Post-Fukushima Safety Re-assessment and EU Stress Test in Taiwan

Department of Nuclear Regulation
Atomic Energy Council, Taiwan

July 9, 2013

Outlines

- Introduction
- Results of Evaluation
- Nuclear Safety Re-assessment
  - Beyond-DBA Reinforcement
  - Follow-up Action Plan
  - Regulatory Orders
  - Major Findings of NEA Peer Review
- Concluding Remarks

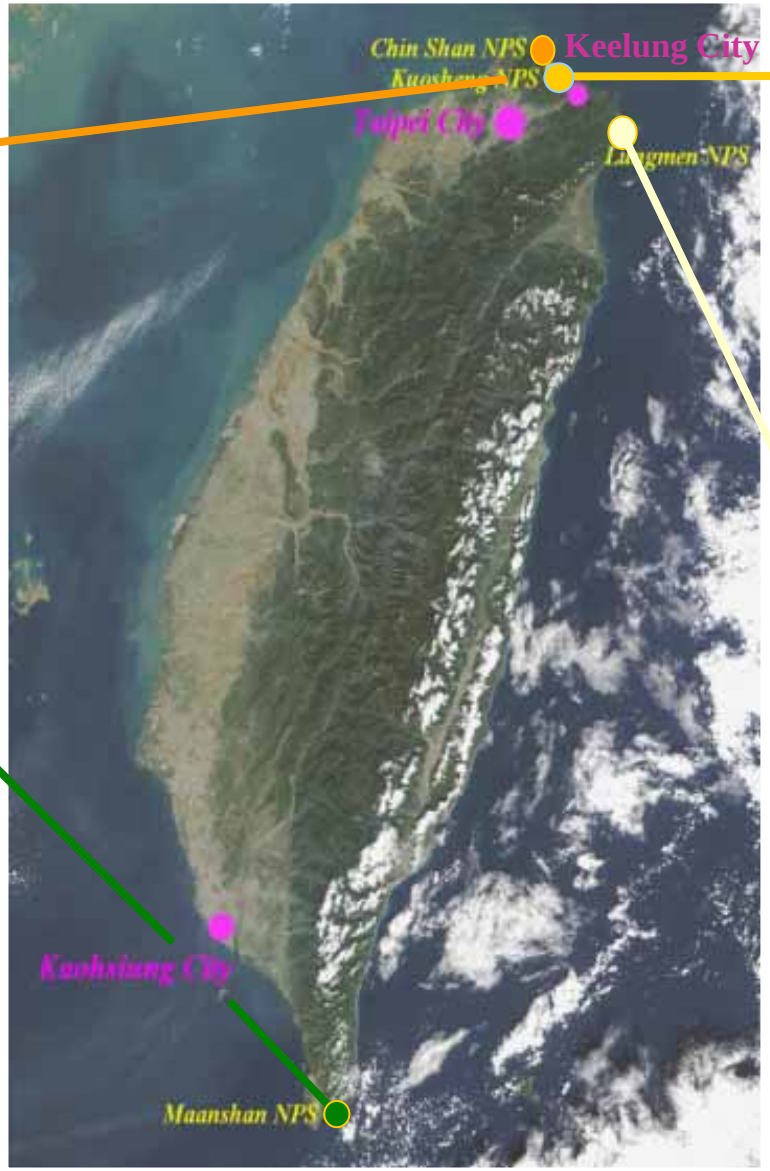
Nuclear Power Plants in Taiwan

Chinshan NPS

GE BWR-4 1804 MWt ㄨ 2
Commercial Dec-1978 Unit 1
Jul-1979 Unit 2

Maanshan NPS

Westinghouse 3-loop PWR
2822 MWt ㄨ 2
Commercial Jul-1984 Unit 1
May-1985 Unit 2



Kuosheng NPS

GE BWR-6 2943 MWt ㄨ 2
Commercial Dec-1981 Unit 1
Mar-1983 Unit 2

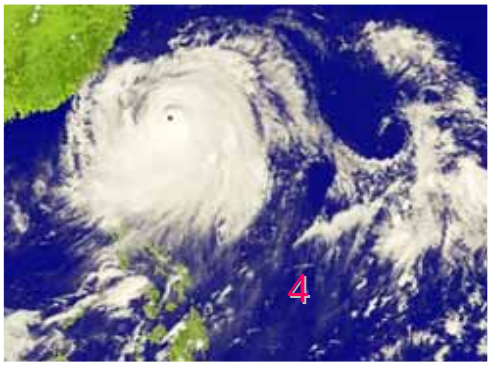
Lungmen NPS

GE ABWR 3926 MWt ㄨ 2
Commercial Under construction

Introduction (1/2)

- After Japan's Fukushima Daiichi Accident, Atomic Energy Council (AEC) required Licensee (TPC) to re-evaluate each site's capability to cope with extreme natural disasters, including earthquake, tsunami, and 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 required TPC to verify the capability of NPPs in response to both the DBA and beyond DBA
- Two-Stage Approach
  - Near-Term Evaluation (by June, 2011)
  - Mid-Term Evaluation (by December, 2011)

AEC Actions Timelines (1/2)

March 11, 2011	Fukushima Daiichi Accident	
	Task Force	
April 19, 2011	"Programs for Safety Re-assessment"	"Stress tests" specifications Proposal, WENRA, April 21, 2011
May 30, 2011	Preliminary Assessment Report of Nuclear Safety	
June, 2011	Special Inspection (1st)	The draft report issued in July 2011 is included with "EU stress test specifications" ,ENSREG, May 25, 2011
July, 2011	High-level review meetings (three)	
October, 2011	The Near-Term Overall Safety Assessment Report for NPP in Taiwan in Response to the Lessons Learned from Fukushima Daiichi Accident	Five progress meetings request by AEC from November 2011 to January 2012
November, 2011	Special Inspection (2nd)	

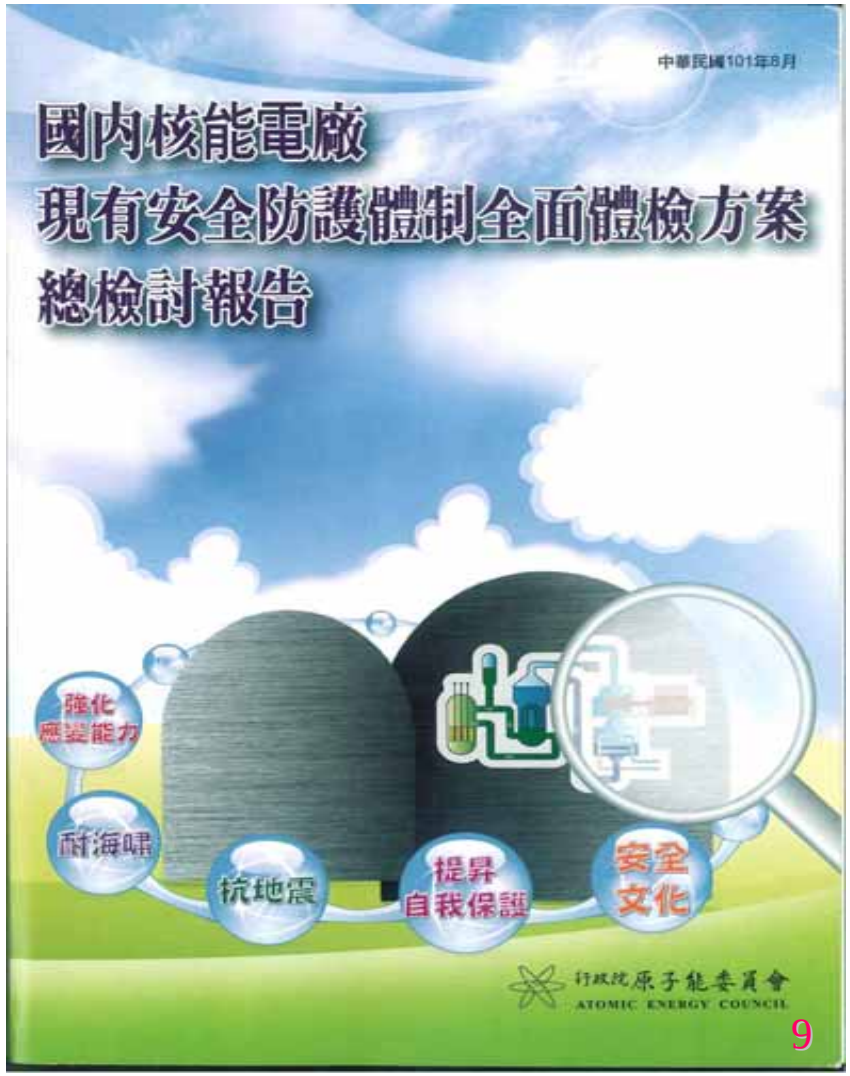
AEC Actions Timelines (2/2)

Results of Evaluation (1/2)

- **May 31, 2011:** AEC issued "Preliminary Assessment Report of Nuclear Safety" and held a public meeting
- **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"

Results of Evaluation (2/2)

- **August, 2012 : AEC issued "The Overall Safety Assessment Report for Nuclear Power Plants in Taiwan in Response to the Lessons Learned from Fukushima Daiichi Accident" final version and the draft regulatory orders**
- **November, 2012 : the final regulatory orders were issued by AEC**



Nuclear Safety Re-assessment

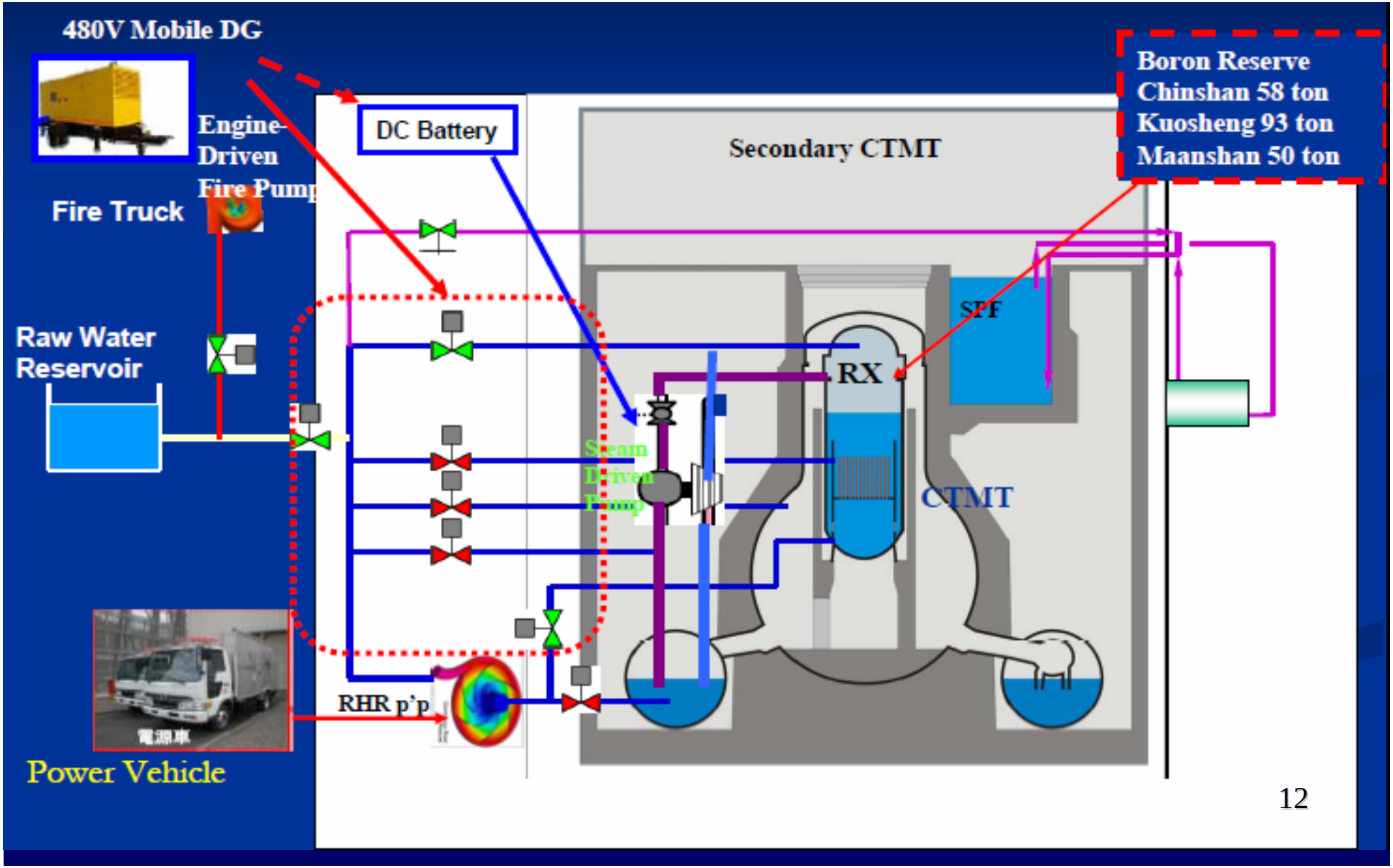
- **Areas for re-evaluation (TPC) and review (AEC)**
  - **Re-examine the Capability for Loss of All AC Power (SBO)**
  - **Re-evaluate Flooding and Tsunami Protection**
  - **Ensure Integrity and Cooling of Spent Fuel Pool**
  - **Assess Heat Removal and Ultimate Heat Sink**
  - **EOP Re-examination and Re-training**
  - **Build up the Ultimate Response Guidelines (URG)**
  - **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

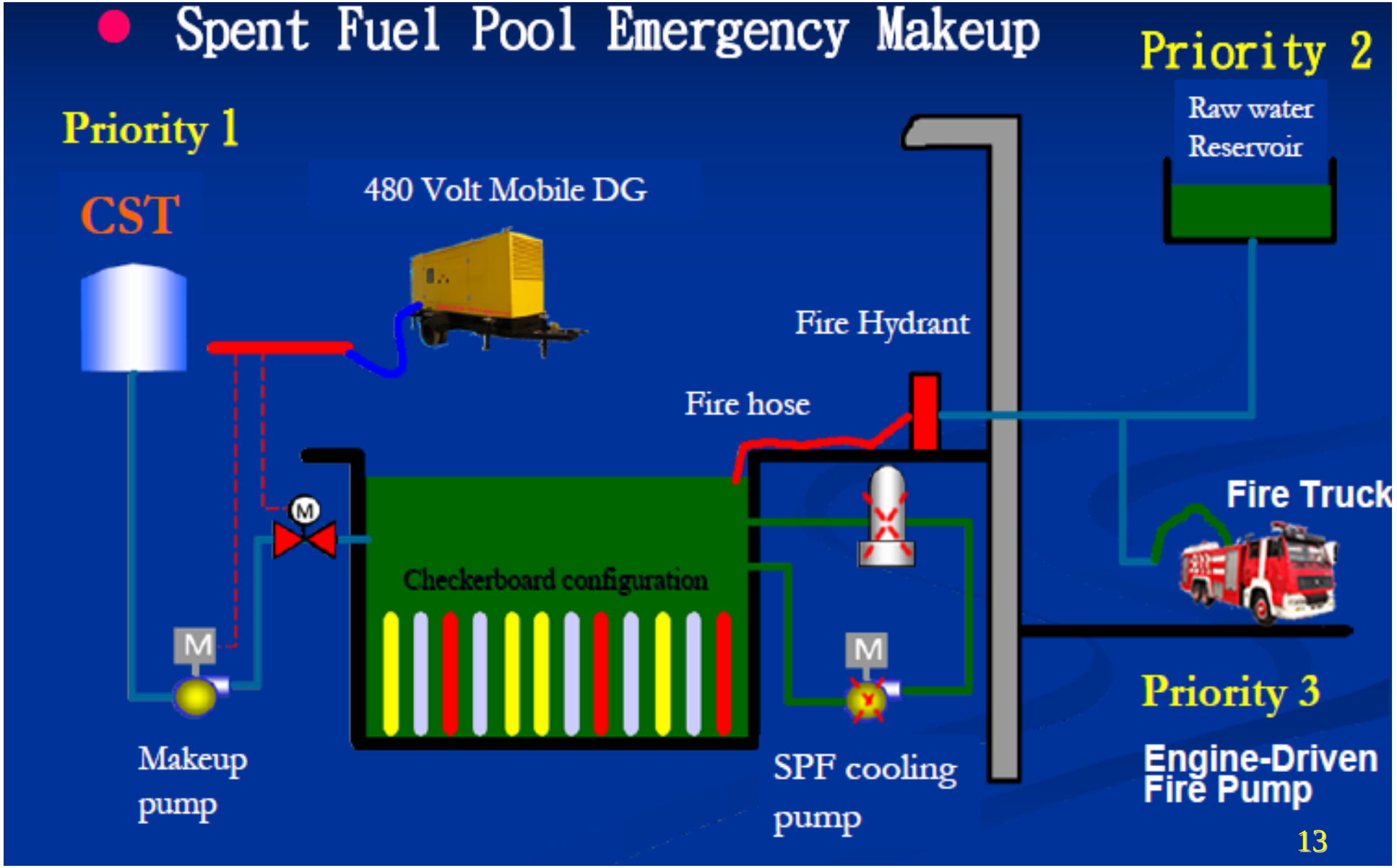
Item	AEC	NRC	NEI	WENRA	WANO	NISA
(1)	Re-examine the Capability for Loss of All AC Power (SBO)	✓	✓	✓	✓	✓
(2)	Re-evaluate Flooding and Tsunami Protection	✓	✓	✓	✓	✓
(3)	Ensure Integrity and Cooling of Spent Fuel Pool	✓		✓		✓
(4)	Assess Heat Removal and Ultimate Heat Sink	✓		✓		✓
(5)	EOPs Re-examination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

Beyond Design Basis – Reinforcement (1/4)

- Core, Containment Cooling : Emergency Makeup

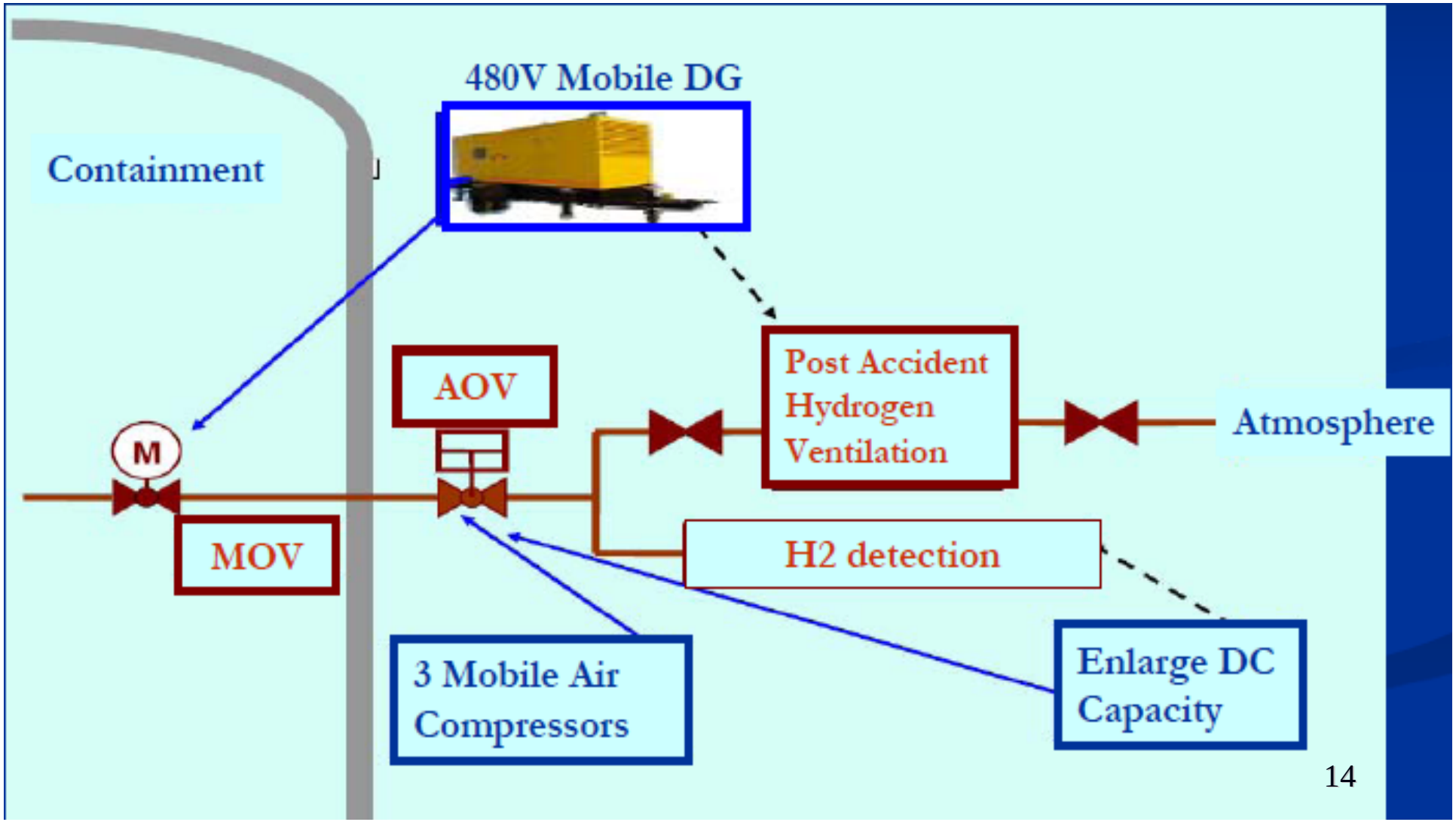


Beyond Design Basis – Reinforcement (2/4)



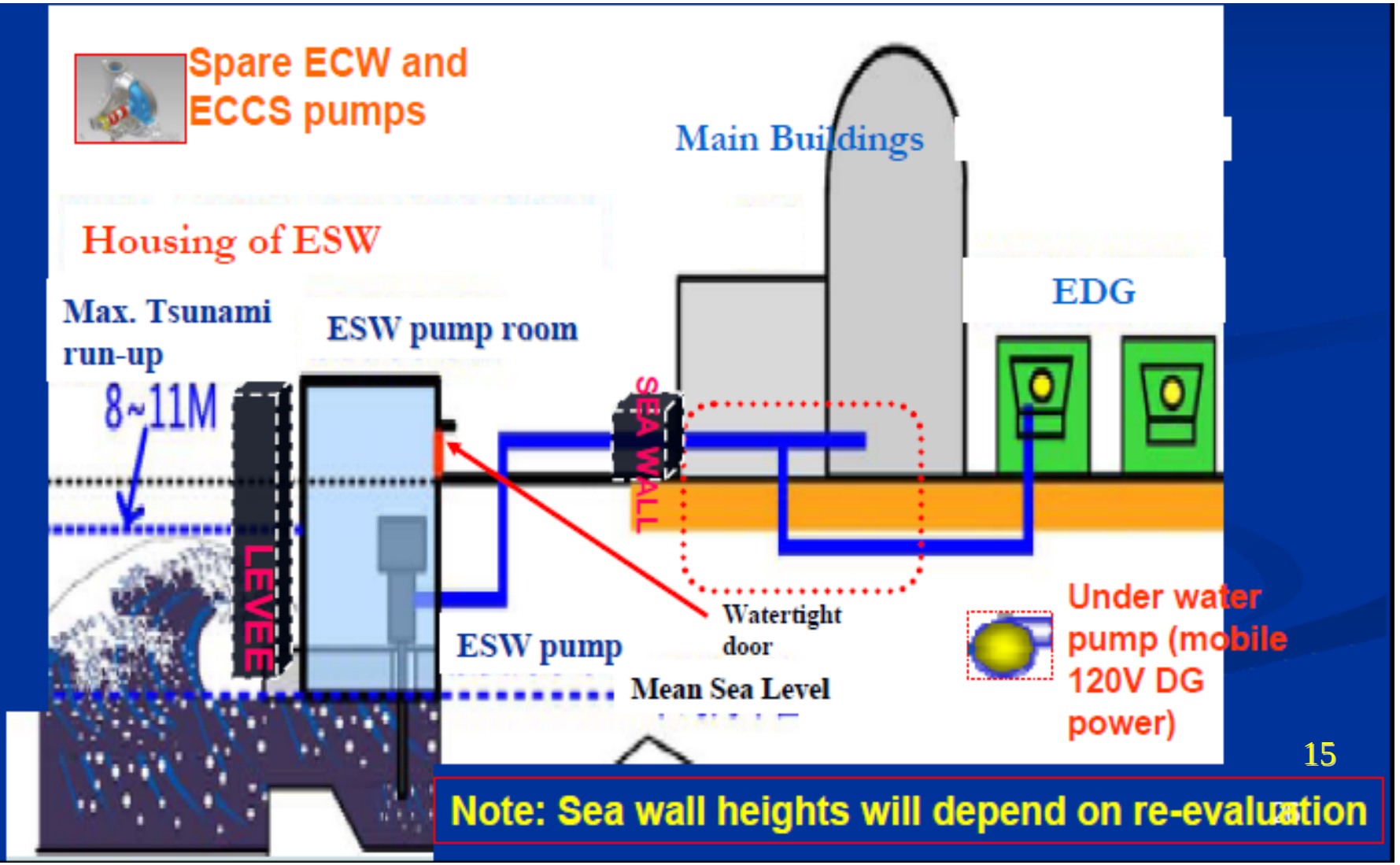
Beyond Design Basis – Reinforcement (3/4)

- Containment H_2 Monitoring & Emergency Purge



Beyond Design Basis – Reinforcement (4/4)

- **Ultimate Heat Sink & Flood Protection**



Capability to cope with Beyond DBAs

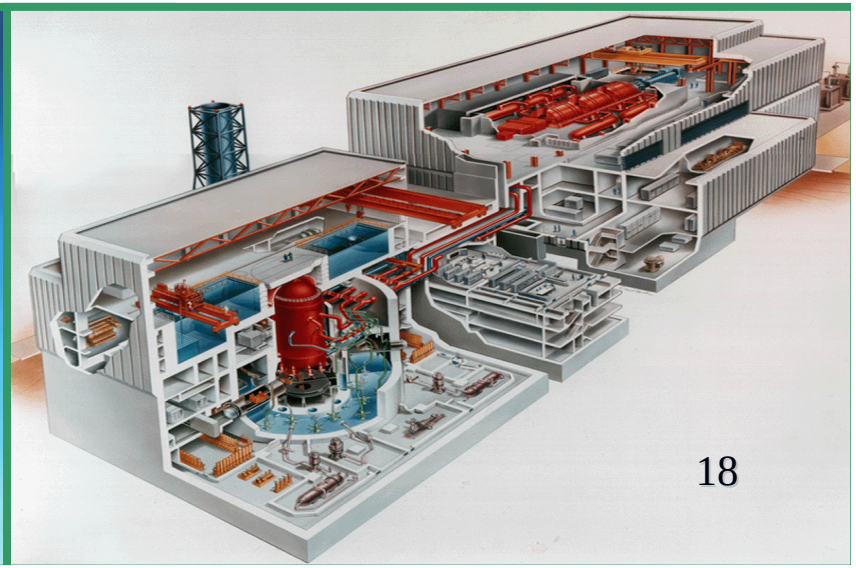
Item and Usage	CS	KS	MS
Power Vehicle - 4.16kV/1500kW (includes interfaces)	2	2	2
Mobile diesel generator - 480V (includes interfaces)	12	4	10
Diesel engine water pump – standby pump for CST, fire hydrant pressure boosting, and temporary water injection	8	5	7
Fire-fighting truck	-	1	2
Diesel engine water pump - temporary dewater pump	4	6	30
Spare motors of emergency service water pump	1	1	-
Mobile air compressor	3	3	3
Spare Borax and/or Boric acid (tons)	58	93	50

The mobile equipment is stored in the warehouse at higher elevation.
The mobile equipment including mobile diesel generators, diesel engine water pumps, etc. must be inspected, tested, and properly maintained to operable conditions followed by the program plans of NPPs.

Follow-up Action Plan (1/3)

- **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-Turbine Generators should be installed in Lungmen**



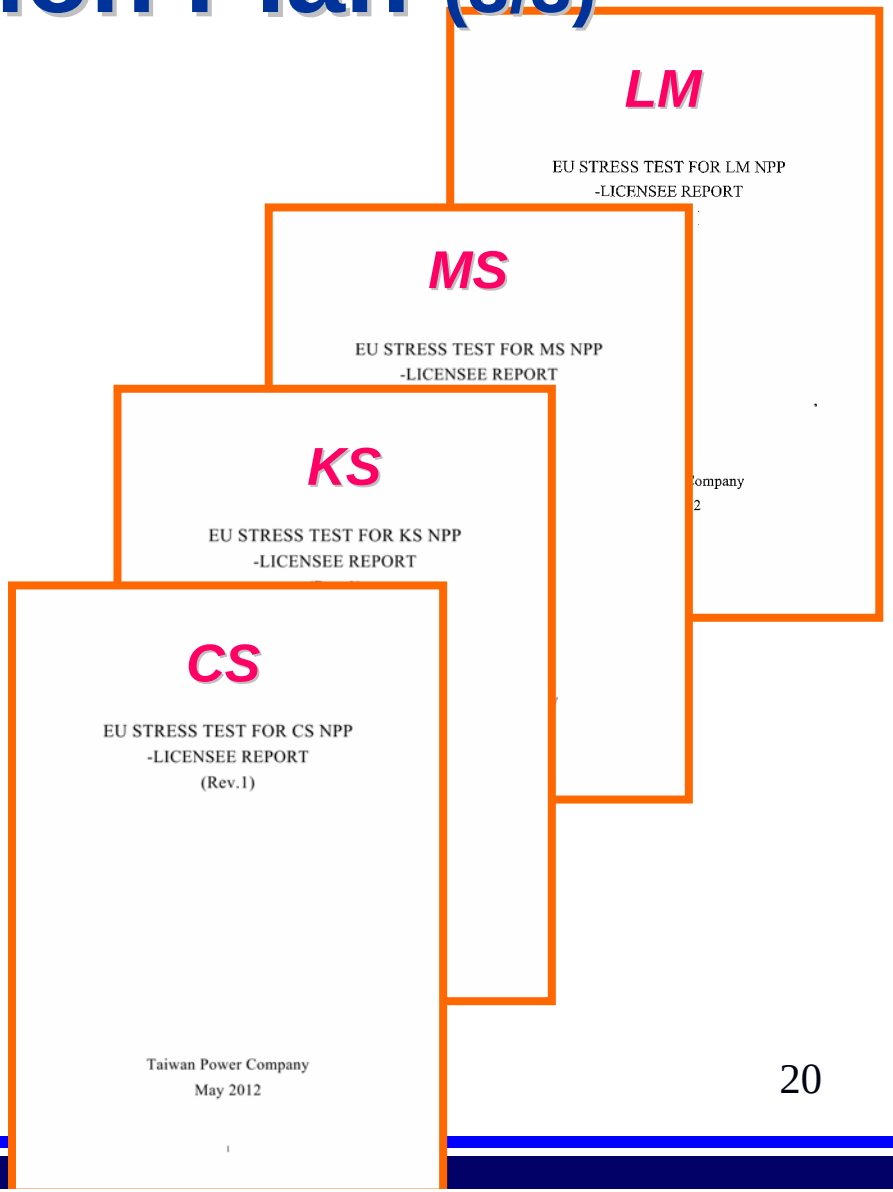


Follow-up Action Plan (2/3)

- According to EU Stress Test Specification, Implementing Stress Test to confirm defense-in-depth and safety margins and identify Cliff-edge Effect and effectiveness of countermeasures
- Initiating events
  - Earthquake
  - Flooding
- Consequence of loss of safety functions from any initiating event conceivable at the plant site
  - Loss of electrical power, including station blackout (SBO)
  - Loss of the ultimate heat sink (UHS)
  - Combination of both

Follow-up Action Plan (3/3)

- **Compliance with the EU specifications**
  - Utilities Final Report for operating NPPs: March, 2012
  - Utilities Final Report for NPP under construction :April, 2012
  - Draft National Report : June, 2012
  - Final National Report : January, 2013
  - Peer Review by International Experts organized by OECD/NEA: March 2013
    ENSREG: September 2013

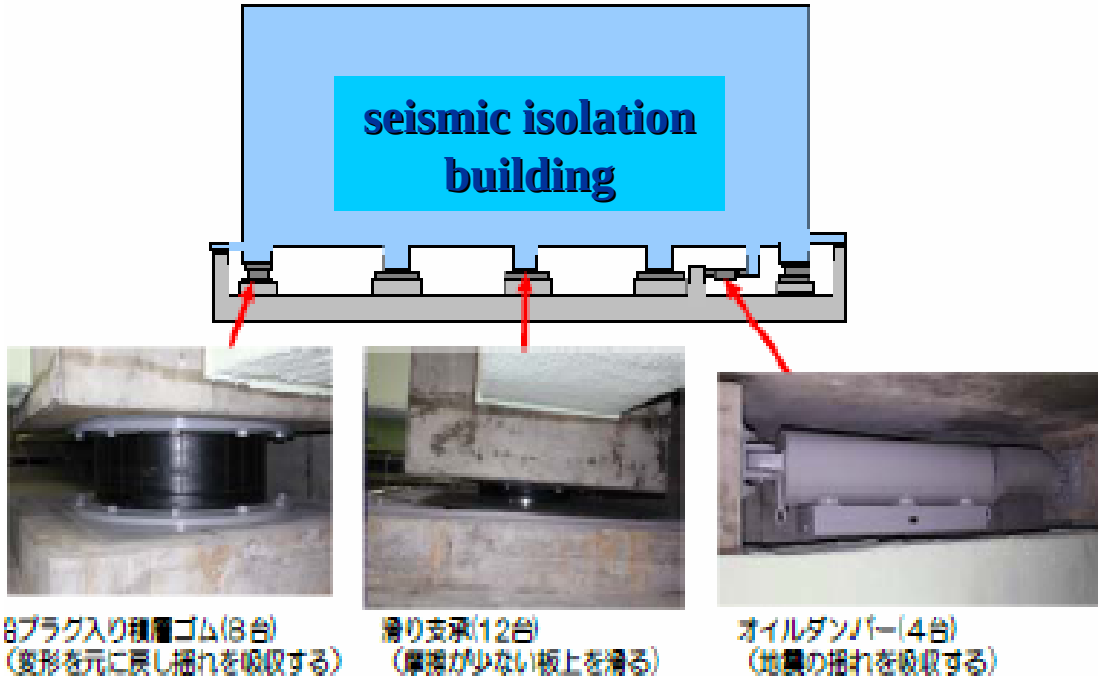


Regulatory Orders (1/4)

- **AEC required TPC to adopt the conclusions of USNRC NTTF Report Tier 1 Recommendations**
  - **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 10 CFR 50.54(hh)(2) (implementation of B.5.b)**
  - **5.1 Reliable hardened vents for Mark I and Mark II containments (Filtration, different types of 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)**

Regulatory Orders (2/4)

- Follow-up the Tier 2 & Tier 3 Recommendations by USNRC
- Follow-up the ENSREG's Action Plans from EU stress tests
- Special Countermeasures for issues related to the Seismic, Tsunami, and SBO, by referring to international good practices
  - To conduct survey on the newly found faults near NPPs 3 years ago
  - Install additional seismic instrumentation for monitoring and system identification
  - Re-evaluate the hazard by state-of-the-art methodology and incorporate the new findings
  - Simulate the mechanism of seismic and tsunami hazards and the resulting risks
  - Enhance the watertightness of Buildings (or build seawall, or tidal barrier) to the level 6 meters above current licensing bases
  - Enhance the structure of non-seismic qualified TSC
  - Build the seismic isolation TSC building



Enhance the structure of non-seismic TSC

Regulatory Orders (3/4)

- **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 offsite power in 2 hours
  - Initiating event frequency of LOOP
  - North-south elongated island surrounded by the sea with isolated grid, no backup
- **Countermeasures for SBO**
  - Enhance emergency DC power supply
    - to secure a storage capacity of at least 8 hours with the storage capacity of the batteries of one system without isolating the load/ and at least 24 hours after the unnecessary loads are isolated
  - Extend the SBO coping time to at least 24 hours
  - Installation of seismic qualified 6th gas-cooled EDG
  - Installation the alternate UHS
- **Install Passive Autocatalytic Recombiners (PAR) to prevent hydrogen explosions**

Regulatory Orders (4/4)

- Perform the Volcanic PRA of NPPs and study the impacts from ash dispersion
- Enhance the water-tight capabilities for the fire doors of essential electrical equipment rooms
- Enhance the seismic resistance for the fire brigade buildings to cope with BDBE
- Improve the seismic resistance of raw water reservoir and consider to install the impermeable liner
- Improve the reliability of offsite power supplies
- RCP seal LOCA issue of PWR plant
- TPC may submit alternative plans to provide the equivalent function to comply with the requirements of regulatory orders subject to AEC approval

Major Findings of NEA Peer Review

- To perform fault displacement hazard analysis
- To deploy a local seismic network near NPPs
- To provide an interface between post-earthquake and post-tsunami operating procedures
- To systematically assess the combinations of events in the areas of flooding and extreme natural events
- To check the probable maximum precipitation with regional topographical maps

Note: Other findings are already included in the AEC's regulatory orders

Concluding Remarks (1/8)

- AEC has reviewed TPC's countermeasures for Post-Fukushima responses and conducted inspections for all NPPs in Taiwan
- Two issues related to the current licensing basis of the nuclear power plants were found and confirmed resolved upon site inspection
- Many areas of improvement have been identified in the issues of nuclear safety assurance

Concluding Remarks (2/8)

- The key areas include the extended SBO, natural hazard, SAMG, SFP cooling, and
  - critical infrastructure
    - the enhancement of plant's sustainabilities for extended periods in terms of electrical power, cooling and necessary supplies
  - safety culture
    - While demanding TPC to improve its nuclear safety culture, AEC will strengthen regulatory oversight of licensee safety performance (i.e., the Reactor Oversight Process)

Concluding Remarks (3/8)

- The evaluation 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 required TPC more countermeasures in the regulatory orders to further enhance the capability to cope with extreme natural disasters

Concluding Remarks (4/8)

- **Radiation Protection**
  - **Concerning the impacts of released radioactive material resulted from the Fukushima nuclear accident as well as new builds of nuclear power plants in mainland China and Korea, the capability for assessing dose resulted from overseas nuclear accidents should be established in an effort to provide early warnings and take appropriate radiation protection measures**

Concluding Remarks (5/8)

- **Radiation Protection**
  - **As a result of the re-assessment, the EPZ has been expanded from 5 km to 8 km for all four nuclear plants in Taiwan**
  - **It is also essential to advance the effective range and processing speed of the existing accident dose assessment system, based on the lessons learned from the Fukushima accident**

Concluding Remarks (6/8)

- **Radiation Protection**
  - **In order to enhance domestic capability of radiation fallout monitoring in a timely manner, AEC has purchased mobile detection equipment with automatic data transmission capability, and actively establishing aerial and marine monitoring systems and capability, strengthening radiation hazard response capacity and setting up a radiation monitoring preparedness platform, so as to be prepared in the event of a compound disaster**

Concluding Remarks (7/8)

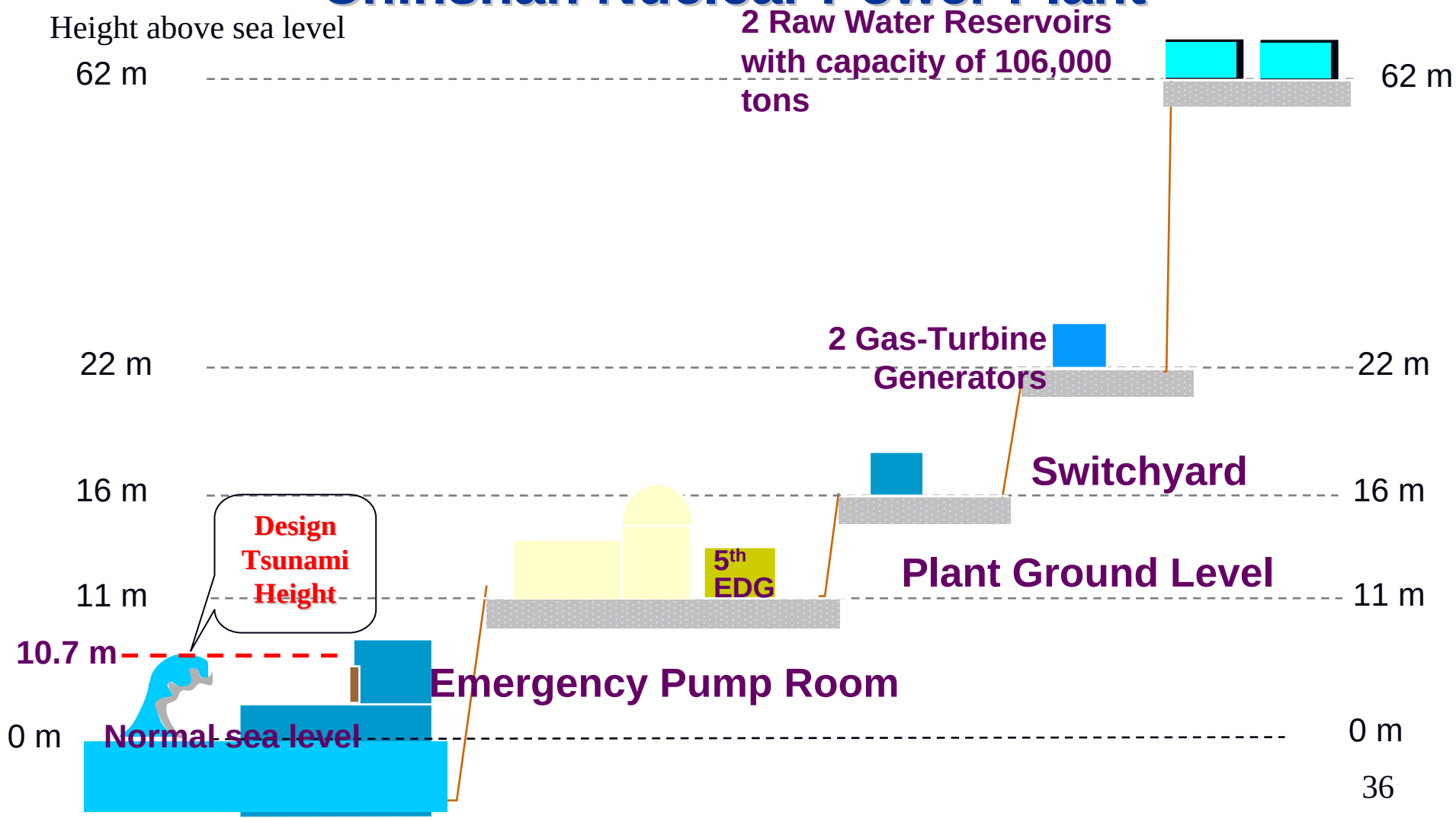
- **Emergency Response and Preparedness**
  - **The improved plans or measures are based on the lessons learned from Fukushima accident (beyond design basis) after a review on the current status of related issues as a baseline**
  - **It includes expanding the Emergency Planning Zone (EPZ), reviewing the Nuclear Emergency Response Act and related regulations, establishing a mechanism to respond to compound disasters, re-assessing the mission and functions of response units, and enhancing the capabilities and abilities of the nuclear emergency preparedness and response system**

Concluding Remarks (8/8)

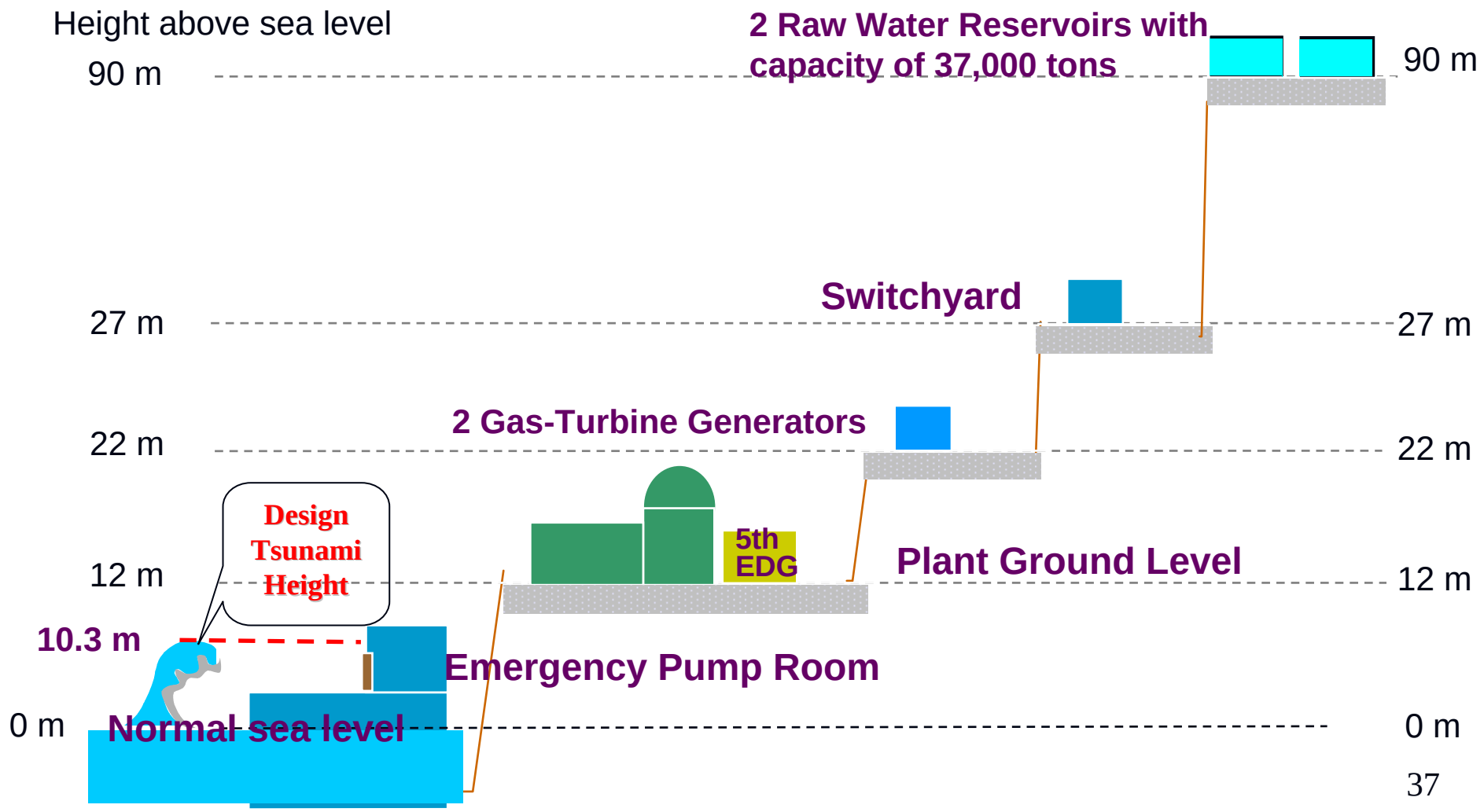
- **Emergency Response and Preparedness**
  - **All the measures are to ensure the nuclear emergency preparedness and response system more efficient and effective**

Thank you for your attention

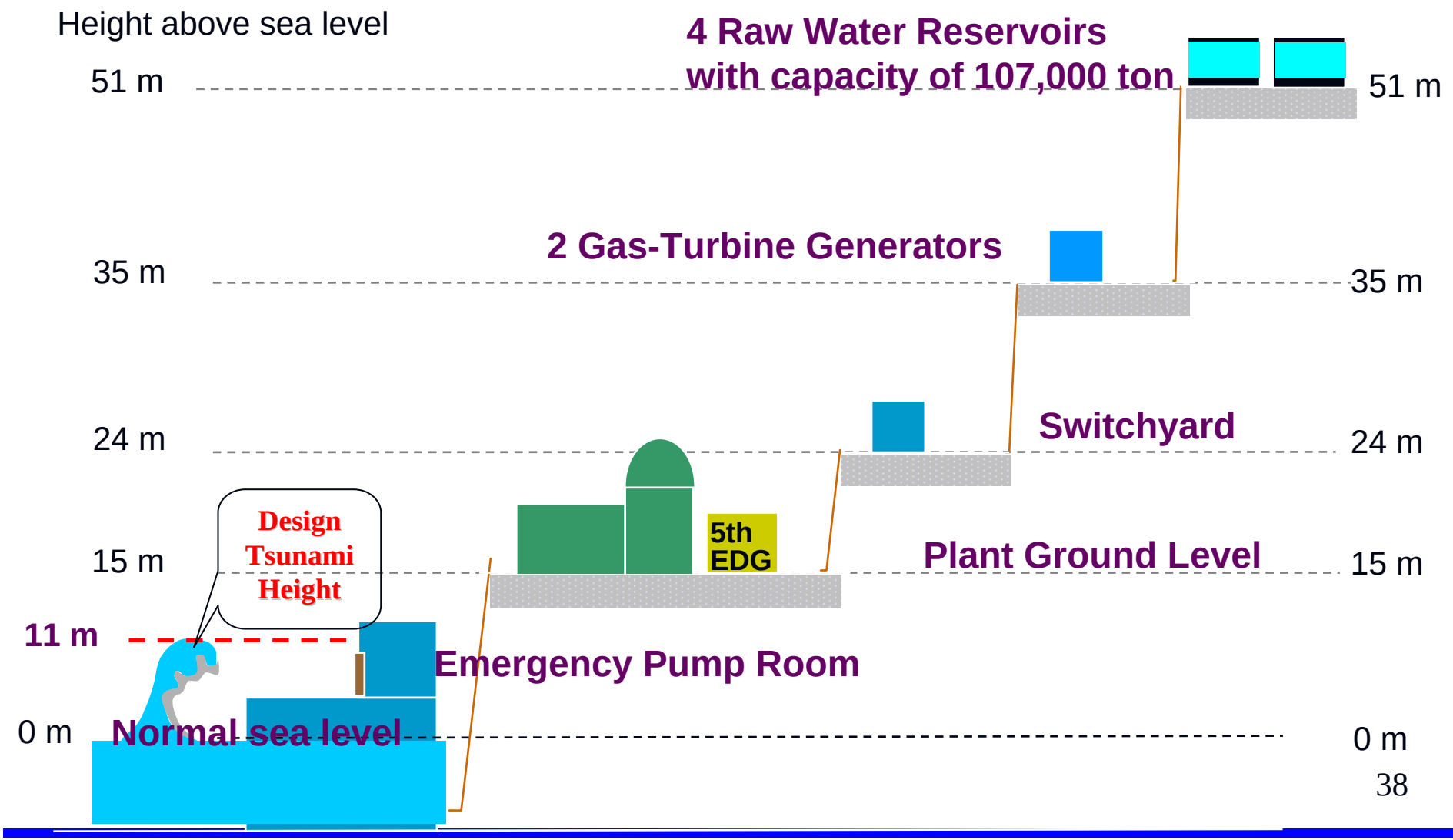
Heights of Major Facilities of Chinshan Nuclear Power Plant



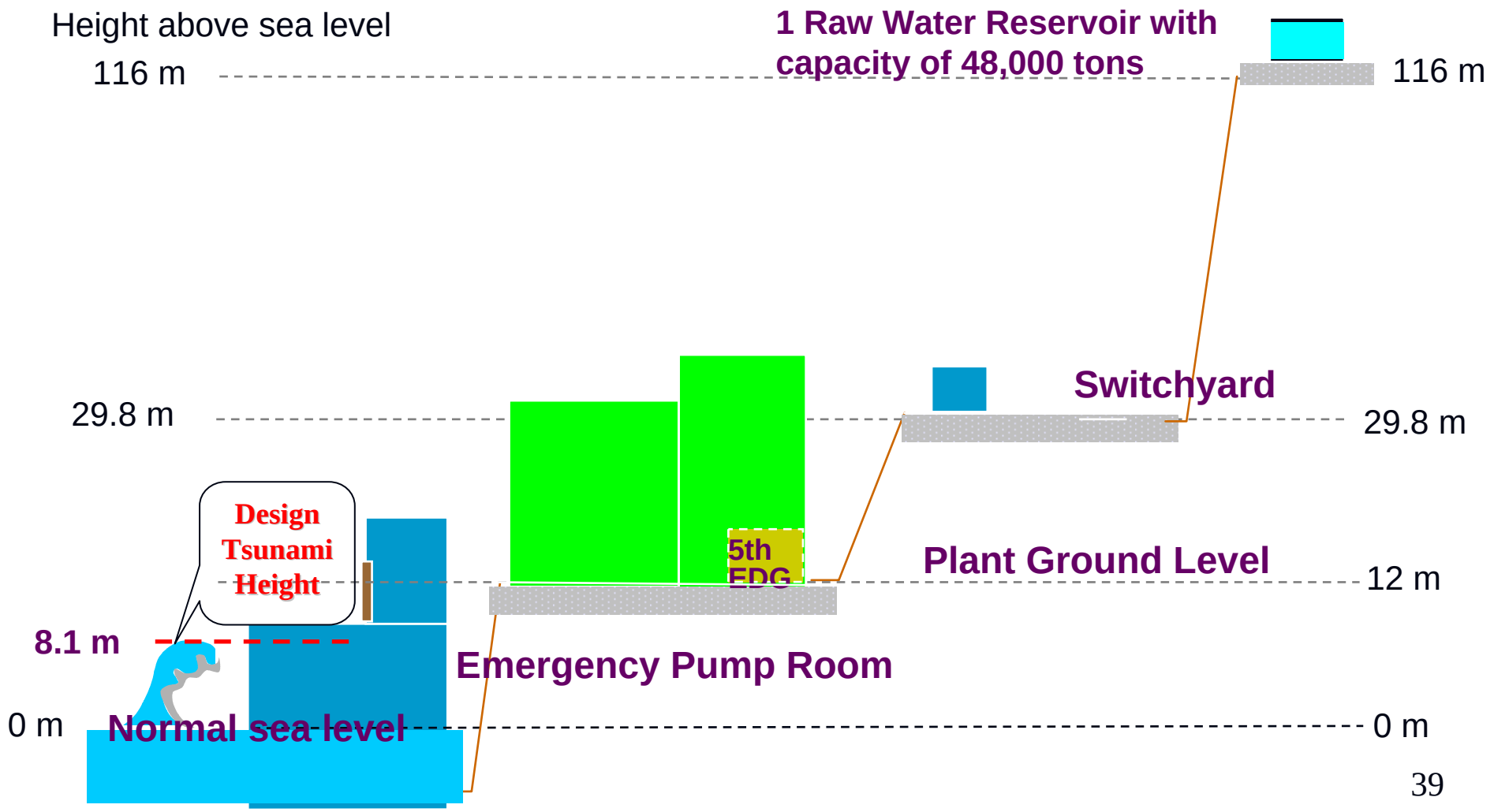
Heights of Major Facilities of Kuosheng Nuclear Power Plant



Heights of Major Facilities of Maanshan Nuclear Power Plant



Heights of Major Facilities of Lungmen Nuclear Power Plant



Enhancement of Protective Countermeasures requested to be Implemented

- **Housing of ESW**
  - **Installed flood barrier walls and water-tight doors to the pump house building**
- **5th DG Building**
  - **will install water-tight doors at the outer gates of safety related buildings at and below plant ground level**
- **Additional EDG or Equivalent**
  - **will Install additional gas-cooled EDG at higher elevation**
- **Raw water Reservoir**
  - **improves the seismic resistance of the raw water reservoir and its connecting pipes**
  - **Consider to install an impermeable liner on the inner surface of the raw water reservoir**
- **Switchyard**
  - **will increase the robustness of switchyard in order to improve the reliability of offsite power**

EU Stress Test: Taiwan Action Plan (1/4)

- **Compilation of Recommendations and Suggestions from the Review of the European Stress Tests - July 26, 2012**
- **European Level Recommendations**

2.1. European guidance on assessment of natural hazards and margins	AEC Requirement
2.2. Periodic Safety Review	AEC Requirement
2.3. Containment integrity	AEC Requirement
2.4. Prevention of accidents resulting from natural hazards and limiting their consequences	AEC Requirement

EU Stress Test: Taiwan Action Plan (2/4)

- **Other topics to be considered**

3.1 Topic I items (natural hazards) to be considered	
3.1.1 Hazard Frequency	AEC Requirement
3.1.2 Secondary Effects of Earthquakes	Future Plan
3.1.3 Protected Volume Approach	AEC Requirement
3.1.4 Early Warning Notifications	AEC Requirement
3.1.5 Seismic Monitoring	AEC Requirement
3.1.6 Qualified Walkdowns	AEC Requirement
3.1.7 Flooding Margin Assessments	AEC Requirement
3.1.8 External Hazard Margins	AEC Requirement

EU Stress Test: Taiwan Action Plan (3/4)

3.2 Topic 2 items (loss of safety systems) to be considered	
3.2.1 Alternate Cooling and Heat Sink	AEC Requirement
3.2.2 AC Power Supplies	AEC Requirement
3.2.3 DC Power Supplies	AEC Requirement
3.2.4 Operational and Preparatory Actions	AEC Requirement
3.2.5 Instrumentation and Monitoring	AEC Requirement
3.2.6 Shutdown Improvements	Under Evaluation
3.2.7 Reactor Coolant Pump Seals	AEC Requirement
3.2.8 Ventilation	AEC Requirement
3.2.9 Main and Emergency Control Rooms	Future Plan
3.2.10 Spent Fuel Pool	AEC Requirement
3.2.11 Separation and Independence	AEC Requirement
3.2.12 Flow Path and Access Availability	Under Evaluation
3.2.13 Mobile Devices	AEC Requirement
3.2.14 Bunkered/Hardened Systems	Future Plan
3.2.15 Multiple Accidents	AEC Requirement
3.2.16 Equipment Inspection and Training Programs	AEC Requirement
3.2.17 Further Studies to Address Uncertainties	Under Evaluation

EU Stress Test: Taiwan Action Plan (4/4)

3.3 Topic 3 items (severe accident management) to consider	
3.3.1 WENRA Reference Levels •Hydrogen mitigation in the containment •Hydrogen monitoring system •Reliable depressurization of the reactor coolant system •Containment overpressure protection •Molten corium stabilization	 AEC Requirement AEC Requirement AEC Requirement AEC Requirement Under Evaluation
3.3.2 SAM Hardware Provisions	AEC Evaluation
3.3.3 Review of SAM Provisions Following Severe External Events	Under Evaluation
3.3.4 Enhancement of SAMG	AEC Requirement
3.3.5 SAMG Validation	AEC Requirement
3.3.6 SAM Exercises	AEC Requirement
3.3.7 SAM Training	AEC Requirement
3.3.8 Extension of SAMGs to All Plant States	Under Evaluation
3.3.9 Improved Communications	AEC Requirement
3.3.10 Presence of Hydrogen in Unexpected Places	AEC Requirement
3.3.11 Large Volumes of Contaminated Water	Future Plan
3.3.12 Radiation Protection	AEC Requirement
3.3.13 On Site Emergency Center	AEC Requirement
3.3.14 Support to Local Operators	AEC Requirement
3.3.15 Level 2 Probabilistic Safety Assessments (PSAs)	Under Evaluation
3.3.16 Severe Accident Studies	Under Evaluation