Status of Nuclear Hydrogen Production Technology Development Project in Korea

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- Status of Key technology development

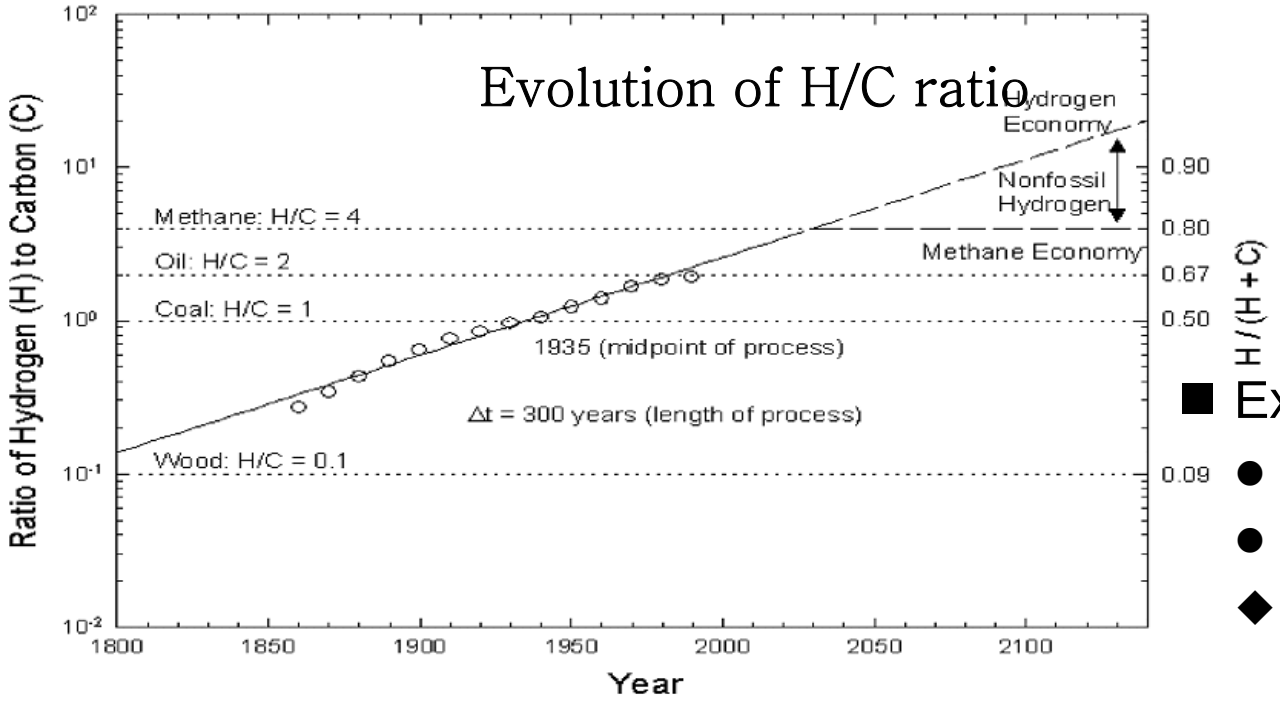
Energy Situation in Korea

Earth at Night, 2003 avg, NASA DMSP

- N. Korea (2006 est.)
- Population : 23 Million
- Electricity : 21,710 GWh/yr
  - per capita : 78 kWh/month
- Oil : 22,000 bbl/day
  - per capita : 0.15 liter/day

- S. Korea (2006 est.)
- Population : 49 Million
- Electricity : 342,148 GWh/yr
  - per capita : 584 kWh/month
- Oil : 2,149,000 bbl/day
  - per capita : 7 liter/day

Energy and Society



■ Expense per household

- **Electricity 36 k₩/month**
- **Fuel 190 k₩ (Daejeon)**
- **Communication 160 k₩**

19C Carbon economy

- **Industry revolution**

⇨**Democracy**

20C Oil economy

- **Transportation rev.**

⇨**Globalization**

21C Hydrogen economy ?

- **Prosumer revolution ?**

⇨**Distributed community?**

Energy problems in 21st century

- Global warming
  - Rapid change of climate
  - Reduction of carbon emission
- Shortage in oil and gas supply
  - Energy production from natural environment
  - Energy security of a country

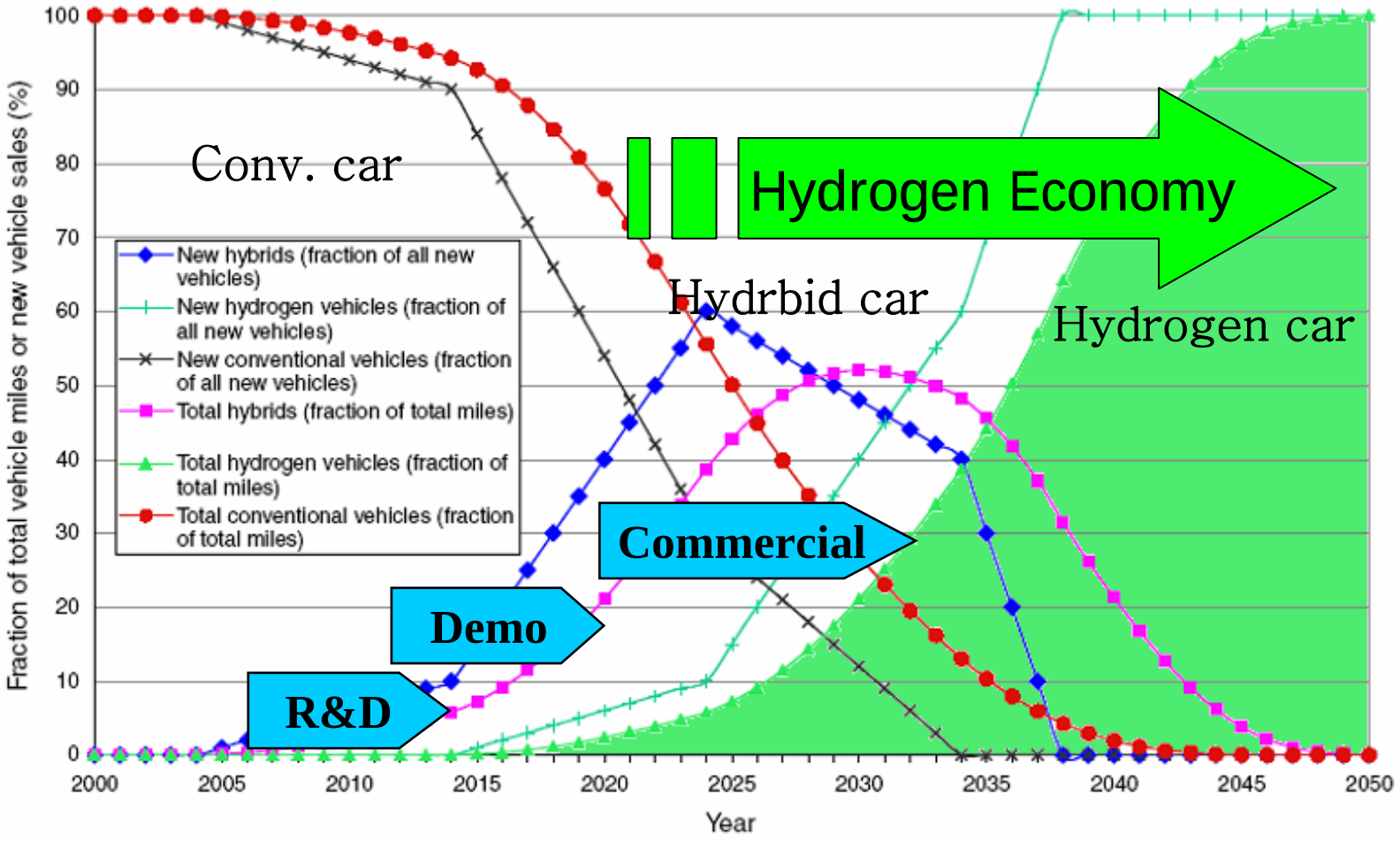
Vision of Hydrogen Economy

- Energy independence
  - Domestic energy resource
  - Renewable energy
  - Semi-indegeous energy
- Environmentally benign fuel
  - No carbon emission
- Economic competitiveness
  - Gasoline price at the time

- **Hydrogen can be produced from domestic energy sources in a manner that is affordable and environmentally benign.**
- **Applications using hydrogen can gain market share in competition with alternatives.**

-- Hydrogen Economy, NAS, 2005.

US Scenario for Hydrogen Economy



출처 : **The Hydrogen Economy, The National Academies Press, 2004**

Korean situation ?

- Kyoto protocol ?
  - 2002.11.8 ratified
  - emission right trade
- Energy resource ?
  - Import 96.8%
- Renewable energy ?
  - High population density
    - Korea 483/km^2, Japan 339/km^2, Germany 232/km^2, USA 32/km^2, Australlia, Canada, Iceland 3/km^2
  - Investment and Land usage
    - Solar PV 3,300k₩/py Invest ⇨ 350 kWh/yr/py (18k₩/yr)
    - Wind 130k₩/py Invest ⇨ 93 kWh/yr/py (4.7k₩/yr)

    ✓Interest rate of 3,300k₩(4%) ~= 130k₩.

    ✓Revenue of forestry : ~ 8%/yr

Third nuclear R&D promotion plan (MOST)

Objective 3 : Technology driven energy supply system from diversification of nuclear application

- **Development of massive hydrogen energy production system using nuclear energy for preparing nuclear hydrogen economy.**
  - ○ Develope Key technologies for VHTR which wll be used as the energy source for hydrogen production.
    - Acquistion of key technology by involvement in GIF.
    - Feasibilty study of commercialization of VHTR for hydrogen production.
  - ○ Encourage industry to involvement in demonstration project when commercial feasibility is forseeable.
    - Detail design, Construction, and Operation of a demonstration reactor and hydrogen production plant.

Hydrogen economy Master plan (MOCIE)

□ Nuclear : “Deploy when technology is mature”

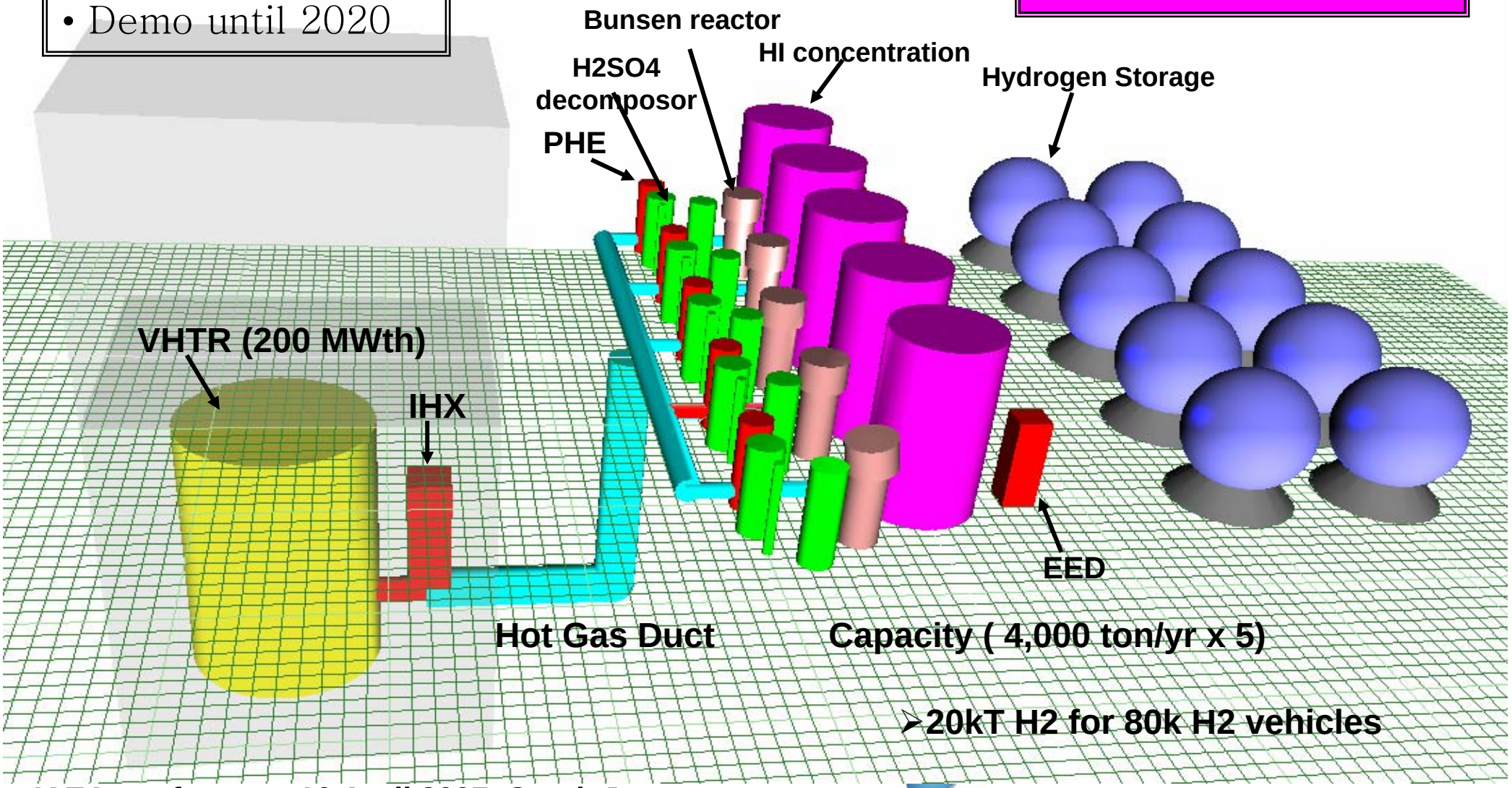
○ Massive hydrogen production by water spliting using a higher than 900°C heat from Generation 4 reactor.

● USA MIT : Uranium may be used for more than 200 years and can be avaiable for more than 1,000 years with recycle of fuel.

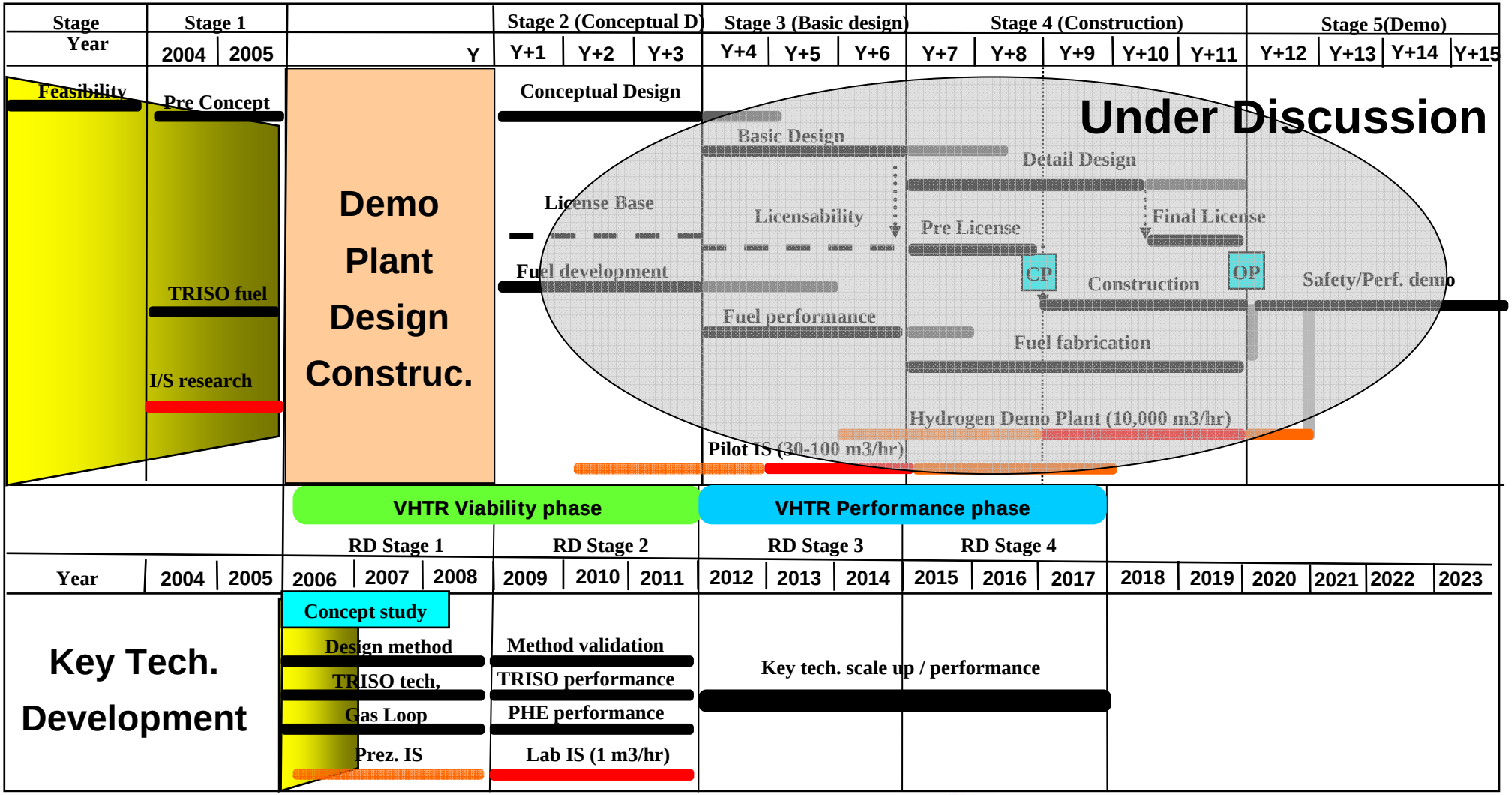
Devel. Area	•Construction and demonstration of a Gen-IV reactor when its technology is proven in safety and environmental aspect. •Development of key technology for economic hydrogen production using IS thermochemical or electrolysis.

A sketch of NHDD Plant

- Demo until 2020
- Comercialization in middle of 2020s



Nuclear Hydrogen Project Master Schedule



Major Challenge

- Nuclear reactor has no experience with heat market
- Modern licensing is based on LWR experiences
- High Temperature, High Pressure, High Corrosion, High efficiency

200 MWth NHDD Core

Design Parameter	PMR	PBR	unit
Thermal power	200	200	MW
Inlet/outlet helium temperature	490/950	490/950	°C
Vessel outer diameter	600	550	cm
Reflector thickness	100	90	cm
Equivalent active core inner/outer radius	50/140	0/124	cm
Effective core height	555	873	cm
Average power density	6.7	4.74	W/cc
Average U235 enrichment	15.5	9.76	w/o

Heat Usage

- I/S Thermochemical

Vessel

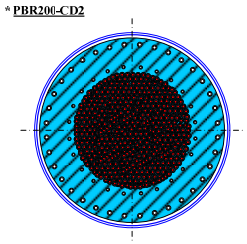
- Forged Vessel

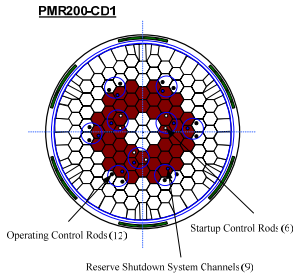
- Domestic limit : 6.5 m

- Cooled Vessel

Fuel

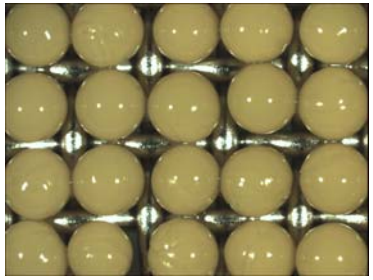
- UO2 SiC TRISO



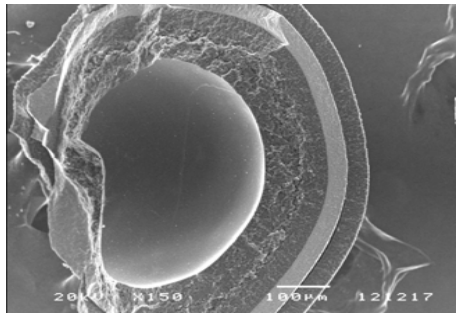


Fabrication of TRISO particle fuel

Kernel fabrication



Fuel Coating



Fuel Qualification and Performance

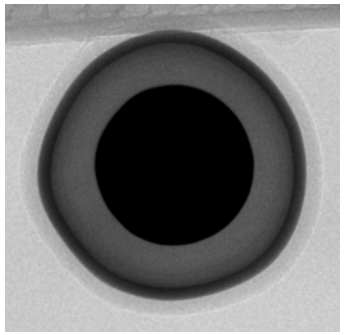
Irradiated Material Database

IAEA DB

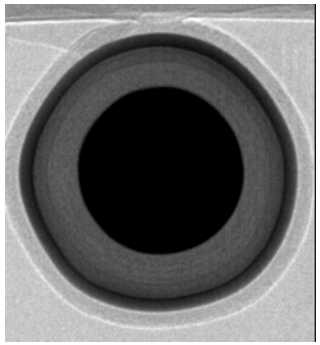
COPA

Fuel Performance
- **Temp. Burnup distribution**
- **Stress, Failure, Crack**
- **F.P. release**

Phase Contrast X-ray Radiography
- Non destructive test



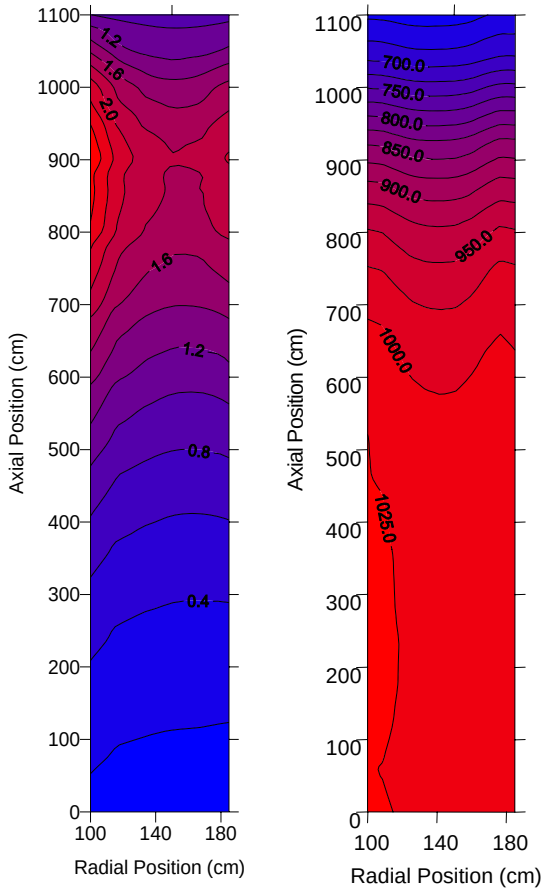
Conventional X-ray



Phase Contrast X-ray

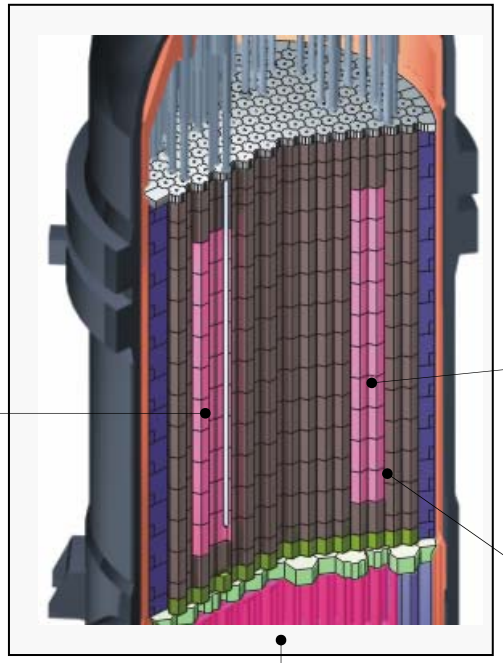
Reactor Analysis

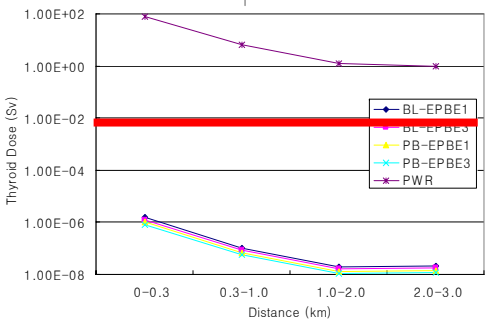
Core Analysis



Power

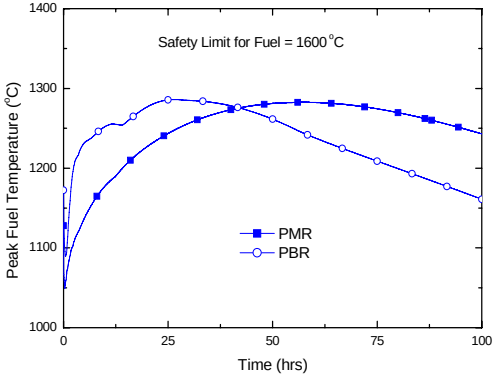
Temperature



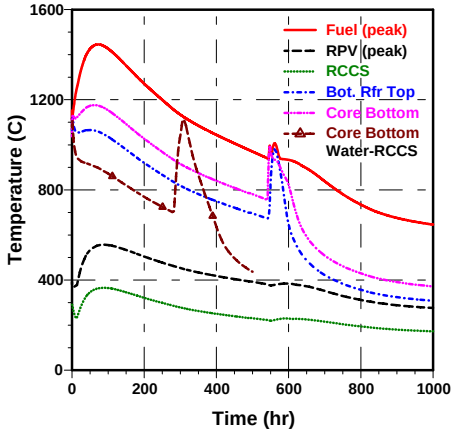


Public Dose rate

Accident Analysis



Loss of Flow accident

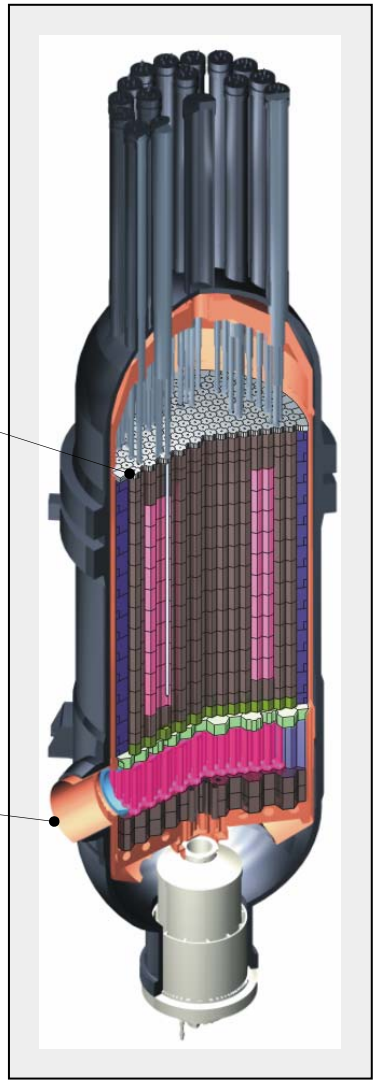


Duct rupture and Air ingress

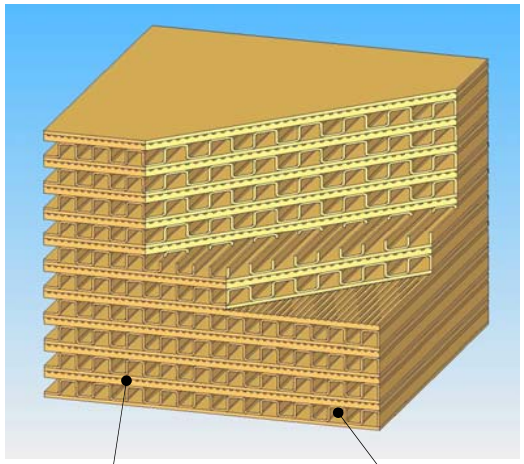
Material assessment and Coating

Graphite

Superalloy



Process Heat Exchanger

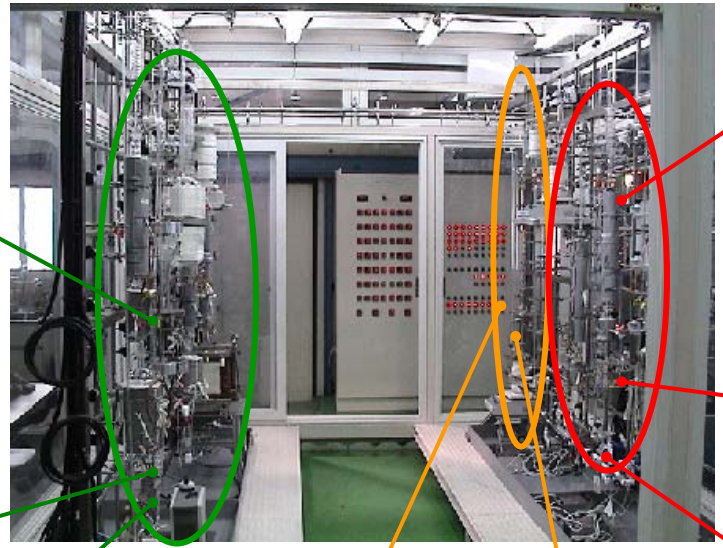


Coating

Corrosion

Bench scale I/S cycle

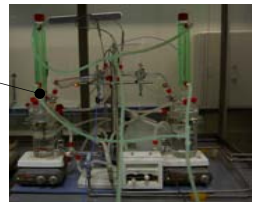
Iodine-Sulfur Cycle (20 liter/hour)



Membrane

H2/HI separation

EED



HIx concentration

Material HI corrosion test

Bunsen reaction

HIx/H2SO4 separation

H2SO4/SO3 separation

SO3 decomposition

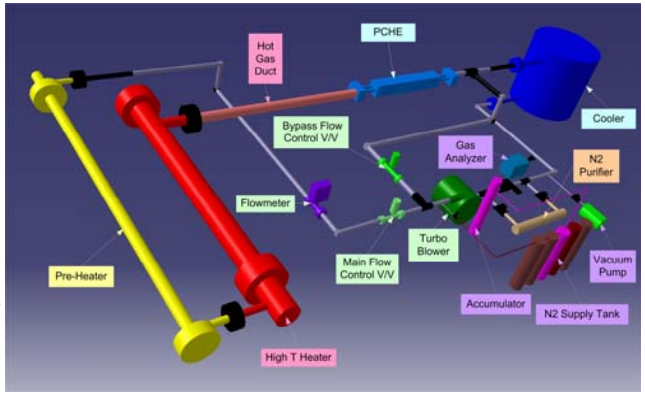
H2SO4 concentration

Pressurized I/S process

Sulfric acid decomposition

- IR spectroscopy
- flow control

Ta crucible for Busen reaction



Small Gas Loop for coupling test
(under construction)

✓target : 40 ~ 70 bar
✓current : 5 bar

I/S Database

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Flowsheet Analysis

- Plant design
- Optimization

Thank You for Attention.

감사합니다.

Any Question ?