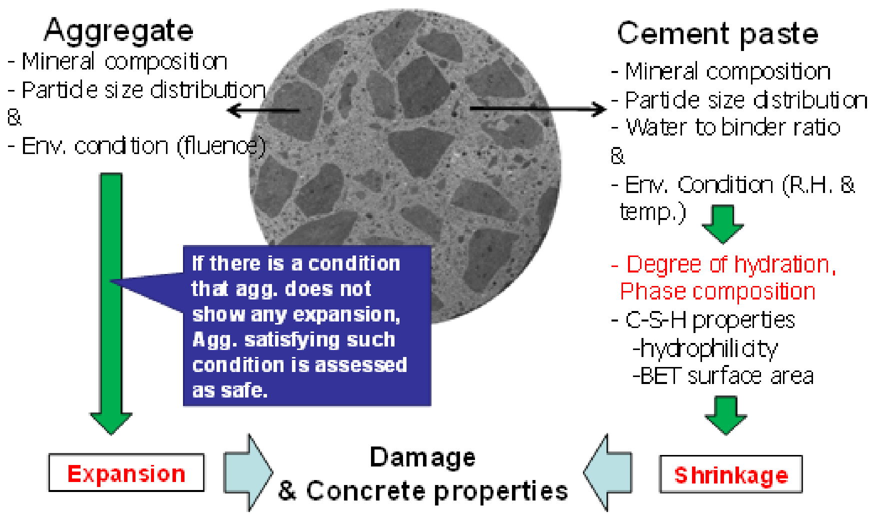
Heterogenous behavior in concrete.



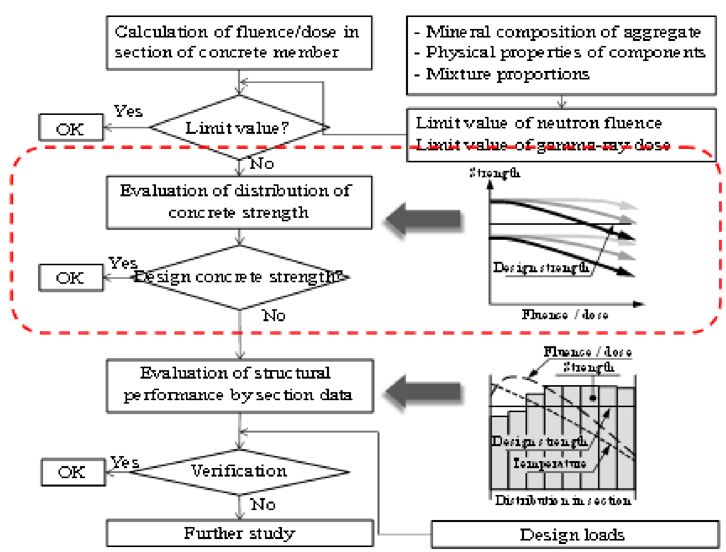
(a) Shrinkage strain of cement paste and aggregate

(b) Shrinkage strain and internal strain distribution of concrete

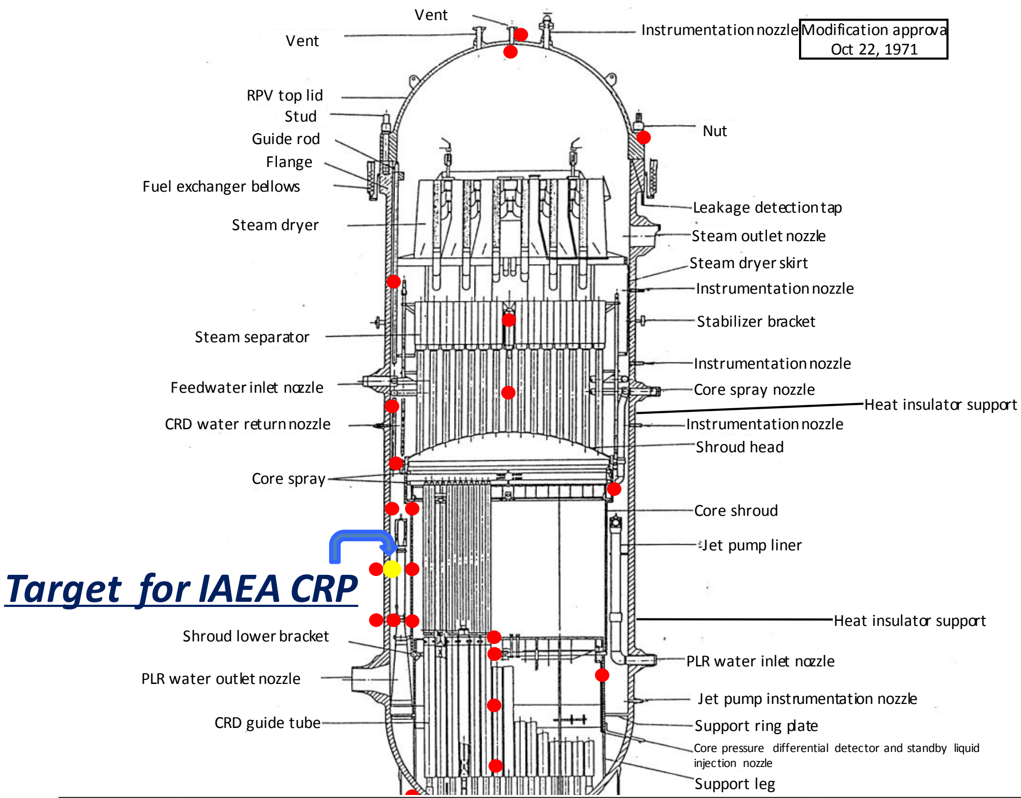
Assessment method (level 1)

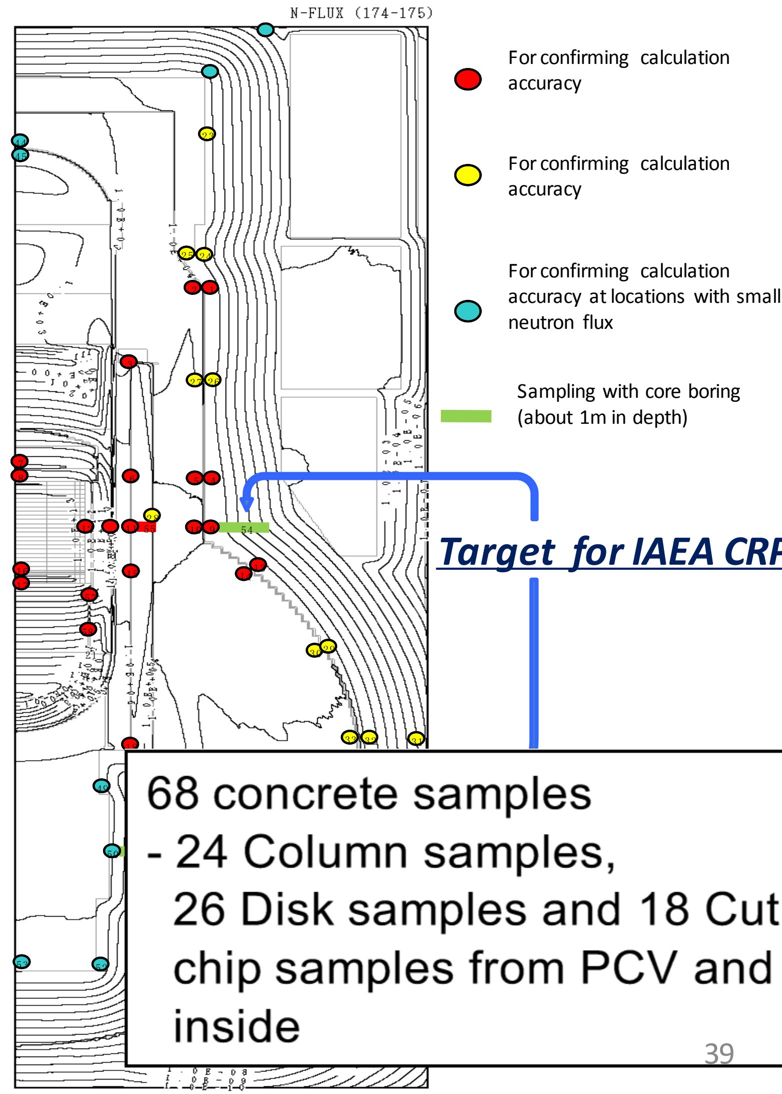


Assessment methods



Sampling of RPV Materials and Concrete Structure from the Decommissioning Reactor : Hamaoka Unit 1

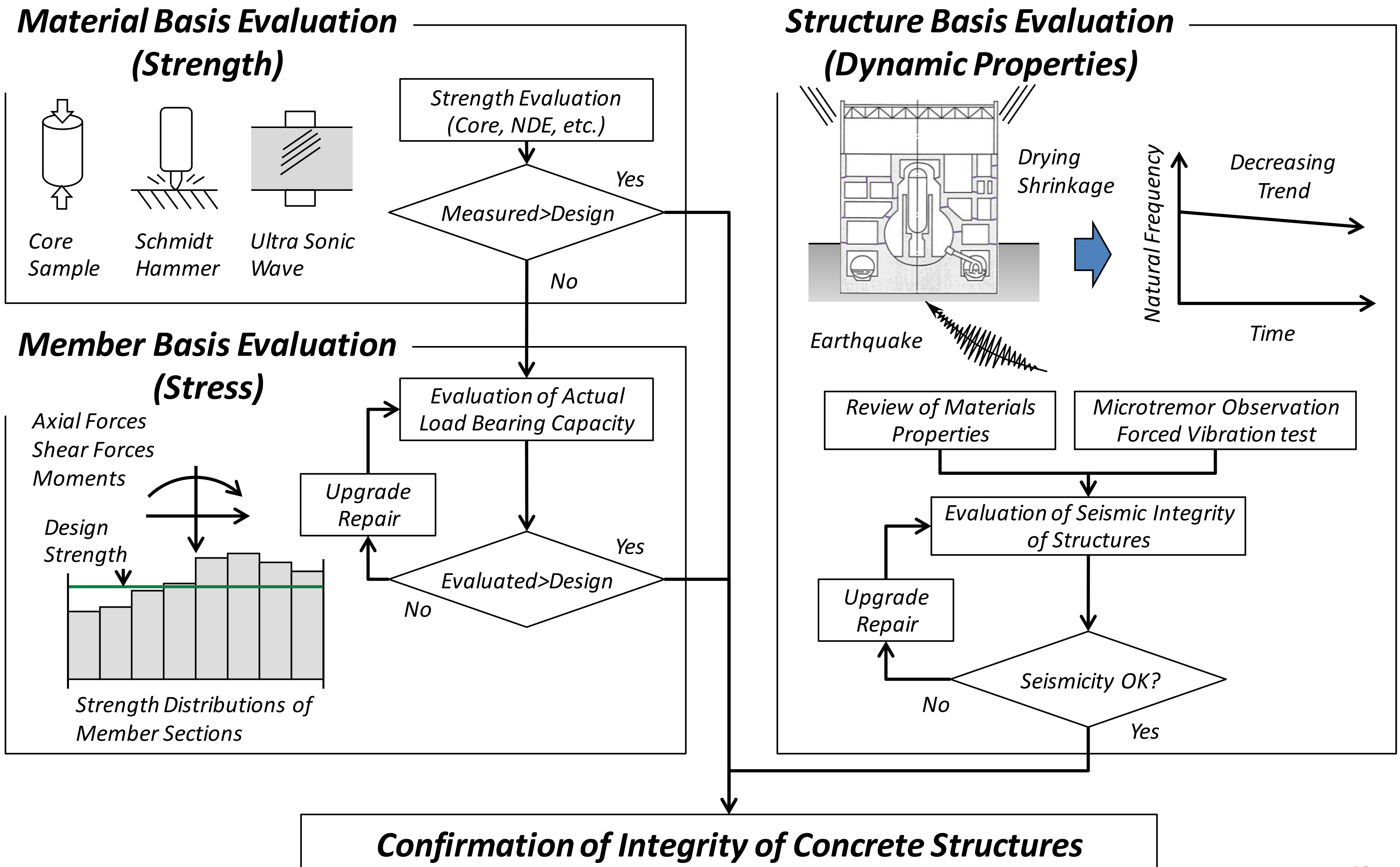




27 metal samples
- 5 Boat samples from RPV belt-line
- 5 Column samples from Shroud
- 10 Disc samples from Top guide etc.)
- 7 Cut chip samples from RPV top,bottom&side

68 concrete samples
- 24 Column samples,
  26 Disk samples and 18 Cut chip samples from PCV and inside

Integrity Evaluation System of Concrete Structures



"IAEA New Coordinated Research Project", ORNL Meeting (July 30, 2013) , Osamu Kontani, Kajima Corporation,