East-Asian Nuclear Energy Forum

Nuclear Safety after the Fukushima Accident

Nuclear Power in Taiwan

Lin Cheng-Chung

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Outline

- National Energy Policy
- Nuclear Power Performance in 2012
- Safety Improvement Progress after Fukushima
- Status and controversy of Lungmen

National Energy Policy

Announced by President Ma on November 3, 2011

- **Ensure nuclear safety**
- **Gradually reduce reliance on nuclear power**
- **Create a green power and low-carbon environment**
- **Gradually become a nuclear-free country**

Under the three major principles

- no power rationing
- maintaining reasonable power prices
- making good on our pledges to reduce carbon emissions"

Nuclear Free is approaching

- **Decommission**
  - Chinshan Units 1&2 in 2018 & 2019
  - Kuosheng Units 1&2 in 2021 & 2023
  - Maanshan Units 1&2 in 2024 & 2025
- **Lungmen project may continue provided that the Referendum is passed in favor of continuing construction**

Nuclear Power Performance in 2012

Outline of Taipower's NPPs

Chinshan

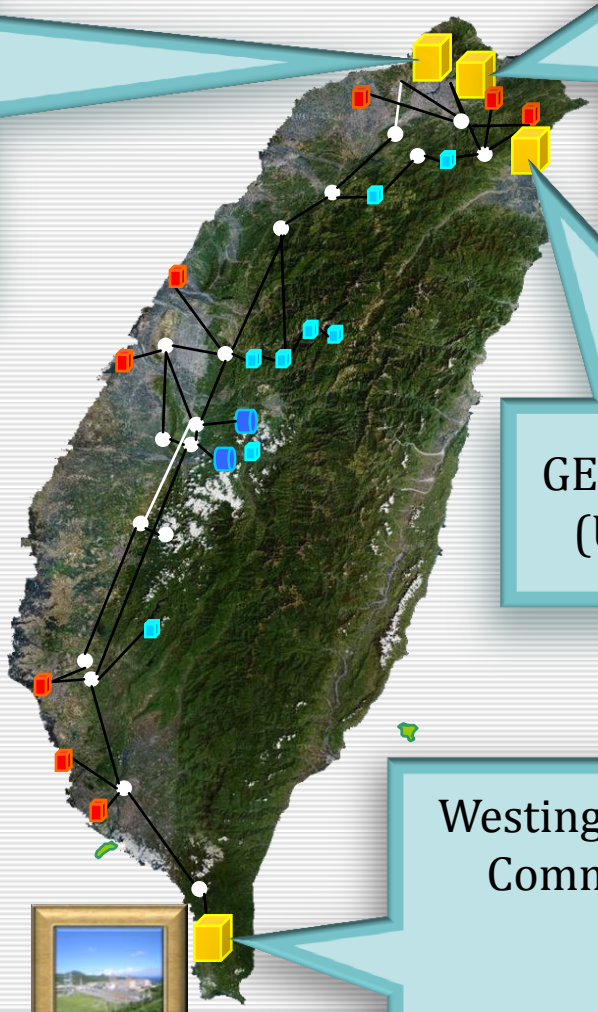
GE BWR-4
636 MWe x 2
Commercial Operation Date :
1 Dec. 1978
2 July 1979

Kuosheng

GE BWR-6 985 MWe x 2
Commercial Operation Date :
#1 Dec. 1981
#2 Mar. 1983

Lungmen

GE ABWR 1350 MWe x2
(Under Construction)



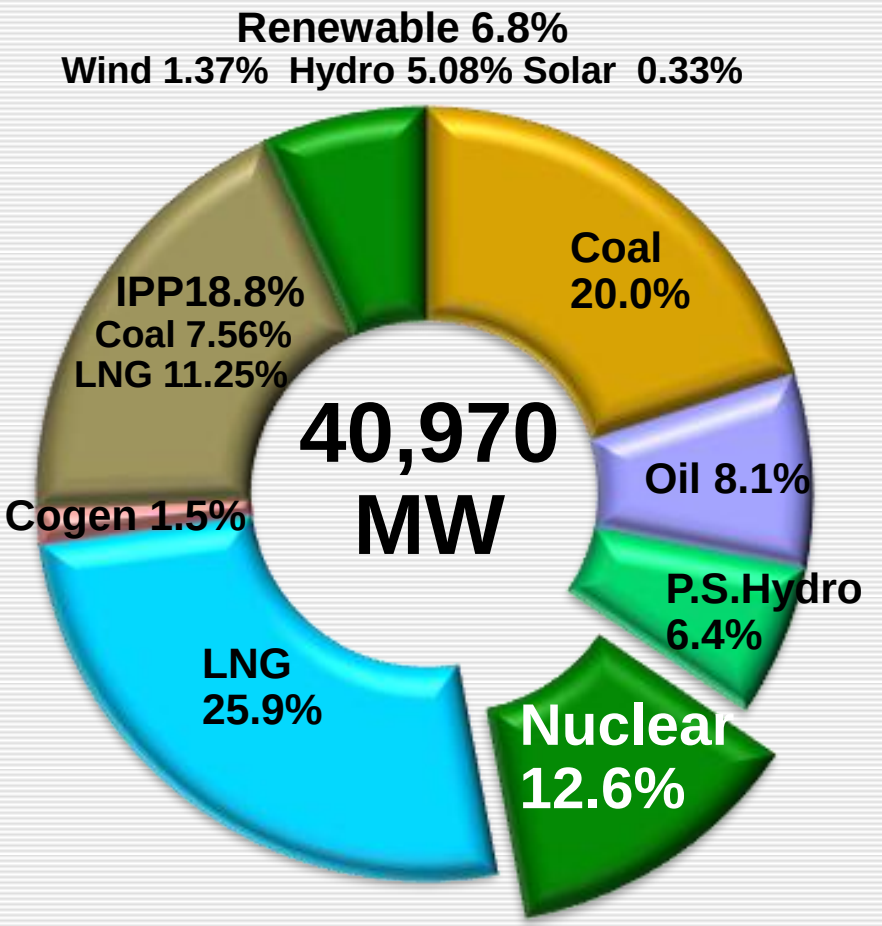
Nuclear Installed Capacity
5,144 MW

Electricity Generation
38.9 billion kWh

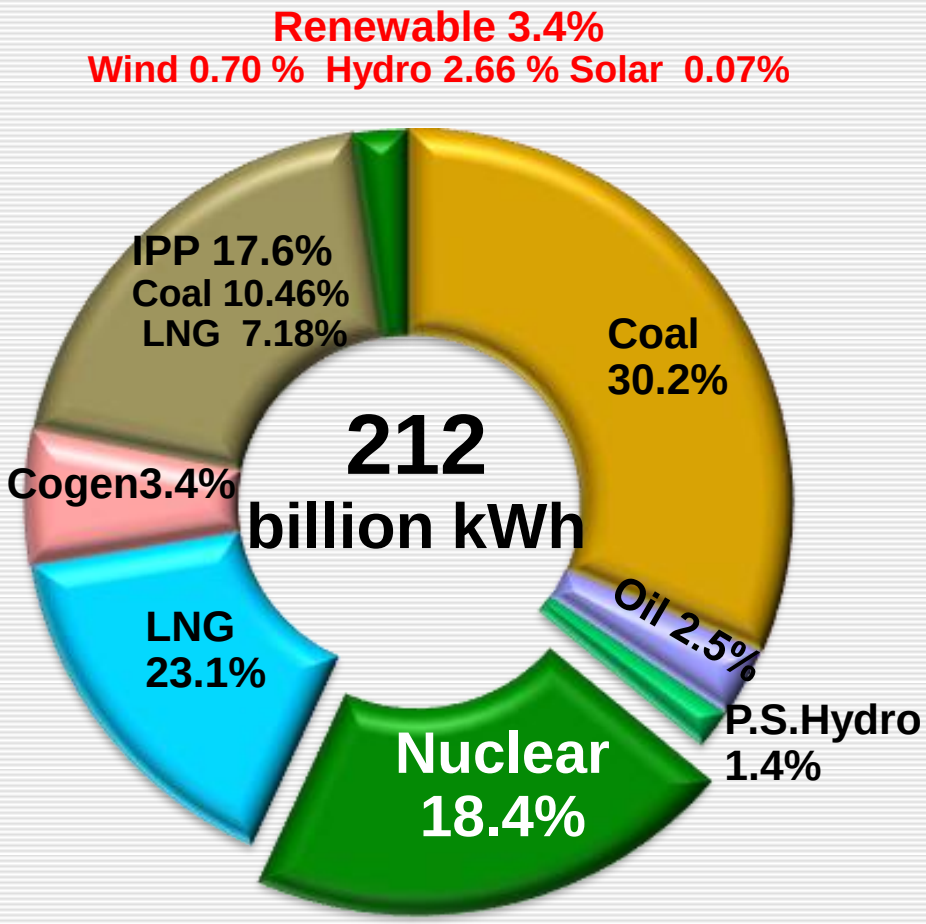
Maanshan

Westinghouse PWR 951 MWe x 2
Commercial Operation Date :
1 July 1984
#2 May 1985

Power System Performance in Taiwan

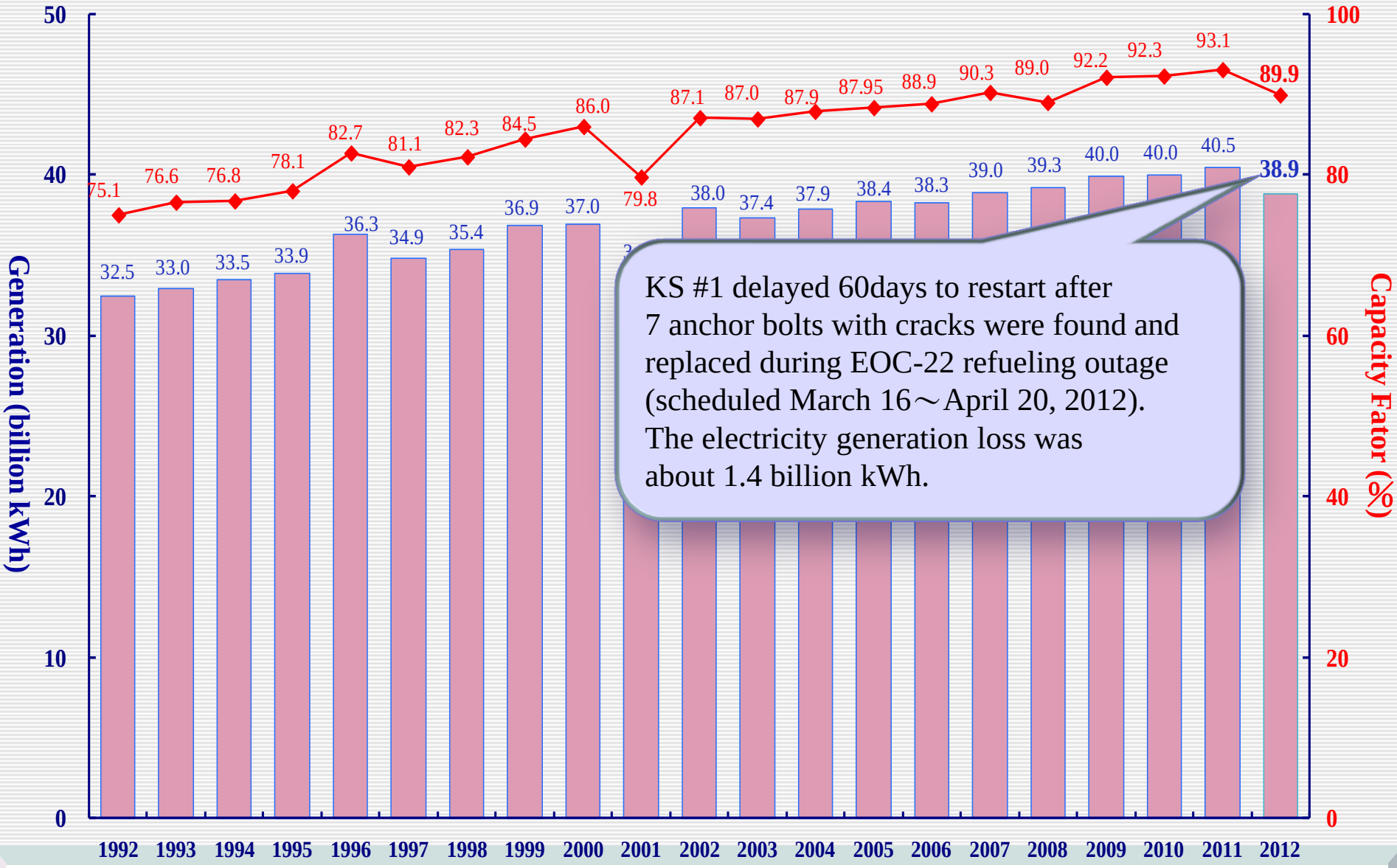


Installed Capacity in 2012

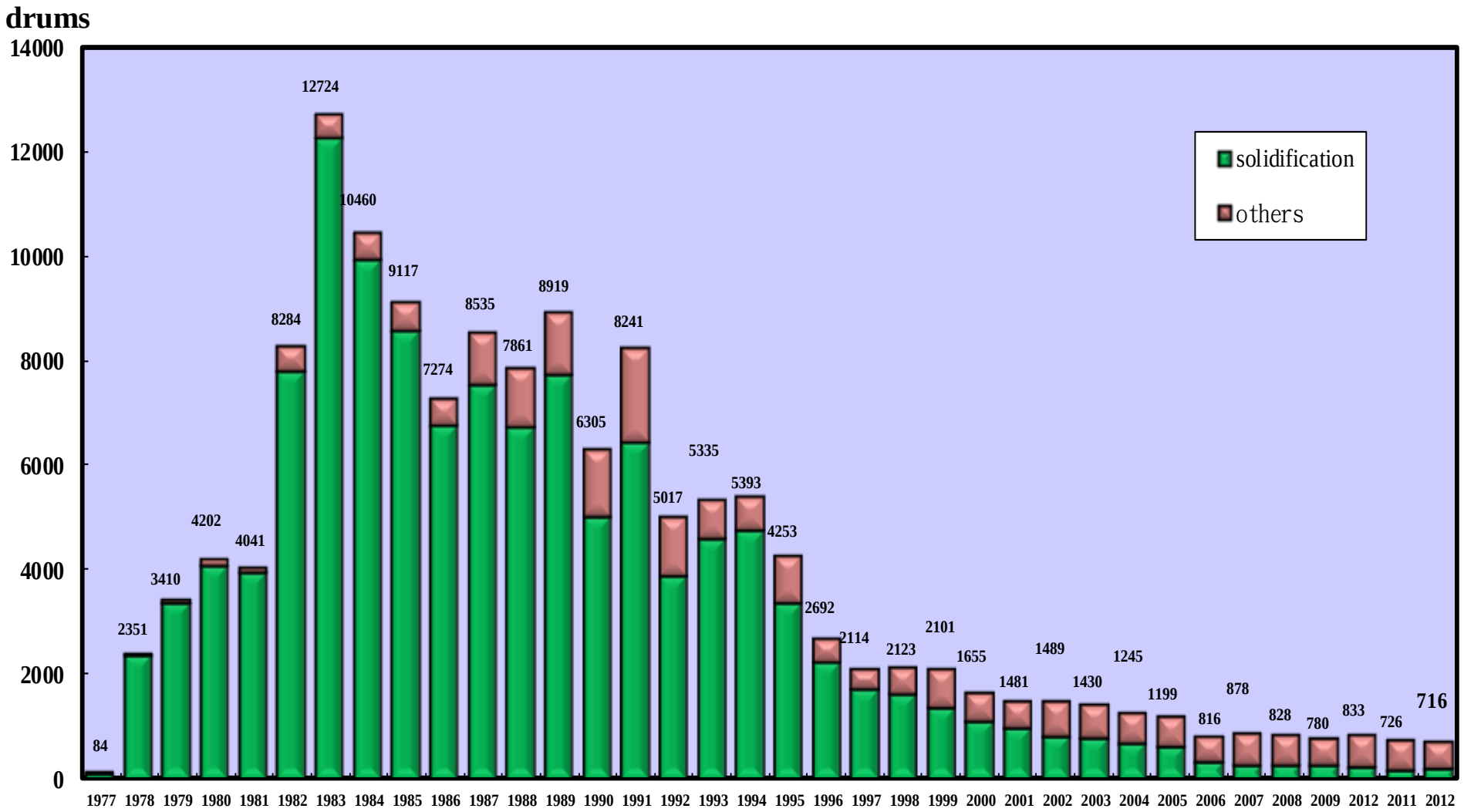


Electricity Generation in 2012

Nuclear Performance of TPC



Low-Level Radwaste



others：combustible, compressible, spent resin……

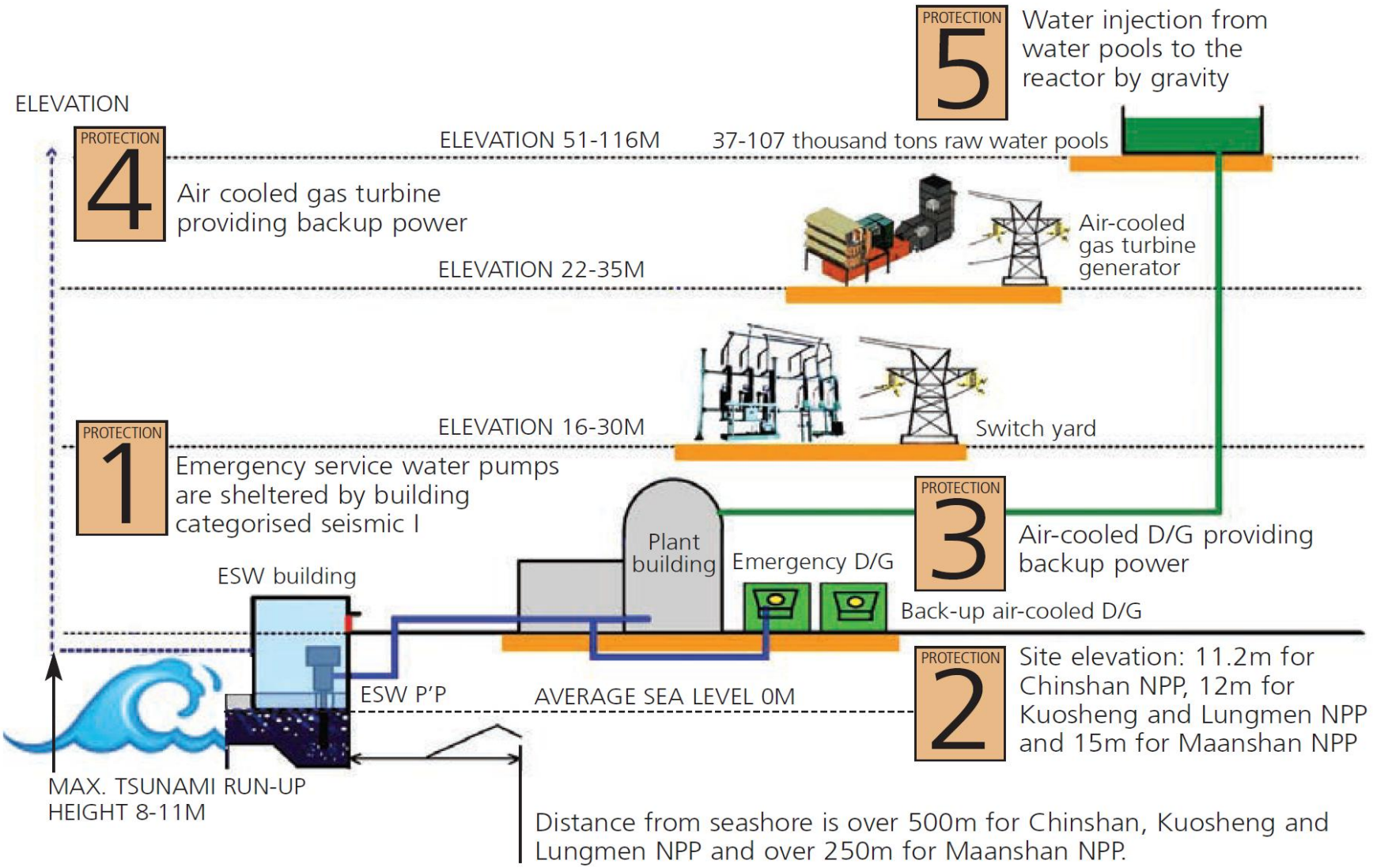
Additional Power gained in 2012

	Plant	Electric Power Gained
SPU (Stretch Power Uprate)	Chinshan	27.72 MW
H/P TB Rotor Replacement	Maanshan	34.83 MW

Safety Improvement Progresses After Fukushima Accident

Lessons Learned - Comparison

Defences against multi-pronged natural hazards at Taiwan's NPPs



Lessons Learned - Comparison

- *Advantages of Taiwan's nuclear power plants to cope with combined natural hazards*

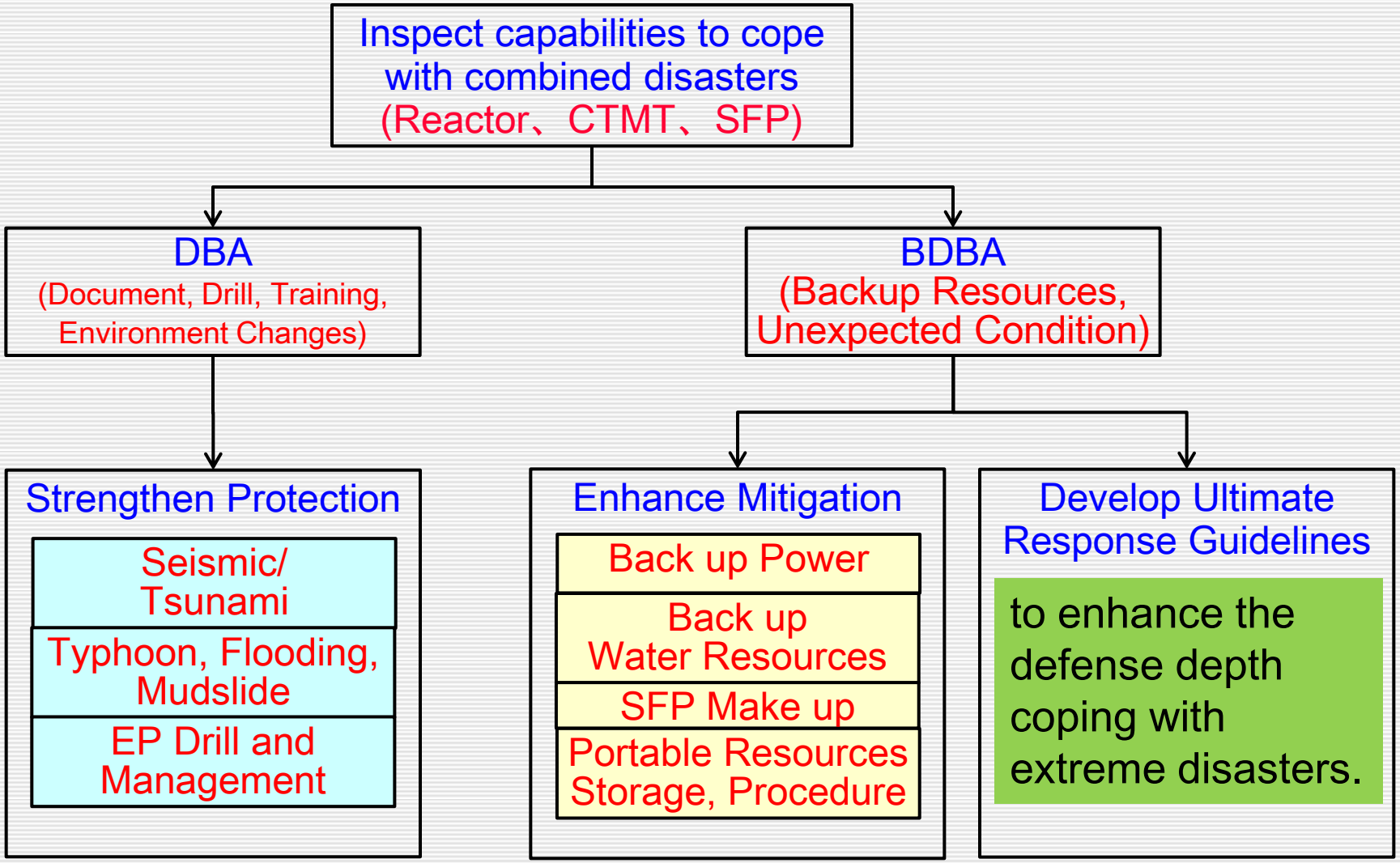
#	Items	Fukushima Dai-ichi	TPC NPPs
1	ESW Sheltered	None	Yes
2	Distance from sea shore	100m	CS,KS,LM Over 500 m
			MS Over 250m
3	Back up air-cooled D/G (CS,KS,MS：5th；LM：7th)	None	Yes (elevation 11.2~15 m)
4	Back up air-cooled G/T	None	Yes (elevation 22~35 m)
5	Raw water storage pool	None	Yes (37~107 thousand ton, 51~116 m)

Responses to Fukushima Accident

Comprehensive Safety Assessments (CSA):

- **Phase I (*Safety Assessment*):** Fully inspected/evaluated various aspects including site selection, DBA, construction quality, maintenance, accident management, and worked out improvement programs to reinforce the capabilities of prevention and mitigation of accidents *(CSA report)*
- **Phase II (*Stress Test*)** : Verify the robustness of design and recognize cliff-edge effect and hidden weakness. Refer to EU Stress Test specification and adopt PRA methodology to recognize the cliff edge *(Stress Test report)*

Techniques of CSA-Phase I



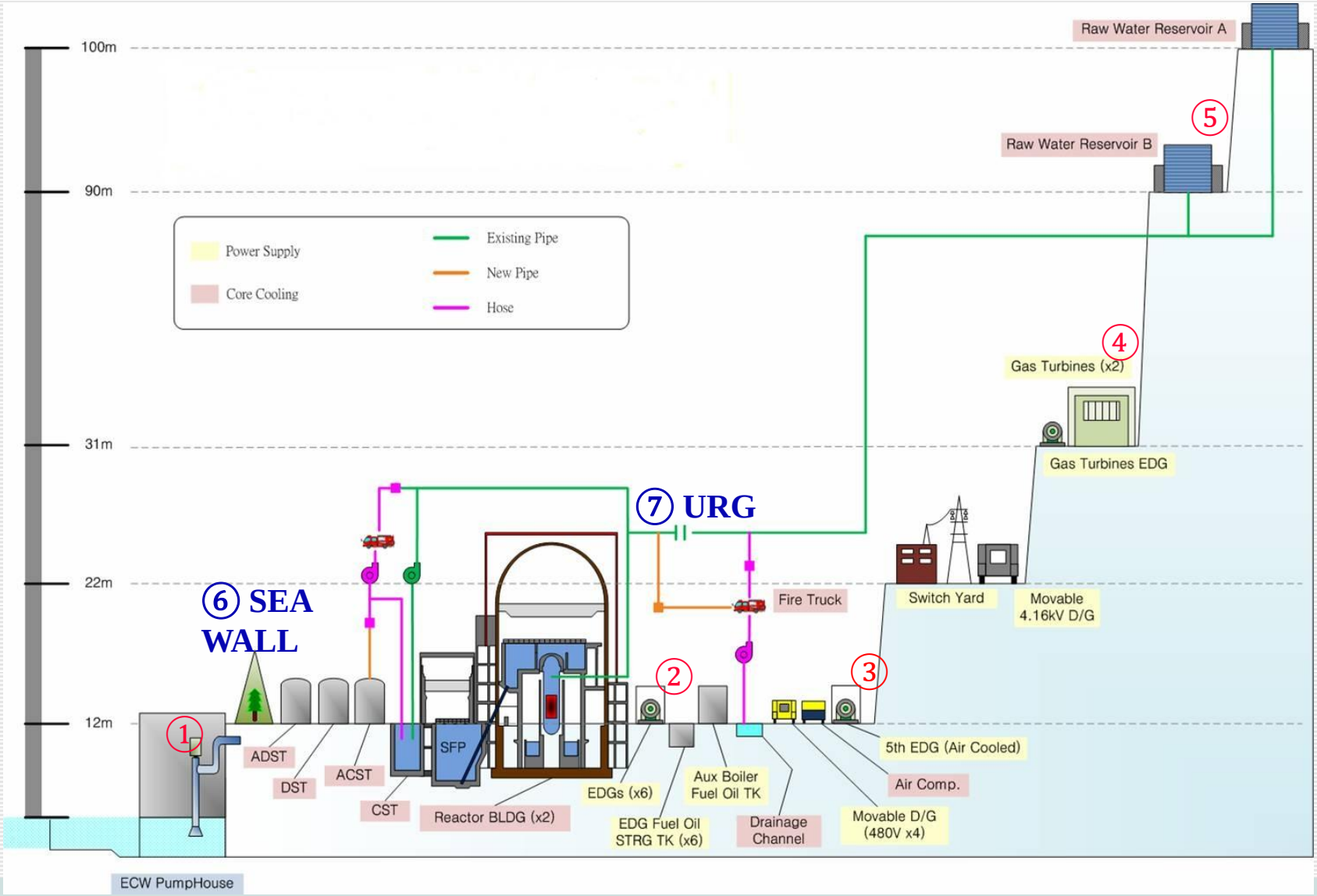
Safety Improvements

- According to the results of phase I of CSA, 96 key improvement items for operating plants and 67 items for Lungmen site have been developed.

- Improvements are classified into 4 areas :

1. Enhance earthquake-resistant capabilities
2. Enhance tsunami/flooding-protection capabilities
3. Enhance event mitigation capabilities
   - Backup power supply
   - Water resources and injection
   - Spent fuel pool cooling
   - Resources preparedness
4. Ultimate Response Guidelines (URG)

Overall Safety Enhancement

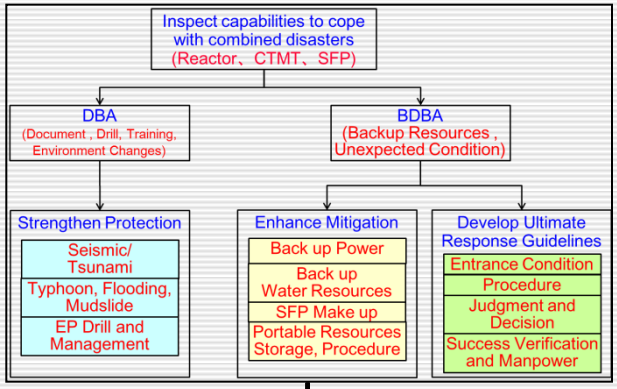


Phase II : Stress Test

Verify the Safety Margin Against Natural Hazards

- Stress Test implemented in accordance with EU Stress Test to identify Cliff-edge and effectiveness of countermeasures developed in CSA-Phase I.
- Initiating events
  - Earthquake
  - Flooding
  - Extreme natural event
- Consequence of loss of safety functions from any initiating event conceivable at the plant site
  - Loss of electrical power, including station black out (SBO)
  - Loss of the ultimate heat sink (UHS)
  - Combination of both
- Progress
  - Stress Test report completed in Q1, 2012

Techniques of CSA-Phase II



Phase I：Inspect capabilities to cope with combined disasters

PRA SSC Seismic Margin

Phase II：Stress Test (Follow EU)

Building Openings and Equipment Elevation

PRA Seismic Event Tree

PRA Tsunami Event Tree

General data about site/plant

Earthquake (Including DBE+DBF)

Earthquake (Including Tsunami)

Extreme natural hazards

Loss of electrical power and loss of ultimate heat sink

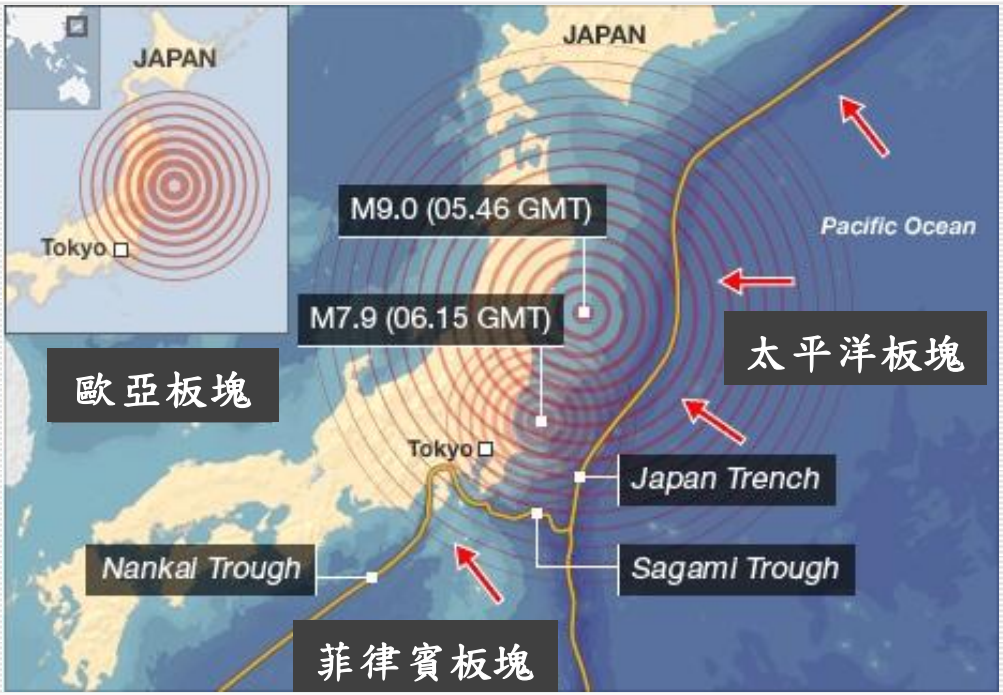
Severe accident management

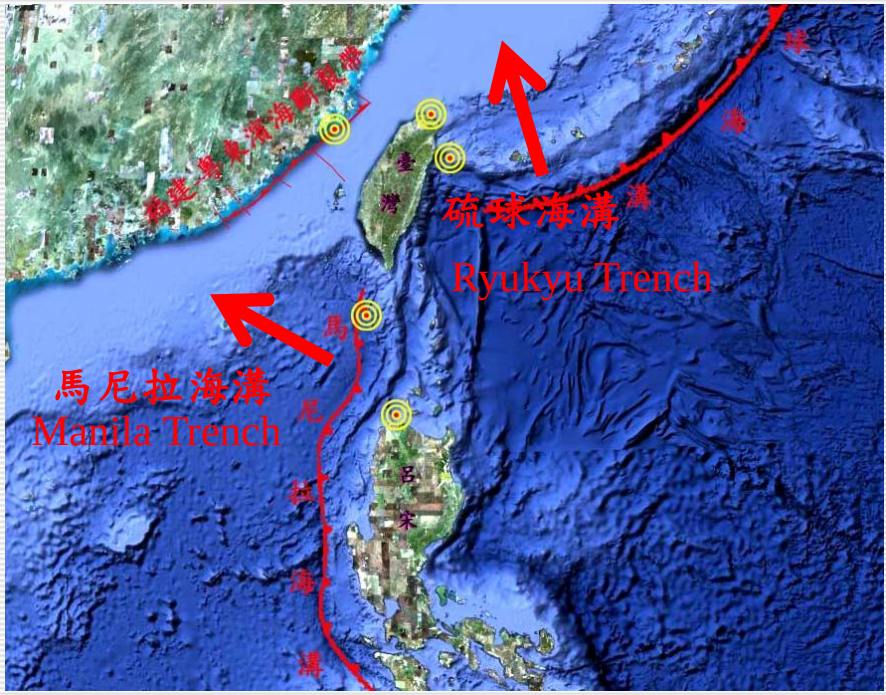
Result of Stress Test - Tsunami

- 22 potential massive scale of sea trench type initiated earthquakes, and the induced Tsunami has been evaluated
- The maximum potential tsunami run-up height is still much lower than the design basis tsunami elevations assumed in FSAR

Site Name	CS	KS	MS	LM
Site Elevation	11.2m	12.0m	15.0m	12.0m
Simulated Tsunami run up	5.47m	4.54m	7.26m	3.92m
FSAR Tsunami run up	10.73m	10.28m	12.53	8.07m

Topographic advantage of Taiwan





Safety Enhancements Against BDBA

Earthquake Resistant Capabilities Enhancement

- Further geological survey
- Implement betterments based on result of SMA and SPRA (NTTF 2.1)(to be completed in 2015)
- Enhance RCIC and RHR system earthquake-resistant capabilities to guarantee success of URG.
- Establish connection of earthquake and tsunami alert system with Central Weather Bureau.
- Enhance earthquake-resistant capabilities of raw water pool , raw water piping and add flexible expansion

Strengthen seismic capability of raw water reservoir supply piping

Safety Enhancements Against BDBA
Tsunami Resistant Capabilities Enhancement

- Inspected all tsunami/flooding – protective devices and seal functions (WANO SOER 2011-2 recommendations)
- Flooding Hazard Re-evaluation (NTTF2.1)
  - With rainfall records of recent 30 years to reconstruct 10,000 years flooding regression and to re-assess the adequacy of flooding design base in FSAR
- Added water-tight barrier on ECW in KS and NSCW in MS.
- Enhanced tsunami protective gates in CS (motor operated)
- Procured 40 sets of engine driving drain pumps to strengthen portable drain capabilities.
- Planning to build Tsunami-protective wall for all plants
- Planning to bunker the air-cooled swing D/G

Flood-protection wall and water-tight doors (KS)

Physical Separation for NSCW Motors (MS)

Safety Enhancements Against BDBA

Electrical Power Source

- Completed 5th D/G (swing D/G) supply to both units.
- Completed G/T black out D/G supply to ESF bus.
- Procured 4 sets of 4.16 kV power vehicles and 26 sets of 480V portable D/Gs.
- Extended coping time of DC power in response to SBO from 8 hours to 24 hours.
- Prepared portable generators and batteries for control power and supervisory instruments.

AC Power Enhancement

Extra features over Fukushima

Post-Fukushima

Off-site power 345kV

Off-site power 69 /161 kV

EDG ×2~3

5th (7th) D/G

G/T×2

G/T D/G×2

Power Vehicle ×1~2/site

4.16 kV Bus

Safety make-up & cooling systems

Post-Fukushima

480V Portable D/G ×4~12/Site (capacity≧200kW)

480V Bus

MOV

Low Pressure make-up systems

DC Charger

Supervisory Instruments

Portable Gen. and Battery sets

Post-Fukushima

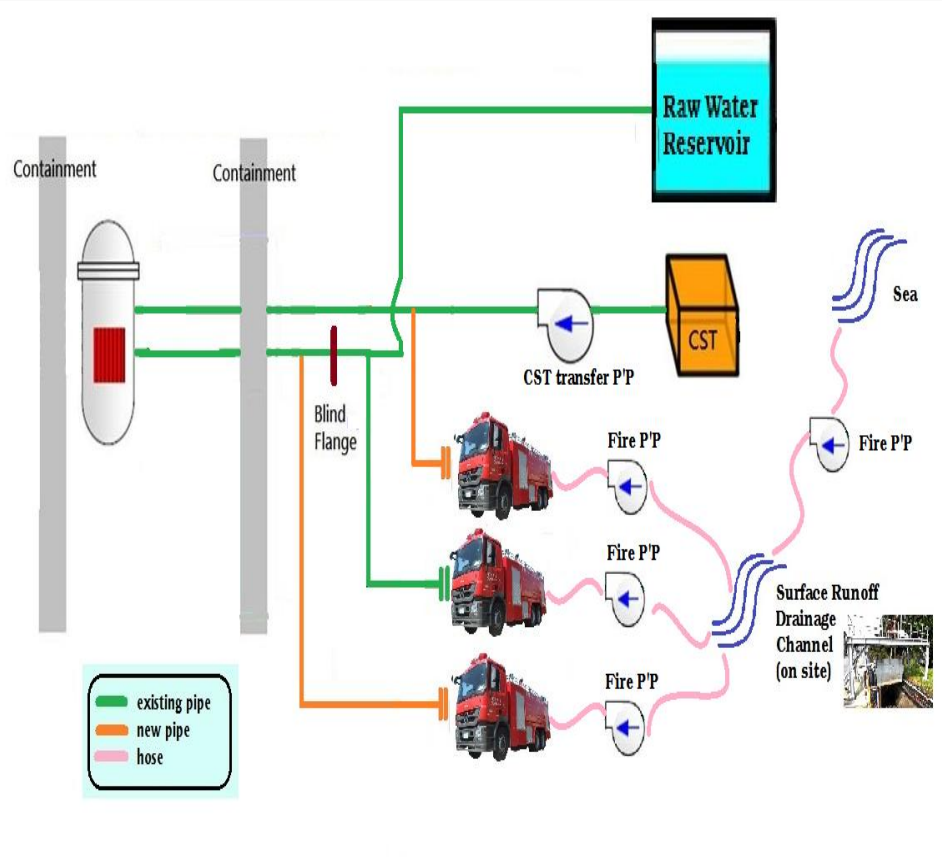
Safety Enhancements Against BDBA

Water Injection & Core Cooling

- Checked capacity of all water resources onsite and offsite, and developed transportation and injection procedures.
- Checked fire engine resources - quantity, capacity, discharge pressure, and procured redundancies.
- Developed a scheme of alternative reactor water injection (various paths)
- Developed a scheme of alternative heat sink and recovery of ultimate heat sink
- Procured portable air compressors and spare nitrogen bottles for SRVs and air-operated valves.

Safety Enhancement of Core Cooling

Multiple path of Core Injection



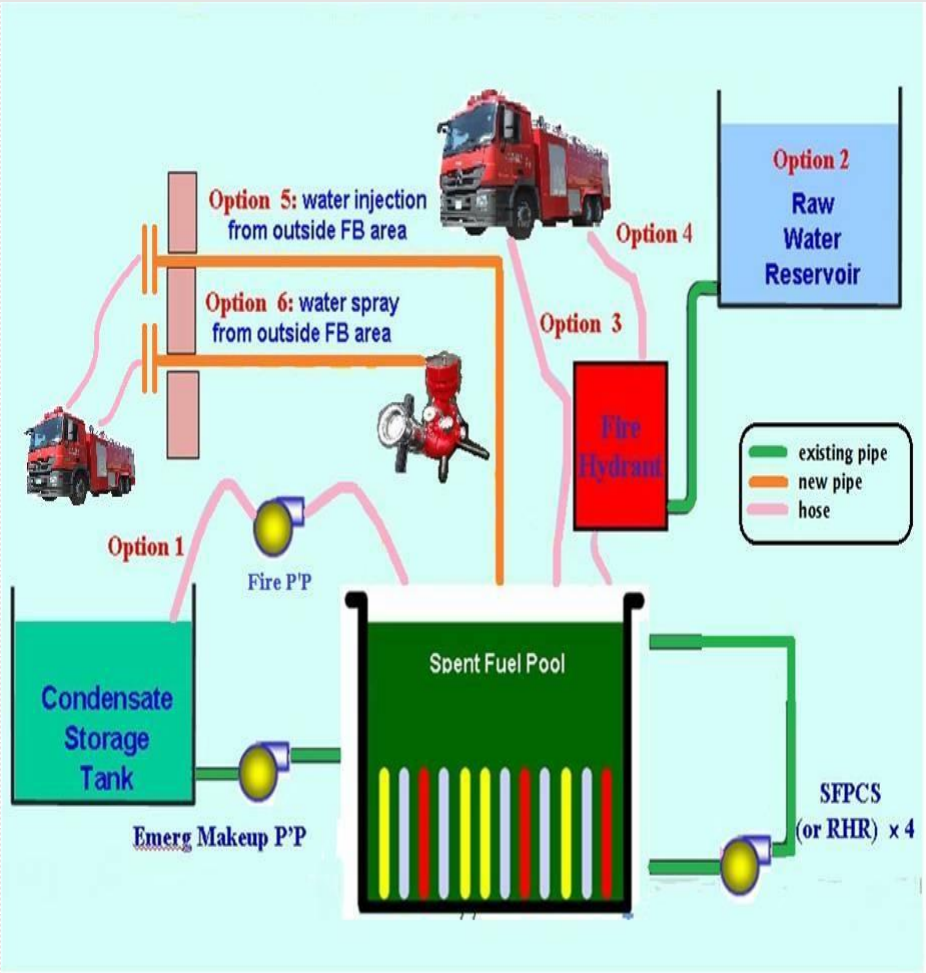
Sluice Gate for Emergency Water Reservoir in KSNPP

The New-Built Alternated Cooling Water Transfer Pipe

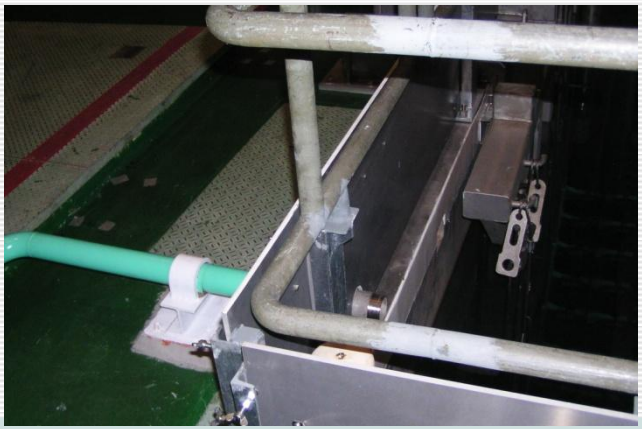
Safety Enhancements Against BDBA

Water Injection & SFP Cooling

- Various SFP make up strategies developed
- Extra inject and spray flow path installed according to NEI 06-12.
- Enhance the spent fuel pool instrumentation, per USNRC NTTF 7.1
  - Instruments for monitoring water level, temperature are to be upgraded to safety grade equivalent



New facilities for emergency water injection / spray for spent fuel pool



Safety Enhancements Against BDBA

Containment integrity and Hydrogen control

- Adding a robust and reliable containment filter venting system is progressing per USNRC NTTF 5.1
- Adding Passive Autocatalytic Recombiners (PARs) for Maanshan NPP (PWR) is progressing per EU's experience
- Containment early venting strategy developed
  - Reduce the temperature and pressure rise in the torus
  - Lengthen the injection time for RCIC

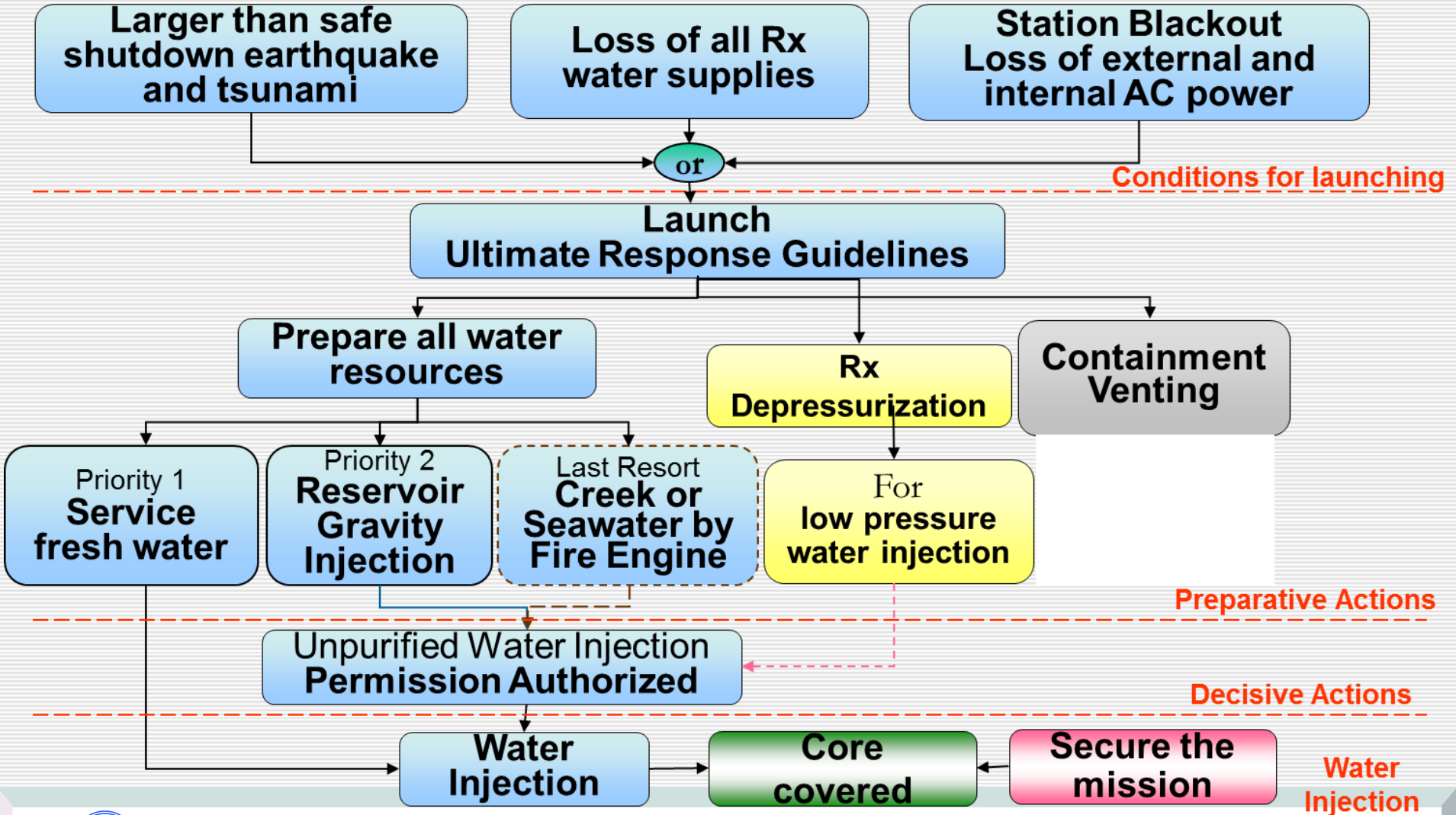
Safety Enhancements Against BDBA

Newly authored Developed Ultimate Response Guidelines

- Principle of URG
  - DIVing: Depressurizing of Rx, Injecting water into Core and Venting CTMT within one hour as required
- To secure the reactor core RPV or SG with any available water (even seawater) through any available injection paths as any of the conditions reached
  - Plant suffered from larger than SSE earthquake and Tsunami alarm is announced by the weather bureau
  - SBO
  - Loss of UHS

Safety Enhancements Against BDBA

URG -- Flow Chart



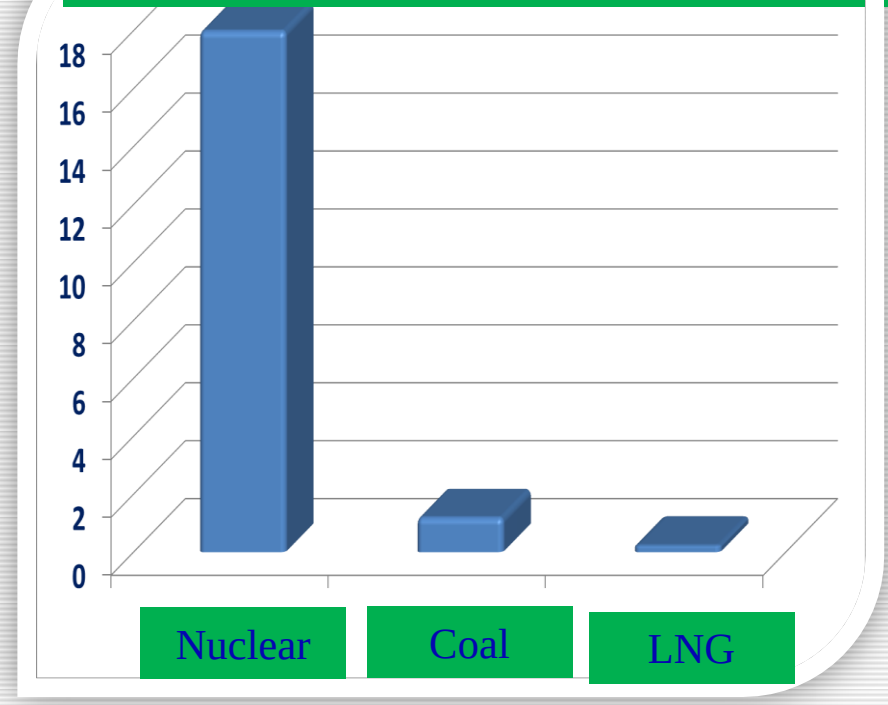
Peer Review for CSA and SR

- TPC invited WANO to conduct TSM for all TPC's plants on Feb 2012
  - The teams confirmed that the CSA done by Taipower conformed to US NRC requirements and EU stress test specification and no major concerns
- AEC invited OECD/NEA's to conduct the review of the stress test for all TPC's plants on March 2013
  - Enhancements that have been identified are consistent with those identified in other countries
  - Overall the team found that AEC and TPC implementation of the stress test was acceptable, no safety concerns for Taiwan nuclear plants for the event like Fukushima

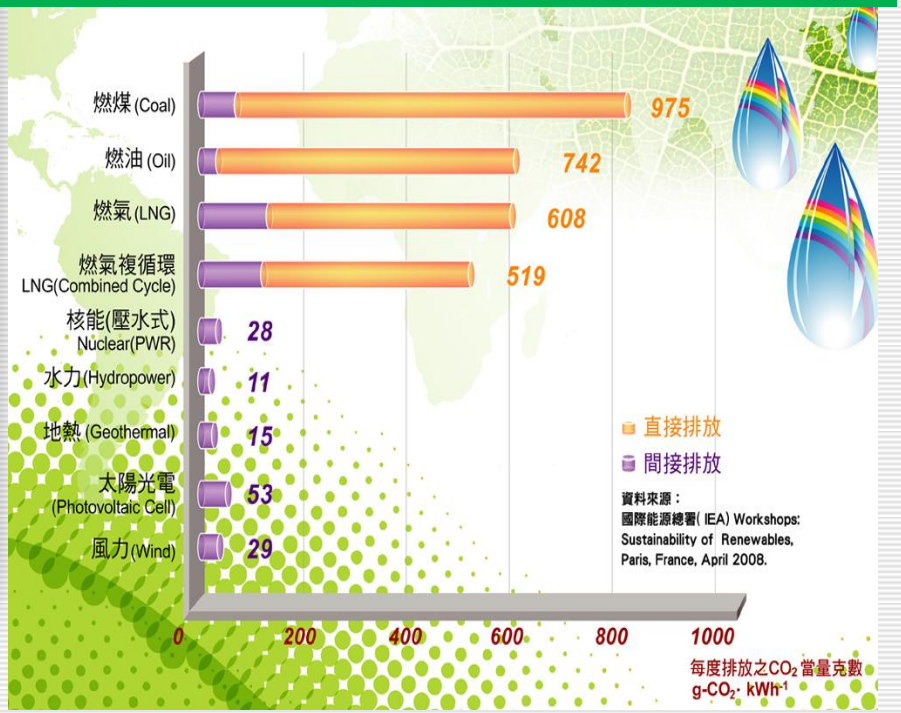
Status and Controversy of Nuclear Power and Lungmen

Necessity of Lungmen Project for Taiwan

Energy Security

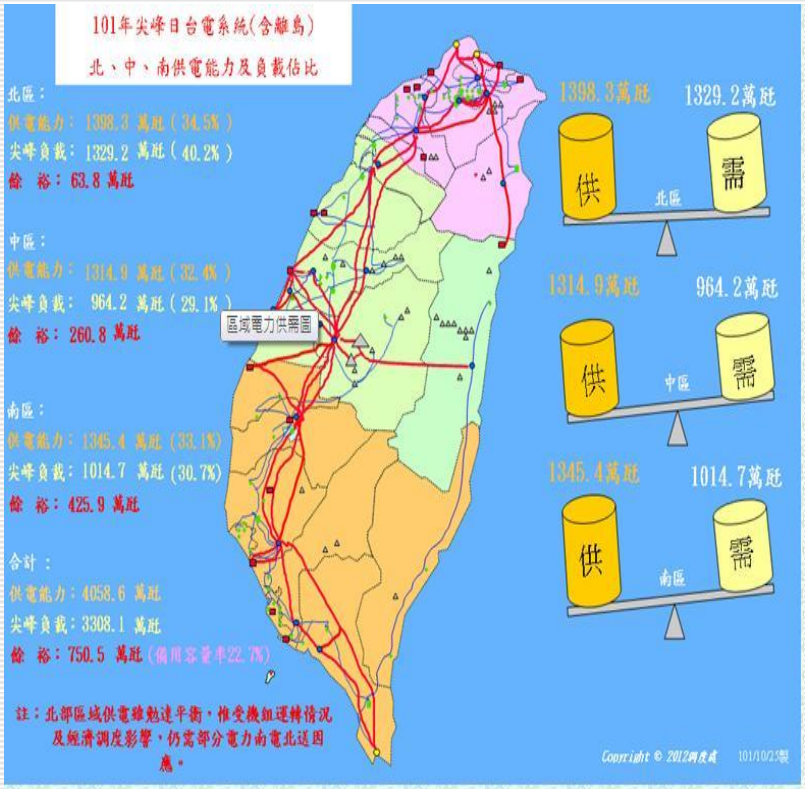


Carbon Emission Reduction

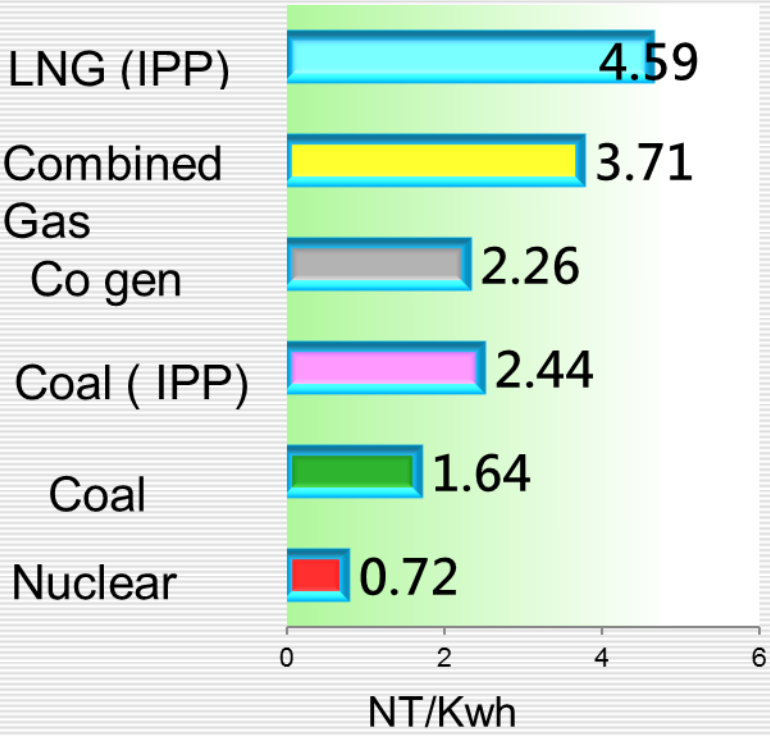


Necessity of Lungmen Project for Taiwan

Grid Stability



Generation Cost



Current Status of Lungmen

- Before the referendum is conducted
  - No extra budget will be authorized for the facility
  - Fuel loading will not be permitted
  - All works in Lungmen will be suspended except for safety related tests or jobs that have already been contracted out

Claims and Government Position

Claims

- Taipower should release all and real nuclear power plant information to the public
- Terminate construction of Lungmen NPP Immediately
- Set new energy plans

Government Position

- Fully committed to provide comprehensive information of Lungmen NPP
- Communicate the pros and cons of halting the project and possible impact on Taiwan's economy
- Build consensus for future power development

Anti-nuclear turns into fashion

- In addition to DPP, environmental group and celebrated people of Art and Literature field are now come forward against nuclear
- Communicating and providing correct and adequate information to public is essential for the referendum debate
  - Need to distinguish the group that worthy and necessary to communicate
  - Need to get the pro nuclear celebrated people to conduct right message

Taipower ‘s Director Mr. Lin is on TV talk show .

Celebrity Ms. Chen Call 100,000 Mom come out for anti-nuclear

Critical Disputes

- Confirm Safety prior to the referendum, otherwise, stop Lungmen project directly
  - Concern about earthquakes, undersea volcanoes, tsunamis and other threats
  - Deficiencies of Lungmen NPP project on construction, design changes, procedures, project management, and staff inexperience
  - If nuclear accident occurs, ability to handle large radioactive releases, evacuation, shelter?
  - Final disposal for low and high level radwaste still not yet resolved

Critical Disputes

- Is Taipower's reserve capacity too high ? Do we really need lungmen?
- Is the cost of nuclear power underestimated ?
- Could the renewable energy replace nuclear ?

Conclusion

- Nuclear power is the largest source of carbon-free electricity and it is relatively cheap
- It would be a mistake to abandon nuclear power and its benefits in Taiwan.
- Every cloud has a silver lining, we need to work closely for the future of nuclear power.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