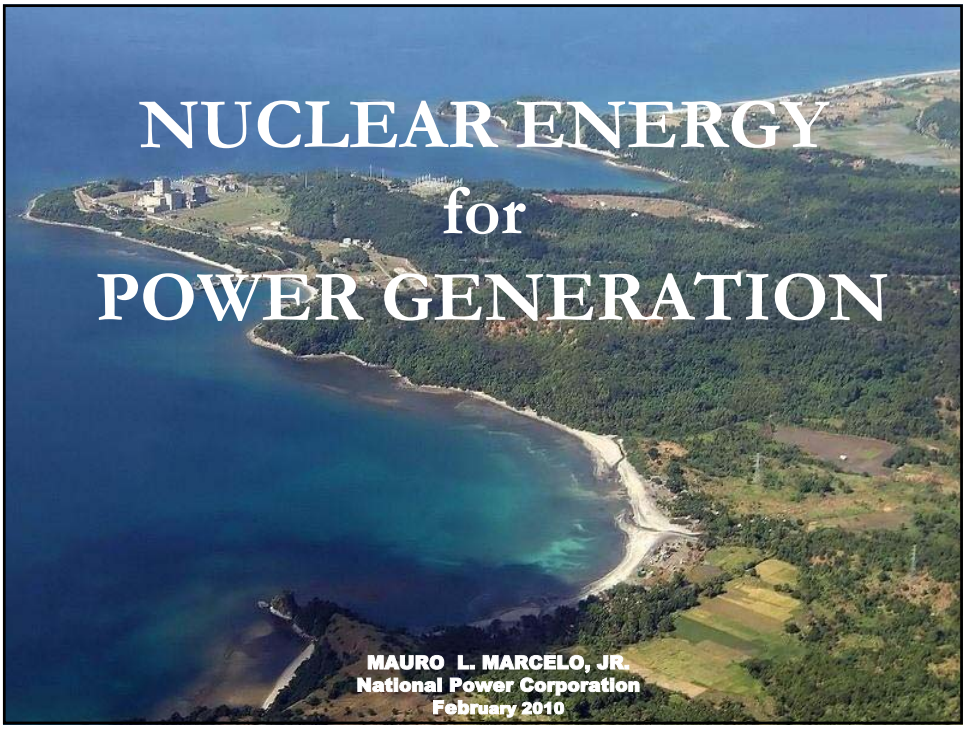

NUCLEAR ENERGY
for
POWER GENERATION
MAURO L. MARCELO, JR.
National Power Corporation
February 2010


What is Nuclear Power?
Why Do We Need it?
Global Trends
The Bataan Nuclear Power Plant
Future Considerations

HYDROELECTRIC

CONVENTIONAL THERMAL

SOLAR

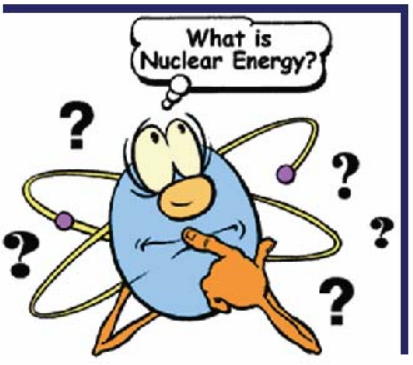
WIND FARM

GEOTHERMAL

NUCLEAR

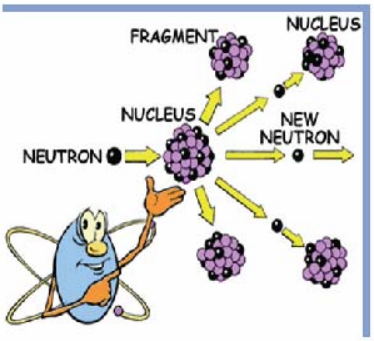
What is Nuclear Energy ?

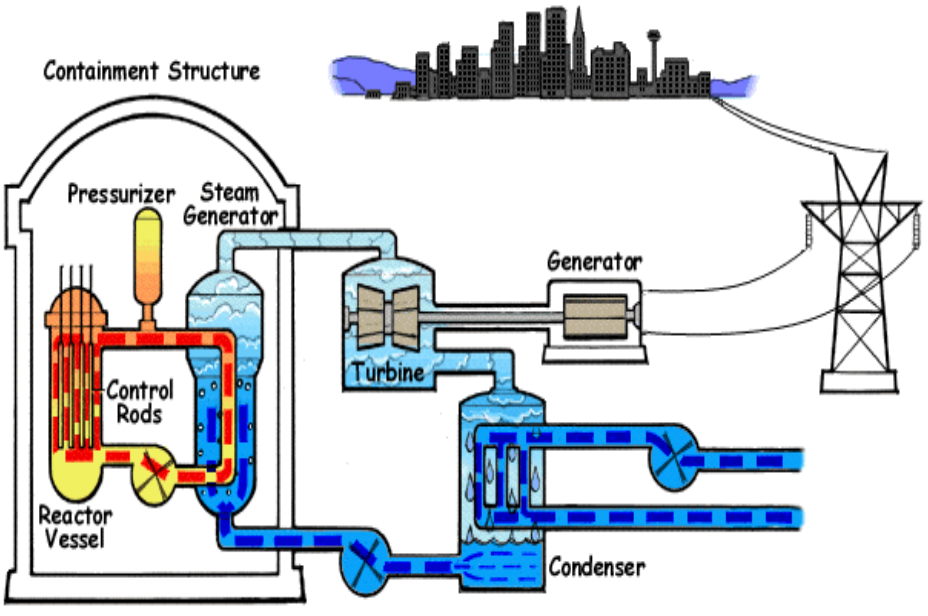
- Nuclear energy is a way to generate heat using the fission process of atoms.
- A nuclear power plant converts the heat into electricity.



Fission and Chain Reaction

- Fission is the splitting of atoms into smaller pieces, caused by neutrons hitting each other.
- Smaller pieces strike other atoms, releasing energy.
- When this process continues, it is called a chain reaction



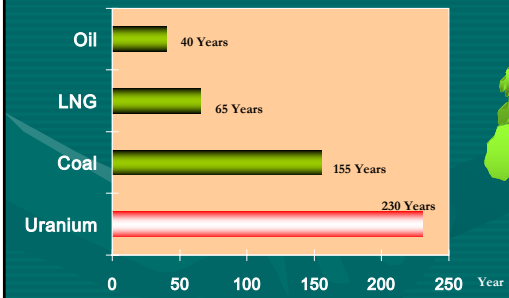


Pressurized Water Reactor

Nuclear, a Sustainable Energy Sourc

National Energy Security

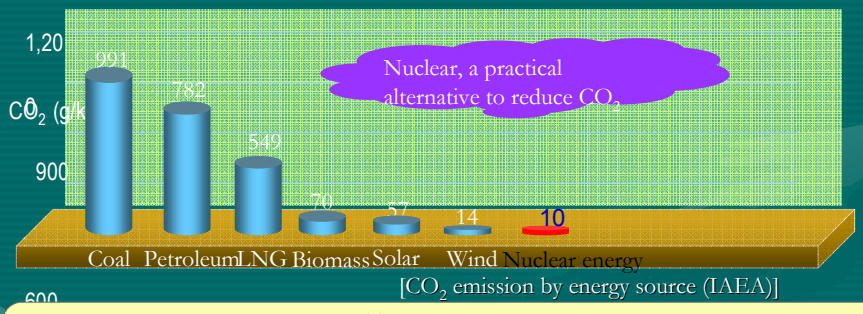
- Nuclear power can contribute to energy security by stably supplying fuel regardless of the global energy landscape.
  - ✓ Uranium has the longest period of reserve-production ratio and is well-spread around the world.



[Reserve-production Ratio]

[Uranium Producing Countries]

Nuclear Power, a Green Energy Source



[CO_2 emission by energy source (IAEA)]

If there were no nuclear power ⇨ The world's total CO_2 emission would increase by 10%

Stable Supply of Electricity

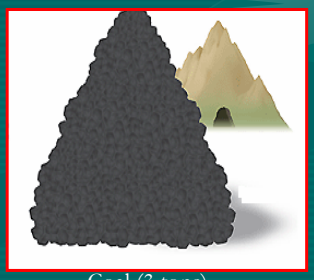
◆The high energy density of uranium guarantees a stable supply of electricity.
- ✓ One load of fuel can generate power for more than 18 months.

Uranium (1g)

=

Oil (9 Drums=1,800L)

=



Coal (3 tons)

The Prospect of Nuclear in the world

◆According to the IAEA, 300 new nuclear power plants will be constructed by 2030.

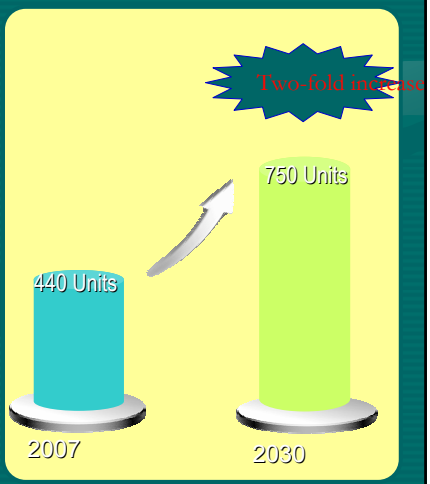
"The share of nuclear power generation must be increased to 59% in order to achieve energy self-reliance by 2030."
(Lee, President of Korea)

" We must invest in nuclear, wind and solar and other clean energy industries in order to reduce our dependence on fossil fuel energy."
(Obama, President-elect of USA)

"We believe that the national interest of France is linked to nuclear power."
(Sarkozy, President of France)

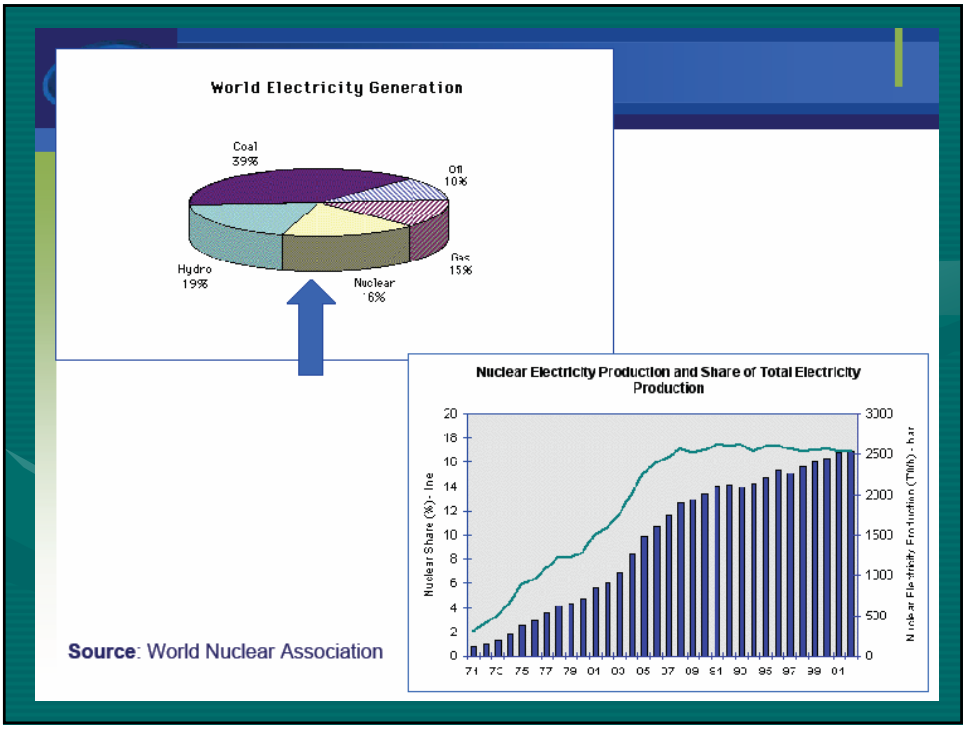
"The importance of nuclear power generation is increasing as we must achieve energy security and reduce carbon dioxide emissions."
(Aso, Prime Minister of Japan)

"The peaceful use of nuclear energy is vital and we must concentrate on developing this clean energy."
(Medvedev, President of Russia)

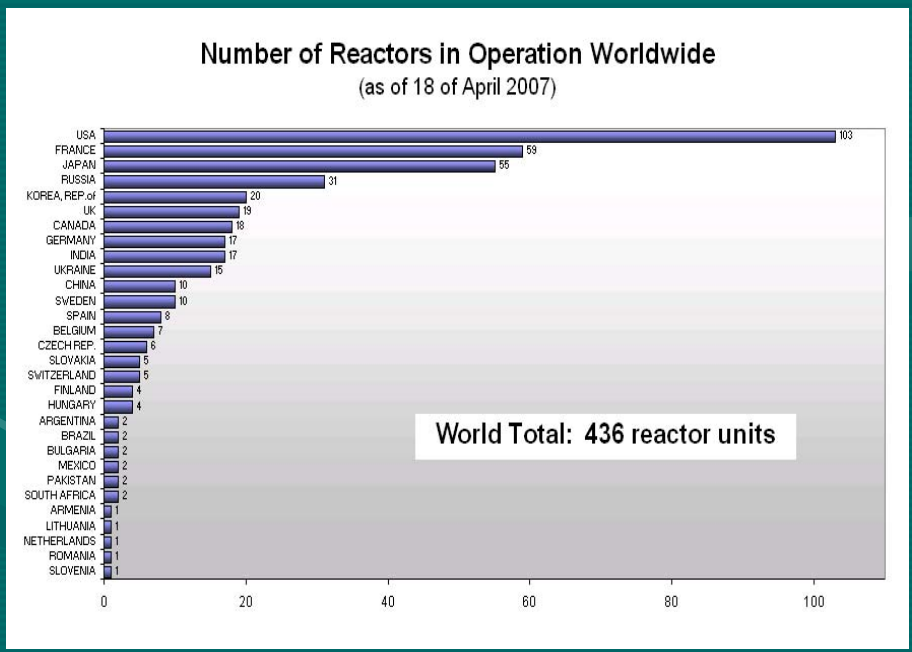


[Source: IAEA]


Global Trends


World Electricity Generation
Coal
39%
Oil
10%
Gas
15%
Nuclear
16%
Hydro
19%
Nuclear Electricity Production and Share of Total Electricity Production
Nuclear Share (%) - line
Nuclear Electricity Production (TWh) - bar
Source: World Nuclear Association

- As of January 2009
  - There are 436 nuclear power reactors in operation in 30 countries with almost 372,000 MWe capacity.
  - They supply about 15 % of the world's electricity requirement.
  - Other 43 nuclear power plants are under construction in 12 countries, with about 38,000 MWe capacity.
  - About 106 NPPs are planned by 24 countries , with about 118,000 MWe capacity.
  - About 266 NPPs are proposed by 37 countries with about 262,000 MWe by 2030



Nuclear Power Development in Asia

- **As of May 2007**
  - Asia is the only region in the world where electricity generating capacity specifically, nuclear power is growing rapidly.
  - There are currently 111 nuclear power reactors operating in five countries of the region, 16 units under construction, 55 planned, 69 proposed
  - The greatest growth in nuclear generation is expected in China, Japan, South Korea and India

Nuclear Power Development in Asia

	Power Reactors in Operation	Power Reactors Under Construction	Power Reactors Planned/Proposed
Australia	-	-	-
Bangladesh	-	-	1
China mainland	11	4	23/54
China-Taiwan	6	2	
India	17	6	4/15
Indonesia	-	-	4
Japan	55	2	11
S. Korea	20	1	7
N. Korea	-	-	1
Malaysia	-	-	-
Pakistan	2	1	2
Philippines	-	-	-
Thailand	-	-	-
Vietnam	-	-	2
Total	111	16	55/69

Sources: WNA Reactor table, country papers, OECD/IEA World Energy Outlook 2000, Nuclear Engineering International, World Nuclear Industry Handbook 2005.

Competitive Cost

- Nuclear power is cost competitive with other forms of electricity generation, except where there is direct access to low-cost fossil fuels.
- Fuel costs for nuclear plants are a minor proportion of total generating costs, though capital costs are greater than those for coal-fired plants.
- In assessing the cost competitiveness of nuclear energy, decommissioning and waste disposal costs are taken into account.

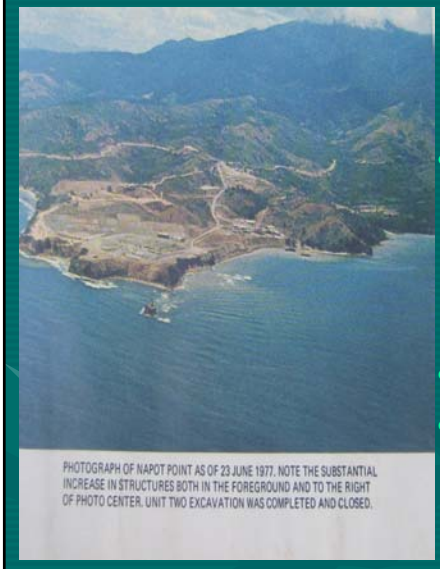
Competitive Cost

Some comparative electricity generating cost projections for year 2010 on - 5% discount rate

	NUCLEAR	COAL	GAS
Finland	2.76	3.64	-
France	2.54	3.33	3.92
Germany	2.86	3.52	4.90
Switzerland	2.88	-	4.36
Netherlands	3.58	-	6.04
Czech Rep	2.30	2.94	4.97
Slovakia	3.13	4.78	5.59
Romania	3.06	4.55	-
Japan	4.80	4.95	5.21
Korea	2.34	2.16	4.65
USA	3.01	2.71	4.67
Canada	2.60	3.11	4.00

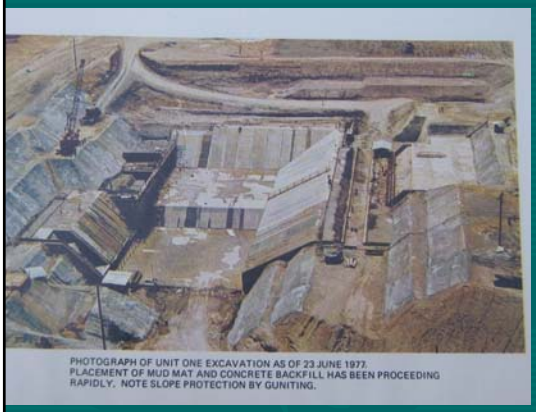
US 2003 cents/kWh, Discount rate 5%, 40 year lifetime, 85% load factor.
Source: OECD/IEA NEA 2005.

➢ The Bataan Nuclear Power Plant



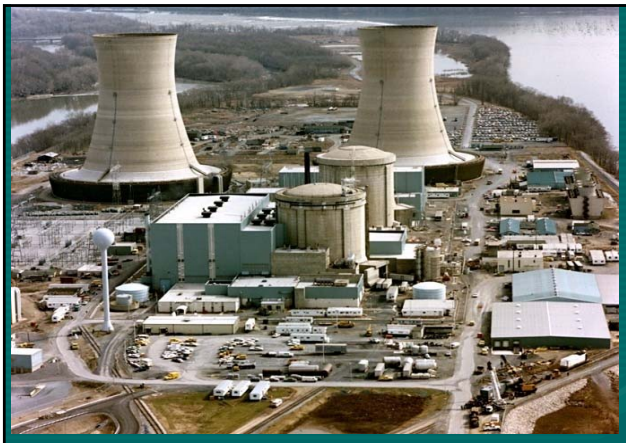
PHOTOGRAPH OF NAPOT POINT AS OF 23 JUNE 1977. NOTE THE SUBSTANTIAL INCREASE IN STRUCTURES BOTH IN THE FOREGROUND AND TO THE RIGHT OF PHOTO CENTER. UNIT TWO EXCAVATION WAS COMPLETED AND CLOSED.

- *Located at Napot Point, a small peninsula in the west coast of Morong, Bataan in Luzon*
- *356 Hectare Land*
- *About 2 – ½ hours drive from Manila (168 km land travel)*



PHOTOGRAPH OF UNIT ONE EXCAVATION AS OF 23 JUNE 1977.
PLACEMENT OF MUD MAT AND CONCRETE BACKFILL HAS BEEN PROCEEDING RAPIDLY. NOTE SLOPE PROTECTION BY GUNITING.

- **February 1976…** *Contract signed*
- **July 1977…** *IAEA safety mission (PSAR review)*
- **May 1978…** *IAEA safety mission (geological review)*



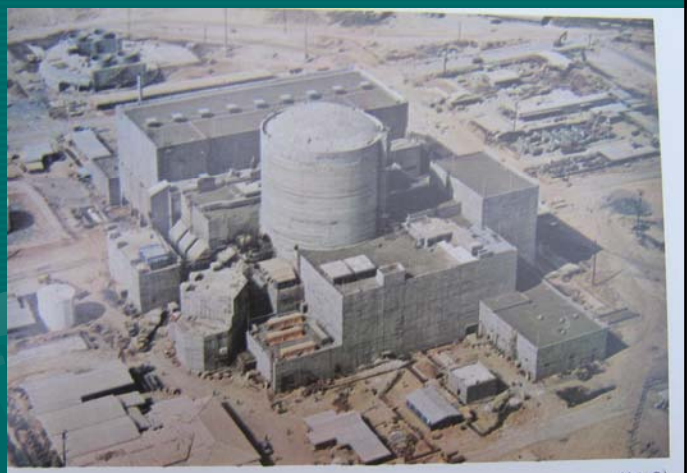
- **April 1979…** *Construction Permit issued by PAEC*
- **June 1979…** *President Marcos issued order to suspend construction*
- **June 1979…** *Puno Commission formed to evaluate safety concerns*

- **July 1979 through September 1980… Public hearings on BNPP safety**
- **January 1981…** *Full construction resumed*

2nd Quarter, 1983

Stator generator rotor being installed.

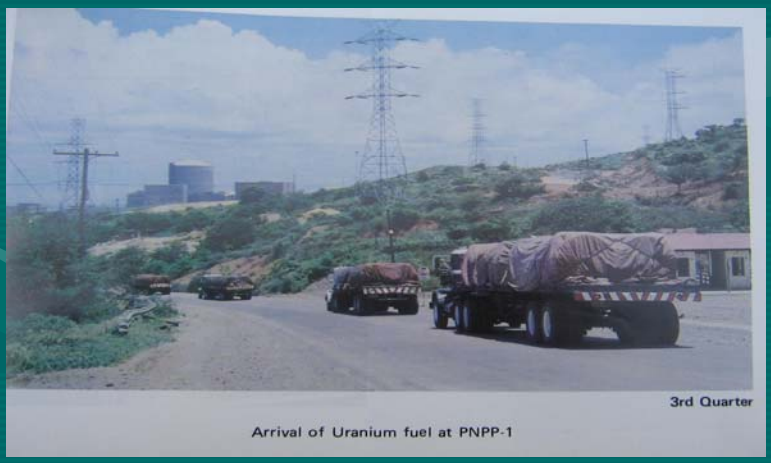
- **May 1984…** *Hot functional tests completed, initial synchronization to grid.*



(4th Q)

Aerial view from southwest.

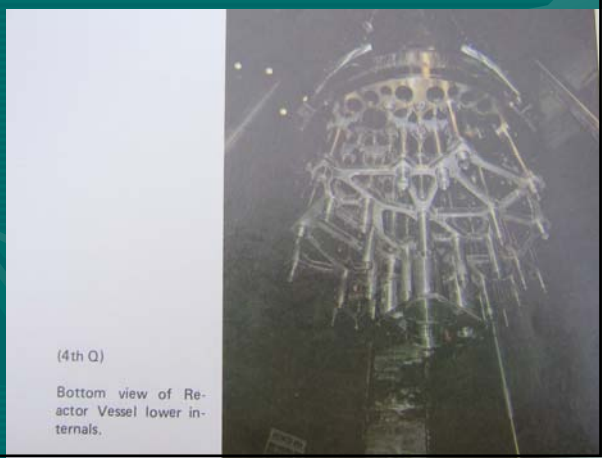
- **June 1984…** ***Fuel delivered***



3rd Quarter

Arrival of Uranium fuel at PNPP-1

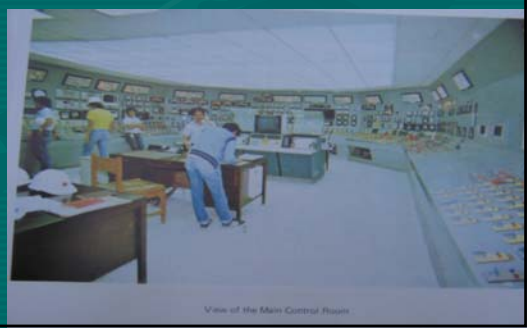
- **July 1984…** *IAEA OSARTI review construction appraisal review*
- **February 1985…** *IAEA OSART II review operational readiness review*

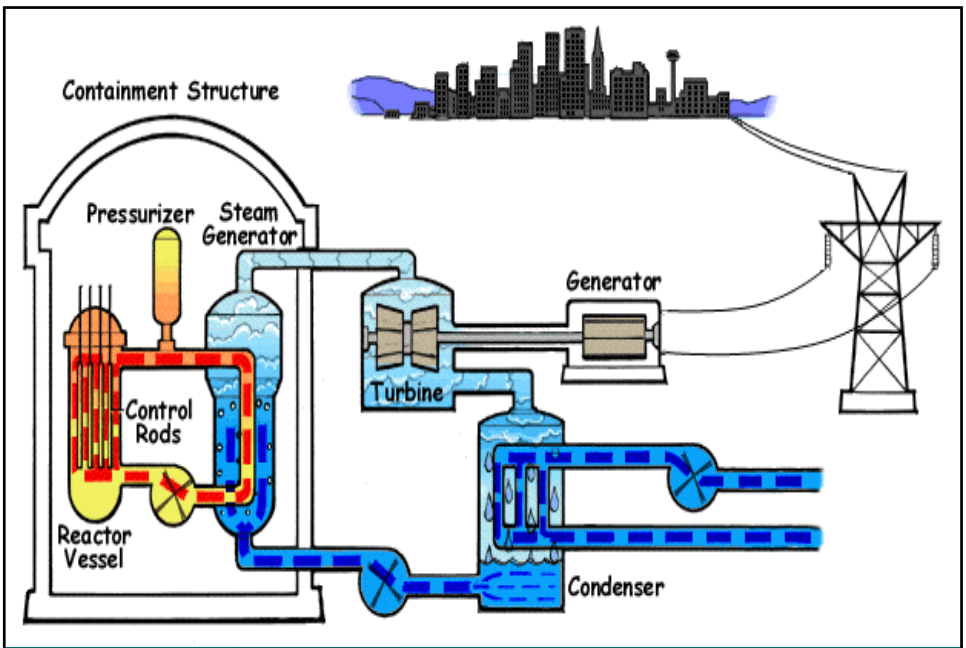


(4th Q)

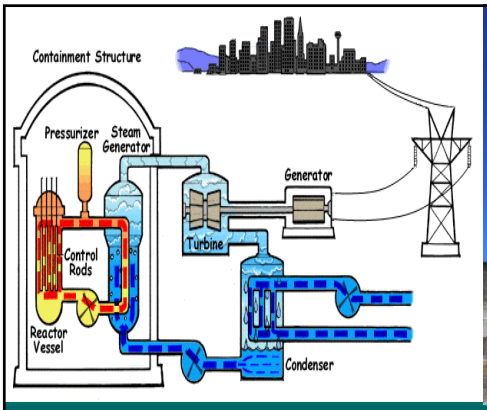
Bottom view of Reactor Vessel lower internals.

- **June 1985…** *Public hearings began for plant licensing*
- **April 1986…** *Philippine government decision to mothball plant*
- **1986 to present …** *Preservation & Maintenance of the plant*
- **December 1997 …** *Nuclear Fuel was sold*



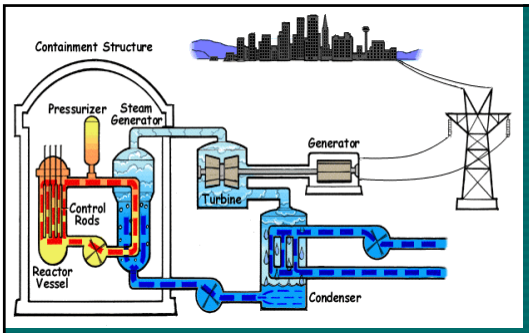


Pressurized Water Reactor



Pressurized Water Reactor

- **Reactor System Supplier : WESTINGHOUSE**
- **Turbine Generator Supplier : WESTINGHOUSE**
- **Architect/Engineer : BURNS & ROE INC.**
- **REACTOR UNIT RATING**
  - ✓Nuclear Thermal, MWth : 1876
  - ✓Gross Electrical, Mwe : 651.073
  - ✓Net Electrical, Mwe : 620.825



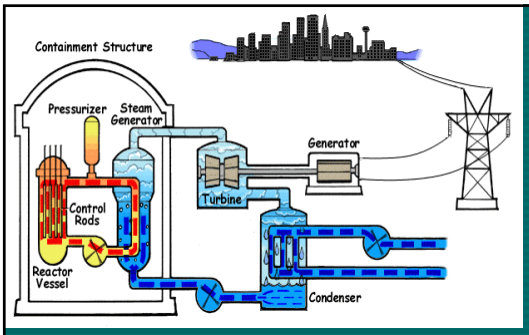
Pressurized Water Reactor

REACTOR VESSEL

Basic material	: Carbon Steel
Weight	: 245 tons
Overall height	: 39.1 ft.
Shell thickness	: 6.63 in.
Design temp, °F(°C)	: 650/343.3
Design pressure, Psia/ (kg./cm2)	:2500/175.0

Fuel Material : Uranium dioxide (UO2) sintered
Means of reactivity control :
a. Control rods
b. Chemical shim
c. Burnable poison

No. of fuel assemblies	: 121
No. of fuel rods per assembly	: 235
Fuel rod arrangement	: 16 x 16
Cladding, material	: Zircaloy 4
Design frequency of refueling	: 12 months



Pressurized Water Reactor

EARTHQUAKE DESIGN PARAMETERS

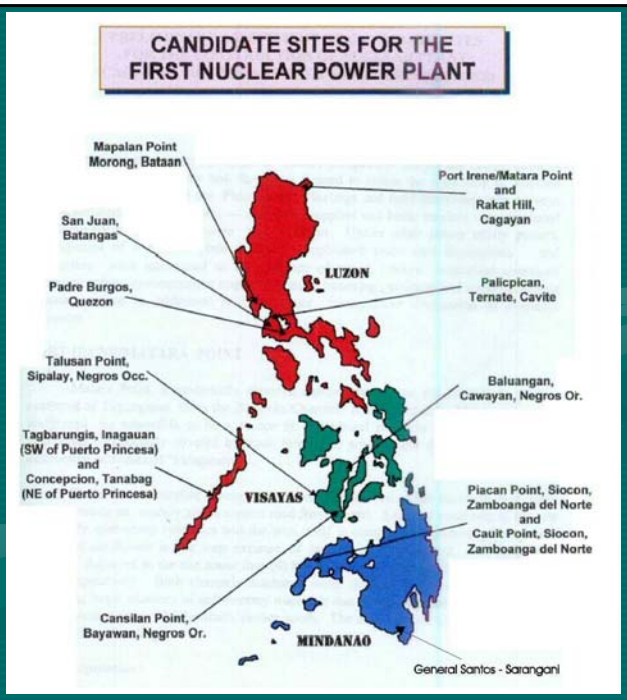
Safe Shutdown Earthquake (SSE) : 0.40g
Operating Basis Earthquake (OBE) : 0.20g

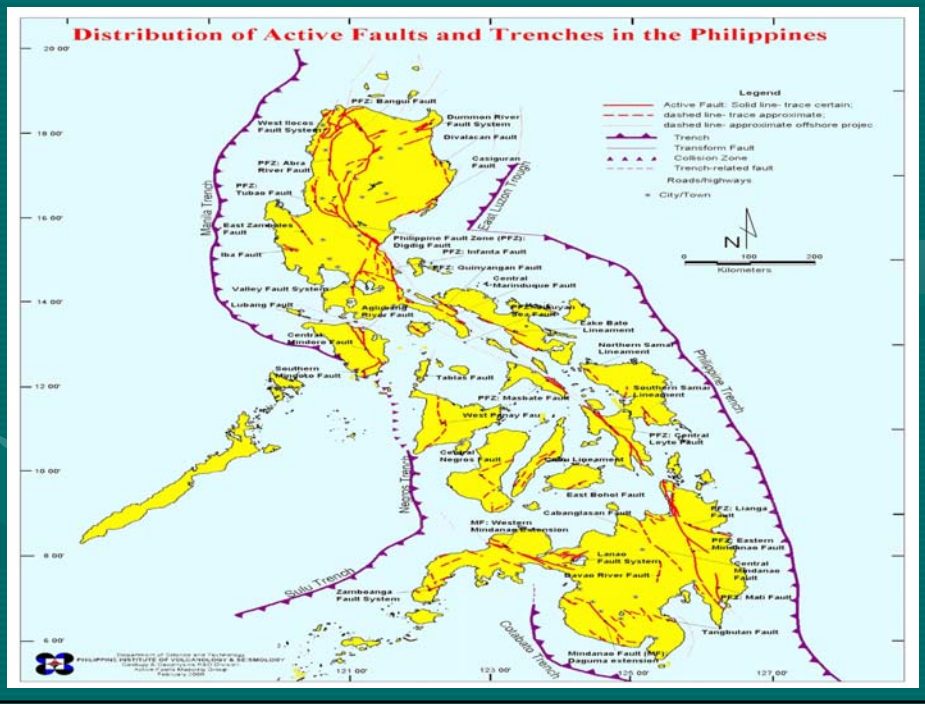
STEEL CONTAINMENT VESSEL

Material :SA 516 Grade 70
Inside diameter, ft. (m.) :105.2/(32.08)
Total height, ft. (m.) : 230/(70.166)
Design Internal Pressure, :
Psi (kg./cm2) : 2.0/(0.14)
Cylindrical Portion plate
Thickness, inches (mm) : 1.5/(38)
Dome thickness : 0.75/(19)

CONCRETE SHIELD WALL

Thickness, ft. (m.) : 3.38/(1.0)
Annulus space, ft. (m.) : 3.75/(1.142)


CANDIDATE SITES FOR THE FIRST NUCLEAR POWER PLANT
Mapalan Point Morong, Bataan
Port Irene/Matara Point and Rakat Hill, Cagayan
San Juan, Batangas
LUZON
Padre Burgos, Quezon
Palicpican, Ternate, Cavite
Talusan Point, Sipalay, Negros Occ.
Baluangan, Cawayan, Negros Or.
Tagbarungis, Inagauan (SW of Puerto Princesa) and Concepcion, Tanabag (NE of Puerto Princesa)
VISAYAS
Piacan Point, Siocon, Zamboanga del Norte and Cauit Point, Siocon, Zamboanga del Norte
Cansilan Point, Bayawan, Negros Or.
MINDANAO
General Santos - Sarangani


Distribution of Active Faults and Trenches in the Philippines
Legend
Active Fault: Solid line- trace certain; dashed line- trace approximate; dashed line- approximate offshore projec
Trench
Transform Fault
Collision Zone
Trench-related fault
Roads/highways
City/Town
N
Kilometers
PFZ: Bangui Fault
West Boco Fault System
Dummon River Fault System
Divalacan Fault
PFZ: Abra River Fault
Casiguran Fault
PFZ: Tubao Fault
East Luzon Trough
Manila Trench
East Zambales Fault
Philippine Fault Zone (PFZ): Digdig Fault
PFZ: Infanta Fault
Iba Fault
PFZ: Guinyangan Fault
Central Marinduque Fault
Valley Fault System
Lubang Fault
Agbulang River Fault
Lake Bato Lineament
Central Mindoro Fault
Northern Samar Lineament
Southern Mindoro Fault
Tablas Fault
Philippine Trench
Southern Samar Lineament
PFZ: Masbate Fault
West Panay Fau
PFZ: Central Leyte Fault
Negros Trench
Central Negros Fault
Cebu Lineament
East Bohol Fault
Cabanglasan Fault
MF: Western Mindanao Extension
PFZ: Liang Fault
PFZ: Eastern Mindanao Fault
Lanao Fault System
Central Mindanao Fault
Agusan River Fault
PFZ: Mati Fault
Sulu Trench
Zamboanga Fault System
Tangbulan Fault
Cotabato Trench
Mindanao Fault (MF) Daguma extension
20 00'
18 00'
16 00'
14 00'
12 00'
10 00'
8 00'
6 00'
121 00'
123 00'
125 00'
127 00'

Summary of nuclear power today:

- A proven technology that provides clean electricity at predictable and competitive costs
- More the 12,000 years of accumulated reactor experience
- Operation of nuclear installations have safety as highest priority
- Lessons learned from past mistakes or accidents have been acted on
- The industry's safety record is second to none
- Nuclear takes full responsibility for all its waste

IAEA

Nuclear Safety

- From the outset, there has been a strong awareness of the potential hazard of both nuclear criticality and release of radioactive materials.
- There have been two major reactor accidents in the history of civil nuclear power - Three Mile Island and Chernobyl. One was contained without harm to anyone and the other involved an intense fire without provision for containment.
- These are the only major accidents to have occurred in more than 12,000 cumulative reactor-years of commercial operation in 32 countries.
- The risks from western nuclear power plants, in terms of the consequences of an accident or terrorist attack, are minimal compared with other commonly accepted risks. Nuclear power plants are very robust.

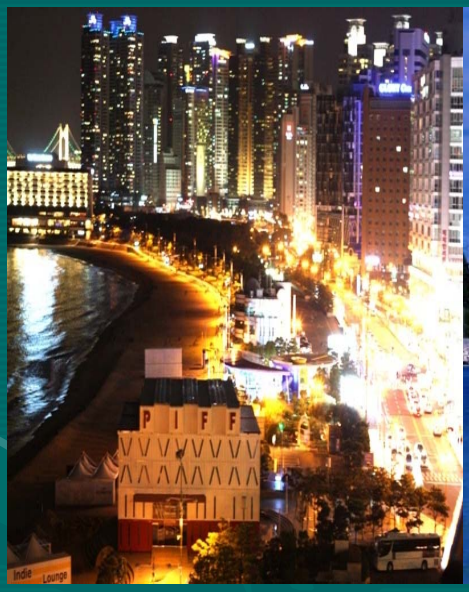
Nuclear Safety

- **To achieve optimum safety, nuclear plants in the western world operate using a 'defense-in-depth' approach, with multiple safety systems supplementing the natural features of the reactor core. Key aspects of the approach are:**
  - High-quality design and construction
  - Equipment which prevents operational disturbances developing into problems
  - Redundant and diverse systems to detect problems, control damage to the fuel and prevent significant radioactive releases
  - Provision to confine the effects of severe fuel damage to the plant itself.

Technological Development/Advancement

- **Contributes to technological development/advancement of the country**

  A vigorous nuclear program enhances the technological base of the country.



Busan City

KORI Site

Status of Nuclear Power Plants in Korea

In operation
20 units
(17,716 MW)

Under construction
6 units
(6,800 MW)

Planned for construction by 2030
12 units
(16,800 MW)

Ulchin
6 units

Wolsung
6 units

Kori
8 units

Yonggwang
6 units

In operation
Under construction


Thank You!