PHILIPPINE COUNTRY REPORT

Neil Raymund D. Guillermo

Philippine Nuclear Research Institute

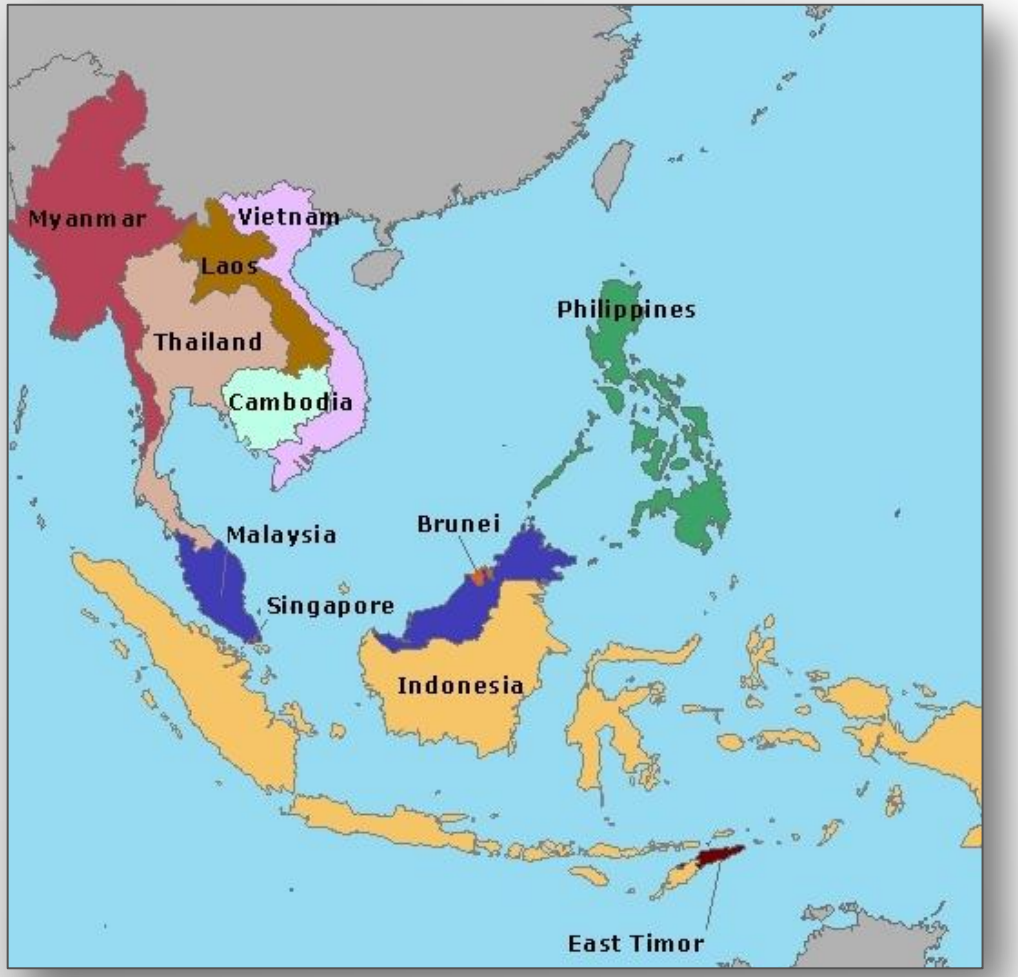
Presented at the 2nd ASEAN Workshop on Nuclear Power Safety Research
March 07-08, 2017

Bangkok, Thailand

OUTLINE

- The Philippines
- National Energy Situation
  - Nuclear Energy as an option
- Bataan Nuclear Power Plant (BNPP)
- Philippine Nuclear Research Institute
  - Philippine Research Reactor – 1 (PRR-1)
- Summary
- Proposal for benchmark problems and research collaborations

THE PHILIPPINES



Selected Macro Economic Indicators

Number of Islands : 7,107 Islands
Population : 103 Million
(est. end 2016)
GDP Growth Rate : 6.8% (2016)

GDP Shares of Economic Sectors (2015)

Agriculture : 9.49%
Industry : 33.48%
Services : 57.03%

GDP / Capita : $6547 PPP (2015)
Energy / Capita : 0.48 TOE/person (2014)

PHILIPPINES

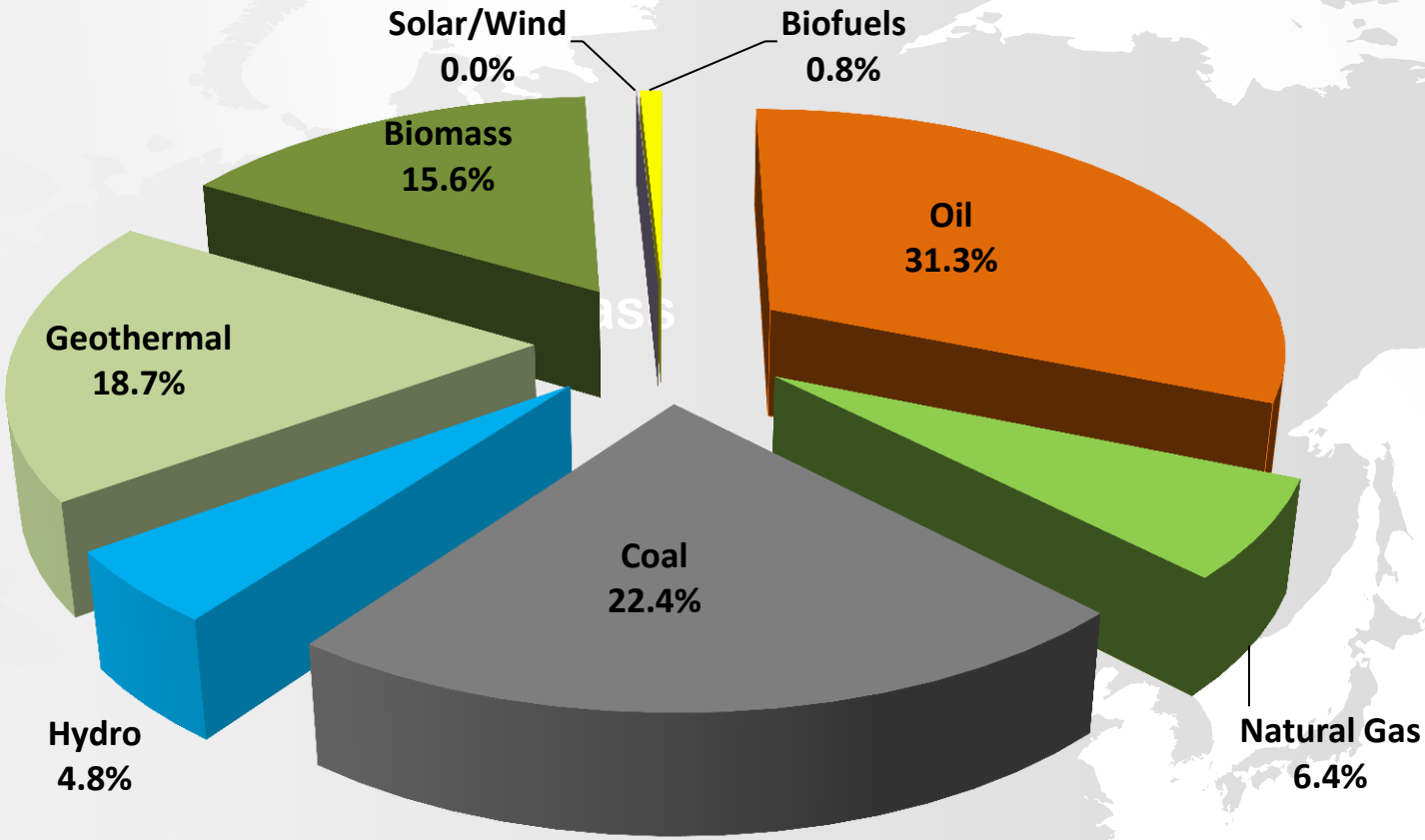
- Tropical country
- Religion: mostly Christian & Muslim
- Combination of Spanish & American & Asian Cultures
- Known for its warm hospitality & sweet mangoes
- Long Christmas season (September – January)

NATIONAL ENERGY SITUATION

PHILIPPINE ENERGY PLAN (PEP) (2012 – 2030)

- Growing Energy demand
- Tight energy supply
- Limited Foreign Investments
- Critical power development issues
- DOE PEP
  - Highlights the plans and programs of the energy sector to fuel support for the economic growth of the country
  - Deal with the future of energy development
  - Ensuring the best energy choices for a better quality of life

TOTAL PRIMARY ENERGY MIX - 2014



Total Energy: 47.5 MTOE

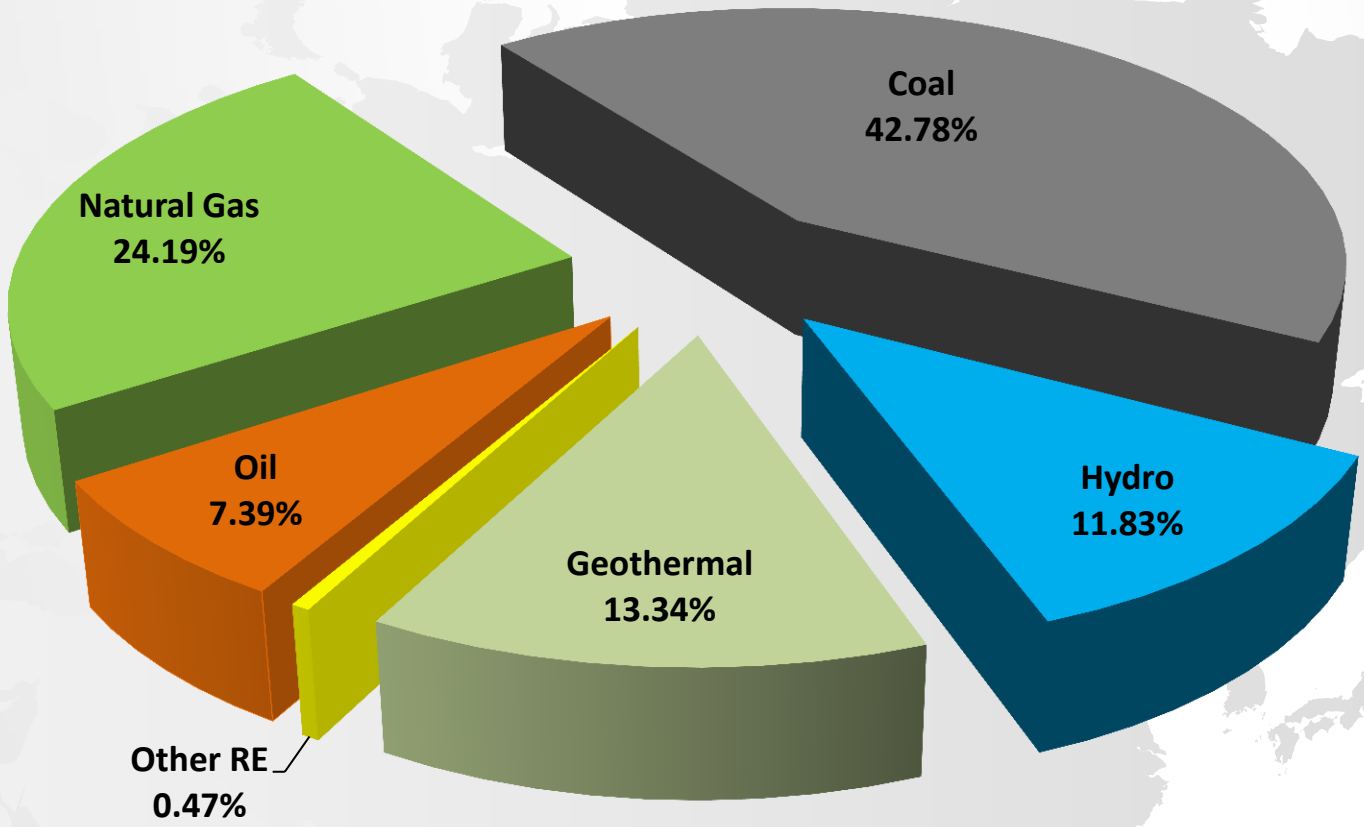
Self Sufficiency: ***56.1%***

Renewable Energy (RE) = ***39.9%***

Share of Green Energy (RE + Natural Gas)

= ***46.3%***

POWER GENERATION MIX - 2014



Total Generation: 77.3 TWh

Self Sufficiency: ***53.5%***

Renewable Energy (RE) = ***25.6%***

Share of Green Energy (RE + Natural Gas)
= ***49.8%***

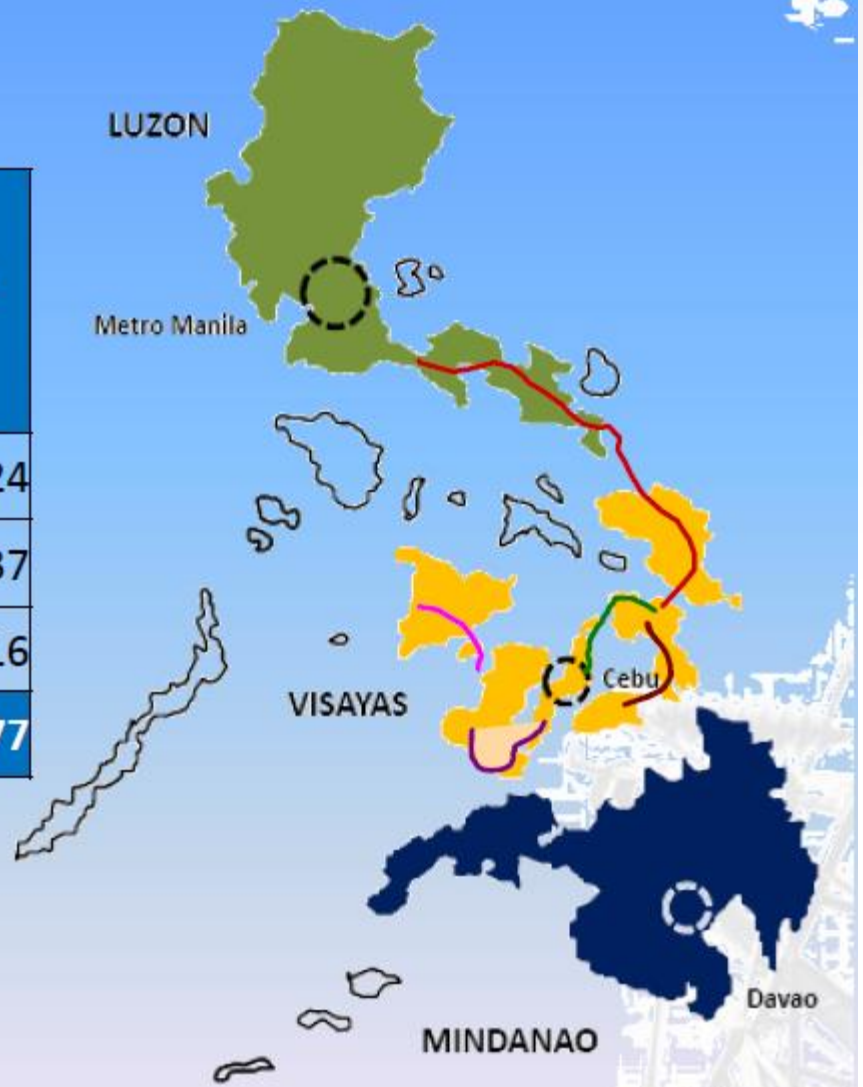
Power Sector Situation

Overview of the Power System

GRID	Installed Capacity	Dependable Capacity
LUZON	11,739	10,824
VISAYAS	2,402	2,037
MINDANAO	2,022	1,616
TOTAL	**16,162**	**14,477**

Interconnection Line Capacity

- Leyte-Luzon (440 MW)
- Leyte-Cebu (400 MW)
- Cebu-Negros (200 MW)
- Negros – Panay (100 MW)
- Leyte-Bohol (100 MW)



Note: Transparent islands in the above diagram are not covered by NGCP's network.

ABOUT 15,000 MW ADDITIONAL CAPACITY IS NEEDED UNTIL 2030

NUCLEAR ENERGY AS AN OPTION

- The Philippine Energy Sector Plans and Programs 2012-2030 does not include nuclear power as energy source

The estimated capacity addition of 9,865 MW is broken down as follows:

Sector	Installed Capacity, (MW) as of 2010	Target Capacity Addition by				Total Capacity Addition (MW) 2011-2030	Total Installed Capacity by 2030
		2015	2020	2025	2030		
Geothermal	1,966.0	220.0	1,100.0	95.0	80.0	1,495.0	3,461.0
Hydro	3,400.0	341.3	3,161.0	1,891.8	0.0	5,394.1	8,724.1
Biomass	39.0	276.7	0.0	0.0	0.0	276.7	315.7
Wind	33.0	1,048.0	855.0	442.0	0.0	2,345.0	2,378.0
Solar	1.0	269.0	5.0	5.0	5.0	284.0	285.0
Ocean	0.0	0.0	35.5	35.0	0.0	70.5	70.5
TOTAL	5,438.0	2,155.0	5,156.5	2,468.8	85.0	9,865.3	15,304.3

NO NATIONAL DECISION YET

NUCLEAR ENERGY AS AN OPTION

- The mothballed Bataan Nuclear Power Plant 1 opened to the public in 2008 for information, education and communication program on nuclear power

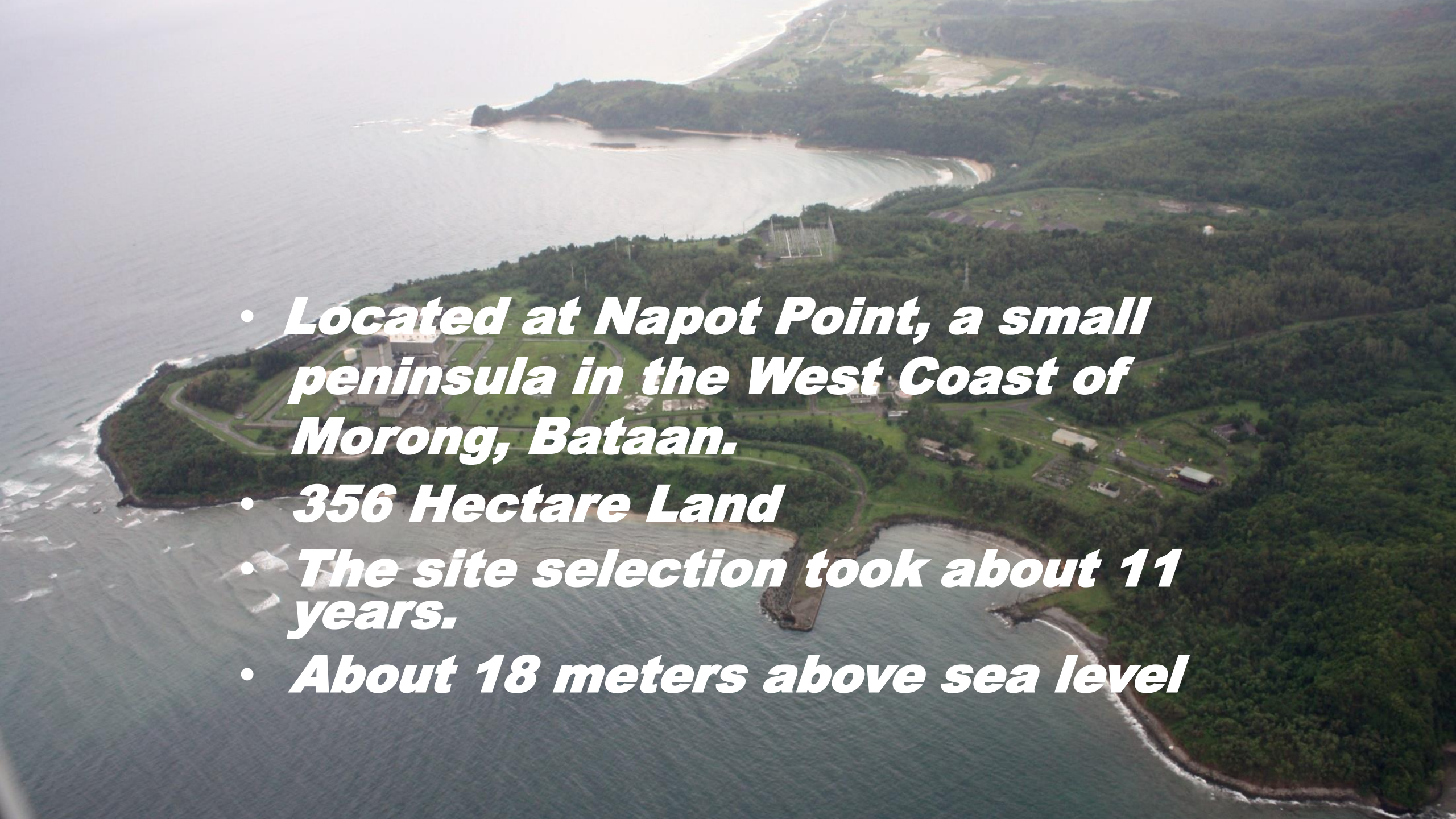
- In 2013, IAEA –TC Project PHI2009: Assessment of long term energy/electricity scenarios to support the government come out with a national decision

- House Bill 147 for the creation of an independent regulatory body is filed in "An Act Providing for a Comprehensive Nuclear Regulation Creating the Philippine Nuclear Regulatory Commission Appropriating Funds Therefor", known as the "Comprehensive Nuclear Regulation Act of 2015

- Existing cooperation between the Philippines (PNRI) and EU (2013-2016) To enhance and strengthen certain aspects of the regulatory regime for nuclear safety in the Philippines

The Bataan Nuclear Power Plant

. . .

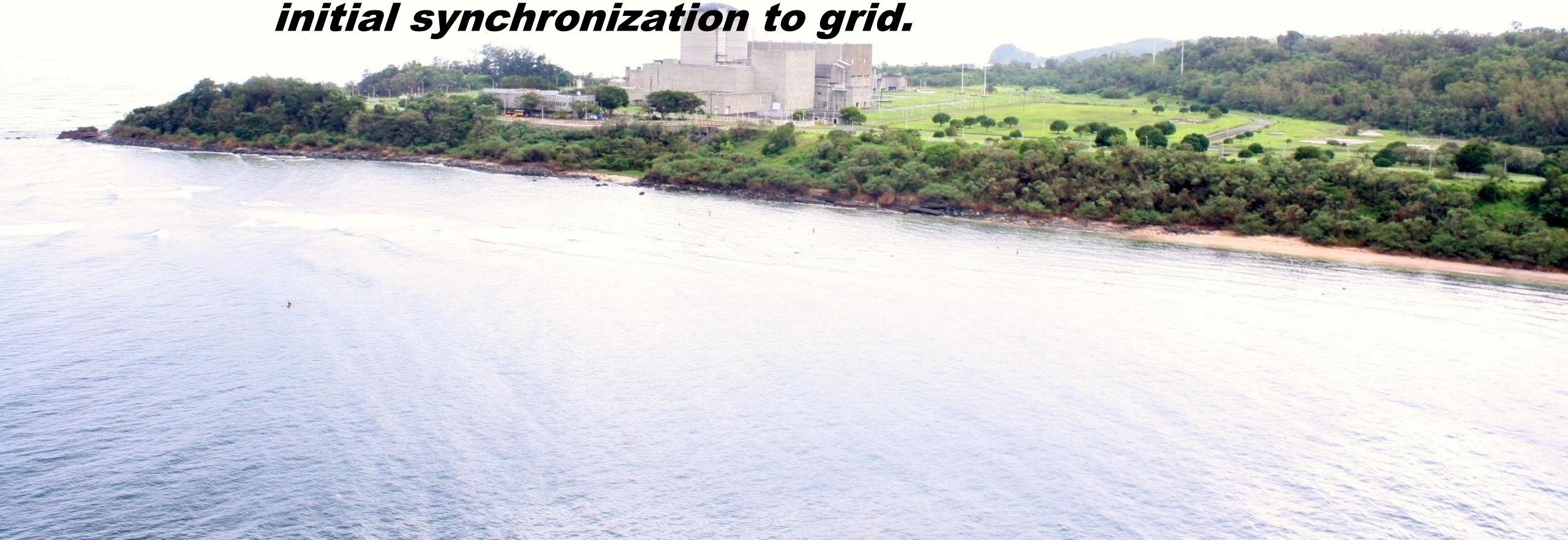


- Located at Napot Point, a small peninsula in the West Coast of Morong, Bataan.
- 356 Hectare Land
- The site selection took about 11 years.
- About 18 meters above sea level

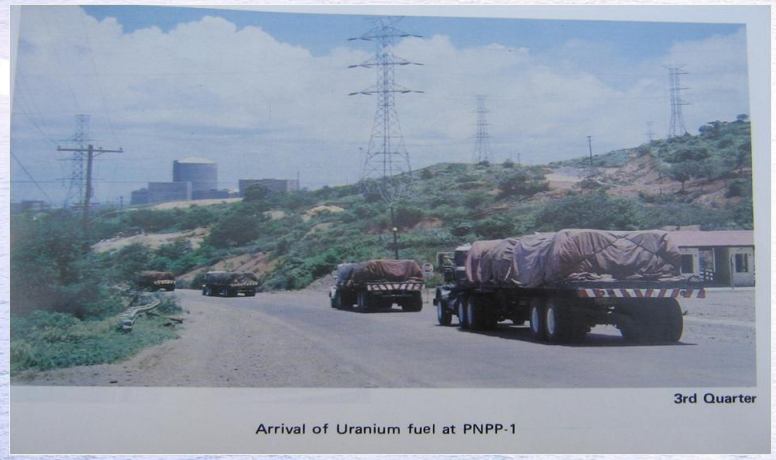
SIGNIFICANT PROJECT EVENTS (1976 to present)

- February 1976... *Contract signed*
- April 1977... *Completed site grading and excavation*
- July 1977... *IAEA safety mission (PSAR review)*
- May 1978... *IAEA safety mission (geological review)*
- March 1979... *Three Mile Island Accident*
- 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***
- **May 1984…** ***Hot functional tests completed, initial synchronization to grid.***

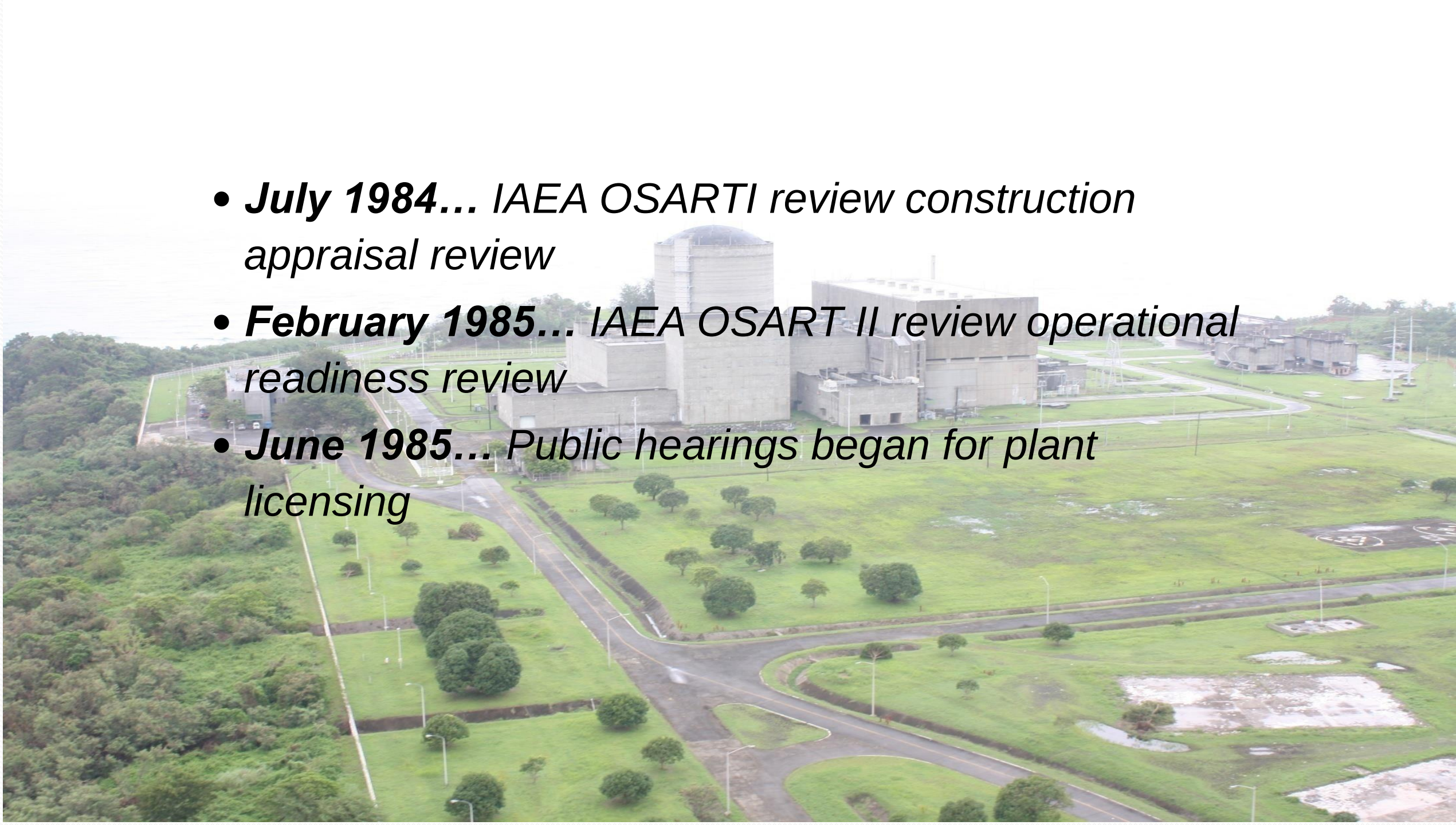


- **June 1984…** ***Fuel delivered***

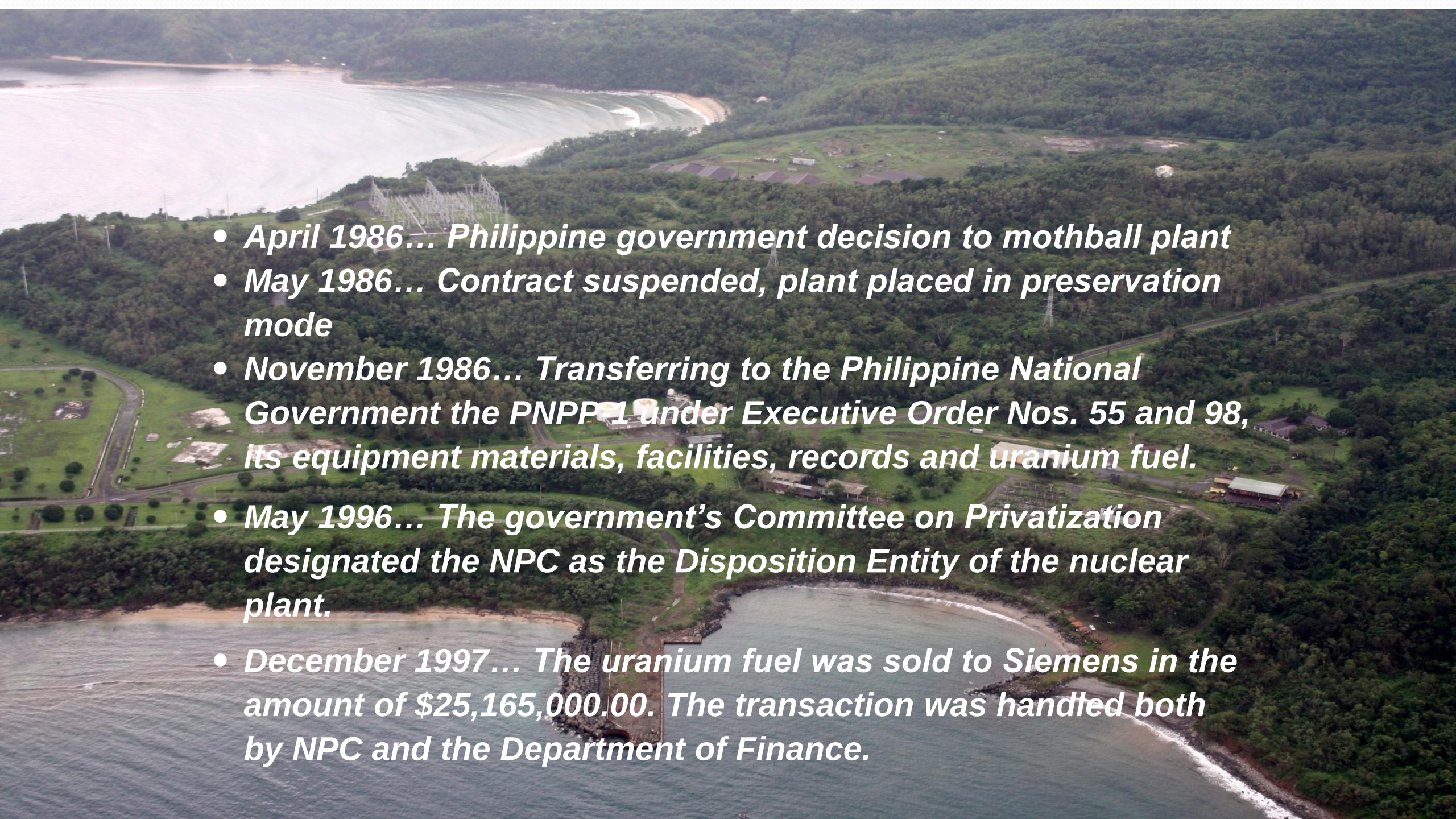


3rd Quarter

Arrival of Uranium fuel at PNPP-1



- ***July 1984…*** *IAEA OSARTI review construction appraisal review*
- ***February 1985…*** *IAEA OSART II review operational readiness review*
- ***June 1985…*** *Public hearings began for plant licensing*



- *April 1986… Philippine government decision to mothball plant*
- *May 1986… Contract suspended, plant placed in preservation mode*
- *November 1986… Transferring to the Philippine National Government the PNPP-1 under Executive Order Nos. 55 and 98, its equipment materials, facilities, records and uranium fuel.*
- *May 1996… The government's Committee on Privatization designated the NPC as the Disposition Entity of the nuclear plant.*
- *December 1997… The uranium fuel was sold to Siemens in the amount of $25,165,000.00. The transaction was handled both by NPC and the Department of Finance.*

Way Forward

- Draft of National Nuclear Policy
- Address various infrastructure milestones and issues
- Decide on the Bataan Nuclear Power Plant
- Conduct of nuclear information and education to stakeholders
- Continue Human Resource development on the nuclear field

CURRENT DEVELOPMENTS

- DOE recently created the Nuclear Energy Program Implementing Organization (NEPIO)

- On BNPP, decision will rest upon the national policy to be drafted by the NEPIO, however a detailed pre-feasibility study is on the pipeline.
- *"While nuclear power may not be an option under the Duterte administration, it is still a viable power source for the country's baseload requirements moving forward" , Energy Secretary Alfonso Cusi*

PHILIPPINE NUCLEAR RESEARCH INSTITUTE

MANDATE

Established in 1958 by RA 2067

- Conduct research and development on the application of radiation and nuclear materials, processes and techniques in agriculture, food, health, nutrition and medicine and in industrial or commercial applications;
- Undertake the transfer of research results to end-users, including technical extension and training services;
- Operate and maintain nuclear research reactors and other radiation facilities; and
- License and regulate activities related to production, transfer, and utilization of nuclear and radioactive substances

CURRENT INITIATIVE

- House Bill No. 3696 of Congress entitled, "Comprehensive Nuclear Regulation Act", proposes to create a separate and independent nuclear regulatory authority and address the gaps in the present laws, e.g., radioactive waste, emergency planning, nuclear security and physical protection, etc.

THE PHILIPPINE RESEARCH REACTOR (PRR-1)

The Philippine Research Reactor (PRR-1)

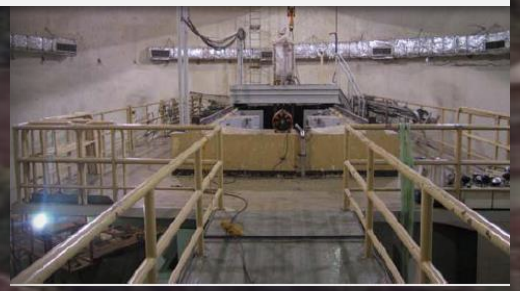
- Open pool type
- 1 MW Research Reactor
- 1980's:
  - converted to TRIGA
  - power upgraded to 3 MW
- 1988:
- After successful restart and testing up to 3 MW, leak developed at the pool lining
- 1992-1997:
- Repair of pool and rehabilitation of some components

In 2007, the PRR-1 was offered as a demonstration facility under Research Reactor Decommissioning Demonstration Project (R2D2P) of the IAEA

Philippine Research Reactor – 1 (PRR-1)

EXTENDED SHUTDOWN

- 1964-1977 - The reactor was then operated regularly, usually at 1 MW for a few hours a day, total burn-up as of that date of 570 MWd
- Used by the Physics and Nuclear Engineering Departments (PNRI), other universities
- Activation analysis and for studies on the techniques of radioisotope production, plastic and glass gamma dosimetry
- TRIGA Conversion & upgrade to 3 MW (1984-1987)
- Unplanned shutdown on 18 April 1988 due to pool liner leak
- Slightly irradiated fuel elements currently stored in a water tank



ALL PROJECTS OVERVIEW

Upgrading the PNRI Neutron Laboratory for Neutron Physics & Dosimetry Research (DOST-GIA)

Build physical laboratory for training & education in neutron & reactor physics

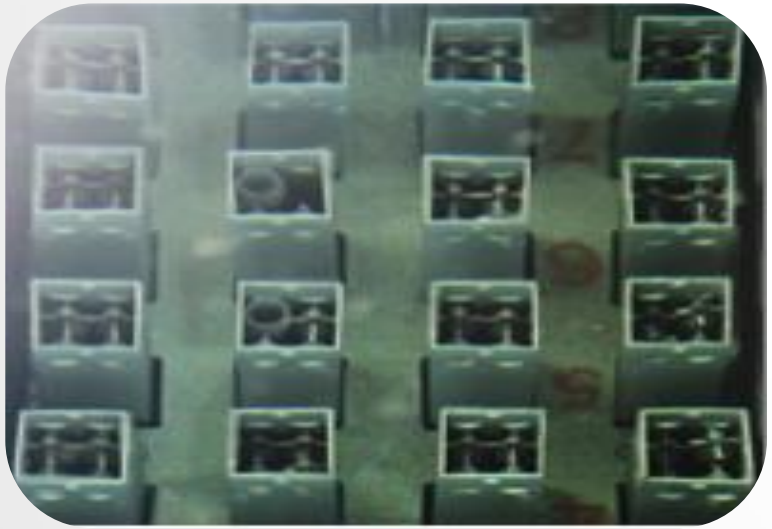
Building Capacity in Nuclear Science & Technology by Re-using the PRR1 into a TRIGA Fuel Subcritical Assembly (IAEA-TC PHI2014001)

Capacity building for nuclear (reactor) engineering of regulators, operators and radiation protection staff

Conduct of F/S for the Establishment of an Accelerator and Research Reactor Facility

Determine potential & viability of ACC and RR facilities in advancing nuclear S&T

NEWCOMER COUNTRY..



SUBCRITICAL FACILITY

MULTI-PURPOSE RR

DESCRIPTION

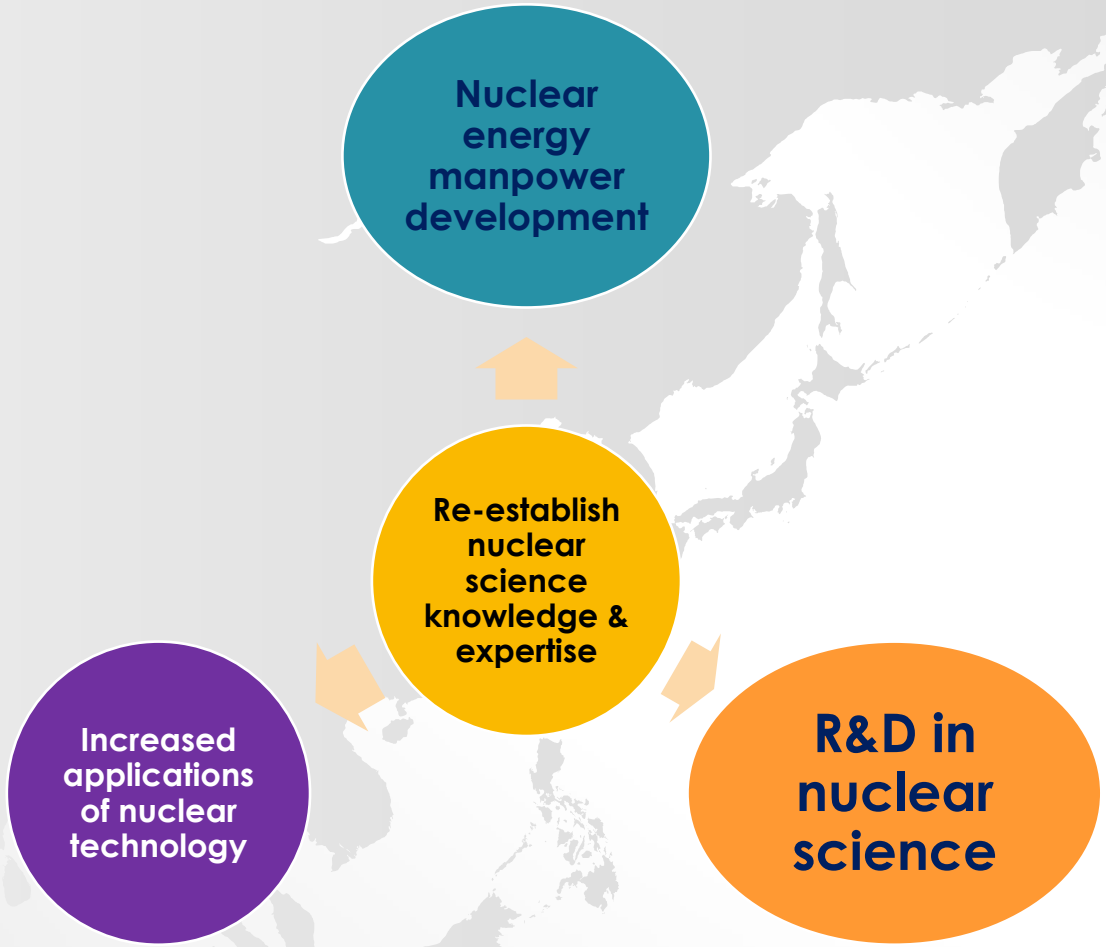
Description	Subcritical Facility (SA)	Multi-purpose RR (MPRR)
Reactor Name	SATER (zero power)	NARRA (10 MW)
Status	Planned (capacity building ongoing)	Planned (Pre-project Assessment Report PPAR completed)
Operation Schedule	--	250 days/yr
Operational facilities	Primarily for Reactor & neutron physics training & education	• Neutron flux up to ~ 3.0 × 10^{14}, • Irradiation facilities for production of Mo-99, I-131, I-125, Ir-192 • 4 beam ports

Overall Objective of Project

Building Capacity in Nuclear Science & Technology by Re-using the PRR1 into a TRIGA Fuel Subcritical Assembly

RE-ESTABLISH NUCLEAR SCIENCE KNOWLEDGE & EXPERTISE IN THE PHILIPPINES INCREASED APPLICATIONS OF NUCLEAR TECHNOLOGY IN HEALTHCARE, INDUSTRY AND AGRICULTURE, R&D IN NUCLEAR SCIENCE AND ITS ALLIED FIELDS AND FOR NUCLEAR ENERGY MANPOWER DEVELOPMENT

Reviving competencies in research reactor technology utilization by Re-using the PRR1 into a TRIGA Fuel Subcritical Assembly



OBJECTIVES OF THE FS PROJECT

- Determine the potential of an RR in advancing the country's capacity in nuclear science and technology
- Cover the technical, socio-economic, financial, and regulatory aspects of establishing an RR facility
- Examine the financial and economic viability of the RR project
- Provide firm, detailed information that will become the basis for DOST-PNRI to authorize subsequent implementation of a viable project (knowledgeable commitment)

MAIN OUTPUT

- The Final FS Report/Pre-Project Assessment Report (PPAR) is the main output of the FS, and will be used to inform national decision makers, project sponsors, users and other stakeholders.
- Include a utilization study
- Provide the conceptual facility functional design, including RR type and power, ancillary facilities, rough project costs and schedule estimates.

GENERAL APPROACH

Preliminary Assessment

- Identify potential stakeholders and quantify their needs
- Evaluate public perception and corresponding challenges and opportunities
- Determine the rationale for establishment of an RR

Techno-economic Evaluation

- Develop the facility specification
- Site selection
- Identify personnel requirements
- Analyze economic and financial viability

Policy and Organizational Framework Evaluation

- Identify and evaluate existing policy and organizational issues

Final Feasibility Study Report/
Pre-Project Assessment Report

IDENTIFYING STAKEHOLDERS

- PNRI – as the implementing agency of the FS and sole authority on nuclear matters in the Philippines; operating organization
- Licensed users of radioactive materials
- Trainees of the Nuclear Training Center/PNRI
- DOST Regional offices
- Academe
- Scientific organizations/research institutes
- Local government officials

STAKEHOLDERS NEEDS of MPRR

Stakeholder (Applications)	Need	Size of Demand / Potential "market"
PNRI (R&D, NAA, RI Prod, E&T)	• Increase in R&D output and advanced studies in nuclear S&T (e.g. neutron beam science, NAA, tracers)	Chemistry, Biomedical, Applied Physics, Health Physics, Nuclear Materials Research Sections,
	• Provide additional services (analytical, isotope and NDT techniques) to support industries	• Projected output: 20,000 samples/yr (e.g. geochemistry) • >100 operating mines, 5 processing plants • Radiotracers for geothermal energy exploration (Ph is 2nd largest producer)
	• Revive competencies in reactor technologies	• Experienced RR manpower retired
	• Enhance capability of the Nuclear Training Center (NTC)	• 900 training participants (2015)

STAKEHOLDERS NEEDS of MPRR

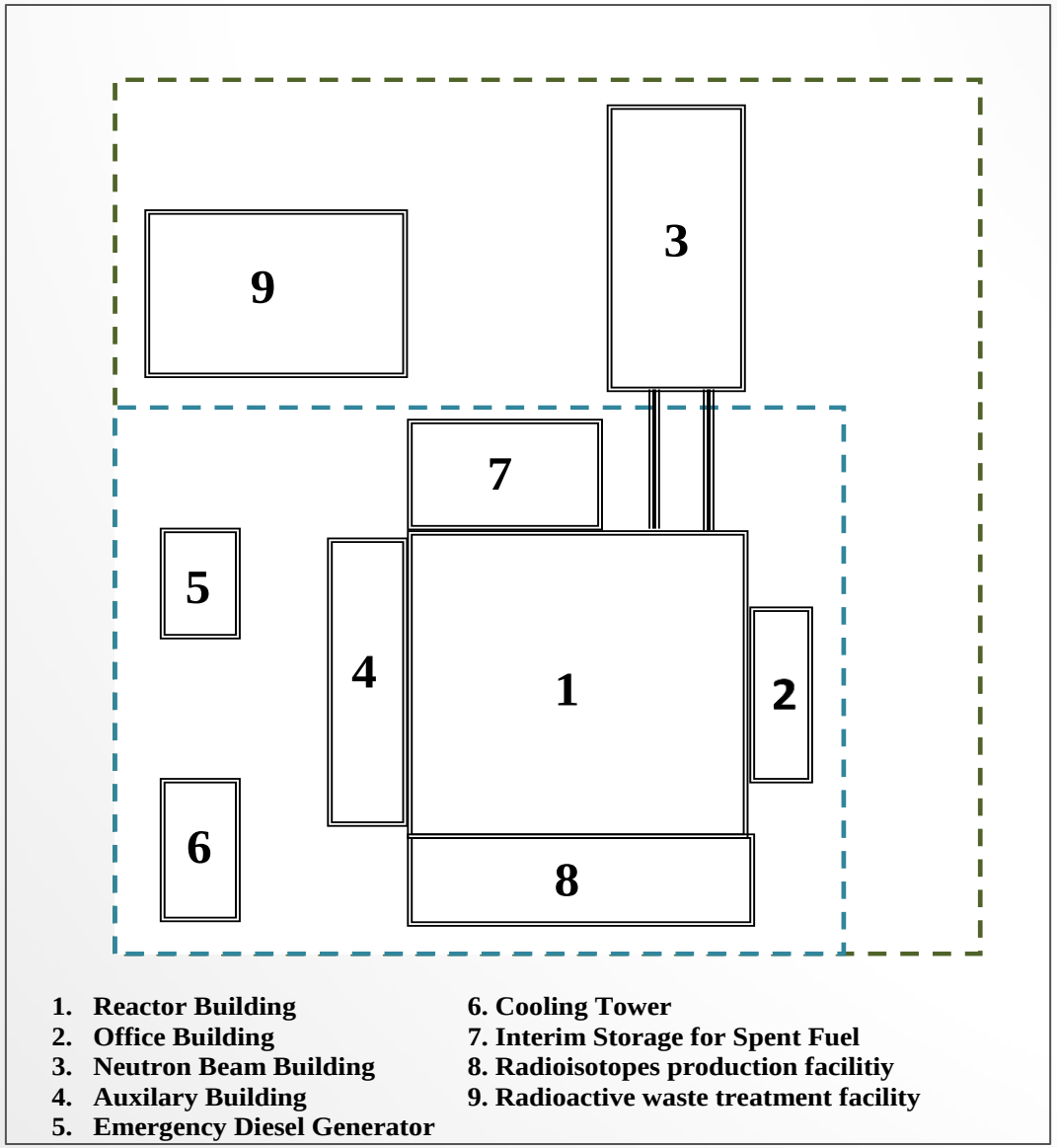
Stakeholder (Applications)	Need	Size of Demand / Potential "market"
Medical Sector (RI Production)	• More affordable and increased availability of medical RIs	• Projected demand for Tc-99m 1,500Ci/yr & I-131 is 850Ci/yr (at 5% annual growth), • Projected demand for Ir-192 is 7000 Ci/yr (at 2% annual growth) • 60 NM Centers, more planned
Academe (Education, R&D)	• Available facility to develop nuclear science & engineering education • More opportunity for interdisciplinary research	• More than 40,000 university students in the sciences and engineering, • 5,000 graduate students in the sciences • Projected output: 10 MS students and 5 Ph.D students per year
Power Sector (E&T)	• Build human capacity & technological readiness for an NPP program	• New government to study feasibility of an NPP in the country

STAKEHOLDERS NEEDS of the SA

Stakeholder (Applications)	Need	Size of Demand / Potential "market"
PNRI (E&T)	• Revive competencies in reactor technologies	• Experienced RR manpower retired
	• Build human capacity for the MPRR	• Personnel has no competence and experience yet in an RR
	• Enhance capability of the Nuclear Training Center (NTC)	• 900 training participants (2015)
Academe (Education, R&D)	• Available facility to develop nuclear science & engineering education • Build capacity for RR utilization	• More than 40,000 university students in the sciences and engineering, • 5,000 graduate students in the sciences
Power Sector (E&T)	• Build human capacity & technological readiness for an NPP program	• New government to study feasibility of an NPP in the country

DRAFT FACILITY CONCEPT DESIGN

Complex consists of 9 buildings; Minimum of 2 hectares is required, without the exclusion zone.



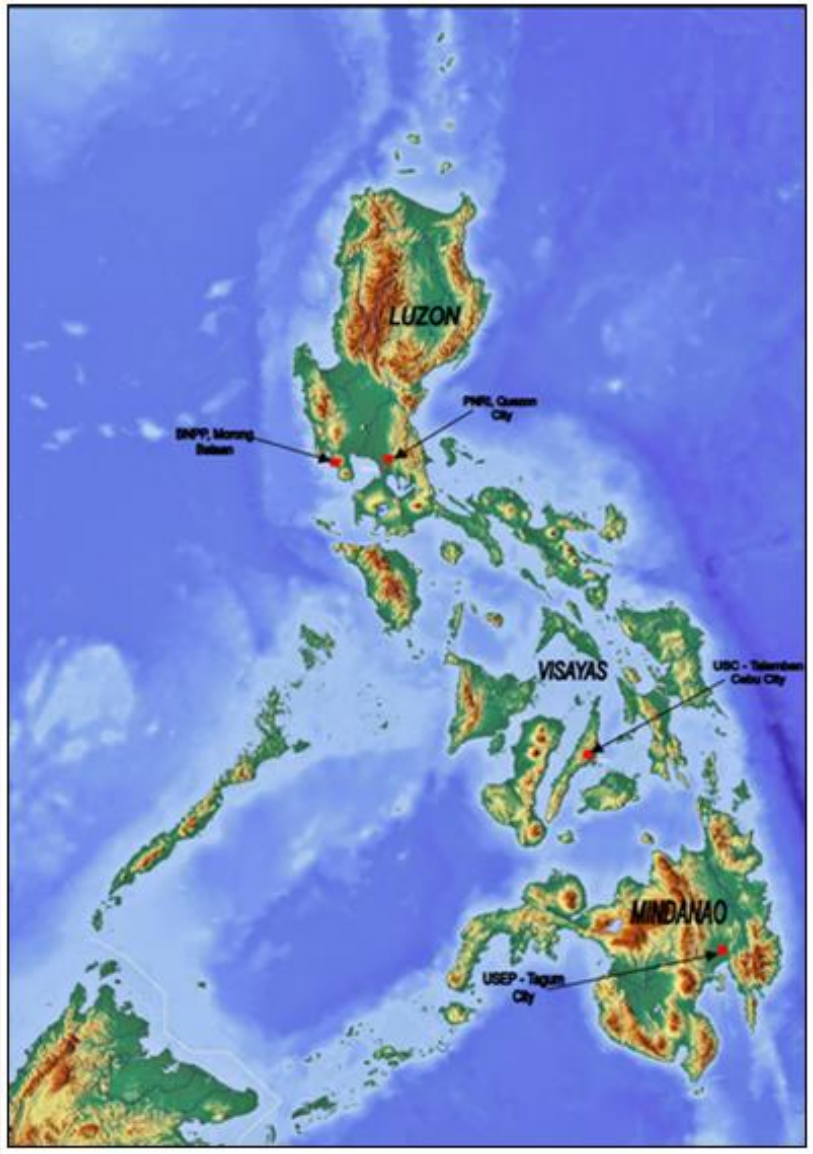
NATIONAL RESEARCH REACTOR FOR VARIOUS APPLICATIONS (NARRA)

- Reactor building: multi-level (20 meters above ground) contains the reactor, all the primary heat removal systems, experimental hall, neutron activation analysis instrumentation facilities including automatic pneumatic system, and post-irradiation storage facilities.
- Personnel access to the reactor building is only possible via the office building. Before entering the reactor, personnel should go through security checks and radiation monitor. Material access (including fresh fuel) into the reactor building is via the material lock in the auxiliary building. The building design should also provide for isolation to the experimental areas from the reactor plant operations area. Shielding inside the reactor building should be constructed by using high density concrete, in order to provide radiation protection to personnel. All walls in the controlled areas are coated with a decontaminable coating.
- Has a gallery or tour route for public tours; route is designed so that the safety of visitors are ensured and radiation protection limits for the public should apply.

PERSPECTIVE

WHERE TO LOCATE?

- Four candidate sites screened based on accessibility to end-users
- PNRI compound
- BNPP
- USC, Cebu
- USEP, Davao



RESULTS OF EVALUATION

1. BNPP site, Bataan
2. PNRI compound (Arboretum), Quezon City
3. University of San Carlos, Cebu City
4. University of Southeastern Philippines, Tagum, Davao

HRD PLANNING

- Training needed for various phases of RR establishment post-FS (preparation of bid specifications (design, preliminary safety analysis etc.), evaluation of bids, construction, commissioning, operations, decommissioning)
- Opportunities for advanced studies (MS and PhD in nuclear science and engineering)
- Training opportunities from IAEA and other country-specific programs (e.g. KAERI, JAEA)
- Research reactor networks and other collaborations

RECOMMENDATIONS

- The operating organization in view of its mandate, is the Philippine Nuclear Research Institute (PNRI)
- A research reactor is a long-term facility that requires assured funds for its operation and maintenance. A mechanism is needed for the revenues generated by the proposed reactor, NARRA, to be returned to PNRI.
- House Bill has been filed which recommends the establishment of an independent, competent regulatory body. This should be enacted as soon as possible, but not later than when the operating organization applies for a construction permit. Further it should also include the addition and funding of 99 plantilla positions to PNRI for the operation and utilization of NARRA.

RECOMMENDATIONS

- For PNRI
- PNRI should develop a preliminary strategic plan for the operation and utilization of NARRA.
- PNRI should prepare and implement a human resources development plan for the different fields of specialization and skills required for NARRA, from design to operations.
- PNRI should prepare a business plan for the export of radioisotopes commonly used in medicine and industry (Mo-99/Tc-99m, I-131, I-125, Ir-192)
- PNRI should continue to assess the 19 infrastructure issues which are important to the successful implementation of a new RR project, monitor if the gaps are being addressed or the countermeasures are effective.
- The site recommended in decreasing order of priority is (a) Bataan nuclear power plant campus; (b) PNRI compound; (c) University of San Carlos, Cebu City and (d) University of Southeastern Philippines, Davao City

- **Based on the results and findings of this feasibility study, it is strongly recommended to proceed with the establishment of a new reactor, the National Research Reactor for various Applications (NARRA), and that the financial, human resource and policy and legislative requirements be supported and enabled to achieve this.**

CURRENT STATUS

- The project's submission to the Investment Coordination Committee (ICC) for review and approval, is scheduled for the 3rd quarter of 2017
- SP for the SA (and MPRR) draft being developed

MIDTERM ACTIONS:

- Fuel inspection by 2Q 2017
- Staff training for SA to be completed by 2017
- Design & authorization to construct the SA by EO 2018
- Need to come up with decision on the remaining TRIGA FEs by 2019

SUMMARY

- The Philippines through PNRI continues to harness the use of nuclear applications with an understanding of the risks involved

- The Philippines' initial attempt to use nuclear energy and operate a nuclear power plant to support its development was not fruitful because of several factors

- There are continued efforts and future projects to promote further nuclear science in the Philippines

PROPOSAL FOR BENCHMARK PROBLEMS AND RESEARCH COLLABORATIONS

1. Difficulty in license acquisition of advanced numerical calculation/ Reactor Physics code such as MCNP and SCALE. (For SA core design, dosimetry - safety, licensing, etc....)
2. Assistance in Core Design (need experts to validate simulation code)
3. Instrumentation - control panel, micro controllers, control system
4. Interested in 19.7% enriched U235 TRIGA fuel. 115 used for 5hrs with 3MW power output. 15 fresh fuels

MARAMING SALAMAT PO!