

BANDI

KEPCO E&C's SMR for Marine Nuclear Power

Current Status and Challenges

IAEA ASAN SMR Workshop Korea 2025

March 31 - April 4, 2025, Daejeon, KOREA

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NO.1



Overview of SMRs

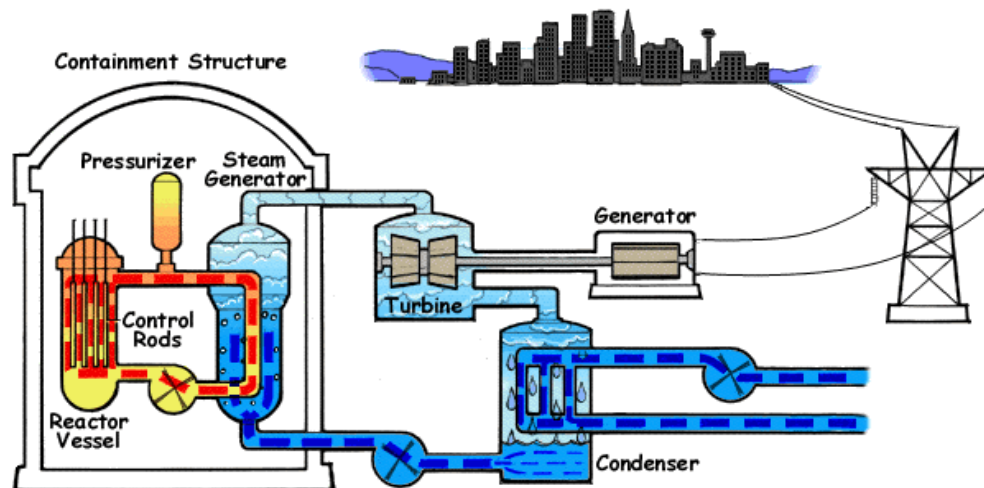
01 Pressurized Water Reactor (PWR)



Nuclear steam supply system (NSSS)
and Balance of Plant (BOP)

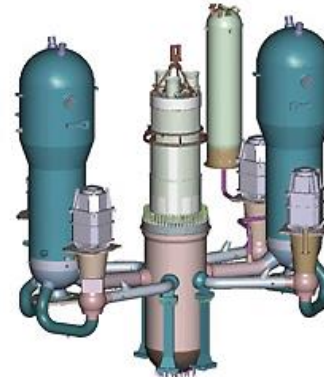


NPPs in Korea are PWRs except
for 4 PHWRs

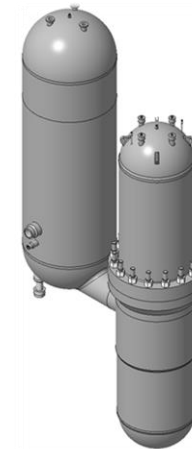


* <http://www.nrc.gov/reading-rm/basic-ref/students/reactors.html>

APR1400



BANDI



SMART-100



☑ Advanced nuclear reactors that have a power capacity of up to 300 MW(e) per unit

Small

Physically a fraction of the size of a conventional nuclear power reactor

Modular

Making it possible for systems and components to be factory-assembled and transported as a unit to a location for installation

Reactors

Harnessing nuclear fission to generate heat to produce energy



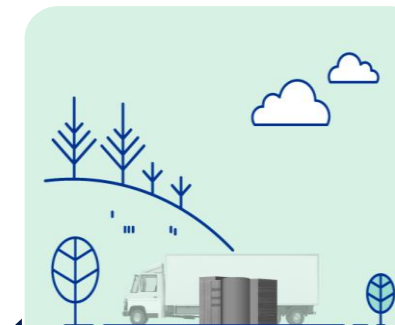
LARGE, CONVENTIONAL REACTOR

700+ MW(e)



SMALL MODULAR REACTOR

Up to 300 MW(e)



MICROREACTOR

Up to ~10 MW(e)



* <http://www.iaea.org>

01 Benefits of SMRs

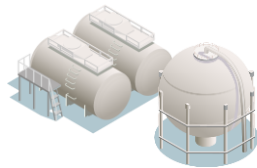
- ☑ Sited on locations not suitable for larger nuclear power plants
- ☑ Prefabricated units of SMRs can be manufactured and then shipped and installed on site
- ☑ Offer savings in cost and construction time
- ☑ Deployed incrementally to match increasing energy demand

Capacity (MWe)		Purpose & Potential Market	
Large	> 700	• Large and centralized power grid	
Medium	300 ~ 700	• Country (region) having less power demand • Replacement of old thermal power plants	
Small	200 ~ 300	• Similar power demand with medium scale reactors	
	25 ~ 200	• Local grid and District heating • Desalination • Industrial process heat • Floating nuclear power system, Nuclear propulsion and etc.	
	10 ~ 25	• Small isolated area • Special purpose	

01 Trend is changing...

Small Reactor(1950's)

- ✓ Shippingport Reactor
- 60MWe (1958, US)



Economy of Scale → get bigger

1978 Kori 1 - 600 MWe

1995 Hanbit 3 - 1000 MWe

2016 Shin-Kori 3 - 1400 MWe

"Smaller" Again!

Safety



Flexible applicability

Generation I

Early prototypes

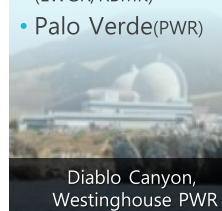
- Calder Hall(GCR)
- Douglas Point (PHWR/CANDU)
- Dresden-1(BWR)
- Fermi-1(SFR)
- Kola 1-2(PWR/VVER)
- Peach Bottom 1 (HTGR)
- Shippingport(PWR)



Generation II

Large-scale Power stations

- Bruce(PHWR/CANDU)
- Calvert Cliffs(PWR)
- Flamanville 1-2 (PWR)
- Fukushima II 1-4 (BWR)
- Grand Gulf(BWR)
- Kalinin(PWR/VVER)
- Kursk 1-4 (LWGR/RBMK)
- Palo Verde(PWR)



Generation III/III+

Evolutionary designs

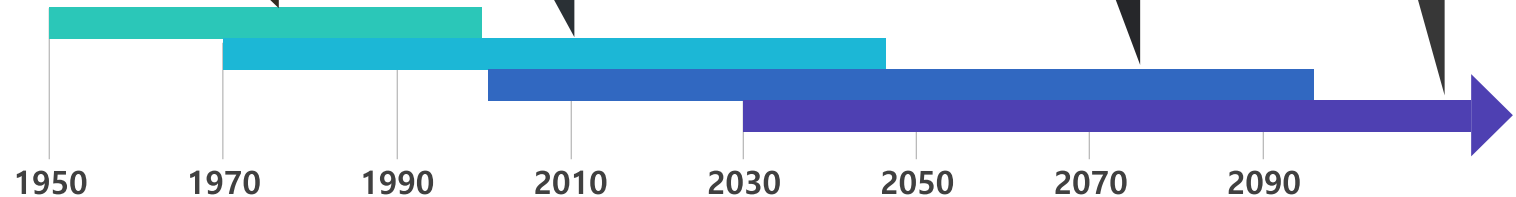
- ABWR (GE-Hitachi; Toshiba BWR)
- ACR 1000 (AECL CANDU PHWR)
- AP1000 (Westinghouse- Toshiba PWR)
- APR-1400 (KHNP PWR)
- APWR (Mitsubishi PWR)
- Atmea-1 (Areva NP-Mitsubishi PWR)
- CANSU 6 (AECL PHWR)
- EPR (AREVA NP PWR)
- ESBWR (GE-Hitachi BWR)
- Small Modular Reactors
 - B&W mPower PWR
 - CNEA CAREM PWR
 - India DAE AHWR
 - KAERI SMART PWR
 - NuScale PWR
 - OKBM KLT-405 PWR
- VVER-1200 (Gidropress PWR)



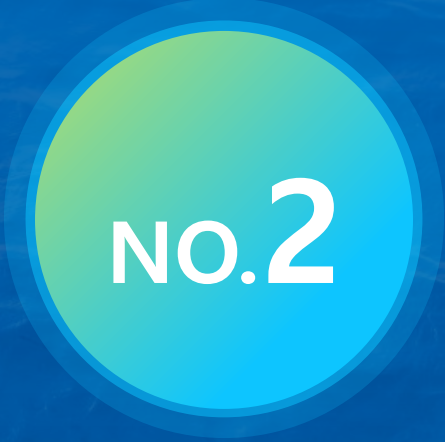
Generation IV

Innovative designs

- GFR - gas-cooled fast reactor
- LFR - lead-cooled fast reactor
- MSR - molten salt reactor
- SFR - sodium-cooled fast reactor
- SCWR - supercritical water-cooled reactor
- VHTR - very high temperature reactor



* <http://gen-4.org>



No.2



SMR Market & Our Choice



» Small reactor's economics comes from the 'Economy of Mass Production'

A big volume of work with a standardized design would be needed to make it competitive in the market



» Small ones... may be more suited for Niche Market

Distributed power for remote or isolated area where populations are scarcely distributed over a wide area

Industrial process heat replacing fossil boilers

Marine-based power supplies Floating nuclear power plants, propulsion for bulky merchant ships, etc.





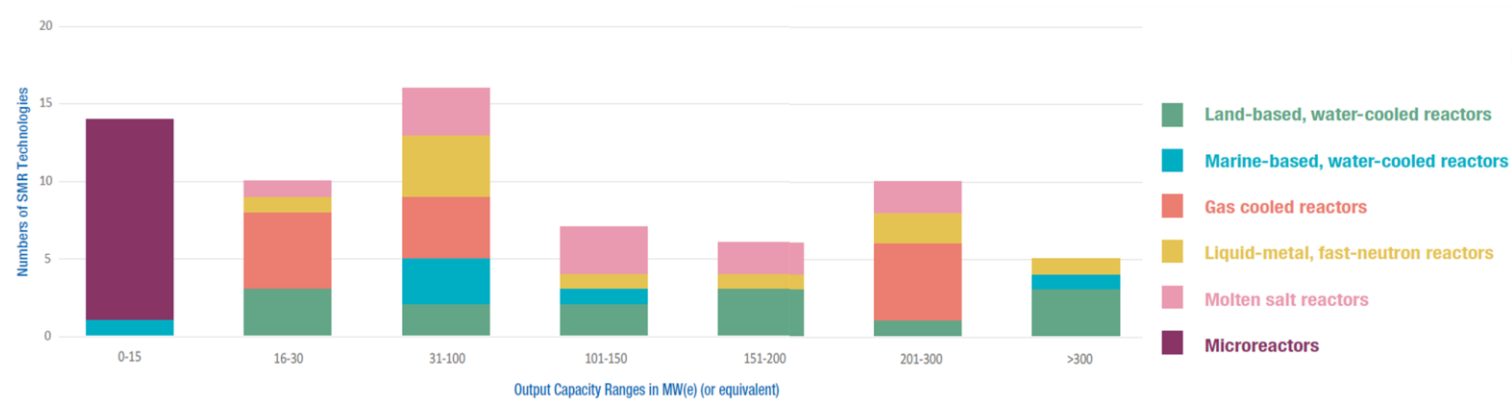
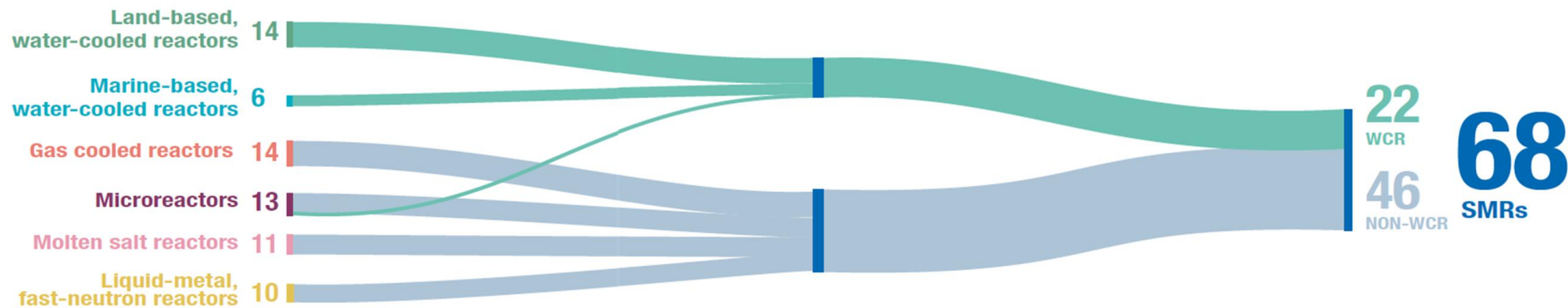
68 SMRs are
in development process (2024)



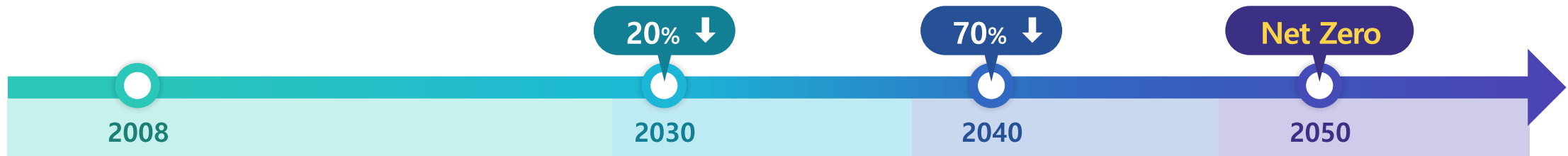
Majority are based on
land operation



Marine-based SMRs are minority
→ **Niche Market**



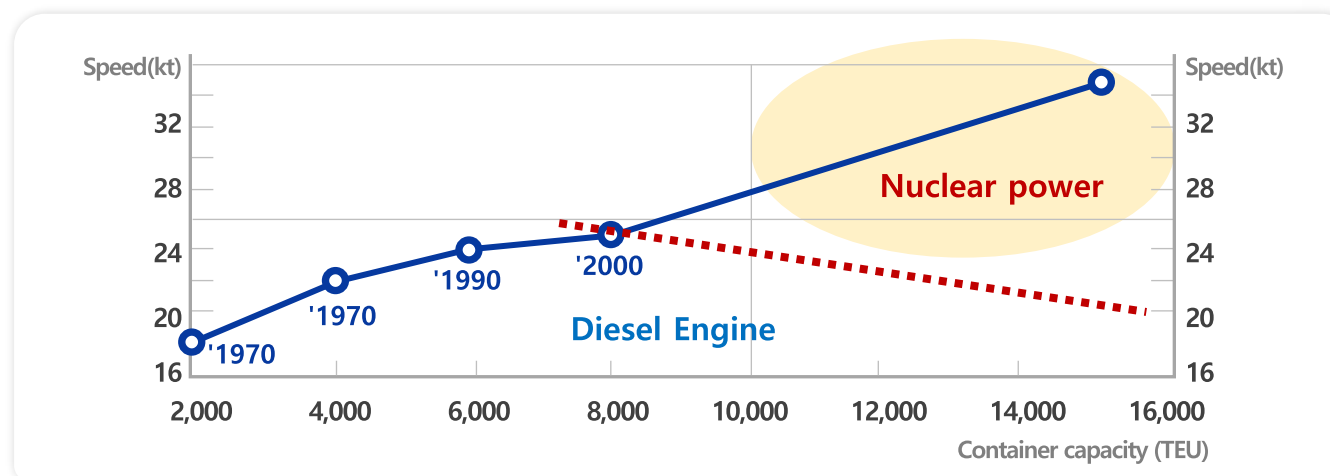
☑ **IMO(International Maritime Organization) GHG Reduction Goal** (as of July 07, 2023)



☑ Improve the efficiency? Limit the speed? ... Not the solutions

☑ Ships... Bigger and faster, but No Carbon.

☑ **SMR, a good option!** ... Especially for merchant ships to get bigger and faster



Marine Digital



**Primary
Target**

Floating nuclear power plants



Nuclear propulsion system
for bulky merchant ships

**Secondary
Target**

Marine Nuclear Power Systems

Gravity-based



100-1400 MWe

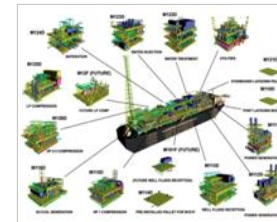
Floating

Coastal



80-120 MWe

Ocean



80-140 MWe

Propulsion



40-120 MWe

* KNS Adhoc Committee for Marine-Nuclear Collaboration, 2015

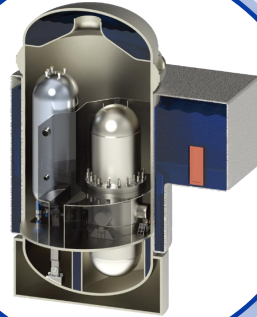
NO.3



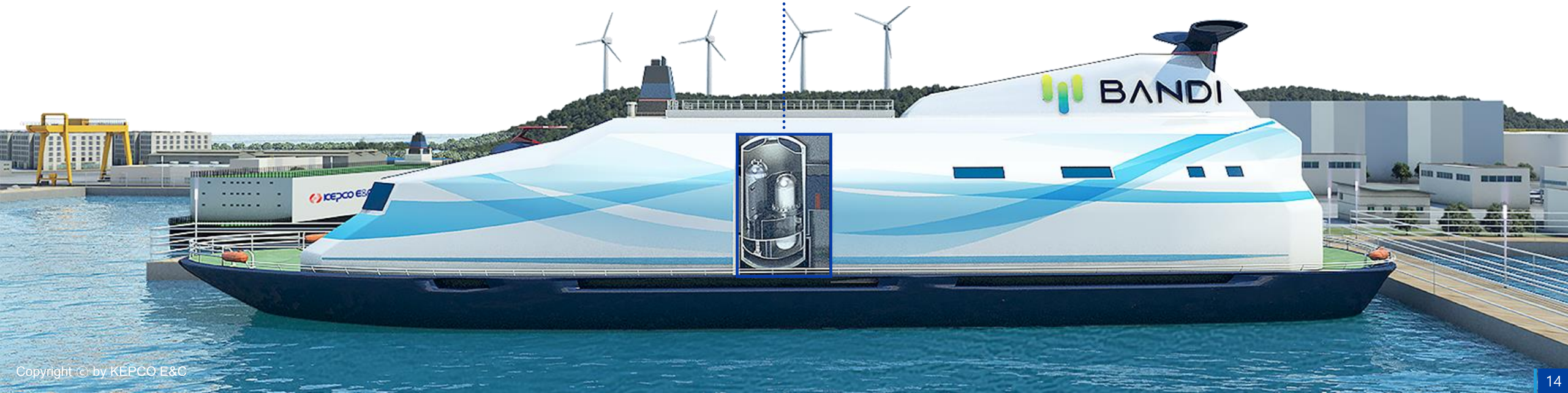
KEPCO E&C's SMR, BANDI

03 Introduction of BANDI

Named after a tiny "firefly" in Korean, inspired by its clean and cute image of brightening up darkness by itself in a deep forest in a summer night

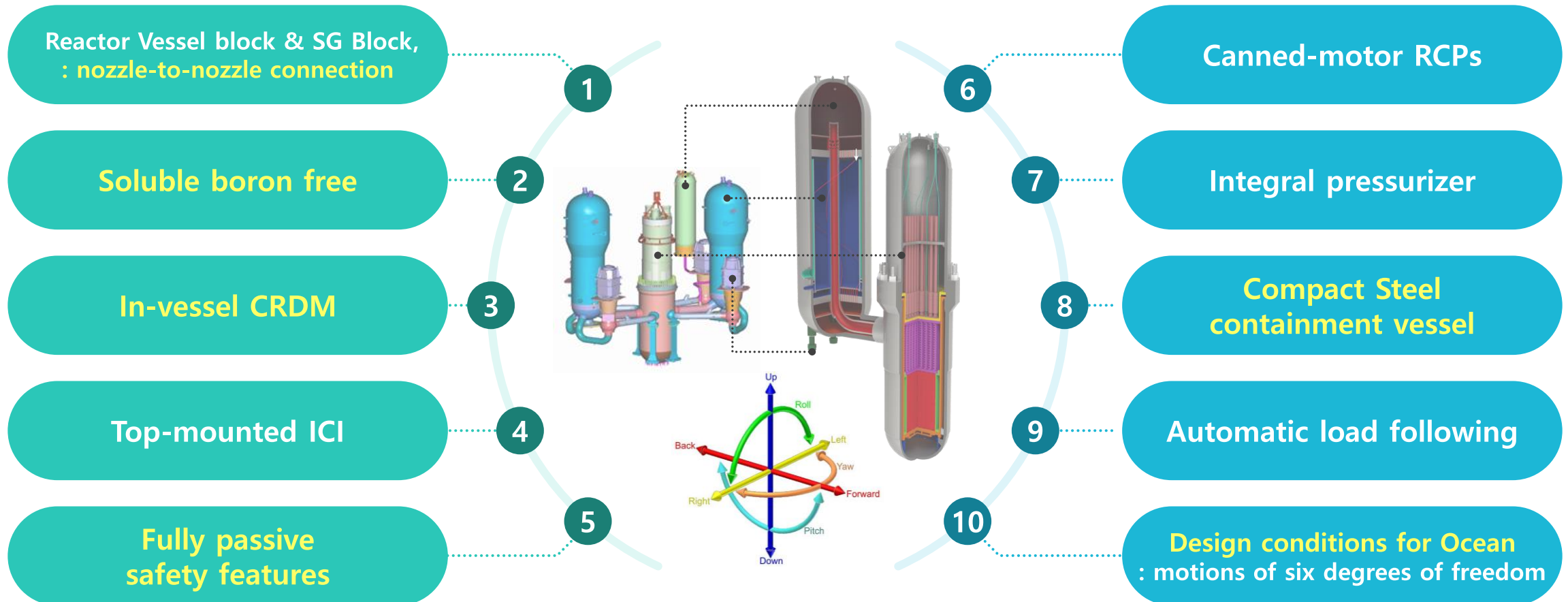


Will supply clean, safe, reliable, affordable energy for remote communities, desalination, renewable energy backup, etc.



03 Key Design Features of BANDI

☑ For being mounted on a Floating Nuclear Power Plant

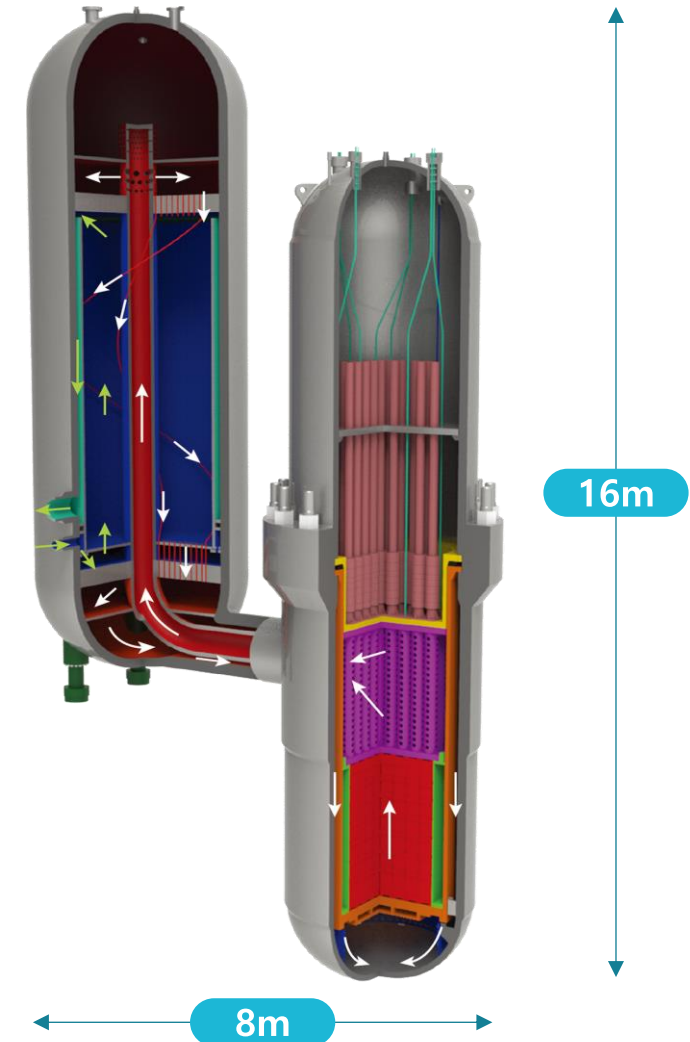
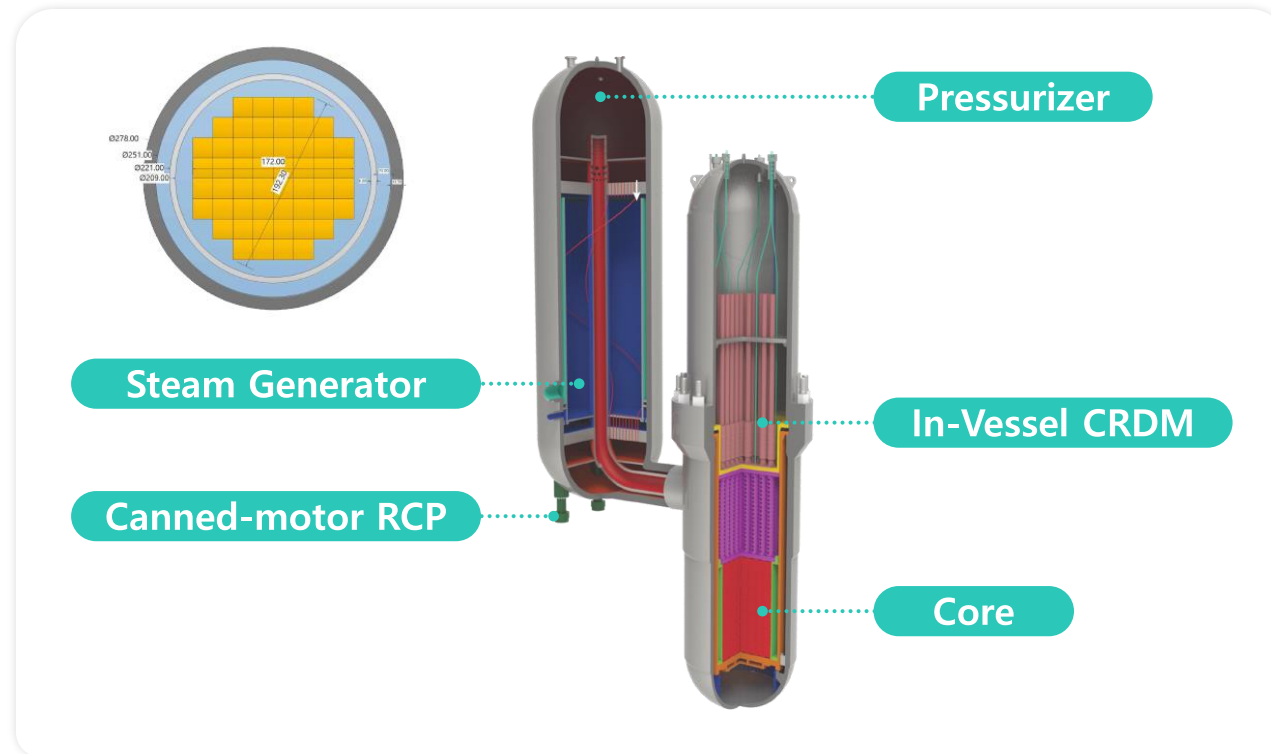


03 Reactor Coolant System of BANDI

☑ Reactor Vessel Block, Steam Generator Block

☑ Nozzle-Nozzle connected

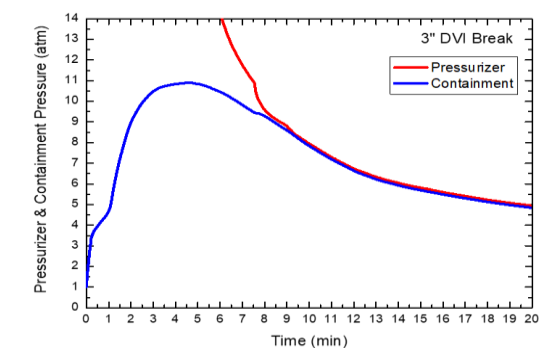
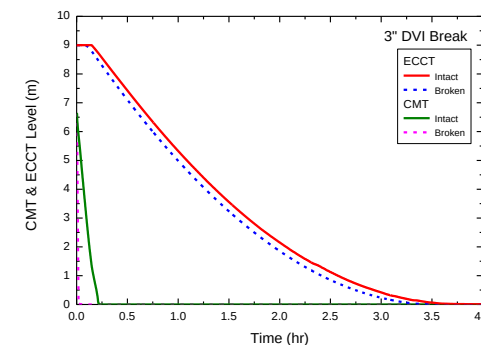
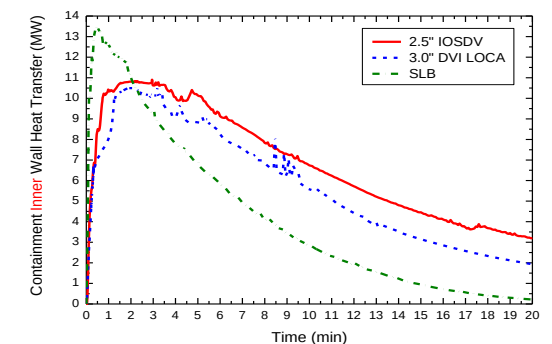
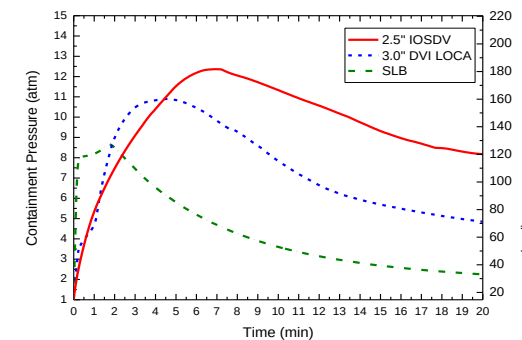
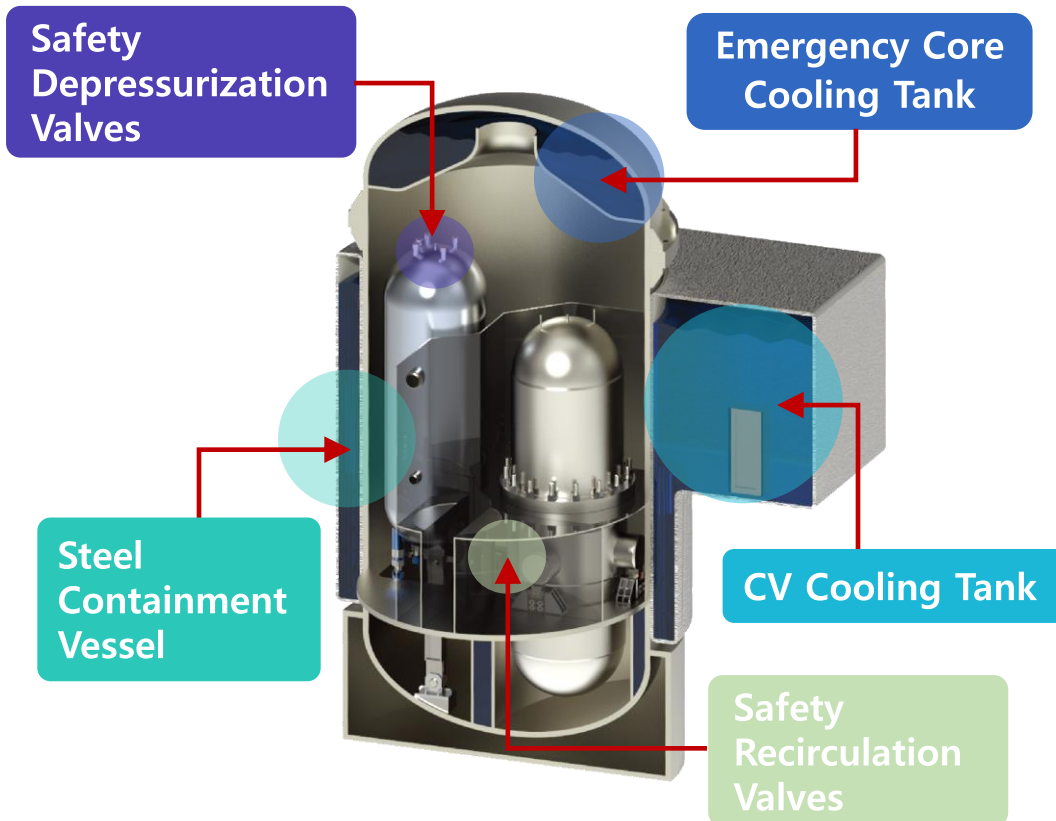
: Break elimination(ASME Sec.III NB-3000)



03 Features for Safety Injection and Decay Heat Removal

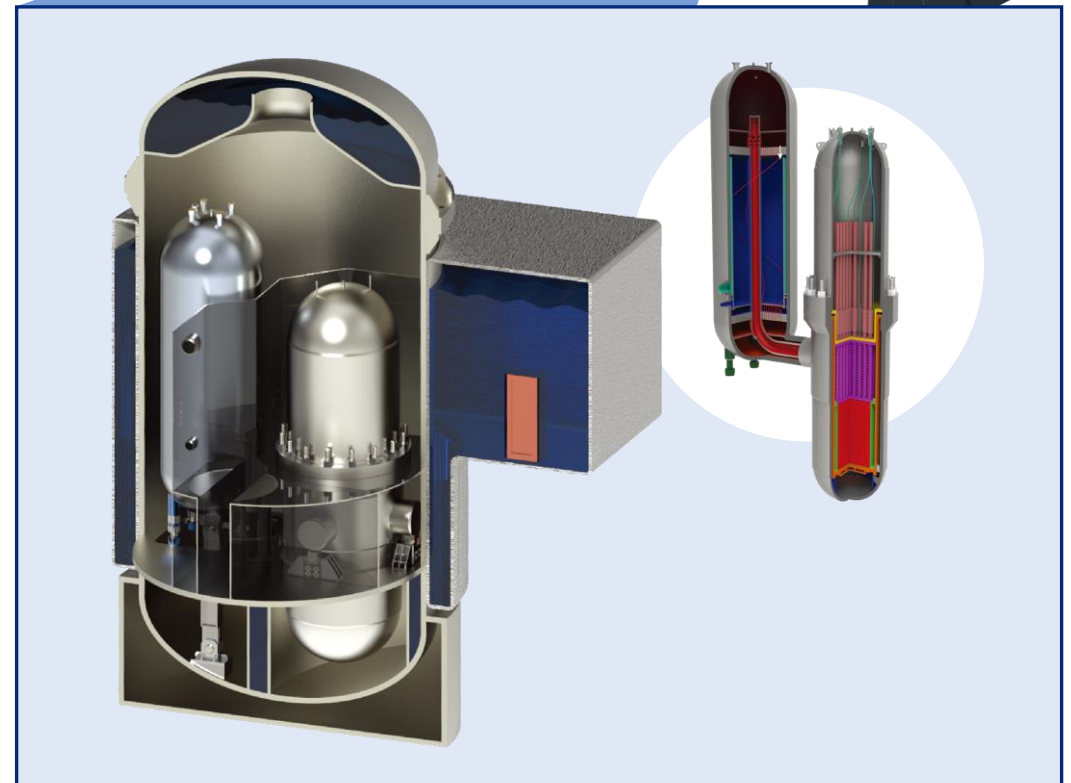
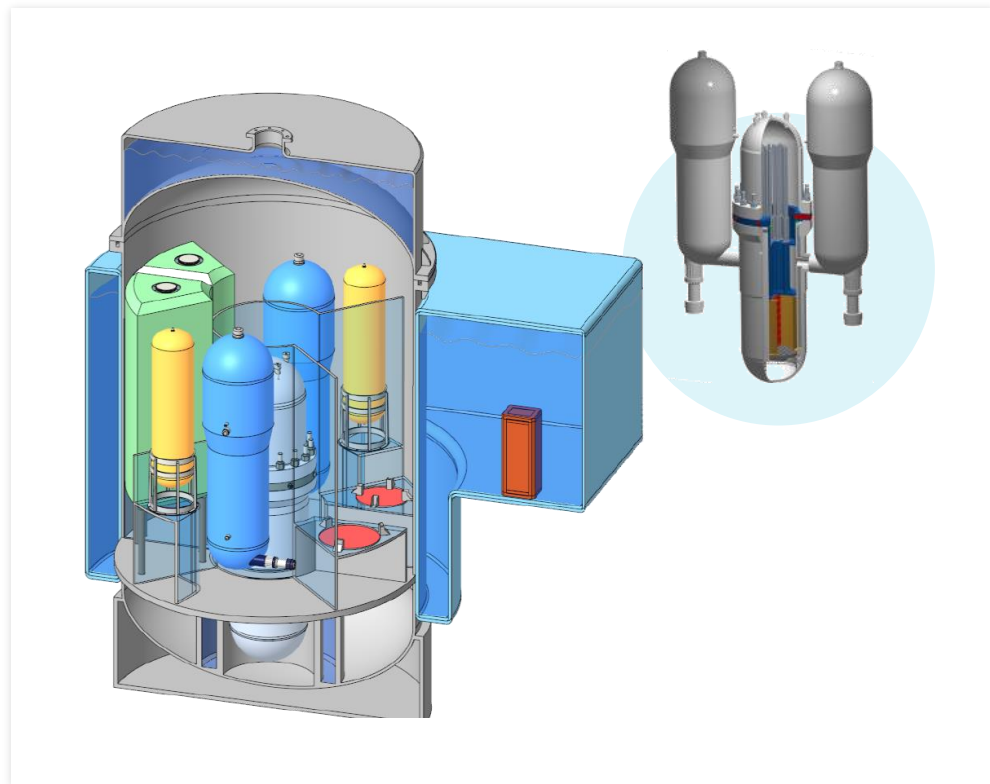
☑ Driven by gravity, natural circulation, conduction, ...

☑ Thermal hydraulic interactions ... closely coupled



03 Design Improvement in Progress

- ☑ Simplification & Optimization
- ☑ Feedback from safety and performance analyses



MOUs (2023) HD Korea Shipbuilding & Offshore Engineering Co.

Joint Works Business models, Economic feasibility, Engineering : nuclear system ↔ floating body



KEPCO E&C - HD Heavy Industry, 2023.05.24



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Challenges

04 Technical Challenges



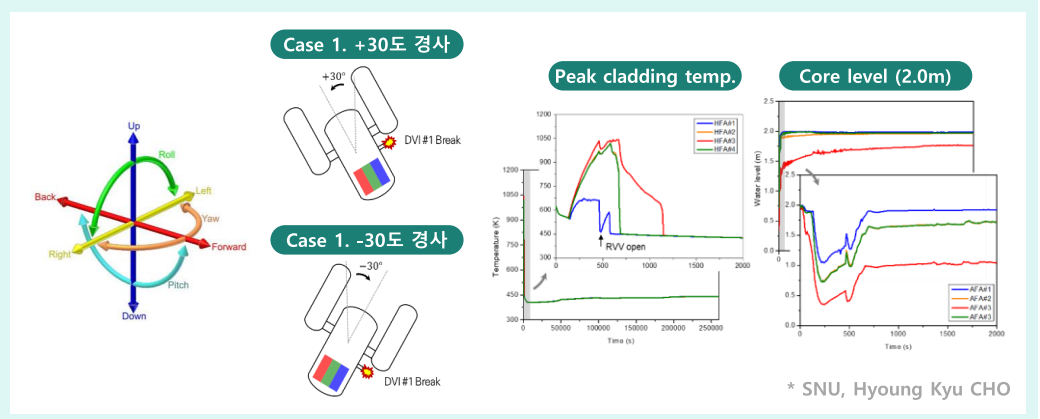
Ship motions

- ✓ Six(6) degrees of freedom of motions
- ✓ Exciting forces

Tide

Wave

Wind ...



Accidents at Sea

Grounding

bumping into the seabed

Stranding

being grounded and unable to refloat by itself

Static list

being tilted to one side and unable to recover

Capsizing

Overturning of a ship

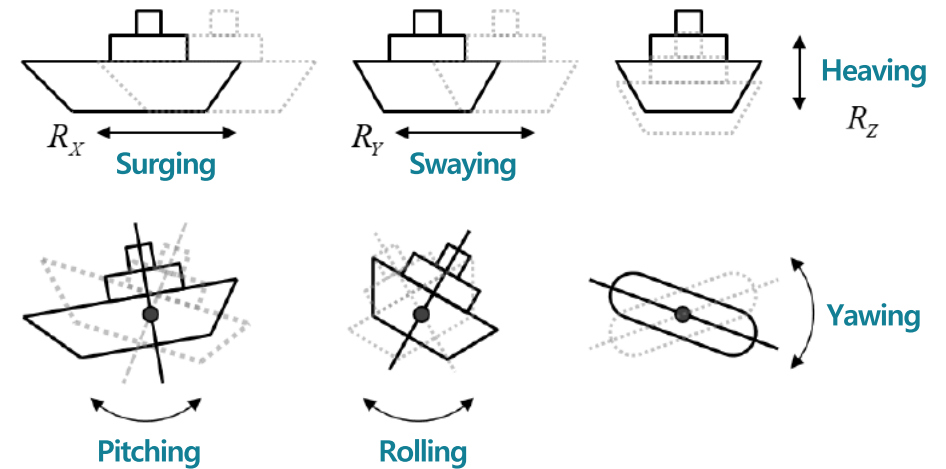
Sinking



Collision



Shipwreck



* CNU, Byoung Jae Kim

04 Technical Challenges

Limited space & weight

- ✓ Shielding for personnel safety, equipment integrity
 - Mass/volume limits for shielding materials
- ✓ System performance may have to be compromised



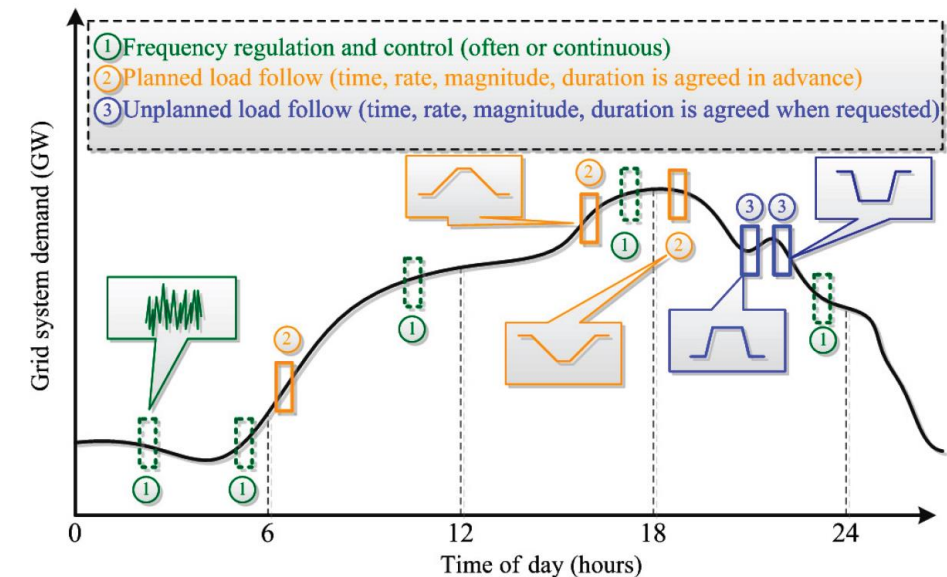
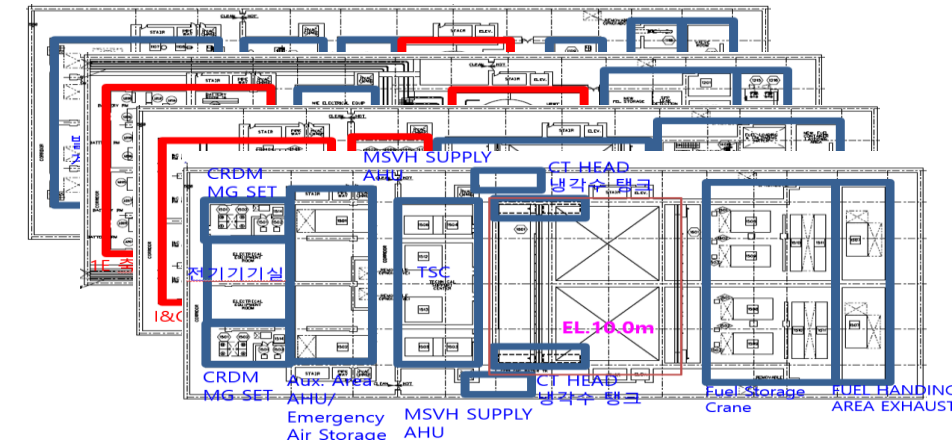
Oceanic harsh environment

- ✓ Material integrity



Load-following capability

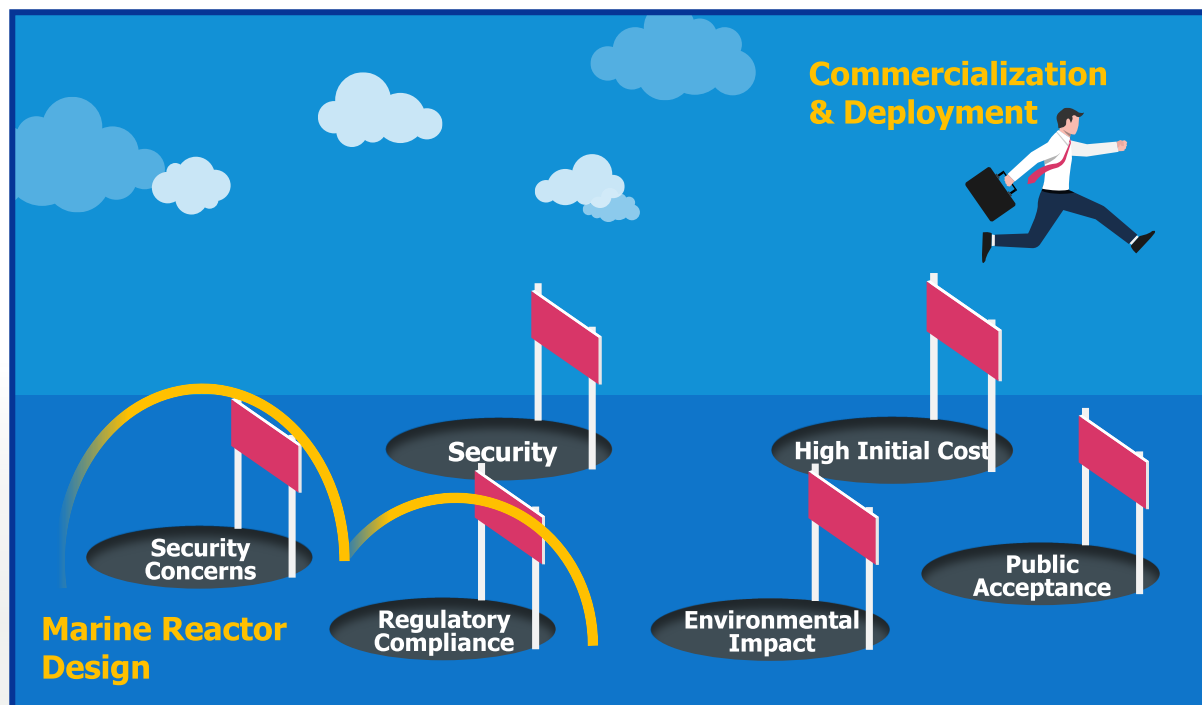
- ✓ Maybe more critical than steady operation



* IAEA Nuclear Energy Series No. NP-T-3.23 (2018)

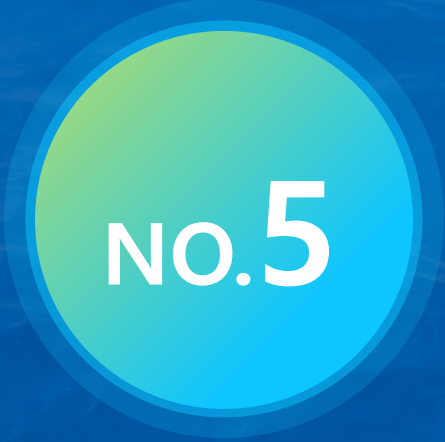
04 Regulations and Licensing at Sea

➤ For New Technologies, New Markets



-  Safety, Security, Safeguards ... across the territory of a country
-  Regulatory compliance
-  International cooperation is in urgent need

* <https://camsys.software/blog/project-proposal-pitfalls>

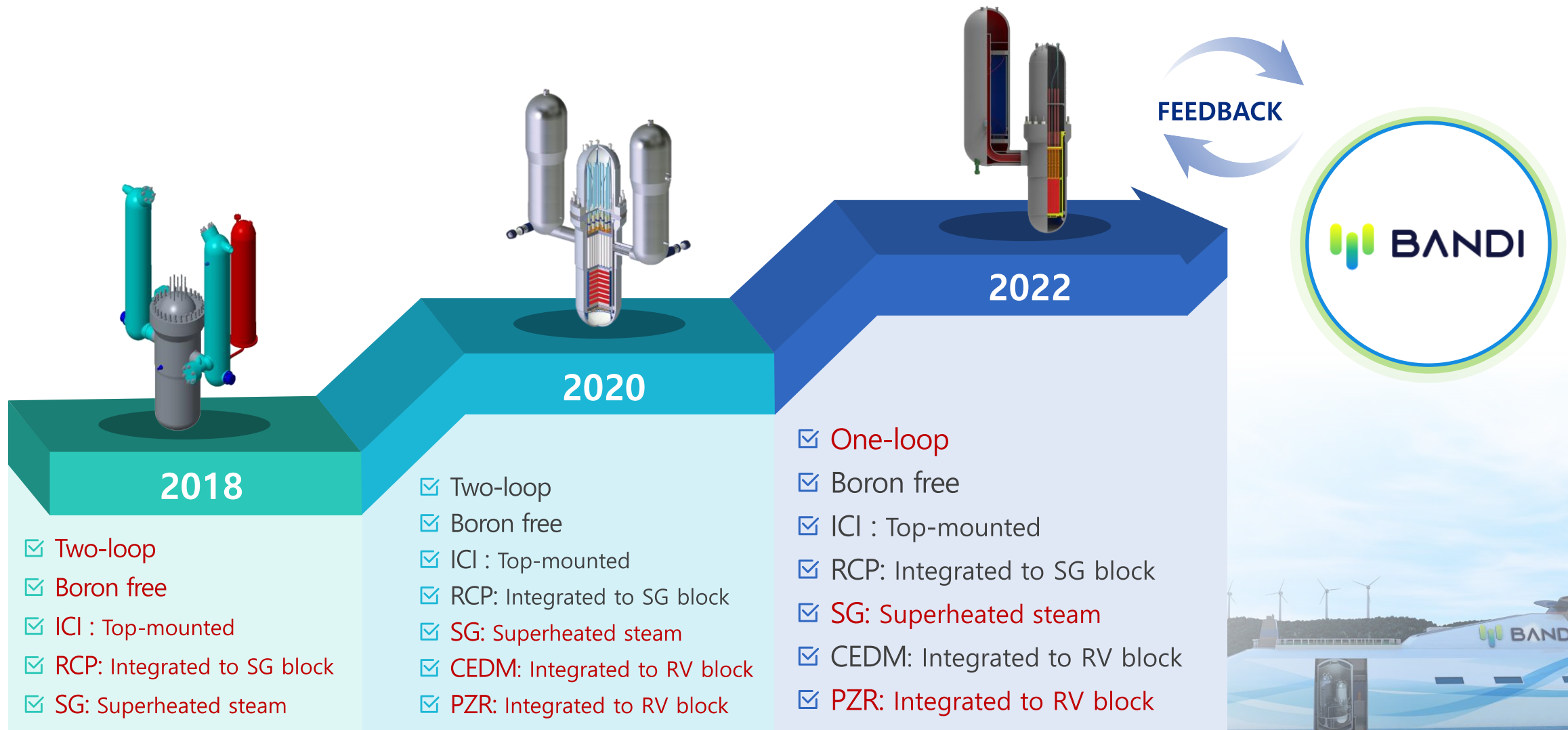


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Future Plan

05 Design History of BANDI



05 Diverse Utilization of BANDI

Floating nuclear power systems

1 unit mounted → 60 MWe

2 unit mounted → 120 MWe

Nuclear merchant ships or containers



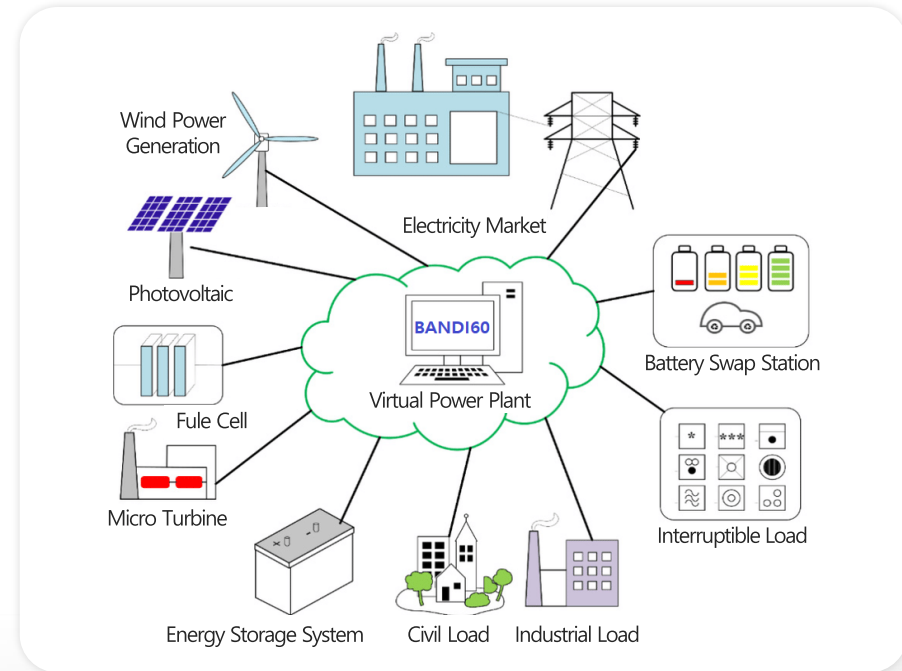
60 MWe

SMR-Renewable Energy Hybrid Systems



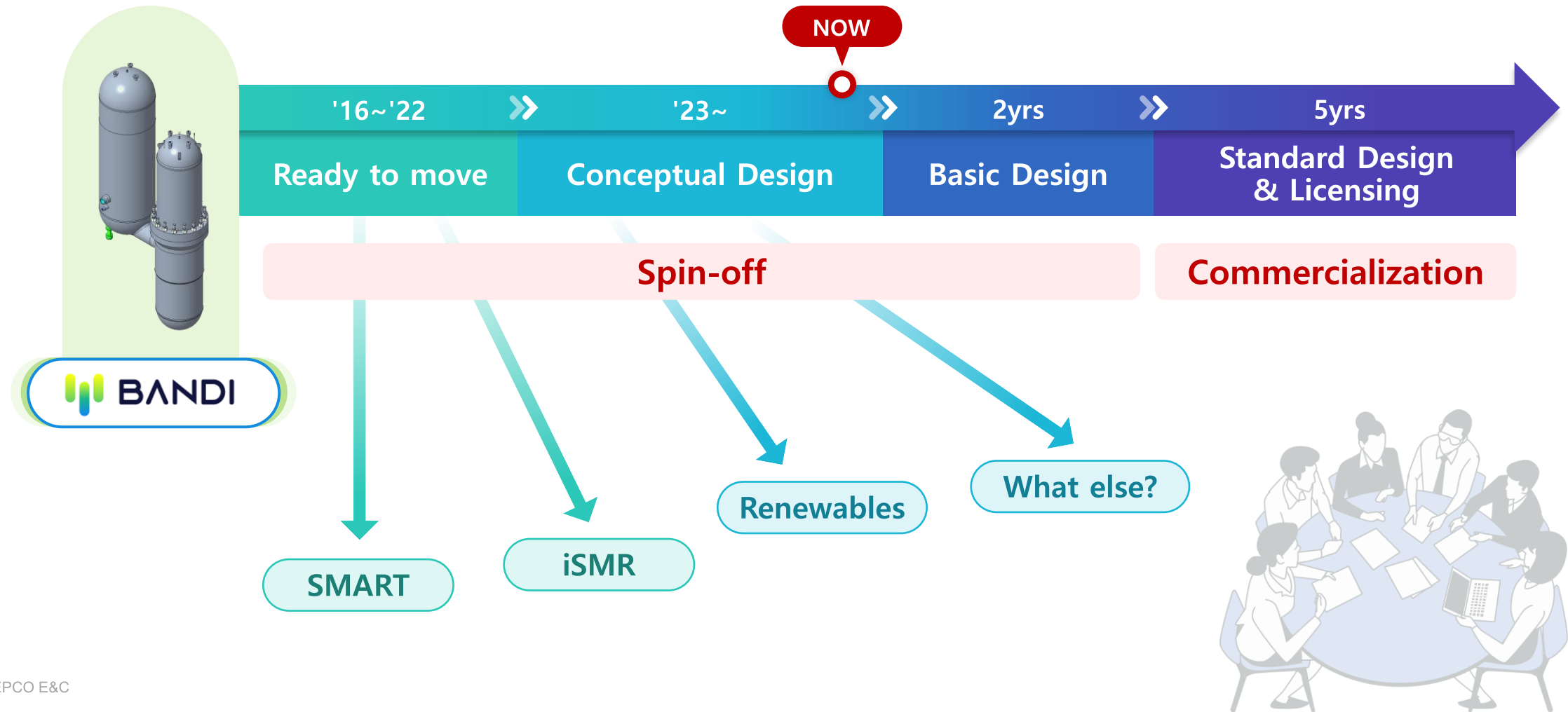
VVP

Virtual Power Plants



05 Strategy and Road Map

☑ Buildup SMR Capability ➡ Expand Opportunities for SMR business



KEPCO E&C's SMR BANDI for Marine-based Applications



Thank You

