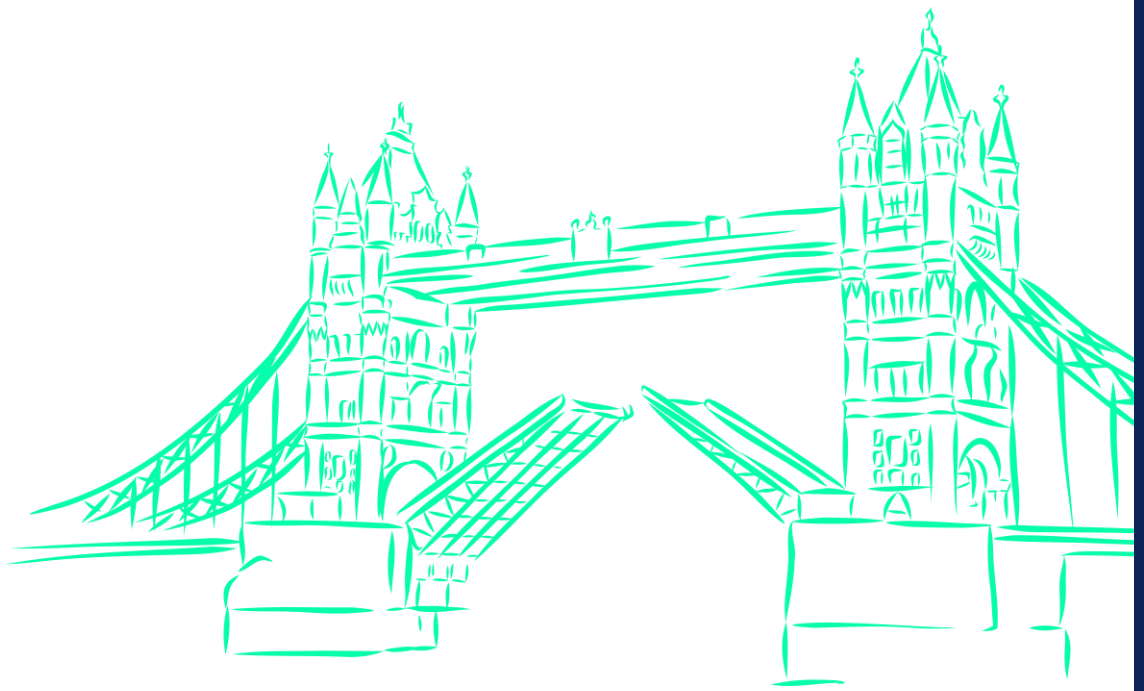
29 November 2022 • 09:00 – 10:30 UK time

ONLINE WEBINAR The prospects of small modular reactors in Southeast Asia

Chaired by Tim Yeo, Chairman, New Nuclear Watch Institute

- Alfred Christopher Gurning, Technical Officer and Expert in Civilian Nuclear Energy and Clean Coal Technology, **ASEAN Centre for Energy (ACE)**
- Victor Nian, Chief Executive Officer, **Centre for Strategic Energy and Resources**
- Dr Carlo Arcilla, Director, Department of Science and Technology, **Philippine Nuclear Research Institute**
- Geni Rina Sunaryo, Principal Researcher, Research Center for Nuclear Reactor Technology, **National Innovation and Research Agency (BRIN)**
- Nikolaj Ager Hamann, Head of Business Development, **Seaborg Technologies**

New Nuclear Watch Institute (NNWI) a London-based internationally focused think-tank



NNWI is an industry supported think-tank, focused on the international development of nuclear energy as a means for governments to safeguard their country's long-term sustainable energy needs.

We strongly believe that nuclear power is without which the binding Paris Climate Agreement objectives cannot be achieved and is therefore an essential part of the global solution to the challenge of climate change.

Introduction to ACE and Potential of Small Modular Reactors (SMRs) Deployment towards a Low-Carbon ASEAN Economy

New Nuclear Watch Institute Webinar
29 November 2022

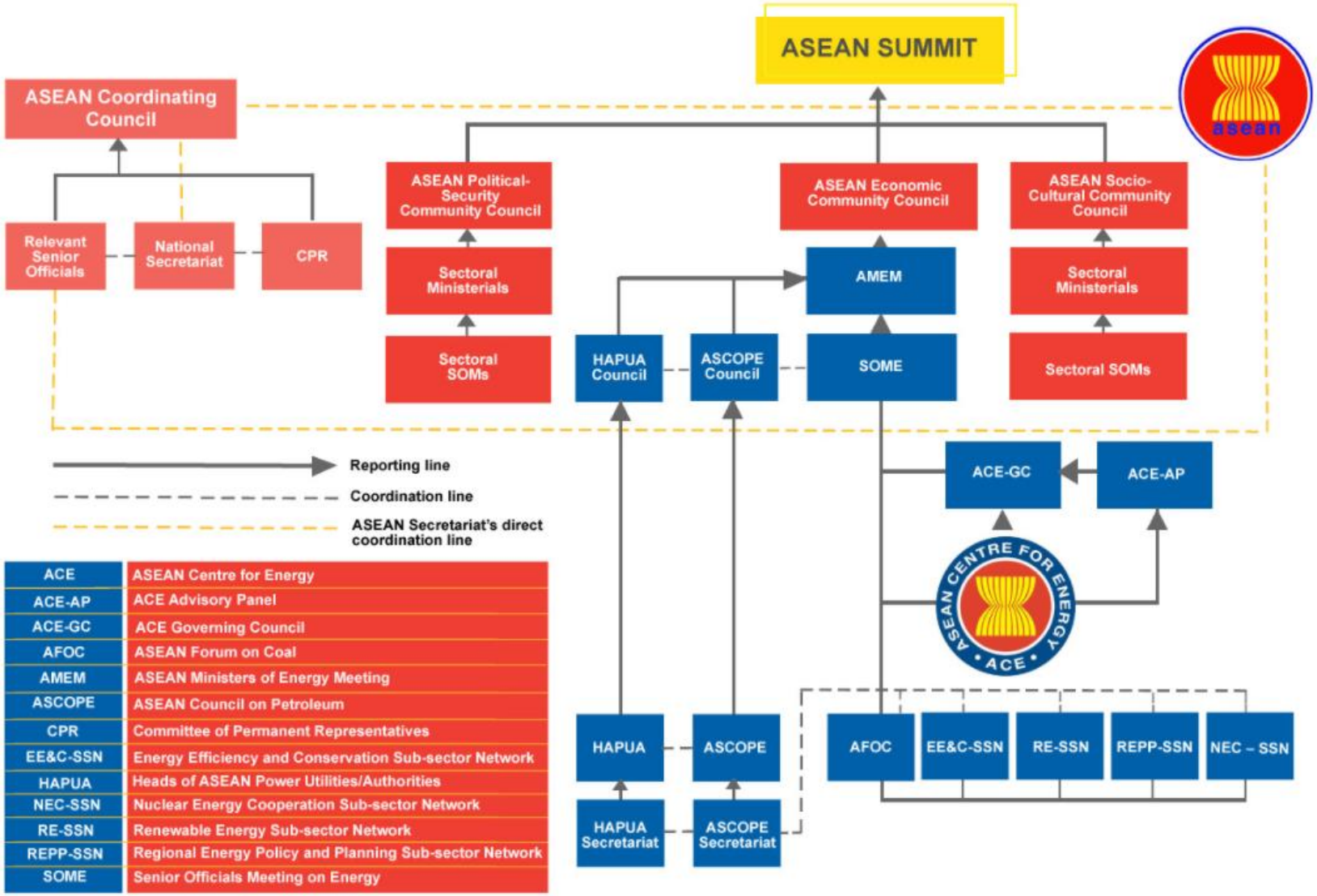
Presented by:
ASEAN Centre for Energy

One Community for Sustainable Energy

Introduction to ACE

One Community
for Sustainable
Energy

ACE in The ASEAN Energy Sector



ACE	ASEAN Centre for Energy
ACE-AP	ACE Advisory Panel
ACE-GC	ACE Governing Council
AFOC	ASEAN Forum on Coal
AMEM	ASEAN Ministers of Energy Meeting
ASCOPE	ASEAN Council on Petroleum
CPR	Committee of Permanent Representatives
EE&C-SSN	Energy Efficiency and Conservation Sub-sector Network
HAPUA	Heads of ASEAN Power Utilities/Authorities
NEC-SSN	Nuclear Energy Cooperation Sub-sector Network
RE-SSN	Renewable Energy Sub-sector Network
REPP-SSN	Regional Energy Policy and Planning Sub-sector Network
SOME	Senior Officials Meeting on Energy

About ASEAN Centre for Energy (ACE)

Think Tank

Identifying and surfacing innovative solutions

Energy Data and Knowledge Hub

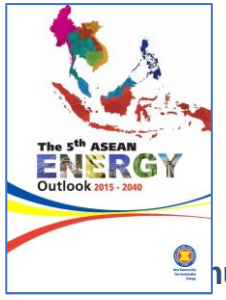
Provide a knowledge depository for AMS

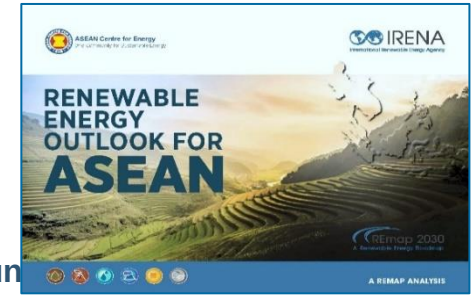
Catalyst

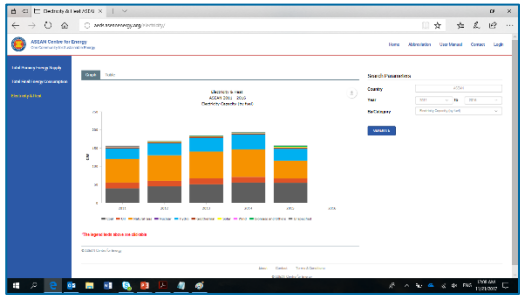
Unify and strengthen ASEAN Energy Cooperation and Integration

- Policies, Legal & Regulatory Frameworks and Technologies
- Policy and Research Analytics
- Energy Database
- APAEC Activities, including with DPs/IOs
- Secretariat

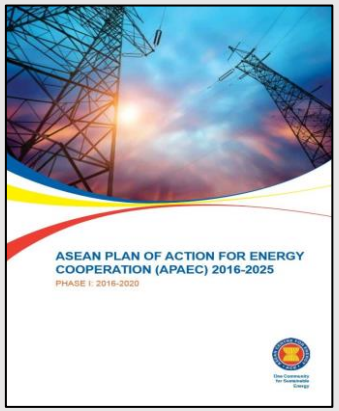
Research, publication, training, capacity building, workshop, policy exchange and recommendations, etc.

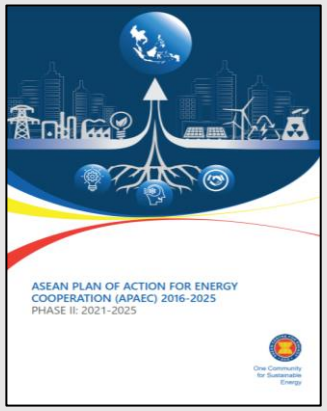






ASEAN Plan of Action for Energy Cooperation (APAEC)





APAEC is **a series of guiding policy documents** to support the implementation of **ASEAN multilateral energy cooperation** to advance regional integration and connectivity goals.

Serves as a blueprint for better energy cooperation under seven (7) programme areas in achieving the goals of the **ASEAN Economic Community (AEC)** pillar of the ASEAN Community.

ASEAN Community Vision 2025: Forging Ahead Together

5-year period

10-year period

APAEC 1999-2004 — **16th AMEM in 1998**

APAEC 2004-2009 — **21st AMEM in 2003**

APAEC 2010-2015 — **27th AMEM in 2009**

APAEC 2016-2025 Phase 1: 2016-2020 — **33rd AMEM in 2015**

APAEC 2016-2025 Phase 2: 2021-2025 — **38th AMEM in 2020**

Upcoming APAEC 2026-2035 Phase 1 and 2

THE ASEAN PLAN OF ACTION FOR ENERGY COOPERATION PHASE II: 2021-2025

APAEC 2016-2025 Theme

Enhancing Energy Connectivity and Market Integration in ASEAN to Achieve Energy Security, Accessibility, Affordability and Sustainability for All

APAEC Phase II Sub-theme

Accelerating Energy Transition and Strengthening Energy Resilience Through Greater Innovation and Cooperation

Reflects the development of global and regional perspectives that shape the energy landscape of ASEAN during the Phase II implementation of APAEC 2016-2025

Global Energy Trends

- SUSTAINABLE DEVELOPMENT GOALS
- 4th Industrial Revolution
- Energy Transition
- Economic Growth
- COVID-19 Pandemic

Key Strategies for APAEC Phase II: 2021 - 2025

1. ASEAN Power Grid

To **expand regional multilateral electricity trading**, **strengthen grid resilience and modernisation**, and **promote clean and renewable energy integration**.

2. Trans-ASEAN Gas Pipeline

To pursue the development of a **common gas market** for ASEAN by enhancing gas and LNG connectivity and accessibility.

3. Clean Coal Technology

To optimise the **role of CCT in facilitating the transition** towards sustainable and lower emission development.

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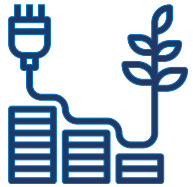
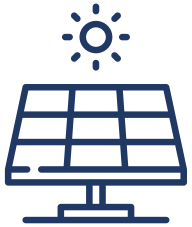


4. Energy Efficiency and Conservation

To **reduce energy intensity** by 32% by 2025 and encourage EE&C efforts, especially in transport and industry



5. Renewable Energy

To **increase the share of RE** to 23% in TPES and 35% in installed power capacity by 2025

6. Regional Energy Policy and Planning

To advance energy policy and planning to **accelerate the region's energy transition** and **resilience**

7. Civilian Nuclear Energy

To build **human resource** capabilities on **nuclear science and technology for power generation**.

Programme Area No 7: Civilian Nuclear Energy
4 Outcome-based Strategies and 13 Action Plans

OBS1
Improve nuclear energy literacy and public engagement

1. Information Education Communication (IEC) Campaigns
2. Raise awareness on nuclear energy as an alternative energy option
3. Regional public communication strategy and plan
4. Portal of nuclear communities and database

OBS2
Strengthen Regional and International Cooperation on Nuclear Energy for Power Generation

5. Study on the potential of regional nuclear energy facilitation and coordination mechanism
6. Multi-year collaboration with DPs/IOs

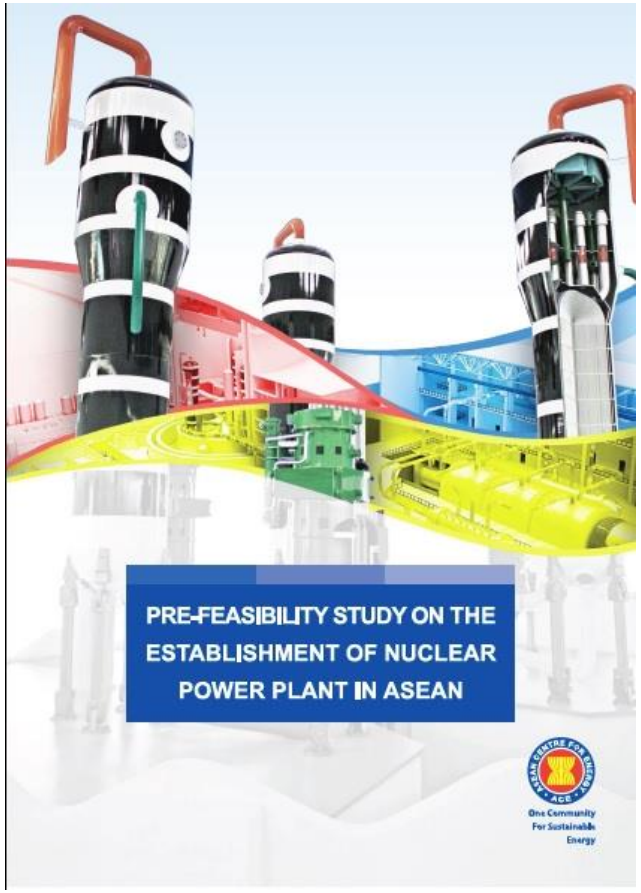
OBS3
Build Human Capabilities on Nuclear Legal and Regulatory Frameworks for Power Generation

7. Activity on nuclear legal and regulatory framework for policy makers and regulatory bodies
8. Study-visits to the established international nuclear regulatory bodies
9. Technical assistance/technical study on nuclear legal and regulatory framework

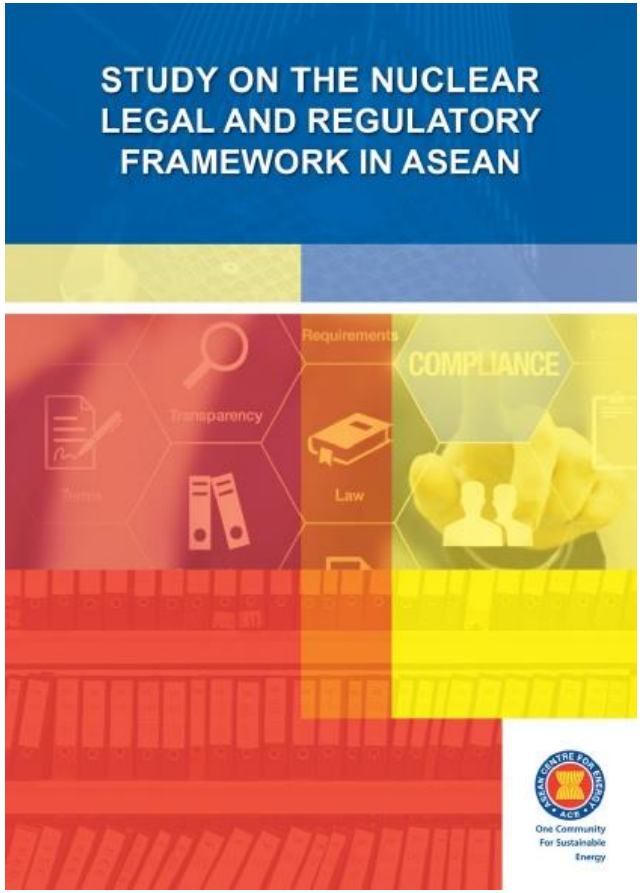
OBS4
Enhance Human Resource Capabilities on Nuclear Science and Technology for Power Generation

10. Research and development, education, and training
11. Capacity building utilising the facilities of established nuclear institutions
12. Secondment/educational opportunity on nuclear energy technology for power generation
13. Practical training activities

ACE Initiatives on Civilian Nuclear Energy



The study provides information on the **current status and milestones** of nuclear energy programmes in the ASEAN Member States (AMS).



The study analyses **nuclear regulation status** in five selected Member States; Indonesia, Malaysia, the Philippines, Thailand, Vietnam.

The factsheet provide information on **energy security, climate change and environment, nuclear safety, radiation**, and **nuclear waste.**

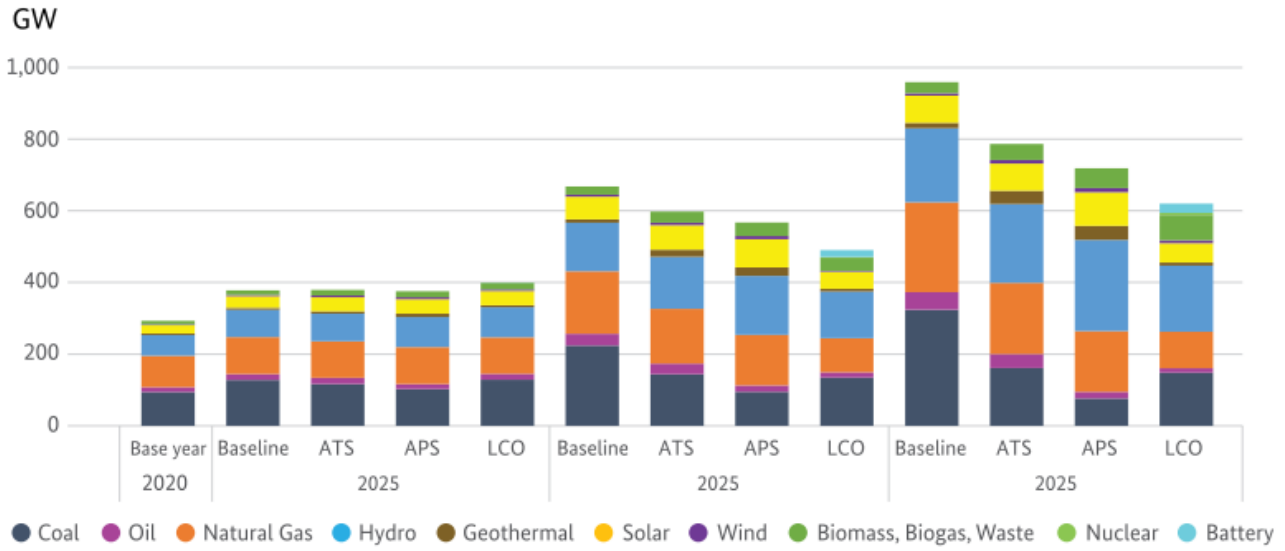
Potential of Small Modular Reactors (SMRs) Deployment towards a Low-Carbon ASEAN Economy

One Community for Sustainable Energy

Findings of 7th ASEAN Energy Outlook (AEO7)

- Nuclear energy is still considered **one of the options** to ensure energy transition in the region while ensuring energy transition towards a low-carbon economy.
- AEO7 presented the potential deployment of nuclear power in the region under the **Least-cost optimization (LCO)** scenario.
- The preference for nuclear was observed based on the high energy content of the nuclear fuel, offering **lower costs for the electricity generated**.
- In the LCO scenario, ASEAN will have its **first operational nuclear power plant in 2034, in which nuclear deployment can reach up to 5.2 GW in 2050** with the Philippines and Singapore as potential AMS adopters.

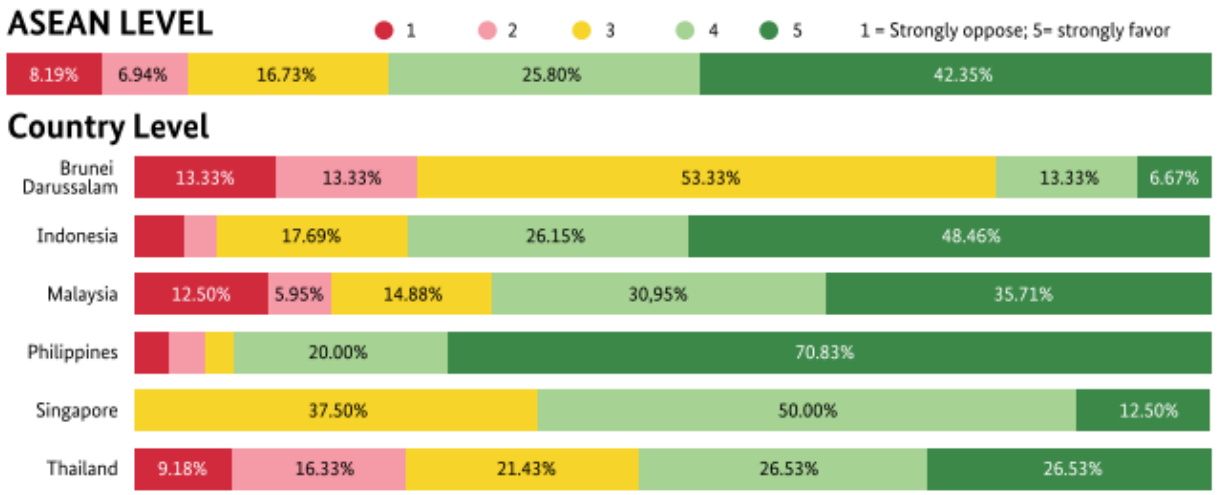
Figure 3.23 ASEAN Installed Power Capacity by Fuel Across Scenarios



ASEAN Public Perception and Acceptance

- Most respondents from member countries **positively perceive using nuclear energy** for power generation in the country, wherein 42% strongly favours NPP deployment.
- Main reasons to support the NPP are that it guarantees the **security of the energy supply** (36%) and contributes to **preventing climate change** (32%).
- Some respondents reject NPP deployment in their country due to the **possibility of a serious accident** (48%) and the uncertainty of the **radioactive waste disposal method** (29%).

Figure 4.16 Civilian Nuclear Energy Public Survey in ASEAN



Challenges and Barriers to SMRs Implementation in the Region

Safety and Waste Disposal

- As the ASEAN region consists of one of the richest and most diverse biospheres in the world, the **selection of a potential disposal site** can remain a large issue.
- Safe nuclear disposal sites could take on the form of old and used mining **repositories that are capable of refurbishment and repurposing**.
- Waste could be injected deep beneath the earth's surface at **uninhabited, small ASEAN islands**, such that radiation contamination with the surrounding environment could be limited as much as possible.

Financing

- Challenges faced in the **financial aspect of the implementation of SMRs can vary**, depending on its design, site location, operating principle, and technological infrastructure.
- Funding for the construction of SMRs can come from **several structures**, such as public (government), private (corporate), or vendor structures, and the funding structure will determine the ownership of the SMR plant.
- The currently ongoing **ASEAN Taxonomy for Sustainable Finance** may also consider and assess nuclear energy, and particularly SMR, as the potential sustainable energy source in the region

Legal and Regulatory Framework

- Improving and/or establishing **a regulatory framework and infrastructure suitable for the regulation of SMRs** will be crucial for ASEAN.
- In the case of SMR, there will be new aspects to be considered from the perspective of the legal and regulatory framework, especially those related to **offsite activities.**
- **Pre-licensing** will allow early engagement and agreement of scope/submissions throughout the process.
- SMR designers and vendors should be encouraged to **contact and communicate safety design and safety regulatory issues with the regulatory body** before the license application.

Conclusions and Way Forward

- SMR technology may play an essential role in the global **decarbonization effort**, and even more so in the ASEAN region that aims to advance its **energy transition efforts** within the upcoming decade.
- SMRs may **complement renewable energy infrastructure** networks in ASEAN such as solar plants and hydropower facilities or even **revamping coal fired power plants** into a nuclear plant.
- **Ensuring secure containment when storing and disposing of nuclear fuel** is a persisting challenge when new nuclear power plants are proposed to be constructed.
- Further study should be done on the **potential of using SMR as industrial heat and microreactors for electric charging station** to explore its use to decarbonize industrial and transportation sectors.
- Proper **funding schemes** are scarce, and even more so for a **standard guideline on legislative issues**.
- ASEAN Energy agencies could work together with investors representing private energy development and utility companies to construct a bipartisan **cooperative financing scheme**, such that benefits can be enjoyed by both mutual parties.
- Strengthening regional cooperation, by **leveraging ASEAN cooperation** will be very crucial in advancing AMS capability on SMR legal and regulatory framework.

ASEAN Centre for Energy
One Community for Sustainable Energy

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Thank You

Centre for Strategic
Energy and Resources

Net-Zero ASEAN Needs Nuclear Energy

Dr Victor Nian
Co-founder and Chief Executive Officer

29 November 2022

Overview

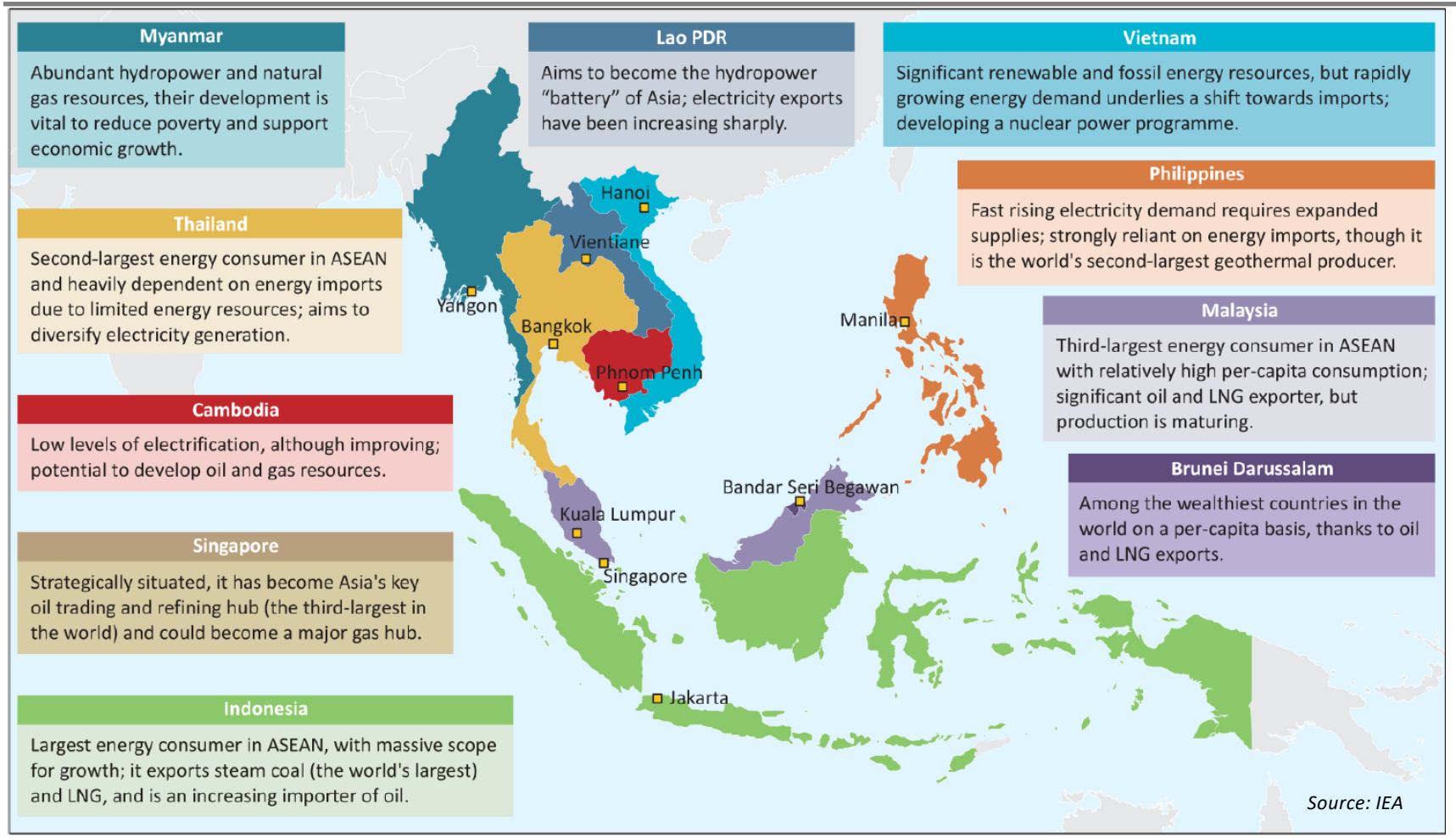
The Centre for Strategic Energy and Resources (CSER) is an independent think-and-do tank with a global headquarters in Singapore.

What we do:
We build enabling ecosystems to accelerate energy transition and platforms for communicating strategic issues in energy and sustainability in Asia.

What we believe:
“Knowledge and innovation without borders.”

What we value:
- Network of experts from 50+ countries and organisations.
- Independent, evidence-based, and unbiased views.
- Innovative practical and nationally appropriate solutions.

ASEAN energy landscape



The “technical potential” for renewables and the reality

IEA’s Projections

Hydropower - 150 GW

Bioenergy - 90 GW

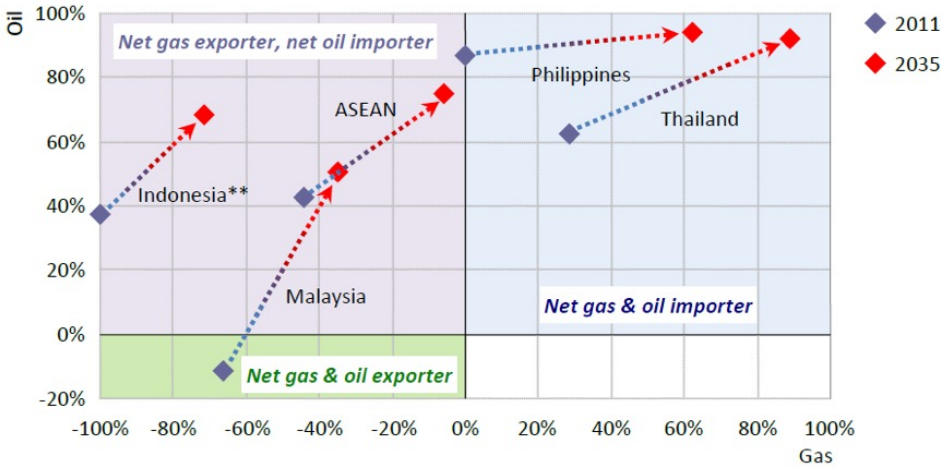
Wind - tens of gigawatts in Vietnam and the Philippines

PV and CSP - minimum grid connection

The Reality

- Difficulty in establishing interconnection
- Limited access to affordable and advanced technologies
- Intermittency and unpredictable climatic conditions
- Geographical dependency – hydropower and geothermal
- No viable option to diversify the base-load supply

The “Net Energy Importer” Prediction

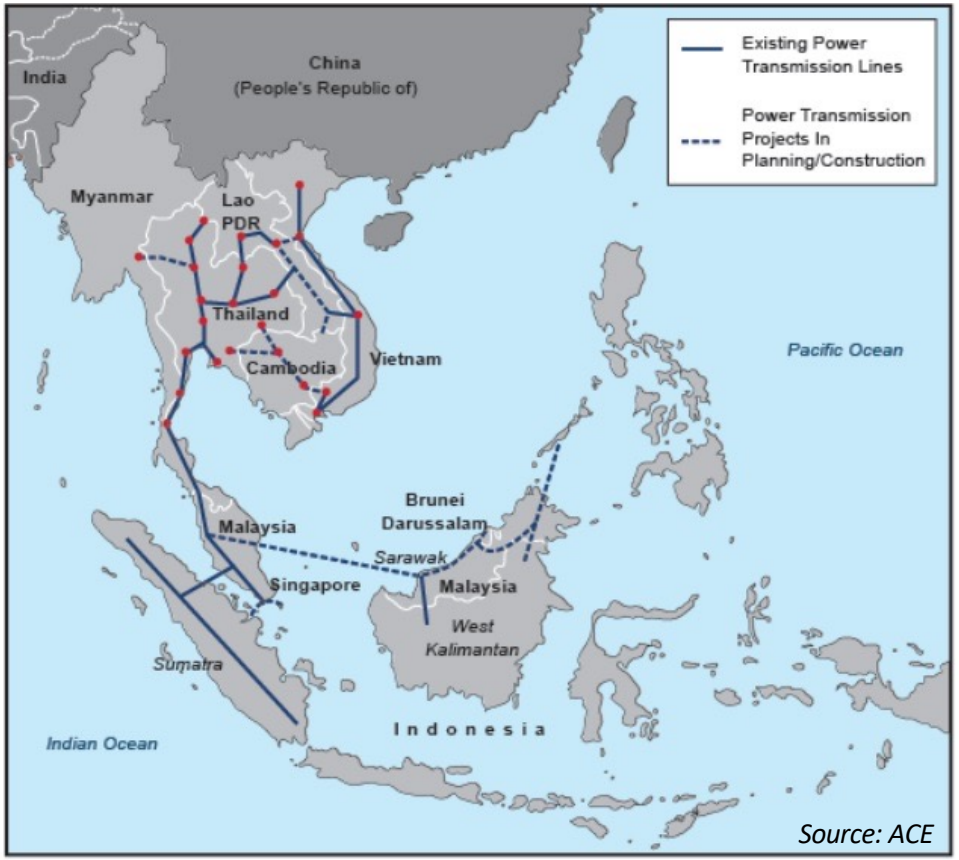


IEA’s Projection

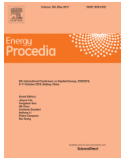
ADB’s Projection

ASEAN Power Grid (APG) Initiative

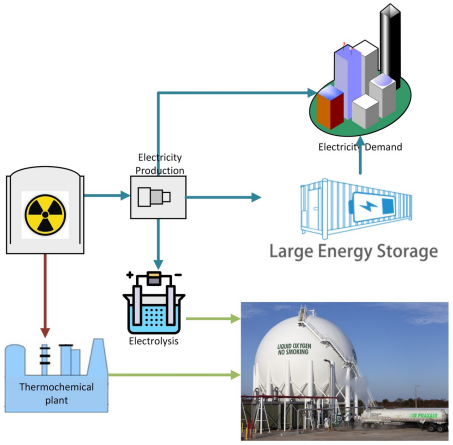
- LTMS-PIP: enable access to carbon-free electricity from Laos
- Opportunities:
  - Matching green electricity supply with energy hungry megacities and industrial clusters
  - Moving towards a regional integrated market framework for electricity trade
- Challenges:
  - An equitable and justified regional energy market framework
  - Geopolitical and other external factors impacting the security, reliability and affordability of APG

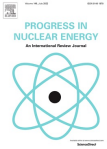


Economics of nuclear energy

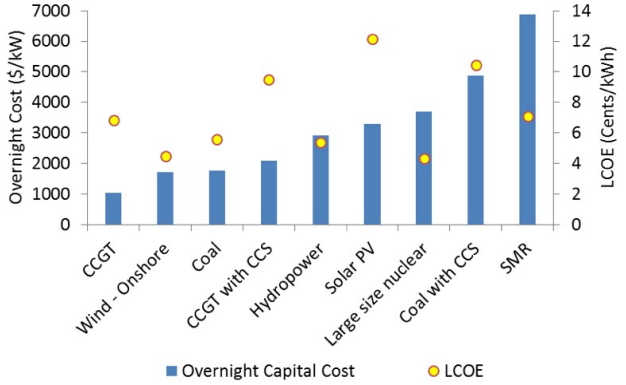


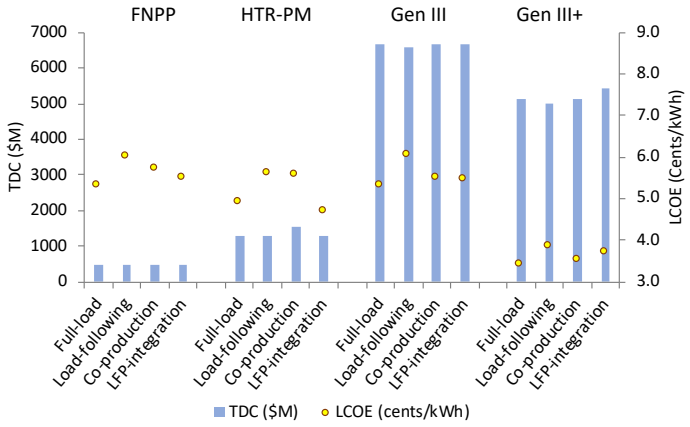
Nian & Hari 2017, Incentivizing the Adoption of Nuclear and Renewable Energy in Southeast Asia, International Conference on Applied Energy 2016.





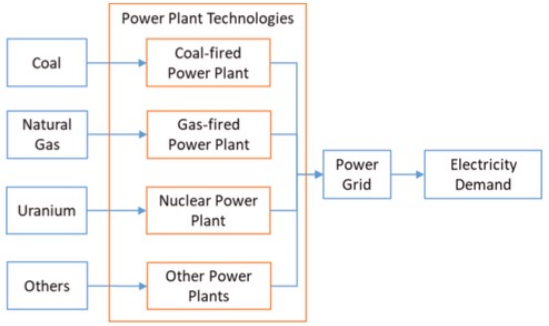
Nian & Zhong (2020). Economic feasibility of flexible energy productions by small modular reactors from the perspective of integrated planning. Progress in Nuclear Energy. Vol 118. 103106.

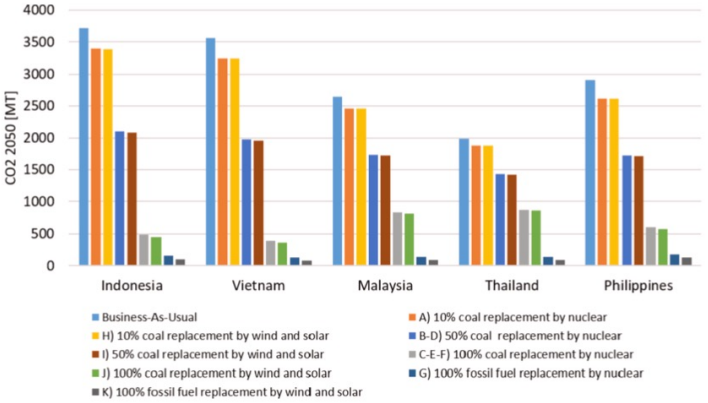


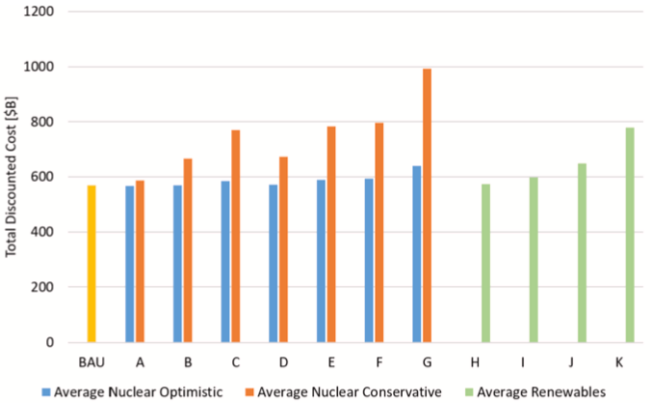


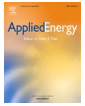
Studies of nuclear energy for a net-zero ASEAN

- Scenario analysis using CSER in-house LCA-TEA modelling tool for a whole-system level modelling analysis.
- Case Studies on comparing the cost to achieve carbon neutrality with nuclear or renewables in five selected ASEAN countries
- Conclusion: nuclear is a cost-competitive carbon-free baseload technology for ASEAN







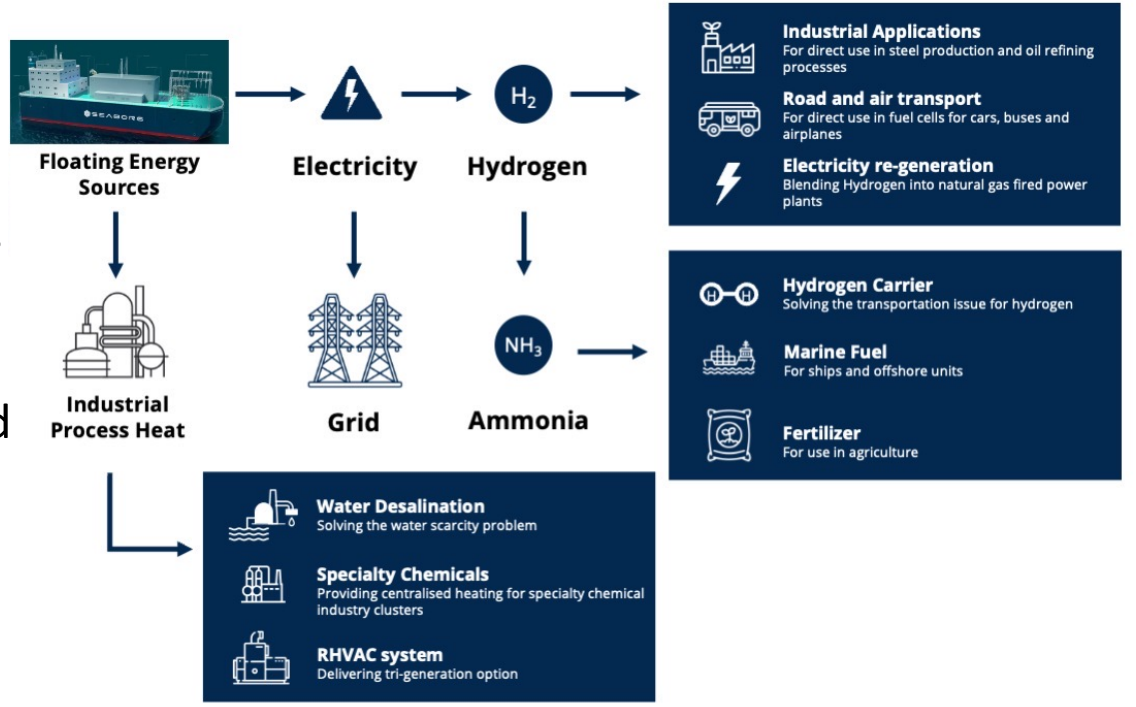


Nian et al. (2022), *Policies toward net-zero: Benchmarking the economic competitiveness of nuclear against wind and solar energy*, Applied Energy, Volume 320, 119275.

Offshore floating multi-utility complex (FMUC) enabled by floating nuclear energy

A CSER's example of an enabling ecosystem

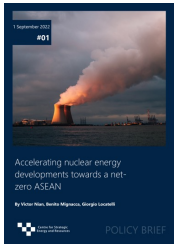
- Harvest heat and power from high quality sustainable offshore energy sources
- Enable multiple and flexible use cases and business models across multiple value chains
- Improve economics, sustainability and resilience of energy
- Drive new policy and regulatory development to accelerate energy transition



***Initial concept of floating multi-utility complex**: https://www.greendkinsea.com/post/an-ecosystem-approach-to-maritime-decarbonisation-in-asean*

Critical success factors for ASEAN

- Recognise the need for a regional approach in safety, security and safeguards in developing sustainable and responsible national civilian nuclear programmes.
- Take a technology- and vendor-neutral approach when evaluating new build options through consultation with international experts, technical institutes, and agencies like the IAEA.
- Communicate the pros and cons with a good degree of transparency to key stakeholders and in a way the general public to ensure maximum support and public trust.
- Conduct studies on cross-sectoral use cases for advanced nuclear power technologies to become an integral part of future national strategies in sustainable development.



Latest CSER Policy Brief

"Accelerating nuclear energy developments towards a net-zero ASEAN"
https://cser.energy/policy-briefs

Centre for Strategic
Energy and Resources

Join our ecosystem and gain access to strategic insights on energy transition

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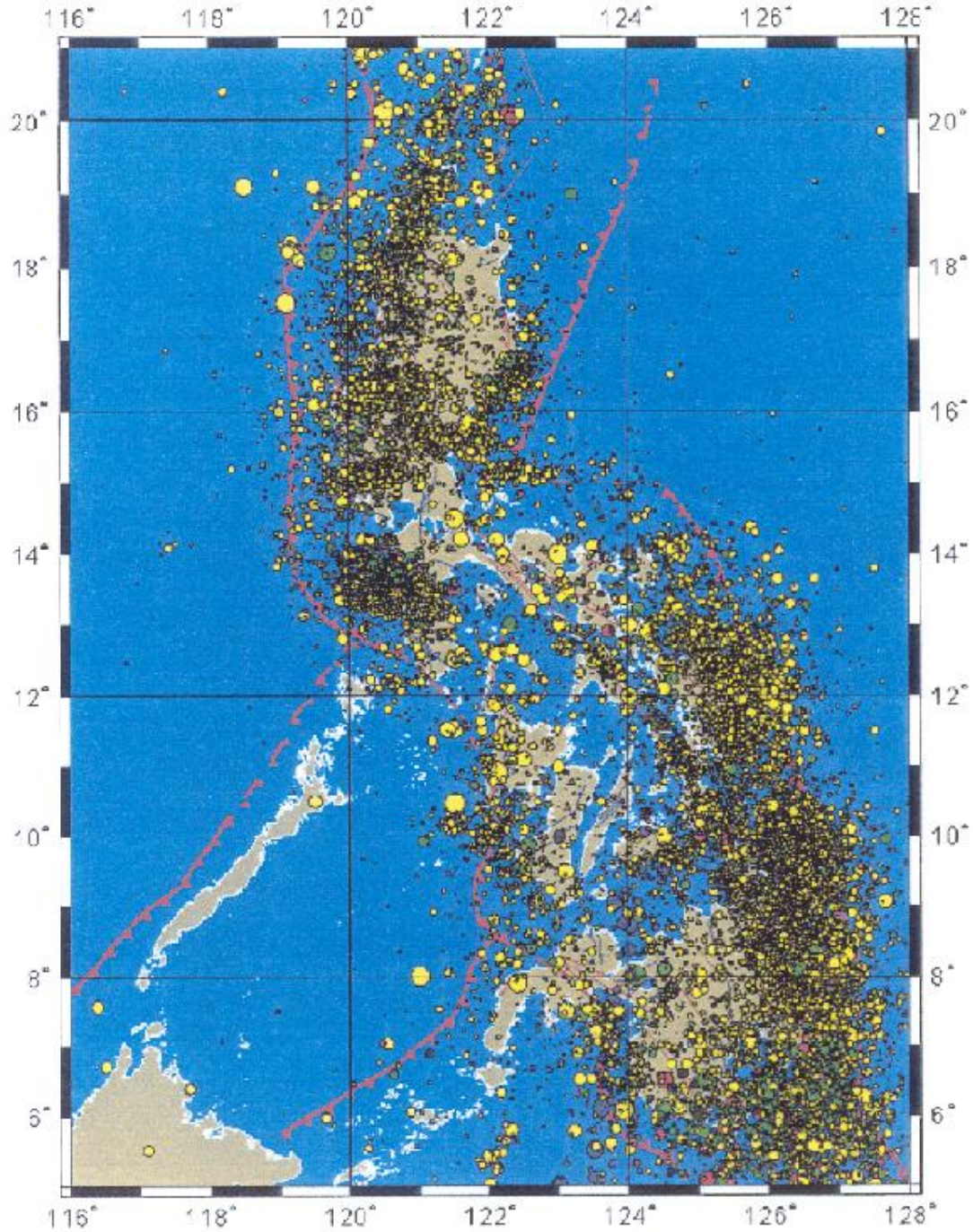
Website: www.cser.energy
LinkedIn: www.linkedin.com/company/energystrategy

Nuclear Power: in the Philippines?

Dr. Carlo Arcilla

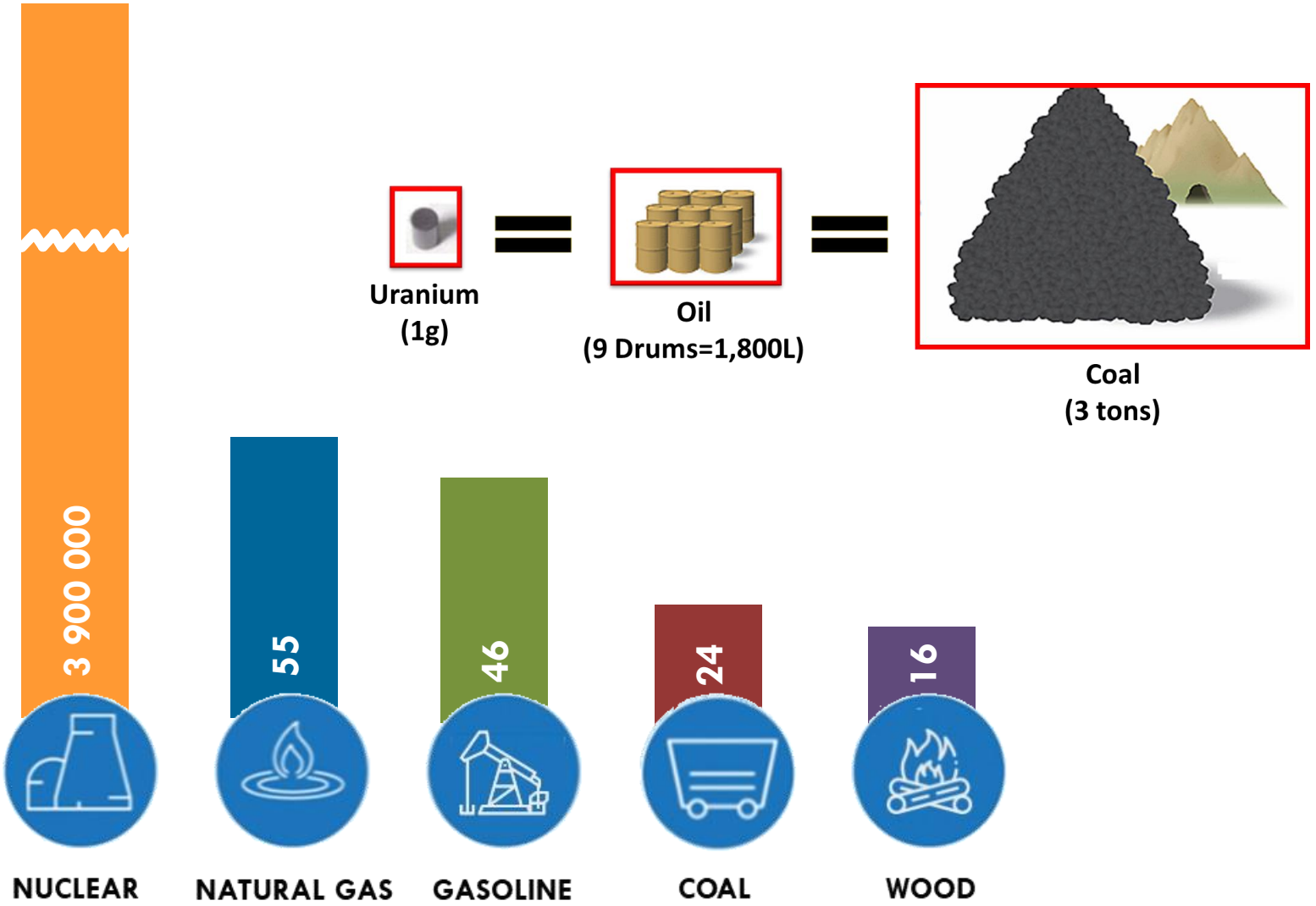
Director, PNRI


116°
118°
120°
122°
124°
126°
128°
20°
18°
16°
14°
12°
10°
8°
6°

Disasters in Philippines

- Typhoons (20 a year)
- Volcanoes
- Tsunami
- Earthquakes
- Floods
- politicians

Energy density (MJ/kg) by energy source



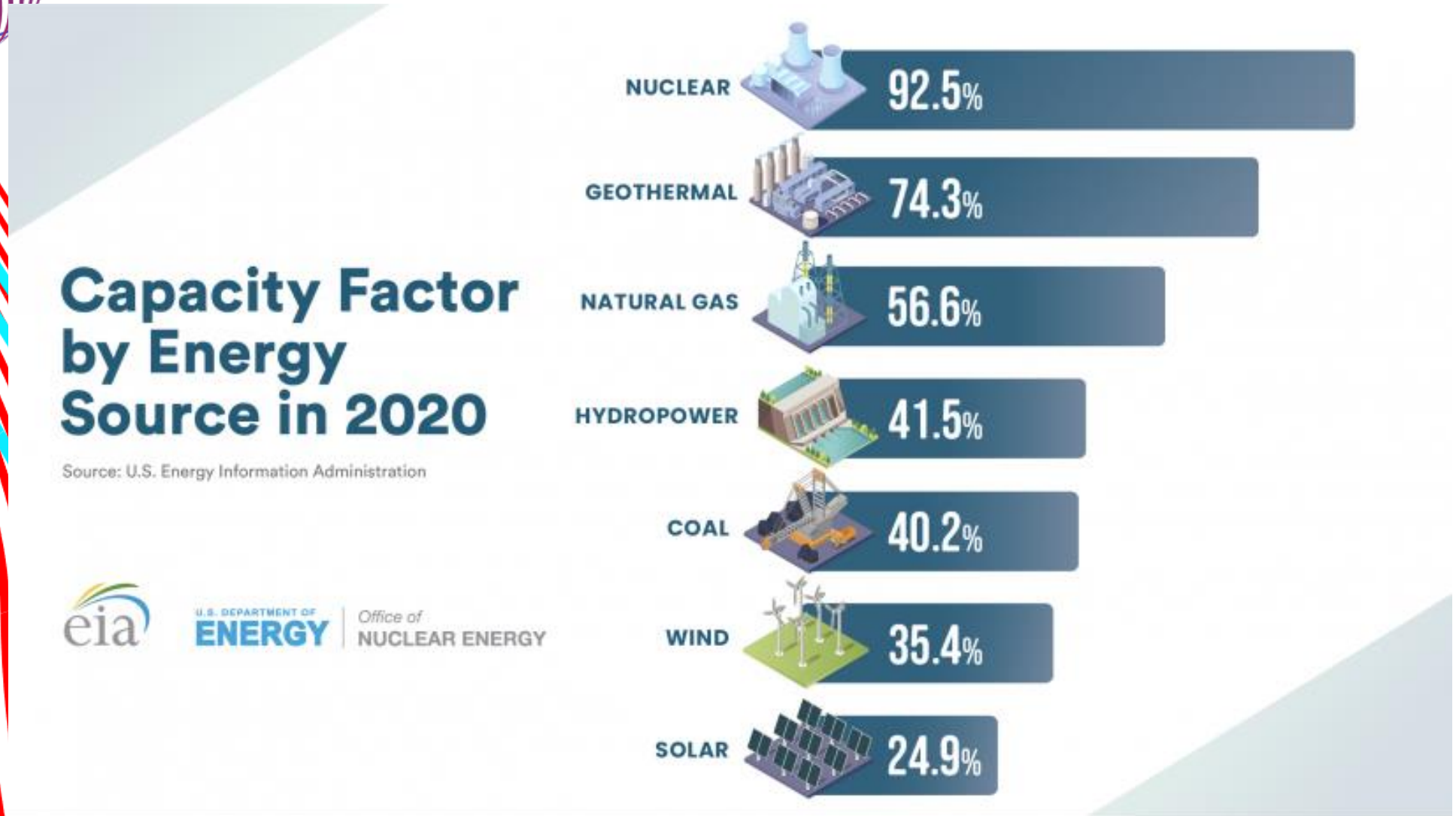
Nuclear Fuel:
Small volumes, high energy contents

- 1 pellet produces the energy of 1.5 tonnes of coal
- Each pellet produces 5000 kWh

IAEA

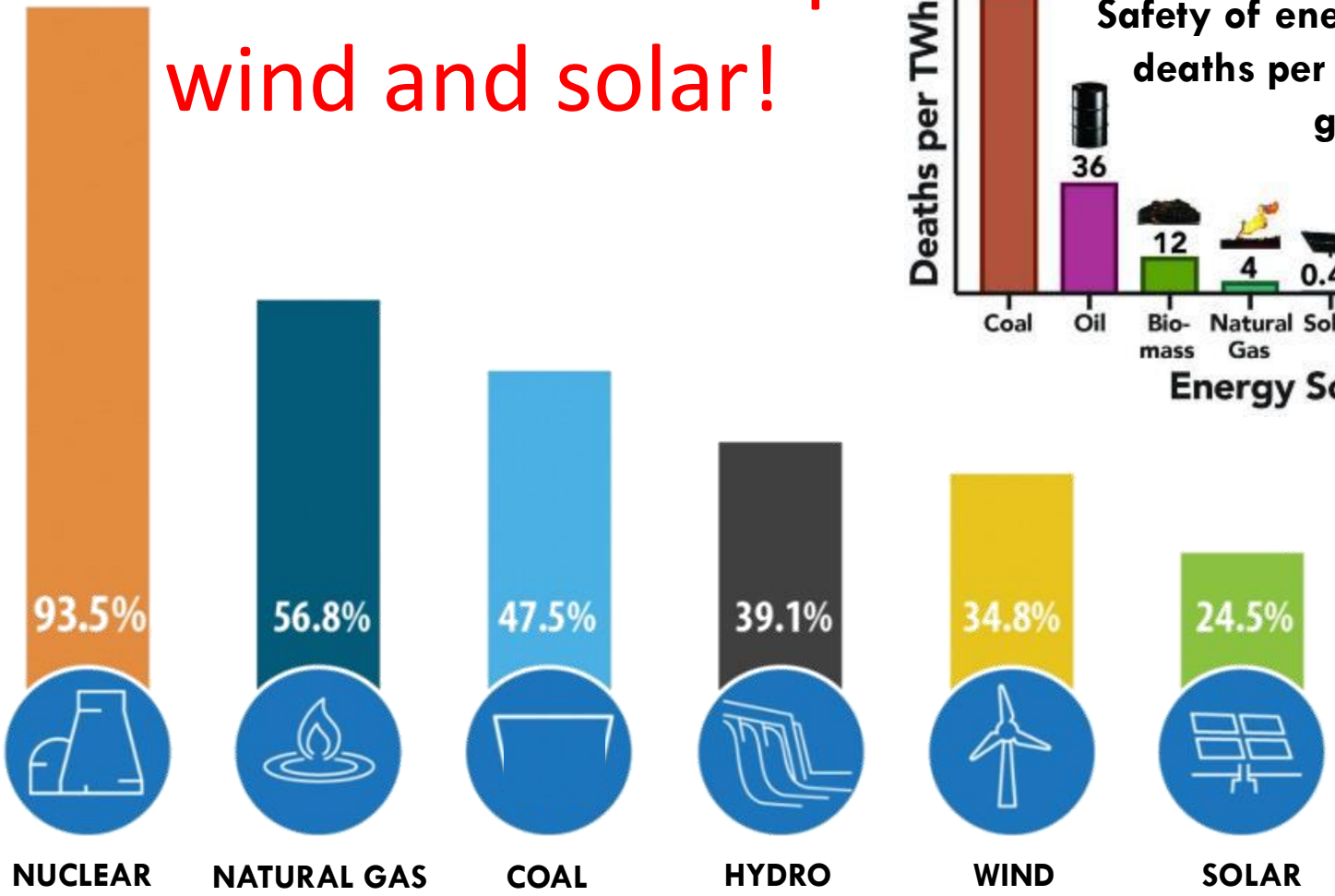
BNFL

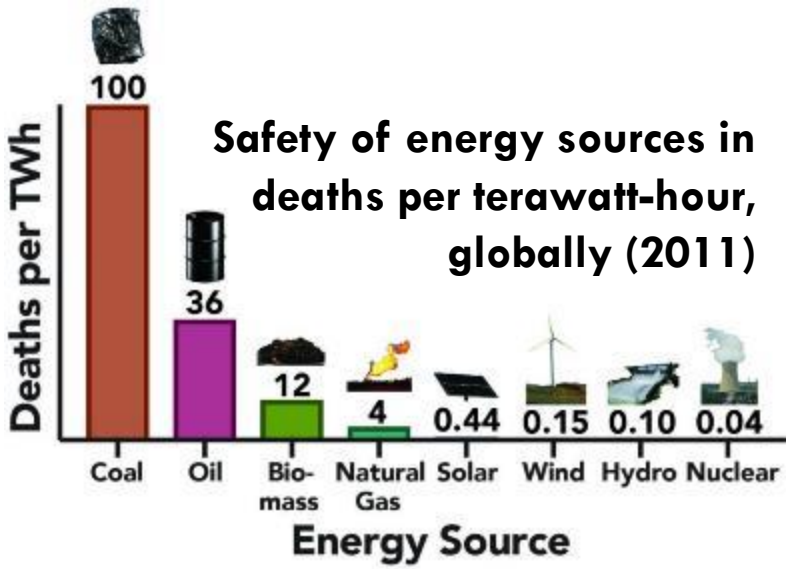
CAPACITY FACTOR
BY ENERGY SOURCE



Capacity factor and safety by energy source

Nuclear can backup wind and solar!





Source: U.S. Energy Information Administration, 2019

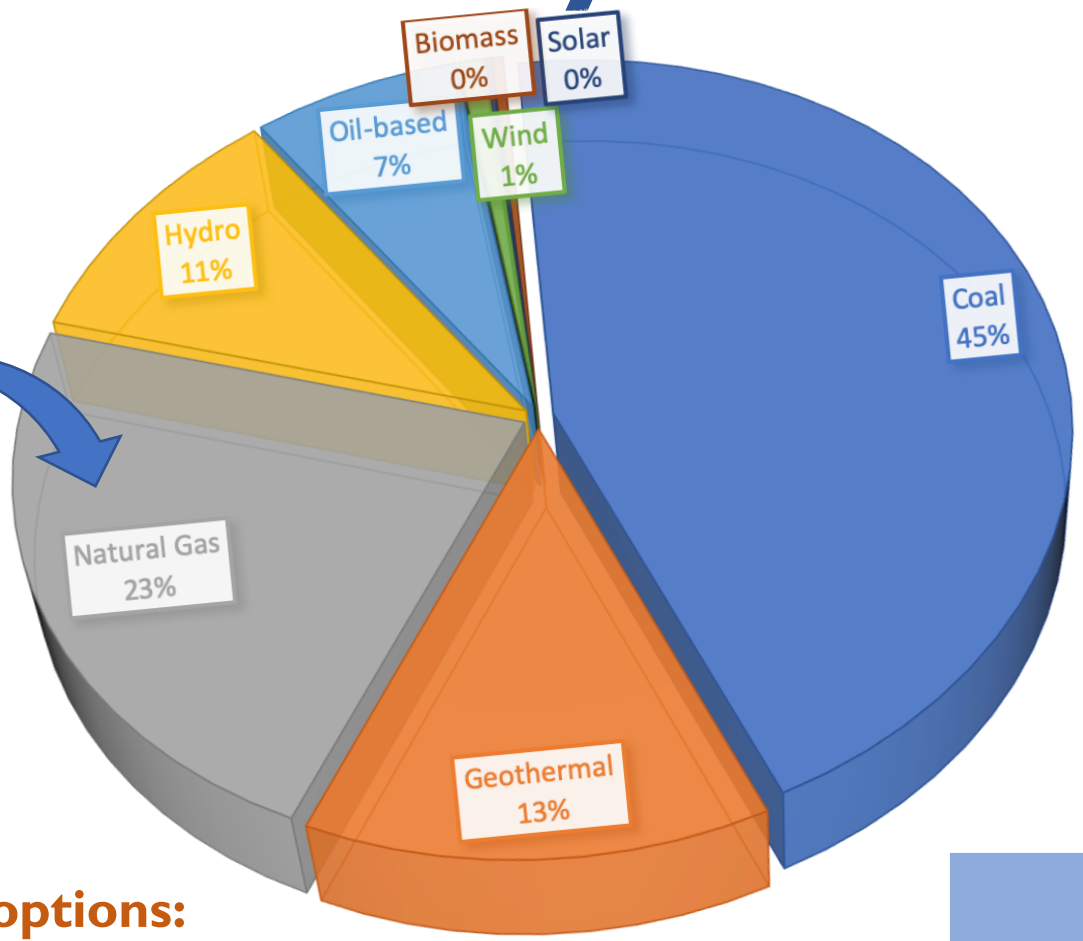
Not about either, or – balanced mix is needed

It is not about either or

It is not possible to deliver energy without negative consequences. It is all about finding a balance that is acceptable and providing the lowest possible total footprint. No single energy source can solve the climate challenge alone, and a power mix consisting only of renewables will, in addition to having practical and economic challenges, bring unnecessarily large negative consequences for nature and the environment. A constructive climate debate therefore requires an understanding of each energy source's impact on climate, environment, health and economy. Hopefully, the work I have done, with good help from geophysics student Wouter Bell Gravendeel, and documented in four different articles, can contribute in the right direction.

PHL Electricity Mix

The current energy mix is composed of coal (47%), natural gas (22%), renewable energy (hydro, geothermal, wind, solar) (24%), and oil-based (6.2%) with current energy capacity at 23GW



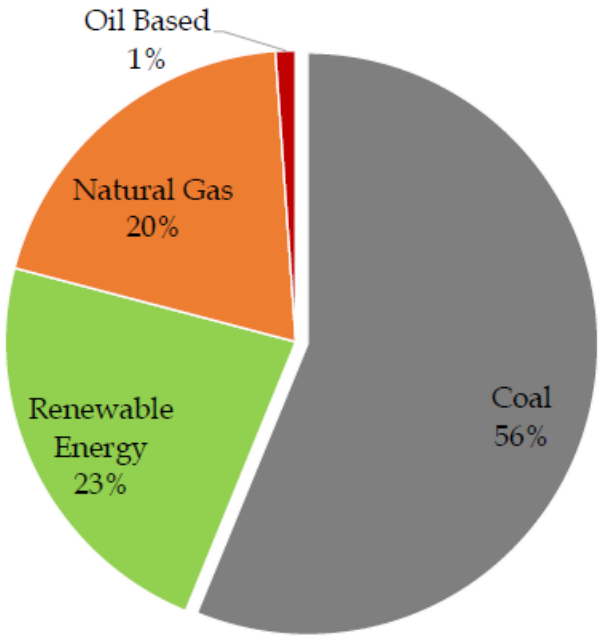
Malampaya gas running out in 5 years

Best replacement options: Liquefied Natural Gas (LNG) along with Nuclear Energy

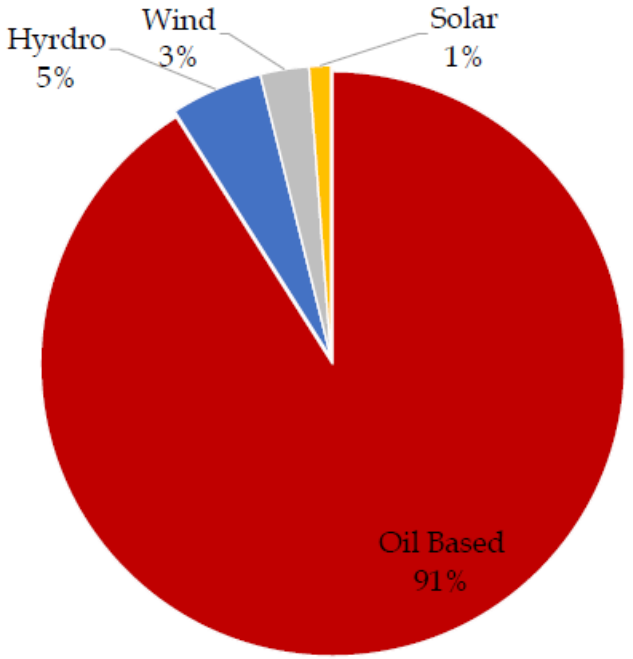
THE REALITY CHECK

Energy Mix

2022 Gross Energy Generation Mix - Main Grid (1ST Quarter)



2020 Energy Generation Mix for Off-Grid



LNG prices from $10M to $281M in one year- 2020-2021!

(Malampaya supplies 40% of Luzon power)

Why Nuclear ?

A median Filipino family pays more than 10% of its monthly income for electricity!

High electricity costs **could be** reason why 79% of PHL population supports nuclear power (DOE Survey, May 2019)

Nuclear is competitive with gas and coal but small volume favors energy security

SAFETY, SAFETY, SAFETY

If nuclear is unsafe why does USA have nearly 100 NPP, suppying 20% of its electricity, operating close to 60 years?

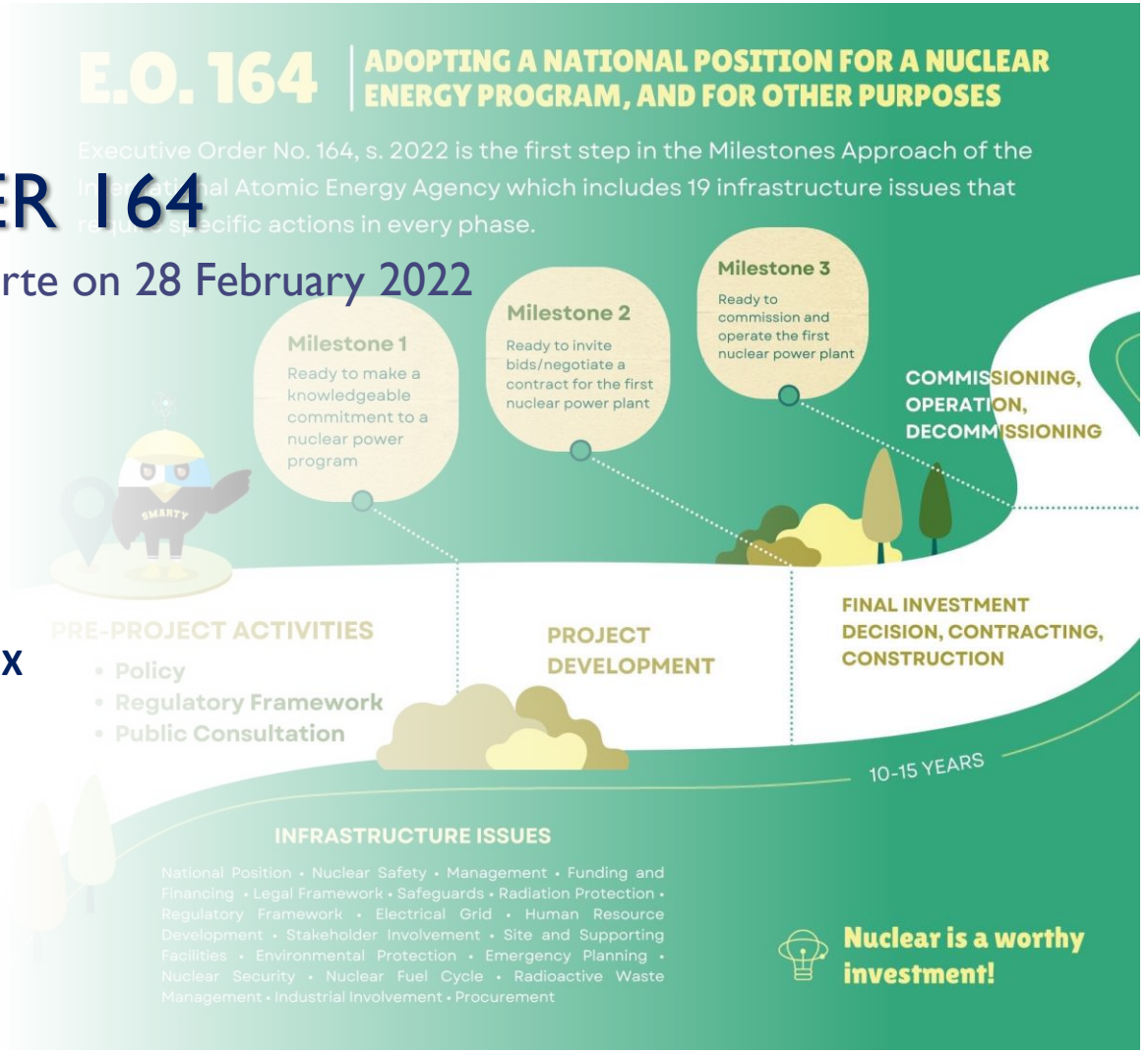
EXECUTIVE ORDER 164

Signed by President Rodrigo Duterte on 28 February 2022

NUCLEAR ENERGY PROGRAM

STARTS WITH THE INCLUSION OF NUCLEAR POWER IN THE ENERGY MIX

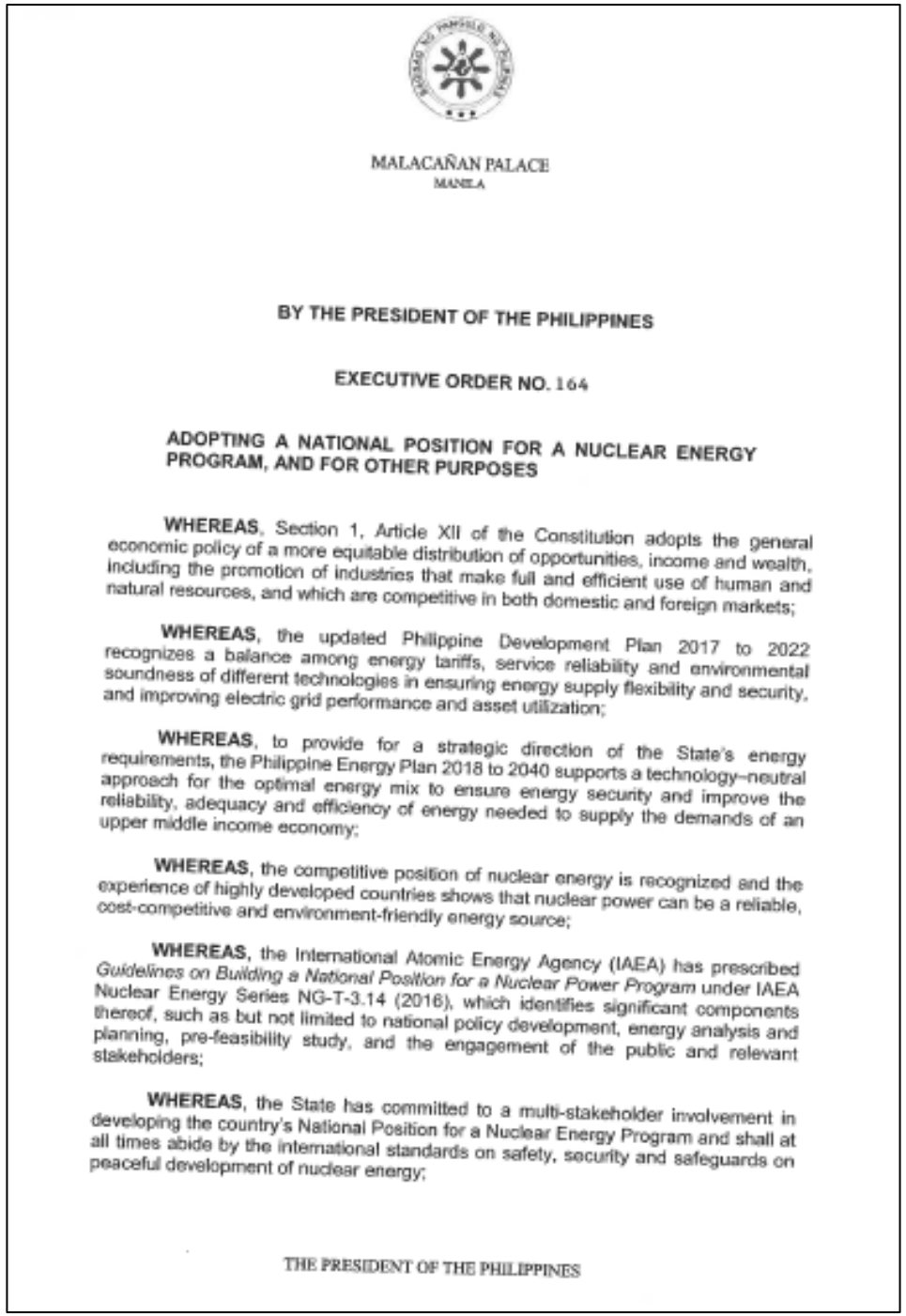
DEVELOPMENT OF NUCLEAR POWER INFRASTRUCTURE



NATIONAL POSITION ON NUCLEAR ENERGY

First requirement of a country embarking on a nuclear power program

- The most significant government action on nuclear since the construction and stoppage of the Bataan Nuclear power plant in the 1980's



MALACAÑAN PALACE
MANILA

BY THE PRESIDENT OF THE PHILIPPINES

EXECUTIVE ORDER NO. 164

ADOPTING A NATIONAL POSITION FOR A NUCLEAR ENERGY PROGRAM, AND FOR OTHER PURPOSES

WHEREAS, Section 1, Article XII of the Constitution adopts the general economic policy of a more equitable distribution of opportunities, income and wealth, including the promotion of industries that make full and efficient use of human and natural resources, and which are competitive in both domestic and foreign markets;

WHEREAS, the updated Philippine Development Plan 2017 to 2022 recognizes a balance among energy tariffs, service reliability and environmental soundness of different technologies in ensuring energy supply flexibility and security, and improving electric grid performance and asset utilization;

WHEREAS, to provide for a strategic direction of the State's energy requirements, the Philippine Energy Plan 2018 to 2040 supports a technology-neutral approach for the optimal energy mix to ensure energy security and improve the reliability, adequacy and efficiency of energy needed to supply the demands of an upper middle income economy;

WHEREAS, the competitive position of nuclear energy is recognized and the experience of highly developed countries shows that nuclear power can be a reliable, cost-competitive and environment-friendly energy source;

WHEREAS, the International Atomic Energy Agency (IAEA) has prescribed *Guidelines on Building a National Position for a Nuclear Power Program* under IAEA Nuclear Energy Series NG-T-3.14 (2016), which identifies significant components thereof, such as but not limited to national policy development, energy analysis and planning, pre-feasibility study, and the engagement of the public and relevant stakeholders;

WHEREAS, the State has committed to a multi-stakeholder involvement in developing the country's National Position for a Nuclear Energy Program and shall at all times abide by the international standards on safety, security and safeguards on peaceful development of nuclear energy;

THE PRESIDENT OF THE PHILIPPINES

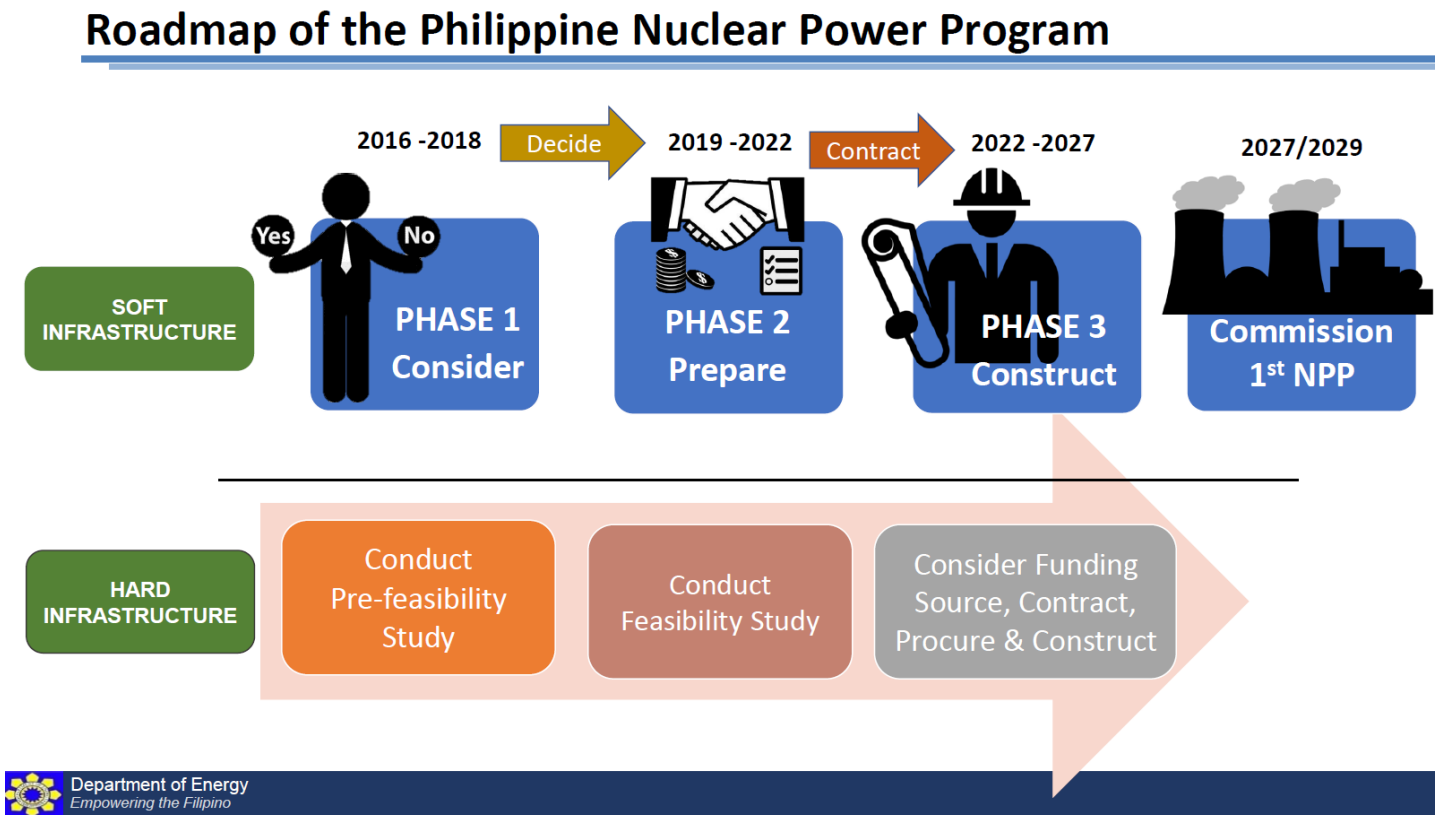
PRESIDENTS WANT NUCLEAR POWER

GMANETWORK.COM

Duterte hopes next administration will look into use of nuclear power

"We're not yet dito sa nuclear level but I hope the next administration would at least explore n...

OUTLINE (IAEA MILESTONES APPROACH)



ASEANTOM

ASEAN CAMBODIA 2022
ASEAN A.C.T.: Addressing Challenges Together

ACTIVITIES

Integrated Nuclear Infrastructure Review

- Identification of the 19 infrastructure issues outlined the following cornerstones:
  - **Policy**
  - **Legislative Framework**
  - **Public Acceptability**
  - **Alignment with International Standards**

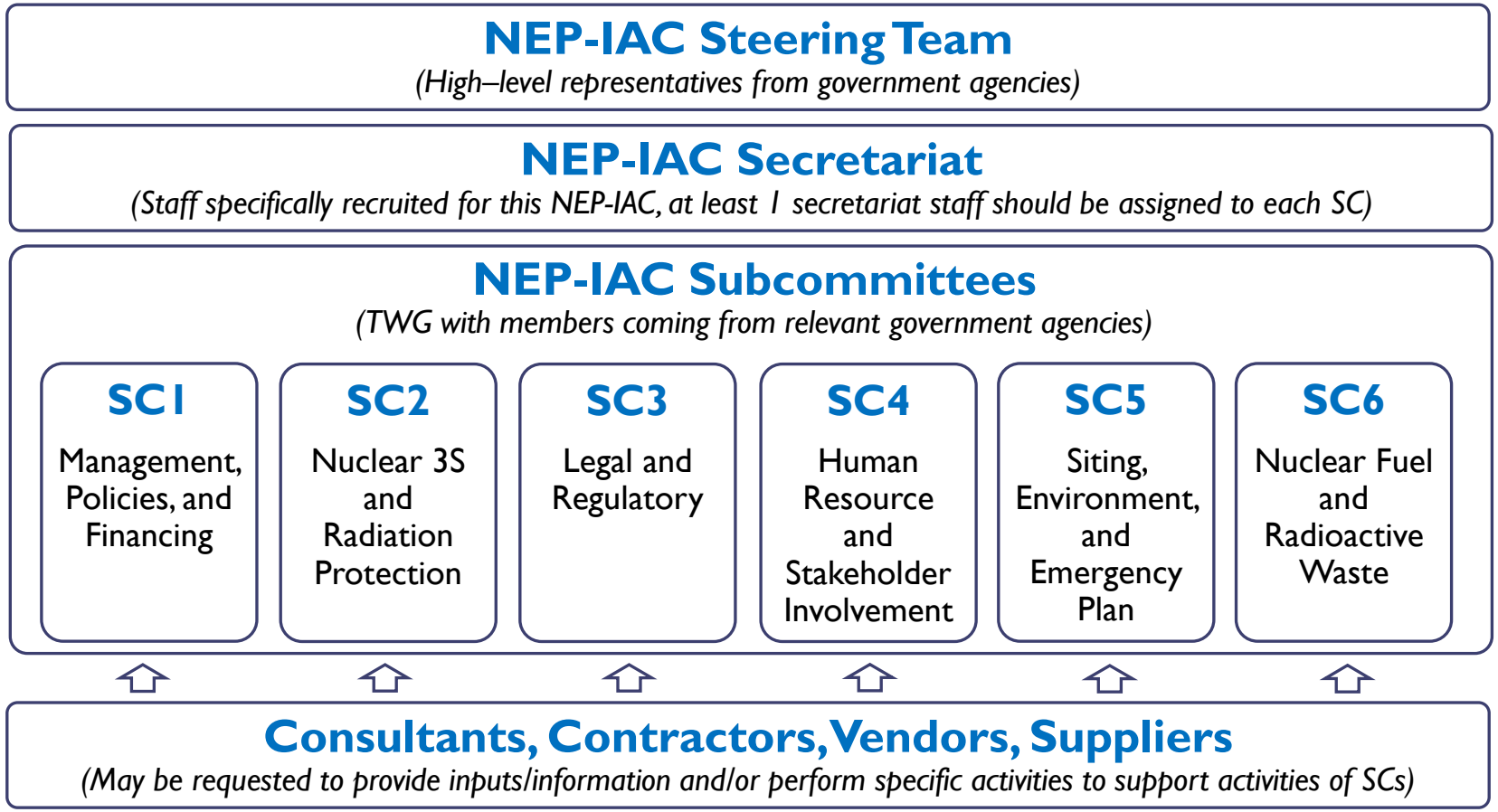
Integrated Work Plan

- A total of 19 activities were identified for the years;

  10 activities for 2020, 9 activities for 2021.
- The largest part of the activities relates to the
  - **National Position**
  - **Legal and Regulatory Framework**
  - **Human Resource Development**
  - **Stakeholders Involvement**

NEP-IAC STRUCTURE

E.O. 116, 2020



INTERNATIONAL ATOMIC ENERGY AGENCY: ATOMS FOR PEACE

Special Congressional Committee on Nuclear Energy approved;
proposed by Cong. Sandro Marcos

PHILSTAR.COM

House creates special panel on nuclear energy

The lower house elected Rep. Mark Cojuangco (Pangasinan) as the chairperson of the 25-mem...

Passage of nuclear law to be championed by Congressman Mark Cojuangco, chair of new Congressional Committee on Nuclear Energy

https://youtu.be/_IpqfBn1Azl

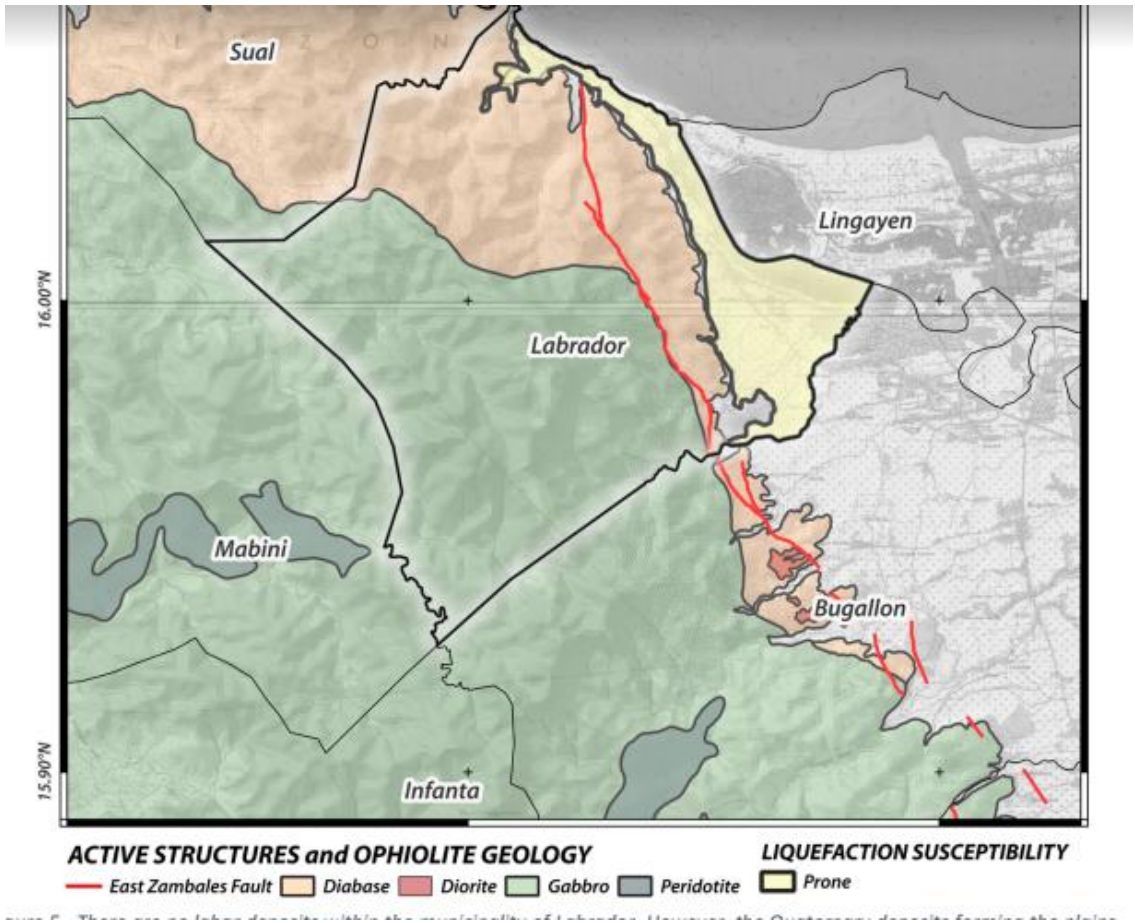
The Urgency and Imperative of Nuclear Electricity for the Philippines

YOUTUBE.COM

The Urgency and Imperative of Nuclear Electricity for the Philippines

Privileged Speech of HON. MARK O. COJUANGCO delivered in the House of Representatives

Pangasinan Town unanimously asking a Nuclear Plant to be sited in their vicinity!



Site exclusion report following IAEA GUIDES

PRELIMINARY NUCLEAR POWER PLANT SITING REPORT

For the Municipality of Labrador, Pangasinan

Selection of sites for nuclear installations requires extensive interdisciplinary studies encompassing geological, hydrological, environmental, engineering, social, and radiological impact assessments. These are described in several safety guidelines set by the international agency that governs nuclear facilities – the International Atomic Energy Agency (IAEA). The Philippines is one of the member states under this agency that benefit from these safety guidelines. Construction of nuclear power plants also falls under the siting for nuclear installation, and the considerations and general criteria are broadly explained in one of their publications on Safety Standards for Site Survey and Site Selection for Nuclear Installation under Specific Safety Guide (SSG) No. 35 (SSG-35) [1]. Under this guide, there are five stages relating to the safety considerations for the site of a nuclear installation, and the first step is the site survey process. In this site survey stage, large regions of interest are investigated to find potential

ASEANTOM

ASEAN CAMBODIA 2022
ASEAN A.C.T.: Addressing Challenges Together

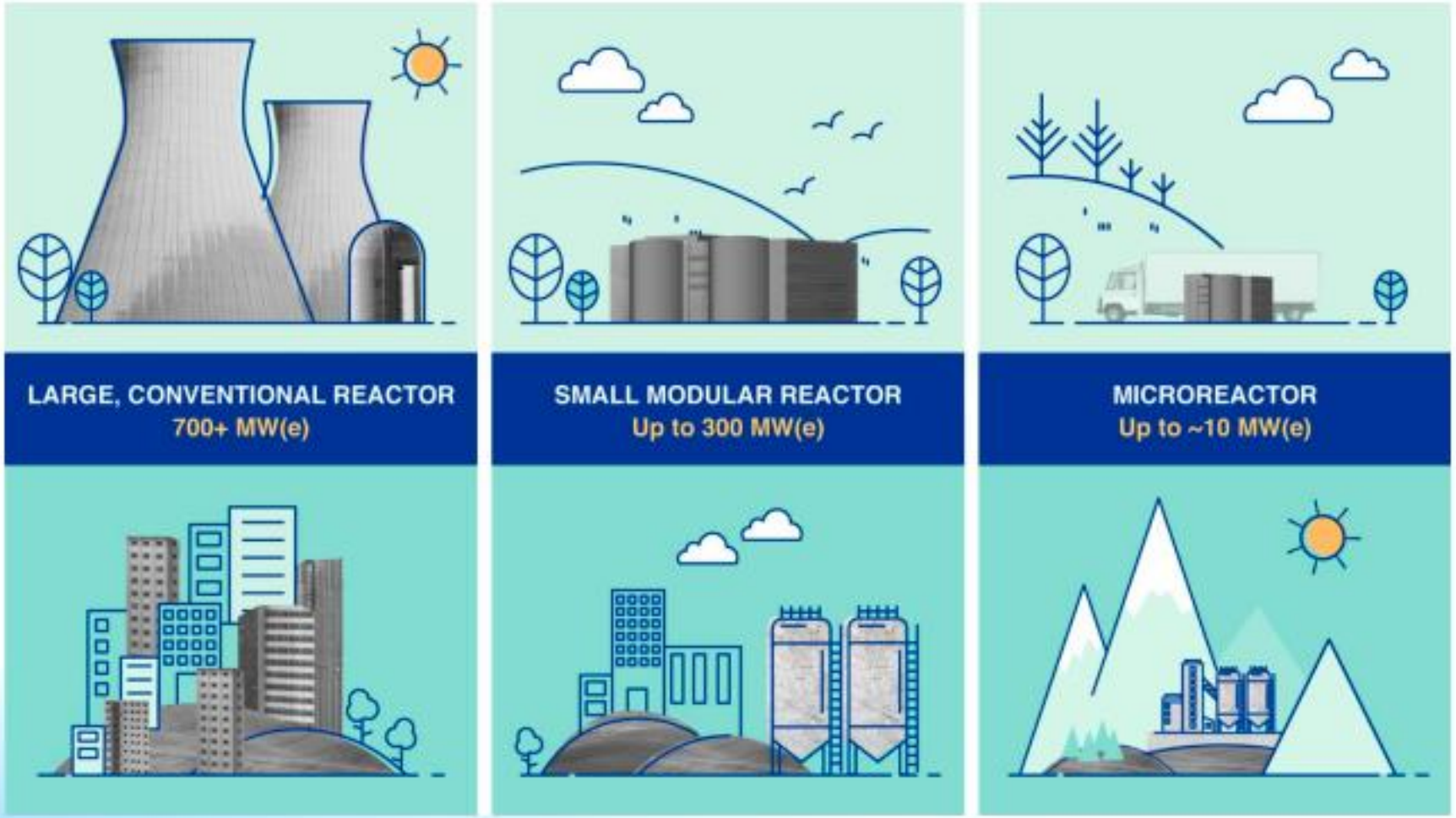
PNRI research reactor team after complete nuclear fuel loading. First TRIGA subcritical reactor worldwide. PROUDLY PINOY!!

PNRI restarts nuclear research reactor after 34 years

Safety, Security and Safeguards

Small Modular Reactor Definition

Advanced Reactors that produce typically up to 300 MWe, built in factories and transported as Modules to sites for Installation as demand arises.

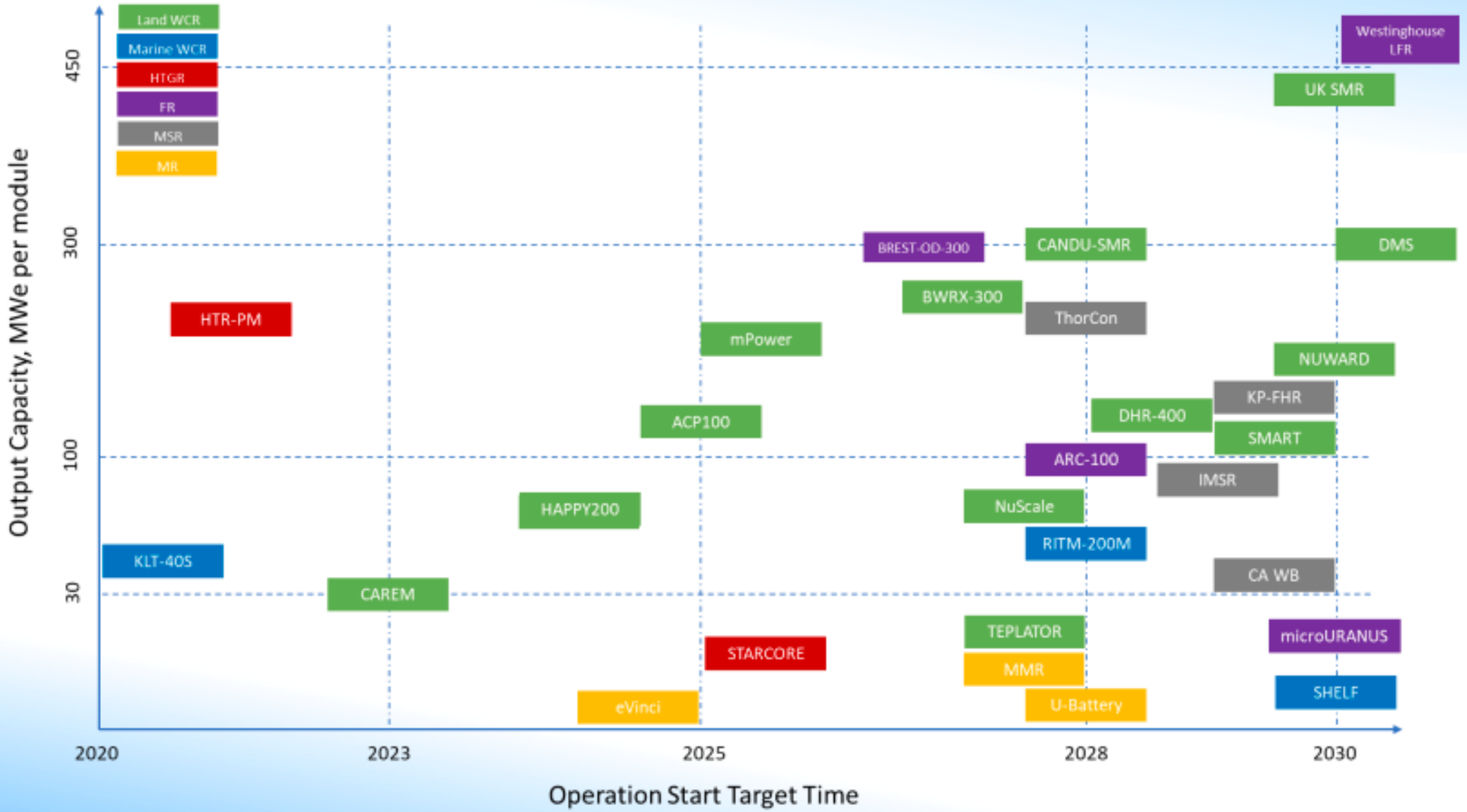


Small: in size, comparing to traditional reactors.

Modular: factory-manufactured, installed onsite.

Reactor: energy generation via nuclear fission.

SMR 10-year Deployment Horizon

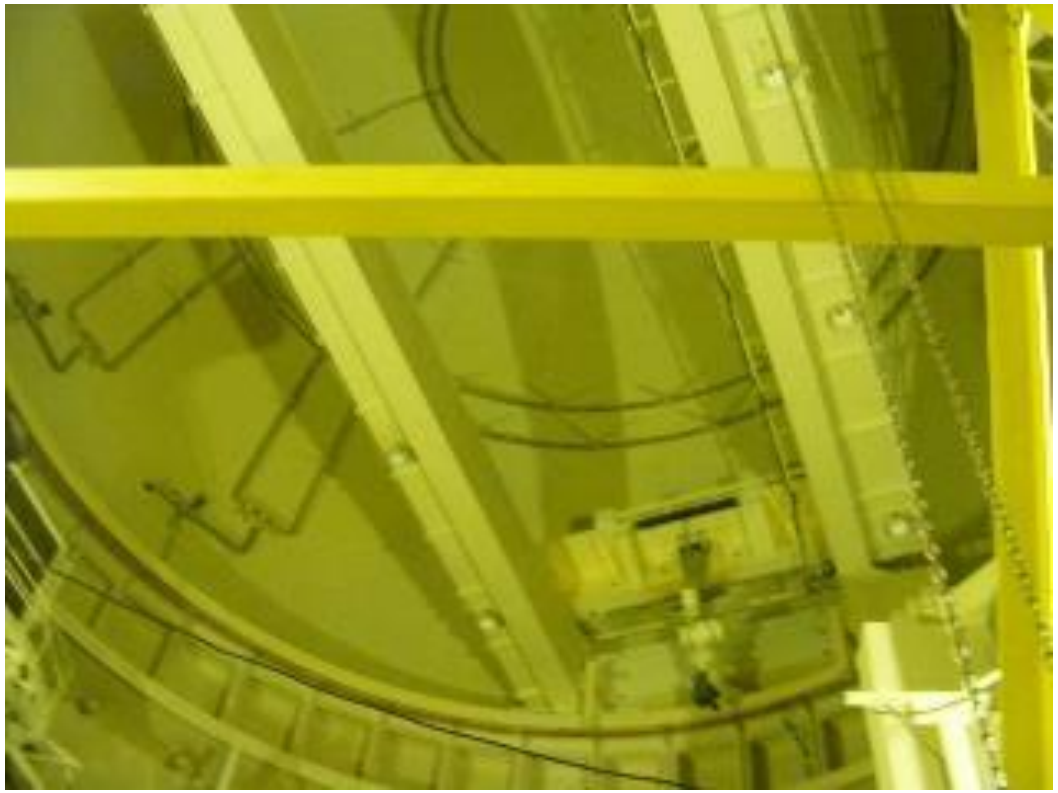


Bataan Nuclear Power Plant

Bataan Nuclear Power Plant

- Built at cost of US$ 2.3 billion
- Alleged corruption by 1st Marcos government AND Westinghouse Corporation
- Completed but closed nearly 35 years ago, mainly due to "safety reasons"--not 1 watt produced
- 3 exact operating models for more than 30 years – Korea, Slovenia and Brazil
- **Situated close to (or on) a "dormant" volcano and a fault – the recurring reason given why the plant was mothballed**

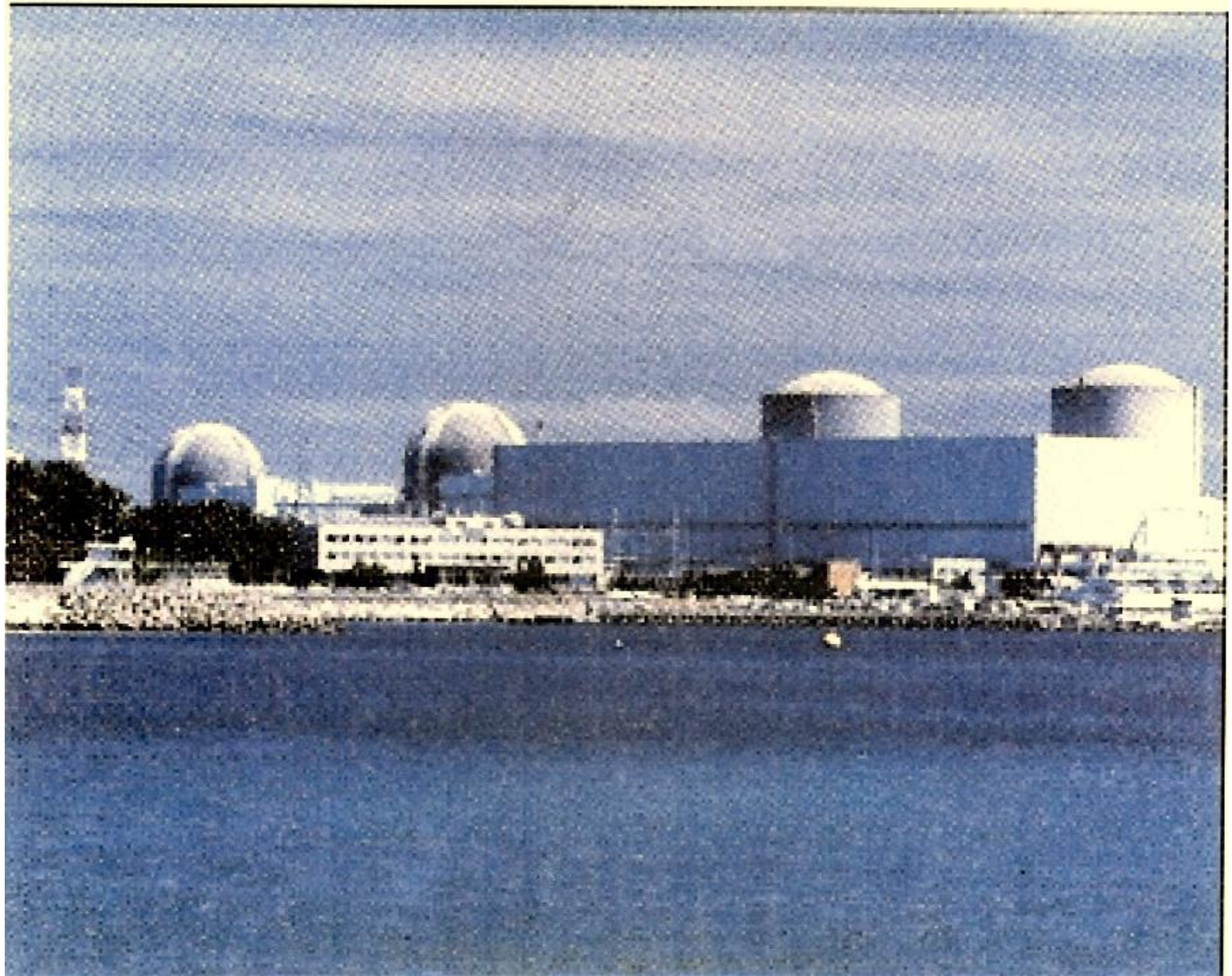

Westinghouse



Soviet	West
Converted weapon plant design	Built to commercial power plant
No containment (warehouse type building structure)	Containment (steel, air gap, concrete wall)
Graphite (flammable, fire)	Superalloys (meltdown)
Military civil management performed illegal experiment on a Civil power plant	Commercial plant not subject to equipment experimental trials
Closed system	International peer review
Positive reaction coefficient	Negative reaction coefficient

Korea has an EXACT copy of the BNPP Westinghouse Designed-plant that has been in operation since 1983

- no major accidents
- cost US $1 billion (compared to US 1.2 billion for BNPP)
- BNPP incorporated safety design lessons learned from Three Mile Island accident; KORI 2 did not
- Korean power rates are approximately half that of RP
- Korean Plant recovered in 7 years (lesser in RP)
- (note that $2.3 billion cost of Philippine nuclear plant is due to interest payments and absence of revenues from power generation)
- Korean nuclear engineers confident BNPP can be operated again



No Fear – Korea now has 23 NPP
has about half our electric rates

Research institute: South Korea offered to rehabilitate Bataan Nuclear Power Plant

By CNN Philippines Staff

Published Mar 6, 2022 8:50:30 PM

Latest from this section

Comelec exec hopes bill strengthening poll body will hurdle 19th Congress

Pharmally execs set to walk free from jail on June 2

BNPP URANIUM FUEL WOULD LAST 18 MONTHS--IF BNPP WERE A 620 MW COAL PLANT:

coal

50 Panamax ships

Importation cost = USD 600 million

nuclear

1 jeepney

USD 20 million

Is there a Fault **Beneath** the Bataan Nuclear Power Plant? A systematic study using Electrical Resistivity, Seismic Refraction and Radon Gas Detection

By

Dr. Carlo A. Arcilla, Richard Jason Antonio

Mario Collado

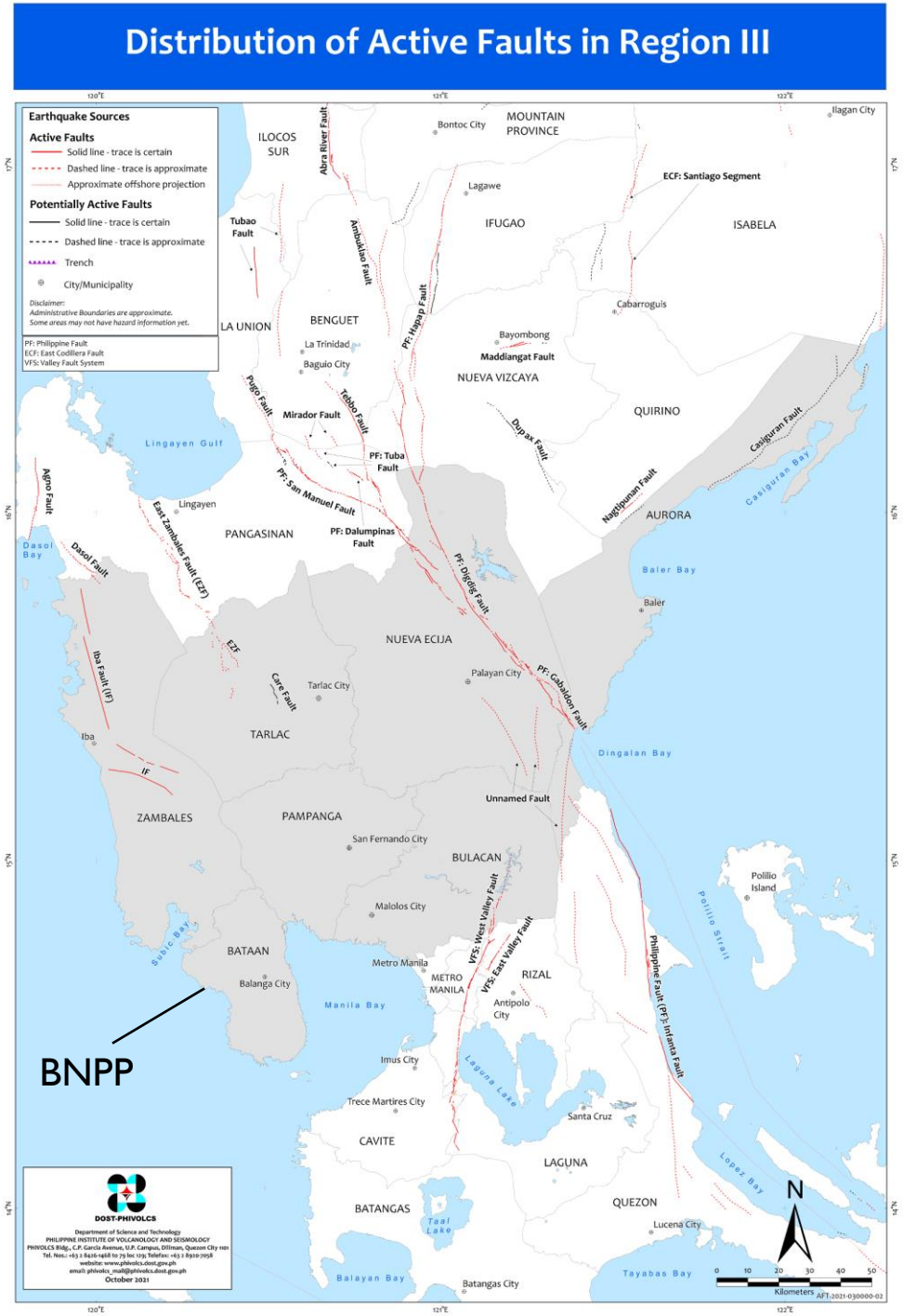
Benjamin Punay (RIP)

This study only aims to test if the BNPP is located ON TOP of an active fault

- It does not seek to study location of faults BESIDE or CLOSE to the structure (covered by engineering design?)
- **An active fault BENEATH the BNPP will condemn the structure immediately AND absolutely.**

Active Faults

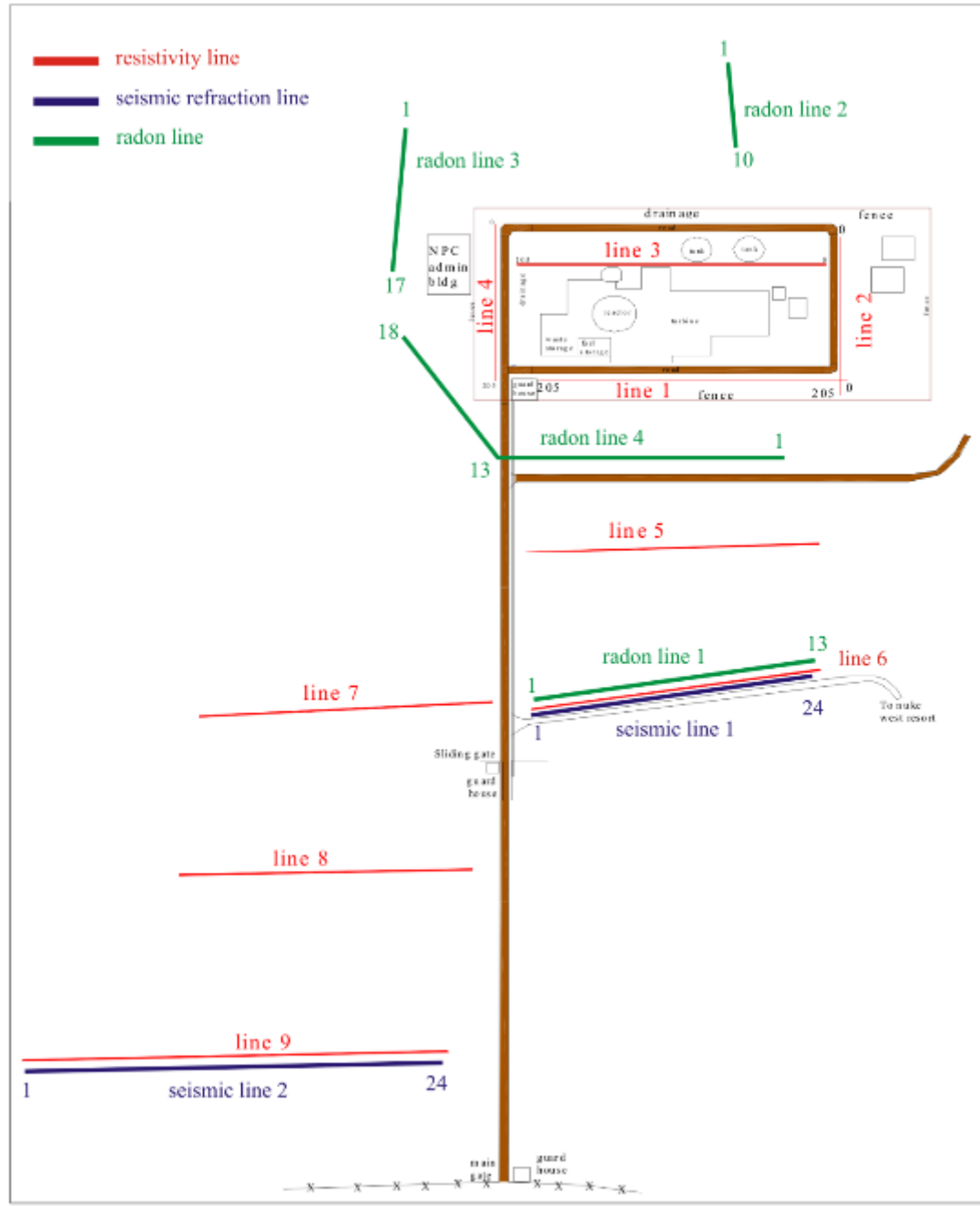
- By definition, *active faults MUST have surficial manifestations* (e.g., stream displacements, damaged structures, etc.)
- The active fault map of the Philippines by PHIVOLCS **does not** list an active fault in the vicinity of the BNPP



Examples of structures with faults beneath them

Methods

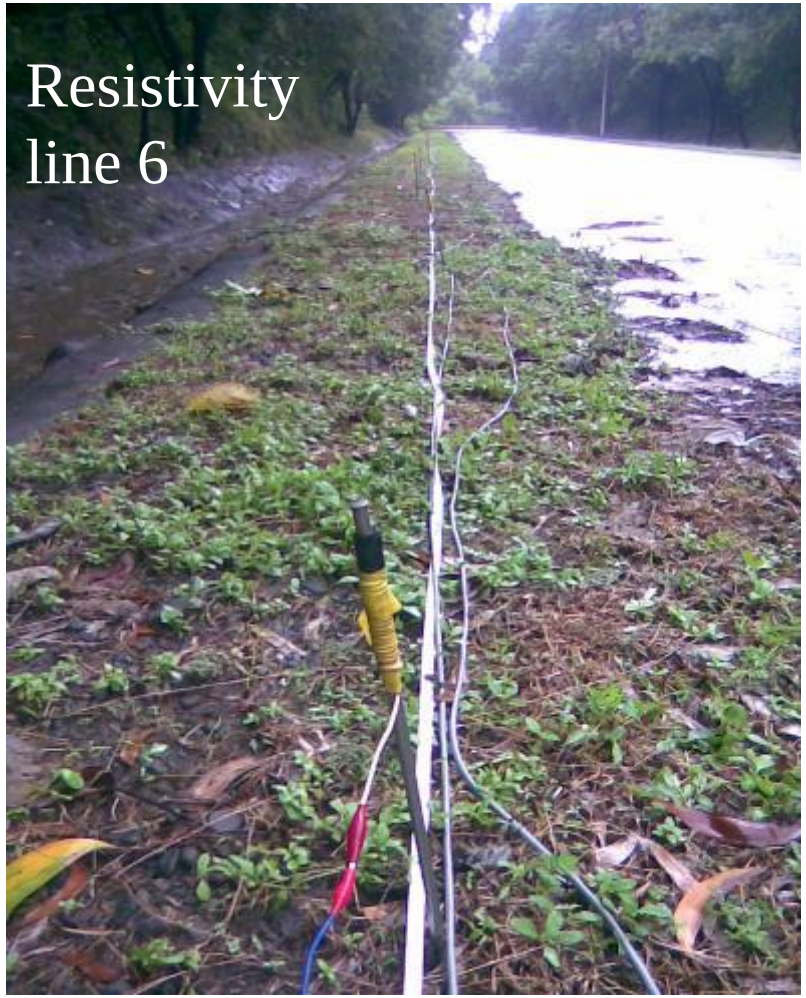
- Electrical Resistivity (Mario Collado)
- Seismic Refraction (Benjamin Punay)
- Geochemical Fault detection by Radon gas survey (with Jason Antonio, Peter Zamora, Tina Petrache)


resistivity line
seismic refraction line
radon line
radon line 2
1
10
radon line 3
1
17
18
NPC admin bldg
drainage
fence
line 3
line 4
line 2
line 1
fence
205
205
0
radon line 4
1
13
line 5
radon line 1
13
line 6
1
24
seismic line 1
1
line 7
Sliding gate
guard house
line 8
line 9
1
seismic line 2
24
main gate
guard house

Field measurement

Resistivity

Set of instrument used



Resistivity line 6

Summary

- NINE (9) lines of electrical resistivity were laid out along the perimeter of the Bataan Nuclear Power Plant to determine if there is a fault beneath the building. Using close-spaced electrodes in a Wenner array, the four 2-D electrical resistivity sounding profiles show NO evidence of faults underneath the Bataan Nuclear Power Plant

The seismic refraction data
strongly support the findings
of the electrical resistivity surveys:
No faults are detected
beneath the BNPP

Radon and Thoron soil gas testing:

Geochemical detection of hidden faults
(another independent test)

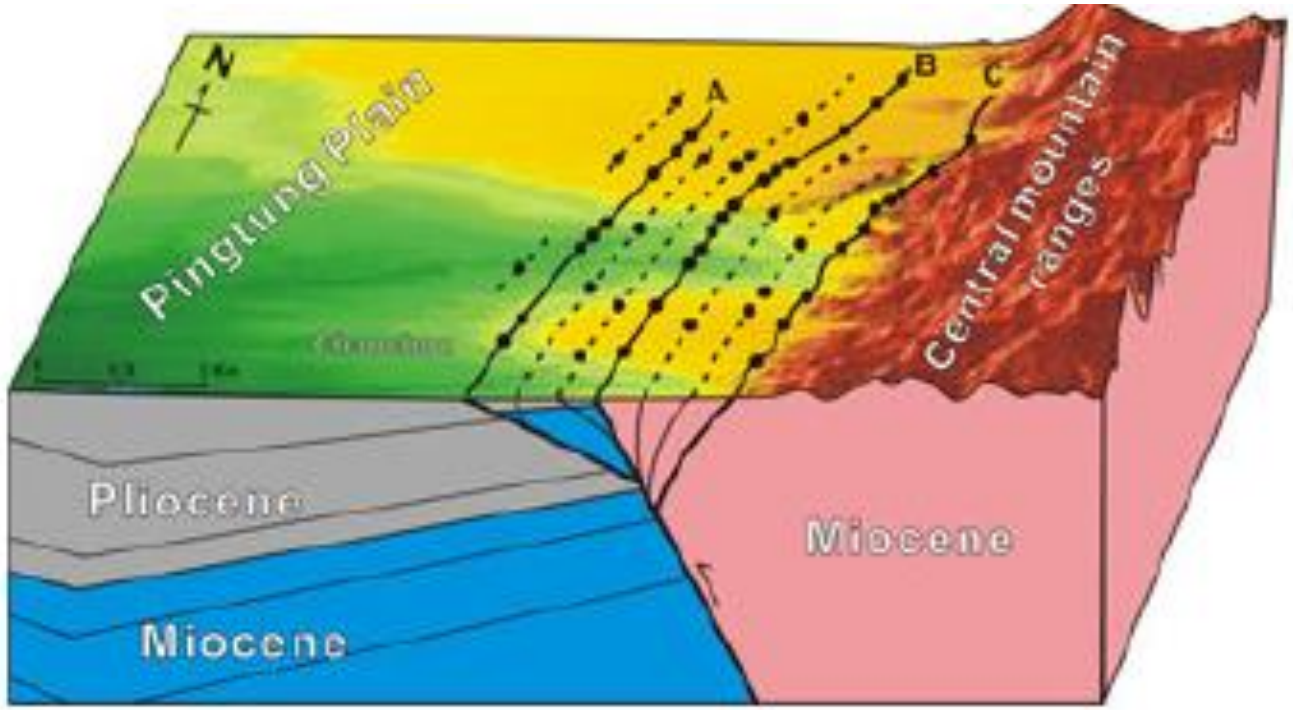
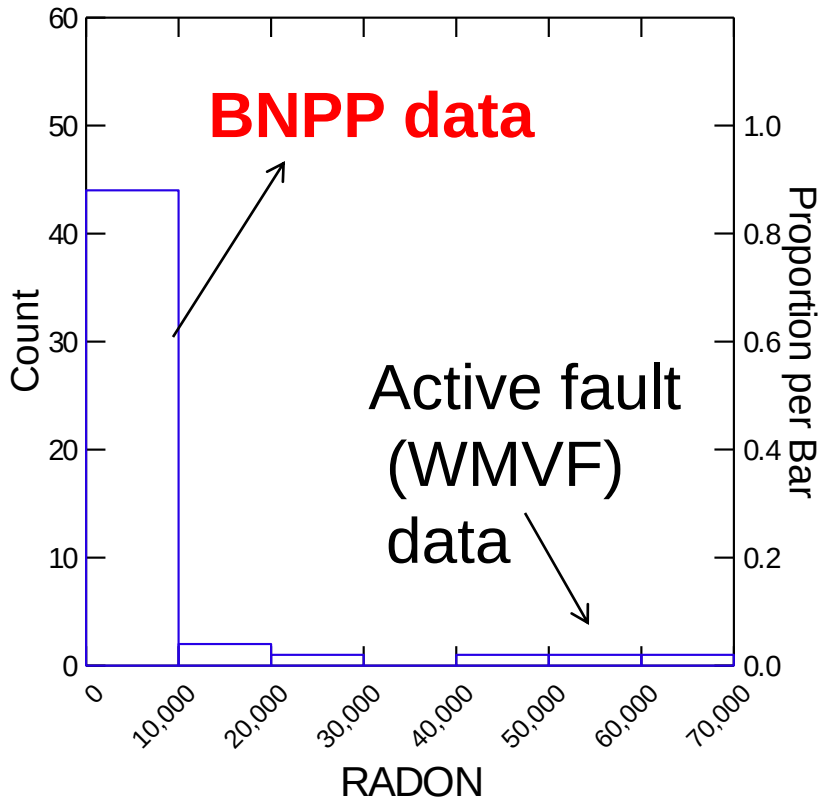


Fig. 5. Example for the delineation of the surface trace of a fault zone by soil gas survey in southern Taiwan (modified from Fu *et al.* 2005). Black circles indicate the sites with anomalous soil concentrations; those sites can delineate the surface traces of the faults/fractures.

Yang et al., 2008

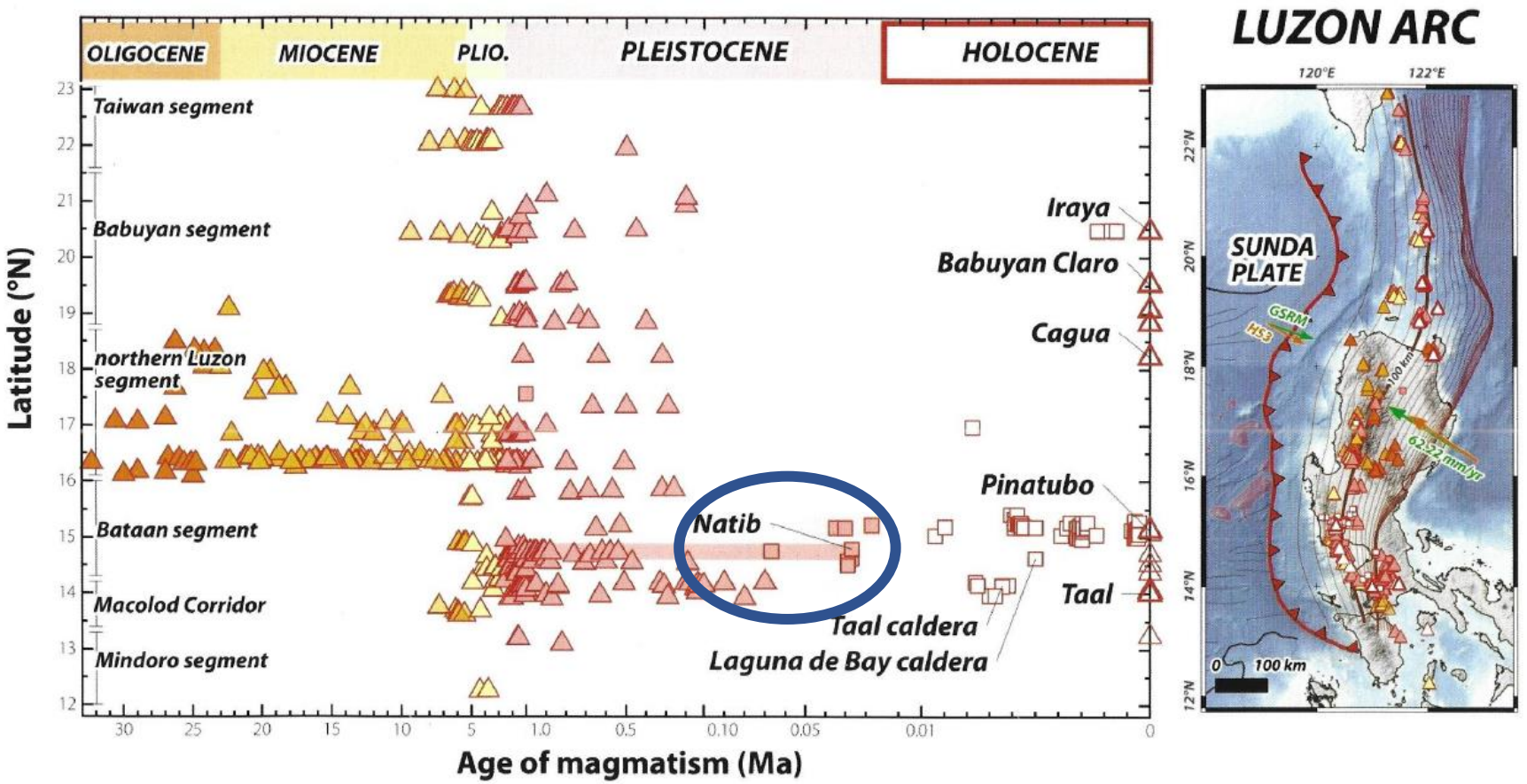


WMVF – West Marikina Valley Fault
Arcilla et al, 1987

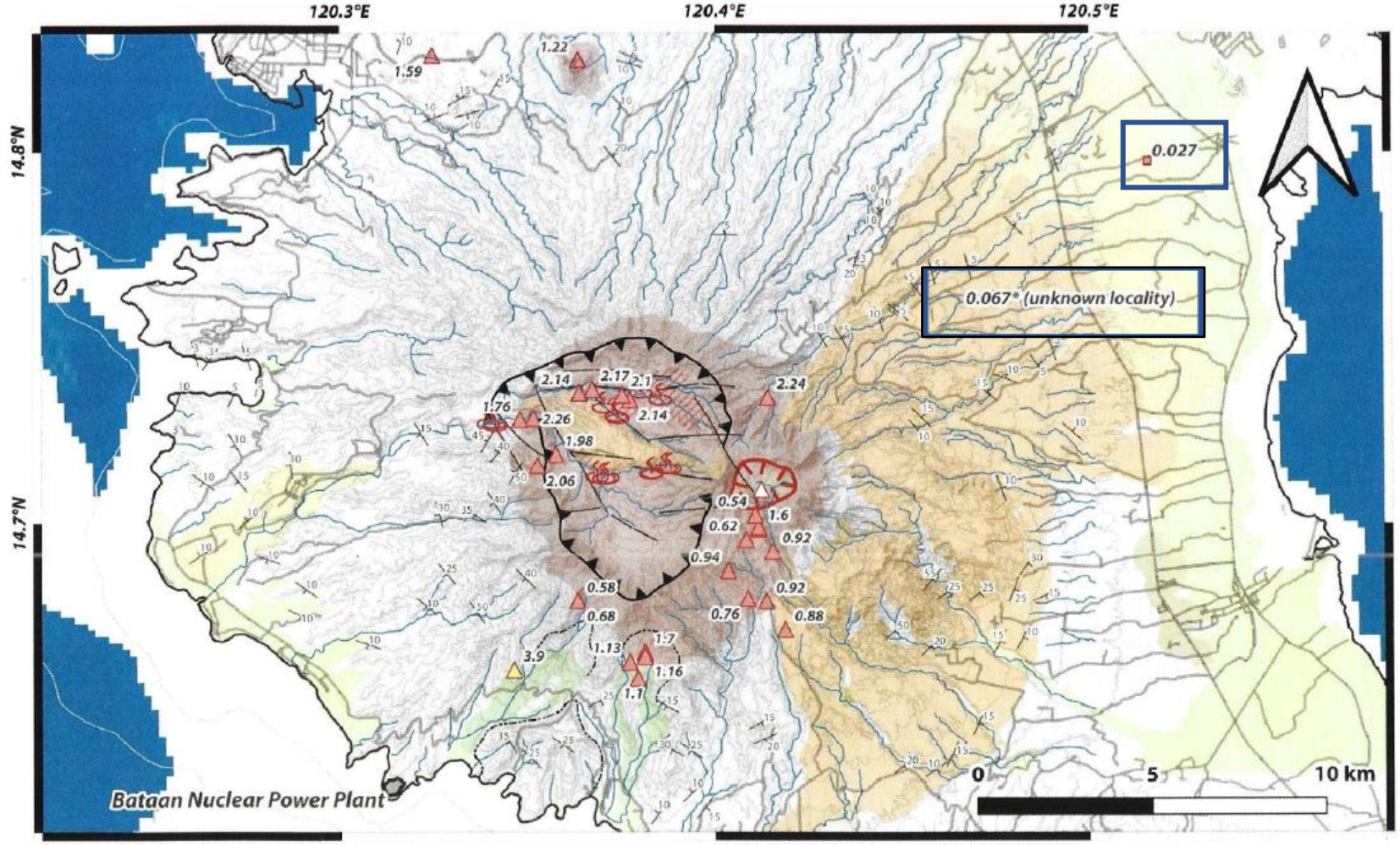
Volcanic Risk

- Age of the volcano in question
- Pyroclastic flows from Mt Natib have been mapped very close to the BNPP
- ONLY TWO reliable age dates :
  - 27,000 (14C, known location) and 67,000- 69,000 years (fission track) Currently searching and testing for charcoal from latest eruption.

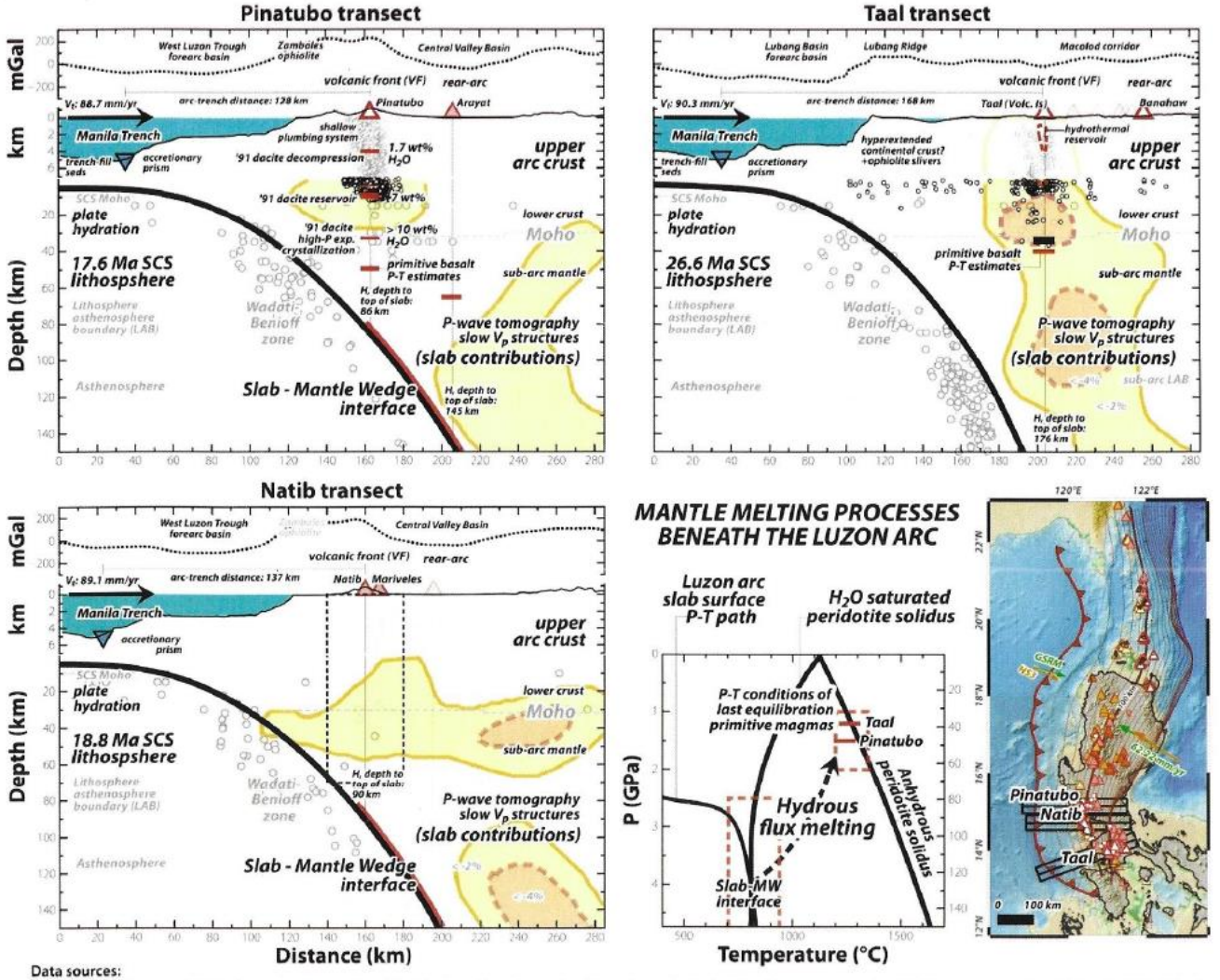
Ages of Philippine Volcanoes



Mt. Natib volcanic age and geology



No volcano seismicity beneath Natib, vis-à-vis very active seismicity beneath Pinatubo and Taal



Data sources:
Slab depths- Hayes et al. 2018, Elevation- Sandwell and Smith 2014, Free-air gravity- Bonvalot et al., 2012, Seismicity- Ramos et al. 1999, You et al. 2013, Engdahl et al. 2020, Seismic tomography and magnetotellurics - Sevilla 2011, Alanis et al. 2015, Subductiong seafloor ages- Seton et al. 2020, Crustal and lithospheric thickness - Besana et al. 1995, Laske et al. 2013, Alfonso and Salajegdeh 2019, SU-PSP plate velocity- DeMets et al. 2010, Petrologically-derived P-T conditions - Arcilla 1998, Rutherford and Devine 1996, Scaillet and Evans 1999, Prouteau and Scaillet 2003, Borisova et al. 2005, Peridotite solidii: Hirschmann 2000, Till et al. 2011, Grove et al. 2012, Slab P-T path: Syracuse et al. 2010

Manila and Clark would not have passed risk criteria imposed by earthquake and volcanic factors!

- If we follow the (defective) reasoning for closing the Bataan Nuclear Power Plant, then the cities of Manila and Angeles (Clark) should have never been built in the first place.

Closure of nuclear facility was very painful economically

- Single largest debt item of the Philippines
- A poor country until April 2007paying $180,000 per day just on interest payments
- Resulted in crippling power failures in the 1990s with untold economic losses
- Crippling power failures opened floodgates to maze of independent power suppliers which has made power very expensive

COMPARING HISTORICAL GDP AND GDP GROWTH RATES WITH A COUNTERFACTUAL THAT ASSUMES BATAAN NUCLEAR POWER PLANT OPERATION, 1988-1993 (JOSEF, 2022)

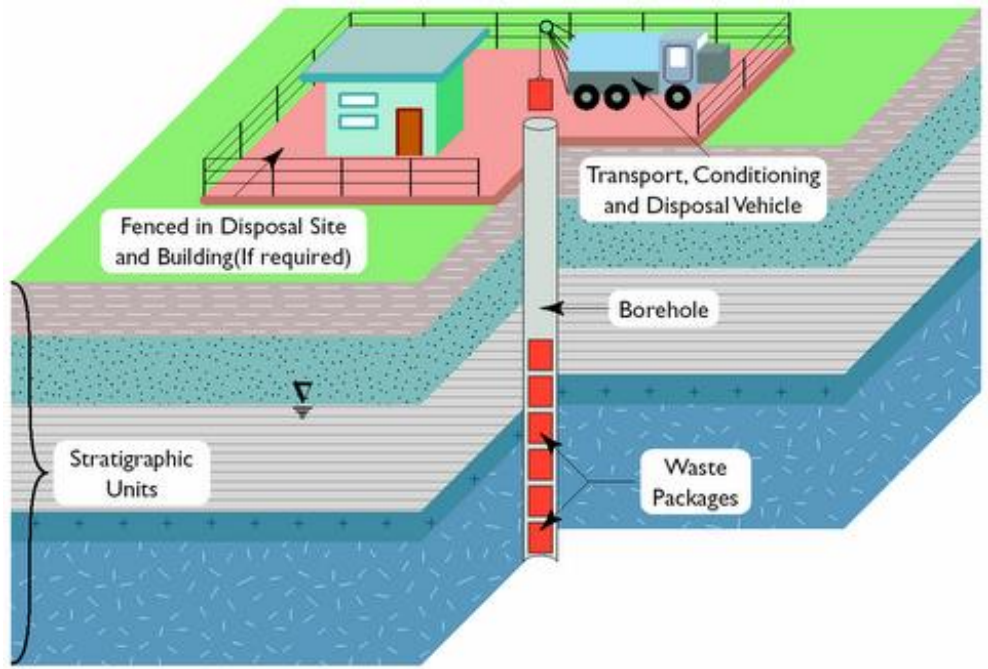
Table 2. Comparing historical GDP and GDP growth rates with a counterfactual that assumes Bataan Nuclear Power Plant operation, 1988–1993.

Year	GDP growth rate	GDP in constant prices (PhP, base year 2018)	Counterfactual GDP growth rate	Counterfactual GDP in constant prices (million pesos, base year 2018)	Actual GDP in US$ (million)	Counterfactual GDP in US$
1988	6.8	4,813,453.58				
1989	6.2	5,112,143.35	6.2	5,112,143.35	42,575.18	42,575.18
1990	3.0	5,267,397.42	5.0	5,367,750.52	44,311.59	45,155.81
1991	-0.6	5,236,934.24	3.0	5,528,783.04	45,417.56	47,948.63
1992	0.3	5,254,614.29	3.0	5,694,646.53	52,976.34	57,412.69
1993	2.1	5,365,818.07	4.0	5,922,432.39	54,368.08	60,007.87

Source of basic data: *World Bank* (*2020*).

Nuclear Waste Management

Borehole technologies



Nuclear waste: Achilles heel of nuclear has technological solution for PHL – deep boreholes

- PHL has technology to drill >2km deep boreholes (from geothermal industry)
- Place waste inside boreholes and plug with bentonite, which will prevent nuclides from reaching surface and groundwater
- Select an isolated island as borehole site which can adequately store ALL future waste SAFELY.

Deep borehole disposal in an isolated island

Challenges

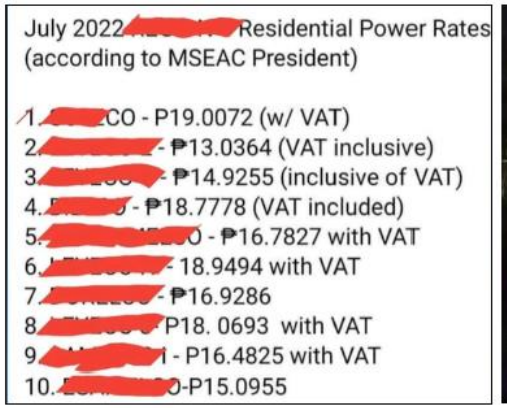
- How to integrate nuclear harmoniously with coal, LNG and other energy players; new nuclear build MUST HAVE electricity buyers
- SMR ownerships should be shared with electric cooperatives to lower electricity costs
- Stakeholder concerns about locating new nuclear power plants “in their backyards”
- Mitigating regulatory and legislative challenges
- Rapid expansion of depleted nuclear human resource base

THE CHALLENGES UNDER THE PRESENT POWER INDUSTRY LANDSCAPE

- EC Franchise are expiring
- Astronomical Cost of Power
- Frequent Power Outages

National Electrification Commission

Certificate of Franchise



July 2022 Residential Power Rates (according to MSEAC President)

1. CO - P19.0072 (w/ VAT)
2. - ₱13.0364 (VAT inclusive)
3. - ₱14.9255 (inclusive of VAT)
4. - ₱18.7778 (VAT included)
5. - ₱16.7827 with VAT
6. - 18.9494 with VAT
7. - ₱16.9286
8. P18. 0693 with VAT
9. - P16.4825 with VAT
10. -P15.0955

Nuclear Program Needs an Empowered
Nuclear Energy Program Implementing Organization

- Strong political will and leadership to forge nuclear program
- Sufficient nuclear contribution to lower electricity rates
- Needs teamwork between DFA and NEPIO in dealing with vendor countries and their regulations
- Nuclear law passage and amendment of laws (e.g. EPIRA) to allow nuclear into the energy mix
- Negotiations with countries to explore Malampaya extension to buy time for nuclear

Availability of scholarships for PhD in nuclear science and engineering

PhD Program

Select a graduate program in a good university anywhere in the world

Get accepted to their PhD program

Recommendation

Ask recommendation from **caarcilla@pnri.dost.gov.ph**

We will ask for FULL FUNDING FOR SCHOLARSHIP from Science Education Institute (SEI)

Slots are still available!

BRIN
BADAN RISET
DAN INOVASI NASIONAL

'The prospects of Small Modular Reactors in Indonesia'

Geni Rina Sunaryo

New Nuclear Watch Institute
Zoom Platform, Tuesday 29 November 2022, 09:00 - 10:30 UK time

DR Geni Rina Sunaryo

Place and Date of Birth, Jakarta, 9 Sep’1962

1994	Doctor, Nuclear Engineering, Fac Engineering *University of Tokyo, Japan*
1990	Master, Nuclear Engineering, Fac Engineering *University of Tokyo, Japan*
1984	Bachelor, Akademi Kimia Analisis, Bogor

2014 – 2020	Director, Center for Nuclear Reactor Safety & Technology, BATAN
2020 – 2021	Principal Researcher, Center for Nuclear Reactor Technology and Safety, BATAN
2021 – present	Principal Researcher, Research Center for Nuclear Reactor Technology, BRIN

Content of Presentation:

1. Indonesian Energy Policy (ESDM)
2. RDE & PeLUITs Lesson Learned
3. Prospect of SMR in Indonesia as Cogeneration NPP Option Strategy for Developing Industry for Indonesia

INDONESIA'S COMMITMENT TO REDUCE Carbon emission

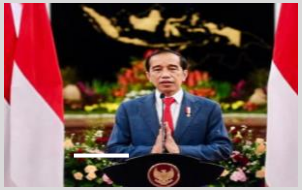
PRESIDENT'S DIRECTIVE

UNFCCC - COP21, DECEMBER 2015

Reducing GHG emission for 29% or **41%** (by international assistance) by **2030** based on NDC.

COP 26, 2 NOVEMBER 2021

Indonesia will be able to **contribute faster to the global Net-Zero Emissions.**



G20 Presidency

"Recover Together, Recover Stronger"

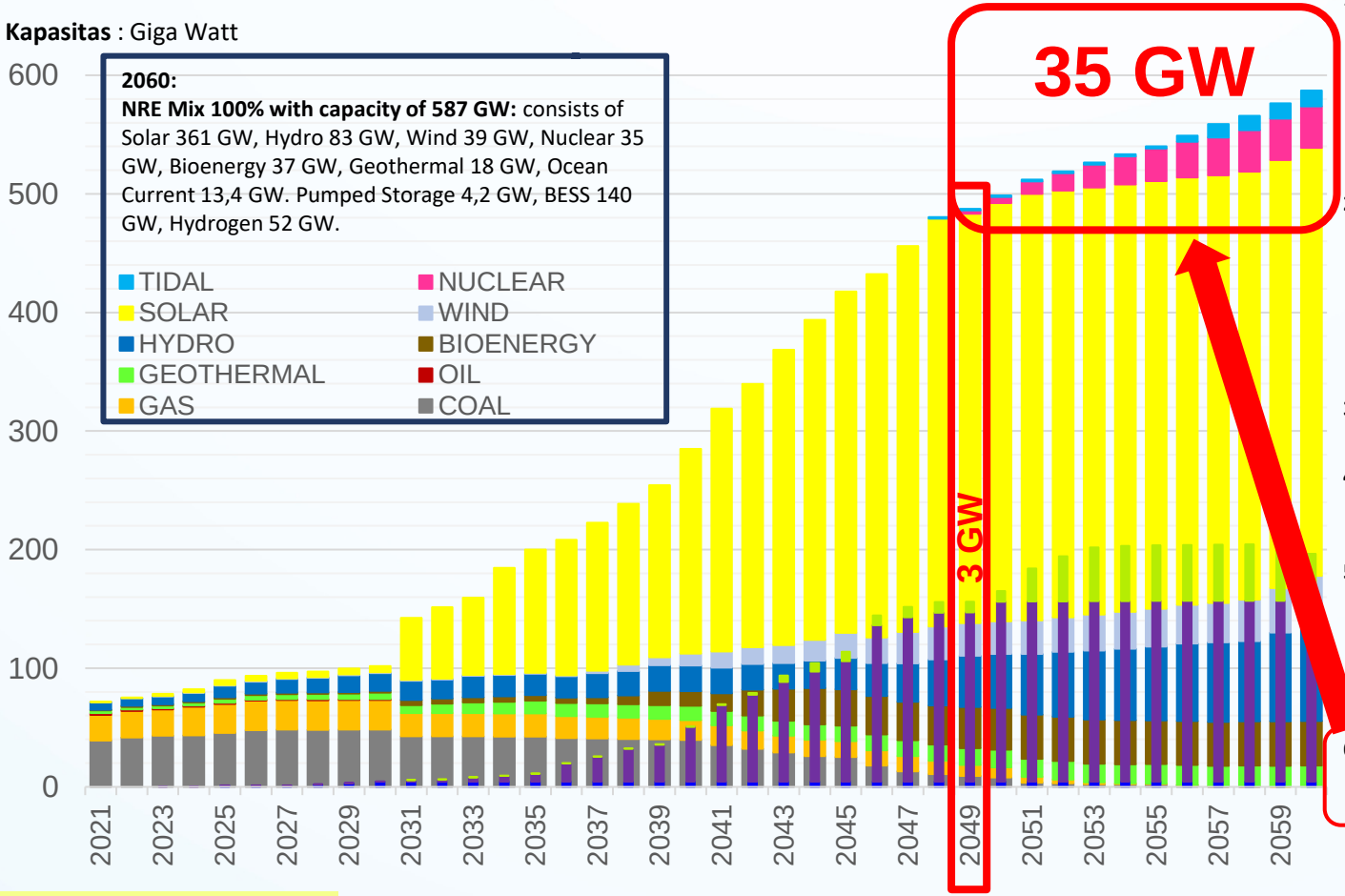
The focus of Indonesia's G20 Presidency lies on 3 main issues:

1. Inclusive Global Health,
2. Digital-Based Economic Transformation,
3. **Transition Towards Sustainable Energy**.

Scenario Note: CM: Counter Measure; CM1: by own effort; CM2: by international assistance; IPPU: industrial processes and production use

ELECTRICITY SUPPLY PLAN

Kapasitas : Giga Watt



1. **Coal/Gas PP:** No additional CFPP unless contracted/under construction. PLN CFPP wil be retired earlier than asset revaluation. IPP CFPP retired after PPA ends. Gas PP retired after 30 years (residual < 1 GW, CFPP: 2057, Gas PP: 2054)
2. **NRE:** Additional power plant after 2030 will only come from NRE. Starting from 2035, will be dominated by Variable Renewable Energy (VRE) in form of Solar PP, followed by Wind PP and Ocean Current PP in the following year.
3. **Geothermal PP:** Maximized up to 75% of potential.
4. **Hydro PP:** Will be maximized and sent to load center in other islands. Serves to balance VRE power plants.
5. **STORAGE:** Pumped storage start in 2025, Battery Energy Storage System (BESS) massively used in 2021. Hydrogen will be utilized gradually starting from 2031 and massively by 2051.
6. **Nuclear PP:** Online to the grid in 2049 to maintain system reliability and will reach 35 GW by 2060.

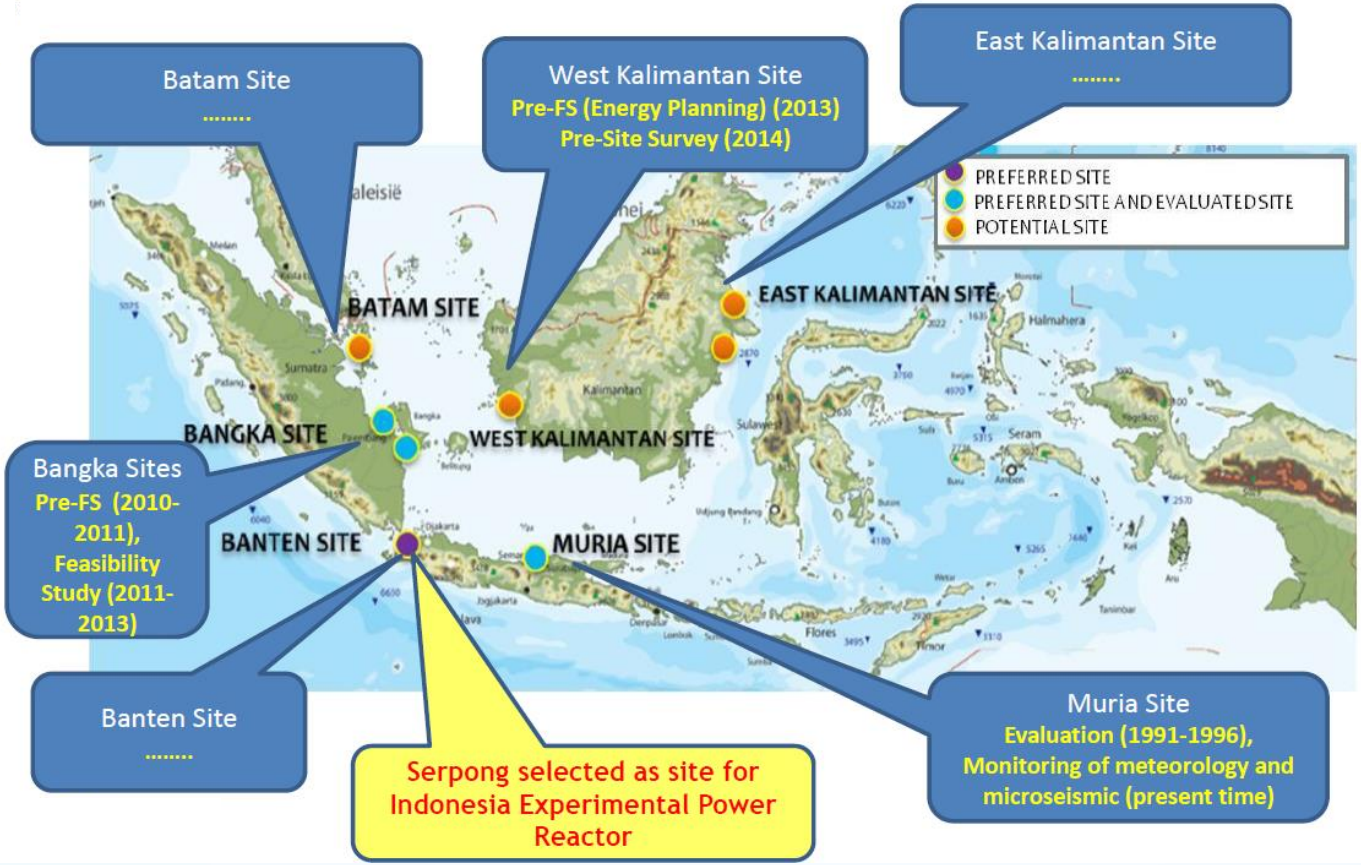
High Electricity Demand Area

Scale Up for High Electricity Generation

Low Electricity Demand Area

SMR Development

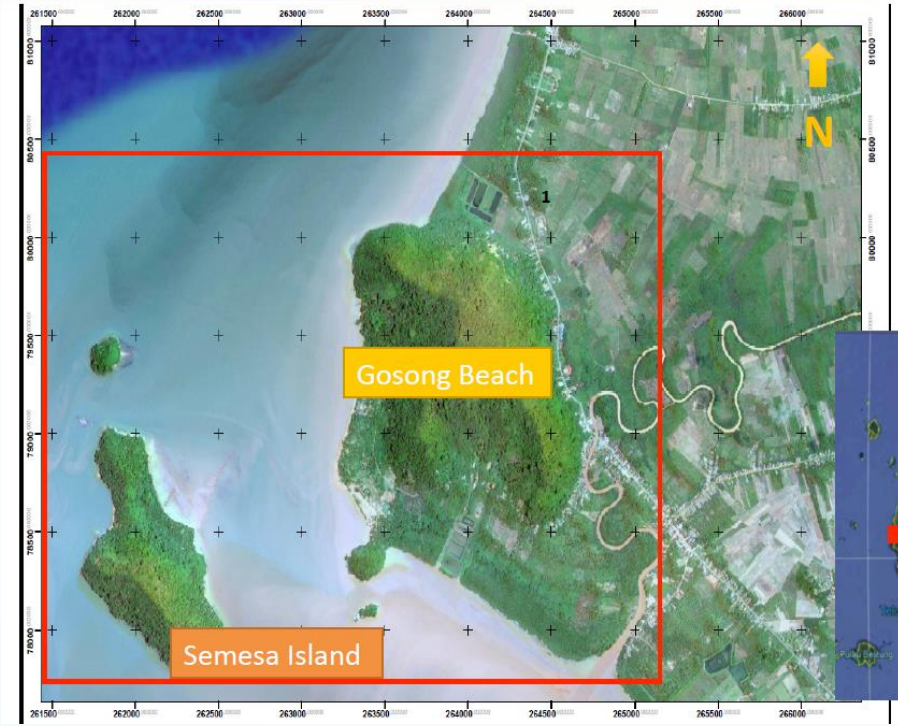
Kegiatan FS & PRA-FS beberapa lokasi di indonesia



What SMR considered?

Preliminary Site study in West Kalimantan

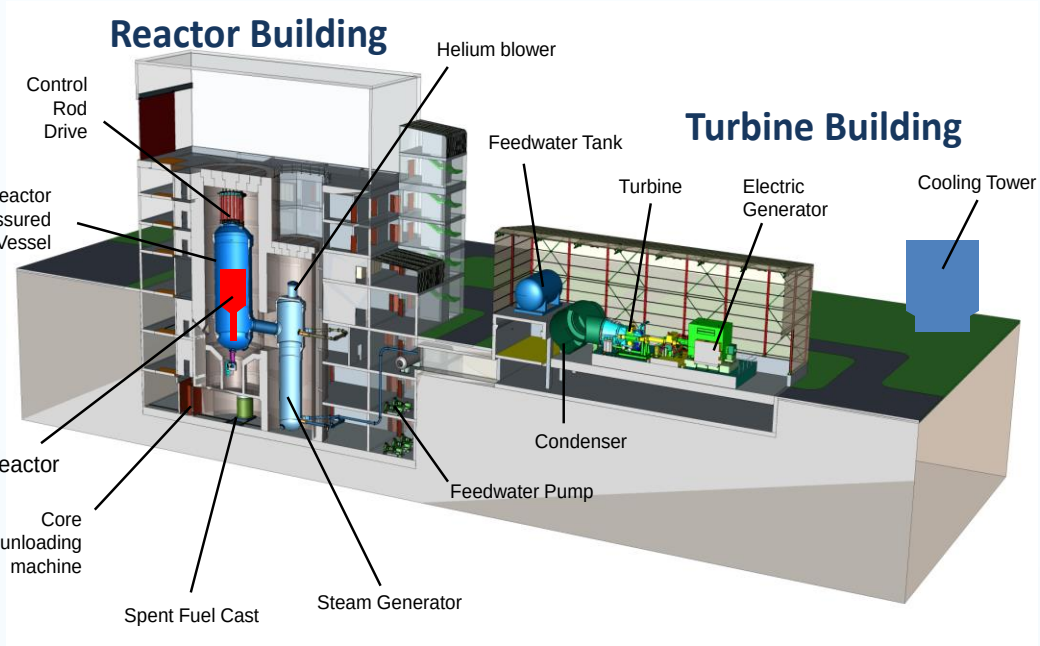
Gosong Beach, West Kalimantan



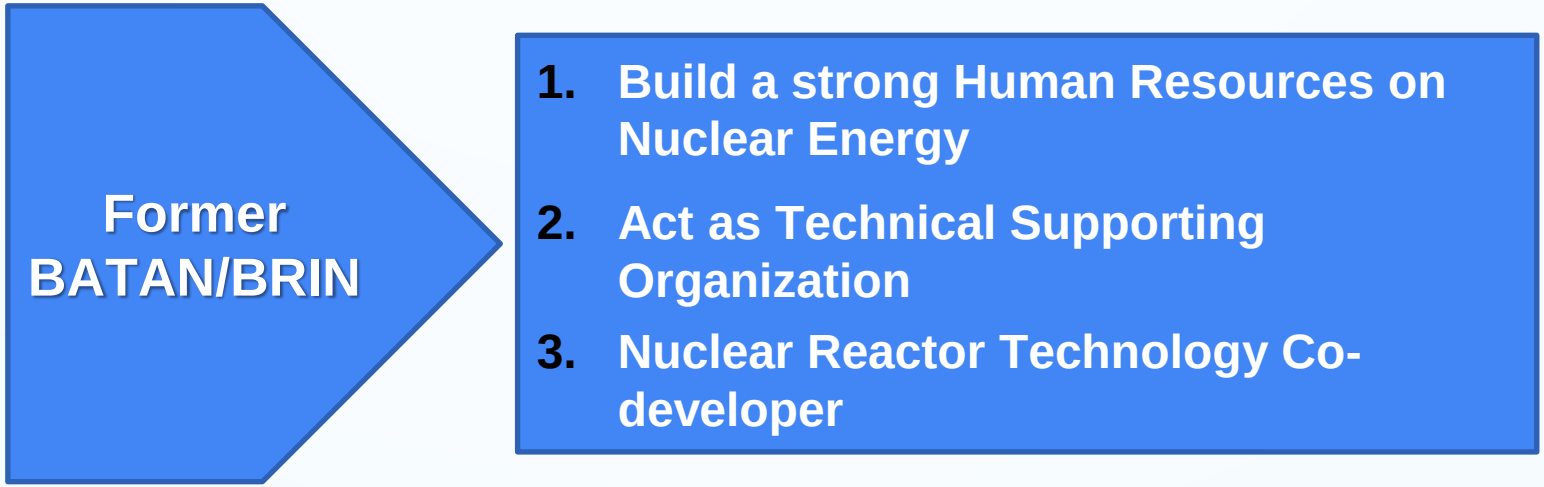
Nuscale?

RDE 10 MWt

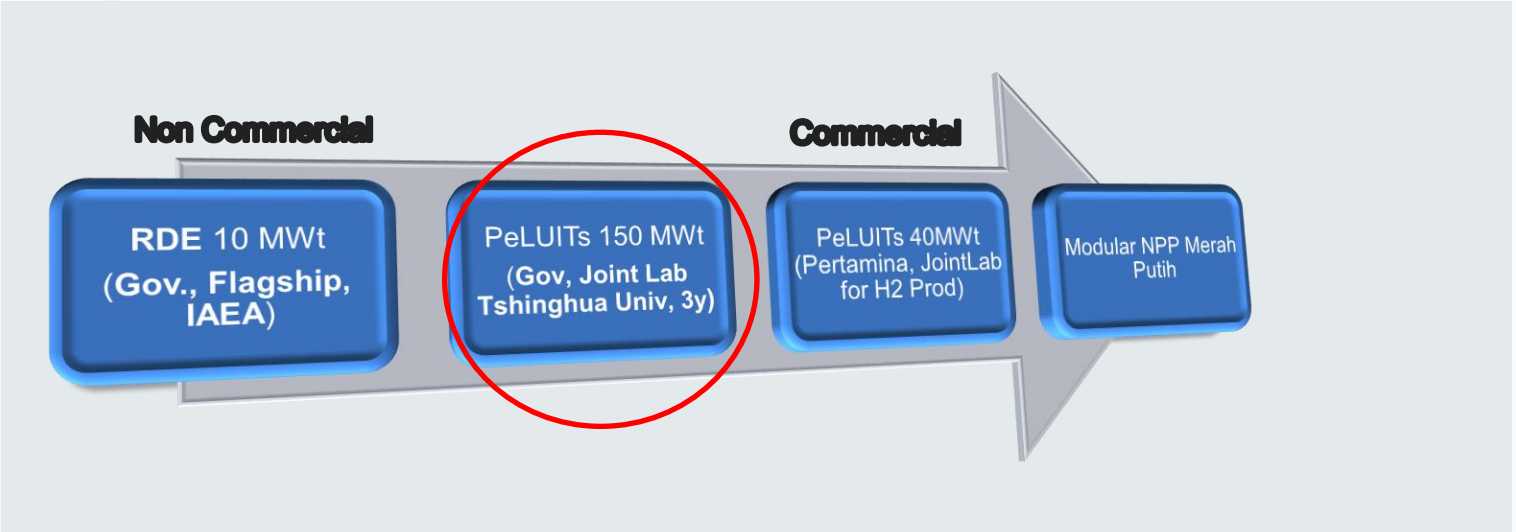
Non-Dieselization?



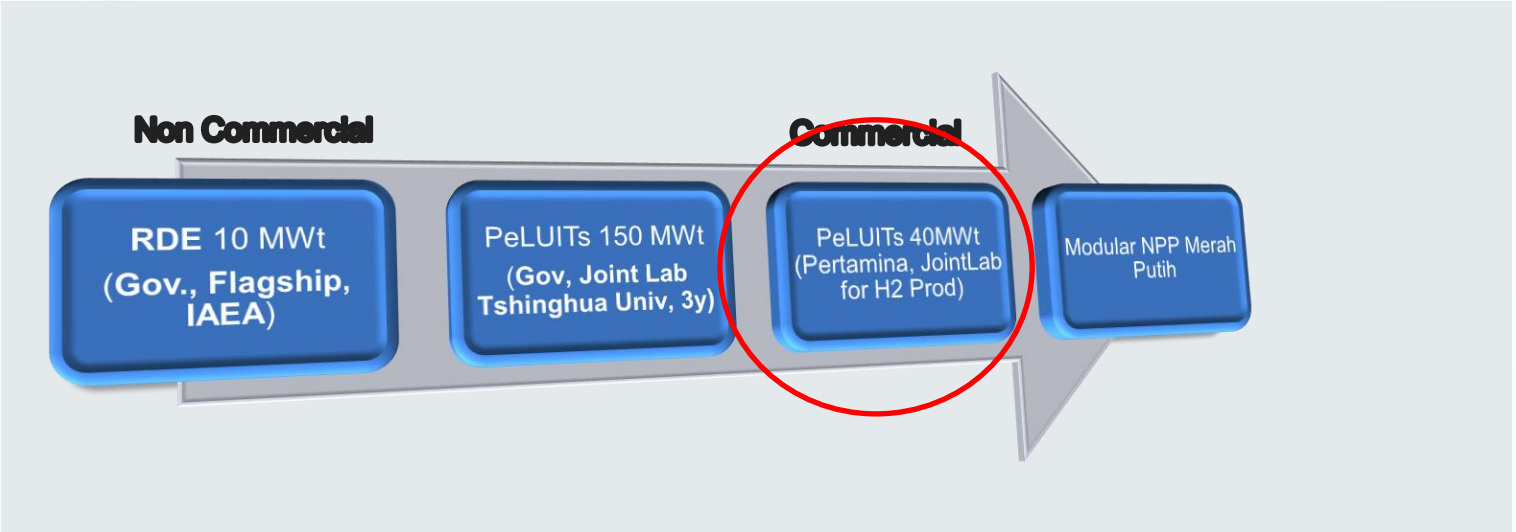
Former BATAN/BRIN's Role as R&D Institution



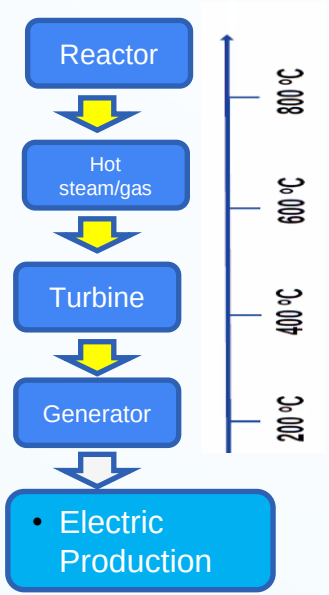
Design development Strategy



Design development Strategy



Co-generation Potential markets



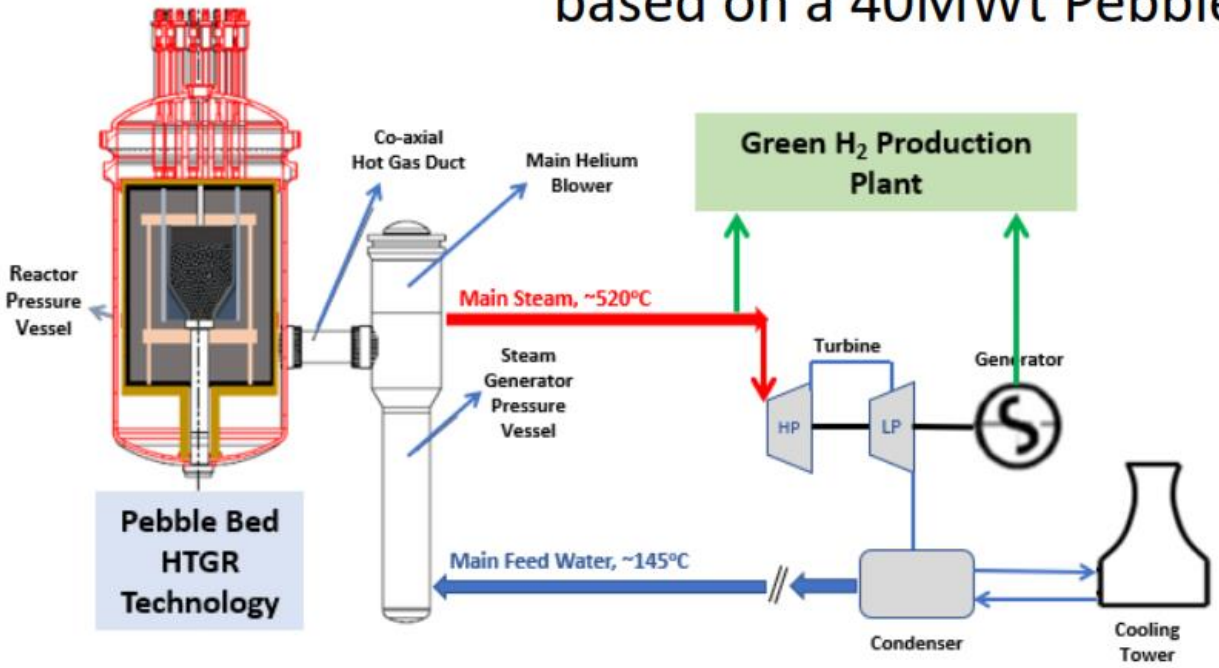
Industrial Process

- Coal Gasifier to produce raw material for industry
- Coal Drying
- Fresh water production – desaiination
- Industrial Salt Production
- Hydrogen Production
- Fertilizer
- Smelter

- **To get Competitive price of electricity**
- **Develop Indonesia industry**

Current Collaboration

Develop a **Zero Emission Hydrogen Production System** based on a 40MWt Pebble Bed HTGR

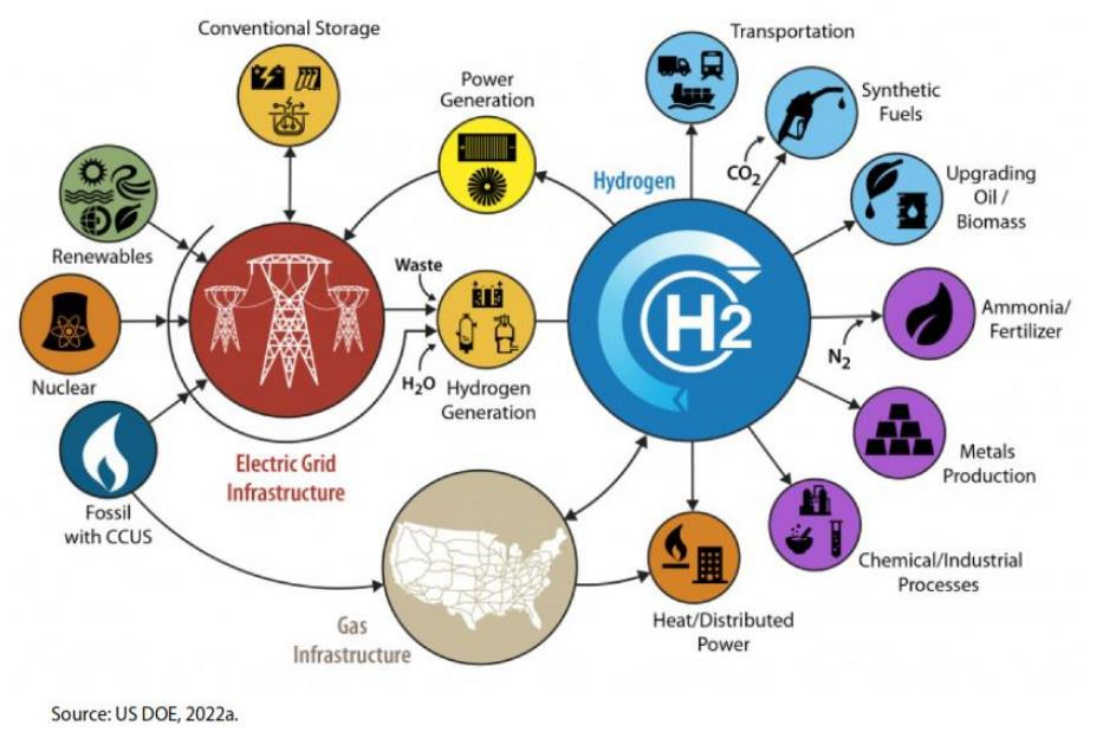


System Performance Target:

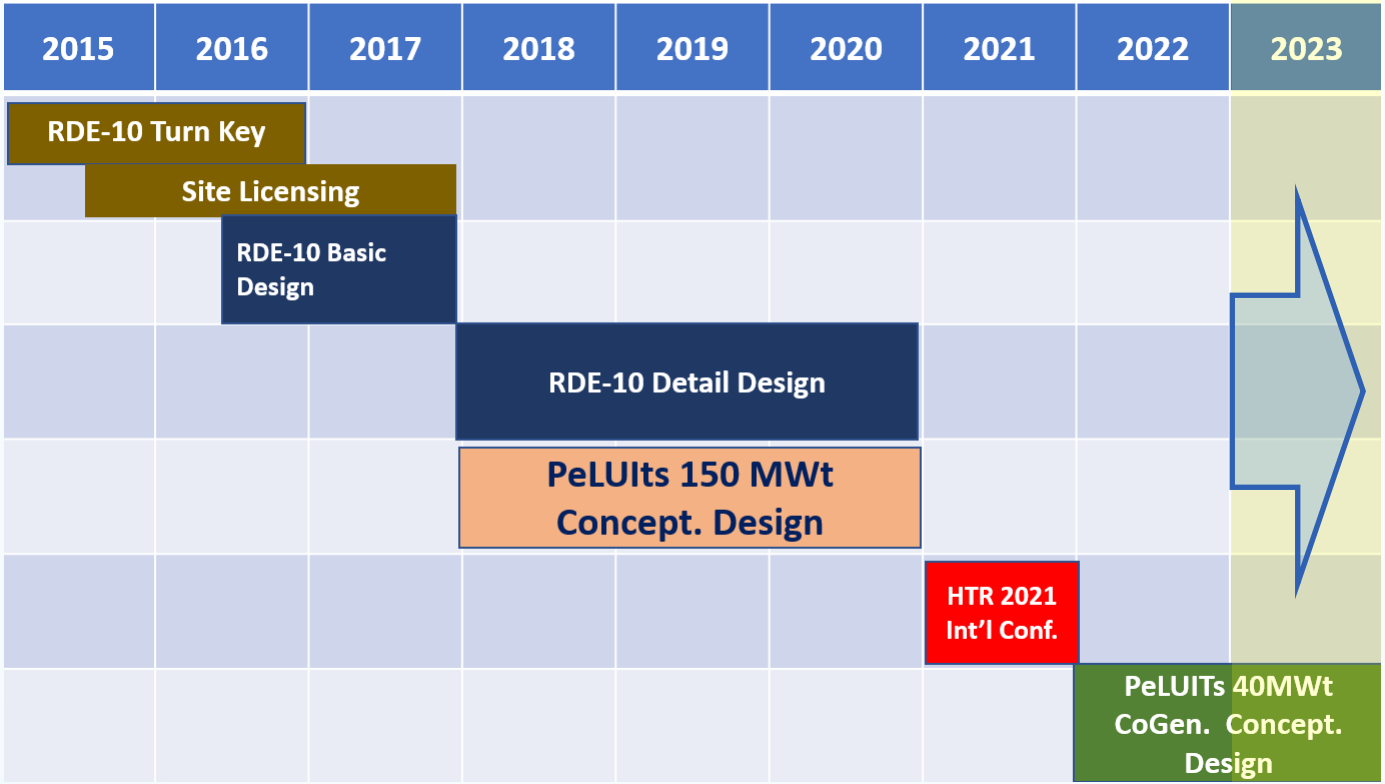
Produce a 2.72k tonnes/year ZeroEmission-H_2 with a cost below **5 USD/Kg**.

You're Cordially invited to joint the collaboration.

Why H_2?


Conventional Storage
Power Generation
Transportation
Synthetic Fuels
Hydrogen
CO_2
Upgrading Oil / Biomass
Renewables
Waste
Ammonia/ Fertilizer
Nuclear
H_2O
Hydrogen Generation
N_2
Electric Grid Infrastructure
Metals Production
Fossil with CCUS
Chemical/Industrial Processes
Gas Infrastructure
Heat/Distributed Power
Source: US DOE, 2022a.

2. HTGR Based, Design Activities

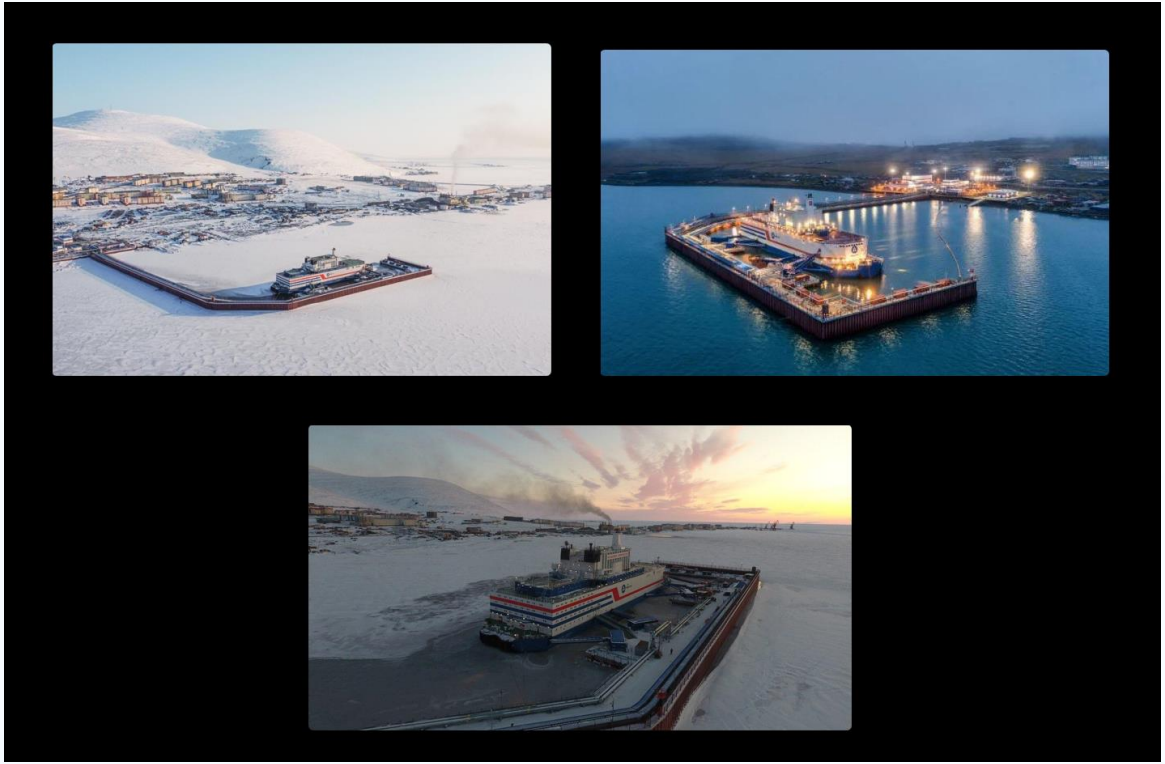


High Electricity Demand Area

Scale Up for High Electricity Generation

Low Electricity Demand Area

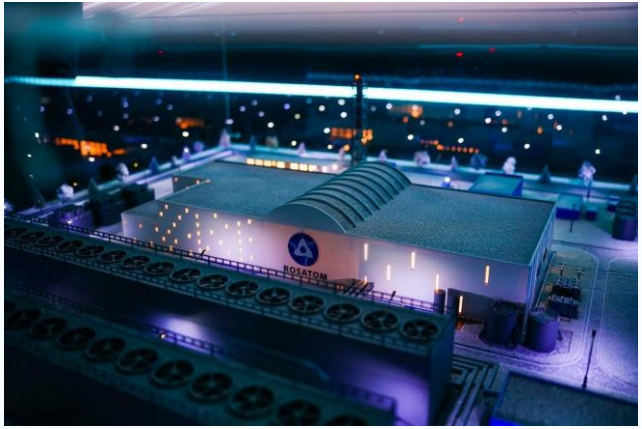
SMR Development

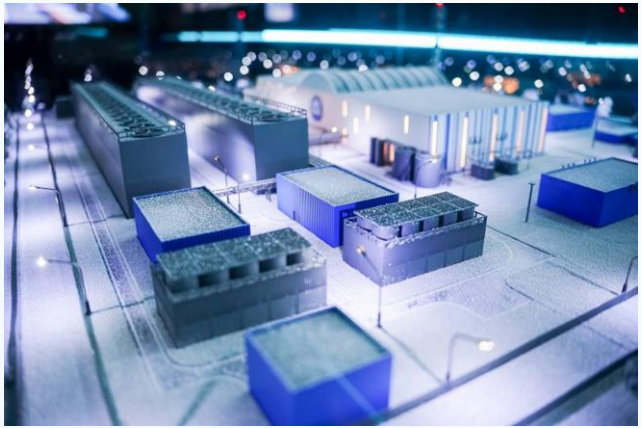


The world’s first floating nuclear power plant Akademik Lomonosov

Floating Nuclear Power Plants (FNPP) Akademik Lomonosov with two small modular reactors (two KLT-40S reactors, with capacity 35 MWe each)

- Generating electricity and heat
- Commissioned in 2019 in Russia’s northernmost town of Pevek
- The total capacity of the FNPP is up to 77 MW of electricity and 146 Gcal/h (300 MW) of heat
- With a displacement of 21,500 metric tons, 140 meters long and 30 meters wide.
- Its design life is 40 years; the repair interval is 12 years.





Rosatom First onshore SMR based on the same **RITM-200N** SMR will be deployed in 2028, in the northern Russian region of Yakutia.

- The plant will supply power to a gold mining facility at the Kyuchus gold deposit.
- The construction site has been selected, and the work is ongoing to design the plant.
- Two years of engineering surveys are coming to an end – application documents for the site license received a positive opinion from environmental experts, and erection of a construction camp began.
- Detailed design will be submitted for a site license by the year end.

RITM-200S Rosatom's second floating nuclear power plant

- consisting of four floating units based on RITM-200S nuclear reactor is under construction.
- The power capacity of a two-reactor FPU will be 106 MWe.
- Same dimensions as Akademik Lomonosov for each unit. However, the turbine will be more powerful. Dedicated to generate electricity only.
- A smaller crew compartment since some of the functions will be relocated onshore.
- Another difference is absence of the refueling area – reactors will be refueled at Atomflot's naval base in Murmansk in a manner similar to nuclear icebreakers.
- Status : Orders for key components have already been placed with manufacturers.
- The first two FPUs are expected by the end of 2026 with the remaining two to be ready by mid-2031.
- RITM is a tried-and-tested, Rosatom flagship SMR technology, which is installed at three latest operating icebreakers. Small modular reactors from the RITM series are built on the back of 4 generations (equivalent to more than 400 reactor-years) of experience developing and operating icebreaker fleet reactors.
- It is being built for the Baimskaya ore zone in Russia, which is a mining project that has the world's largest deposits of copper and gold, which is going to be explored for 40 years.

Rosatom microreactor is called **SHELF-M**.

- It has an electrical capacity of up to 10 MW, a long refueling cycle of 8 years and design life of 60 years. Such reactors are fully factory built and installed on-site. They can be quickly shipped to and removed from site. They are so small that could be transported by a truck.
- The detailed technical design of the reactor systems and equipment for the first small nuclear power plant with SHELF-M reactor will be finalized by the end of 2024.
- The first plant is expected to be put in operation in 2030.

CONCLUSION

- **RDE**, **PeLUITs** 150 and 40MWt, are the Indonesia SMR activities as BEST Lesson Learned on enhancing Capability of Human Resources - as a Techn Providers and TSO for NPP.
- Nuscale, Akademik Lomonosov, RITM-200N, RITM-200S, SHELF-M are most considered as SMR cogeneration - **INDUSTRIAL COGENERATION PLANT,** as a smart approaching strategy for developing Green industry in Indonesia – to achieve NZE at 2060.

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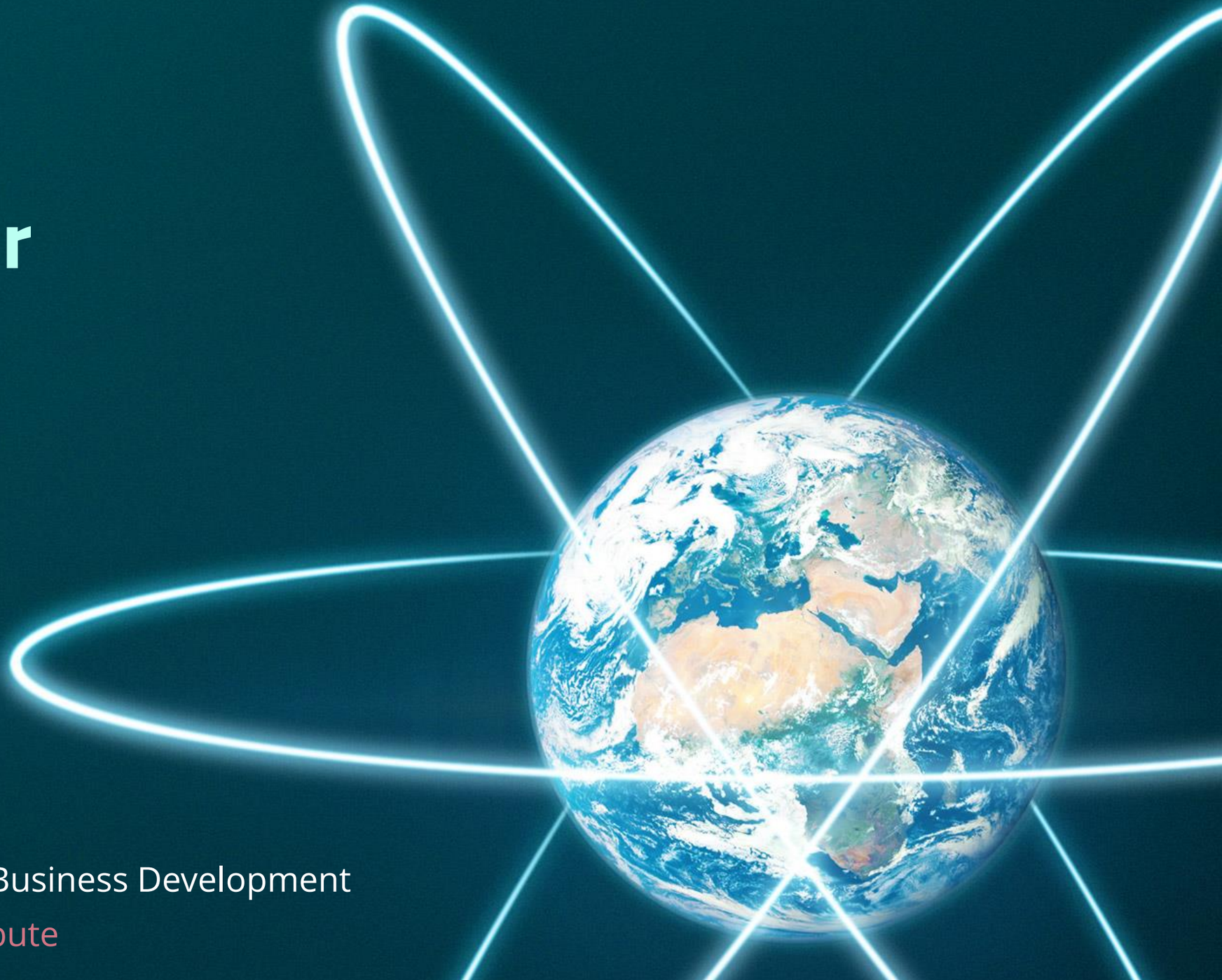
NNWI Webinar



29.11.2022

Nikolaj Ager Hamann, Head of Business Development

Seaborg in a Nutshell

Founded in **2014**

Privately held and privately funded

120+ employees

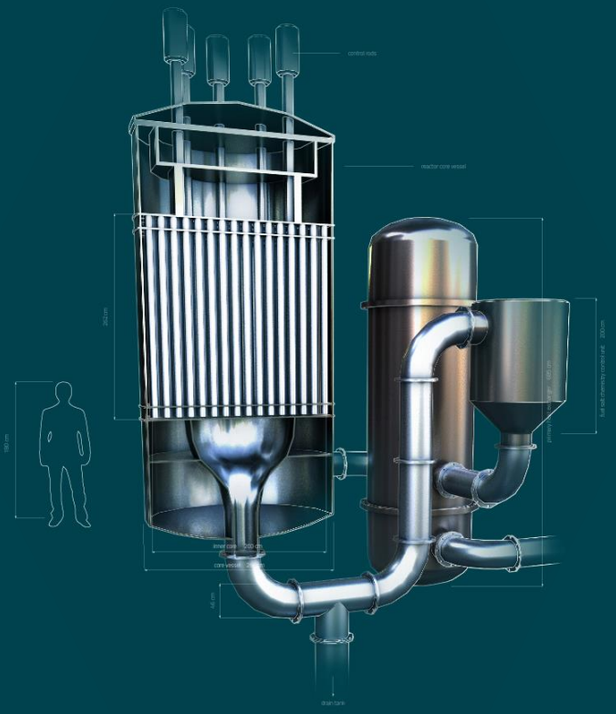
25 nationalities

HQ in Copenhagen, Denmark

Business offices in South Korea & Singapore

Partnerships with shipyards, nuclear players and heavy industry

Scalable next-generation nuclear on power barges



Developing

The Compact Molten Salt Reactor

- Small modular nuclear reactor
- Mass produced
- Deployed on barges
- 200-800 MWe Power Barges
- +88% Capacity Factor
- Inherent safety characteristics due to the properties of the salt

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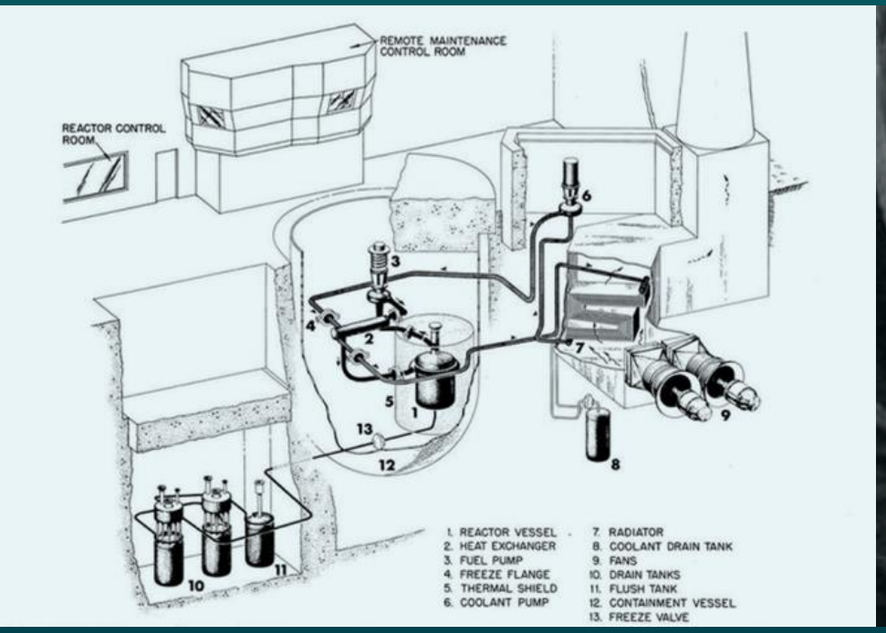
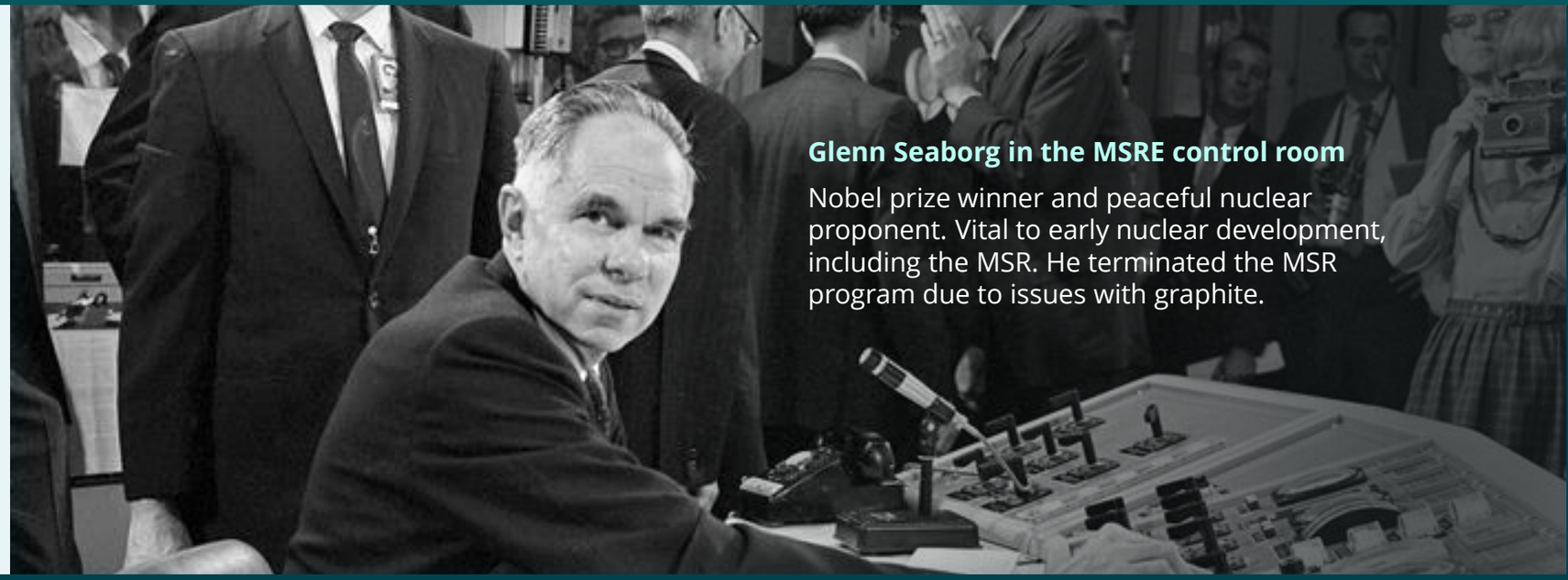
Molten salt reactor technology is nothing new





Glenn Seaborg in the MSRE control room

Nobel prize winner and peaceful nuclear proponent. Vital to early nuclear development, including the MSR. He terminated the MSR program due to issues with graphite.

1st MSR

Operated for a few weeks in 1954 at Oak Ridge National Lab, USA.

2nd MSR

Operated for a year and a half during 1965-1969 at Oak Ridge National Lab, USA.

3rd MSR

Operated 1970-1971, China (first ever Chinese nuclear reactor).

But it was never commercialised...

A new solution to an old problem

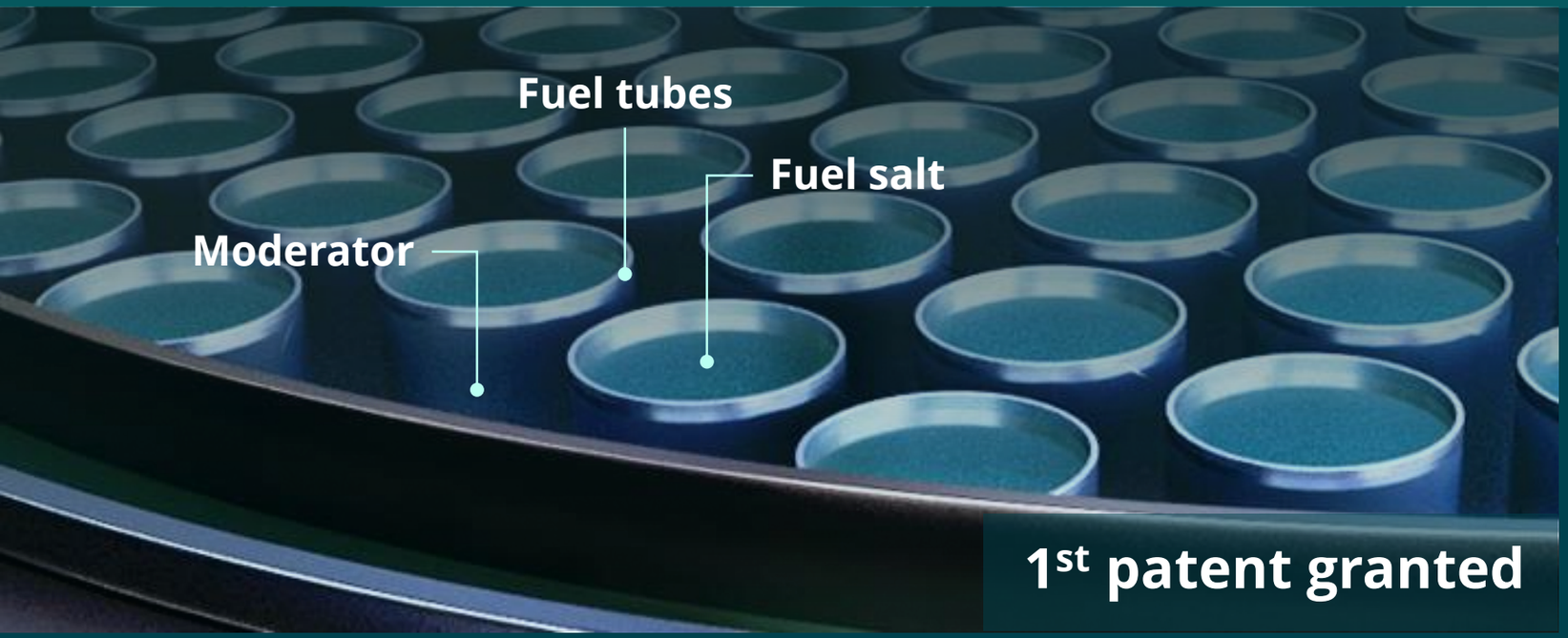
MSRs were never commercialized.

Graphite was used as a moderator. ➡ Encountered graphite **cracking** under irradiation.

Seaborg's **proprietary moderator** avoids the use of graphite and gives us a **unique** compactness in the design.

The Seaborg Solution

Liquid moderator



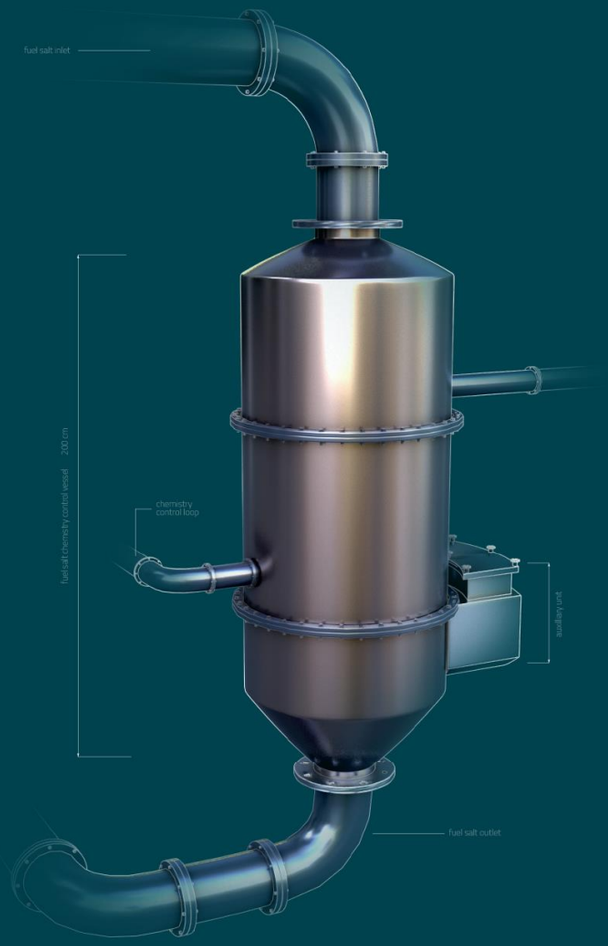
1st patent granted

NaOH

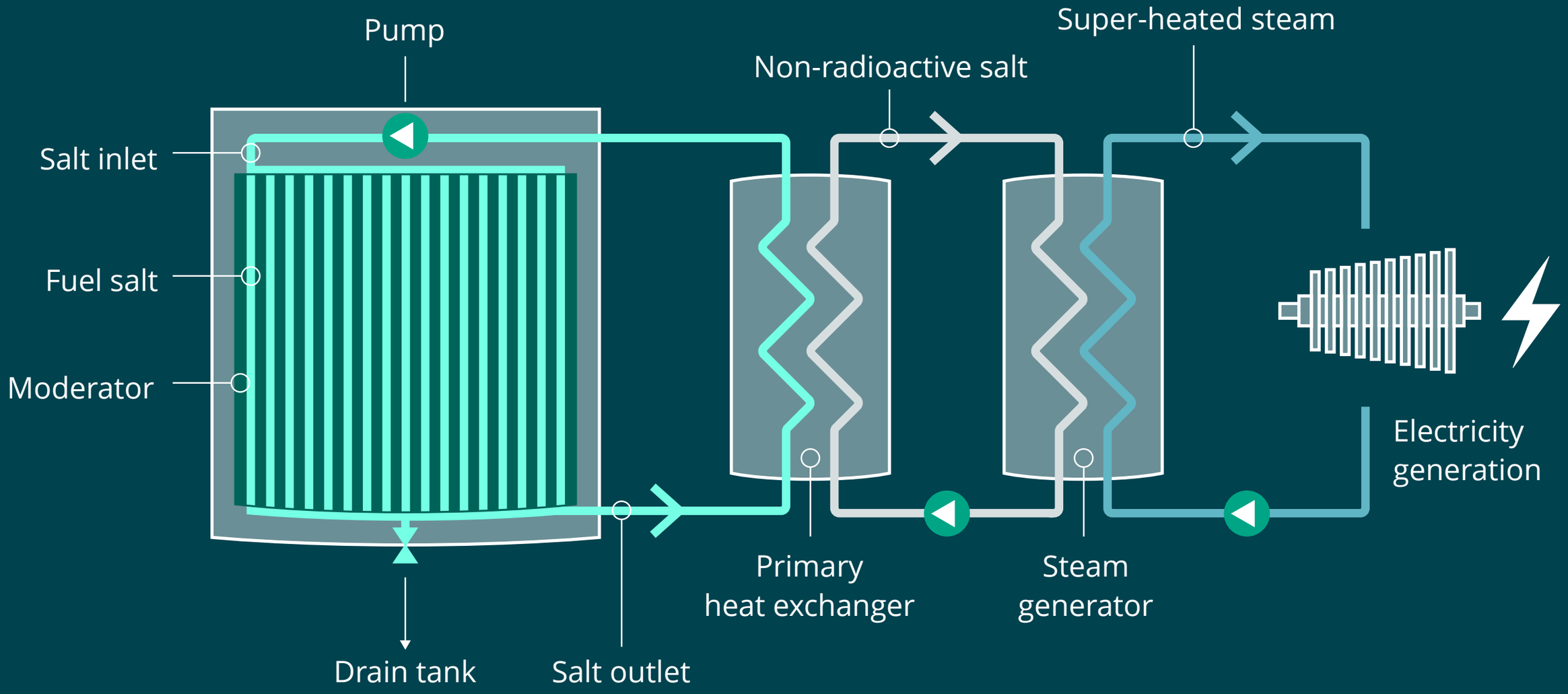
(sodium hydroxide)

Applied in: SEABORG hyme

Chemistry control unit



The Compact Molten Salt Reactor

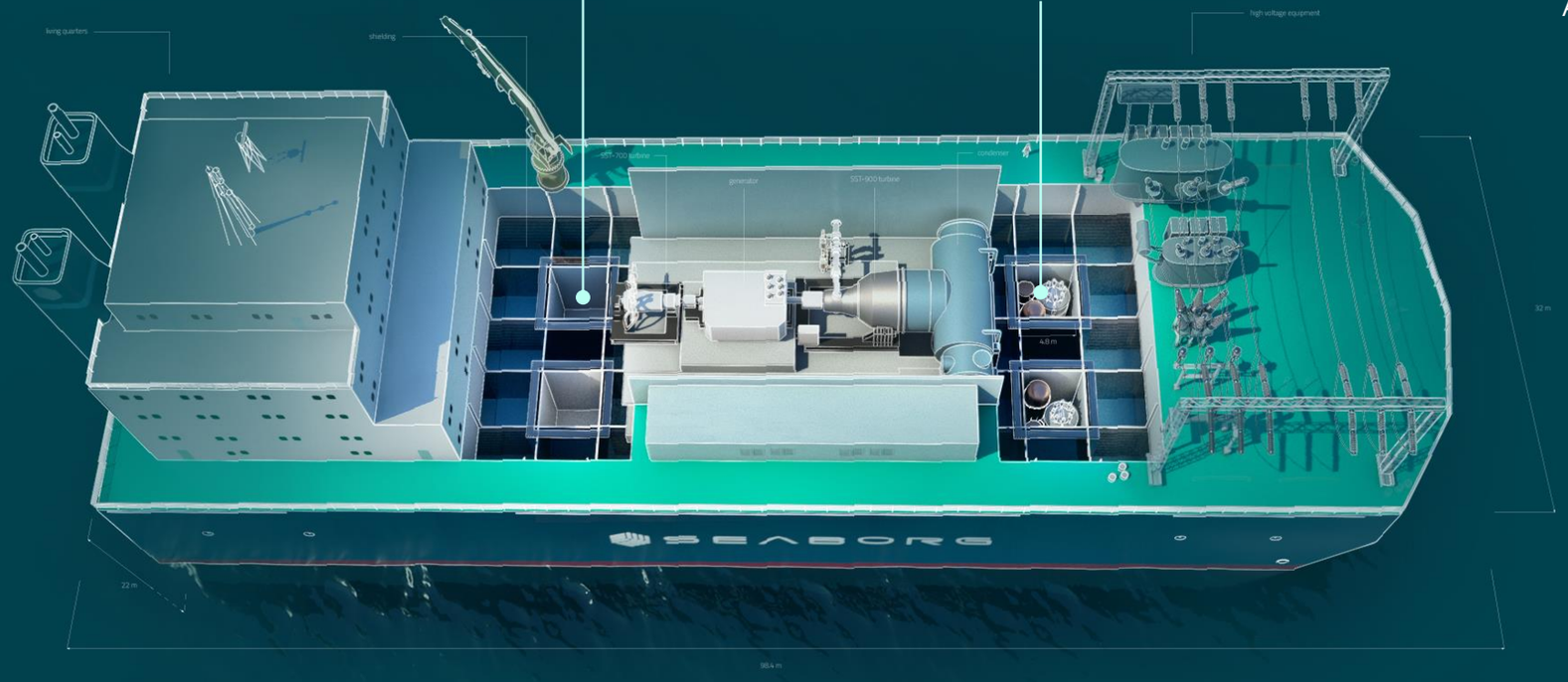


Inside the Power Barge

24 years operational life time

Two empty CMSR compartments
for the **second 12-year fuel cycle**

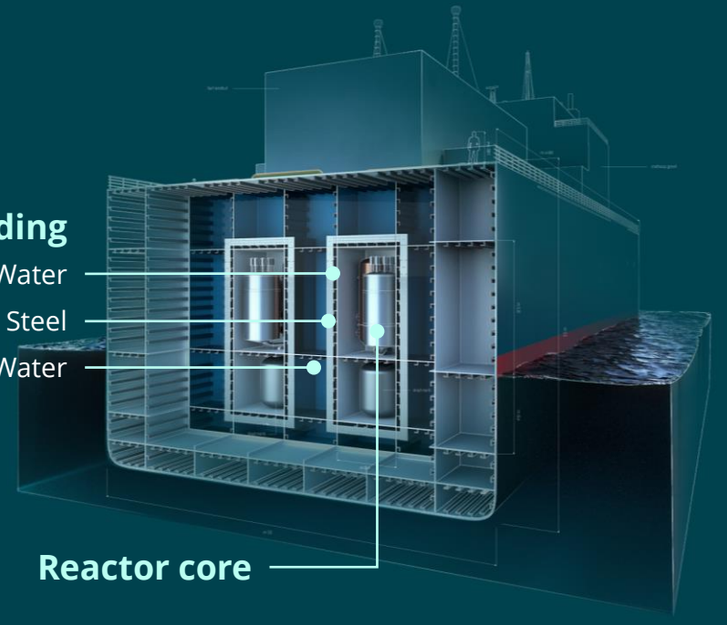
Two CMSRs for the
first 12-year fuel cycle



Accommodation
Control centre

Power module
200 MWe

HV substation



Shielding

Water

Steel

Water

Reactor core

SEABORG

Delivering Energy

Centralised construction, worldwide distribution

South Korea

Built and commissioned at Samsung shipyard

Power Barge
Standardized modular production

CMSR
2/4/6/8 CMSRs x 100 MWe each

The world

Flexible deployment worldwide

Tow to site of fully **tested** and **commissioned** Power Barge

24 year operational life cycle

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Maritime licensing approach

UN authorities

IMO
The International Maritime Organization

IAEA
The International Atomic Energy Agency

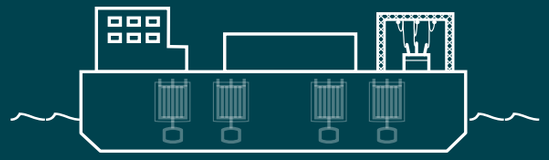
Rules & regulations

Guidelines

ABS
Independent verification

Flag state
Responsible for assuring the safety of the Power Barge

Approval



Safeguards inspections

Global licensing partners

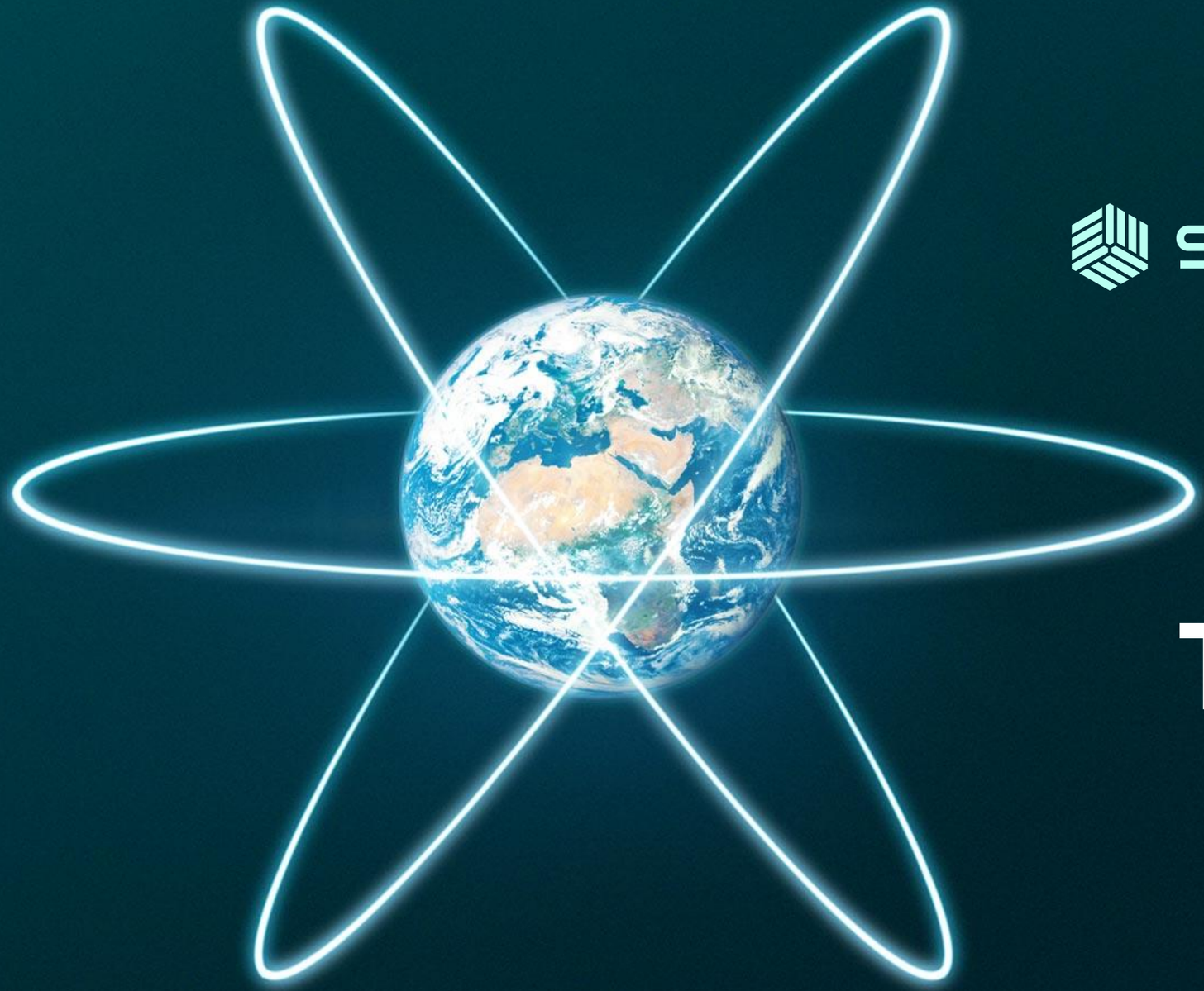
Competent regulators

Local authorities

Nuclear regulations

Port state control

Adapt UN guidelines to local regulation



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Rethinking nuclear

Thank you

www.seaborg.com

Chaired by Tim Yeo, New Nuclear Watch Institute

Q&A Discussion The prospects of small modular reactors in Southeast Asia

- Alfred Christopher Gurning, Technical Officer and Expert in Civilian Nuclear Energy and Clean Coal Technology, **ASEAN Centre for Energy (ACE)**
- Victor Nian, Chief Executive Officer, **Centre for Strategic Energy and Resources**
- Dr Carlo Arcilla, Director, Department of Science and Technology, **Philippine Nuclear Research Institute**
- Geni Rina Sunaryo, Principal Researcher, Research Center for Nuclear Reactor Technology, **National Innovation and Research Agency (BRIN)**
- Nikolaj Ager Hamann, Head of Business Development, **Seaborg Technologies**