Overseas Activities of MHI Nuclear Business

The 51st JAIF ANNUAL CONFERENCE

April 10th, 2018

Mitsubishi Heavy Industries, LTD

History of MHI's Nuclear Energy Business

MITSUBISHI HEAVY INDUSTRIES

MHI has played a key role in various fields of nuclear energy business for more than 50 years as a plant supplier with continuous innovative efforts

1958 Established Mitsubishi Atomic Power Industries

1970 Mihama unit 1, the 1st PWR in Japan, started commercial operation

1972 Constructed Nuclear Component Manufacturing Shop

1974 Obtained ASME "N" certificate

1986 The 1st export of a reactor vessel for Qinshan I, P. R. China

1995 The 1st export of steam generators to Tihange, Belgium

2007 Created ATMEA, the new joint venture between Japan and France

2008 Delivered a reactor vessel of EPR to Olkiluoto-3, Finland

2009 Tomari unit 3, the 24th PWR in Japan, started commercial operation

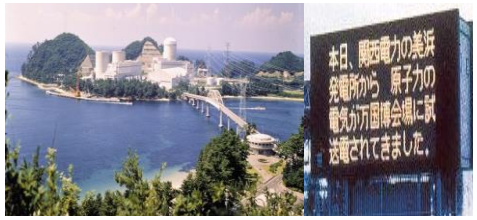
2011 Upon Fukushima Daiichi Accident, making best efforts to enhance safety measures of NPPs in Japan and to stabilize Fukushima Daiichi NPP

2012 French Nuclear Safety Authority, or ASN, completed safety reviews on basic design of ATMEA1

2013 Acquired preferential negotiation rights to apply ATMEA1 to Turkey Sinop project under the agreement between governments of Japan and Turkey

2015 Sendai unit 1/2 restarted commercial operation under the New Regulation Standards

2018 Completed investment into Framatome and Orano. Pursue strategic cooperation with EDF and Framatome



Mihama Nuclear Power Station
("Light of nuclear power" at Japan World Exposition, Osaka)

Replacement of Steam Generator

Construction of Tomari unit 3
Hokkaido Electric Power Co., Inc.

Sendai Nuclear Power Plant

Business Domain

Providing integrated services that covers R&D, design, manufacturing, construction and maintenance

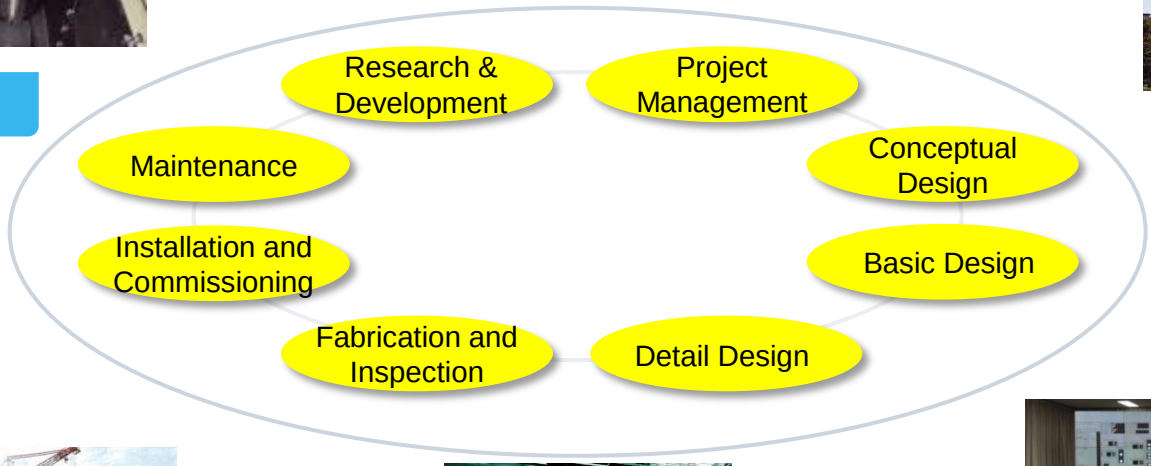
Maintenance Training Center

NDC（Hot Lab）

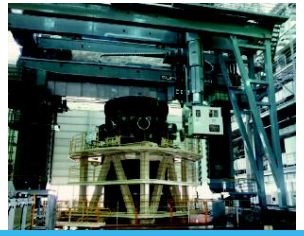
Research & Innovation Center

Engineering Center

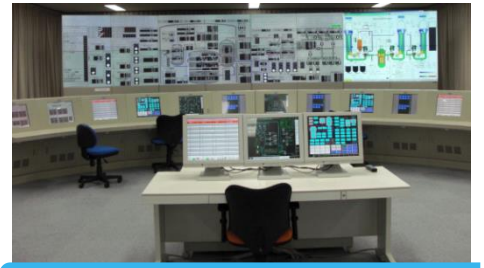
Nuclear Service Center



Tomari Nuclear Power Station
（Unit3 Construction）



Kobe and Futami shops for heavy component manufacturing



Simulator Center

Business Domain

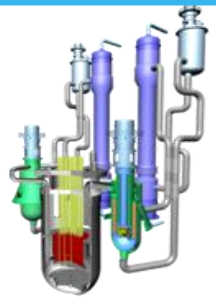
Comprehensively contributing to nuclear fuel cycle

PWR (Japan)

Fuel

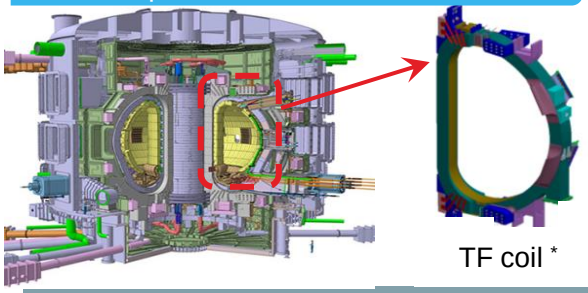
Mitsubishi Nuclear Fuel Co., Ltd.

Fast Breeder Reactor

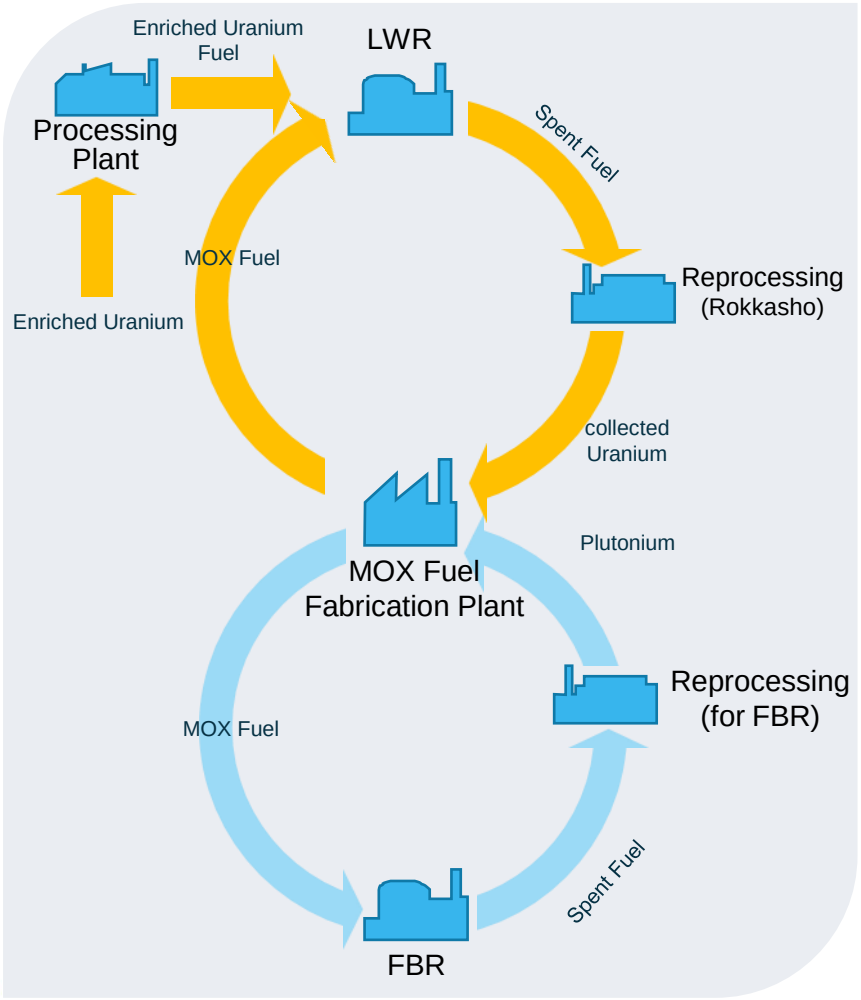


ref:"JAEA-Research 2006-042", 2.1.1-4, p. 69 (2006)

International Thermonuclear Experimental Reactor(ITER)



TF coil *



*TF (Toroidal Field) coil: Produce magnetic field to confine the plasma particles

PWR (overseas)

Nuclear Fuel Cycle

Reprocessing Plant

Intermediate Spent Fuel Storage

Dry cask storage

Major Activities in Japan

Light Water Reactor

20,280 MWe by 24units

- MHI has constructed all of 24 PWRs in Japan since the commercial operation of Mihama Unit 1, Japan's first PWR, in 1970. MHI has been working on technical improvements and provides PWRs that offer world-class safety, reliability, economy, operability and maintainability.

Activities toward Restart of NPPs

- Strengthen safety measures and earthquake resistance to meet the new regulation standards against natural hazards after the Fukushima accident, which is of the highest level in the world.

  Sendai unit 1/2, Takahama unit 3/4, Ikata unit 3, Ohi unit 3 and Genkai unit 3 already restarted commercial operations

- MHI is also providing supports to BWR utilities based on the preceding licensing experiences in the restart of PWRs aiming at supporting overall nuclear energy industry of Japan, .

Rokkasho Nuclear Fuel Cycle

- MHI takes a leading role of suppliers and is in charge of main process for Rokkasho reprocessing plant.
- For the MOX Fuel Fabrication Plant, MHI also takes a leading role of electrical and mechanical suppliers and is in charge of process after fuel rod processing.

Japan Nuclear Fuel Limited
Rokkasho Reprocessing plant

Japan Nuclear Fuel Limited
MOX Fuel Fabrication Plant

Fukushima Daiichi

- MHI provides supports according to the "Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station"
  (development of robots, fuel debris removal devices, tanks for storing contaminated water, etc.)

Manipulator Robot

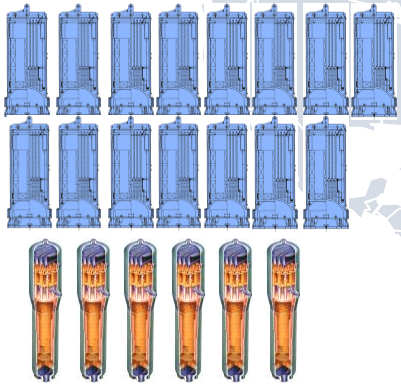
Major Activities in Overseas Market

- Abundant experiences in nuclear component exports (4 Reactor Vessels, 22 Reactor Vessel Heads, 31 Steam Generators, 1 Pressurizers, 12 Turbines and 8 Reactor Coolant Pumps)
- Steady efforts in providing maintenance services for PWRs（completed 3 projects related to countermeasure for corrosion cracking of alloy 600 in last 2 years)

U.S.A

Water Jet Peening for Wolf Creek/Callaway NPP (2016/2017)

Reactor Vessel Head×15
Steam Generator×6
Pressurizer×1



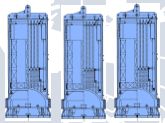
BELGIUM

Steam Generator×10

SWEDEN

Pressurizer Nozzle Spool Piece Replacement on Ringhals unit 3 (2016)

Reactor Vessel Head×3



FINLAND

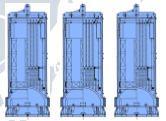
Reactor Vessel×1

SLOVENIA

Turbine×1

KOREA

Reactor Vessel Head×3



MEXICO

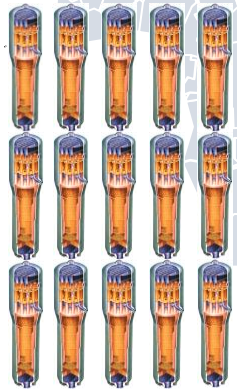
Turbine×2

BRAZIL

Reactor Vessel Head×1

FRANCE

Steam Generator×15



SPAIN

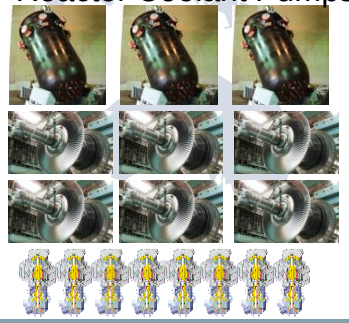
Turbine×1

TAIWAN

Turbine×2

CHINA

Reactor Vessel×3
Turbine×6
Reactor Coolant Pumps×8

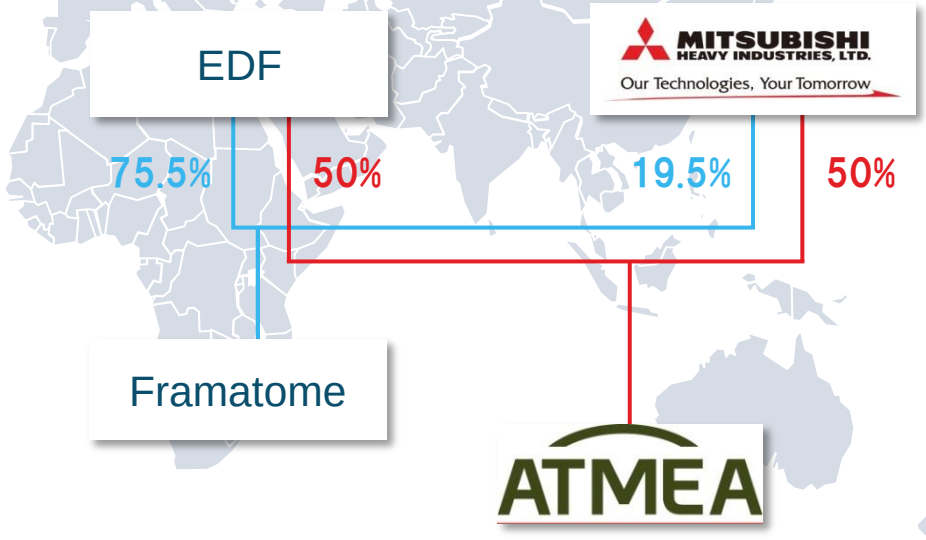


※ Components：main components only
※ Services：most recent projects only

Major Activities in Overseas Market

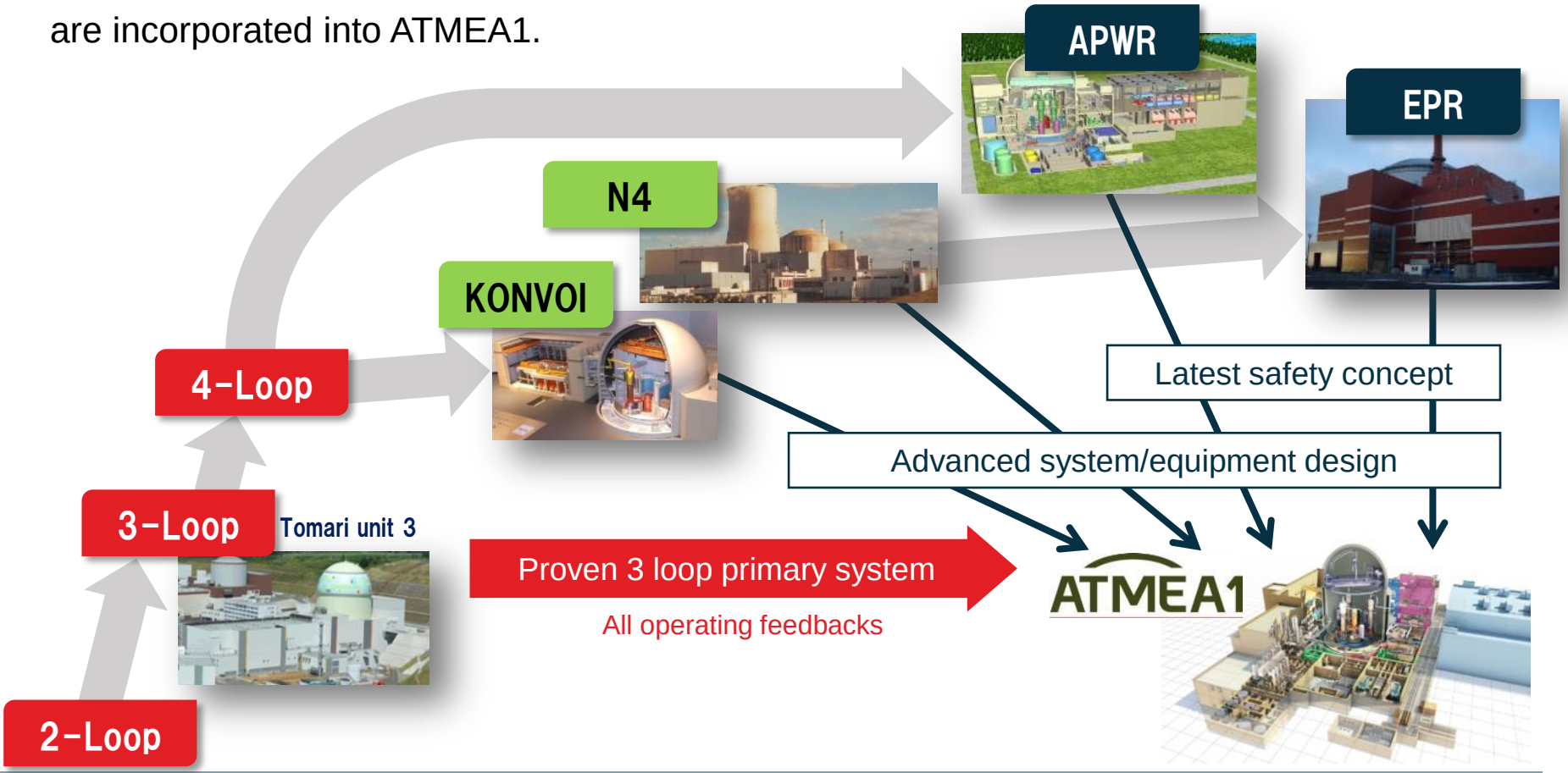
- In November 2007, MHI and AREVA (now Framatome) established ATMEA company for the development and marketing of ATMEA1.
- In January 2018, in the course of restructuring of the French nuclear industry, Framatome became an affiliate of EDF and MHI invested into Framatome and now holds 19.5% shares. ATMEA company is newly formed as a joint venture of MHI and EDF.
- Through the strategic collaboration among MHI, EDF and Framatome, MHI enhances marketing of ATMEA 1 and delivers safe and reliable nuclear technologies worldwide.

Mid-sized Generation Ⅲ+ reactor with highest level of safety features jointly developed by Japan and France



ATMEA1 Plant Concept

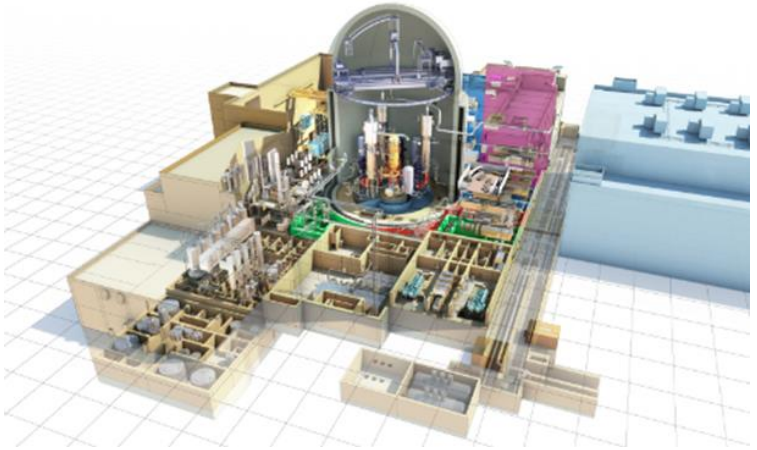
- ATMEA1 is the mid-sized Generation Ⅲ⁺ reactor with the advanced design based on all experiences of PWRs in Japan and France.
- The abundant worldwide operational experiences of PWRs are reflected to the enhanced operability and maintainability of ATMEA1.
- The latest technologies and protection against external hazards including severe accidents are incorporated into ATMEA1.



Features of ATMEA1

Advanced Safety Design
Highest level of safety as a Gen III+ reactor

Latest design based on the proven technologies and experiences of MHI and Framatome

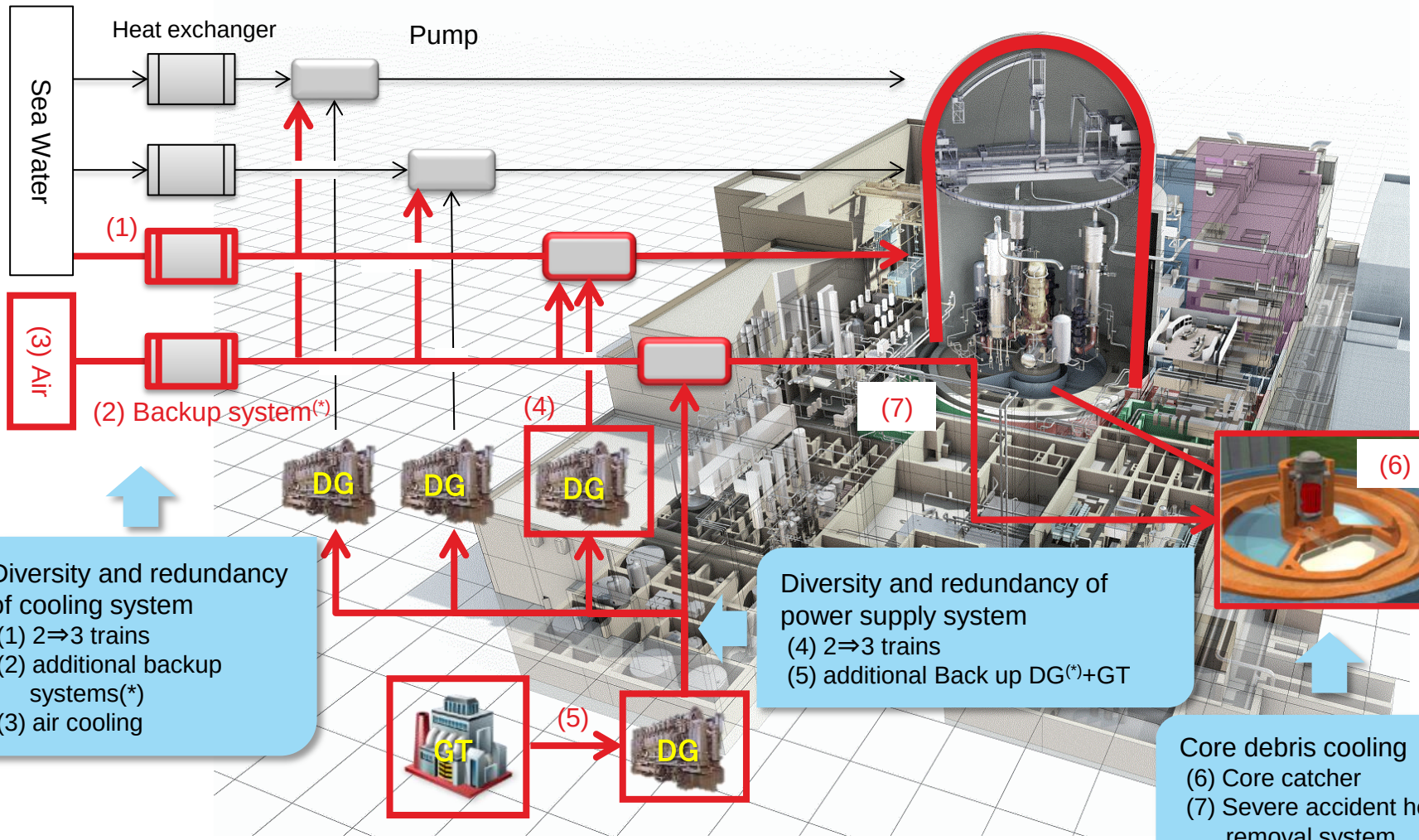


Primary system	3-loop configuration
Electrical output	1,200MWe Class
No. of fuel assemblies	157 (14ft)
Main steam pressure	more than 7MPa

Safety system	3-train, reliable active system with passive systems
Diversity/Redundancy	Diversity and redundancy of cooling systems, power supply systems, I&C systems, etc.
Severe accident mitigation	Core catcher, hydrogen recombiners
Provisions for airplane crash	Prestressed Concrete Containment Vessel
I&C	Full digital I&C

Advanced Safety Design

Diversity and Redundancy of Cooling System and Power Supply System



Diversity and redundancy of cooling system
(1) 2⇒3 trains
(2) additional backup systems(*)
(3) air cooling

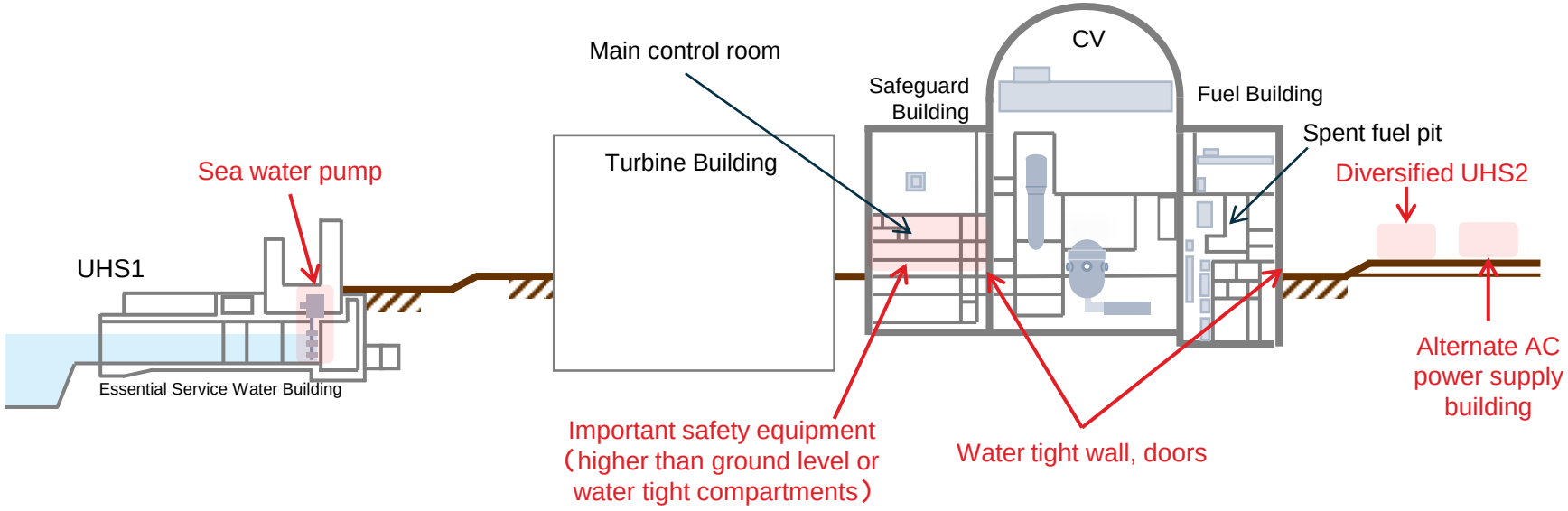
Diversity and redundancy of power supply system
(4) 2⇒3 trains
(5) additional Back up DG(*)+GT

Core debris cooling
(6) Core catcher
(7) Severe accident heat removal system

(*) On-Line Maintenance (maintenance during operation) applied

Countermeasure for Tsunami and Flooding

- Electrical and I&C equipment is located in upper floors.
- Essential Service Water Building is equipped with watertight walls and doors.
- Ground level is set as high enough to avoid consequences from Tsunami with sufficient considerations based on the site specific condition. All safety-related buildings are protected by water-tight walls and doors as additional margins.

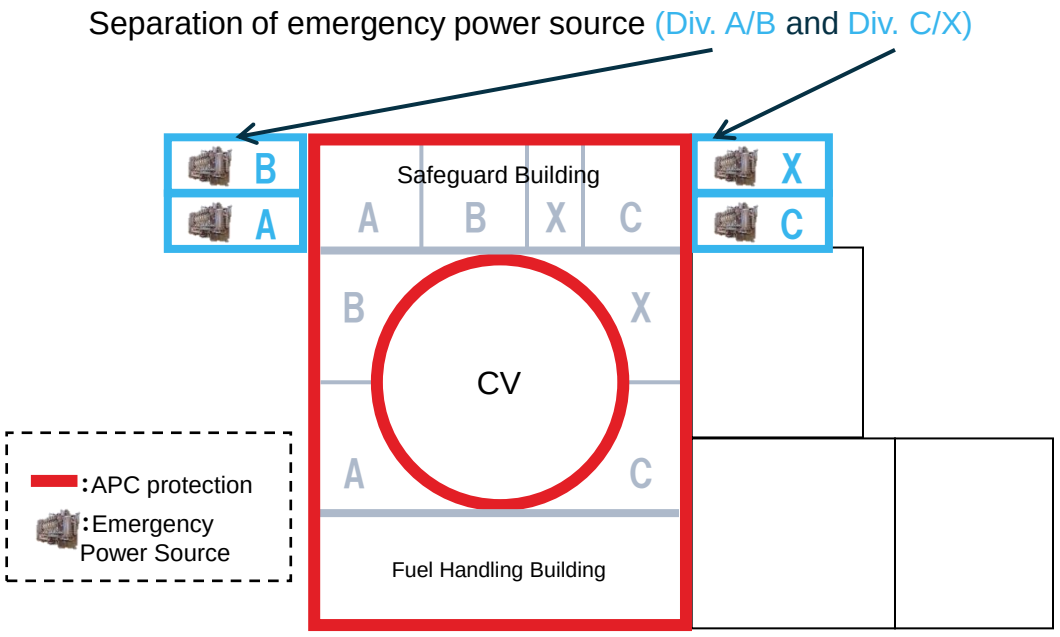


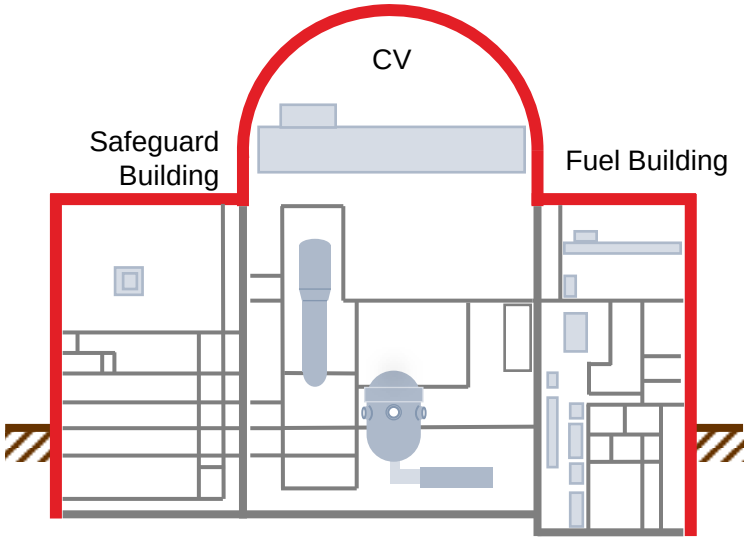
Advanced Safety Design

Airplane Crash Protection

Designed to resist both commercial and military airplane crash, considering worldwide regulatory trends.

- Containment Vessel, Safeguard Building and Fuel Building are equipped with reinforced concrete shielding.
- Emergency power sources are located apart from each other. Physical separations and sufficient capacity (100% x 2) of emergency power source are considered.





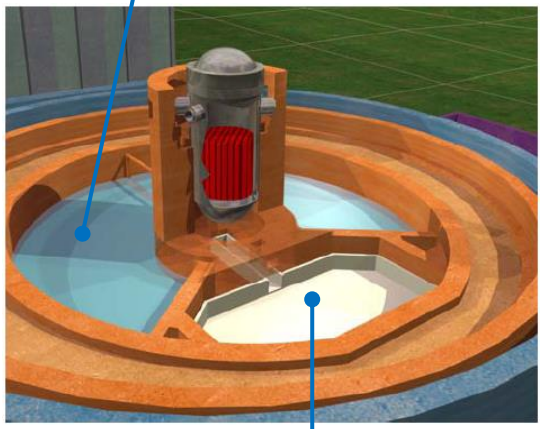
APC: Airplane Crash

Advanced Safety Design

Enhanced Confinement Function of Containment Vessel for Severe Accident

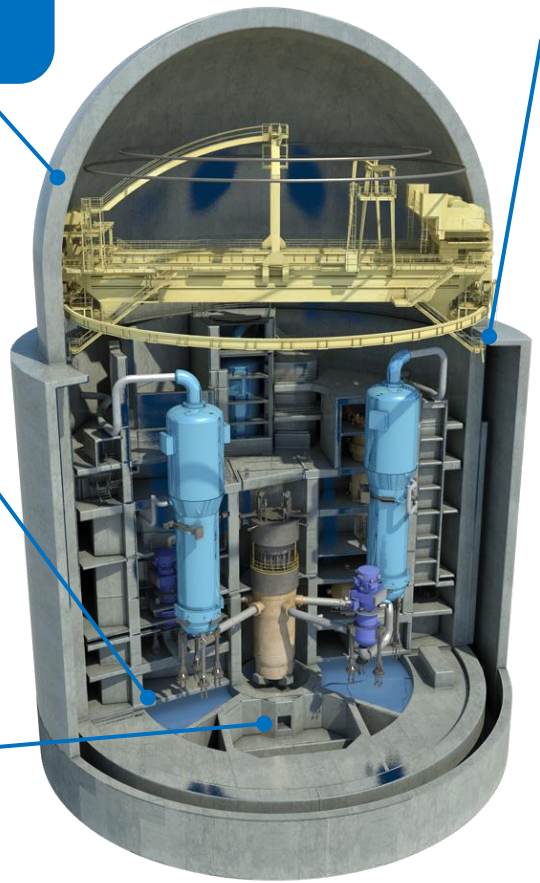
Prestressed Concrete Containment Vessel with Liner to Strengthen Pressure Resistance

Refueling Water Pit in Containment Vessel



Core Catcher

Mitigate incident in long term in case of severe accident



Annulus

- Negative pressure design
- Prevention from radiological release through charcoal filter in case of severe accident

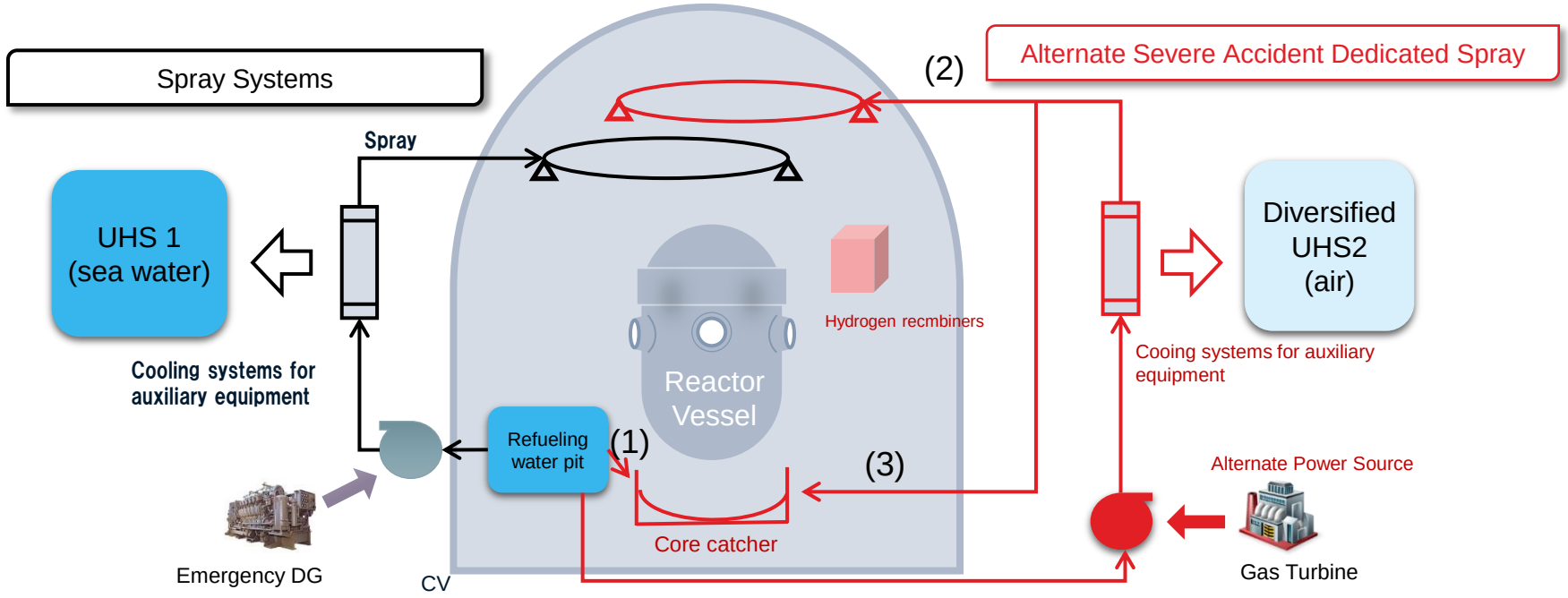
Advanced Safety Design

Severe accident heat removal system maintains long-term cooling of molten core and stability of containment vessel.

(1) Passive cooling water is supplied from refueling water pit to core catcher (initial action).

(2) Alternate Severe Accident Dedicated Spray prevents CV from pressure increase.
（independent from the CV spray system for Design Basis Event mitigation）

(3) Pumps, air cooling system and alternate power source supply cooling water for long term.（stable cooling of molten core confined in the core catcher）



ATMEA1 Safety Design Review

MITSUBISHI HEAVY INDUSTRIES

Conceptual Design	Basic Design		Sinop pre-engineering
IAEA Review (2008)	ASN Review (2010-2012)	CNSC Review (2012-2013)	IAEA seismic review (2016)

Result of IAEA Review

- ATMEA1 addresses the IAEA Fundamental Safety Principles as well as key design and safety assessment requirement.
- ATMEA1 demonstrates a consistent safety approach in line with the more detailed NPP Design Safety Requirement.

ASN review result for safety

- Safety objectives of the ATMEA1 reactor design are satisfactory.
- Those objectives and the related safety options are in compliance with French Technical Guidelines.

Safety Systems

Containment

Airplane Crash Protection

Design of Main Equipment

Post Fukushima Analysis

Compliance to Canadian regulation

- ATMEA1 can be constructed in CANADA.
- Strategy on extreme external hazards and severe accidents fully in line with Canadian expectations for a generation III reactor.
- ATMEA1 design is compliant with the CNSN regulatory requirements and meet the expectations for new nuclear power plants in CANADA.

Conclusion of IAEA SEED mission review

- Seismic methodologies for design and qualification of ATMEA1 is closely aligned to applicable provisions of the IAEA safety standards.
- Seismic design integrates the best international practices and experiences in reactor seismic design and qualification.
- Seismic qualification is based on comprehensive experimental databases and strong test capabilities supporting the advanced seismic design process.

ASN：French Nuclear Safety Authority
CNSC：Canadian Nuclear Safety Commission
SEED: Site and External Events Design Review Service

Turkey Sinop Project

IGA* signed in May 2013.
Preferential negotiation rights given to Japan.

*1) IGA (Intergovernmental Agreement): Agreement between government of Japan and Turkey

Negotiation of HGA*2 completed in October 2013.

*2) HGA (Host Government Agreement): Agreement between government of Turkey and Project Sponsors

IGA and HGA submitted to Turkish parliament in October 2014.

In April 2015, completed necessary procedure in Turkey, including cabinet approval.
In July 2015, through the diplomatic procedure, ratification completed.

Feasibility Study being performed

Welcoming substantial agreement of HGA, two leaders signed the “Joint Declaration by GoT and GoJ on Cooperation in the Field of Nuclear Energy and Science and Technology（Ankara, Oct. 29, 2013.）

©Japanese Prime Minister’s Office
（http://www.kantei.go.jp/jp/96_abe/actions/201310/29turkey.html）

Turkey Sinop Project

4 units of ATMEA1, GEN III+ reactor, are to be constructed at Sinop.

EPC members

The best team under the collaboration of Japan and France moves the project forward.

Nuclear Island E&M construction

MITSUBISHI HEAVY INDUSTRIES, LTD.
Our Technologies, Your Tomorrow

The best collaboration scheme is being discussed under the strategic partnership.

ATMEA

EDF

Framatome

Turbine Island E&M construction

MH

Civil and Building construction

TAISEI
For a Lively World

BOUYGUES TRAVAUX PUBLICS

OBAYASHI

E&M: Electrical and Mechanical

Moving EPC project forward with phased approach

Move the project forward with a phased approach aiming at risk mitigation and incorporation of lessons learned from other new build projects.

Feasibility Study → Site Specific Design (EWC/FEED) → EPC

Current Representative Activities related to EPC

Licensing

- Holding workshops periodically with Turkish Atomic Energy Authority (TAEK) to confirm requirements of construction license and witness/inspection.

Design and Engineering

- Developing the 3D CAD model by incorporating Sinop site specific conditions into ATMEA1 basic design.

Procurement

- Mainly adopting experienced Japanese partners and European supply chain.
- Assessing capabilities (manufacturing, QMS, etc.) of Turkish vendors to maximize selection of Turkish vendors according to localization requirements.

Construction

- Brushing up the construction method and the project schedule on a step-by-step approach to get prepared for the construction in Turkey.
- Proactively introducing ICT into construction.

Studying an increase of localization ratio for procurement and construction.

Analyzing lessons learned from other projects and incorporate those results into our EPC related activities.

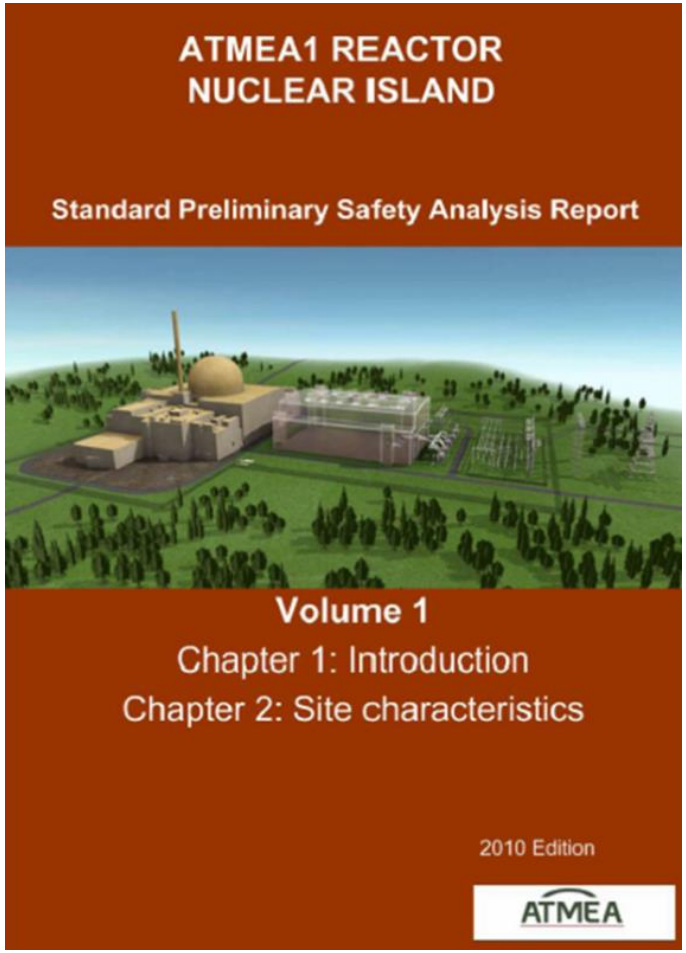
Licensing

Confirming detailed licensing process through periodical workshops with Turkish Atomic Energy Authority(TAEK)

Share the review points and contents of application with TAEK with the ATMEA1 Standard Preliminary Safety Analysis Report (SPSAR).

Since Turkey is an earthquake country, the most appropriate seismic design methodologies are chosen based on the experimental databases accumulated in Japan such as optimized layout of NI building, coupled evaluation of building-loop. We will submit the topical report for seismic design to TAEK in addition to PSAR.

Confirming details of Turkish regulatory requirements such as manufacturer approval, manufacturing approval and inspection during manufacturing.



Design and Engineering

Developing the 3D CAD model dedicated for Sinop through Sinop-Pre Engineering (SPE) by incorporating Sinop site specific conditions into ATMEA1 basic design.

Basic Design

3D CAD model is developed based on ATMEA1 standard design

- Equipment and system design
- Radiation protection requirement
- Layout requirement, etc.

Sinop-Pre Engineering (SPE)

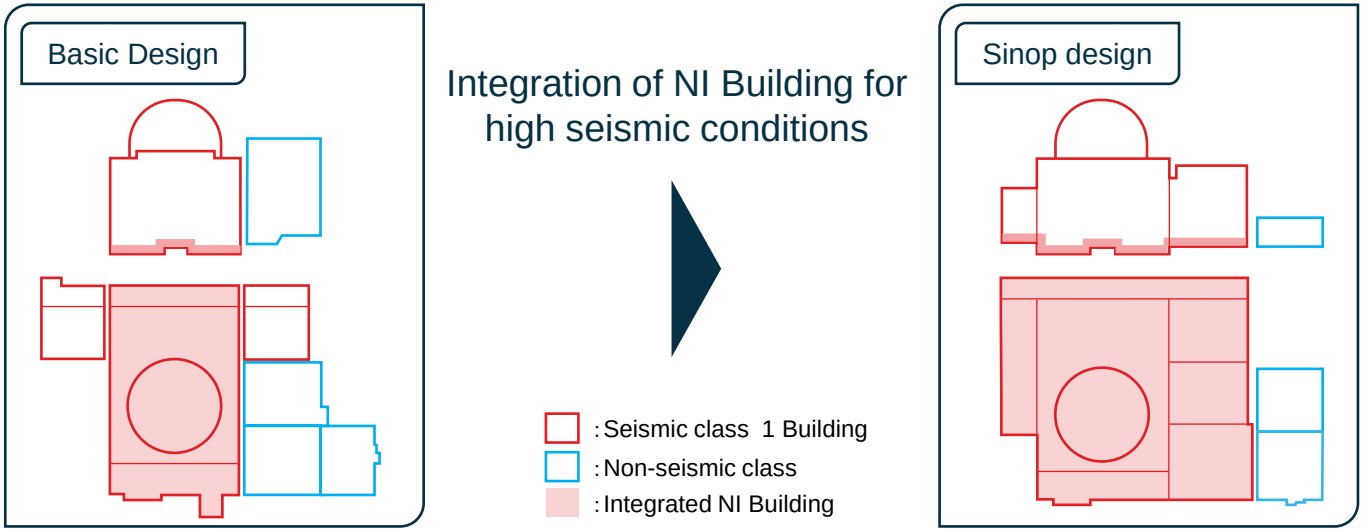
3D CAD model is updated for Sinop based on Sinop site specific conditions (i.e. seismic conditions, etc.)

- Equipment and system design
- Lowered and integrated NI Building (for high seismic condition)
- Structural analysis by ground motion response spectrum for quotation

Plot plan for Sinop is developed

Detail design for actual plant(EWC/FEED)

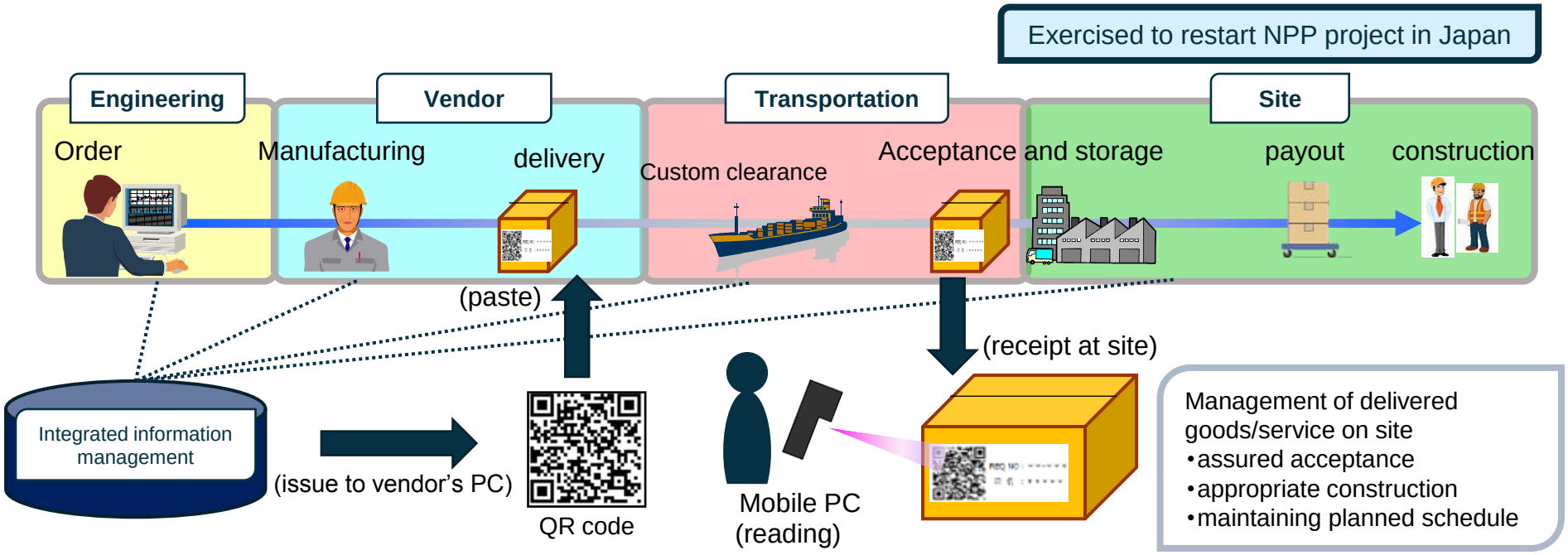
- Finalize seismic design of building equipment after site license granted
- Finalize 3D-CAD by incorporating vendors' information
- Fix design before first concrete



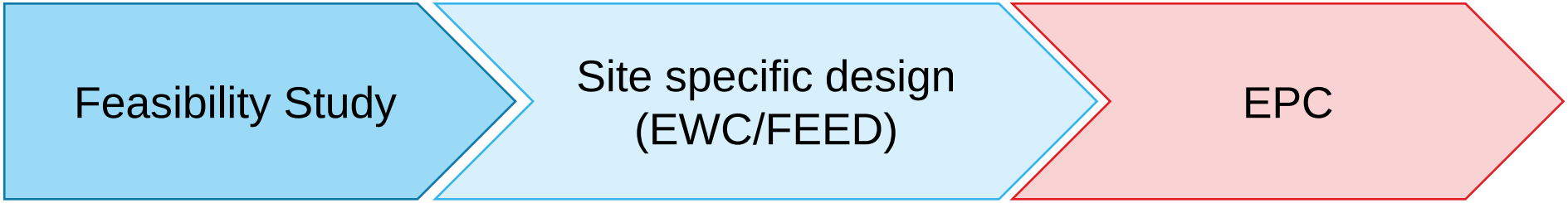
EWC: Early Work Contract
FEED: Front End Engineering Design

Procurement

- For safety equipment, utilize the supply chain of EDF and Framatome in Europe that experienced EPR projects in order to enhance QCD.
- Enhance utilization of Turkish vendors, considering localization requirements, after assessing their capabilities of manufacturing, QMS, etc. (Examples of our activities include holding QA seminar for local vendors.)
- Developed the integrated management system of information of goods from engineering to procurement (vendor) and construction. Manage goods/service on time, utilizing ICT, from order to delivery and construction with the QR code.



Construction



(1) Basic construction plan (Phase-1):
Study with Japanese construction contractors

Studied construction schedule with Taisei/Obayashi who have rich experiences in construction of NPP.

(2) Basic construction plan (Phase-2):
Study with EDF

Brush up construction plan incorporating knowledge of EDF. (experiences of EPR)

(3) Detailed construction plan:
Study with Turkish company

Finalize construction plan together with Turkish company considering capabilities of local workers and local working conditions.

(4) Construction of NPP

Construction

- MHI prepares the work package (WP) for steady NPP construction in Turkey.
- MHI provides business partners (BPs) with drawings and instruction manuals. The latest documents is confirmed through the Document Control System.
- Local BPs prepare construction manuals, etc. MHI provides the formats and approves the documents. Enhancement of the capability of BPs is also required.
- WP necessary for field works is confirmed at daily toolbox meetings (TBMs).
- All necessary quality records are gathered into the fixed formats based on the approved construction manuals and the latest drawings. Those records are stored and controlled to fulfill “accountability”.

The latest documents through the Document Control System

Confirm with workers at daily TBM

Store and control as the quality records

Work Package

(1) Drawings

(2) Instruction manuals

(3) Construction manuals such as procedures and QA check sheets (travellers)
Construction and inspection procedures, evaluation criteria, reference documents, record formats, witness grades, etc. are defined and approved.

(4) Safety work instructions
Work contents of the day, safety and health notice, necessary qualifications, etc. are defined and approved.

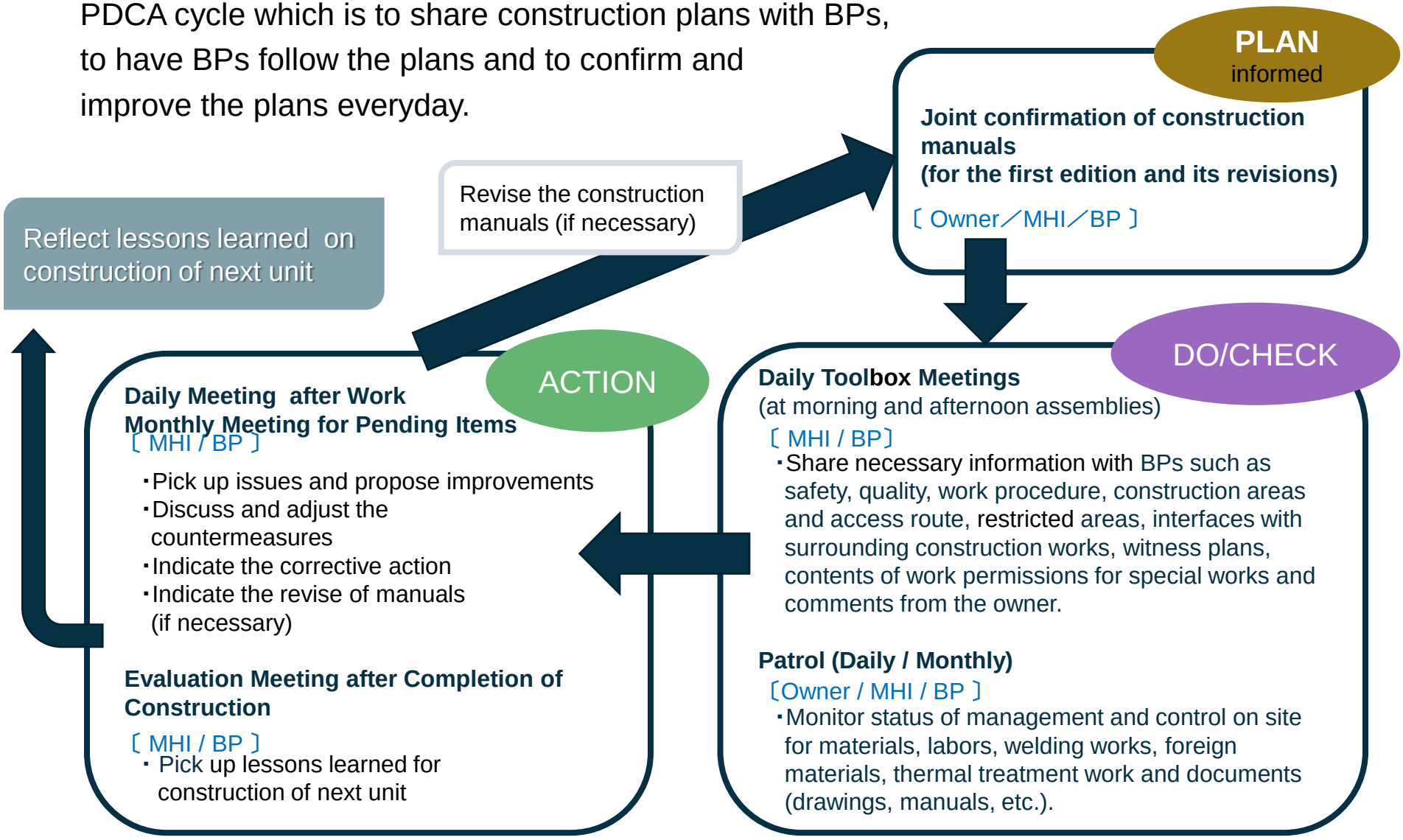
(5) Work permits
Applications for special works (in foreign material controlled area, using fire, at heights, etc.) are approved.

Installation Records
Dimension records, welding records, non-destructive testing records, etc.

Remarks: the owner (utility) is responsible for preparation, execution and records of inspections performed by the Regulatory Body.

Construction

- In order to progress construction steadily and successfully, MHI continuously implements the PDCA cycle which is to share construction plans with BPs, to have BPs follow the plans and to confirm and improve the plans everyday.



Construction

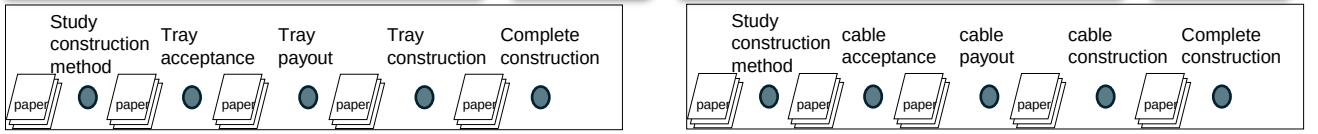
➢ Apply construction supporting system for stable construction progress as one of our proactive efforts to introduce ICT. Start application of the system for a Japanese maintenance project in 2018.

Example of cable construction

(1) Locate cable tray, (2) improve cable laying operation process

Engineering → order → Locate tray → inspection → Lay cable tray → inspection

Before



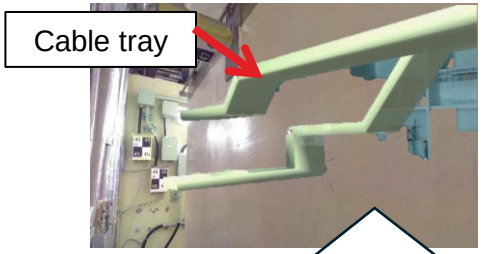
［Engineering data］
3D-CAD data
Cable data
Circuit data

＋  HoloLens ＋ 

tablet
＋cable identification no.

After

(1) Information of tray and support is displayed in AR through HoloLens



- Visualize image after construction
- Distinguish work object by color
- Distinguish work progress management by color

(2) Instant judgement on conformity of engineering document with actual goods is displayed in AR

Just holding a tablet allows cables to be identified

Applied for a patent

AR: Augmented Reality

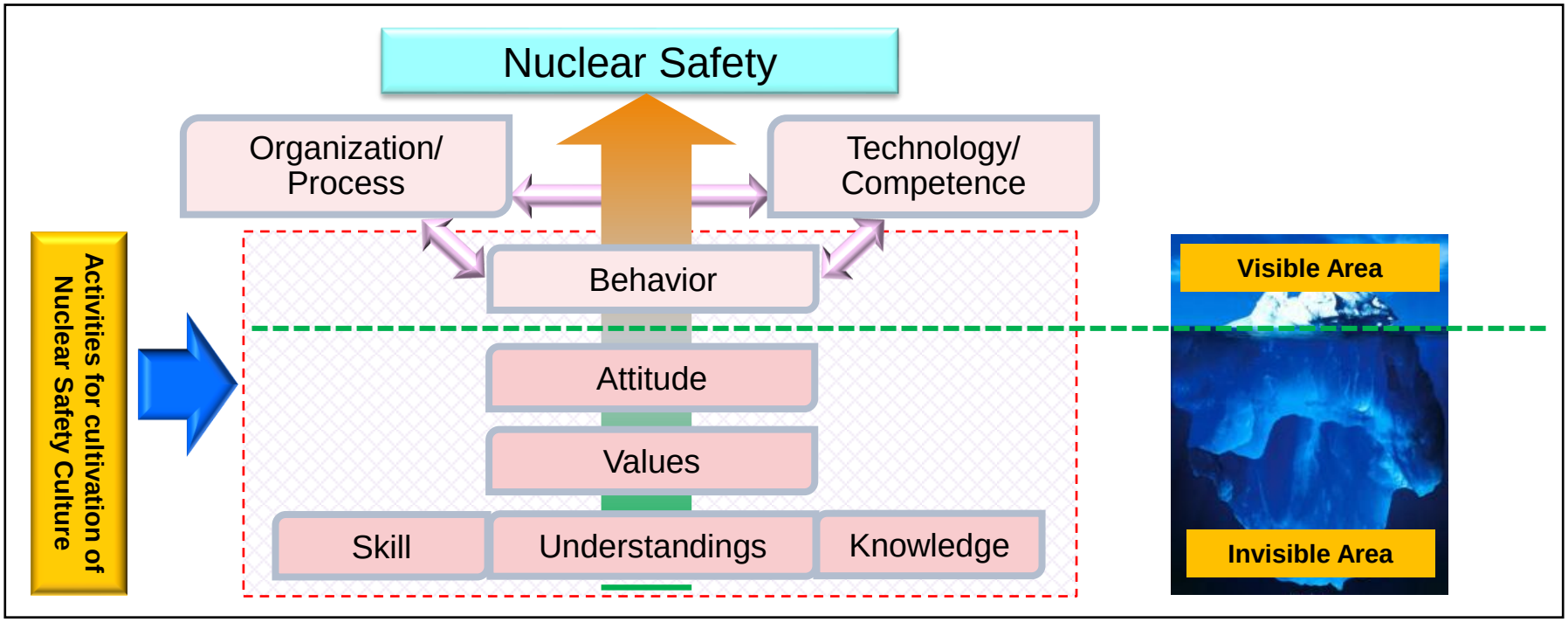
Cultivation of Nuclear Safety Culture

Safety Culture is to improve effectiveness of Quality Management System and to achieve Nuclear Safety at a high level

(i) The awareness for implementation of the work according to the defined process

(ii) Both company and each individuals should have responsibility for the nuclear safety

Safety Culture will be promoted to all supply chains including Turkish suppliers because it is a basis of all activities related to construction of nuclear facility



Conclusion

Our abundant experiences in construction and maintenance of NPPs in Japan have been fostering our comprehensive capabilities as a nuclear power plant supplier.

As for overseas activities, since the first delivery of reactor vessel to China in 1986, we have exported nuclear components to various countries and accumulated knowledges and experiences about regulations, codes and standards, quality management systems, document controls, etc. in those countries. In the field of NPP supply, our experiences in the joint development of ATMEA1 with the French team for more than 10 years have led to enhancing our capabilities to correspond to regulations in Europe and the US.

With the comprehensive strengths above, we are aiming to realize the Turkey Sinop project, market ATMEA1 worldwide, and further expand our global business through the strategic collaboration with EDF.

MOVE THE WORLD FORWARD

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