FNCA 2023 Study Panel: Outlook of Next Generation Reactors Development

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Nuclear power in Viet Nam:
Future prospects for introduction of advanced nuclear power reactors

Nhu Viet Ha Pham[1,2], Chi Thanh Tran[2]

[1]Institute for Nuclear Science and Technology (INST),

[2]Vietnam Atomic Energy Institute (VINATOM)

Presentation outline

1. Nuclear power program in Viet Nam
2. Role of nuclear power in energy transition
3. Future prospects for advanced reactors
4. Concluding remarks

1. Nuclear power program in Viet Nam

1976 — Establishment of National Atomic Energy Institute (VINATOM now)

1979 — Establishment of Dalat Nuclear Research Institute (DNRI), based on the Research Reactor (TRIGA Mark II) which was built and started operation in 1963

1984 — **Study on first NPP introduction into Vietnam**

1996-2002 — **Operation of Dalat Nuclear Research Reactor (DNRR)**

2002-2009 — Establishing Vietnam Agency for Radiation and Nuclear Safety (VARANS)

2003 — **Pre-FS on construction of first NPPs**

2008 — Atomic Law was approved (to be changed)

2010 — **Contracts for Ninh Thuan 1 (NT1) and Ninh Thuan 2 (NT2) NPPs Feasibility Studies (FS)**

Dec. 2013 — **Completion of FS (NT1 and NT2)**

Nov. 2016 — **National Assembly decided to postpone the NPP projects**

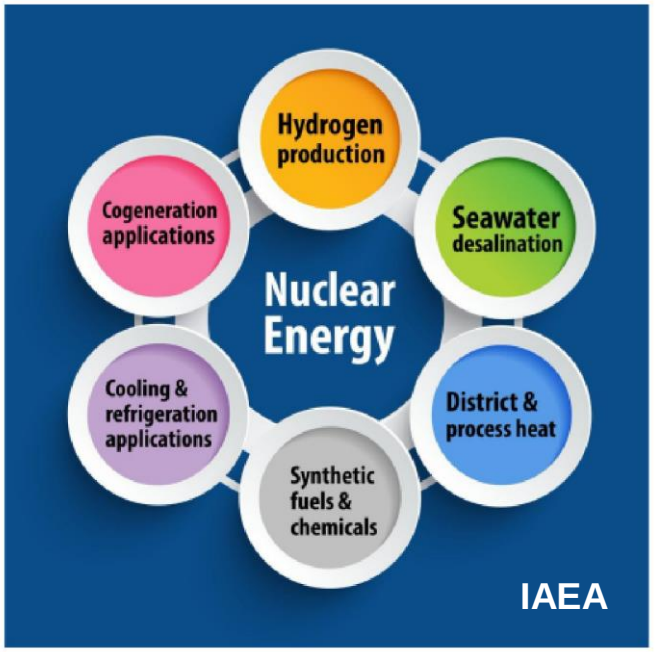
Current status after NPP projects

- **Deploying the Center for Nuclear Science and Technology, CNST (MOST and VINATOM) during 2018-2026**
  - New research reactor (RR) with power of 10 MW, imported from Russia
  - Feasibility Study (FS) stage: planned from 2023
- **Viet Nam targets carbon neutrality by 2050**
  - In 2020, the Party passed Resolution No. 55 on "Vietnam's National Energy Development Strategy Orientation to 2030 with a Vision to 2045", creating a political basis for Vietnam's transition to renewable energy.
  - Commitments of Viet Nam at COP26 (2021)
  - Vietnam's Just Energy Transition Partnership (JETP): political declaration (Dec. 2022)
  - Power Development Plan 8 (PDP8) for the period of 2021-2030 with a vision to 2050 for clean energy transition (approved May 2023)
  - Viet Nam may reconsider nuclear power?

✓ **Tendency:** new RR; advanced light water reactors; SMRs; Gen-IV reactors; nuclear power R&D; HRD in nuclear power.

2. Role of nuclear power in energy transition

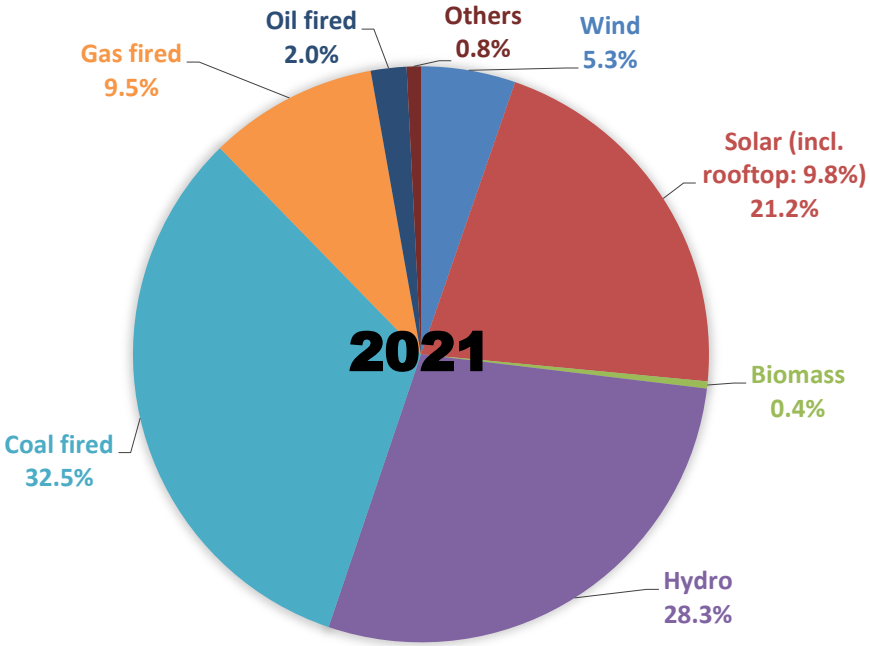
- **Towards global net-zero emissions**
  - Nuclear re-appreciation in the context of climate change and Russia-Ukraine war
  - Nuclear and innovations, e.g., SMRs and micro reactors, can help tackle climate change, enhance energy security and contribute to achieving the UN SDGs.
- **Climate commitments of Viet Nam**
  - Phasing out coal by 2040s
  - Net-zero emissions by 2050



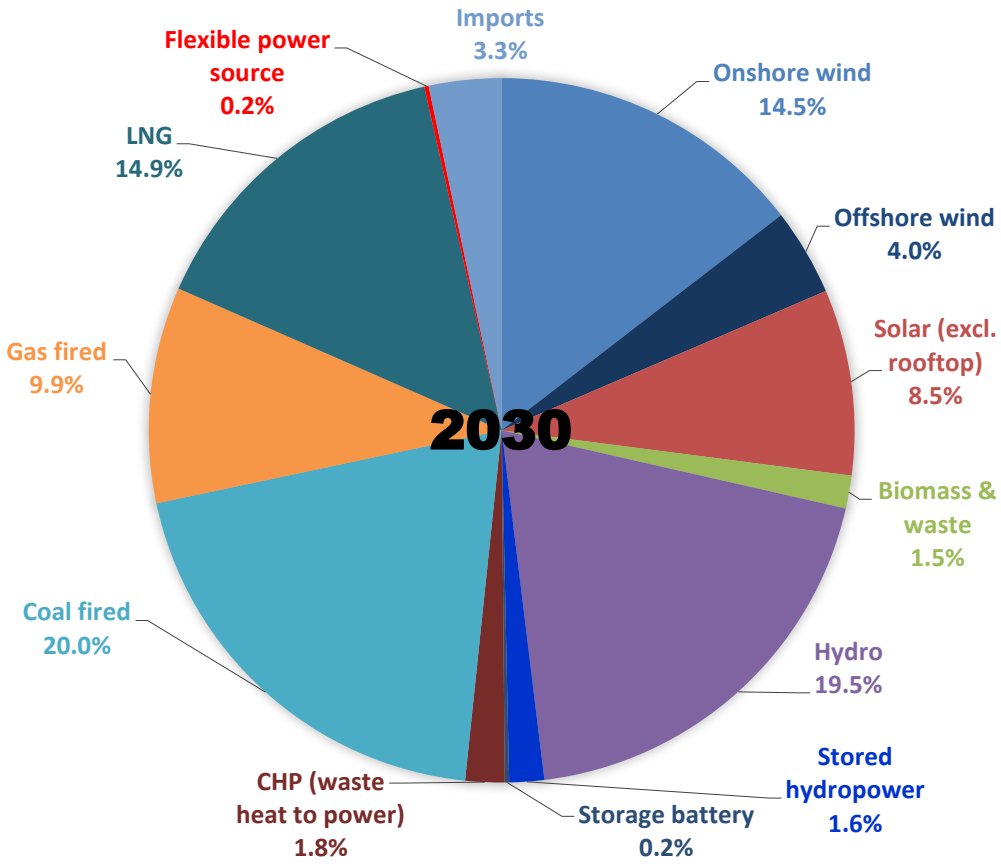
Power Development Plan 8 – by 2030

- Increase renewables to 30.9-39.2% share of the capacity by 2030
- Reduce coal dependency to 20% share by 2030

✓ Nuclear power is not mentioned in PDP8.



2021 power structure
(total capacity: 78,121 MW)
Source: PECC2

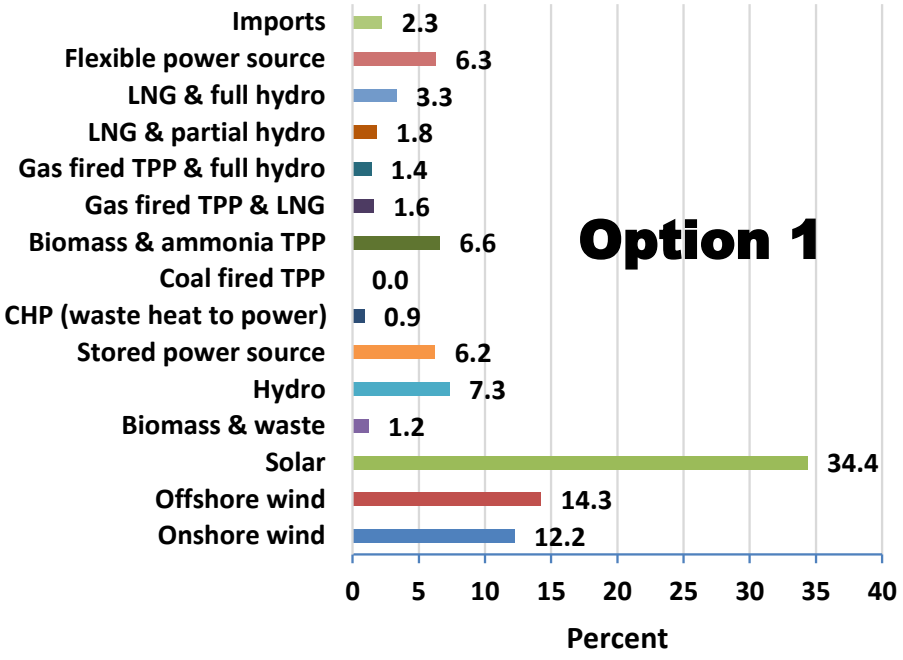


2030 projected power structure
(total capacity: 150,489 MW)

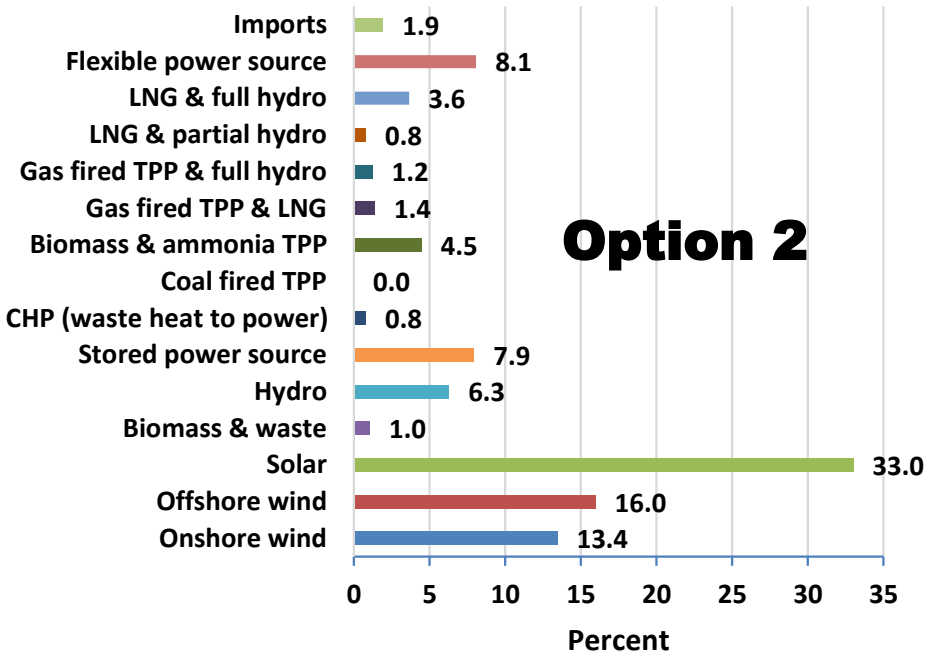
Power Development Plan 8 – oriented by 2050

- Strong transition to renewables: 67.5-71.5% share by 2050
- Phase out coal by 2050

✓ Nuclear power can play a crucial role in the energy transition.



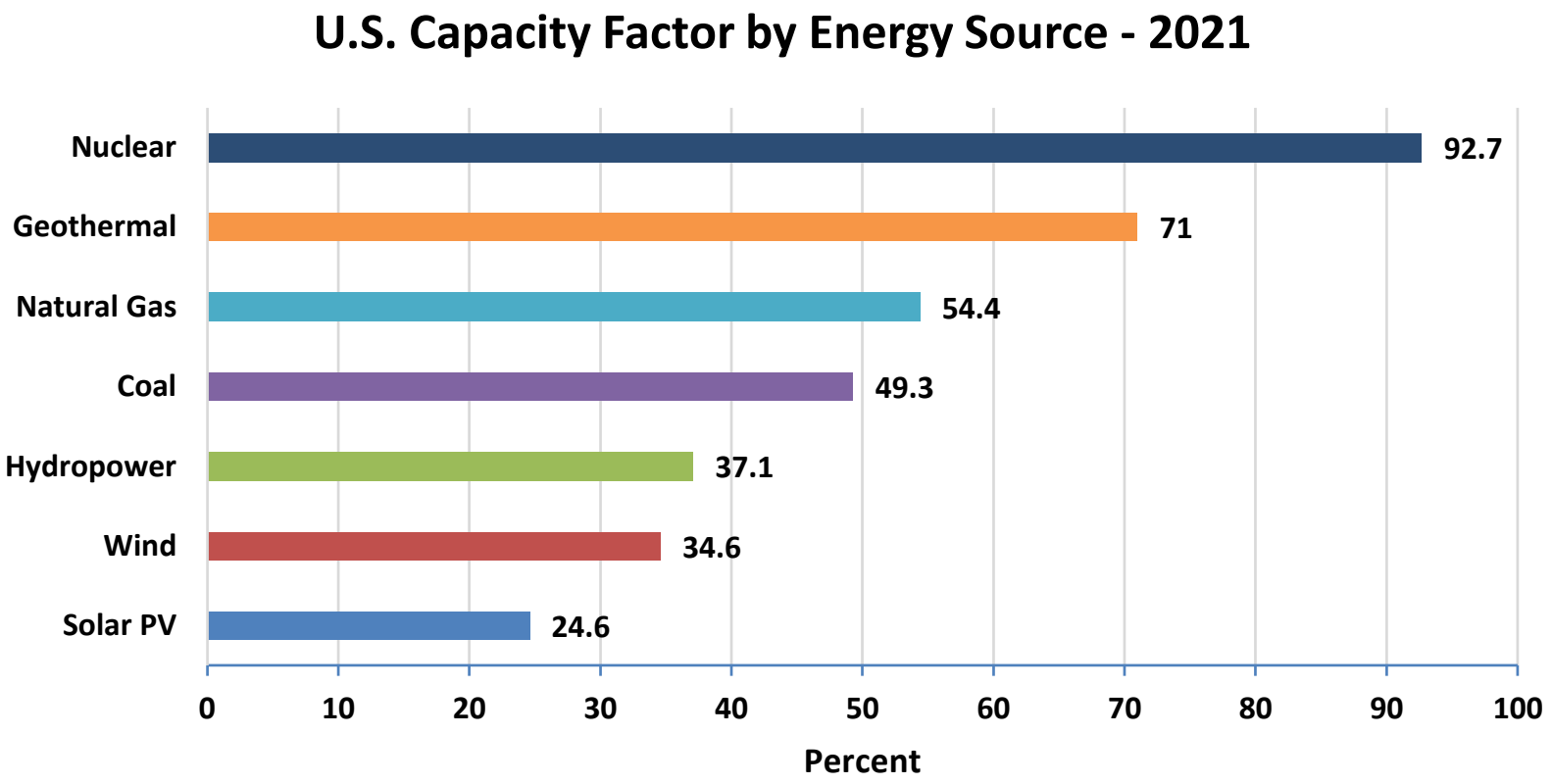
Option 1: 2050 oriented power structure
(total capacity: 490,529 MW)



Option 2: 2050 oriented power structure
(total capacity: 573,129 MW)

Nuclear power: a large and stable energy source

- Nuclear power has large capacity and high capacity factor.
- **A large and stable power supply like nuclear power source** is critical to economic and industrial development in Viet Nam.



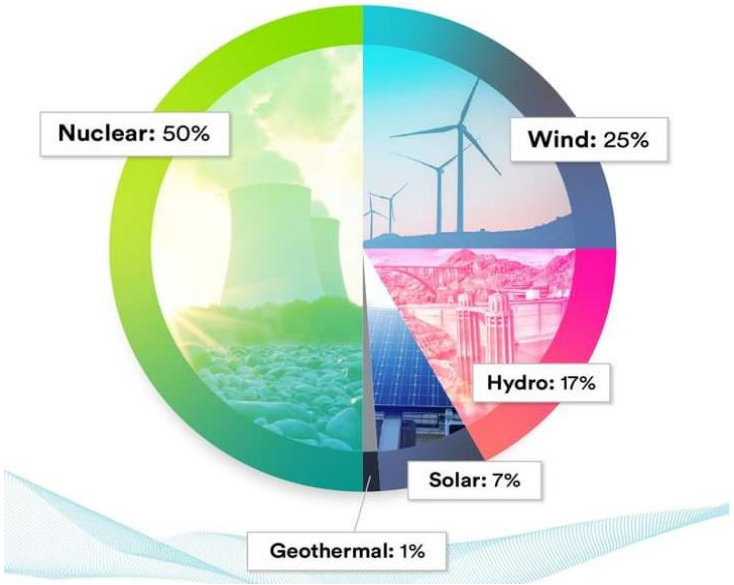
Source: https://www.energy.gov/ne/articles/what-generation-capacity

Nuclear power: a low carbon energy source

"Nuclear is ideal for dealing with climate change, because it is the only carbon-free, scalable energy source that's available 24 hours a day." – Bill Gates

CO_2 emissions comparison between different types of power sources

Source: Nuclear for Climate



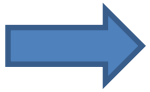
By 2021 nuclear power accounts for 50% of US low-carbon electricity generation

Source: U.S. Energy Information Administration

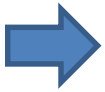
Nuclear power promotes science, technology and industry

- Basic sciences: nuclear physics, thermal hydraulics, fluid dynamics …
- Mechanics, design, construction …
- Chemical technology
- Control and instrumentation
- Steel, alloy materials
- Other fields

NUCLEAR POWER



Other sectors

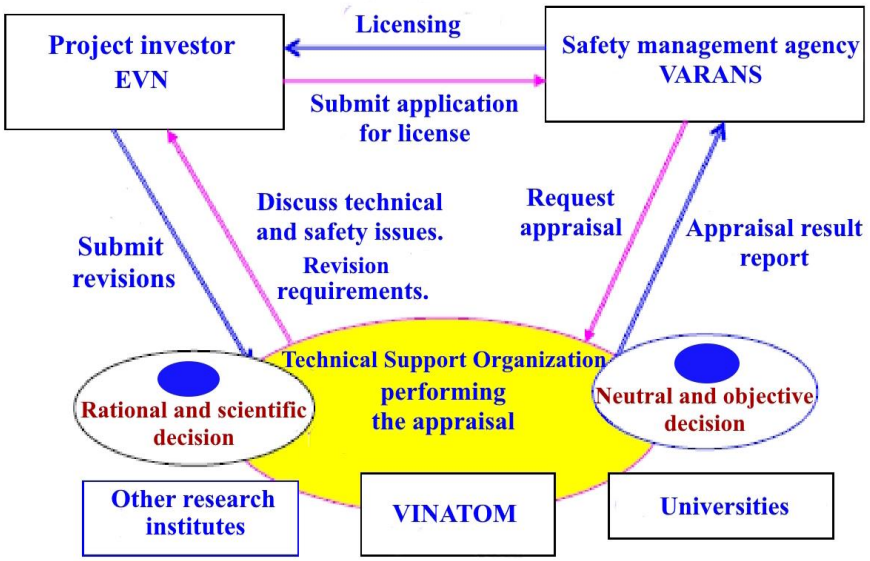


Capacity in science, technology and industry

- **Examples are the countries with nuclear power,** e.g., US, Russia (the former USSR), UK, France, Germany (before April 2023), Canada, Japan, Korea, China, India …

3. Future prospects for advanced reactors

- **What has been done for the Vietnam Nuclear Power Program (VNPP)**
  - VNPP: From 1955 (President Ho Chi Minh visited Obninsk) to 2016
  - HRD: E&T in USSR, Russia, Eastern Europe, Japan, Korea, etc.; Universities; Recently sent 400+ students to Russia, (15+8) key experts to Japan
  - International cooperation: IAEA, EU, Russia, Japan, Korea, France, US, etc.
  - 8 sites for NPPs planned; 2 sites in Ninh Thuan investigated and evaluated
  - Atomic Energy Law (2008); Nuclear regulation system set up
  - **Pre-FS (2002-2009); FS (2011-2016); EVN PM Board**



Three actors' functions and interactions in NPP projects implementation

Moving away from coal by 2040s

- Nuclear can be combined with renewable energy to replace coal.
  - NPPs can be more flexible (e.g., quickly ramped up or down as necessary) than coal and gas fired TPPs.

✓ Advanced LWRs can be introduced after 2030; light water SMRs and other advanced reactor technologies can be considered when they are mature.

Nuclear reactor design	Plant output			Coal replacement applications	Technological and commercial maturity
	Electricity	Low temperature heat (300°C) (district heat, industry, H_2)	High temperature heat (600-700°C) (industry, H_2)		
Large water cooled	√	√		Multi-unit power plant	Mature; more than 300 units in operation
SMR, water cooled	√	√		Single unit, power or CHP	Demonstration; pre-commercial; conventional nuclear licensing process widely applicable
SMR, advanced (gas/sodium cooled)	√	√	√	Single unit, power, CHP, industrial boiler, H_2	Design phase; demonstrated technology; pre-commercial
SMR, advanced (salt or lead cooling; micro-reactors)	√	√	√	Single unit, power, CHP, industrial boiler, H_2	Research, development and demonstration

Categorizing selected reactor technologies suitable for replacing coal

Source: IAEA, Nuclear Energy for a Net Zero World (2021)

Flexible nuclear power for energy transition

- Nuclear is evolving to provide greater flexibility, which can be considered to help Viet Nam manage high renewable integration during 2031-2050.

✓ Those flexibility attributes can be considered for its first NPPs, once the country reconsiders nuclear power to achieve carbon neutrality by 2050.

Beyond Base Load Power: New Flexibility Attributes for Tomorrow's Nuclear Energy Systems (Source: NEA based on EPRI framework)		
Main Attribute	**Sub-Attribute**	**Benefits**
Operational Flexibility	Maneuverability	Load following
	Compatibility with Hybrid Energy Systems and Polygeneration	Economic operation with increasing penetration of variable generation, alternative missions
	Diversified Fuel Use	Economics and security of fuel supply
	Island Operation	System resiliency, remote power, micro-grid, emergency power applications
Deployment Flexibility	Scalability	Ability to deploy at scale needed
	Siting	Ability to deploy where needed
	Constructability	Ability to deploy on schedule and budget
Product Flexibility	Electricity	Reliable, dispatchable power supply
	Industrial Heat	Reliable, dispatchable process heat supply
	District Heating	Reliable, dispatchable district heating supply
	Desalination	Reliable, dispatchable fresh water supply
	Hydrogen	Reliable, dispatchable hydrogen supply
	Radioisotopes	Unique or high demand isotopes supply

Ref.: NICE Future, Flexible Nuclear Energy for Clean Energy Systems (2020)

Roadmap envisioned for nuclear power introduction

- **Introduction of advanced nuclear power** could be key to helping Viet Nam meet national energy, economic, climate, environmental, and security goals. For the period of 2031-2050, a roadmap can be envisioned as follows.
  - **By 2030s, implement the first NPP project (advanced LWRs):** construct and put Unit 1 into operation in 2035 and Unit 2 in 2036; and create favourable conditions for the implementation of the following projects.
  - **By mid-2040s, implement the NPP projects No. 2 and No. 3:** construct and operate the No. 2 and No. 3 NPPs; and fully prepare for the implementation of the subsequent projects.
  - **Consider implementing NPP projects using SMRs** once they are proven through the practical operation (possibly by 2040s).

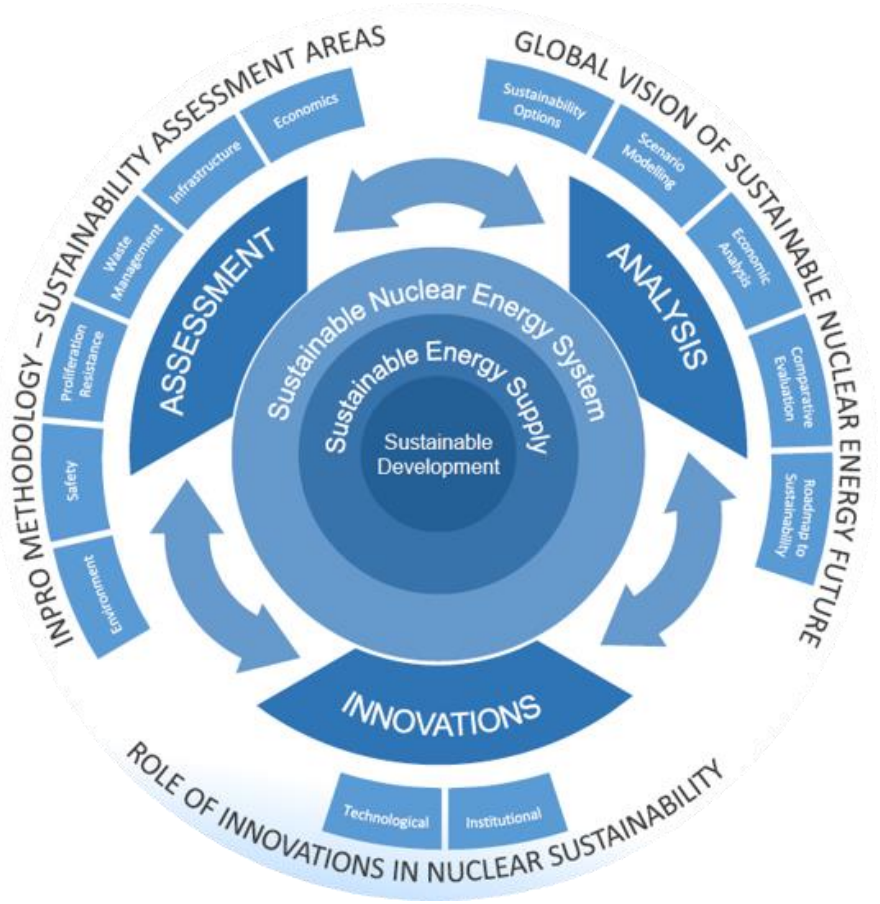
Current main R&D directions in VINATOM

- Enhancing capacity to support the new RR project (CNST) in the FS phase
  - Analysis of the DNRR and new RR design using computational codes
  - Reactor physics experiments and relevant ones with the DNRR
  - Proposing and building T-H test facility in support of safety assessment of the new RR
- Studying advanced reactor technologies which can be introduced to Viet Nam in future
  - Conceptual design study of light water SMR
  - Study on advanced LWRs, SMRs, etc.
  - Nuclear-renewable hybrid energy systems

Model of CNST

A hybrid energy system model
Image: iStockphoto.com

Current main R&D directions in VINATOM (cont'd)



Essence of IAEA INPRO task areas
Source: Wiki-INPRO

- Applying **INPRO methodology and tools** to address and assess the sustainability of potential advanced nuclear energy systems and deployment scenarios to Viet Nam
  - The possibility to introduce nuclear power into the electricity mix to support renewable energy

4. Concluding remarks

- Nuclear technologies which are and will be popular in the world are advanced LWR (and maybe PHWR) Gen III+ and SMRs (possibly in future). Viet Nam is recommended to start (restart) from advanced LWRs.
- Viet Nam has prepared and tried to implement the Ninh Thuan NPP projects. If the country goes back to the Nuclear Power Program (VNPP), it is recommended to continue from what has been done before November 2016.
- **Implementing PDP8 and Resolution No. 55 will lead to high integration of variable renewable sources during 2031-2050 while phasing out coal.** To this end, nuclear power is recommended to be carefully considered in the next PDP to help replace coal and support renewable energy.

Thank you !