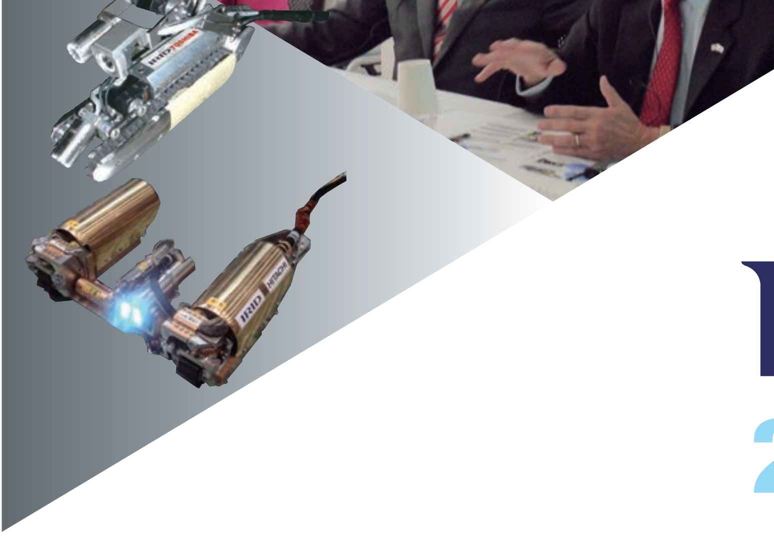


Integrated management of knowledge and expertise in nuclear decommissioning gathered from around the world

IRID

2016-2017

International Research Institute for Nuclear Decommissioning

Our Vision

Purpose

To conduct testing and research related to the decommissioning of nuclear power stations, and implement projects aimed at improving technological level of IRID member organizations and to put technologies they develop into practical use.

Basic Principles

We devote ourselves to research and development (R&D) of technology for the current, most urgent challenge – the decommissioning of the Fukushima Daiichi Nuclear Power Station (NPS) – from the standpoint of strengthening the foundation of nuclear decommissioning technology.

Our Principles in Action

1. We work on R&D projects effectively and efficiently while advancing integrated project management to develop and propose the best technologies and systems that are able to be applied on site at the Fukushima Daiichi NPS at the early stage in the face of numerous extremely difficult technological challenges.

2. We build an optimal R&D structure through cooperation with relevant organizations as well as IRID member organizations and gathering knowledge from Japan and abroad.

3. We actively promote efforts to develop and secure human resources who will comprise the next generation of those working in nuclear decommissioning and related technologies, including efforts to collaborate with universities and research institutions.

4. We strive to release information on our R&D activities and results to obtain the understanding of Japanese people, including those in Fukushima, and the international community to relieve their anxieties.

5. We form an international research hub (center of excellence) through our R&D activities and contribute to acceleration of the decommissioning of the Fukushima Daiichi NPS and improvement of technological capabilities in the international community.

CONTENTS

Message from the President

Since it was established in August 2013, the International Research Institute for Nuclear Decommissioning (IRID) has been fully committed to research and development of technologies required for addressing the urgent issue of decommissioning the Fukushima Daiichi Nuclear Power Station (NPS). Since the Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NDF) was reorganized from the Nuclear Damage Liability Facilitation Fund in August 2014, the roles of the four major entities involved in the decommissioning of the Fukushima Daiichi NPS have been clarified; the NDF that is responsible for formulating decommissioning strategies and R&D plans, Tokyo Electric Power Company Holdings, Inc. (TEPCO) that is responsible for on-site operations, and IRID in its capacity of leading R&D for decommissioning technologies and the Japanese Government. These four key players work closely together in decommissioning efforts.

As a result, the situation inside the reactor has been gradually ascertained through our R&D work and the development of technology for investigation inside the Primary Containment Vessel (PCV) such as the use of cosmic-ray muons to detect fuel debris inside the reactor. Meanwhile, major technical issues to be tackled in order to retrieve fuel debris have been presented.

Under these circumstances, the milestones for fuel debris retrieval were clarified in the government-led “Roadmap towards the Decommissioning of TEPCO’s Fukushima Daiichi NPS” (hereinafter called the Mid-and-Long-Term Roadmap) revised by the government in June 2015. In addition, the NDF revised the “Technical Strategic Plan 2016 for Decommissioning of the Fukushima Daiichi NPS” to provide technical evidence for the Mid-and-Long-Term Roadmap in July 2016. The R&D for fuel debris retrieval is about to enter a crucial phase.

Over five years have passed since the Fukushima Daiichi NPS accident occurred in the wake of the Great East Japan Earthquake. A large number of residents in Fukushima Prefecture are still living as evacuees and the Japanese public is concerned about the decommissioning of the Fukushima Daiichi NPS. To enable evacuees to return home as soon as possible and ease public anxiety, it is essential that decommissioning proceeds safely and steadily. IRID is committed to its responsibility of making steady achievements in R&D for decommissioning, and gathering knowledge from all over the world, conducting R&D projects required for effective and efficient decommissioning according to the purpose of its establishment. We sincerely appreciate your guidance and continued support.

December 2016

International Research Institute for Nuclear Decommissioning

Hirofumi Kenda, President

Role of IRID

IRID is a body comprised of 18 organizations that are key players engaged in the research and development required for decommissioning the Fukushima Daiichi NPS.

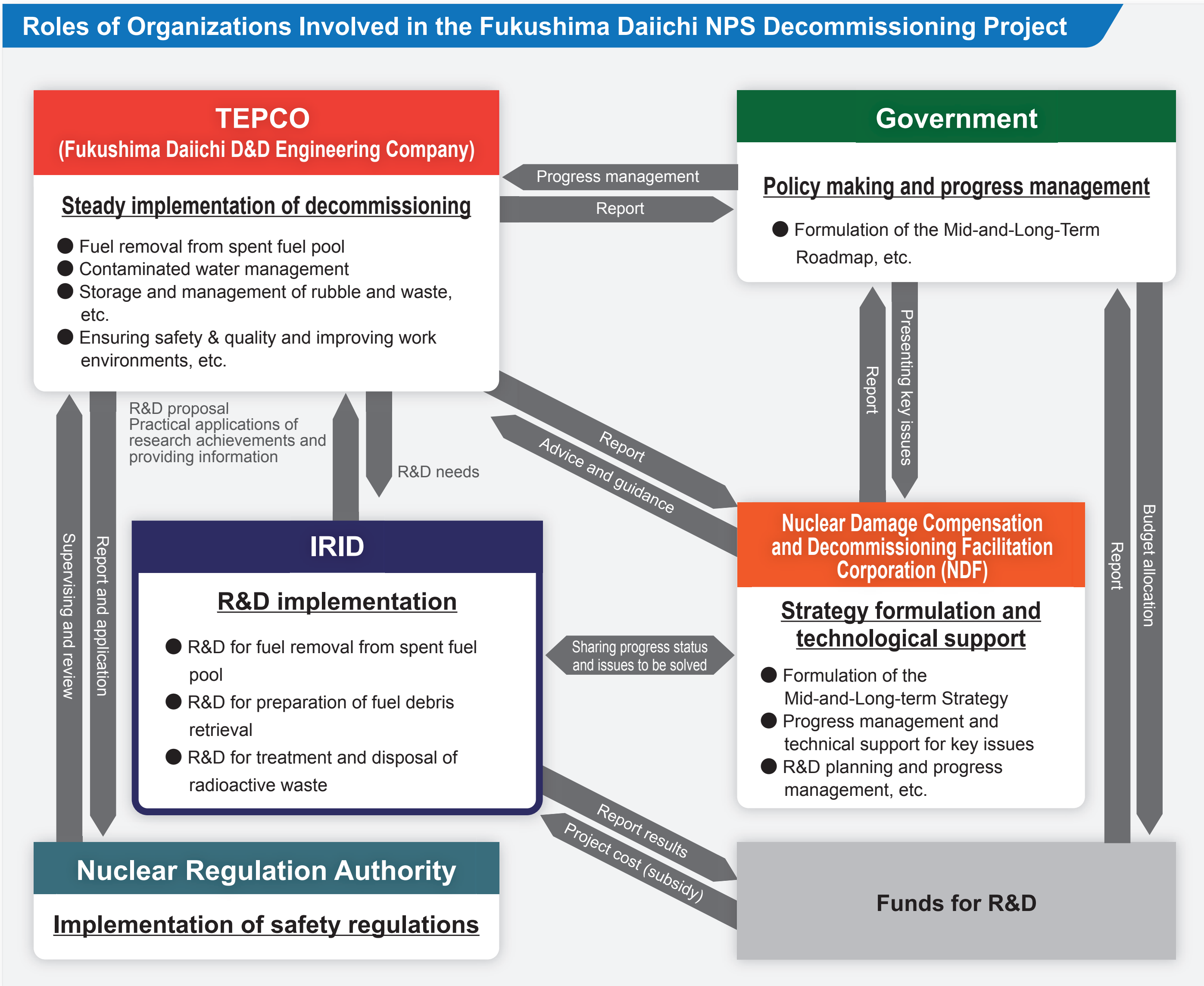
IRID intends to bring together decommissioning and other relevant technologies required for decommissioning all nuclear power stations in Japan in future. However, at the present time, we are addressing R&D for decommissioning of the Fukushima Daiichi NPS as it is the most urgent issue at this time, as outlined in the government-led Mid-and-Long-Term Roadmap.

In order to undertake the unprecedented and extremely difficult – even by global standards – task of decommissioning the Fukushima Daiichi NPS, IRID continues to gather knowledge from around the world to conduct efficient and effective R&D required for decommissioning.

A structure has been established in which three organizations cooperate closely together as one team and where each role for decommissioning the Fukushima Daiichi NPS is clarified: the NDF formulates strategies and R&D plans for decommissioning, TEPCO's Fukushima Daiichi Decontamination and Decommissioning (D&D) Engineering Company performs on-site operations, and IRID conducts R&D.

For its part in this structure, IRID, through its R&D, actively works on risk reduction, ensuring safety, environment preservation, etc., which are required for the decommissioning of the Fukushima Daiichi NPS and help relieve the anxiety felt by people in Fukushima Prefecture and the rest of Japan.

Role of IRID



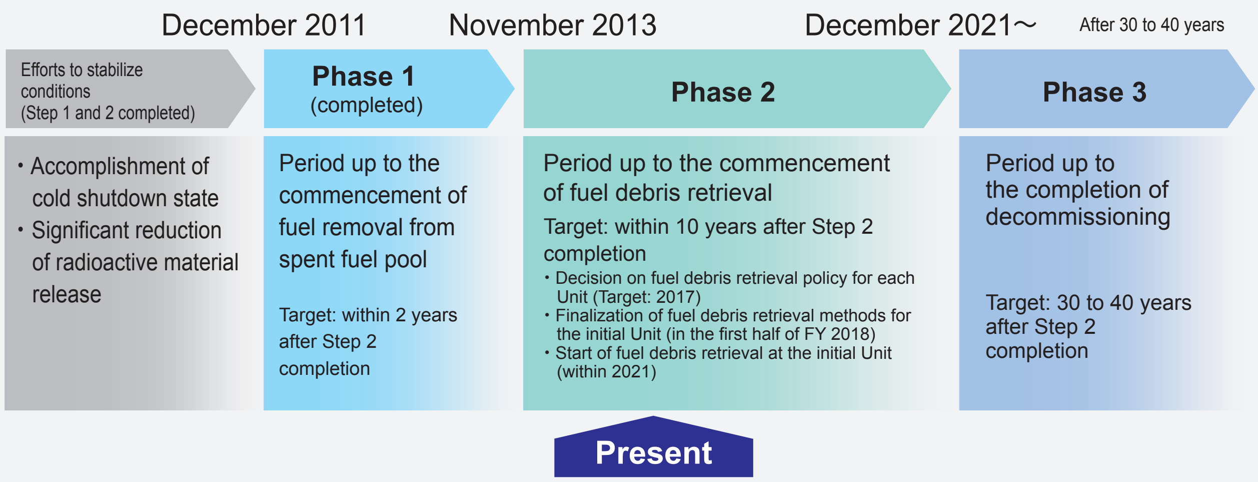
Decommissioning Schedule in the Mid-and-Long-Term Roadmap

“The Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi NPS” (Mid-and-Long-Term Roadmap) has been formulated based on current knowledge and analysis of conditions for each Unit at the Fukushima Daiichi NPS. The third revision of the Roadmap was issued on June 12, 2015. The revised Mid-and-Long-Term Roadmap provides a target schedule of the decommissioning under the premise that it is subject to be revised according to future on-site conditions and R&D results, etc.

The Roadmap divides the decommissioning period into three phases. Currently, R&D is taking place to prepare for fuel debris retrieval in the second phase. IRID is also visually confirming conditions inside the reactor using cosmic ray muon tomography and investigating inside the Primary Containment Vessels (PCVs) utilizing robots. Conditions inside the reactor have previously only been estimated through analysis codes. Through this work, we have gradually collected data that enables us to study technological difficulties and explore new approaches to proceed with R&D for decommissioning.

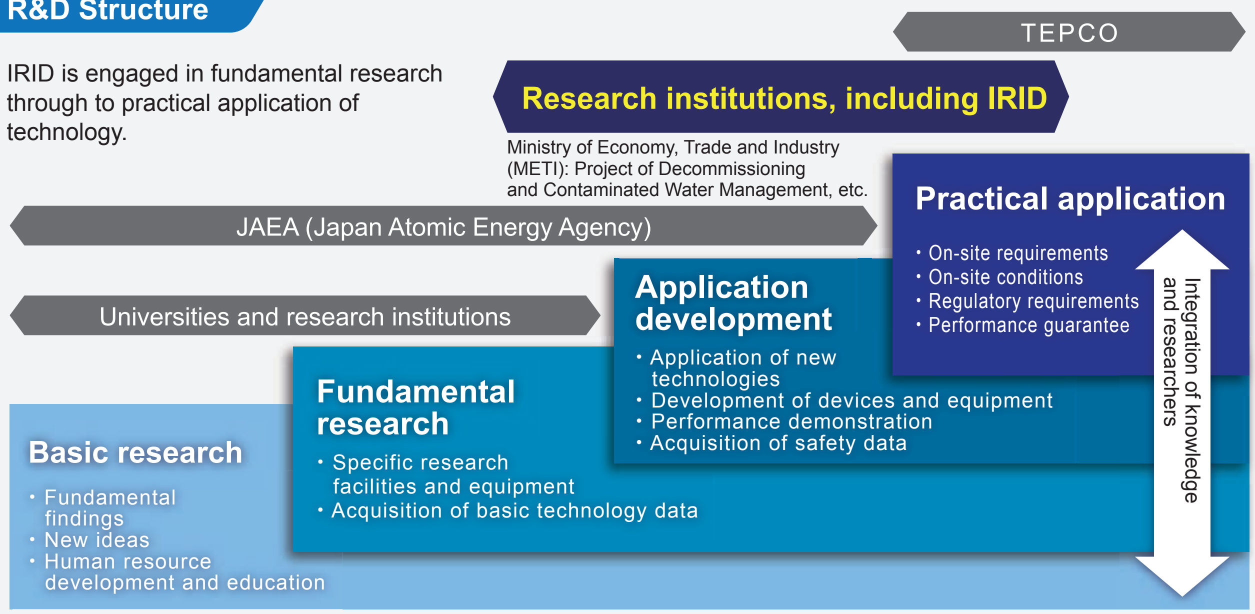
Phases Defined in the Mid-and-Long-Term Roadmap and R&D Structure

Phases in the Mid-and-Long-Term Roadmap



R&D Structure

IRID is engaged in fundamental research through to practical application of technology.



<Resource> The above charts were created based on the Mid-and-Long-Term Roadmap (Third revision), June 12, 2015.

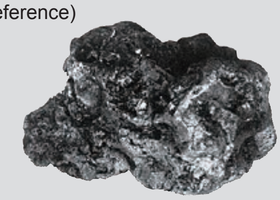
R&D for Nuclear Decommissioning

IRID R&D

IRID conducts research and development to proceed with decommissioning of the Fukushima Daiichi NPS, according to the Mid-and-Long-Term Roadmap. The key area is the advancement of decommissioning strategy. IRID is therefore studying whether there are any other appropriate approaches, how to reduce risks, etc., while exploring how to achieve an optimal end state through tie-ups with TEPCO and other relevant organizations.

Our main decommissioning R&D projects are: "R&D for Fuel Removal from Spent Fuel Pool", "R&D for Preparation of Fuel Debris Retrieval", and "R&D for Treatment and Disposal of Radioactive Waste".

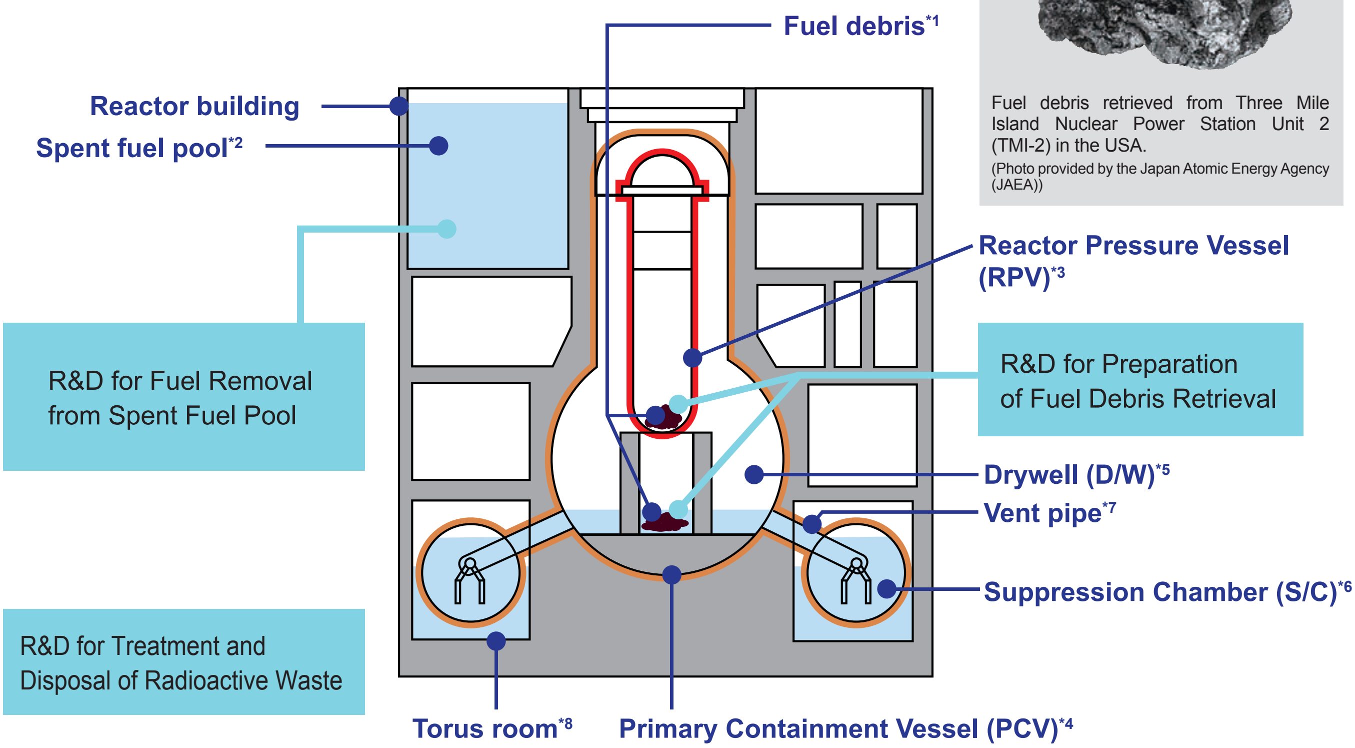
(Reference)



Fuel debris retrieved from Three Mile Island Nuclear Power Station Unit 2 (TMI-2) in the USA.

(Photo provided by the Japan Atomic Energy Agency (JAEA))

Overview of the Reactor Building and R&D Conducted by IRID



*1 Fuel debris: Lava-like fuel containing material that is produced under high temperatures through melting with control rods and structures inside the RPV, after which it cools and re-solidifies.

*2 Spent fuel pool: A water tank that stores spent fuel that is inserted in a rack under water until decay heat generated from fission products decreases. This tank is located on the top floor of the reactor building.

*3 Reactor Pressure Vessel (RPV): A cylindrical steel container that houses fuel assemblies. This container can resist high-temperature water and high-pressure steam generated by the energy released by nuclear fission inside. The RPV is housed within the PCV together with cooling equipment

*4 Primary Containment Vessel (PCV): A steel container that houses the RPV, cooling equipment, and other devices that perform important functions. This prevents radioactive substances from being released into the outside environment under abnormal plant conditions, such as when a reactor accident occurs, or in the event of a breakdown of cooling equipment. It should be noted that each of the PCVs installed in Units 1-3 at the Fukushima Daiichi NPS consists of a flask-shaped drywell, a doughnut-shaped suppression chamber and eight vent pipes connecting the drywell and the suppression chamber.

*5 Drywell (D/W): Safety structure that is comprised of a flask-shaped container that houses equipment, including the RPV, and contains radioactive substances at the time of an accident.

*6 Suppression chamber (S/C): Doughnut-shaped equipment that stores water located in the basement of the reactor building. Condenses vapor generated in the case of reactor piping breakage and prevents excess pressure from building up. It also serves the important function of providing a water source for the Emergency Core Cooling System (ECCS) in the case of a loss-of-coolant accident.

*7 Vent pipe: Connecting piping that takes vapor generated within the D/W to the S/C in case of a reactor pipe breakage. Eight vent pipes are installed in the PCV of Units 1-3 at the Fukushima Daiichi NPS.

*8 Torus room: A room containing the torus-shaped (doughnut-shaped) S/C located in the basement of the reactor building.

Fuel Debris

Units 1-3 at the Fukushima Daiichi NPS lost all power supply at the time of the accident, disabling water injection into the RPV. This resulted in the fuel inside the RPVs overheating without water to cool it down and it is thought temperatures rose above 2,000 degrees Celsius - high enough to melt the fuel rods.

It is assumed that the overheated fuel melted along with control rods and other structural components inside the RPVs and the melted material solidified again after reaching the bottom of the RPVs, and partially at the bottom of the PCVs. This solidified material is called "fuel debris."

The shape and location of fuel debris can only be estimated at the present time, since radiation levels inside the PCVs are still extremely high and workers cannot gain access.

The decommissioning process demands fuel debris retrieval and stored under safe and stable conditions.

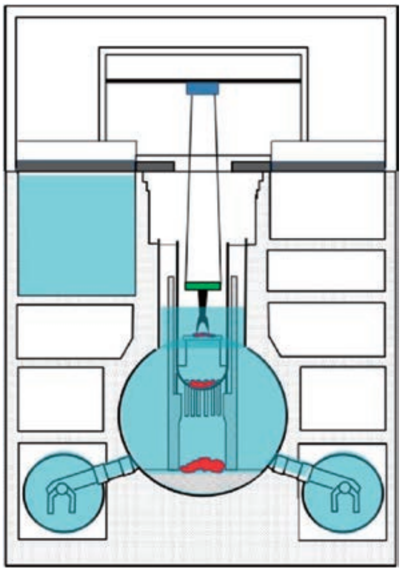
Study of Options for Fuel Debris Retrieval Methods

Taking the Three Mile Island accident in the USA as a precedent, we have studied fuel debris retrieval methods while prioritizing the "submersion method," whereby fuel debris is fully submerged in water. This is because the method offers advantages in that water is expected to provide a shielding effect against radiation and dust scattered during the fuel debris retrieval process. This helps reduce the radiation exposure for workers.

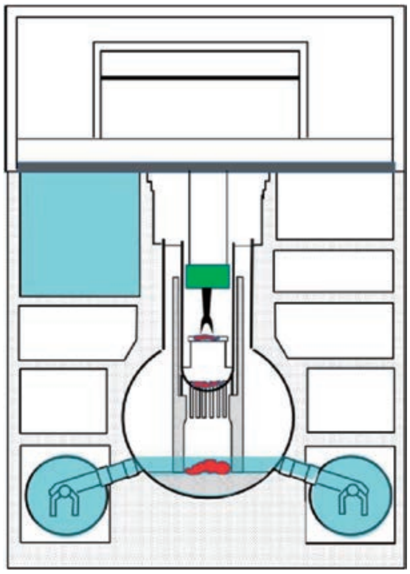
However, in order to submerge fuel debris under water, it is necessary to fill the upper part of the PCVs that have been affected by the severe accident at the Fukushima Daiichi NPS with water. There are many developmental challenges in repairing the PCVs and stopping water leakage. It is therefore assumed that it may be difficult to fully submerge fuel debris in water. Given these points, the Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NDF) suggested, in its Technical Strategic Plan 2015 for Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company, that there is a need to study not only the submersion method, but also the partial submersion method where fuel debris is retrieved with a part of it being exposed to the air.

The NDF also showed three fuel debris retrieval methods to be focused on as options that consider water levels in the PCVs and fuel debris access direction (top and side), based on the viewpoints of the progress status and feasibility of technology development and risk management.

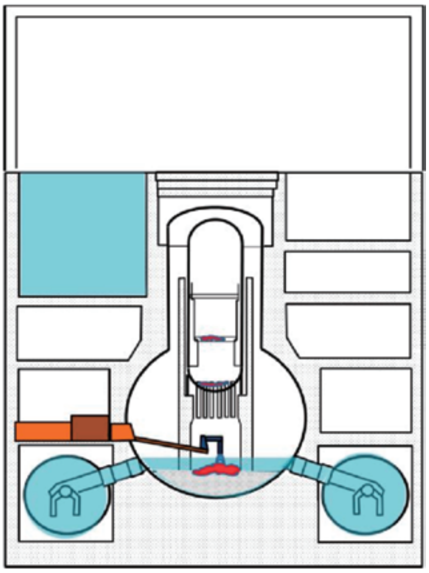
Three Representative Methods for Fuel Debris Retrieval of Primary Focus - Conceptual Diagrams



Submersion—Top entry method
Assuming in-core structures above the fuel debris are removed



Partial submersion—Top entry method
Assuming in-core structures above the fuel debris are removed



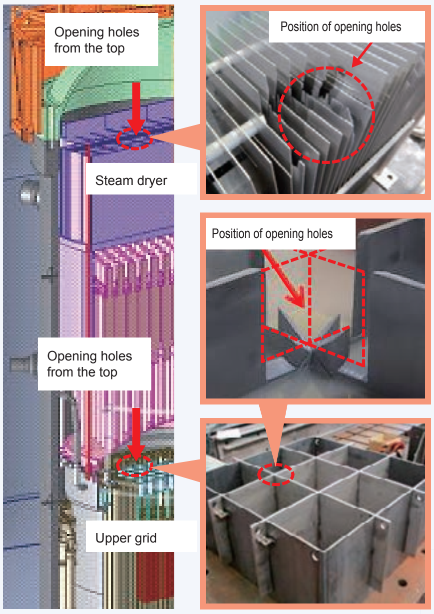
Partial submersion—Side entry method
Assuming equipment and other objects outside the RPV pedestal in the PCV are removed

<Source> NDF "Technical Strategic Plan 2015 for Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company"

Overview of IRID R&D Projects

Technology for Investigation

Technology for Investigation inside the RPV



Elemental test condition for opening holes using partial simulated reactor internals test device

Technology for Investigation inside the PCV

Development of investigation robots inside the PCV

Technology for Detection of Fuel Debris

Technology for Detection of Fuel Debris

Simulated image

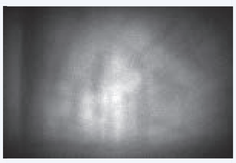
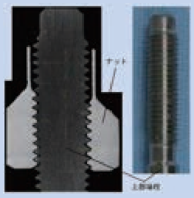


Image captured by muon tomography

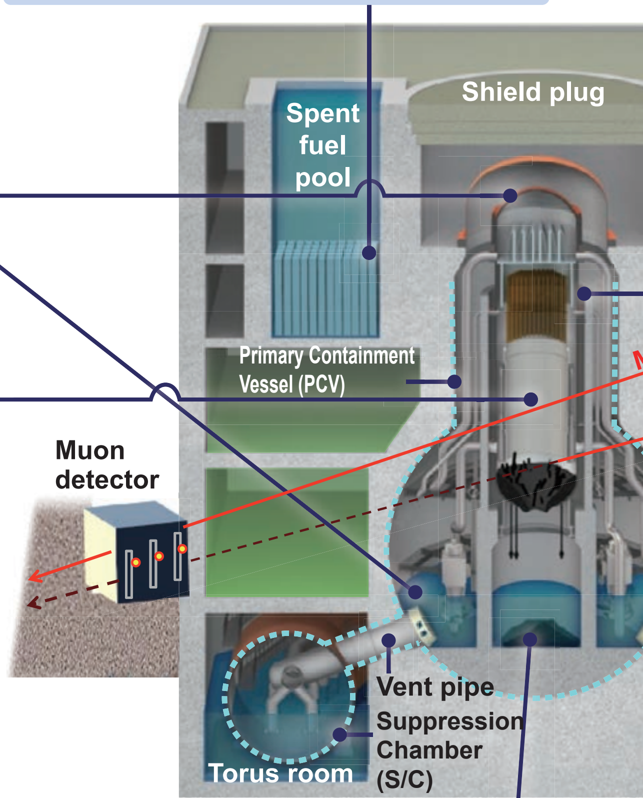
R&D for Fuel Removal from the Spent Fuel Pool

- Evaluation of long-term structural integrity of fuel assemblies (corrosion tests under assumed storage environments for removed fuel assemblies and investigation of actual fuel assemblies)
- Study of methods of processing damaged fuel and evaluation of impact on damaged fuel when it is processed



Corrosion evaluation

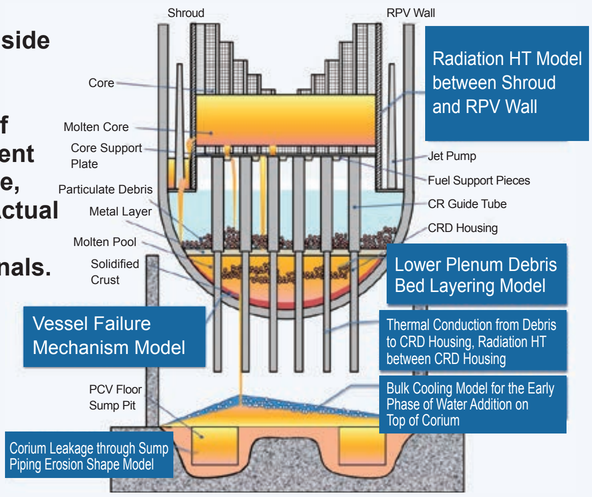
Investigation of the condition of stored fuel



Technology for Investigation and Analysis (Characterization) inside the Reactor

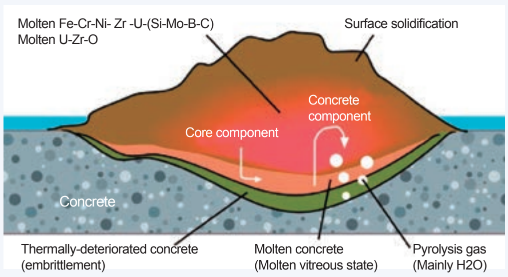
Identifying Conditions inside the Reactor through Application of Severe Accident Analysis Code, Data on the Actual Reactor, and Reactor Internals.

Improvement of the physical phenomenon model



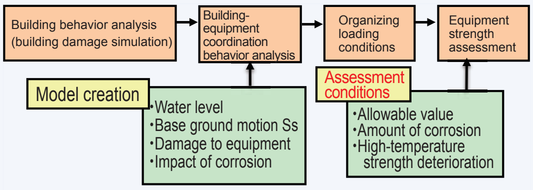
Fuel Debris Characterization

Characterization using simulated debris

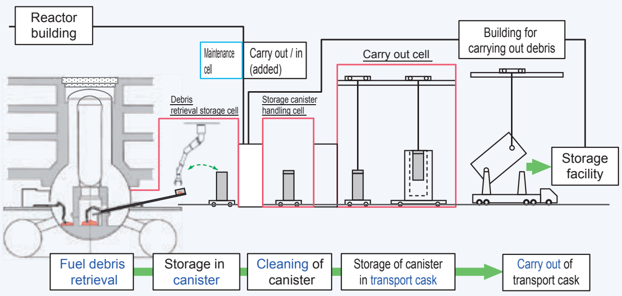


Technology for Fuel Debris Retrieval

Technology for Evaluating the Integrity of the RPV/PCV



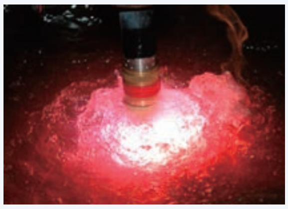
Technology for Collection, Transfer and Storage of Fuel Debris

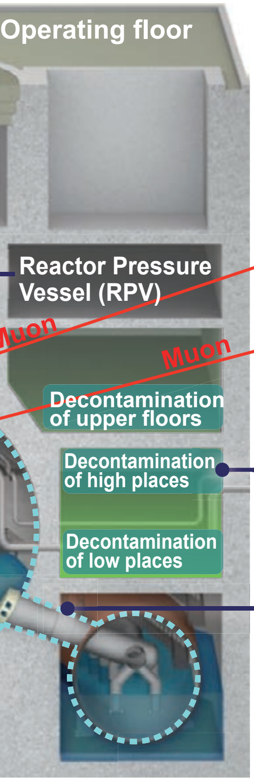


Criticality Control Basic Concept

	PCV submersion		Debris retrieval
Criticality control methods	Pure water	Boric acid water solution	Retrieving while confirming subcriticality condition
	Submerging gradually while confirming subcriticality condition	Same as left	
Criticality prevention system (PS)	Submerging gradually at limited speed while confirming subcriticality condition	● Criticality prevention by boric acid	● Monitoring subcriticality of criticality approach detection system nearby debris ● Criticality prevention by soluble/insoluble neutron absorbing material
Mitigation of impact at the time of criticality (MS)	Criticality detection by FP gamma detector system using gas sampling, and terminating criticality by injecting boric acid solution		Same as left

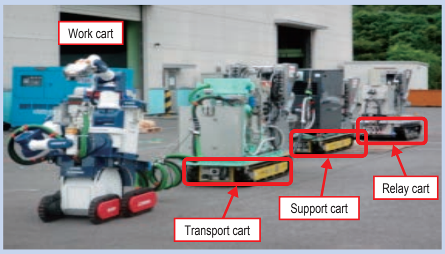
Technology for Retrieval of Fuel Debris and Reactor Internals





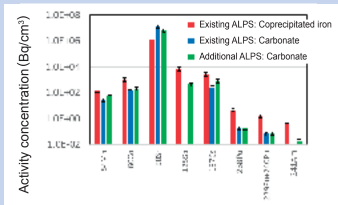
Technology for Decontamination and Dose Reduction

Technology for Remotely-operated Decontamination in the Reactor Building



Upper floor decontamination equipment (mounted suction/blast decontamination equipment)

Technology for Treatment and Disposal of Solid Waste



Analysis data of radioactive waste (slurry) generated by ALPS operation

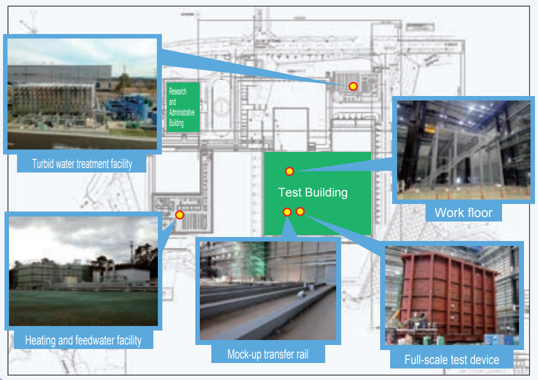
Full-scale absorber vessel to be used for various absorption tests

Pressure filtering test device to examine dehydration treatment of ALPS slurry

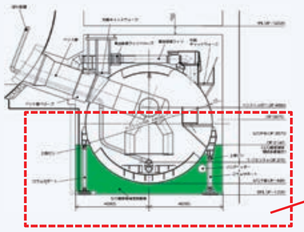
Technology for Repair and Water Stoppage of the PCV

Full-scale Mock-up Test

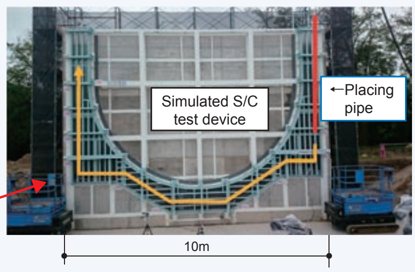
Preparation for testing



Repair Technology for Water Leakage Section of the PCV



Reinforcement material placing in Unit 1 S/C support column (green area)



Verification test for evenly balanced flow behavior for strengthening S/C support column (1/1 scale: Simulated Unit 2 and 3)

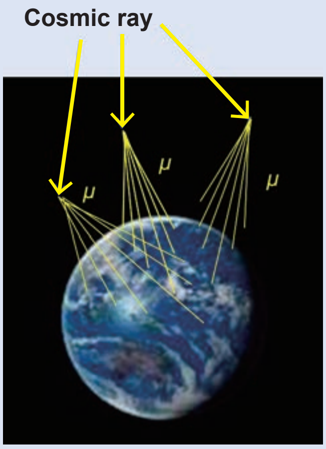
Down-comer long-distance fluidity testing

Major R&D Topics

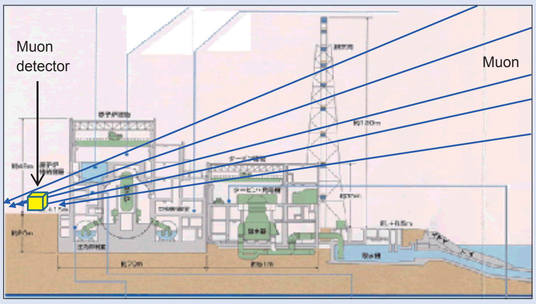
Cosmic Ray Muon Tomography inside the Reactor

Muon particles (muons) are generated by the collision of cosmic rays with the earth's atmosphere; each second, about one muon particle falls on our palms. Muons are characterized by their ability to easily penetrate materials. Some muons, however, cannot penetrate substances because they lose a part of their energy due to interaction with electrons in the process of penetration. Others are deflected from their initial direction due to interaction with nuclides. In collaboration with research institutions all over the world including Japan*, IRID has developed a transmission method system to detect the aforementioned phenomenon and other system using the scattering method that detects the latter muon phenomenon. We successfully visualized inside the reactor at Fukushima Daiichi NPS Unit 1 by the transmission method in 2015, and at Unit 2 in 2016. As a result, we determined that some fuel remains in the Unit 1 reactor core where it originally existed, and high density materials that are assumed to be fuel debris were identified at the bottom of the Unit 2 RPV.

* High Energy Accelerator Research Organization (KEK), Los Alamos National Laboratory (LANL), etc.



About one muon particle falls on a size of human hand on the earth each second.

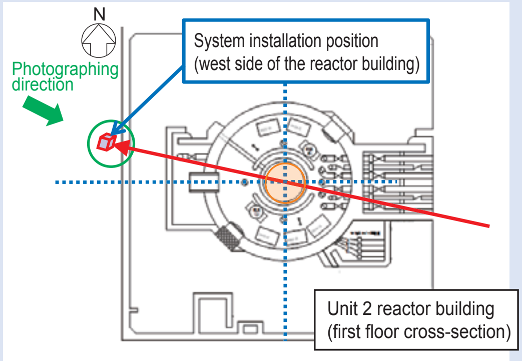


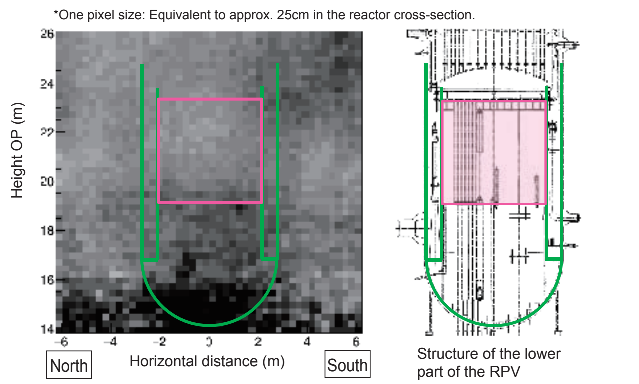
Measuring existence and density of materials at the incoming muon direction based on the measurement amount of muons falling on the reactor (image)

Fuel debris measurement in the Unit 2 reactor by transmission method*

(Small measurement device, approx. 1m x 1m x height 1.3m)

Ground contact area is five times smaller than for the Unit 1 measurement system; therefore, the measurement system can be placed closer to the reactor building and thoroughly measure the bottom of the RPV.





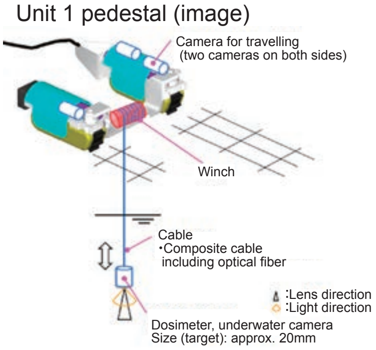
High density materials that are assumed to be fuel debris at the bottom of the RPV were identified.

*TEPCO Holdings Inc. conducted the measurement at Unit 2 as a part of an IRID project.

Investigation Technology Inside the Primary Containment Vessel (PCV)

Robots Designed for Investigating Inside the Unit 1 PCV (shape-changing robot)

Investigation of basement outside of Unit 1 pedestal (image)



*This figure describes an image based on a concept studied by IRID. It might be changed according to an actual investigation.

Investigation Robot inside the Unit 2 PCV

IRID has developed a robot to investigate inside the pedestal of the Unit 2 PCV. After entering the pedestal, the shape of robot changes into a shape like a scorpion raising its tail to improve its field of view.

Repair Technology for Water Leakage Sections in the Reactor Containment Vessel

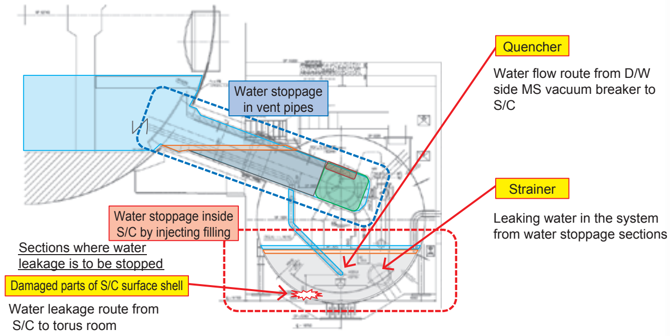
■ Water Stoppage Testing by injecting concrete into S/C

Full-scale concrete injection testing for water leakage stoppage using S/C mock-up

In order to fill the PCV with water, water stoppage treatment whereby concrete is placed into the S/C has been developed to stop water in vent pipes connected to the PCV, and also to prevent water release from the S/C to other systems.
A water stoppage test that involved injecting filling concrete into the S/C was conducted to verify water stoppage capability on October 15, 2016.
Test devices incorporating a strainer, quencher and holes (50 mm) that simulated actual damage conditions in the surface shell of S/C were manufactured. For the purpose of verification of the water stoppage capability of these devices and damaged holes, concrete was placed into the test devices. Concrete moved under water and gradually accumulated in damaged holes, quencher, and strainer, in that order. It was ultimately successful in stopping water flow.

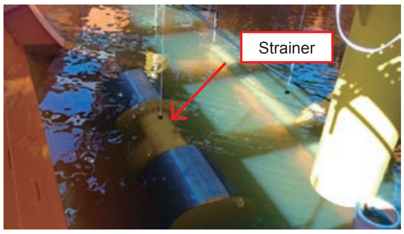
Overview of water stoppage sections

Overview of repair sections in lower part of the PCV (Ex.1F-2)



Full scale testing

Test facility during injection of concrete



Strainer before injection of concrete

■ Full-scale Mock-up Test at the JAEA Naraha Remote Technology Development Center

In order to verify on-site applicability as the last phase of the technology development, full-scale mock-up testing for the three following techniques are planned to take place at the JAEA Naraha Remote Technology Development Center. A full-scale mock-up test of one of these methods (workability verification test for strengthening S/C support columns) has been underway at the JAEA Naraha Remote Technology Development Center since November 2016.

①Vent pipe water stoppage technology

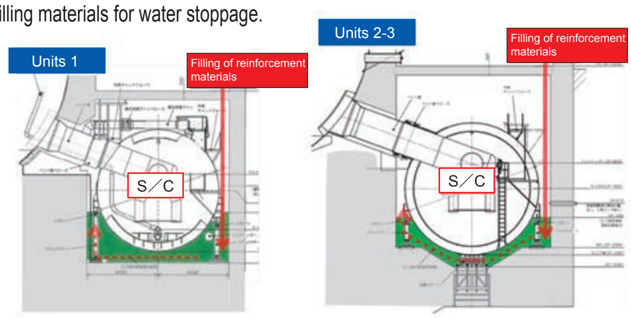
This technology is intended to stop water leakage from the PCV through vent pipes, the main path that water leakage takes, in order for submersion to take place.

②Water stoppage technology by filling of suppression chamber (S/C)

This technology is intended to stop water leaks at piping ends (quencher and strainer) and damaged parts of S/C (assumed to be belowϕ50mm).

③Technology for strengthening S/C support columns

This technology development is designed for seismic strengthening of S/C support columns, as the total weight of S/C is expected to increase due to the injection of filling materials for water stoppage.



Candidate material: mortar which does not separate in water


Lowering hose operation into a mock-up torus room


Remote operation via monitor


Mixer agitator pressure pump to inject reinforcement materials (mortar)

Information

For more information on the R&D IRID is undertaking, please visit our website or see brochures we have published.

IRID Website: http://irid.or.jp/

IRID Annual Research Report 2015

Robots

Scope of Work 2:
Promotion of Cooperation with Relevant International Organizations

IRID has striven to enhance relationships with relevant international organizations and experts in order to collect expertise from all over the world under an “open structure” management policy.

International Advisors

The International Advisor committee consists of three nuclear experts from abroad. This advisory committee was established with the purpose of advising the IRID Board of Directors on organizational operation and management.

International Advisors provide advice on future challenges and required improvements as well as leading discussion on international efforts and management approaches.

Members

Mr. Lake Barrett (USA):
Independent Consultant (former Site Director for the Nuclear Regulatory Commission (NRC) for the Three Mile Island accident)

Mr. Luis E. Echavarri (Spain):
Former Director General of the OECD/NEA (experienced in the International Nuclear Safety Group (INSAG))

Professor Melanie Brownridge (UK):
Head of Technology, the Nuclear Decommissioning Authority (NDA)

The Fourth IRID International Advisors Meeting (November 30, 2016)*
* From left: Prof. Brownridge, Mr. Echavarri, and Mr. Barrett

Meeting Schedule

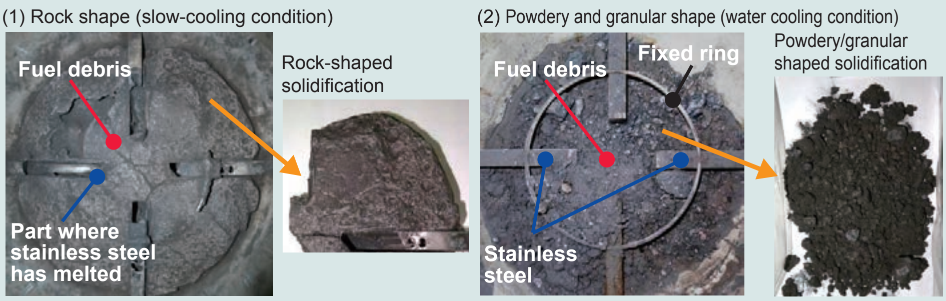
- 1st : January 9-10, 2014
- 2nd: November 17-19, 2014
- 3rd : December 2-4, 2015
- 4th : November 30−December 2, 2016

Joint Research with Overseas Research Institutions

IRID is collaborating with overseas research institutions to produce and analyze large-scale simulated debris using uranium.

National Nuclear Center of the Republic of Kazakhstan (NNC)

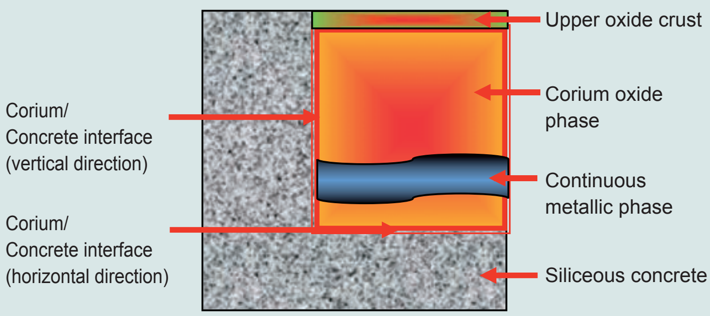
Heterogeneous solidified substances are produced by mixing and melting tens of kilograms of uranium fuel and cladding tube material, and causing a reaction of this with metal, such as reactor components.
Test samples of the solidified substance are used to study conditions when mixed with metal or ceramics, and boundary zone properties.



Production of metal ceramic melt-solidification using UO_2 at the Kazakhstan NNC

French Atomic Energy and Alternative Energies Commission (CEA: Commissariat a l'Energie Atomique et aux Energies Alternatives)

Using test products produced in Molten Core-Concrete Interaction (MCCI) testing that the CEA conducted using tens of kilograms of uranium, analysis to determine characteristics of the MCCI products was conducted.



Technical Cooperation with Overseas Nuclear Organizations

We are promoting technical cooperation with overseas nuclear organizations that have experience in nuclear decommissioning and handling damaged fuel.

Paks Nuclear Power Plant (Hungary)

Discussion focused on the handling of damaged fuel and safety concepts when storing removed fuel. Results were utilized for development of fuel debris canisters.

International Atomic Energy Agency (IAEA) Headquarters (Vienna, Austria)

Concepts of decommissioning activities for the Fukushima Daiichi NPS were discussed with an IAEA expert team consisting of engineers from various countries. We were also advised how to collect technical information required for the future.

Sellafield Ltd. (U.K.)

Information on damaged fuel handling, storage methods and criticality control after removal of fuel as well as general decommissioning activities was exchanged.

Idaho National Laboratory (U.S.A.)

IRID participated in the TMI workshop to exchange knowledge and experience gained in TMI-2 and how this may be applied to the Fukushima Daiichi NPS. We are utilizing this information in furthering decommissioning activities at Fukushima Daiichi.

Argonne National Laboratory (U.S.A.)

Information on the reaction and products of MCCI testing was exchanged with engineers with extensive knowledge of the reaction between fuel debris and concrete.

Overseas Public Relations

IRID introduces results of research and development at forums etc., organized by relevant international organizations.

IAEA International Conference on Advancing the Global Implementation of Decommissioning and Environmental Remediation Programmes (May 23, 2016)

Japan-United States Forum on Fukushima Recovery and Decommissioning (“Fukushima Recovery Forum”) (February 24, 2016)

Scope of Work 3:
Human Resources Development for R&D

Nuclear decommissioning is a long-term project that may last 30 to 40 years. It is therefore essential that we have young people engaging in nuclear decommissioning activities.
IRID is committed to promoting development of the next generation that will be involved in nuclear decommissioning R&D.

R&D in Collaboration with Universities (Achievements)

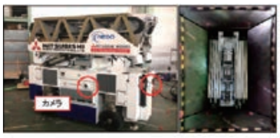
IRID has been developing technology for improving the operability of remotely operated decontamination devices in cooperation with various universities.

Technical challenges

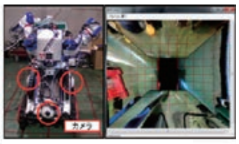
- Easy-to-understand display of conditions around robots
- Improving operability of multi-joint manipulator
- Reducing of labor required for remote control operations and cart positioning

Improvement of capability of determining surrounding conditions
[Yamashita Laboratory, University of Tokyo]

Development of technology to enable easy-adjustment of image correction, and flexibly respond to change for the type, installation position, and direction of cameras.



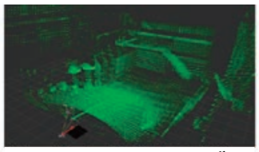
Simulated overview image captured by Super Giraffe



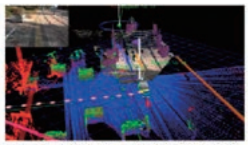
Simulated overview image captured by MEISTeR

Improvement of capability of determining surrounding conditions
[Tsubouchi Laboratory, University of Tsukuba]

Development of a system to enable the clear display of 3D measurement data obtained by mapping area around robots via cameras and laser sensors.



3D mapping data captured by Super Giraffe (under development)

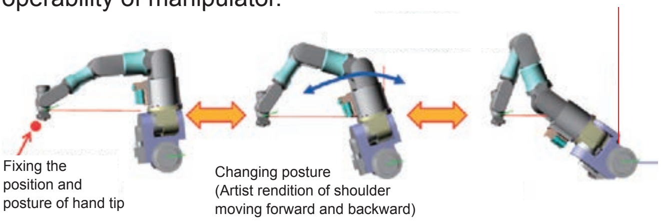


Displayed surrounding environment using sensor-captured 3D data and camera-captured images

Improvement of operability
[Yokokohji Laboratory, Kobe University]

Development of control interface to convey immediate self-motion* motor commands to improve operability of manipulator.

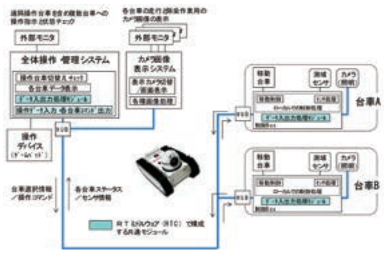
* Movement to change the manipulator's overall shape with position of hand tip and base fixed



Examples of self-motion movement of manipulator with nine degrees of freedom

Reducing labour required for operation of remote control and cart positioning
[Matsuhira Laboratory, Shibaura Institute of Technology]

Establishment of mechanism for the easy processing of data between specific devices connected on a network of multiple controllable devices.



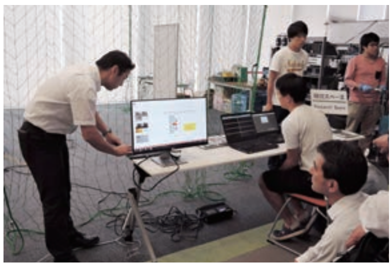
Formation of system for coordinating and controlling movement of multiple moving carts

Human Resources Development through Small Workshops with Universities

1. Small workshop with universities

IRID is promoting activities to enhance communication with young researchers and cooperate with universities partly engaged in national decommissioning projects.

Small workshop with University of Tsukuba (February 9, 2016)



Small workshop with Shibaura Institute of Technology (September 26, 2016)

2. PR activities at universities and research institutes, etc.

IRID is actively involved in the development of human resources by providing information through visits to universities and research institutes.

Lecture at the Oarai Nuclear Summer School (August 1, 2016)

Nuclear Science and Technology for Decommissioning intensive course at Tohoku University (September 15, 2016)

Lecture at National Institute of Technology, Fukushima College (October 27, 2016)

3. IRID Symposium

Entitled ‘Develop the Future for Decommissioning’, the FY2016 IRID symposium (held in Tokyo) was intended to develop young researchers and engineers who will engage in future decommissioning activities, Approximately 400 people attended the symposium.
A site tour at the Fukushima Daiichi Nuclear Power Station and JAEA Naraha Remote Technology Development Center was conducted the day prior to the symposium. The tour was attended by students and post graduate students participating in the symposium, and by Atomic Energy Society of Japan Kanto/Koshinetsu branches member universities.

Lecture at the symposium

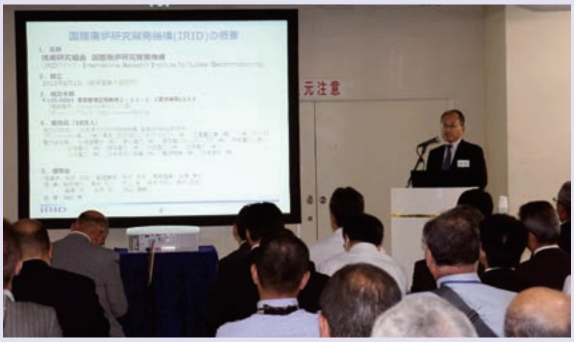
Robot exhibition

Facility visit

4. Participation in various events

IRID actively participates in lectures and events held by various organizations, including academic meetings.

Presentation at Atomic Energy Society of Japan 2016 Fall Meeting (September, 2016)



Lecture at Environmental Radioactivity Measures & Radioactive Waste Disposal International Exhibition - RADIEX2016 (October, 2016)

Exhibition at Science Agora 2016 (November, 2016)

Exhibition at Robot Festa Fukushima 2016 (November, 2016)

Information — IRID glossary is available on our website —

The IRID Glossary consists of the ‘Glossary of Nuclear Technical Terms’ (containing approx. 2,500 terms) and ‘Nuclear Abbreviation Glossary’ (containing approx. 12,000 terms).

We appreciate the opportunity to provide the IRID Glossary to companies and students engaged in decommissioning projects all over the world, and also contribute to promoting decommissioning activities related to the Fukushima Daiichi NPS.

IRID Glossary URL
▶ http://irid.or.jp/glosy_index.html

(Note) This system is available only in Internet Explorer; it is not operational in other browsers.

IRID Glossary search system

Data

Organization Profile

1. Name
Technology Research Association, International Research Institute for Nuclear Decommissioning (IRID)

2. Headquarters
5F, 3 Toyokaiji Building, 2-23-1 Nishi-Shimbashi, Minato-ku, Tokyo 105-0003, Japan

TEL: +81 3 6435 8601 (main)

3. Date of Establishment
August 1, 2013

4. Scope of Work
・R&D for nuclear decommissioning
・Promotion of cooperation on nuclear decommissioning with relevant international and domestic organizations
・Human resource development for R&D

5. Membership (18 organizations)
National Research and Development Agencies:
Japan Atomic Energy Agency
National Institute of Advanced Industrial Science and Technology

Manufacturers:
TOSHIBA CORPORATION
Hitachi-GE Nuclear Energy, Ltd.
Mitsubishi Heavy Industries, Ltd.
ATOX Co., Ltd.

Electric utilities, etc.:
Hokkaido Electric Power Co., Inc.
Tohoku Electric Power Co., Inc.
Tokyo Electric Power Company Holdings, Inc. (TEPCO)
Chubu Electric Power Co., Inc.
Hokuriku Electric Power Company
The Kansai Electric Power Company, Inc.
The Chugoku Electric Power Co., Inc.
Shikoku Electric Power Company, Inc.
Kyushu Electric Power Co., Inc.
The Japan Atomic Power Company
Electric Power Development Co., Ltd.
Japan Nuclear Fuel Limited

6. Board of Directors
President: Mr. Hirofumi Kenda
Vice President: Dr. Tamio Arai
Executive Director: Mr. Atsufumi Yoshizawa
Directors: Mr. Hirotsugu Fujiwara, Mr. Hiroto Uozumi, Mr. Ei Kadokami, Mr. Kunikazu Kishimoto, Mr. Masahiro Seto, Mr. Mamoru Hatazawa, Mr. Jun Matsumoto, and Mr. Yoshinori Moriyama
Auditor: Mr. Atsushi Isobe

7. Number of Employees
859* (excluding directors)
* Including a number of staff engaged in research conducted by IRID.
(as of October 1, 2016)

<Establishment of Organization>
August 1, 2013: Establishment approved by the Minister of Economy, Trade and Industry under the Act on Research and Development Partnership
August 8, 2013: Operation starts and holding of IRID General Meeting and Board of Directors

<Organizational Role>
IRID is dedicated to R&D activities to address the urgent issue of decommissioning the Fukushima Daiichi NPS in cooperation with the Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NDF) and Tokyo Electric Power Company Holdings, Inc. (TEPCO) in order to strengthen fundamental technologies for future decommissioning, and also develop, accumulate, and upgrade related technologies.

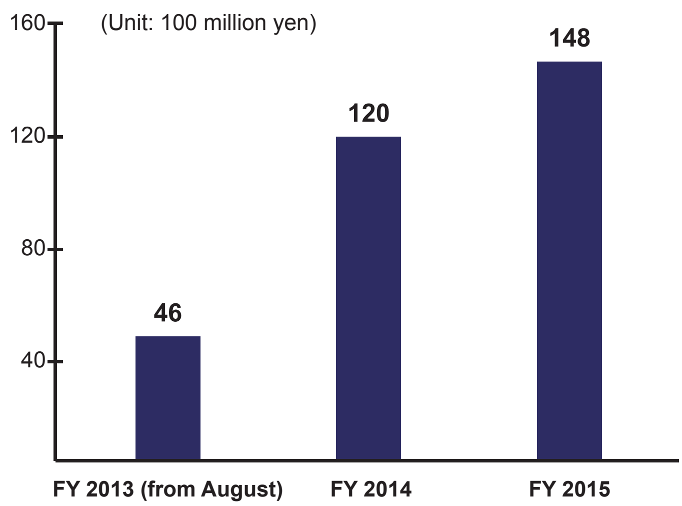
<Organizational Structure>
・IRID was established in accordance with the Act on Research and Development Partnership with an initial membership of 17 organizations, with a General Meeting as the highest decision-making authority and Board of Directors as executive body. Currently, there are 18 member organizations in total after ATOX Co., Ltd., joined in May 2015.

・Eleven directors and one auditor have been appointed. Some directors are from non-IRID member organizations (i.e., universities and private sector companies).

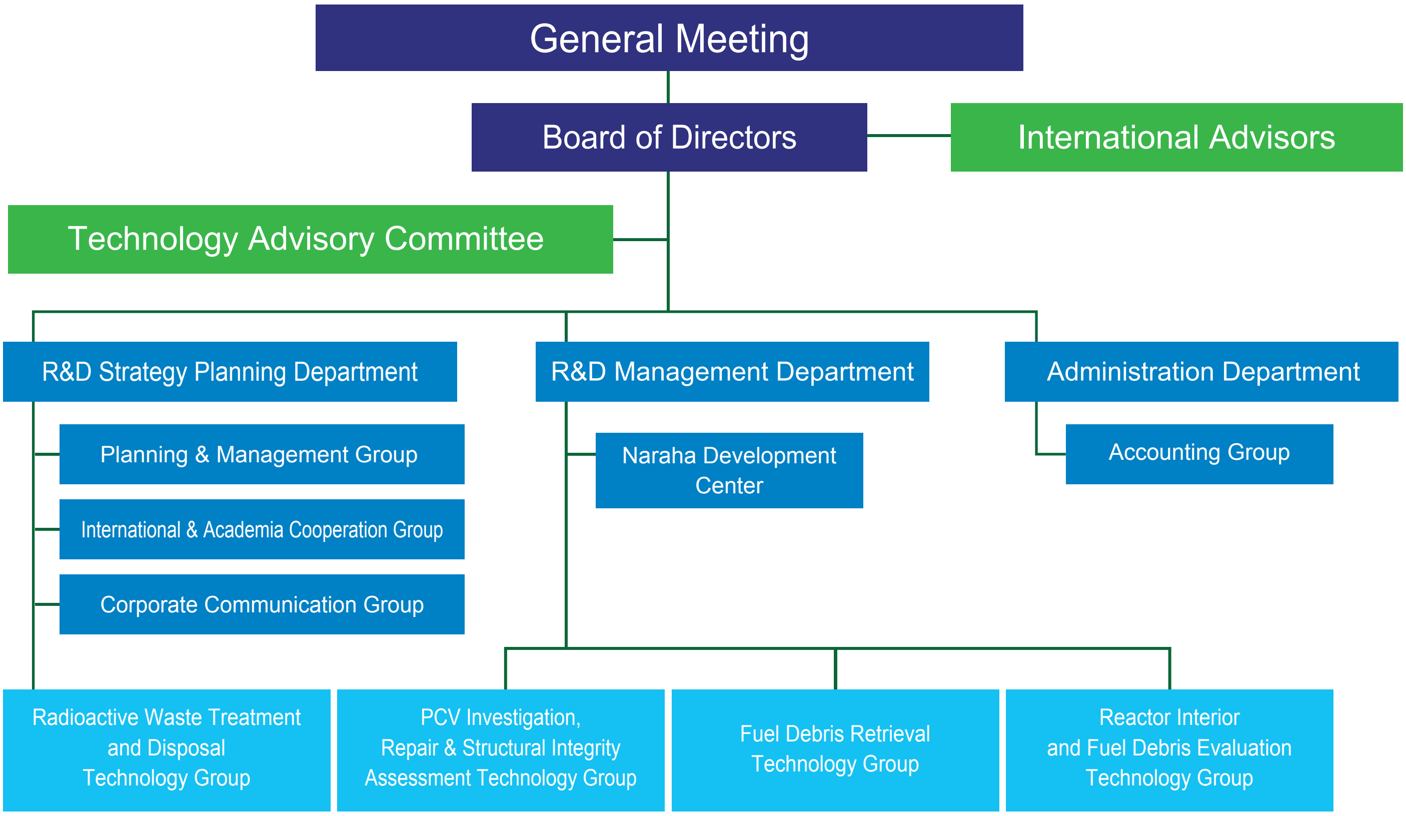
・The International Advisors and the Technology Advisory Committees have been established to obtain the latest in global expertise for promotion of decommissioning.

・IRID is comprised of three departments: the R&D Strategy Planning Department (responsible for planning, human resource development, international cooperation, and public relations); the R&D Management Department (responsible for R&D management); and, the Administration Department. In addition, there are four project teams engaged in specific research areas: the Radioactive Waste Treatment and Disposal Technology Group; the PCV Investigation, Repair & Structural Integrity Assessment Technology Group; the Debris Retrieval Technology Group; and, the Reactor Interior and Fuel Debris Evaluation Technology Group.

<Project Costs>



IRID Organizational Structure



(as of May 30, 2016)

Technology Advisory Committee / Expert Advisors

IRID established the Technology Advisory Committee to obtain advice from highly knowledgeable external experts who provide a wide range of opinions from broad viewpoints, including advice on technologies that are extremely difficult to realize based on the latest information, planning of whole projects, and human resources development, etc.

Expert Advisors provide opinions that are reflected in our R&D planning, implementation methods, and evaluation of results for each project.

The 6th Technical Advisory Committee (August 4, 2016)

Visit to robot development facility by IRID Expert Advisors (May 22, 2015)*

* 'TEMBO' equipment to remove shielding blocks and iron plates

IRID Member Technical Capabilities

1. Japan Atomic Energy Agency (JAEA)

JAEA is the sole comprehensive nuclear research and development institute in Japan. It contributes to recovery approaches and reconstruction efforts related to the Fukushima Daiichi NPS accident, bringing specific technical expertise to what it considers as its most important project.

2. National Institute of Advanced Industrial Science and Technology (AIST)

AIST conducts R&D covering seven areas: energy and environment; biotechnology; information and human engineering; material and chemistry; electronics and manufacturing; geology; and measurement standards. The AIST possesses the broad scientific knowledge and technical capabilities required for implementing IRID projects.

3. TOSHIBA CORPORATION (TOSHIBA)

As plant manufacturer, TOSHIBA has the know-how, experience, and track-record in the development of decontamination technology, inspection of storage containers, and establishment of repair and remote control technologies related to the Project of Decommissioning and Contaminated Water Management.

4. Hitachi-GE Nuclear Energy, Ltd. (HITACHI –GE)

HITACHI-GE is capable of developing applicable technology for a mid-and-long term approaches towards the decommissioning of the Fukushima Daiichi NPS. Furthermore, the organization possesses a coherent structure for the planning, designing, manufacturing, construction and maintenance of nuclear power stations, and provides operator training.

5. Mitsubishi Heavy Industries, Ltd. (MHI)

MHI brings expertise that encompasses all facets of nuclear power plants (pressurized-water reactor (PWR) type), from basic planning to design, manufacturing, construction, maintenance, and repair. The company has accumulated sufficient technology in each business area, including nuclear fuel, new reactor plants, and the nuclear fuel cycle, can effectively engage in project management when planning R&D, and has the capacity to widely utilize, apply, and develop obtained results.

6. ATOX Co., Ltd.

ATOX possesses practical capability in the operation, inspection, maintenance, decontamination, and radiation control of general nuclear facilities, with extensive know-how, experience and achievements in these fields. ATOX also has gamma irradiation facilities and high capability of developing applicable decontamination technologies.

7. Tohoku Electric Power Co., Inc., Tokyo Electric Power Company Holdings, Inc., (TEPCO), Chubu Electric Power Co., Inc., Hokuriku Electric Power Company and The Chugoku Electric Power Co., Inc.

These utilities possess extensive know-how, experience and achievements in the operation and maintenance of boiling water reactor (BWR) nuclear power stations, in addition to accumulated technologies gained through joint research with utility companies. These technologies are applicable to the management of IRID projects. Development results can also be widely applied based on the company's knowledge of and experience with nuclear power stations.

8. Hokkaido Electric Power Co., Inc., The Kansai Electric Power Company, Inc., Shikoku Electric Power Company, Inc., and Kyushu Electric Power Co., Inc.

These utilities possess extensive know-how, experience and achievements in the operation and maintenance of pressurized water reactor (PWR) nuclear power stations, in addition to accumulated technologies gained through joint research with utility companies. These technologies are applicable to the management of IRID projects. Development results can also be widely applied based on the company's knowledge of and experience with nuclear power stations.

9. The Japan Atomic Power Company (JAPC)

The Japan Atomic Power Company is engaged in demolition work at the Tokai Power Station, Japan's first commercial nuclear power plant, as part of the site's decommissioning. JAPC is committed to verifying safe and effective decommissioning activities as a pioneer in the field, and to promoting the establishment of remotely-operated demolition technology, evaluation of material quantities and radioactivity, treatment and disposal of radioactive waste, and development of project management systems, accumulating applicable technologies for future decommissioning through these efforts.

10. Electric Power Development Co., Ltd.

Electric Power Development Co., Ltd., possesses the expertise, experience, and track record in the construction of boiling-water reactor (BWR) nuclear power stations, and has accumulated various technologies through joint research with utility companies. These technologies can be effectively applied in project management for IRID projects and the company has the ability to widely apply development results based on its on-site knowledge of nuclear power plants.

11. Japan Nuclear Fuel Limited

Japan Nuclear Fuel Limited has experience uranium enrichment, waste burial and management, reprocessing, mixed oxide fuel production and transportation, and has accumulated various technologies through joint research with utility companies. In particular, the wide-ranging expertise, experience, and track record it has related to radioactive waste treatment and disposal technologies can be effectively leveraged in project management, such as determining implementation plans for IRID projects.

List of Government Subsidized R&D Projects Conducted by IRID

Subsidy Project of Decommissioning and Contaminated Water Management in the FY2014 and the FY2015 Supplementary Budgets

経済産業省 資源エネルギー庁

Key Challenge 1: R&D for Fuel Removal from the Spent Fuel Pool
Key Challenge 2: R&D for Preparation of Fuel Debris Retrieval
Key Challenge 3: R&D for Treatment and Disposal of Radioactive Waste

(as of the end of November 2016)*1

	Project Name	Project Summary	Period	Supplementary Budget	Project Maximum Cost *2 (Subsidy Rate)
1	Evaluation of Long-term Structural Integrity of Fuel Assemblies Removed from the Spent Fuel Pool	(1) Development of technology for evaluation of long-term structural integrity of fuel assemblies (2) Basic test for long-term integrity, etc.	April 1, 2015-March 31, 2017	FY2014 (Conducted in FY2015 - FY2016)	700 million JPY (100%)
2	Fuel Debris Characterization	(1) Estimation of properties of fuel debris in the reactor (2) Characterization using simulated debris (3) Development of element technology for fuel debris analysis	April 1, 2015-March 31, 2017	FY2014 (conducted in FY2015-FY2016)	2 billion JPY (100%)
	Project of Upgrading Approach and System for Retrieval of Fuel Debris and Internal Structures	(1) Organization of plant information toward determining retrieval of fuel debris policy and internal structures (2) Study of approaches, systems and equipment for retrieval of fuel debris and internal structures, etc.	September15, 2015-March 31, 2017	FY2014 (conducted in FY2015-FY2016)	1.5 billion JPY (100%)
	Project for Development of Fundamental Technologies for Retrieval of Fuel Debris and Internal Structures	(1) Comprehensive coordination of each element test and analysis of element test results (2) Element test required for determining the feasibility of methods to retrieve fuel debris and internal structures, etc.	September 15, 2015-March 31, 2017	FY2014 (conducted in FY2016-FY2016)	4 billion JPY (100%)
	Development of Technology for Collection, Transfer and Storage of Fuel Debris	(1) Investigation and formulation of research plan for transfer and storage of damaged fuel (2) Study of fuel debris storage systems (3) Development of safety evaluation methods (4) Development of technology for collection of fuel debris (5) Development of technology for transfer and storage of canisters, etc.	April 1, 2015-March 31, 2017	FY2014 (conducted in FY2016-FY2017)	800 million JPY (50%)
	Upgrading Level of Grasping State inside Reactor	(1) Integrated analysis and evaluation of conditions inside the reactor (2) Estimation/evaluation of behavior and characteristics of fuel debris and fission products for integrated analysis and evaluation (3) Management of R&D	April 1, 2016-March 31, 2018	FY2014 (conducted in FY2016) Budget allocation is not yet determined.	2 billion JPY (100%)
	Development and Management of Evaluation Method of Seismic Performance/Impact of RPV and PCV	(1) Construction of safety scenario for possible large-scale earthquake (2) Development of seismic performance and impact evaluation method for safety scenario (3) Upgrading of safety scenario (4) Management of R&D	April 18, 2016-March 31, 2018	FY2014 (conducted in FY2016) Budget allocation is not yet determined (FY2017)	1 billion JPY (100%)
	Development of Corrosion ControlTechnology for RPV and PCV	(1) Evaluation of effectiveness and impact of corrosion control measures (2) Study of fuel debris storage system (3) Management of R&D	April 1, 2016-March 31, 2017	FY2014 (conducted in FY2016)	1 billion JPY (50%)
	Development of Technology for Criticality Control in Fuel Debris Retrieval	(1) Establishment of criticality evaluation methods (2) Development of technology for criticality control in fuel debris retrieval (3) Management of R&D	April 1, 2016-March 31, 2018	FY2014 (conducted in FY2016) Budget allocation is not yet determined (FY2017)	1 billion JPY (50%)
	Development of Technology for Investigation inside the Primary Containment Vessel	(1) Formulation and upgrading of investigation plan and development plan (2) Development of equipment and systems to access and investigate specific area (3) On-site demonstrations (4) Management of R&D	April 1, 2016-March 31, 2018	FY2014 (partly in FY2016) FY2015 (conducted in FY2016 and FY2017)	8 billion JPY (50%)
	Development of Repair Technology for Leakage Sections in PCV	(1) Consideration and planning of process leading to water replenishment in the PCV (2) Development of the PCV lower part repair technology (3) Development of the PCV upper part repair technology (4) Consideration of environmental improvement concept for application of repair construction method in actual equipment (5) Management of R&D	April 1, 2016-March 31, 2018	2015 (conducted for FY2016 and FY2017)	6 billion JPY (50%)
	Full-scale Testing of Technology for Repairing PCV Leakage Points	(1) Full-scale tests of PCV lower part repair technology ① Strengthening S/C support columns ② Stopping water in vent pipes ③ Water stoppage by injecting filling in S/C (2) Confirmation of integrity of reinforcement materials and water stoppage materials after testing (3) Maintenance of VR data for preliminary simulation test (4) Management of R&D	April 1, 2016-March 31, 2018	FY2014 (partly conducted in FY2016) FY2015 (conducted in FY2016 and FY2017)	4 billion JPY (100%)
	Development of Technology for Investigation inside the Reactor Pressure Vessel	(1) Establishment and upgrading of the investigation/development plans (2) Conceptual design of corrosion control system (3) Development and selection of reactor core investigation method (4) Design and construction plan of integrated investigation system (5) Management of R&D	April 1, 2016-March 31, 2018	FY2015 (conducted in FY2016 and FY2017)	2 billion JPY (50%)
3	R&D for Treatment and Disposal of Solid Waste	(1) Integration of R&D results (Presenting basic concept of waste treatment and disposal) (2) Characterization (3) Study of treatment of radioactive waste and long-term radioactive waste storage policy (4) Study of radioactive waste disposal, etc.	April 1, 2015-March 31, 2017	FY2014 (conducted in FY2015 and FY2016)	2 billion JPY (100%)

*1 Projects listed in IRID "Project Plan" *2 Project maximum cost and subsidy rates are cited from value in the Solicitation Information.

International Research Institute
for Nuclear Decommissioning

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