14th Pacific Basin Nuclear Conference
"New Technologies for a New Era"
March 21-25, 2004, Honolulu, Hawaii, U.S.A.

Advanced Nuclear Reactor Programs in Korea

Plenary: "Looking Ahead: Developing a New Generation of Advanced Nuclear Reactor and Fuel Cycle Technologies"

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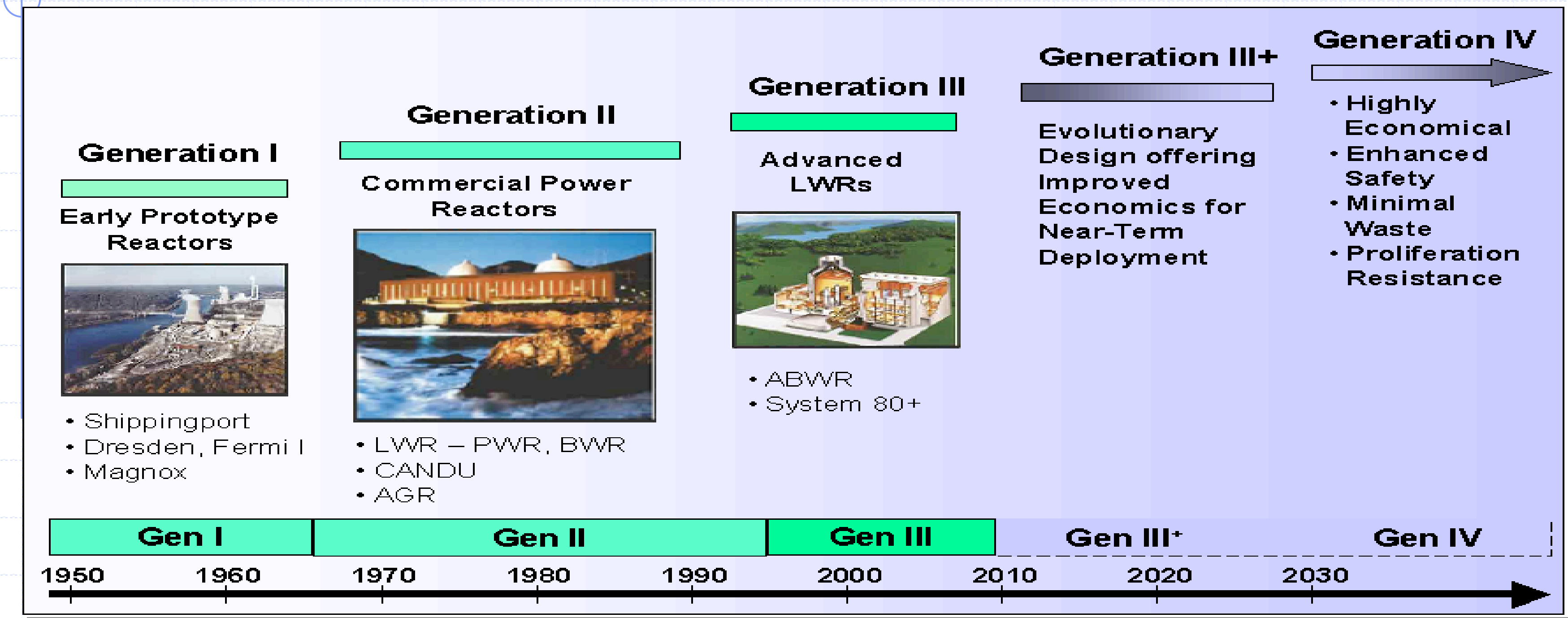
Nuclear Reactor Programs in Korea



- PWR (14 units)
  - 6-Westinghouse
  - 2-Combustion Eng.
  - 2-FRATOME
  - 4-KSNP
- PHWR (4 units)
  - 4-CANDU(AECL)

- KSNP+(1,000 MWe)
  - 2 under commissioning
  - 2 under construction
  - 2 under negotiating
  - 2 under planning

- APR1400(1400 MWe)
  - 2 under negotiating (2010)
- SMART (330 MWt)
  - Pilot plant under construction (2008)

- SFR
  - KALIMER (600 MWe)
- VHTR
  - Hydrogen (300 MWt) Production

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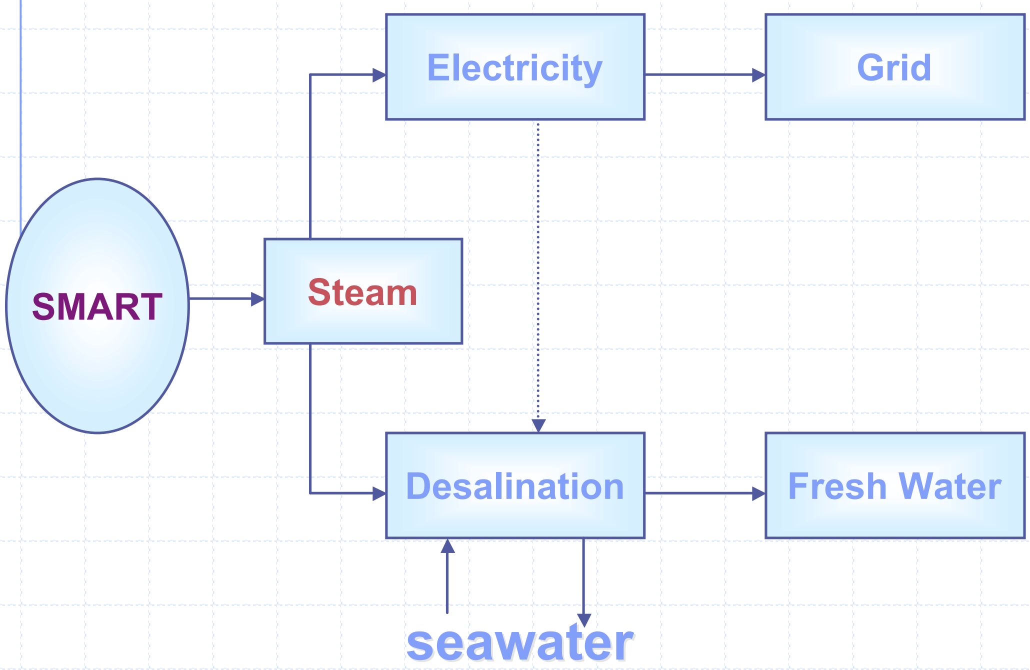
SMART

A Small- & Medium-Sized Multi-Purpose Integral-Type Reactor

Advanced Reactor Programs in Korea
(GEN III+: Near-Term Deployment)

SMART (System integrated Modular Advanced ReacTor)

Electricity Generation System



Desalination System

System (Plant) Concept

- SMART Thermal Power : 330 MWt
- Desalination Process : MED
- Water Production : 40,000 tons/day
- Electricity Generation
  - Efficiency : ~ 30%
  - To the Grid : ~ 90 MWe

Water and Electricity Supply to the Area with Approximately 100,000 Population or to an Industrial Complex

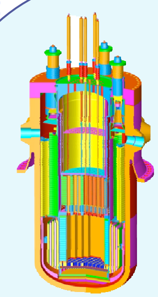
SMART - General Characteristics

DESIGN INNOVATION

- Integral Arrangement of Primary Components
- Soluble Boron Free Operation
- Passive Residual Heat Removal
- Safeguard Vessel
- Full Size Condenser

INHERENT SAFETY

ENHANCED OPERABILITY



SIMPLIFICATION & MODULARIZATION

- System Simplification
- Modularized Components for Easy Manufacturing and Maintenance
- Multiple Units for Higher Power

IMPROVED ECONOMICS

PERFORMANCE UPGRADE

- Wide Operation Range
- Ultra Long Cycle Operation (3 Years)
- Advanced Man Machine Interface Systems
- Digital Core Protection/Monitoring System

SMART Design Goal: What do we achieve?

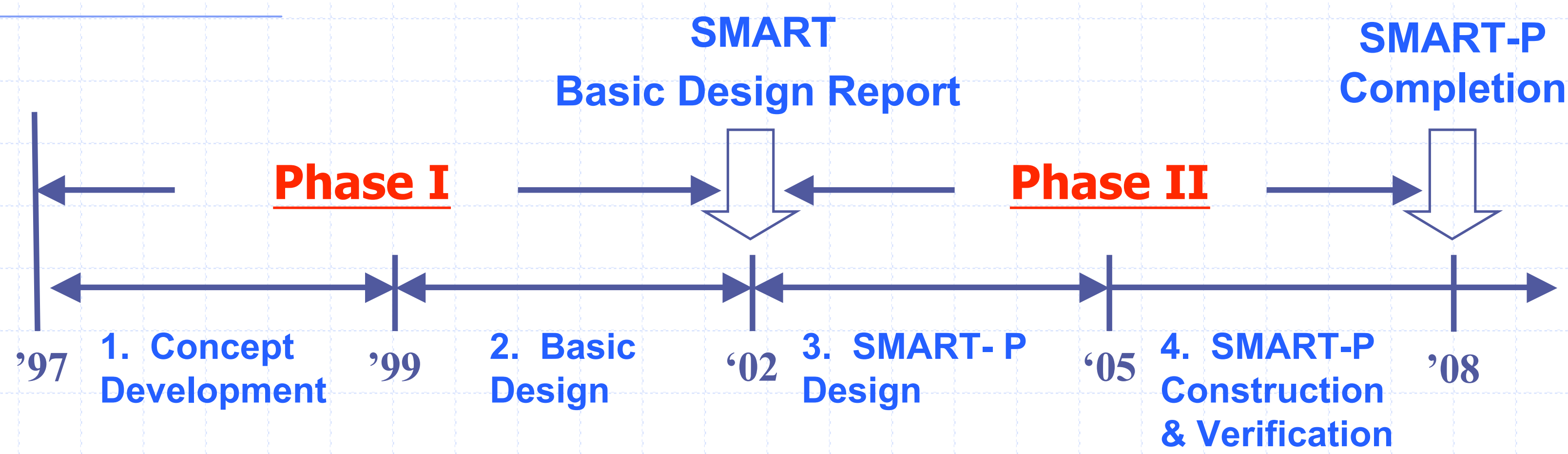
Safety	Core Damage Frequency	< 10^{-7}/RY
	Large Release Frequency	< 10^{-8}/RY
Economics	Electricity Generation Cost	< Gas Turbine
	◆Construction Period < 36 Months ◆Availability > 95% ◆Reactor Lifetime 60 year	

Results of Economic Assessment

Categories	*construction cost ($/kW)*	*electricity generation ($/MWh)*	*seawater desalination ($/ton)*
*1-Unit Plant (first unit)**	2,510	38.45	0.537
2-Unit Plant	2,409	37.22	0.509
4-Unit Plant	2,055	33.03	0.475

*** Base Case: 90 MWe electricity generation and 40,000 ton/day seaw ater desalination with 330 MWt power.**

Milestone Schedule of SMART Technology



- Phase I: Technology Development
  - Basic design work under KAERI: Design Criteria and Requirements, System Design Descriptions, System Interface Requirements, P&ID, & Drawings.
- Phase II: Technology Verification
  - Construct a 1/5-Scale Pilot Plant ("SMART-P") under Project Team (KAERI +Industries): Perform the integral verification tests of overall system performance and safety of SMART technology.
- Phase III: Technology Commercialization
  - Proceed commercialization under industries.

Budget for SMART Technology Development

(billion won)

Phase	Time Period	Budget	SMART-P*
I-1	'97.7- '99.3 (1 year 9 months)	Conceptual Design: 13.05	-
I-2	'99.4-'02.3 (3 years)	Basic Design : 18.95	
II-1	'02.4-'05.3 (3 years)		Design & Tests : 70.0 (CP by March, 2005)
II-2	'05.4-'08.6 (3 years 3 months)		Construction & Tests : 200.0
Total		32.00	270.0

- Financing of SMART-P: 30% by Government; and 70% by Industries.

Note: Government approved the investment of full 270×10^9 won for SMART-P Project on January 15, 2002 over a 7 year period (2002-2008).

International Activities in Promoting SMART

- **Indonesia + IAEA**
  - Preliminary Economic Feasibility Study of Nuclear Desalination in Madura Island, Indonesia
  - BATAN, KAERI, and IAEA: Jan. 2002 ~ Dec. 2004 (3 years)
  - Draft Study Report and User Requirement Document for Nuclear Desalination Plant Issued
  - IAEA's Technical Cooperation Program for 2005 –2006 will be carried out.
- **Other Countries**
  - Chile: Feasibility Study on Small- & Medium-Sized Reactors (11/03)
  - Russia: Joint Study on Marine Use of SMART (03/04)
  - China, UAE, Philippines, Vietnam, and Morocco: Technical Cooperation

Advanced Reactor Programs in Korea
(GEN IV: Long-Term R&D)

- Interest of Korea
  - High Interest : SFR (KALIMER), VHTR (for H-2 Generation)
  - Medium Interest : SCWR, GFR
  - Low Interest : LFR, MSR

- Gen IV R&D Planning Report Was Completed by Gen IV Technical Committee in May 2003.

- 2004 Budget for Gen IV
  - About 1 billion Won for Gen IV R&D Collaboration thru GIF
  - About 3 billion Won for Nuclear Hydrogen (VHTR)

Advanced Reactor Programs in Korea
(INERI Program)

- INERI Program: Bilateral Nuclear R&D Collaboration between Korea and U.S.A. for Developing Gen IV and Advanced Nuclear Technologies since 2001.

- Current INERI Projects (11 projects)
  - 4 projects for advanced LWR technologies (started in 2002)
  - 2 projects for advanced I&C technologies (started in 2002)
  - 5 projects for Gen IV technologies (started in 2003)

- 3 New Collaboration Areas
  - Gen IV Nuclear Energy Systems
  - AFCI (Advanced Fuel Cycle Initiatives)
  - Nuclear Hydrogen

- Budget for INERI Program: 6.8 billion won for the year 2003

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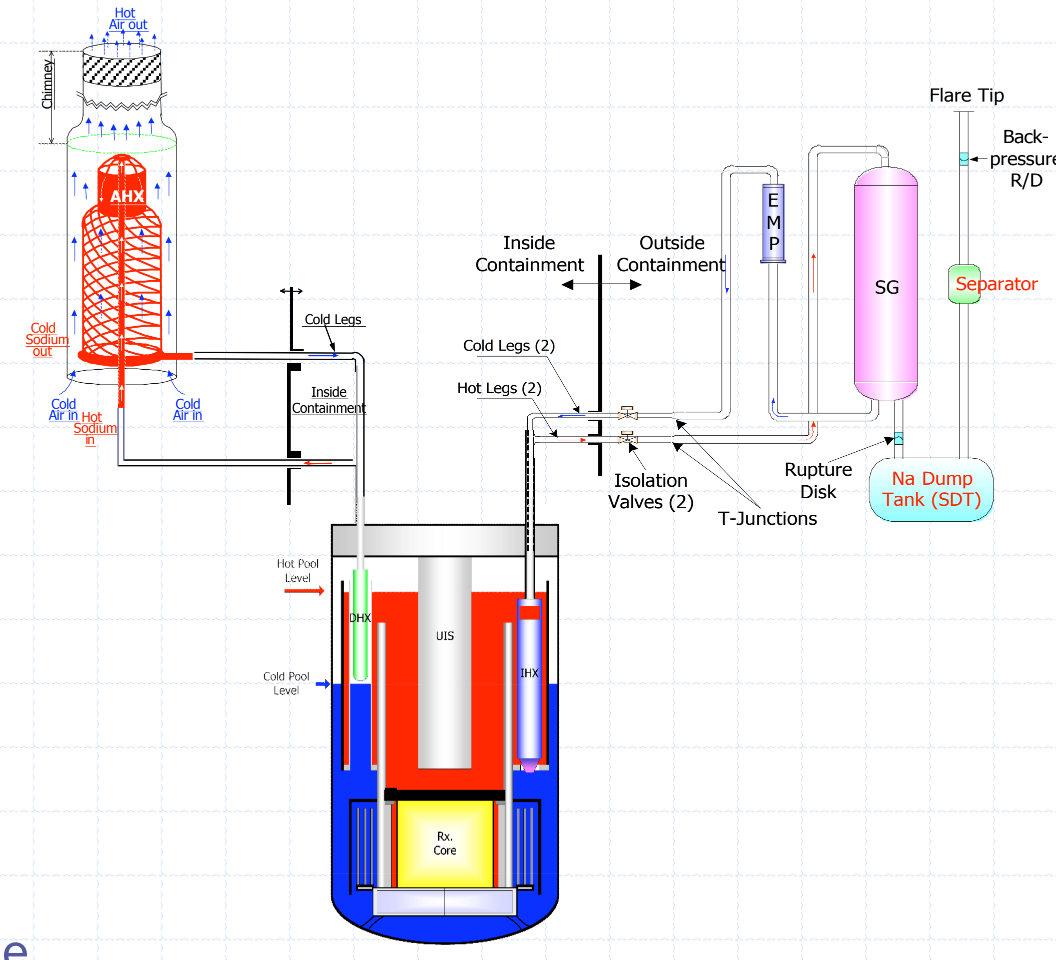
KALIMER – Korean Advanced Liquid Metal Reactor

Sodium-Cooled Fast Reactor Development Program

Design Concept of KALIMER-600

- ❑ Design Objectives
  - Sustainability
  - Safety & Reliability
  - Economics
  - Proliferation Resistance
- ❑ Key Design Features
  - Pool type reactor
  - Power : 600 MWe
  - Core exit temp: 510^{o}C
  - 2-Loop IHTS
  - Passive RHRS : PDRC
  - Plant efficiency : 39%
  - Superheated steam cycle



Design Concept of KALIMER-600

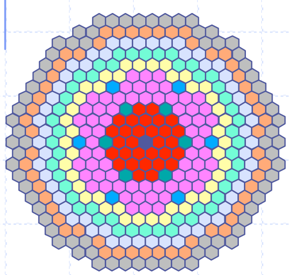
On-Going R&D Activities

- ❑ **Core Design Studies**
- ❑ **Development of Integrated IHX/SG**
- ❑ Thermal Striping Analysis Methods
- ❑ Structural Integrity Assessment for Elevated Temperature Structures
- ❑ Water Leak Detection Techniques
- ❑ Computer Codes
  - Core Design
  - Core Seismic Response Analysis
  - System Transient Analysis
  - Flow Blockage Analysis
  - Long-term Behavior of SWR

Core Designs

Enriched Uranium
1997 ~ 1998

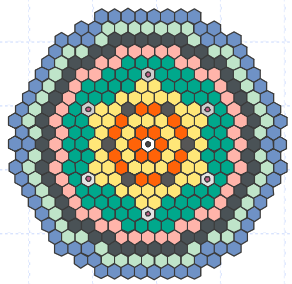
No Initial Loading of Pu



Power : 150MWe
Fuel form : U-Zr
Enrichment : 15.4/20%
Once-through fuel cycle
Conversion ratio : 0.67

Breeder
1999

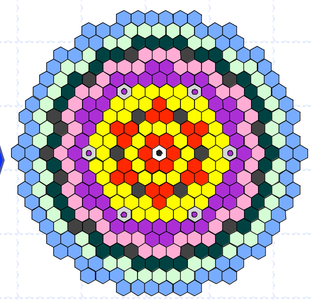
Breeding Characteristics



Power : 150MWe
Fuel form : U-TRU-Zr
Enrichment : 26.3%
TRU Recycling
Conversion ratio : 1.18

Breakeven
2000 ~ 2001

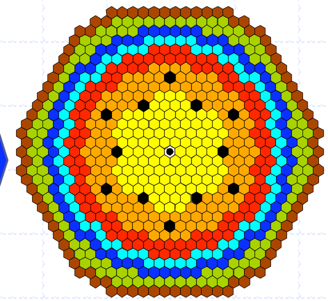
Self-sufficient Fissile



Power : 150MWe
Fuel form : U-TRU-Zr
Enrichment : 30.0%
TRU Recycling
Conversion ratio : 1.05

Breakeven
2002 ~ 2004

Enhanced Proliferation Resistance: No Blanket



Power : 600MWe
Fuel form : U-TRU-Zr
Enrichment : 13.5/15.7/18.9%
TRU Recycling
Conversion ratio : 1.004

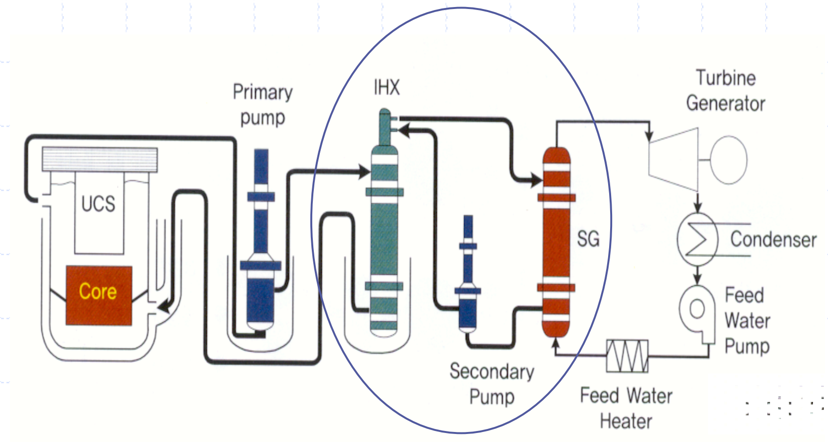
Transmuter
2004 ~

Actinide Transmutation

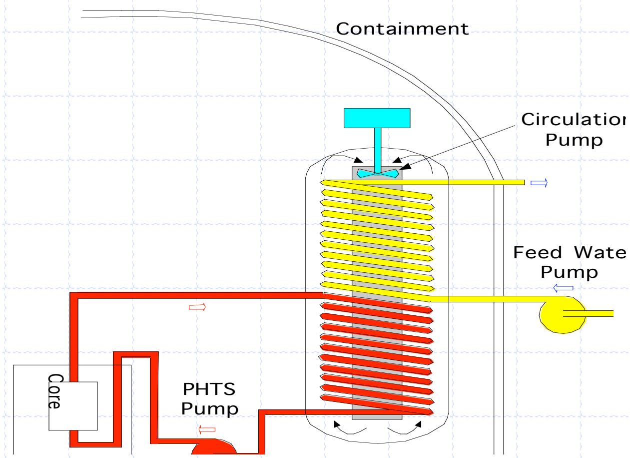
Development of Integrated IHX/SG

- Objective
  - Enhanced plant safety through elimination of SWR event in SG
  - Reduced construction cost through simplification of IHTS

- On-going Activities
  - Development of integrated IHX/SG concepts
    - Tube arrangements
    - Flow paths for intermediate medium
  - Evaluation of heat transfer capabilities

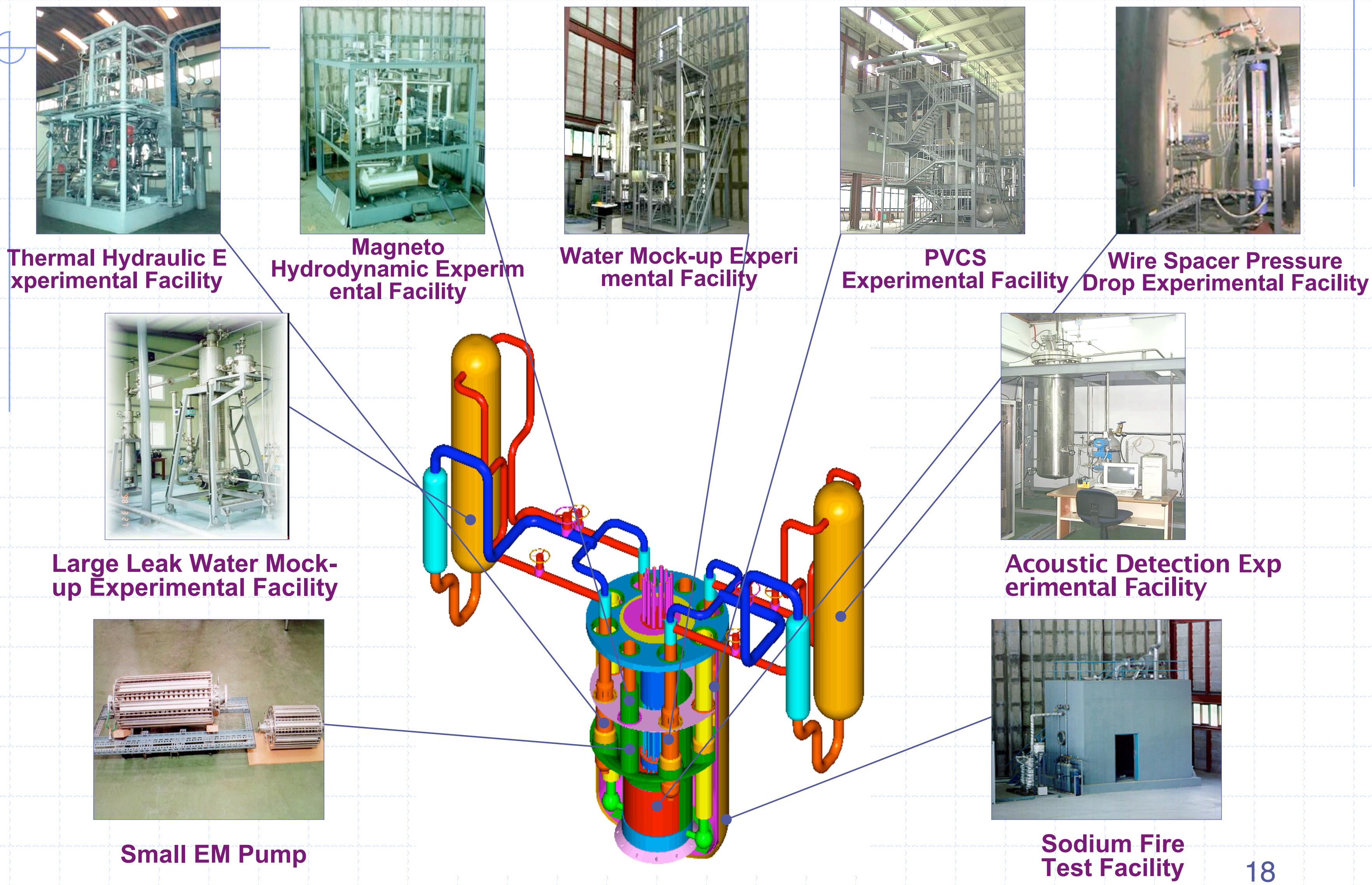


Typical NSSS arrangements of Sodium-cooled LMR



NSSS arrangements with integrated IHX /SG

Sodium Experimental Facilities



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VHTR - Very High Temperature Reactor

Development of Hydrogen Production System Using Nuclear Energy

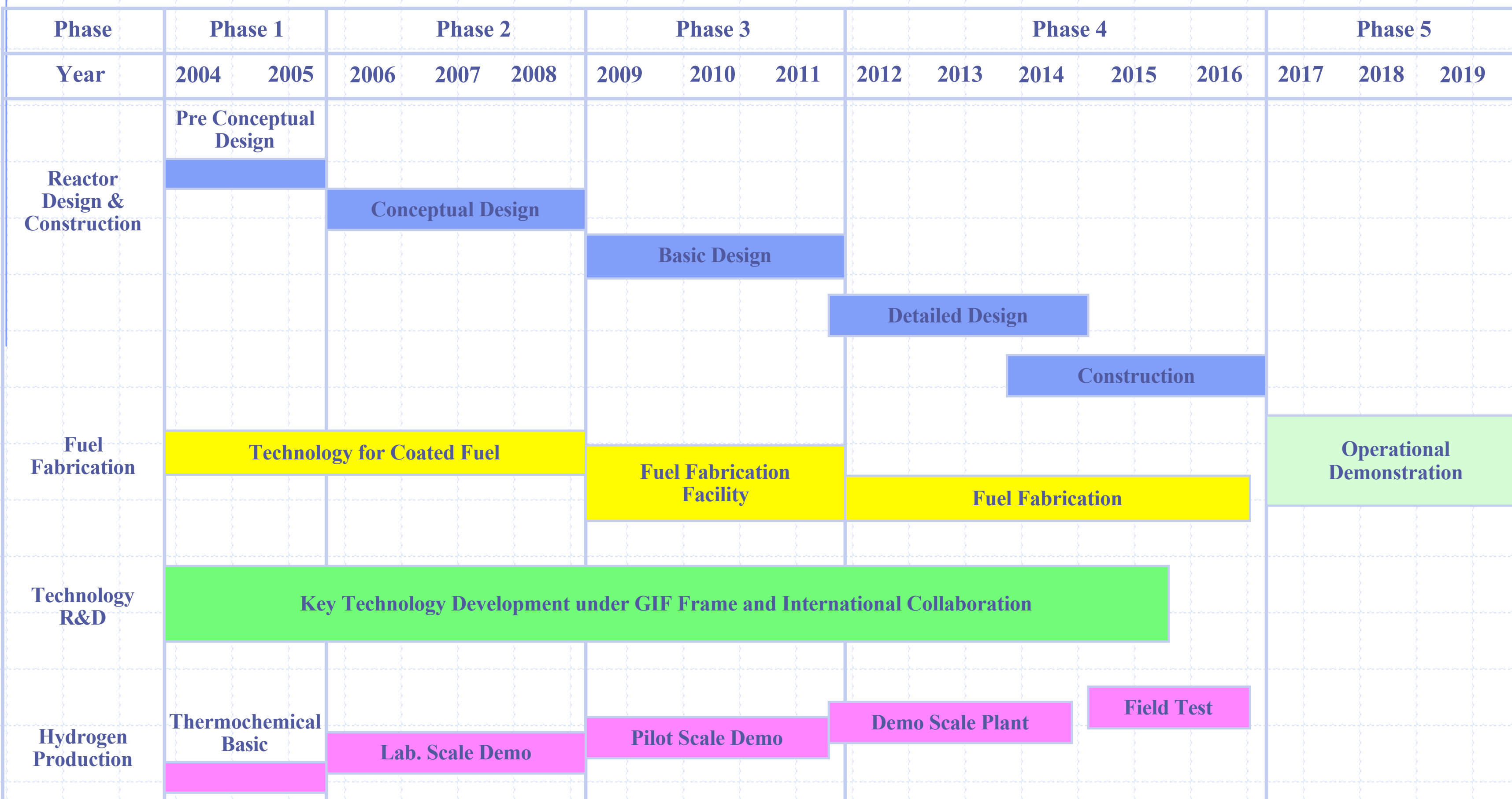
Objective of Project

Project started March of 2004 under a team in KAERI.

- Develop Technology for Hydrogen Production
  - HTGR (High Temperature Gas Cooled Reactor)
  - Fuel for HTGR
  - Sulfur Iodine Thermochemical process for hydrogen production
- Demonstration of Developed Technology by constructing and operating a Dedicated Nuclear Hydrogen Production Plant.
  - One 300 MWth VHTR-type module
  - Production of 30,000 ton of hydrogen per year (equivalent to the su pply fuel for 150,000 automobiles)
  - At the cost of 1,200 USD/ton of hydrogen

Project Timelines and Budget

Estimated Budget: 986.1 billion Wons (843 million U$) by 2019



Conclusion

•Korea does not have any other choice than keeping an aggressive nuclear power program since more than 97% of its energy required are imported from foreign countries.

•Hence, nuclear power has been one of major sources of electricity supply (about 40%) in Korea last 30 years.

•It has provided Korea with most economic and environmentally-frie ndly way of producing electric energy, and has contributed a lot in it s national economy growth. It will continue to do so in the future.

•Let me tell you in this occasion, Korea is really looking ahead in de veloping a new generation of advanced nuclear reactor and fuel cy cle technologies.