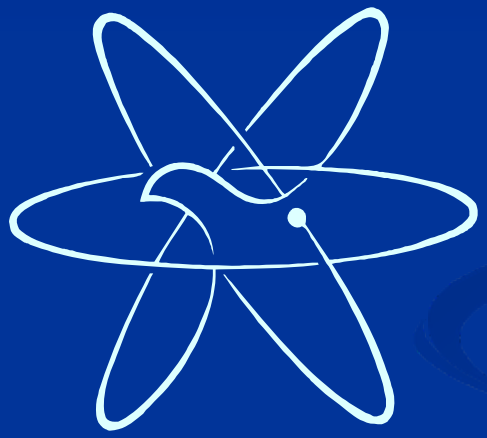
Post-Fukushima Safety Re-Evaluation



Atomic Energy Council, Taiwan

June 2012

Outlines

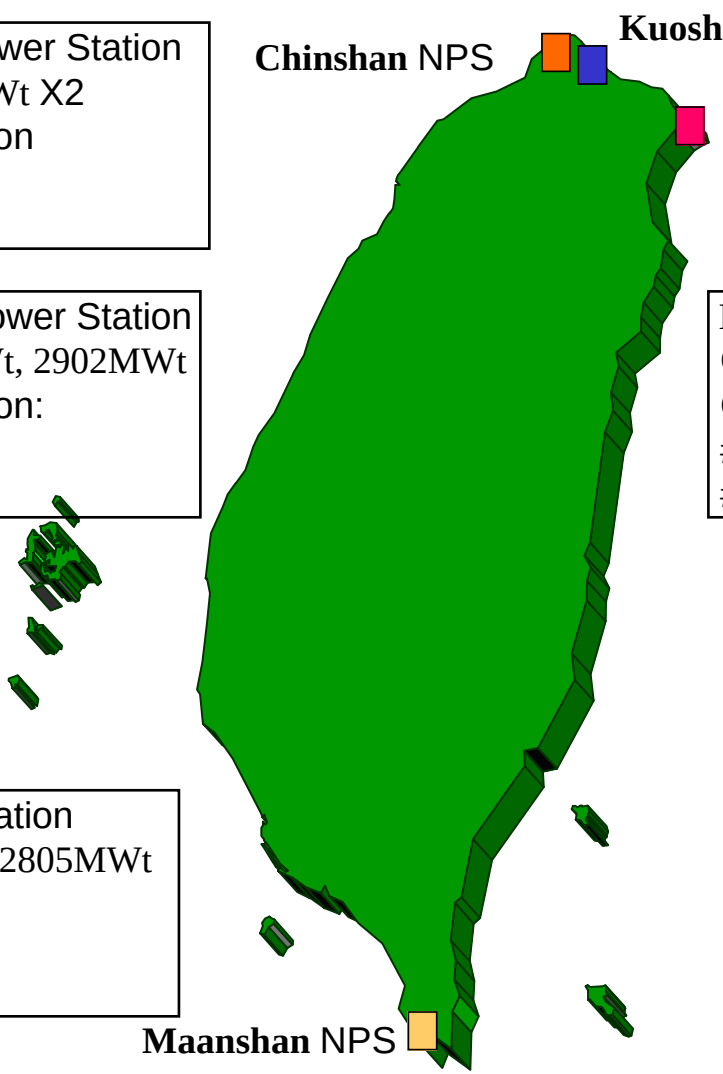
- Introduction
- Evaluation Progress
- Nuclear Safety Re-Assessment
  - Preliminary Inspection Findings (DBA)
  - Areas for Improvement
  - Beyond-DBA Reinforcement
  - Follow-up Action Plan
- Concluding Remarks
- Part II：Radiation Protection and Emergency Response (for reference)

Nuclear Power Plants in Taiwan

Chinshan Nuclear Power Station
GE BWR-4, 1791 MWt X2
Commercial Operation
#1: Dec. 1978
#2: July 1979

Kuosheng Nuclear Power Station
GE BWR-6, 2937MWt, 2902MWt
Commercial Operation:
#1: Dec. 1981
#2: Mar. 1983

Maanshan Nuclear Power Station
W PWR, 3 loop, 2804MWt, 2805MWt
Commercial Operation
#1: July 1984
#2: May 1985



Lungmen Nuclear Power Station
GE ABWR, 1350 MWe X2
Commercial Operation **Expected**
#1: 2014 (?)
#2: 2015 (?)

Introduction (1/2)

- After Japan's Fukushima Daiichi Accident, Atomic Energy Council (AEC) requested Taiwan's Nuclear Power Plant operator (TPC) to re-evaluate its capability to cope with extreme natural disasters, including earthquake, tsunami, flooding.
- The re-assessment comprises following parts
  - Nuclear Safety (focus of this presentation)
  - Radiation Protection
  - Emergency Response and Preparedness

Introduction (2/2)

- By reference to measures recommended by various major nuclear authorities or international organizations, such as NRC, NEI, WENRA (later ENSREG), WANO and NISA, AEC requested the TPC to verify the capability of NPPs in response to both the DBA and beyond-DBA accident.
- Two-Stage Approach
  - Near-Term Evaluation (by June, 2011)
  - Mid-Term Evaluation (by December, 2011)

Evaluation Progress (1/3)

- **April-May, 2011: TPC self-evaluated for responding to Fukushima Daiichi Accident based on the subjects prescribed by AEC, and submitted evaluation report and improvement plan to AEC**
- **May 31, 2011 : AEC issued preliminary assessment report of nuclear safety and held a public hearing**
- **June, 2011 : AEC conducted inspections of operating NPPs with findings related to non-conformance of design basis .**

Evaluation Progress (2/3)

- **July, 2011 : AEC submitted the post-Fukushima safety assessment report to Executive Yuan for high-level taskforce review, which is composed of 11 experts in various science and engineering fields.**
- **October, 2011 : AEC issued "The Near-Term Overall Safety Assessment Report for Nuclear Power Plants in Taiwan in response to the Lessons Learned from Fukushima Daiichi Accident"**

Evaluation Progress (3/3)

- **October-end of 2011: TPC re-evaluated for responding to Fukushima Daiichi Accident based on the review comments by AEC, and submitted revised report and improvement plan to AEC**
- **February 29, 2012： AEC issued "The Overall Safety Assessment Report for Nuclear Power Plants in Taiwan in response to the Lessons Learned from Fukushima Daiichi Accident" for review by experts.**

The Overall Safety Assessment Report Content

- Chapter 1: Introduction
- Chapter 2: Lessons Learned from Japanese Fukushima Daiichi Accident
- Chapter 3: Nuclear Safety Assessment
- Chapter 4: Radiation Protection and Emergency Preparedness
- Chapter 5: Conclusion and Follow-Up Action Plan

Nuclear Safety Assessment (1/3)

- **Areas for re-evaluation (TPC) and review (AEC)**
  - Re-examine the Capability for Loss of All AC Power (SBO)
  - Re-evaluate Flooding and Tsunami Protection
  - Ensure Integrity and Cooling of Spent Fuel Pool
  - Assess Heat Removal and Ultimate Heat Sink
  - EOP Re-examination and Re-training
  - The Emphatic Measures (procedure to abandon the reactor)
  - Support between Different Units
  - Considerations for Compound Accidents
  - Mitigation beyond DBA
  - Preparedness and Backup Equipment
  - Manpower, Organization, Safety Culture

Comparison between AEC and International Authorities/Organizations

Item	AEC	NRC	NEI	WENRA	WANO	NISA
(1)	Re-examine the Capability for Loss of All AC Power (SBO)	✓	✓	✓	✓	✓
(2)	Re-evaluate Flooding and Tsunami Protection	✓	✓	✓	✓	✓
(3)	Ensure Integrity and Cooling of Spent Fuel Pool	✓		✓		✓
(4)	Assess Heat Removal and Ultimate Heat Sink	✓		✓		✓
(5)	EOPs Re-examination and Re-training	✓	✓	✓		✓
(6)	The procedure to abandon the reactor	✓				✓
(7)	Support between Different Units			✓		✓
(8)	Considerations for Compound Accidents	✓	✓	✓	✓	✓
(9)	Mitigation beyond DBA	✓	✓	✓	✓	✓
(10)	Preparedness and Backup Equipment	✓	✓	✓		✓
(11)	Manpower, Organization, Safety Culture	✓		✓		✓

Nuclear Safety Assessment (3/3)

- The assessment of post-Fukushima evaluation shows that continued operation does not pose imminent risk to the public health and safety
- However, some areas for improvement identified to demonstrate the capability in response to DBA and Beyond-DBA disasters
- AEC conducted inspection using NRC 2515/183, 2515/184 last June
- TPC is also requested to perform the EU stress test by the EU specification

Preliminary Inspection Findings for DBA (1/2)

- Chinshan's plant recent elevation re-measurement (ESW pump room, Turbine Building, Auxiliary building, etc.) does not comply with FSAR
  - About 1 meter less than FSAR description, still greater than height of Design Basis Tsunami (10.7 meter)
  - FSAR contents (text and drawings) require updating

Preliminary Inspection Findings for DBA (2/2)

- Kuosheng's ECW pump room does not comply with it's Tsunami Design
  - Many openings below Design Basis Tsunami height (10.28 meter)
  - Require operator training to tackle with tsunami event, including replacing damaged ECW pump caused by tsunami
  - Establish physically independent ECW pump compartments and seal openings
  - Work completed by June 30, 2011

ECW pump and motor (Floor El. 6.6 meter)

ECW motor 7.9 meter above mean sea level

Opening of the ladder (El. 6.6 meter)

Opening of the traveling screen's manhole (El. 6.6 meter)

Areas for Improvement (1/5)

- Many areas for improvement have been identified. Parts are listed below:
- SBO
  - Re-analysis for 24-hr SBO capability
  - Establish procedures and necessary portable equipment for extended SBO (72 hrs)
  - Load distribution planning of air-cooled Swing Diesel Generator for two units

Areas for Improvement (2/5)

- Flooding Protection
  - Enhance flooding protection and water tight design for emergency service water room and other supporting facilities
  - Additional spare parts of emergency service water and ECCS pumps and store in higher ground
  - Re-evaluate the design basis tsunami heights
  - Physical separation of service water system for different unit

Areas for Improvement (3/5)

- Spent Fuel Pool
  - Safety-related instrumentation for monitoring water level, temperature, etc.
  - Safety-related power for SFP makeup water
  - On-site emergency power to pumps and instrumentation
  - Seismic resistant spray to the pool
- Vent
  - Mobile air compressor to operate vent valves
  - Re-examine vent route for hydrogen
  - Prevention of H2 accumulation in the buildings

Areas for Improvement (4/5)

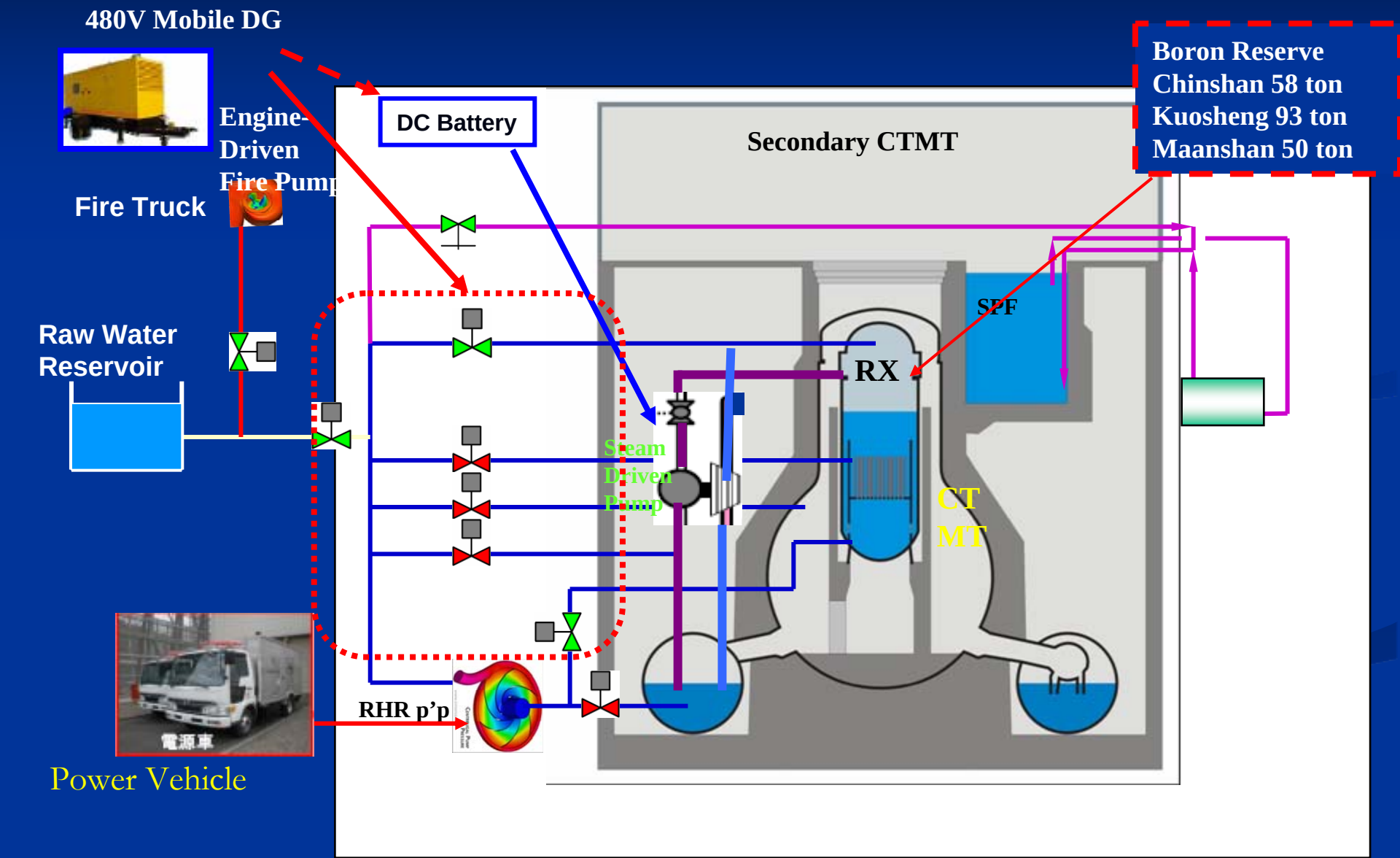
- Severe Accident Management
  - Establish procedure (URG) to abandon the reactor in case of emergency
  - Purchase more natural boric acid
  - Build seismic-resistant technical support center
  - Simulate severe accident scenario of Fukushima-like case for NPPs
- Seismic Enhancement
  - Increase SSE of Chinshan NPP from 0.3 g to 0.4 g
  - Strength the robustness of raw water reservoir and its piping
  - Re-evaluate the seismic hazard analysis

Areas for Improvement (5/5)

- Infrastructure
  - Coordination with outside supports (military, fire department)
  - Examine Internal capability and training in response to extended accident sequence
- Safety Culture
  - IAEA safety principle(SF-1) implementation
  - NRC safety culture statement and ROP inspection for cross-cutting issues

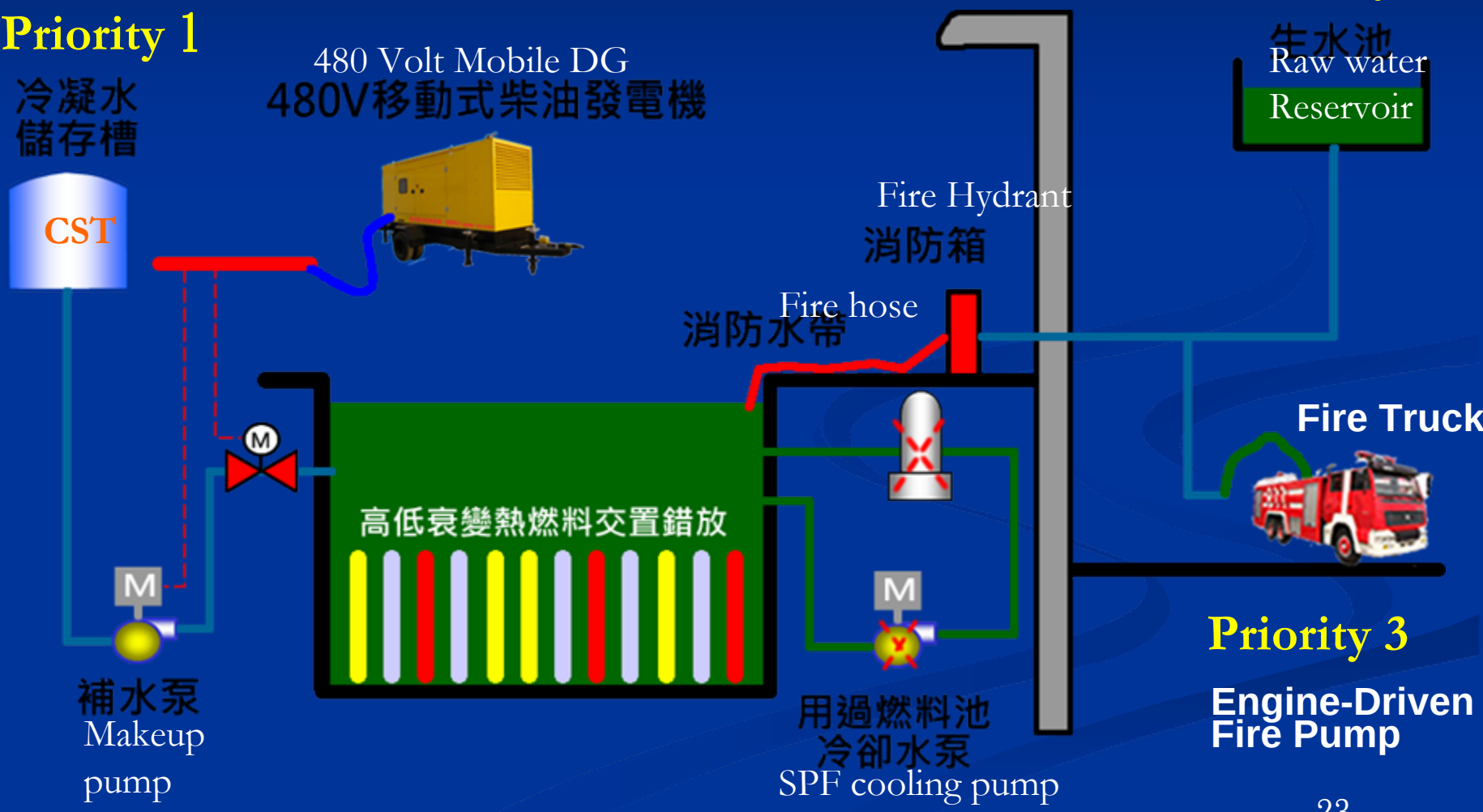
Beyond Design Basis – Reinforcement (1/4)

- Core, Containment Cooling : Emergency Makeup



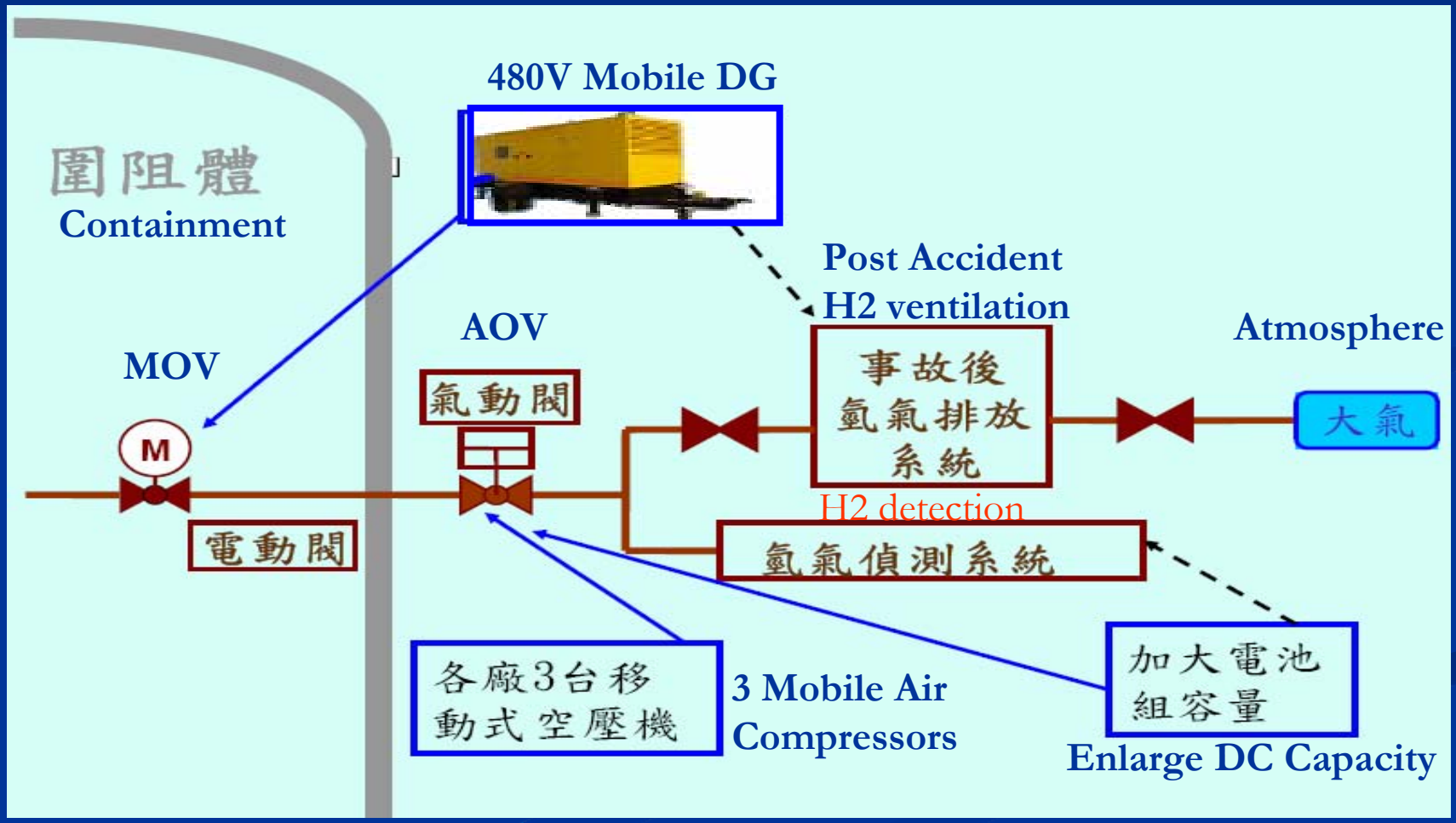
Beyond Design Basis – Reinforcement (2/4)

- Spent Fuel Pool Emergency Makeup



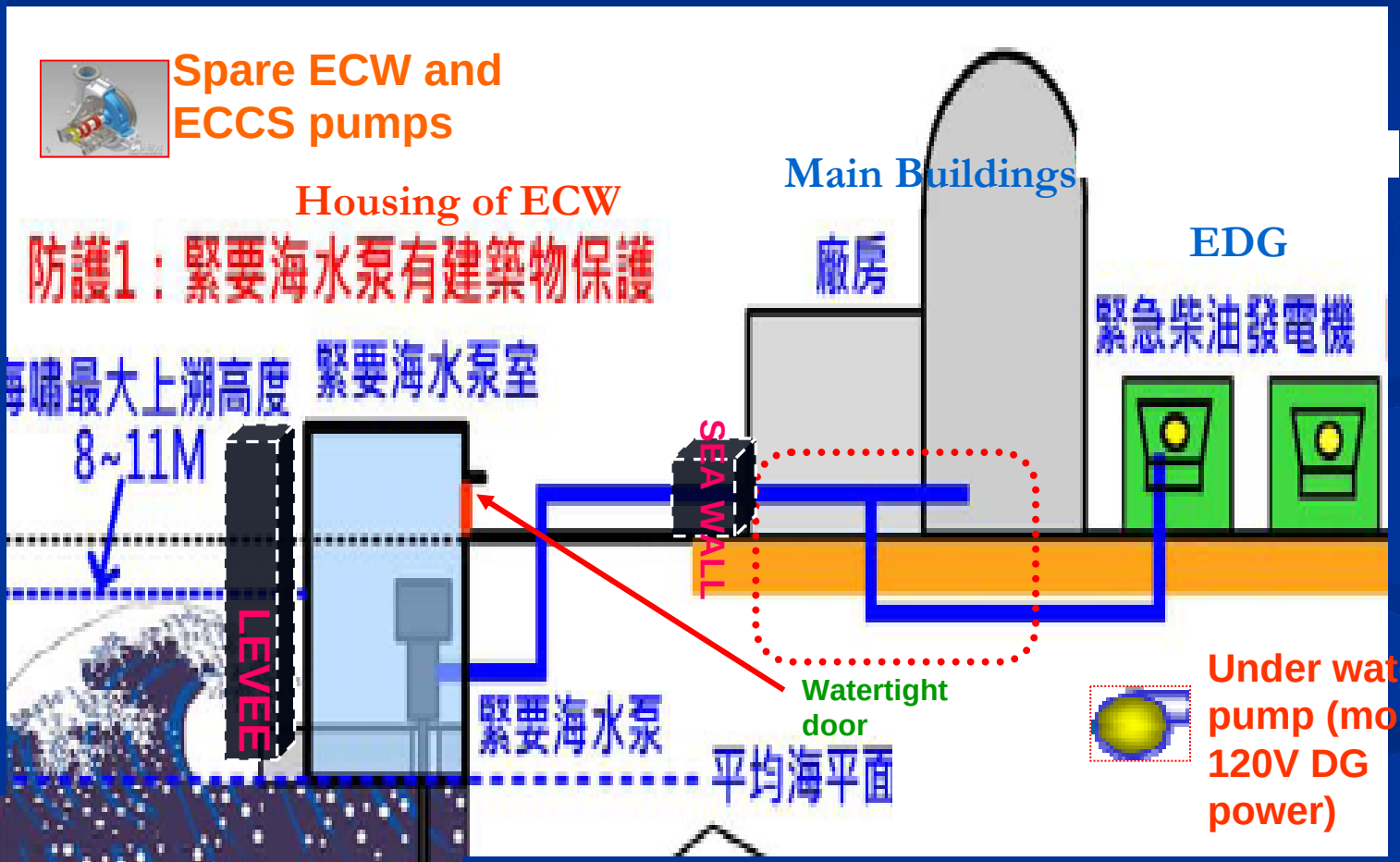
Beyond Design Basis – Reinforcement (3/4)

- Containment H_2 Monitoring & Emergency Purge



Beyond Design Basis – Reinforcement (4/4)

- Ultimate Heat Sink & Flood Protection



Note: Sea wall heights will depend on re-evaluation

Follow-up Action Plan (1/3)

- European Union's Stress Test
- Compliance with the EU specifications
  - **Utilities Final Report for operating NPPs: Early March, 2012**
  - **National Report : Late June, 2012**
  - **Utilities Final Report for NPP under construction : By the end of April, 2012**
  - **Peer Review by Internal and International Experts**

European Union's Stress Test

- Initiating Events:
  - Earthquake
  - Flooding
- Consequence of Loss of Safety Functions from IEs
  - Electrical Power
  - Ultimate Heat Sink
- Severe Accident Management Guidance
  - Means to protect from and to manage loss of core cooling / SFP cooling/ CTMT integrity

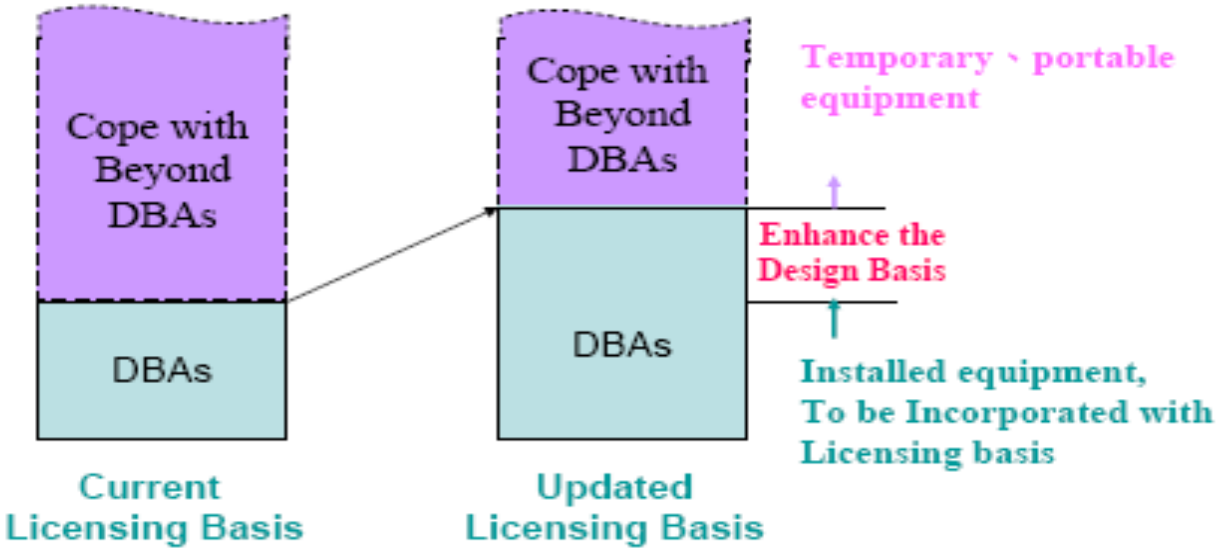
Follow-up Action Plan (2/3)

- **Mid-term Actions for Operating NPPs** - Periodic Integrated Safety Assessment by 2012
  - **Routine Periodic Assessment every 10 Years**
  - **To Include the Coping Capability of Fukushima Accident**
  - **To advance the schedule by 2 years for Maanshan NPP**

Follow-up Action Plan (3/3)

- Evaluation for Lungmen Plant
  - No immediate threat since no nuclear fuels in the reactor
  - Complete the required actions similar to operating NPPs before the initial fuel Loading
  - Two Gas-Turbines Generators should be installed in Lungmen
    - the completion date now is set to June 30, 2013 or the date for issuing operating license of Unit 1, whichever is earlier.
- Issuance of Regulatory Orders

Capability to cope with Beyond DBAs

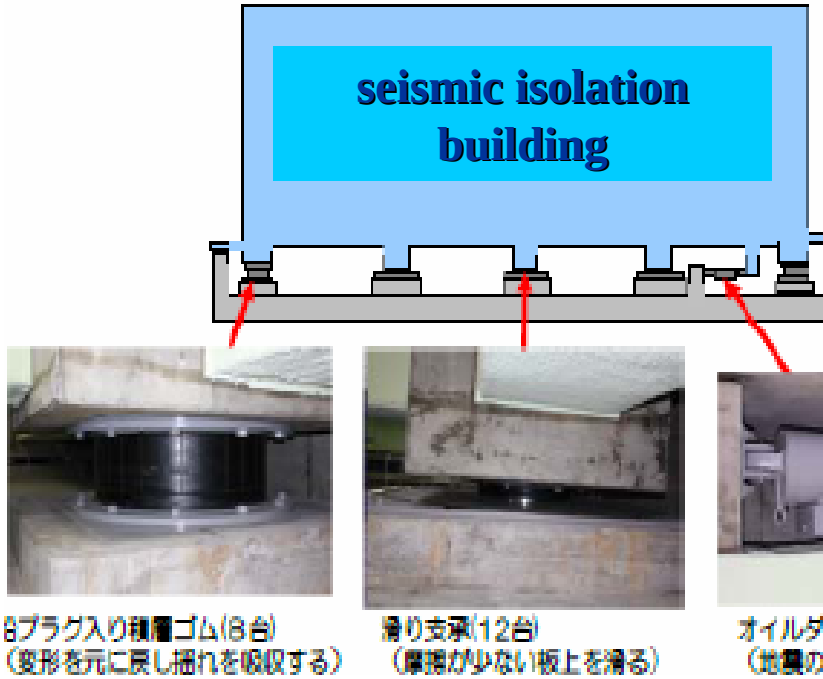


Regulatory Orders (1/3)

- AEC requested TPC to adopt the results by USNRC NTTF Report Tier 1 Recommendations (SECY 12-0025)
  - 2.1 Seismic and flood hazard reevaluations
  - 2.3 Seismic and flood walkdowns
  - 4.1 Station blackout (SBO) regulatory actions
  - 4.2 Equipment covered under Title 10 of the Code of Federal Regulations (10 CFR) 50.54(hh)(2) (implementation of NEI 06-12)
  - 5.1 Reliable hardened vents for Mark I and Mark II containments (other CTMT design)
  - 7.1 SFP instrumentation
  - 8 Strengthening and integration of EOPs, SAMGs, and EDMGs (& URGs)
  - 9.3 Emergency preparedness regulatory actions (staffing and communications) – *Department of Nuclear Technology*
- Follow-up the Tier 2 & Tier 3 Recommendations by USNRC
- Special Countermeasures for issues related to the Seismic, Tsunami, and SBO, by referring to international practice

Regulatory Orders (2/3)

- **Countermeasures for Seismic, Tsunami Hazard**
  - **To conduct survey on the newly found faults near NPPs 3 years ago (in 2009)**
  - **Install additional seismic instrumentation for monitoring and system identification**
  - **Re-evaluate the hazard by state-of-the-art methodology and incorporate the new findings**
  - **Simulation the mechanism of seismic and tsunami hazards and the resulting risks**
  - **Enhance the watertight of Buildings (or build seawall, or tidal barrier)**
  - **Enhance the structure of non-seismic qualified TSC**
  - **Build the seismic isolation building** – *Department of Nuclear Technology*



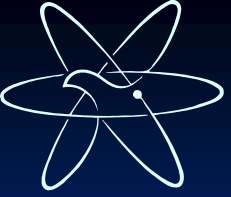
Enhance the structure of non-seismic TSC

Regulatory Orders (3/3)

- Additional Considerations for SBO Rule
  - It includes snowfall, hurricane, tornado, and storm resulting the LOOP in RG 1.155 but not seismic, tsunami, salt fog and landslides damage
  - Specific natural events with high hazard
  - Capability to recover OSP in 2 hours
  - Initiating event frequency of LOOP
  - North-south elongated island surrounded by the sea with independent grid, no backup
- Countermeasures for SBO
  - Extend the coping time to at least 24 hours
  - Installation of seismic qualified 6th gas-cooled EDG
  - Installation the alternate UHS
- TPC may submit alternative plans approved by AEC to provide the equivalent function to conform the requirement of nuclear regulatory cases

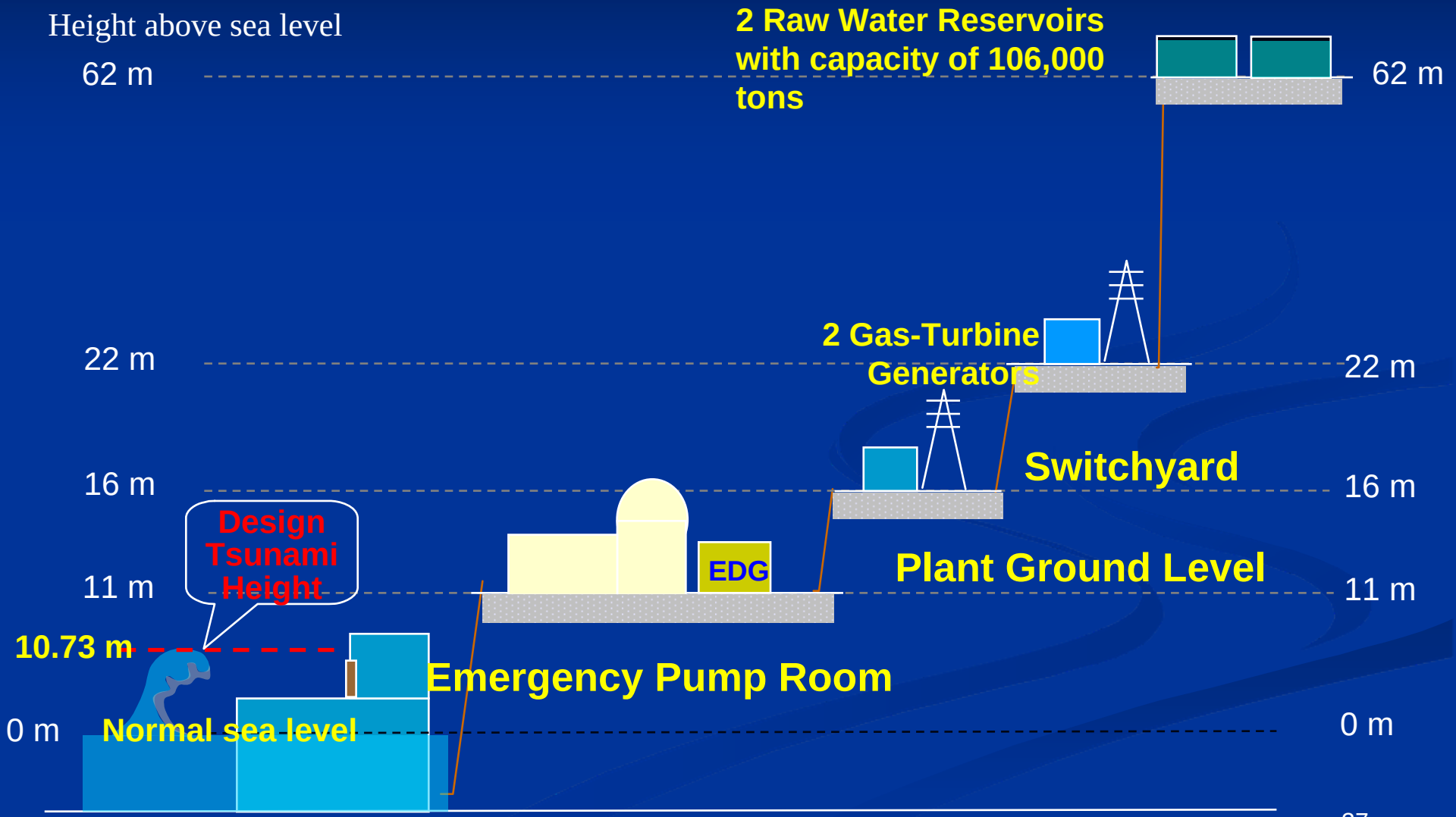
Concluding Remarks

- AEC has reviewed TPC's countermeasures for Post-Fukushima responses and conducted inspections for all NPPs in Taiwan
- The preliminary results show that continued operation of nuclear power plants pose no imminent risk to the public health and safety, while some areas need improvement
- AEC requested TPC more countermeasures in the regulatory orders to further enhance the capability to cope with extreme natural disasters

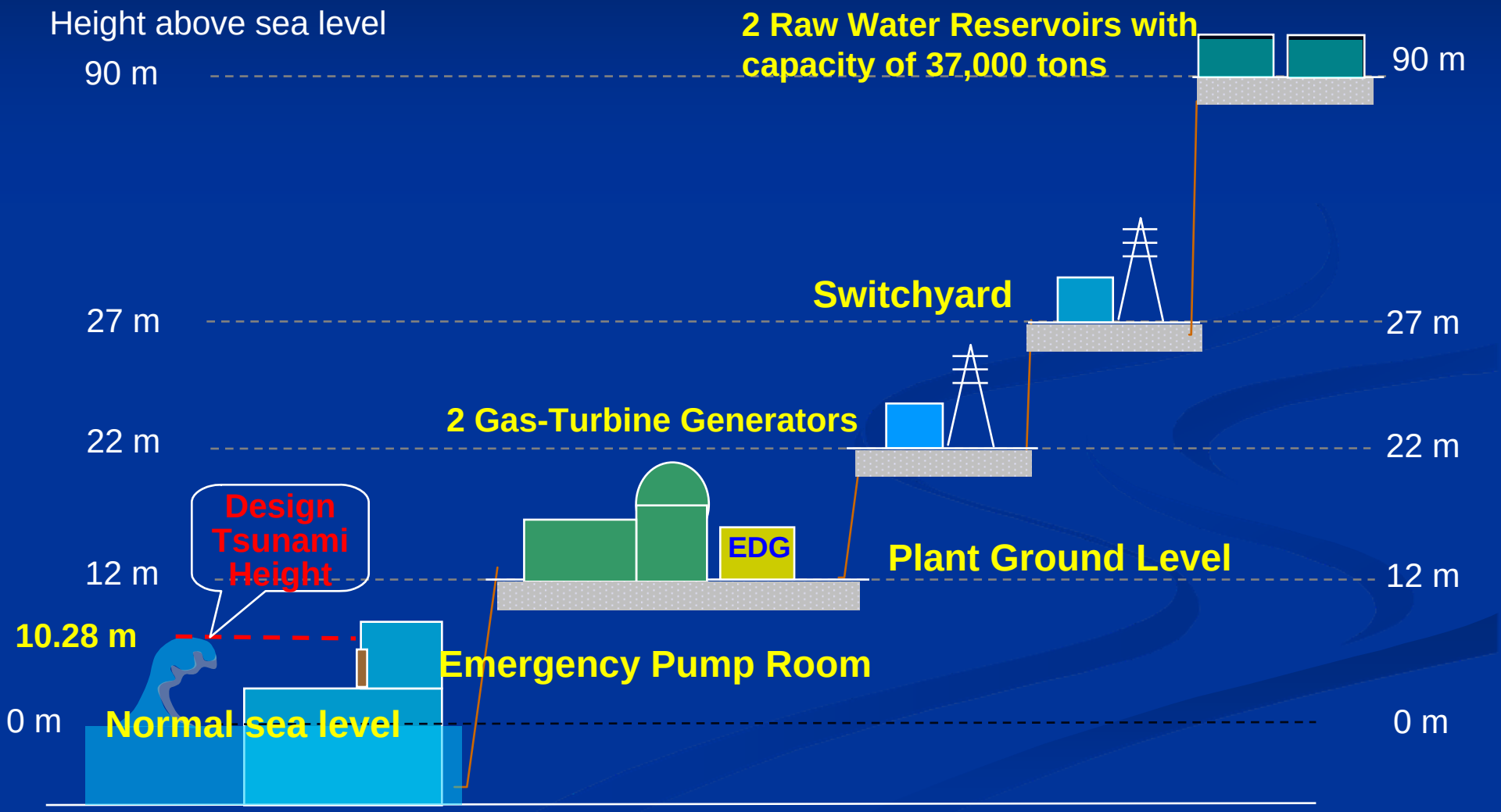


Thank You for Your Attention

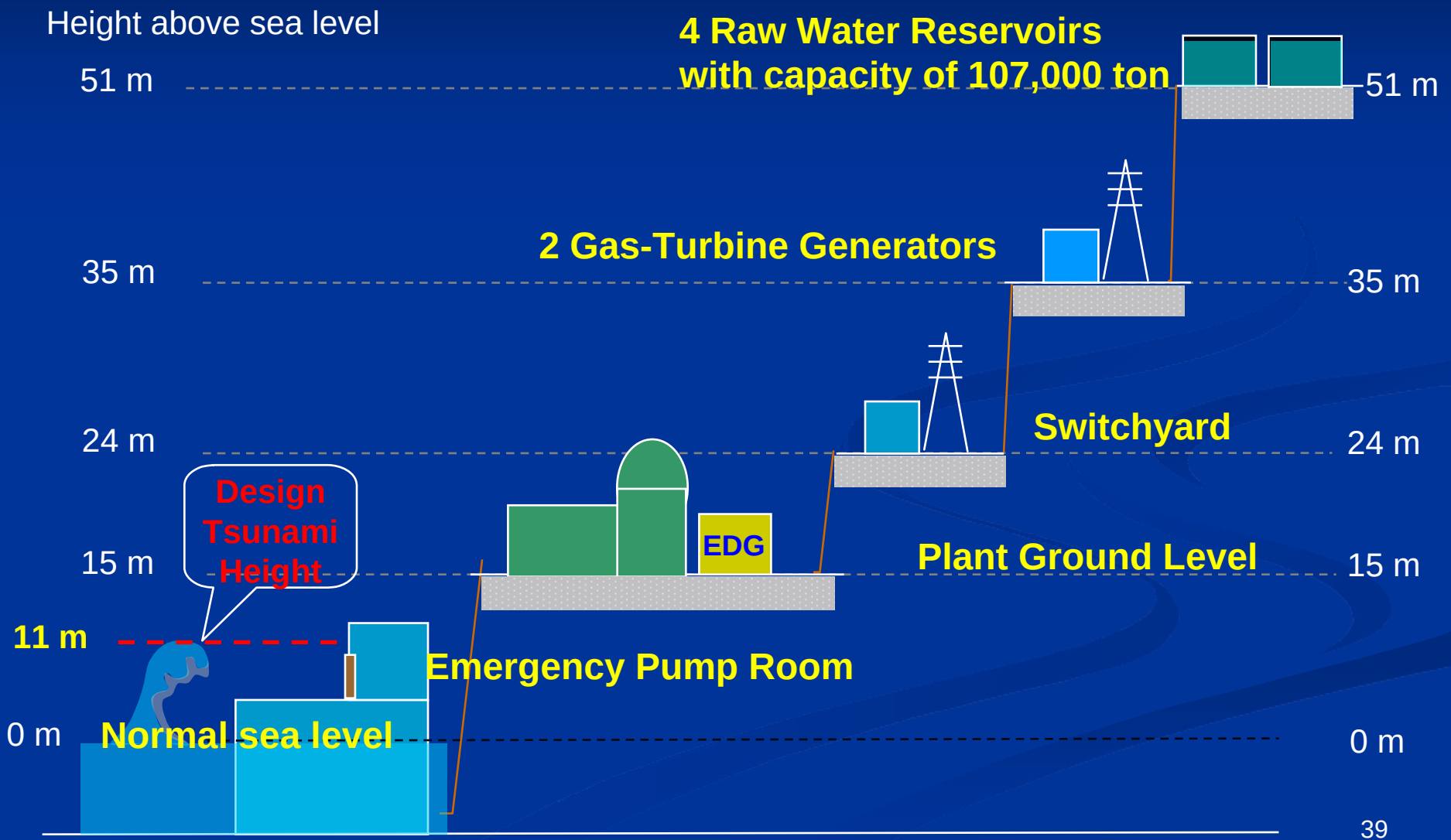
Heights of Major Facilities of Chinshan Nuclear Power Plant



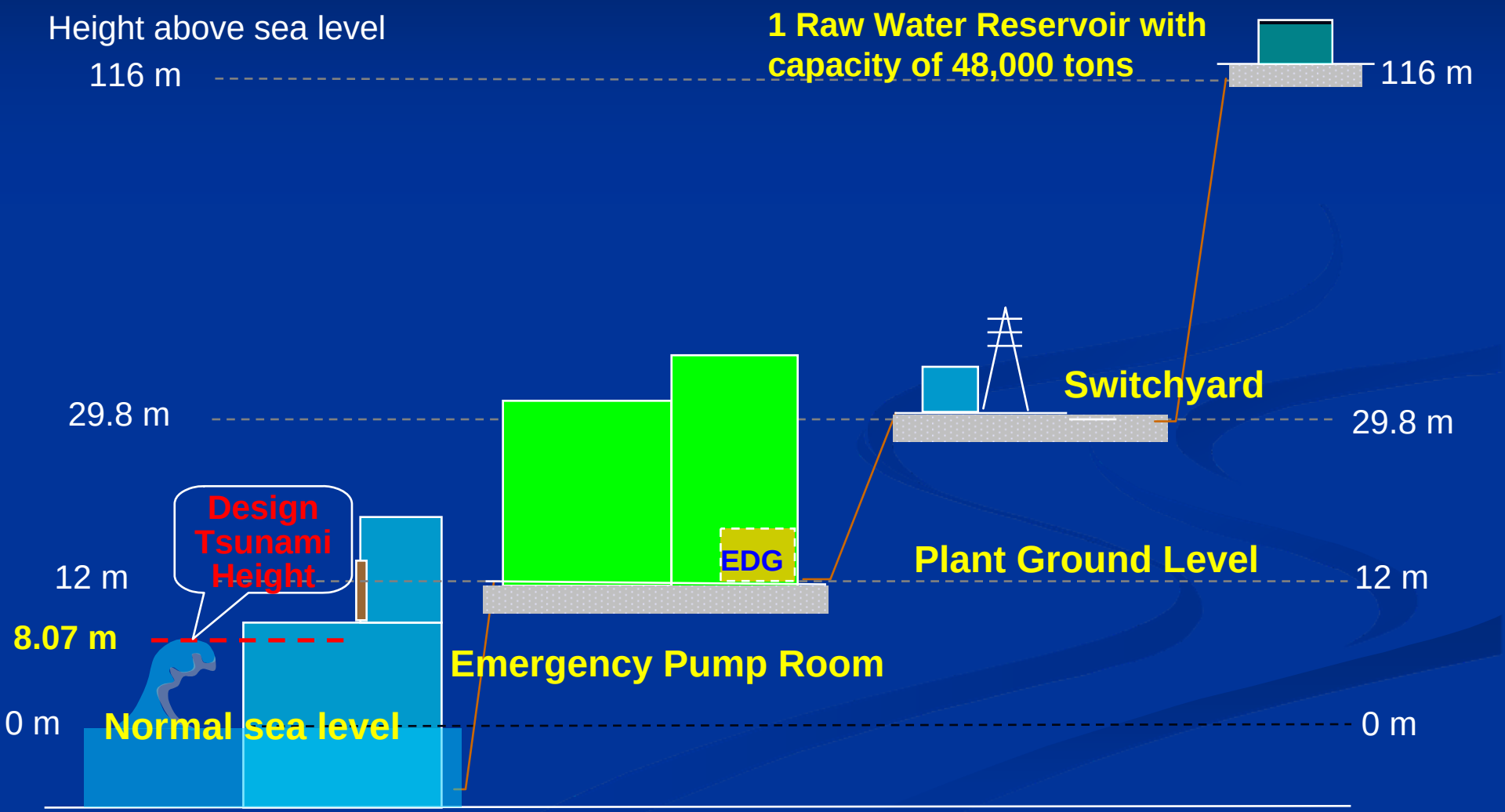
Heights of Major Facilities of Kuosheng Nuclear Power Plant



Heights of Major Facilities of Maanshan Nuclear Power Plant



Heights of Major Facilities of Lungmen Nuclear Power Plant



Part II：Radiation Protection and Emergency Response

- Emergency Response and Its Regulations
- Emergency Preparedness
- Emergency Response Capability

Emergency Response and Its Regulations

- **Emergency Response, mechanisms and regulations**

  It includes expanding the Emergency Planning Zone (EPZ), reviewing the Nuclear Emergency Response Act and related regulations, establishing a mechanism to response compound disasters, re-assessing the mission and functions of response units, and enhancing the capabilities and abilities of the nuclear emergency preparedness & response system. All the measures are to ensure the nuclear emergency preparedness & response system more efficient and effective.

Emergency Response and Its Regulations

- **Offshore nuclear accident monitoring**
  - **The application of atmospheric dispersion model**

In the past, the research had focused on the atmospheric dispersion assessment near the nuclear power plant area. The so-called two or three dimensional model has been established. After the Japan's Fukushima accident, the focus of research will shift to the long range atmospheric dispersion. It is important to realize how to integrate those different models or harness a highly recognized model in the international community. The cooperation with NNSA/DOE could benefit the ongoing model development in Taiwan.

Emergency Response and Its Regulations

- **Marine and airborne radiation monitoring**

- Marine monitoring: coordinated with coast guard and Ministry of Defense to establish supportive procedure to monitor marine radiation level.

- Airborne monitoring technique : Airborne monitoring is an effective way to monitor the radiation level in the air in an effort to judge its possible radiological impact to the environment and the public. Meanwhile, the government can use the information to guide the public to take early evacuation or sheltering measures. In Taiwan, small unmanned aircrafts was developed mainly for meteorological studies. The hardware and software for the airborne radiation monitoring technique will be developed with the assistance of the NNSA/DOE.

Radiological Protection Guideline following a nuclear accident

- Department of Health is amending the Guidelines of permitted radioactive contamination in food
- AEC has already promulgated an interim standard on the radioactivity control of imported consumer products and inbound passengers after Fukushima nuclear accident. (0.2 μ Sv/h)
- AEC has finalized Radiation Guidelines for Interrupting School Classes and Work Duties

Review rescue and support capability

- Mobilized and coordinated man power and equipment of relevant organization for radiation monitoring and protection purposes.
- Local government agencies should either establish their own laboratories or partnership with universities or research institutes to enhance their monitoring capability.

Environmental Radiation Detection Laboratories and analysis capability

- Purchase “High efficiency pure germanium Multi-channel analyzer system” and “Wide range pure germanium energy spectrum analysis system”
- Establish prompt accidental detection and analysis capability, upgrade environmental detection techniques and quality, and purchase Induction Coupled Plasma Mass Spectrum (ICP-MS) equipments.
- Establish 3G wireless-transmission for “Emergency Response Environmental Radiation Monitoring and Display Network” which can be installed at any chosen locations, and can transmit real-time radiation level and meteorological information.

Emergency Preparedness

- **Review of Radiation Detection Plan**
  - Planning to add real-time environmental radiation monitoring stations and monitoring routes
  - Each nuclear power plant should be equipped with radiation detection vehicles for necessary emergency detection.
  - Reinforcement of air and land environmental monitoring in collaboration with Ministry of Defense and Ministry of Interior.
- **Establish dose reconstruction capabilities for public and rescuers**
  - Establishing the biodosimetry laboratory, purchasing automated microscope, establishing in vitro dose calibration curves, participating in inter-comparison (biodose network), in order to provide fully functioning biodosimetry service after accidental exposure.

Emergency Response Capability

- Response Operational tools
- Dose Evaluation System
- Update meteorological database, establish atmospheric dispersion models in view of the characteristics of different nuclides, and taking into consideration of nuclides' dry and wet condensation mechanism so as to analyze the atmospheric dispersion and evaluate public dose during the entire accident period.