

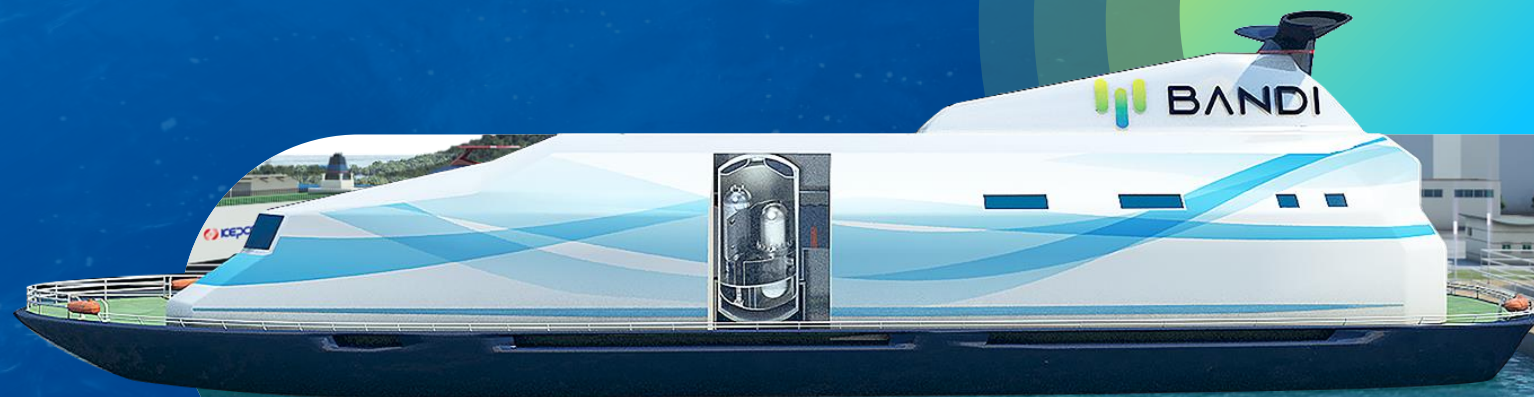
해양 SMR BANDI

기술개발 현황 및 사업화 추진 계획

한국원자력학회 워크숍

2024. 10. 23. 창원

이 병 진

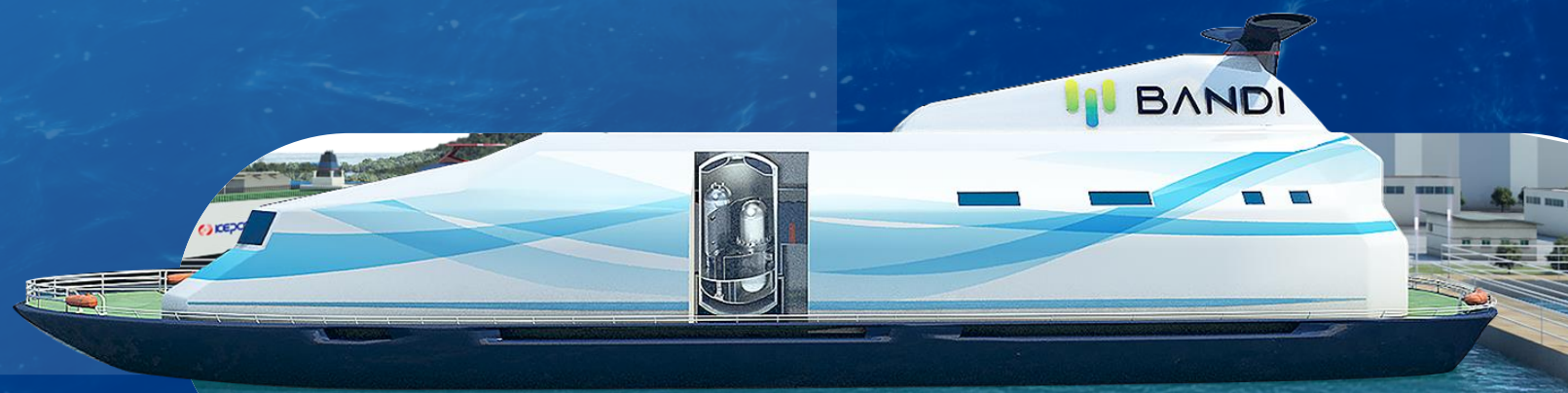


Contents

NO. 1 한기 해양 SMR 개발 배경과 목표

NO. 2 BANDI 개발 현황

NO. 3 향후 추진 계획



NO.1

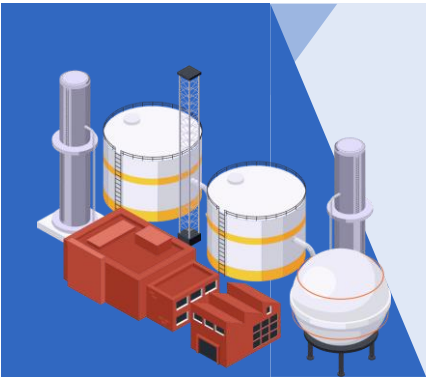


한기 해양 SMR 개발 배경과 목표



» SMR 경제성의 기본은 “대량 생산”

기존 시장에서 타 에너지원과 경쟁하려면, **설계 표준화 & 대량 연속 생산이 필수적**



» 작은 원자로, 특수 목적 시장에서 새로운 기회를 찾을 수 있어

무탄소 **분산 전원**

무탄소 **산업 공정열**

무탄소 **해양 부유식 발전원, 대형상선 추진 동력 ...**

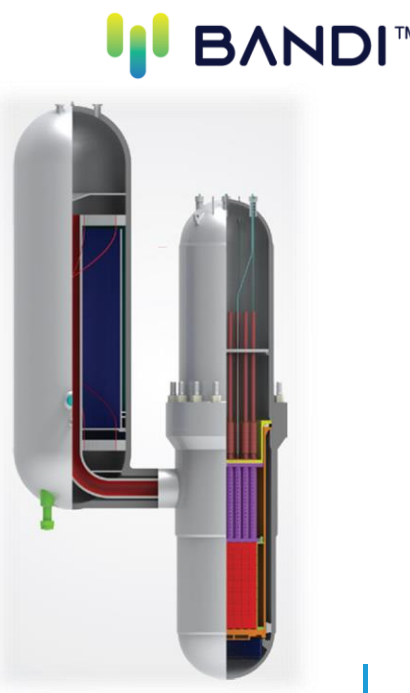
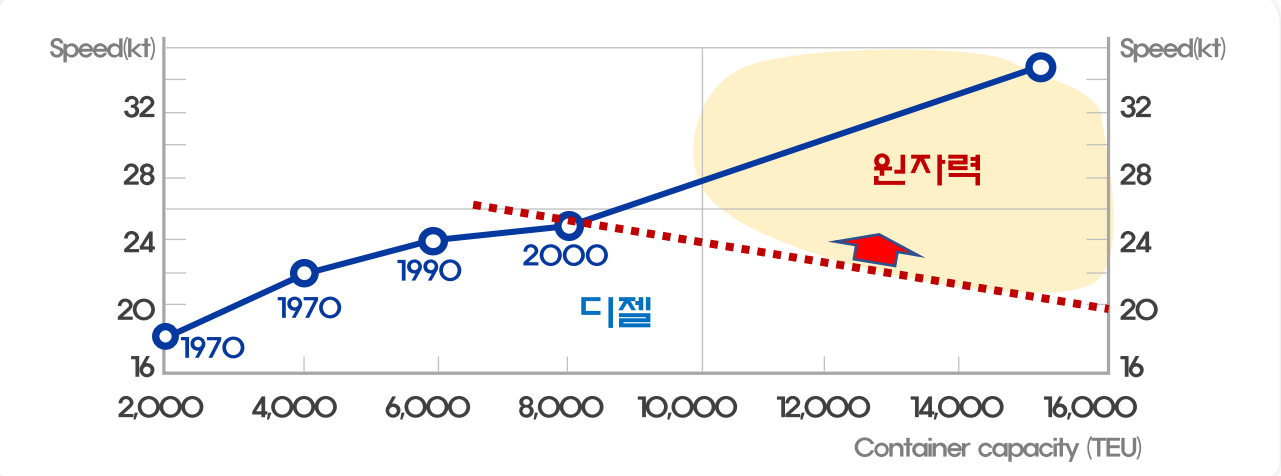


O2 해양 Net Zero ... 원자력으로

- 국제해사기구(IMO) 탄소감축 로드맵 (2023. 7)

✓ 2050년까지 해양 탄소중립 달성!

* IMO : International Maritime Organization



- 상선 ... 좀 더 크고, 좀 더 빠르게... 무탄소로

- SMR, 최적의 대안

기본

원자력 부유식 발전선



원자력 추진 대형 상선

확대

해양 원자력 시스템

착저식

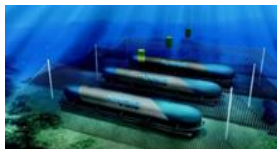


100-1400 MWe

부유식

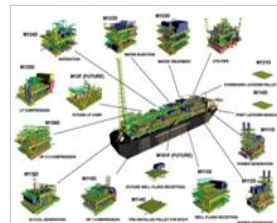


연안



80-120 MWe

대양



80-140 MWe

선박 추진 



40-120 MWe

* KNS 조선해양-원자력 특별위원회, 2015

04 해양 원자력, 최근 동향

● 원자력 발전선

- ✓ SMR, 격오지 분산 전원



Rosatom Akademik Lomonosov 운전 개시, 2019.12



Seaborg, FNPP 개념, 2024.05

● 원자력 추진선

- ✓ 해운업계, 탄소감축 수단으로 원자력에 대한 관심 고조
- ✓ SMR, 상용선박 추진동력

IAEA 사무총장 (2024. 6)



IAEA's Grossi: Marine propulsion among potential uses of SMRs

In his recent address to the IAEA's Board of Governors, Director General Rafael Mariano Grossi highlighted commercial marine propulsion as one of the many possible uses of Small Modular Reactors, noting the growing interest of the shipping industry in using nuclear propulsion to cut its carbon emissions.

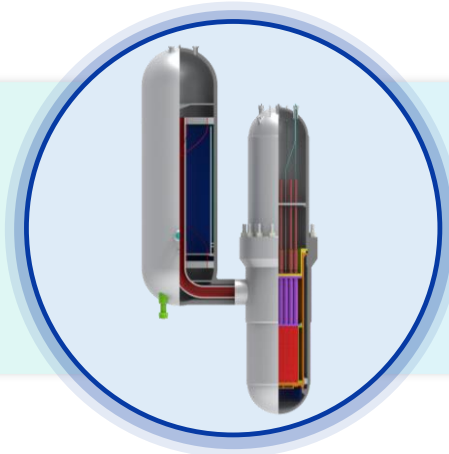
[Read more.](#)

NO.2



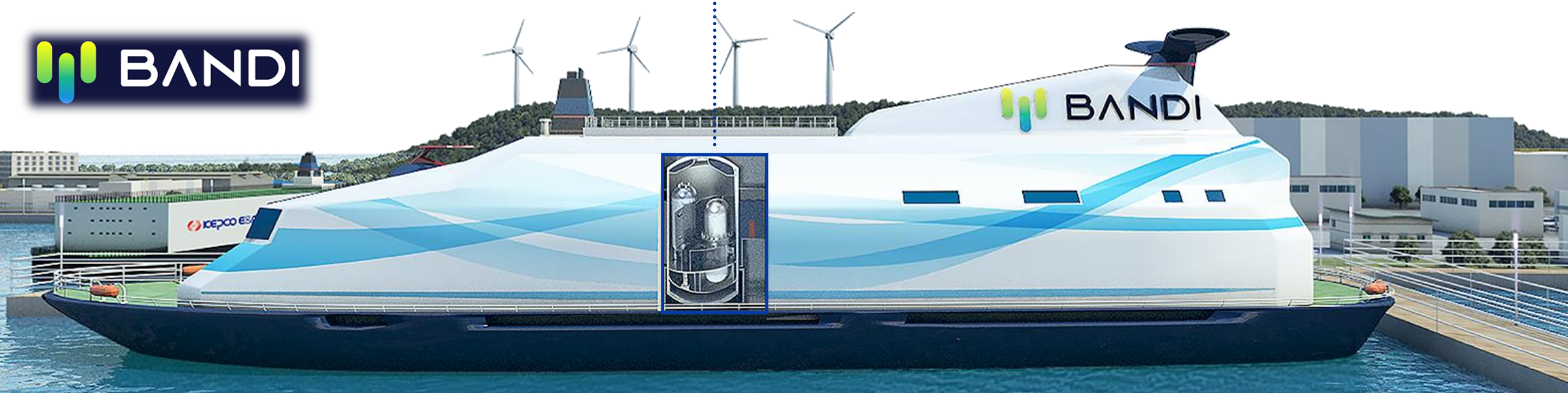
BANDI 개발 내용과 성과

발전선, 대형상선에
깨끗하고, 안전하고, 안정적이고, 경제적인
에너지원 제공

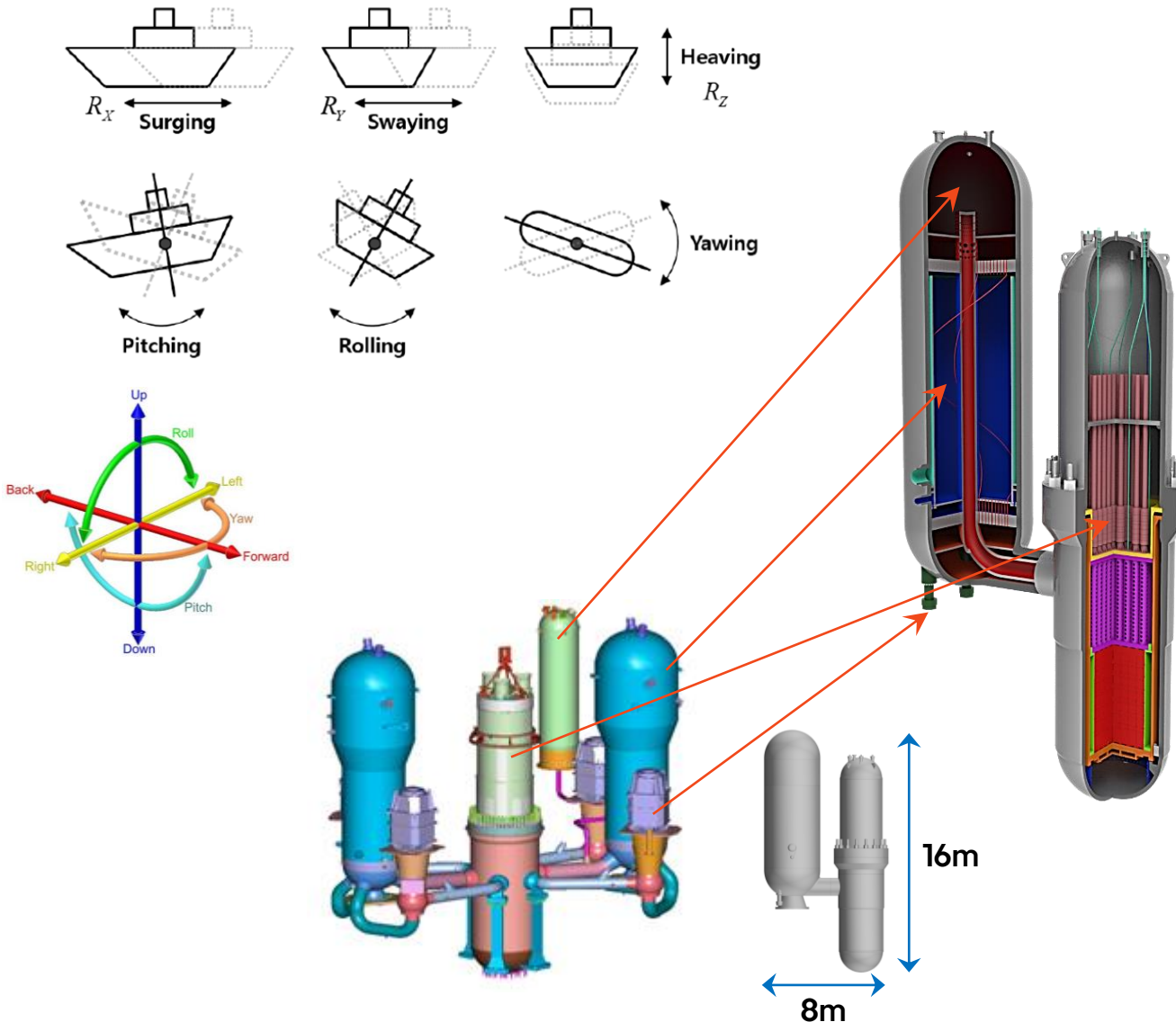


반디 (BANDI)

여름 밤 깊은 숲 까만 어둠을 밝히는 조그만
불빛의 깨끗하고 귀여운 이미지에서 연상

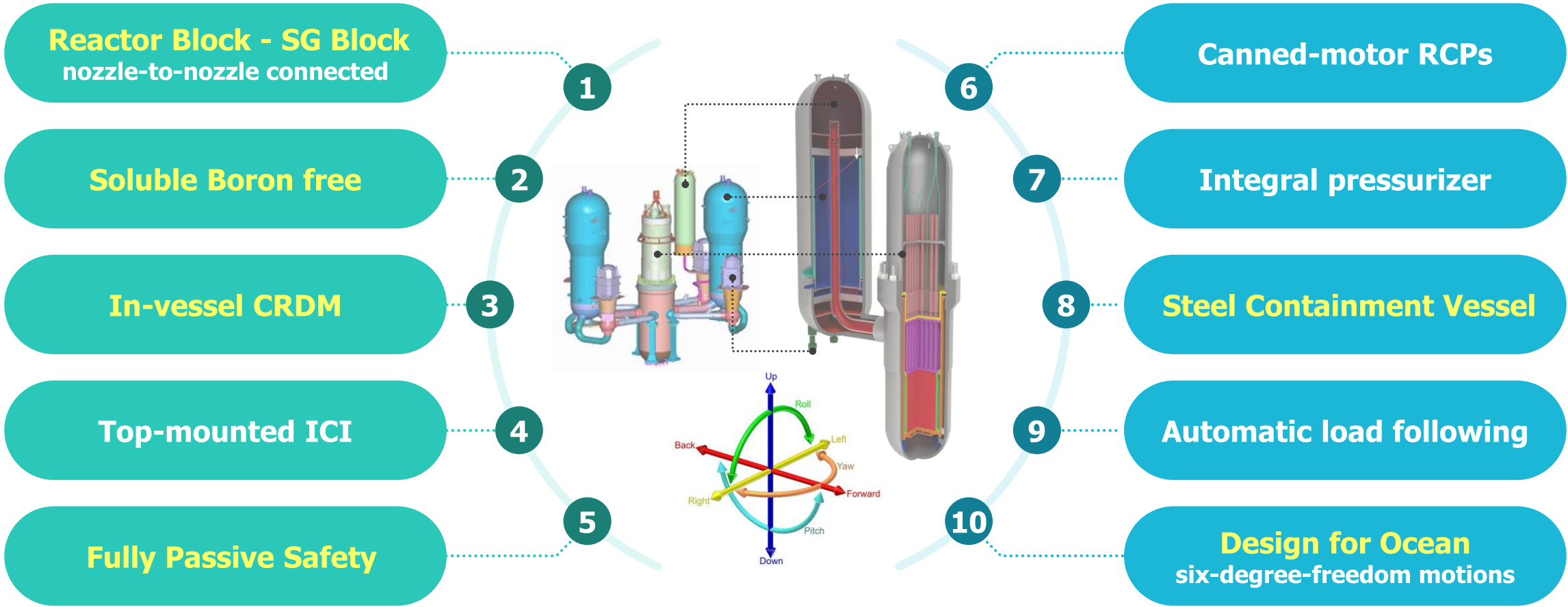


● BANDI-60 (기본형)



원자로	블록형 (반일체형) 기압경수로 ✓ 노즐-노즐 직접 연결
출력 (열/전기)	200 MWt 60 MWe (발전선, 효율 30%) * 선박추진용, 30~40MWe
핵연료 및 노심	17x17 봉형, 농축도 ≤ 5% UO ₂ 52다발, 유효노심 높이 2m 재장전 주기 4~5년
반응도 제어	제어봉 (IV-CRDM), MTC & 온도프로그램 기연성독물질 (BP) (필요시) 이차정지 독물질
중기발생기	과열중기 관류형(OTSG) 1대 나선형 전열관 (중기 shell side)
기압기	중기압 제어 (SG 블록 상부 일체형)
냉각재펌프	캔드모터 펌프 2대 (SG 블록 장착)
안전 주입, 잔열 제거	피동 (안전) 능동 (비안전)
해양 환경 설계	6-자유도 경사요동 하중 등
설계 수명	60년 (부유체 수명 연계 조정 가능)

● 주요 진보 설계 특성



O4 BANDI의 진화는 진행 중 ...

● 단순화, 최적화

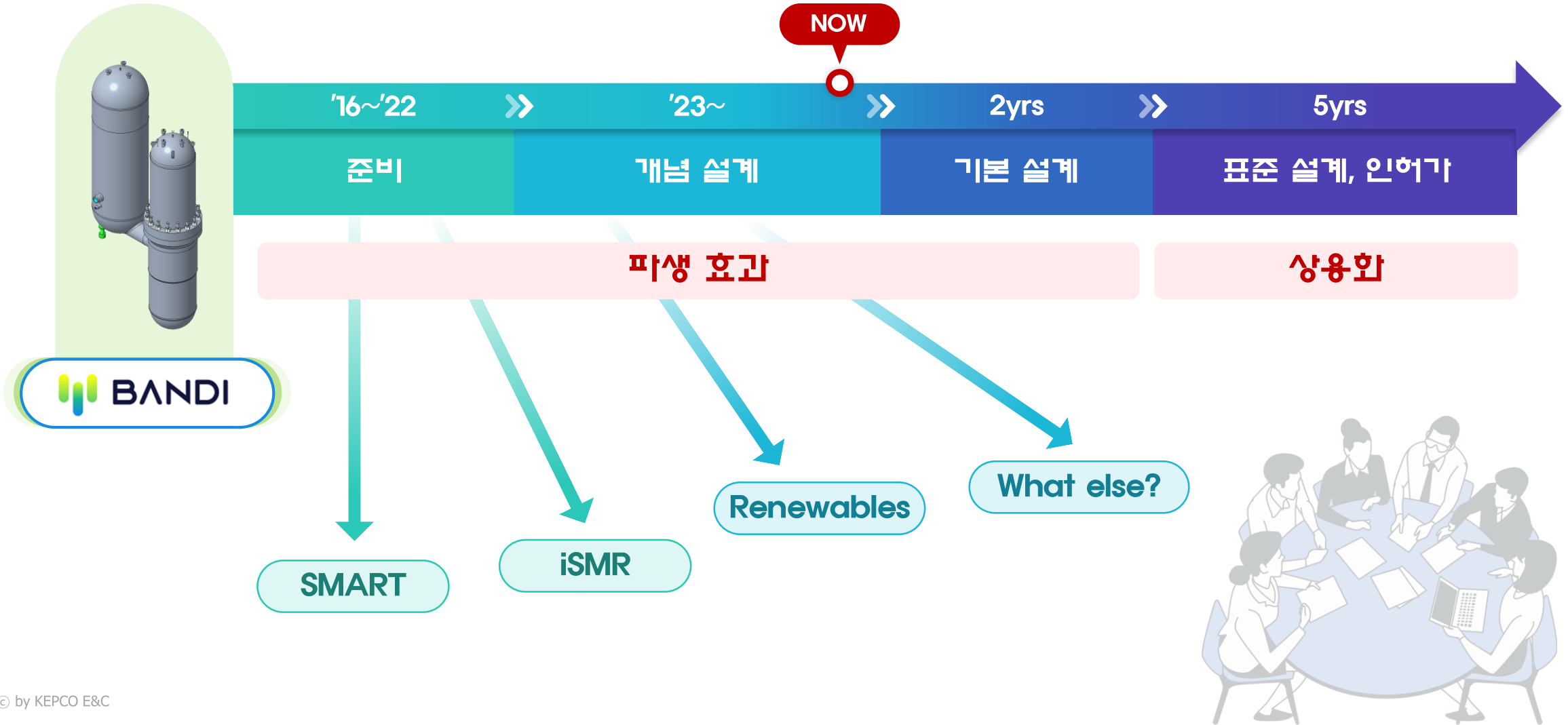


NO.3



향후 추진 계획

SMR 기술 역량 강화 → SMR 사업 기회 확대



Advances in Small Modular Reactor Technology Developments

A Supplement to:
IAEA Advanced Reactors Information System (ARIS)
2022 Edition



TARGET MARKET AND ITS COMPETITIVENESS

BANDI is primarily aiming at the floating nuclear power plants, and later may extend its applications to nuclear merchant ships and land-based nuclear power plants. Following are its strategy to gain competitiveness in the market.

Competitive Strategy

- Ensure public acceptance with an ultimate safety not requiring community evacuation
- Minimize licensing procedures by utilizing proven technologies
- Supply clean and stable energy at reasonable price as compared to conventional fossil fuels (coal, gas, diesel, etc.)
- Start construction time through modular fabrication and assembly at factory before sailing to the site
- High-capacity heater with storage heat cycle system

MARKET FLEXIBILITY

BANDI mounted on the floating barges can supply clean heat, electricity and water to remote areas, islands or offshore plants. It collaborates with other industrial sectors. It can also offer various new business models.

Flexible Power Output

- One set of BANDI can provide electricity for about 150,000 homes by generating 500MW a year
- Simplicity of BANDI design allows to meet various levels of power demand easily

Collaboration with Other Technologies

- New zero-carbon business models in cooperation with shipbuilding and marine industries
- Nuclear-renewable hybrid energy systems

BANDI™

Like a band, "BANDI" in Korea, that brightens up a deep darkness in the forest in a summer night by itself. KEPCO E&C's SMR BANDI promises to supply safe and clean energy to remote and isolated areas.

KEPCO ENGINEERING & CONSTRUCTION COMPANY
38000-200, Incheon-si, Ganghwa-gu, Gyeonggi-do, Korea | TEL: 82-10-442-0104 | www.kepcoec.com

BANDI™
KEPCO E&C'S SMALL MODULAR REACTOR (SMR)

INNOVATION

BANDI adopts new innovative technologies to further enhance the safety, economics and applicability to raise its market competitiveness in the future.

Block-Type Reactor Coolant System (BTRCS)

- Reactor tank and steam generator located in one vessel to reduce connected external piping
- Elimination of large pipe break accidents
- Reduce power and design charges in the needs of customers
- Easy to service, replacement and maintenance

In-Vessel Control Rod Drive Mechanism (ICRDM)

- ICRDM is located inside the reactor pressure vessel to prevent neutron moderation on the primary coolant loop
- Elimination of the control rod ejection accident which may be critical in the basin-less small reactors
- Key heat technologies were obtained by KEPCO E&C through long-term R&D
- A government-appointed MO project (2010-2016)

Integral Pressurizer

- The pressurizer is integrated into the down leg of the steam generator tank
- Elimination of the single pipe
- Large pressure space for better mitigating capability of transients

Boron-Free Design

- Complete active boron distribution from the core secondary circuit
- Elimination of boron dilution accident
- Elimination of boron-induced corrosion
- Reduction of the water and moderator volume
- Simplified design for removing boron injection and removal systems

Autonomous Operation

- Enhanced autonomous control and mitigation functions
- Optimized control logic
- Minimized intervention of operators
- Early warning of abnormal symptoms
- Passive-based automation

MAJOR DESIGN FEATURES OF BANDI

Reactor Type	Block-Type Pressurized Water Reactor (BTRCS)
Thermal/Electrical Power	200MWt / 50MWel
Core Configuration	Frontal Core Design
Fuel and Core	1 UO ₂ fuel rods in 17x17 assembly Number of assemblies = 162 Active Fuel Length = 220cm Enrichment = 19.5% U-235 Extended Core Length = 8.7 years
Neutronic Control	Control Rods / Burnable Absorbers / Assisted by strong negative void coefficient reactivity
Pressurizer	Down-through integral-pressure vessel / Refill tank transfer system
Primary Circuit	Single loop type
Reactor Coolant Pump	Directly driven motor / Enhanced load-shed performance by superconductor
Safety Injection	Passive Gravity Driven
Emergency Core Cooling	Passive Pressure Driven / Active Backup up
Core Lifetime	~ 60 years (reactor year)
Design Size	600 mm

BANDI-60 (KEPCO E&C, Republic of Korea)

All content included in this section has been provided by, and is reproduced with permission of KEPCO E&C, Republic of Korea.

MAJOR TECHNICAL PARAMETERS	
Parameter	Value
Technology developer, country of origin	KEPCO E&C, Republic of Korea
Reactor type	PWR
Coolant/moderator	H ₂ O (Light Water)
Thermal/electrical capacity, MWt/MWe	200 / 60
Primary circulation	Forced
NSSS operating pressure (primary/secondary), MPa	15.5 / 6
Core inlet/outlet coolant temperature (°C)	290 / 325
Fuel type/assembly array	Oxide / 17x17
Number of fuel assemblies in the core	52
Fuel enrichment (%)	4.95
Refuelling cycle (months)	48-60
Core discharge burnup (GWd/ton)	29.4
Reactivity control mechanism	Rods
Approach to safety systems	Passive safety system
Design life (years)	60
Plant footprint (m ²)	8,500
RPV height/diameter (m)	11.2 / 2.8
RPV weight (metric ton)	110
Seismic design (SSE)	N/A
Fuel cycle requirements/approach	4-5 years / Single batch 4.95%
Distinguishing features	Passive Safety System
Design status	Conceptual design

1. Introduction

BANDI-60 is a compact two-loop PWR with two U-tube type steam generators. KEPCO E&C focuses on deploying a floating nuclear power plant in the sea. BANDI-60 is designed for niche markets, for instance, distributed power and heat supply to remote communities, desalination, and hybrid energy systems with renewables, through a collaboration with marine and shipbuilding industries.

Typical Plant Layout

2. Target Application

BANDI-60 is designed for off-grid and remote areas such as islands, Arctic area and isolated grid.

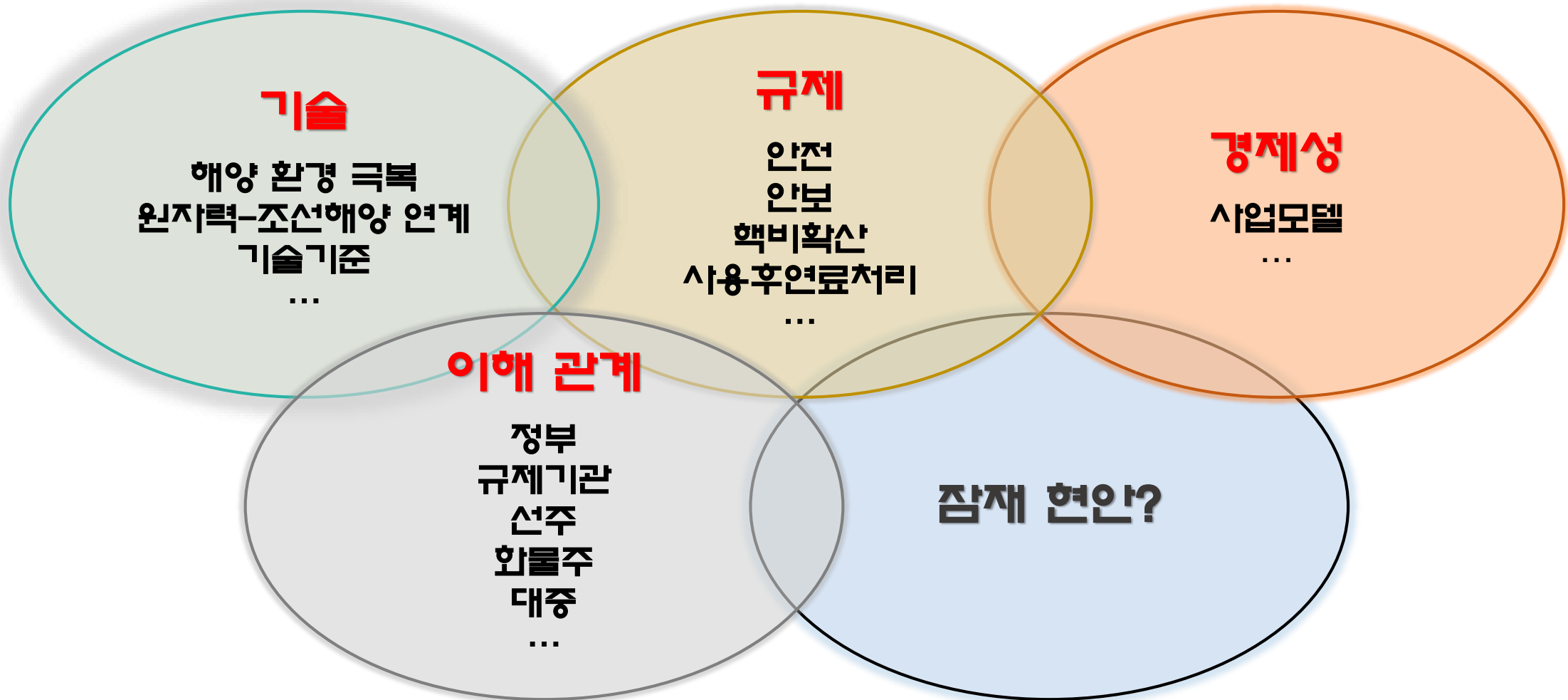
3. Design Philosophy

The BANDI-60 design adopts technology innovations developed in-house from 2013, such as the in-vessel control element drive mechanism (IV-CEDM), soluble boron-free (SBF) design and operation, and the Top-Mounted In-Core Instrumentations (TM-ICI). The CEDM inside of reactor pressure vessel will eliminate control element ejection accident. BANDI-60 is designed to operate at soluble boron-free conditions to simplify the design, operation and maintenance of nuclear reactor.

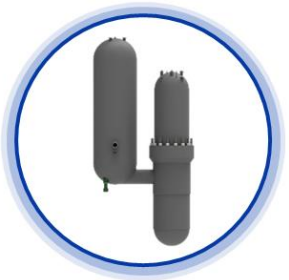


03 극복해야할 난제들

- 모든 현안이 중요하고, 상호 밀접히 연계되어 있어



- 공동 설계
- 사업모델 개발
- 인허가 계획 수립 ...



해양 SMR BANDI

감사합니다.

