Daya Bay Outage Management

Atoms for the Future 2012 Seminar
Paris
24 October 2012

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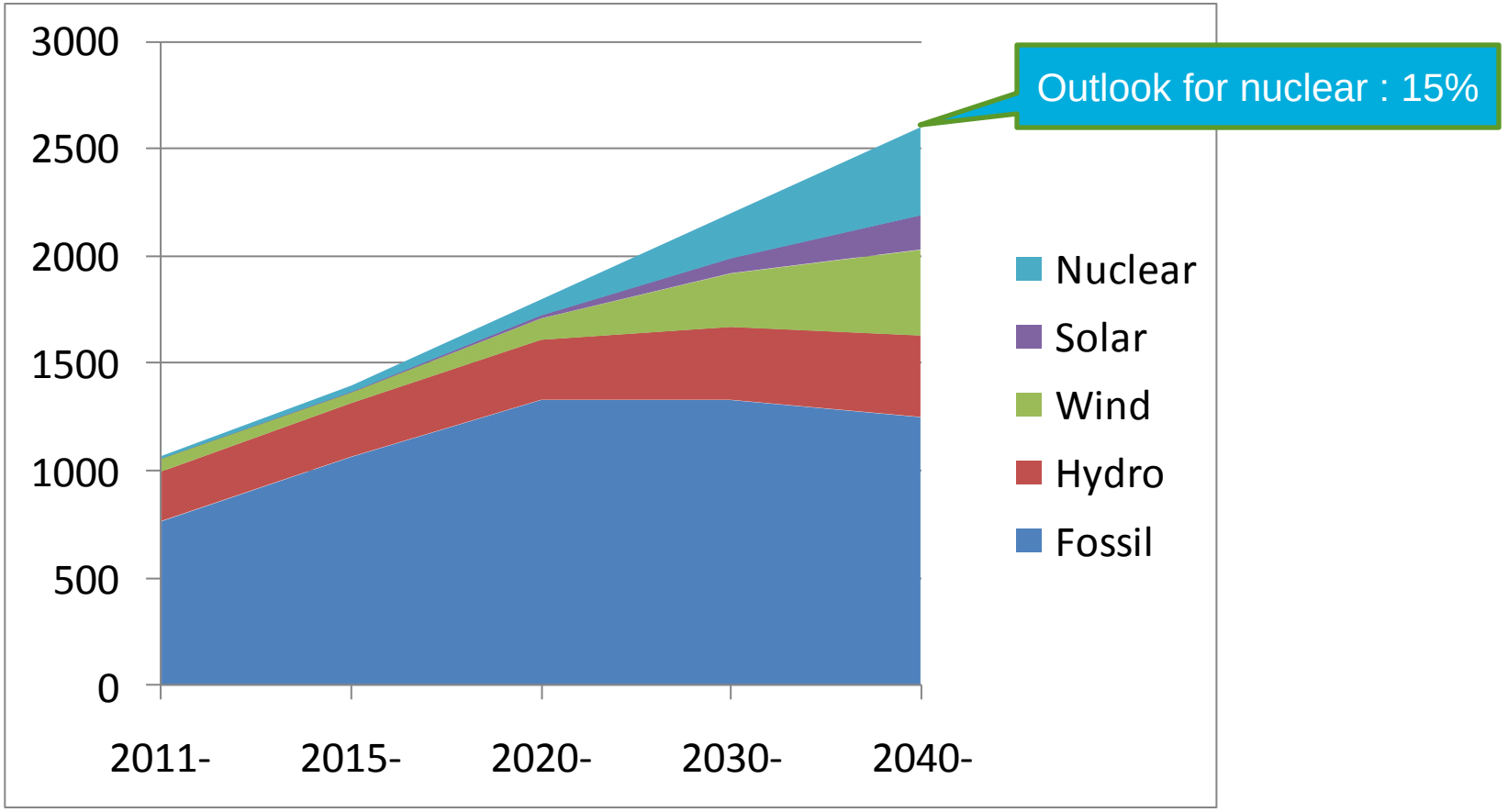
1. Nuclear Power Development in China
2. Daya Bay Performance
3. Daya Bay Outage Management

Nuclear power development in Mainland China

- First civil nuclear reactor, Qinshan, commissioned in Feb 1994
- First commercial scale nuclear power station, Daya Bay, commissioned in May 1994
- By 2020, target installed capacity in China is 40 GW
- Chinese Government officials had indicated a higher national target of 60-70 GW (5% of total installed capacity)

2011-2040 Installed Generating Capacity (GW)

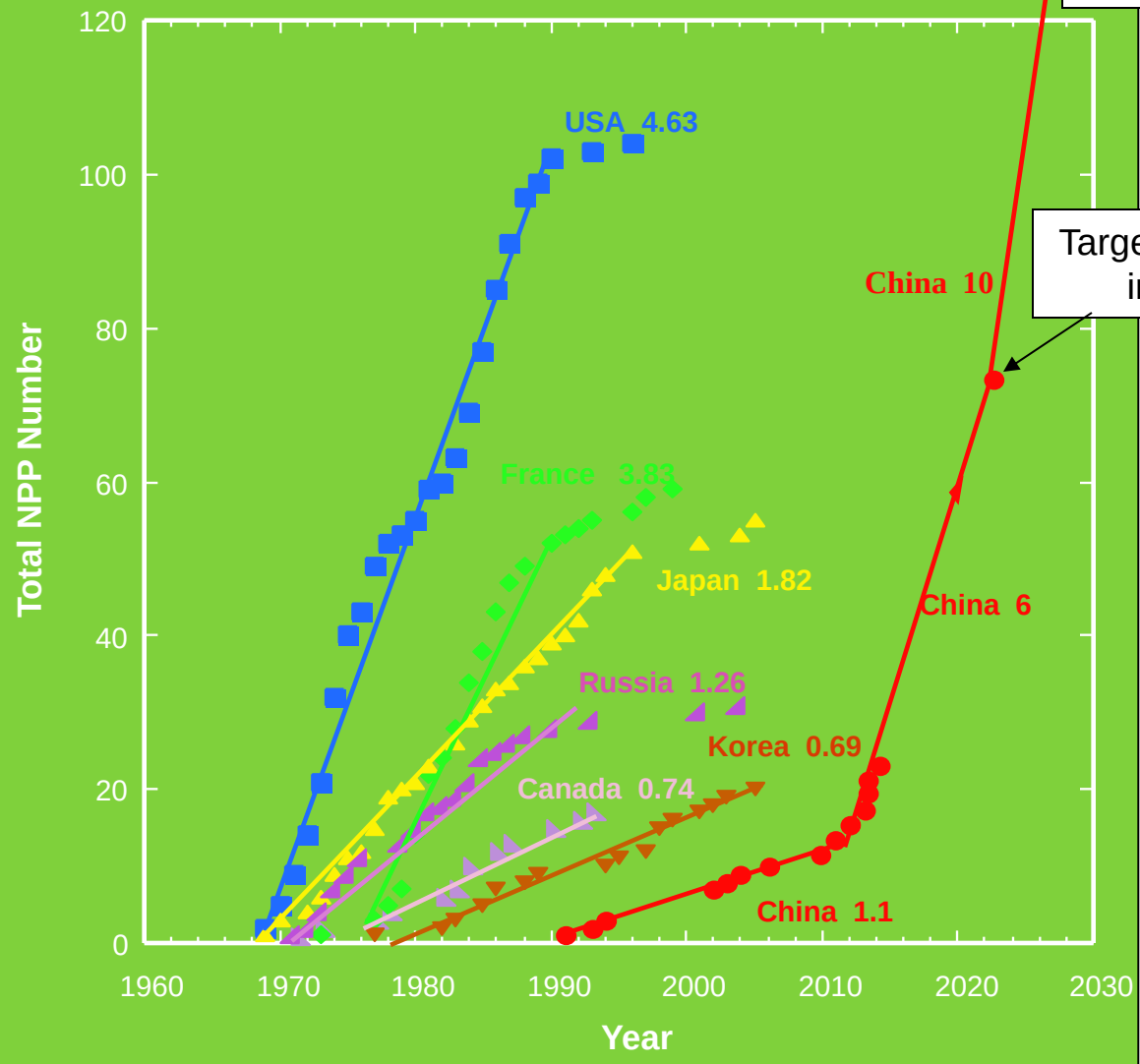


China would increase its decarbonization targets in the future years, impacting the Nuclear Power deployment pace and magnitude.

Source: Nuclear Power 2012

Projected Rate of NPP Construction in China

China needs to build 280 CAP1400 (or 230 CEPR1750 units) for achieving its presently stated goal of 15% nuclear capacity share by 2040



Source – Dr. Staehle

Operating Nuclear Units in China

Owner	NPP	Gross Power (MWe)	Total (MWe)	Reactor Type
CGNPC	Daya Bay	2x984	6,120	PWR(M310)
	Lingao I	2x990		PWR(M310)
	Lingao II	2x1086		PWR(CPR1000)
CNNC	Qinshan I	320	6,440	PWR
	Qinshan II	4x650		PWR
	Qinshan III	2x700		PHWR
	Tianwan	2x1060		VVER
CPIC	NIL			
Mainland Total			12,560 MWe	

CGNPC – China Guangdong Nuclear Power Co.

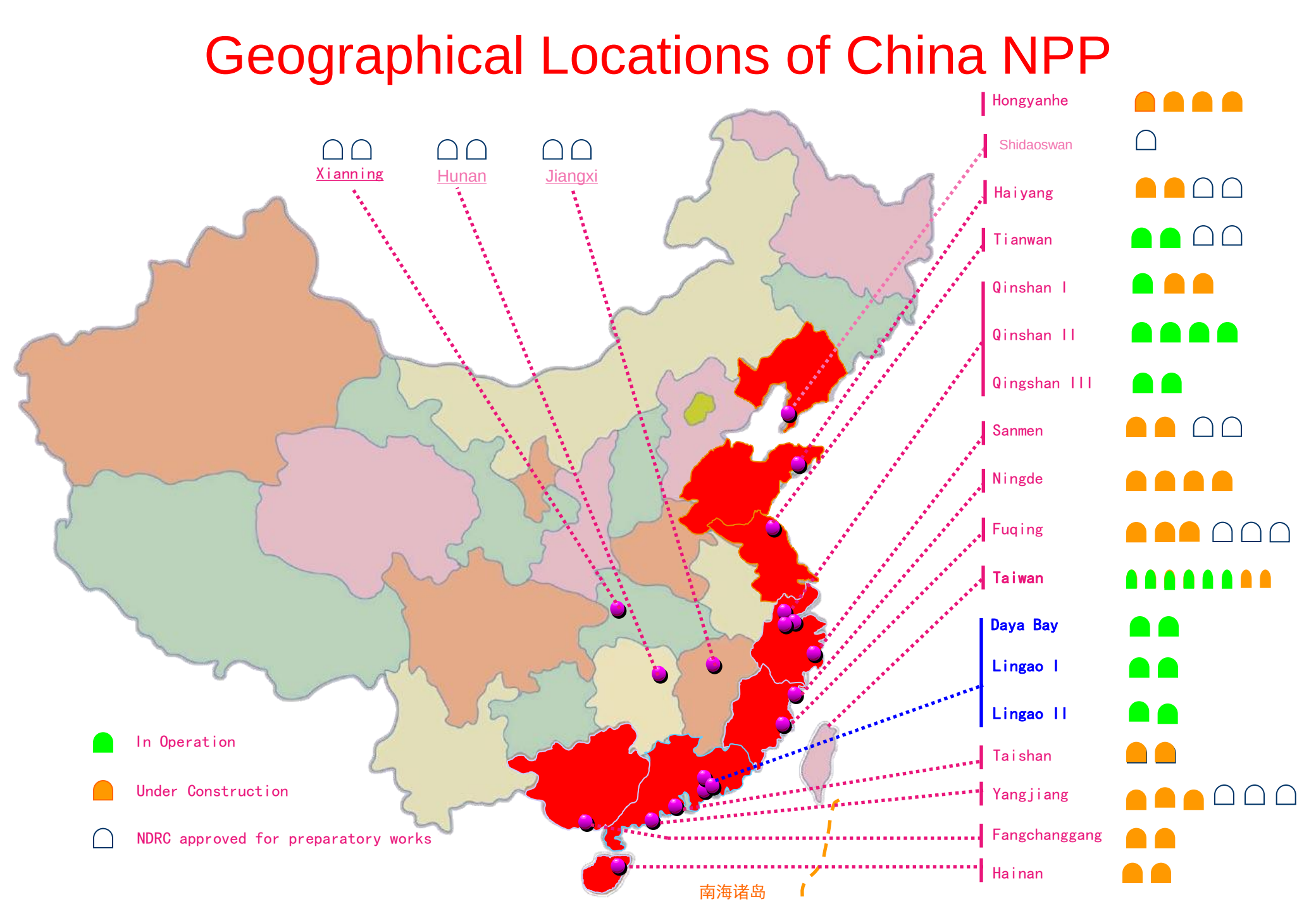
CNNC – China National Nuclear Co.

CPIC – China Power International Co.

China Nuclear Projects Under Construction / Preparation

Owner	Name of NPP	Gross Power（MWe）	Total (MWe)	Reactor Type
CGNPC	Hongyanhe	4×1080	29,760	CPR1000
	Ningde	4×1080		CPR1000
	Yangjiang	(3+3)×1080		CPR1000
	Taishan	2×1750		EPR
	Fangchanggang（Hongsha）	2×1080		CPR1000
	Lufeng	6 X 1080		ACPR1000
	Xianning (Dafan)	2 x 1250		AP1000
CNNC			19,660	
	Qinshan I Ext (fangjiashan)	2×1086		PWR
	Sanmen	2+2×1250		AP1000
	Fuqing	4+2×1086		PWR
	Tianwan II	2×1086		PWR
	Hunan	2×1250		AP1000
	Hainan	2×650		PWR
CPI	Jiangxi	2×1250	7500	AP1000
	Haiyang	2+2×1250		AP1000
Total	Shidaowan Pebble bed 200MW		57,120 MWe	

Geographical Locations of China NPP



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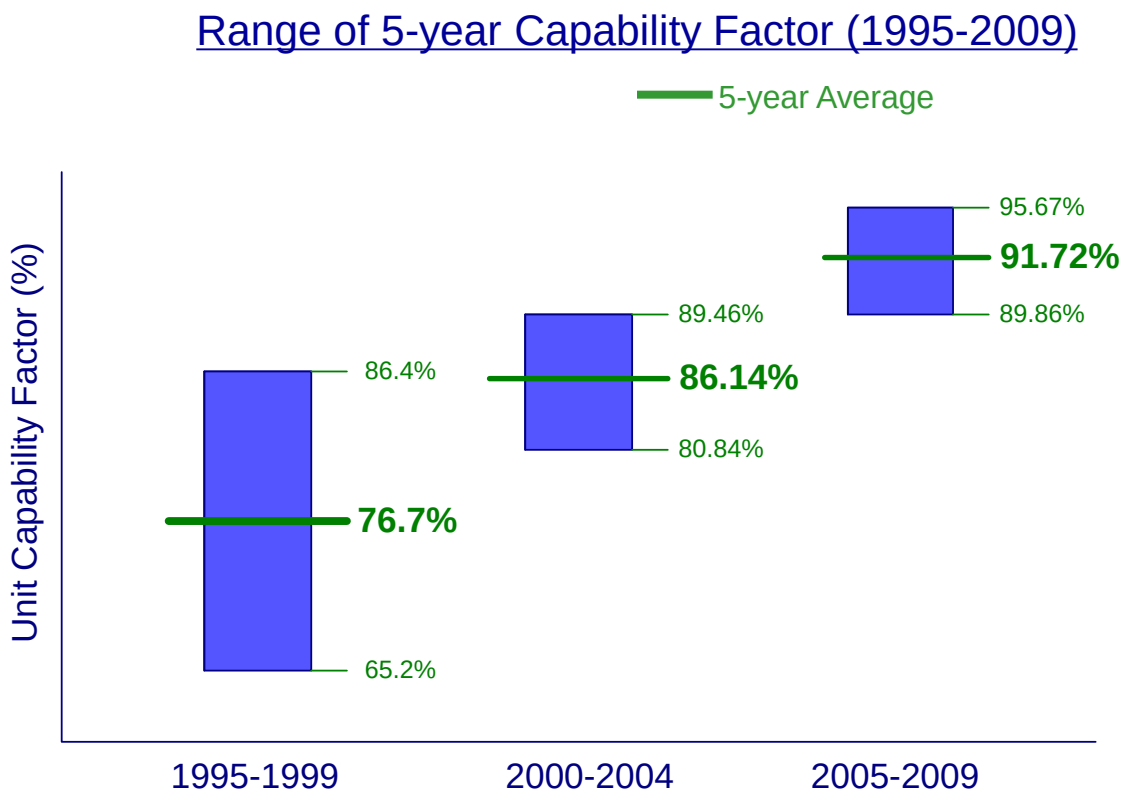
6 Operating Units at Daya Bay Site

Unit Name	Reactor Type	Gross Capability (MWe)	Date of Commercial Operation	Refueling Cycle
Daya Bay 1	PWR	984	1994-02-01	18 months
Daya Bay 2	PWR	984	1994-05-06	18 months
Lingao 1	PWR	990	2002-05-28	12 months
Lingao 2	PWR	990	2003-01-08	12 months
Lingao 3	PWR	1,080	2010-09-20	12 months
Lingao 4	PWR	1,080	2011-08-07	12 months

Increasing Daya Bay Generation Capability

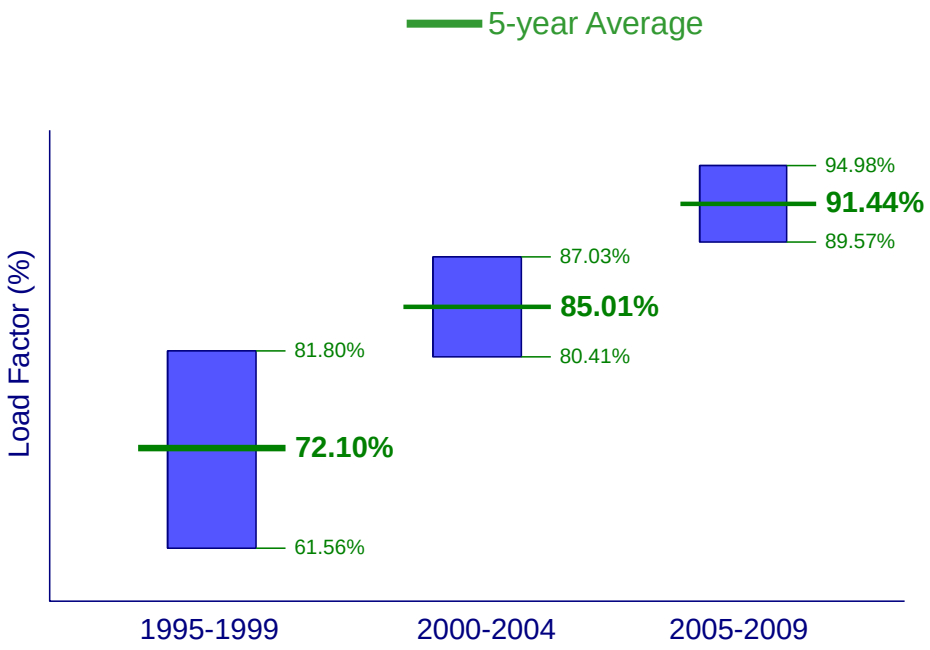
Sustaining the Performance Improvement of the Fleet:

- •Identify the best method
- •Standardizing it
- •Continue improving it
- •Transfer the improvements company-wide

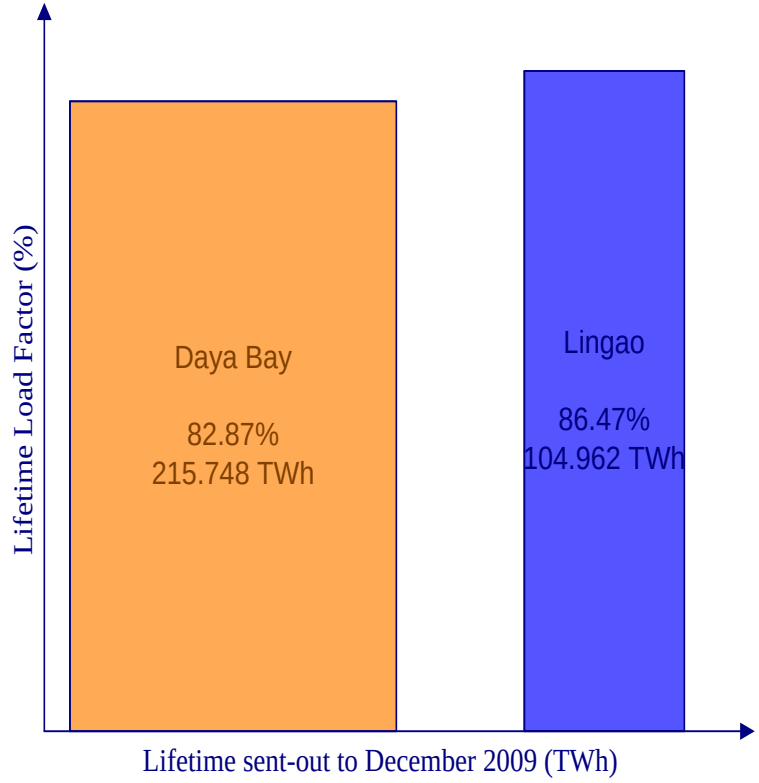


Replicating & Sustaining the Improvements Across Every Unit CGN Operates

Range of 5-year Load Factor (Daya Bay 1995-2009)



Lifetime Average Load Factor and Electricity Sent-out



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Outage Purpose

1. Refueling;
2. Regulatory Inspection and Test;
3. Preventive and Corrective Maintenance;
4. Performance Improvement Works.

Types of Refueling Outage

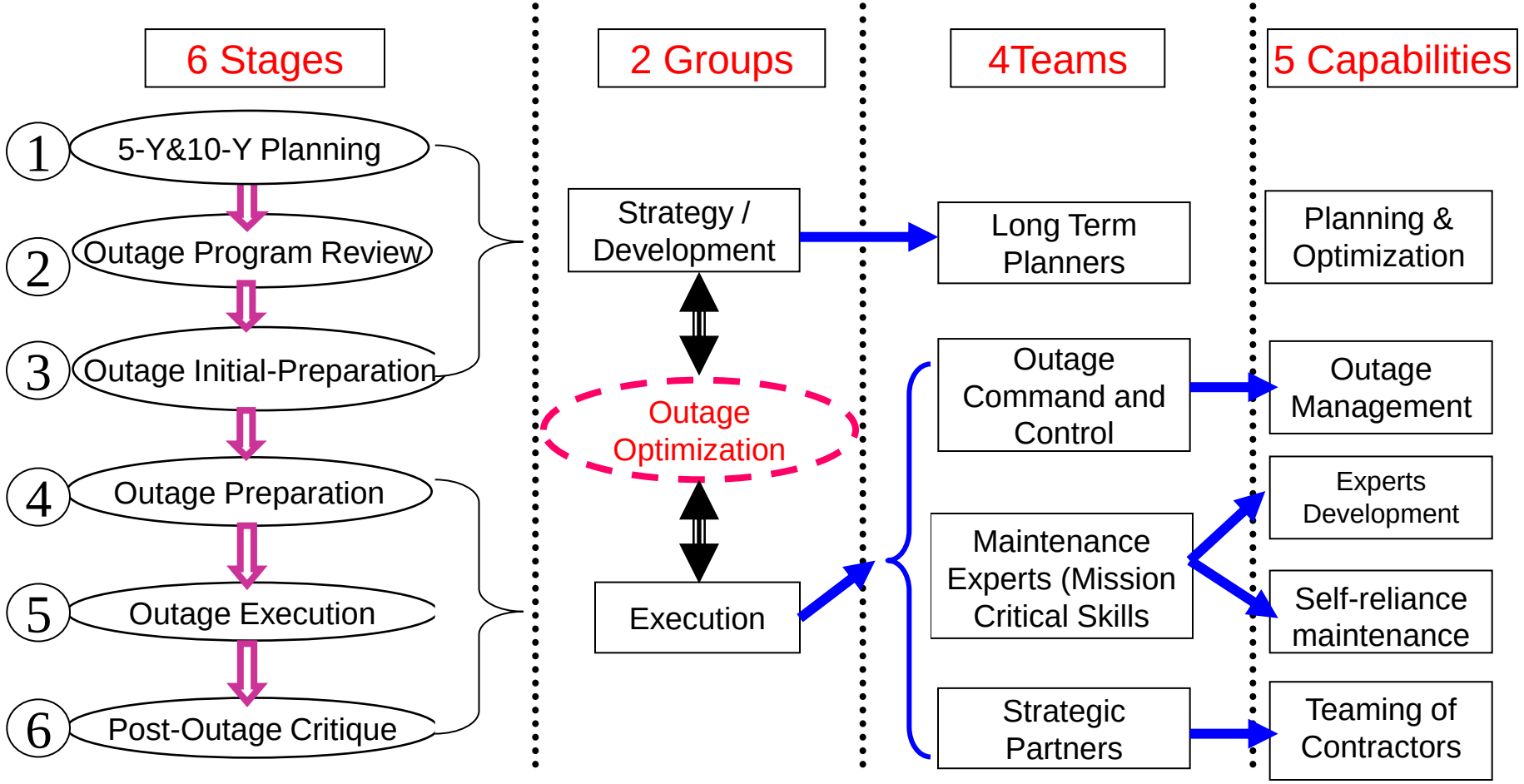
1. First Refueling Outage
   - Primary Circuit hydraulic test;
   - Containment pressure test;
   - RPV In-Service-Inspection;
   - Clearance of teething problems and post-service inspections on major equipment/system…
2. Normal Refueling Outage
   - Refueling;
   - Regulatory inspections, tests and preventive maintenance.
   - Preventive and Corrective maintenance and engineering works.
3. Short Refueling Outage
   - Refueling;
   - Regulatory inspections, tests and preventive maintenance.
   - Preventive and Corrective maintenance and slight engineering works.
4. 10^{th} Year Outage
   - Similar regulatory required works as 1^{st} refueling outage
   - Post-PSA required inspections and improvement works
   - Major engineering works/modifications.

Outage Management

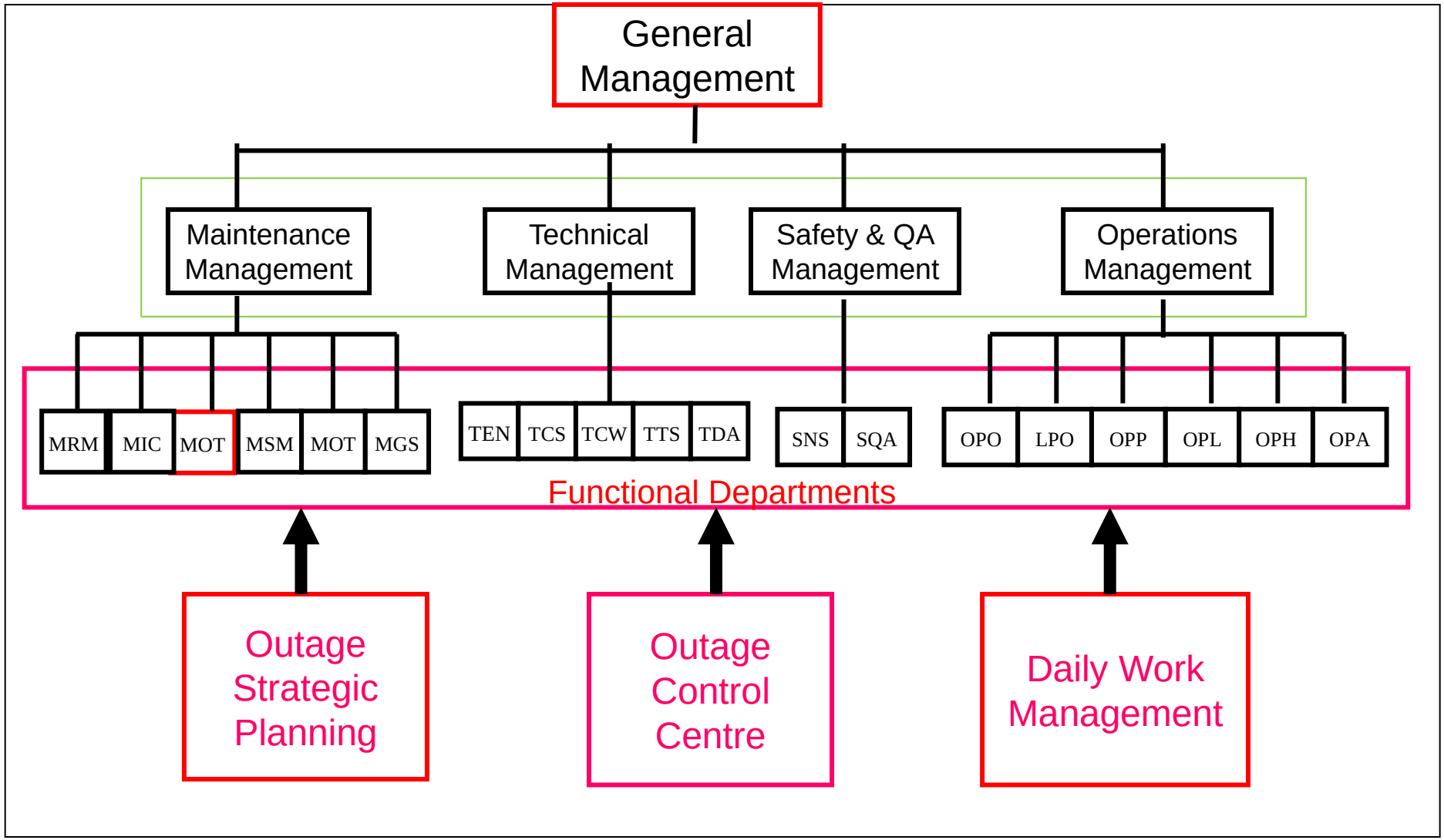
- Planning, Preparations and Execution
- Outage Safety, QA, ALARA, HPI and Communications.
- Process and Technology Integration
- Cost Control and Reduction
- Using New Technology
- Evaluating Specific Long-term Outage Performance Strategies
- Appling Best Practices, Lessons Learned and Operating Experience
- Completing Benchmarking, Standardization and Plant Assessments
- Performing Risk Assessments
- Issue Resolution, Deep Contingencies and Recommendations

Outage Management Program

Leadership and integration to improve outage planning, preparation and execution



Outage Management Organization



XXX Outage Organization

广东核电

Operations manager

Outage manager
Assistant outage manager

STA

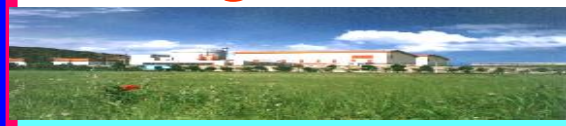
NI Manager

Quality assurance engineer

CI manager

Planning engineer

Equipment engineer



Persons responsible for major projects

Planning assistant

Operational assistant

NI planning

NI blocking manager

CI planning

CI blocking manager

WR management

Periodic test

Shift scheduling

3-waste management

MSM head	MRM head	MEE head	MIC head	MGS head	TEN head	TTS head	TCW head
MSM coordinator	MRM coordinator	MEE coordinator	MIC coordinator	MGS coordinator	TEN coordinator	TTS coordinator	TCW coordinator
MSM assistant	MRM assistant	MEE assistant	MIC assistant	MGS assistant	Engineering modification	In-service inspection	Civil works
CI coordinator	CI coordinator	CI coordinator	CI coordinator	Decontam-ination	Item substitution	Performance test	Corrosion Prevention
MSM QC leader	MRM QC leader	MEE QC leader	MIC QC leader	MGS QC leader	TEN QC leader	TTS QC leader	TCW QC leader

Quality assurance

Contractors

AREVA	Coordinator		
NUCLEAR	Coordinator	Planner	QC leader
HUAINAN	Coordinator	Planner	QC leader
DONG BEI	Coordinator	Planner	QC leader

Safety surveillance

Radiation protection

Industrial safety

STA assistant

Equipment surveillance

Responsible persons

NCR management

CI Machinery

NI machinery

Instrument control

Electric equipment

RCM

Supports

Chemical control

Labor management

Contracted procurement

License application

Fuel management

Experience feedback

Generation planning

Training engineer

Requalification team

Requalification manager

MRM

MIC

MEE

Performance & vibration test

MSM

TEN

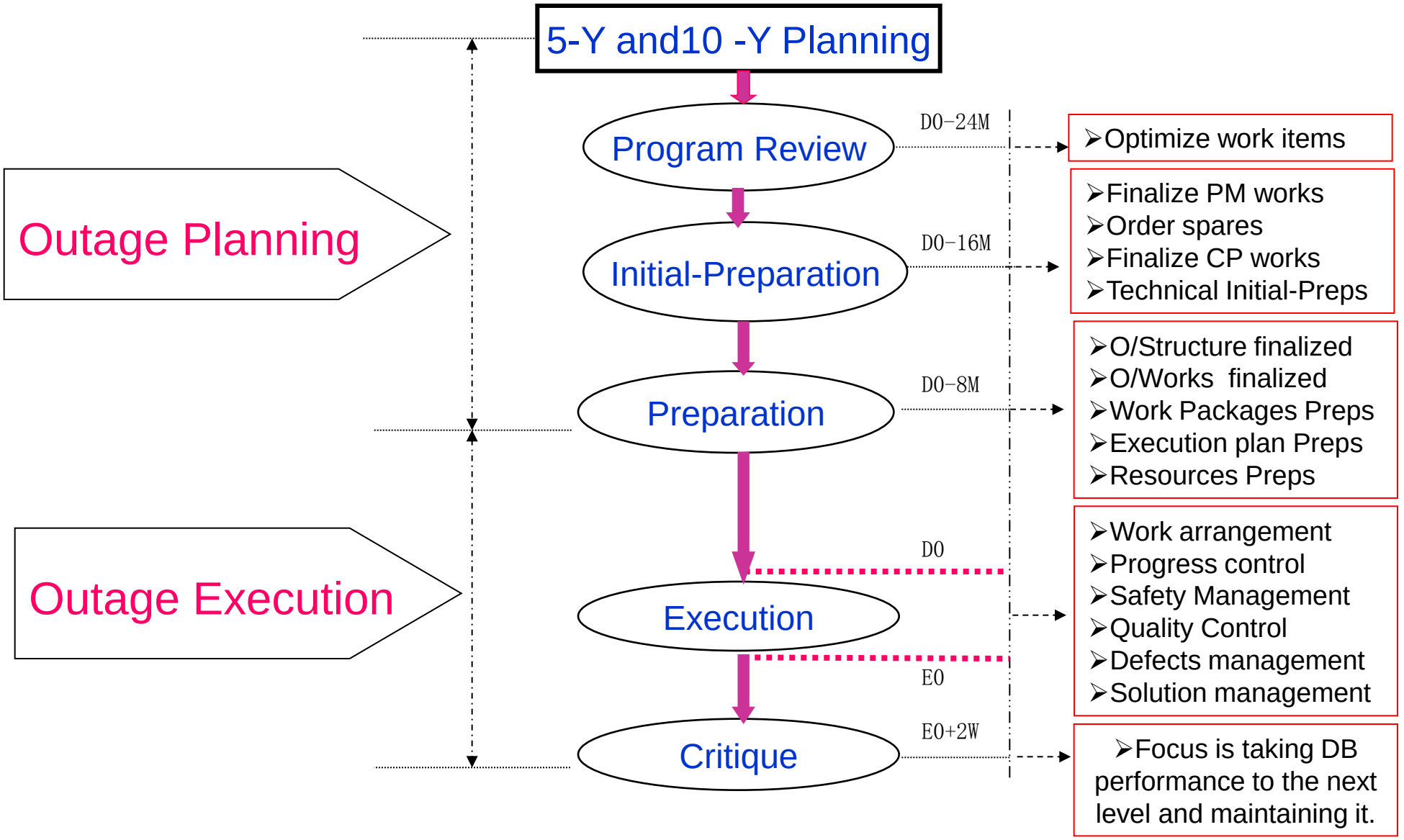
HUAI NAN

DONG BEI

NUCLEAR Company

Date: year/month/day

Solid Program Structure Drives Execution

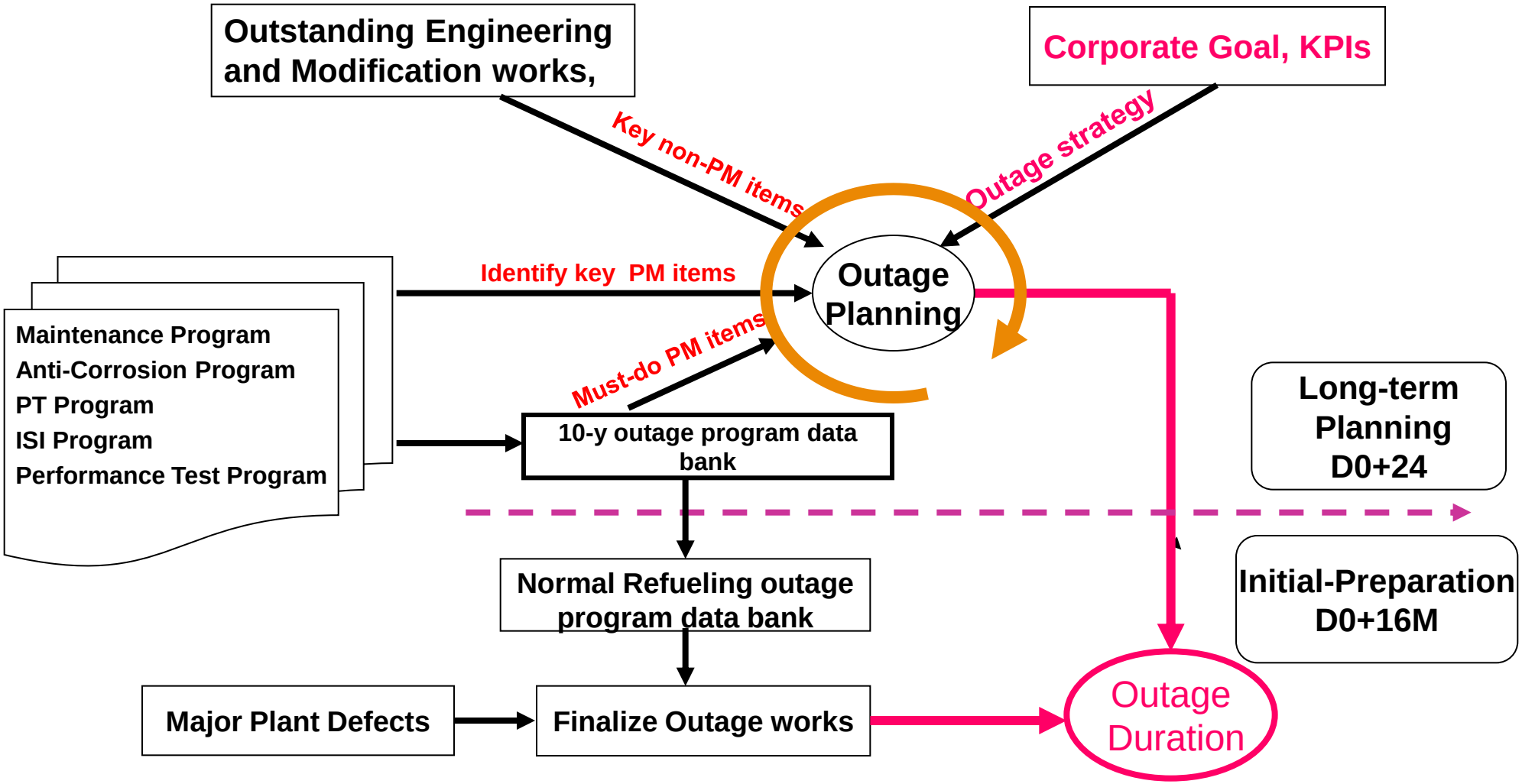


Solid Outage Management Structure

Value added to outage process

- Improved outage planning and implementation
- Reduced costs through integration of plant and vendor/sub-contractor teams
- Improved communication, integration and performance
- Incorporation of best practices
- Improved working relationships through Increased presence and direct interaction
- Increased oversight drives safety, Human Performance initiatives.

Outage Duration Decision Chart



Planning Team Goal

Focus on optimizing outage planning and performance

- Outage Milestone Enhancement
- Schedule Development
- Horizontal Schedule Review
- Vertical Schedule Review
- Peer Group Assessment
- Focus Team
- Resource Review

Outage Initial-Preparation Milestones

	Milestones	Month before Outage Starts (D0)	
		Refueling Outage	10-year Outage
IP0	Outage Initial-preparation (IP)starts	+16 M	
IP1	Outage spares procurement orders issued	+13 M	
IP2	Outage program developed and validated	+9 M	+13 M
IP3	Outage major work items finalized	+9 M	+13 M
IP4	Outage critical path developed	+9 M	+13 M
IP5	Outage IP work hand-over	+8 M	+12 M

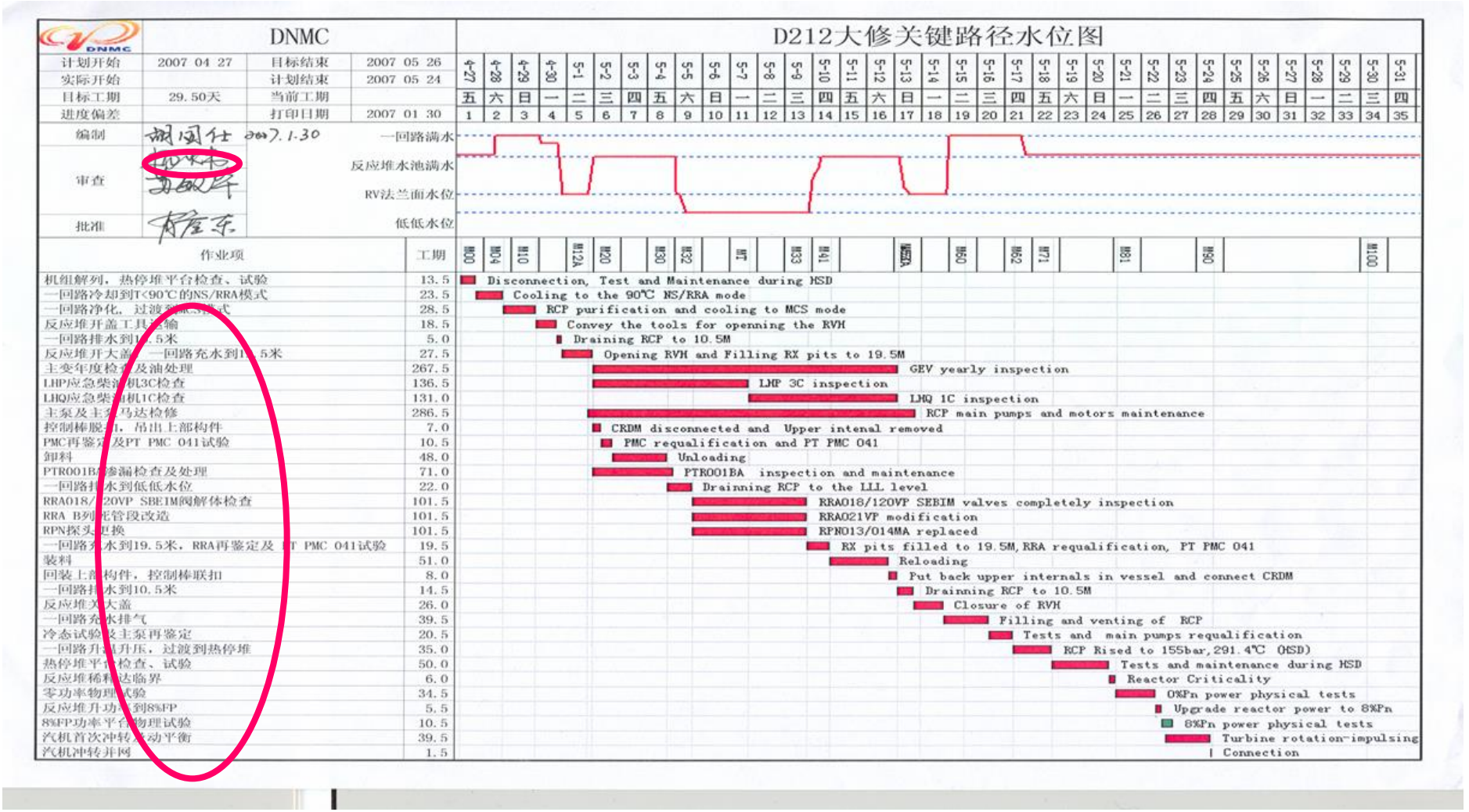
Outage Preparation Milestones

Milestone	Activity	Refueling Outage	10-year Outage
P0	Outage preparation starts	8 months before outage	12 months before outage
P1	PM work requests submitted	9 weeks after outage preparation work starts	13 weeks after outage preparation work starts
P2	Outage major works finalized	1 week after program validation	2 weeks after program validation
P3	Outage organization finalized	3weeks after program validation	4 weeks after program validation
P4	Tech Spec of all sub- contracted works ready and PR issued	1 week after finalizing the major works	1 week after finalizing the major works
P5	Freeze the major work list	6 weeks after program validation	8 weeks after program validation
P6	PM packages preparation completed	9 weeks after program validation	13 weeks after program validation
P7	PM packages review completed	10 weeks after submission	13 weeks after submission
P8	Print and issue the critical path chart and main blocking chart	4 weeks after completing preparation	6 weeks after completing preparation
P9	List out the concerned spares	13 weeks before outage	13 weeks before outage
P10	PM submitted to NNSA for approval	13 weeks before outage	13 weeks before outage
P11	Critical path activities finalized	6 weeks before outage	9 weeks before outage
P12	PM work requests to SAP completed	4 weeks before outage	4 weeks before outage
P13	Daily work/outage team hand-over meeting started	3 days before outage	3 days before outage
M00	Outage commence	offline	offline

Outage Execution Milestones

M11	- Offline
M01	- Enter HSD
M02	- Leaving HSD
M03	- Entering NS/RRA mode
M04	- NS/RRA mode with T < 90degC
M10	- Entering MCS with P < 5 bar
M11	- MCS with small opening
M12	- MCS with large opening
M13	- RVH opening (RIC seal open)
M14	- Lifting RVH
M20	- Reactor cavity full
M21	- Start core offloading
M30	- Finish core offloading
M31	- Start lowering cavity water level
M32	- LL water work started
M33	- LL water work finished
Mt	- Train Change-over
M40	- Reactor cavity full
M41	- Start core reloading
M42	- Core reloaded and validated
M50	- Start lowering cavity water level
M51	- Closing RVH (lifting from stand)
M52	- RVH closed
M53	- PZR manhole closed
M60	- Leaving MCS with P > 5 bar
M61	- RCS dynamic venting
M62	- NS/RRA mode with T >90deg C
M70	- Leaving RRA (NS/SG mode)
M71	- Entering HSD
M80	- Start dilution
M81	- Reactor critical
M82	- Start charging main steam lines
M83	- Steam to turbine set
M90	-Synchronization (on line)
M100	- Reactor at full power

Critical Path Chart with RCS water level



Structured Outage Execution Process

- Organizational Management
  - Ownership/responsibility/expectation/performance appraisal
  - Functioning of the organization in preparation and execution stages
- Safety Management
  - Safety surveillance; decision making mechanism (ODM during outage execution)
  - Occupational safety management expectation, surveillance and control.
  - Control on sensitive area, RCA …
- Quality Management
  - Quality control group function; CCM critical skilled team assessment
  - Project management; documentation management
  - Pre-job briefing; FME management; QDR and defect rectification management
  - Requalification / re-commissioning
- Progress Management
  - 15 minutes reporting rule
  - Critical path activities planning and control; special project planning and control; HR planning; deep contingency planning for critical path activity windows
- Risk management
  - Level1/2/3 risk management
- Contractor management
  - Contractor worker training, qualification, assessment and appraisal
  - Contractor tooling management
- Resource Management
  - HR, contracts, spares, tooling management
- Support Services management
  - Unit shutdown and start-up support services, administrative services, licensing and reporting

Outage Control Daily Meeting Schedule

	Meeting Purpose	Daily Meeting
1	Morning Progress Meeting with all functional Branch heads	0800 hr
2	Convention Island work coordination meeting	0820hr
3	Outage work coordination with all project leaders	0930hr
4	NCR actions tracking coordination meeting with stakeholders	1000hr
5	FME and quality assurance meeting with stakeholders	1110hr
6	Outage Planning meeting	1500hr
7	Convention Island Planning meeting	1620hr
8	Safety Health and environmental protection meeting	1630hr
9	Outage Control Centre management meeting	1845hr
10	Outage management Planning Meeting	1100hr and 2200hr

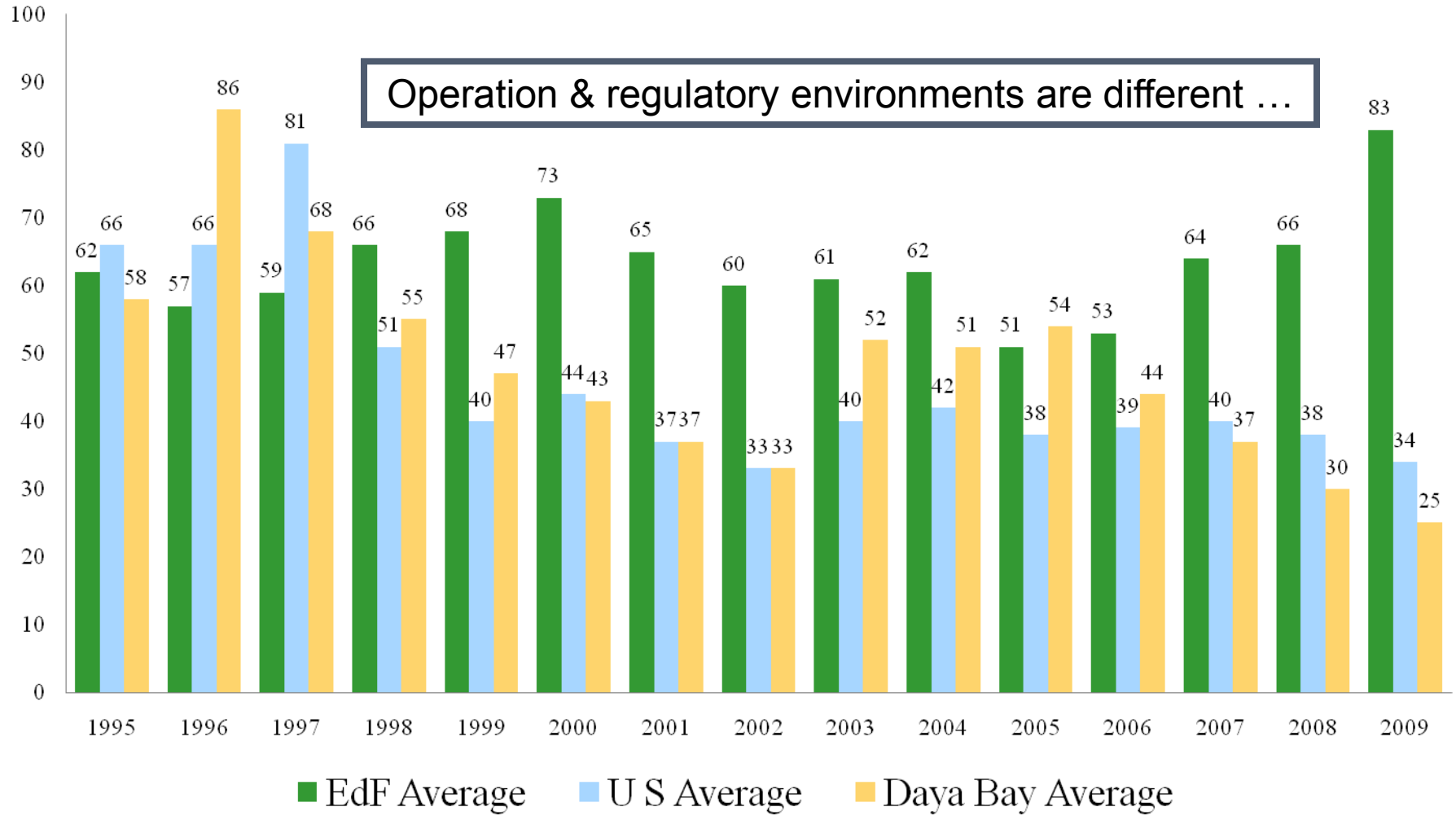
Partnering with Contractors

- Teaming of vendors/contractors for a mutually beneficial relationship
- Establish a joint alliance team focused on improving safety and outage performance
- Form teams to focus on all aspects of an outage from setting goals and key performance objectives to planning, training, implementation, post-outage critique and drawing lessons learned.

Benchmarking with FROG Outage Windows

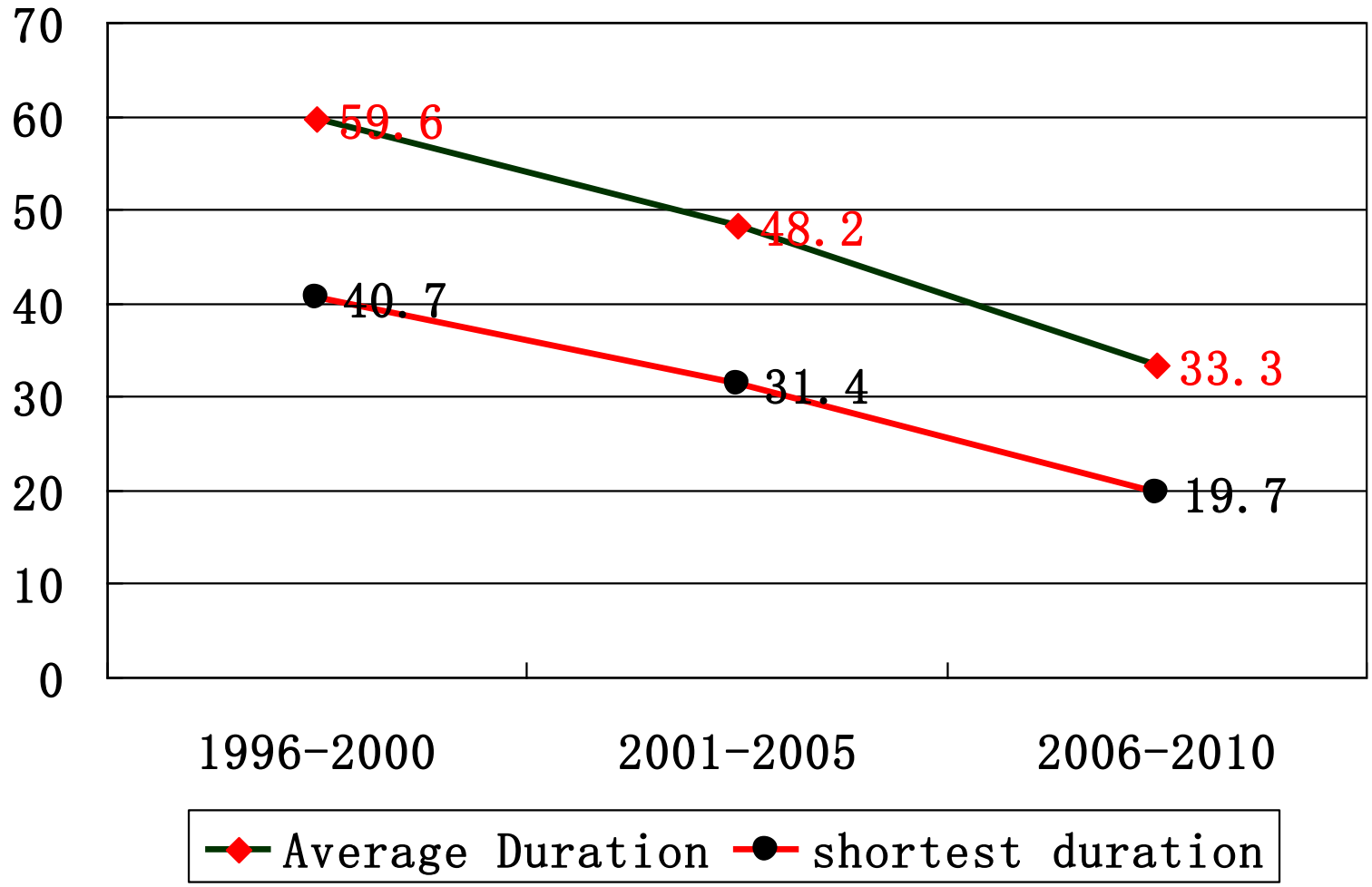
FROG Window	FORG Window Information	DNMC Window	DNMC Window Information	DNMC Shortest
FROG 1	Offline to Mode 5（<90oC）	M00--M04	Offline--TRCP<90degC NS/RRA mode	27.3hr
FROG 2	Mode 5 to Mode 6 (unbolting the first bolt on RVH)	M04--M13	TRCP<90DegC NS/RRA mode to start work on RVH（dismantling RIC seal）	37hr
FROG 3	Mode 6 to Start core offloading	M13--M21	Start work on RVH（dismantling RIC seal）to Start Core offloading	36.8hr
FROG 4	Start Core offloading to the last FA in spent Fuel Pool	M21--M30	Star to finish core offloading	35.3hr
FROG 5	Reactor Vessel empty	M30--M41	Core offloaded to core reload starts	98.3hr
FROG 6	Core reload including verification	M41--M42	Core reload start to finish including verification	41.2hr
FROG 7	Core verification to RVH in Place	M42--M51	Core verification to RVH lift-up from stand	18hr
FROG 8	RVH in Place to all bolts tightened	M51--M52	RVH lift-up from stand to RVH boxed（RIC seal replaced)	19hr
FROG 9	All RVH bolts tightened to first RCP started	M52--M60	RVH boxed（RIC seal replaced) to leaving MCS（PRCP>5BAR)	8.5hr
FROG 10	First RCP started to Mode 4（>90oC）	M60--M62	Leaving MCS（PRCP>5BAR) to RCP<90degC NS/RRA mode	15.1hr
FROG 11	Mode 4 to leaving RRA	M62--M70	TRCP<90degC NS/RRA mode to NS/SG mode（leaving RRA）	12.2hr
FROG 12	Leaving RRA to start dilution	M70--M80	NS/SG mode（leaving RRA）to start dilution	31.9hr
FROG 13	To start dilution to online	M80--M90	Start dilution to online	40.1hr
			Total 17.5 days (achievable outage duration)	420.7hr

Outage Comparison



Source: McGraw Hill – "Global LWR Outage Durations"

Daya Bay Units' Actual Outage Duration



Daya Bay – The Way Forward

- 20 days will be the Daya Bay norm for predictable and repeatable refueling outage duration.
- Based on Daya Bay analysis of actual outage windows data, outage durations of 17 days can be achieved.

Thank You