# Possible Scenarios and its Effects by Non-Power Application of Nuclear Energy ; Japanese Cases

16 April 2007
Oarai, Japan

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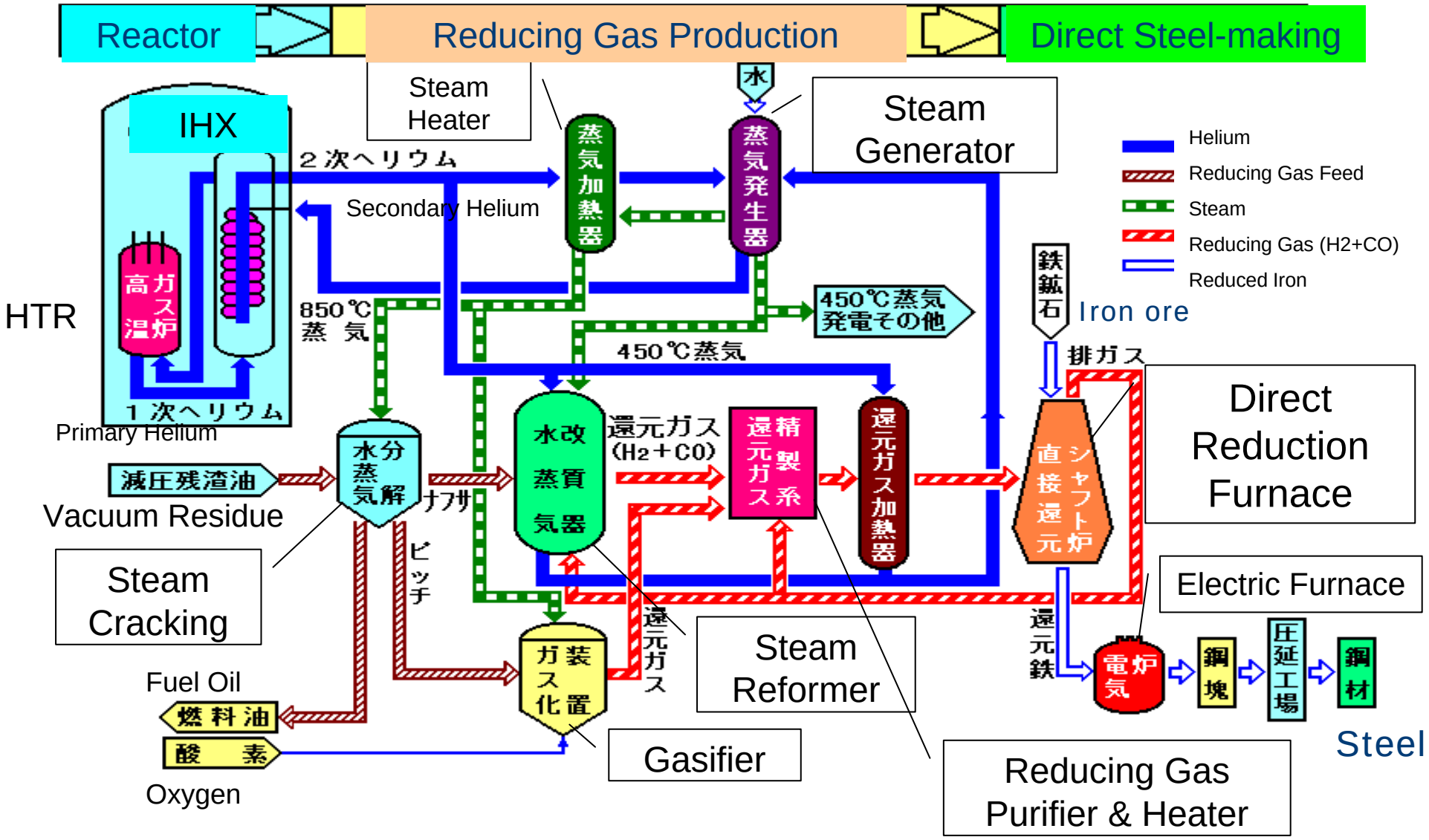
K. Kunitomi, Japan Atomic Energy Agency

# JAIF Committees on Nuclear Heat Application

*Established in* September 1969

*Publications*

- "Industrial Uses of Nuclear Heat"
  - March 1971
  - (Steel, Chemicals, Desalination)
- "The Uses of LWR and HTR Nuclear Heat"
  - September 1981
  - (Coal liquefaction and gasification, Hydrogen production, etc.)
- "The Contribution toward Global Environment Protection"
  - March 1992
  - (Hydrogen production and CO2 recycle / application to steel industry, Cogeneration, Clean energy from fossil fuels)
- Interim Report : "The Study on HTR Future Perspective"
  - June 1999

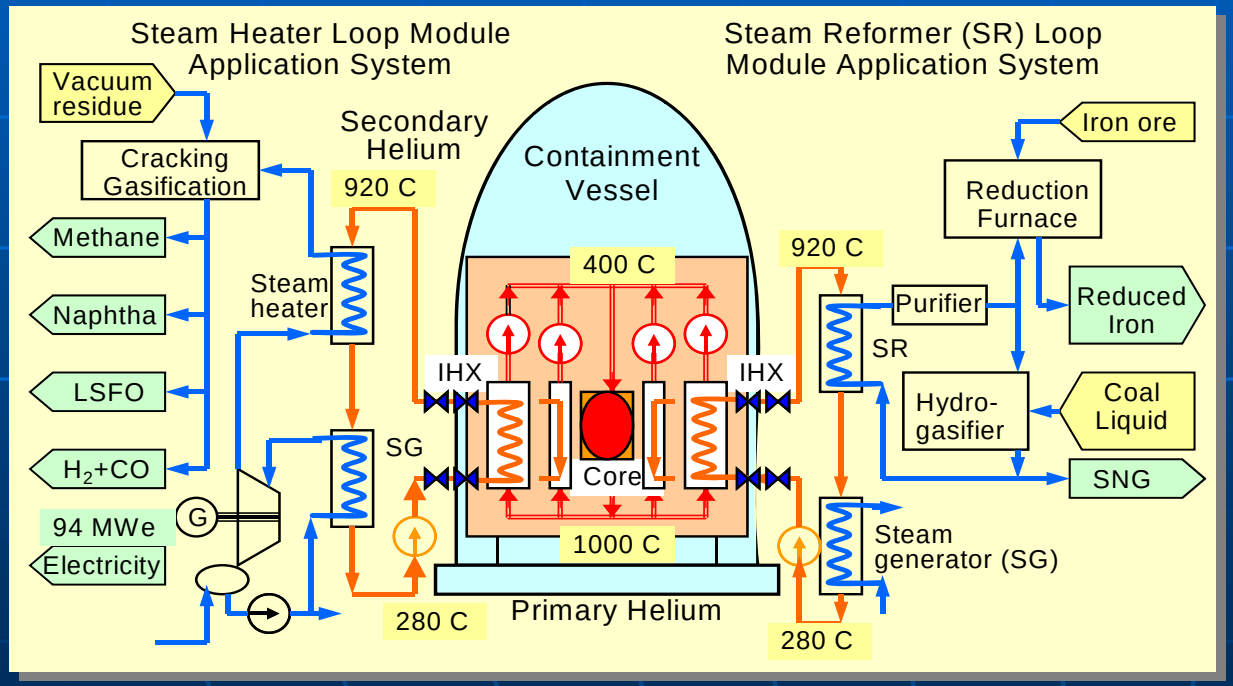



# Japanese Nuclear Steel Concept in 70's

## Nuclear Steel Making Prototype Reactor (500MWt)

(The Engineering Research Association of Nuclear Steel making, Japan)

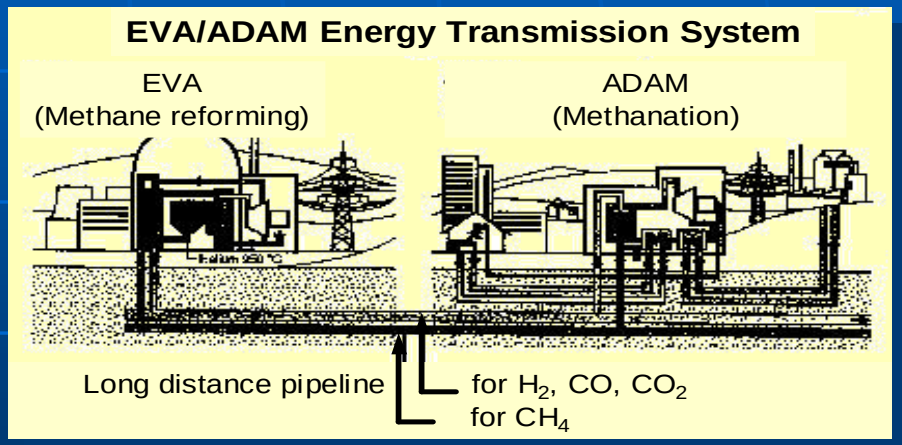
Ref：K.Tsuruoka,et al, Transactions ISU, Vol.23, p.1091 (1983).




## Energy Transportation System

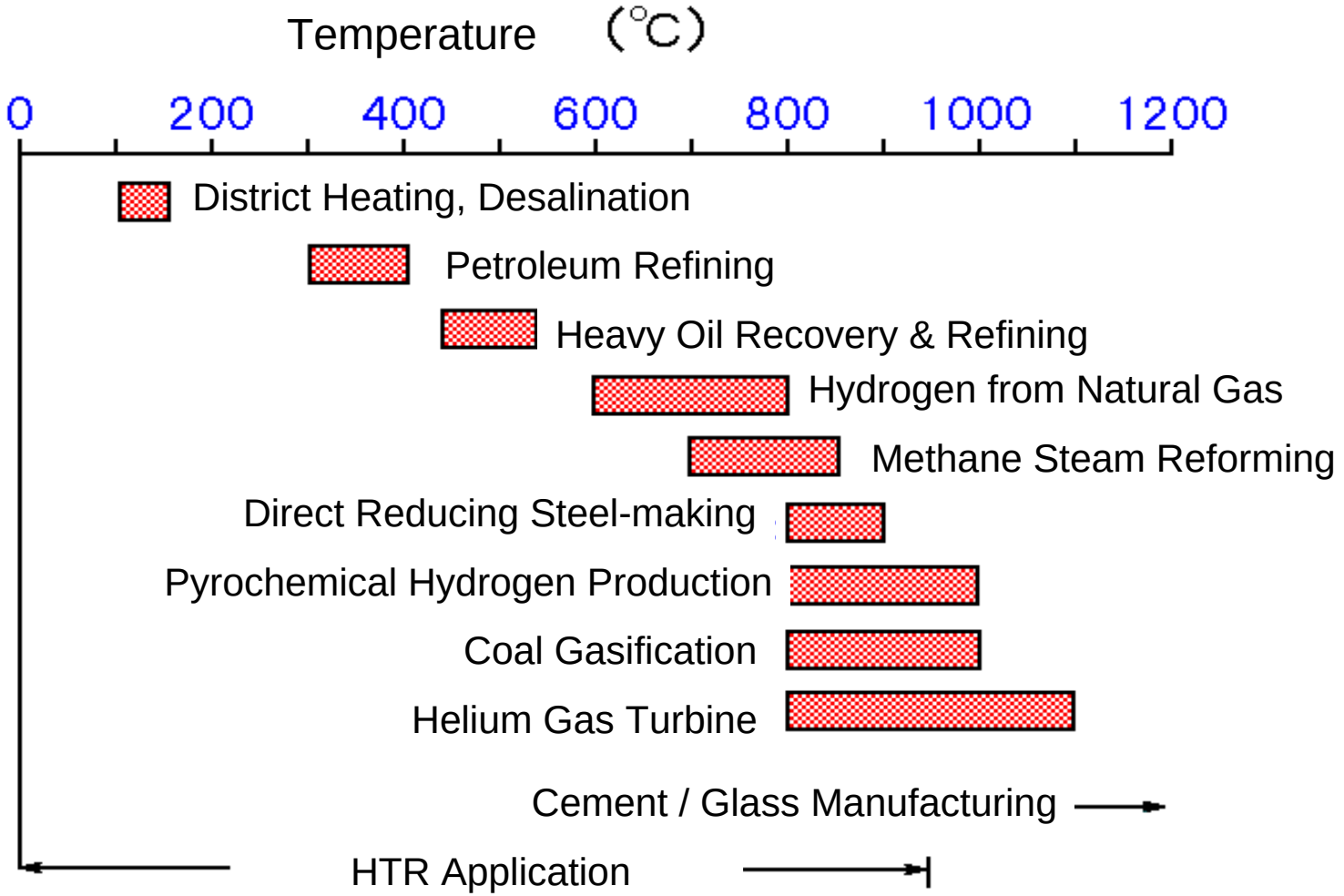
(Germany, Julich)

Ref；IAEA TECDOC-1085 (1999).




Methane Steam Reforming

$CH_4 + H_2O \leftrightarrow 3H_2 + CO$




**Temperature Range of Required Heat for Various Industries (based on survey in 1970's)**

# Operating desalination systems in Nuclear Power Plants in Japan

- Takahama : 1,000ton/day (MED)
- Ohi : 1,300ton/day (MSF), 2,600ton/day(MED), 2,600ton/day(RO)
- Ikata : 2,000ton/day(MED), 2,000ton/day(RO)
- Genkai : 1,000ton/day(MED), 1,000ton/day(RO)

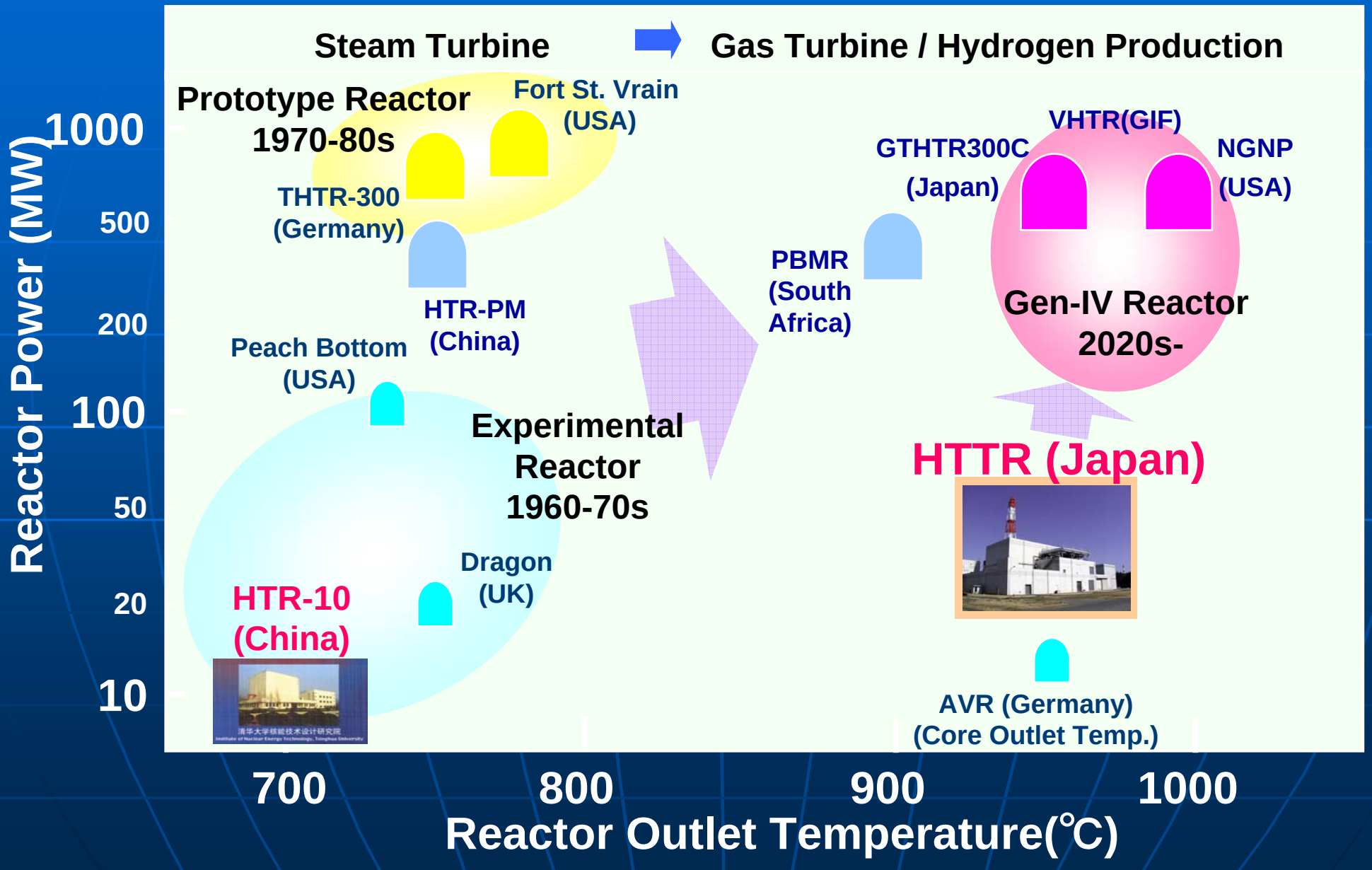
Ohi (MSF)

Ikata (RO)

Genkai (MED)

JAIF
JAPAN ATOMIC INDUSTRIAL FORUM,INC.

# High Temperature Gas-cooled Reactor Development



# VHTR Deployment Scenarios and R&D Roadmap in Japan

April, 2007

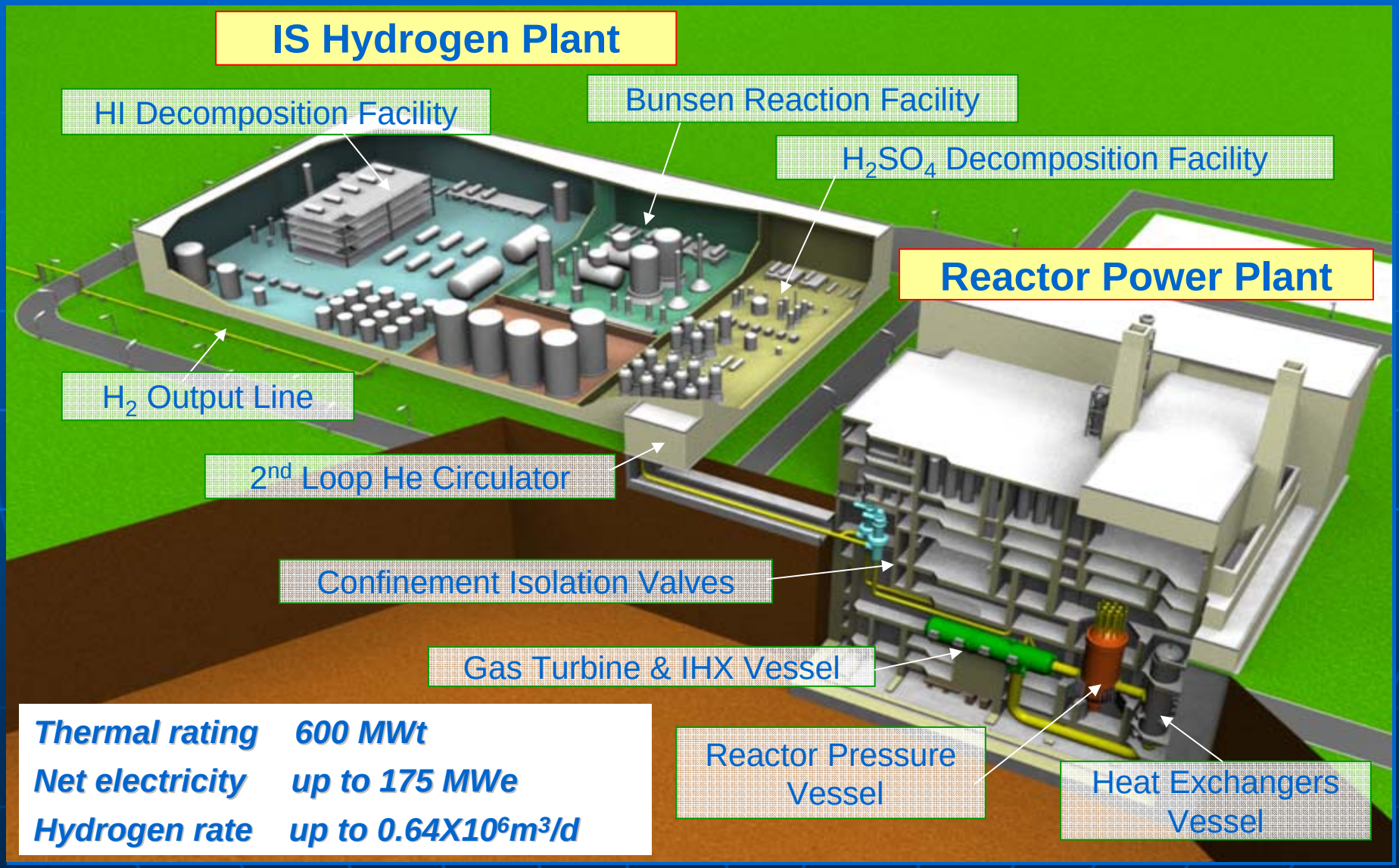
Objectives

- Propose promising VHTR applications and utilization systems
- Estimate possible fossil energy savings and $CO_2$ reduction
- Identify technological gaps for practical use

Promote governmental support

And potential users

# Cogeneration System of VHTR hydrogen production system

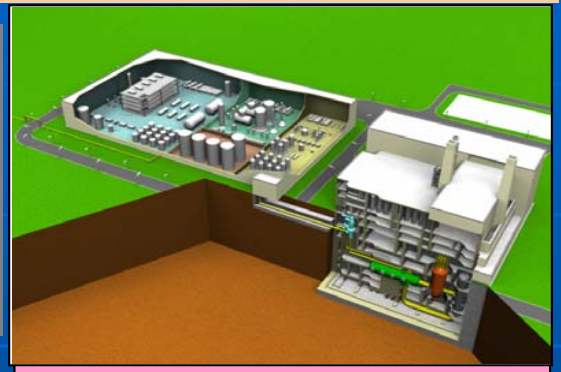


# Outline of VHTR Deployment Scenarios

## VHTR

**600MWt**
**Outlet Temp. 950°C**
**Cogeneration**

Operation starts 2040



**Salient economy**
**Inherent safety**
**Broad use of nuclear heat**
**No emission of $CO_2$**

Electric power, heat, hydrogen

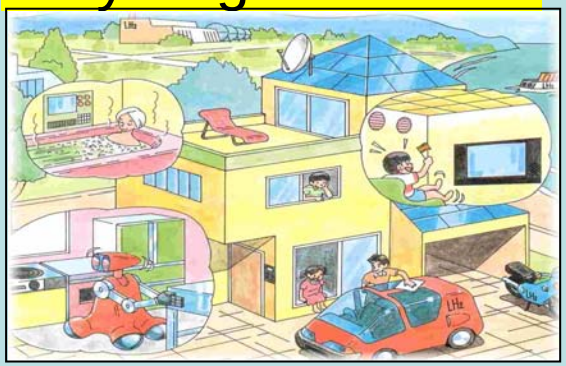
## FCV


**30 units of VHTR (by 2100)→**
**12 million FCV (27% of share)**

## Chemical industries

**Replacement for TPP 15units→**
**20Mt-CO2 reduction**

## Hydrogen Town



**Cooperation with local government**

# The Scenario for FCV (1/2)

## 1. Deployment Schedule

- 2030 ～ : Demonstration plant
- 2040 ～ : Commercial plants
  ⇒ 1 unit / 2 years construction
- ～2100 : 30 operating units

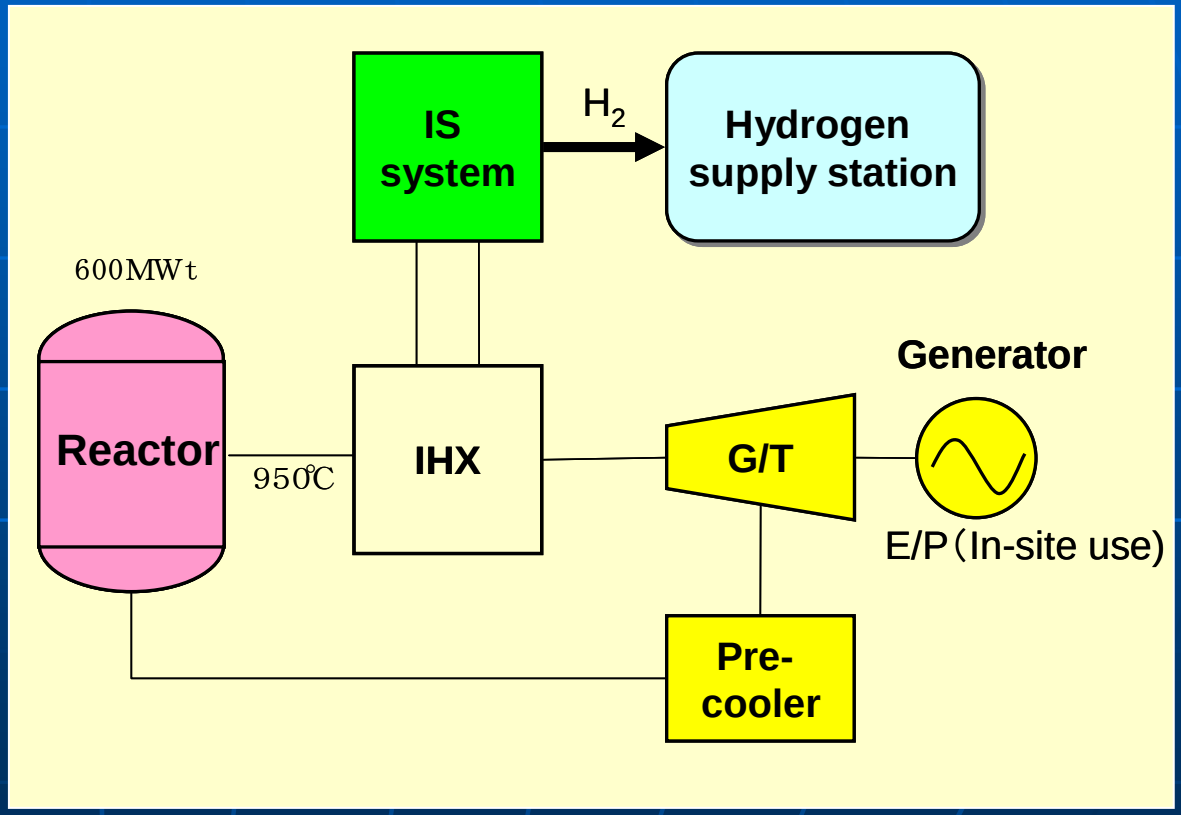
## 3. $H_2$ Supply by VHTR

- 400 M$m^3$/unit/year
  （⇒ 400,000 FCVs）
- 30 units : 12 million FCVs

27% of total FCVs in 2100 in Japan

*Very ambitious target of 15 million FCVs by the year 2030*

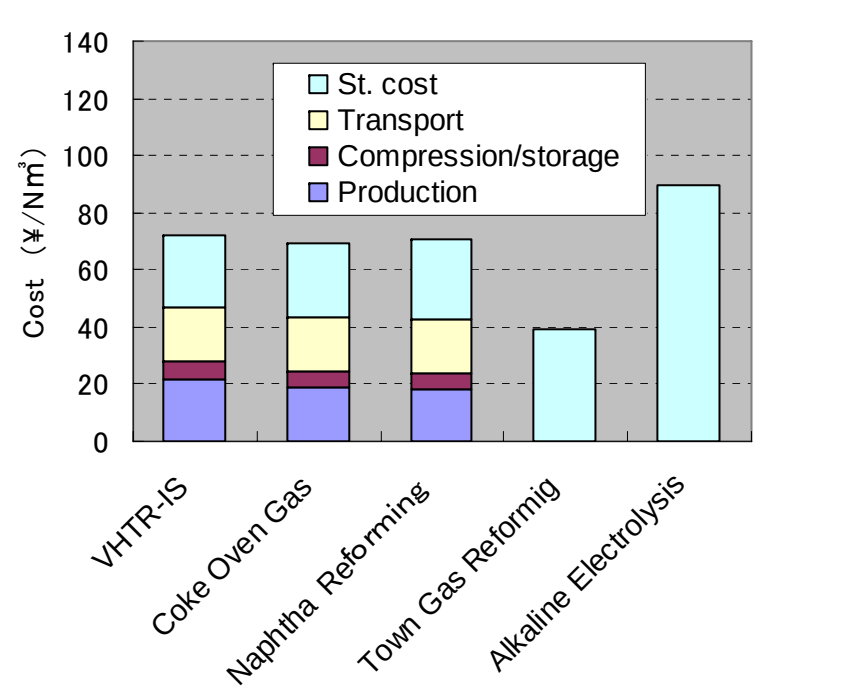
## 2. System Concept

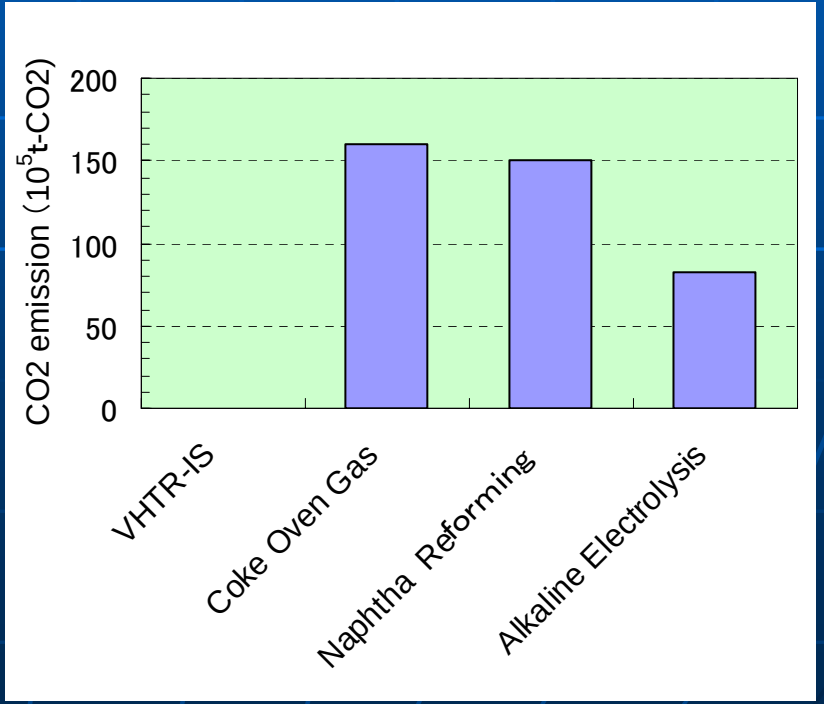


# The Scenario for FCV (2/2)

1. Economics : Cost competitive with existing technologies
2. Environmental protection : 16 Mt-$CO_2$ (COG) reduction
3. Energy Security : 5 % saving of LNG import

Use of VHTR in the transportation sector can contribute greatly to environmental protection and energy security



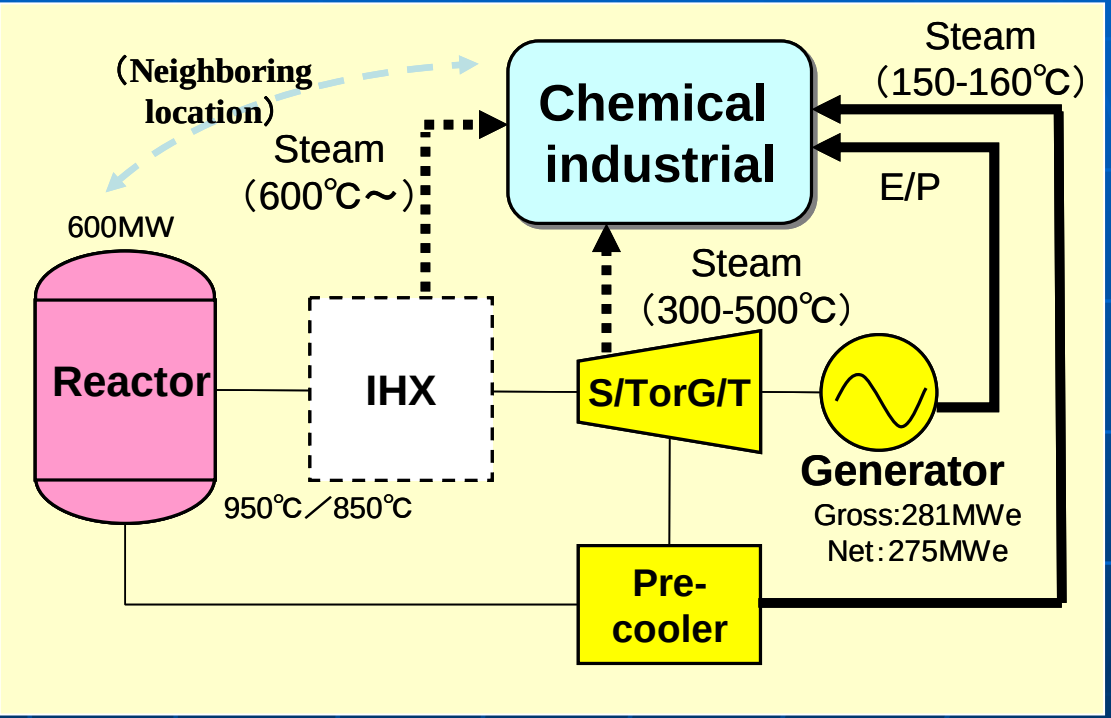
# The Scenario for Chemical Complex

## 1. Deployment Schedule

- 2020 ～ : Demonstration Plant
- 2030 ～ : Commercial Plants

*(VHTR replace all existing and aged industrial power plants in major chemical industrial complex.)*

## 2. System Concept




## 3. Potential Capacity of VHTR

Total electric power capacity in major chemical complex : 3,500 MWe (40units)

⇒ VHTR (15units) could cover

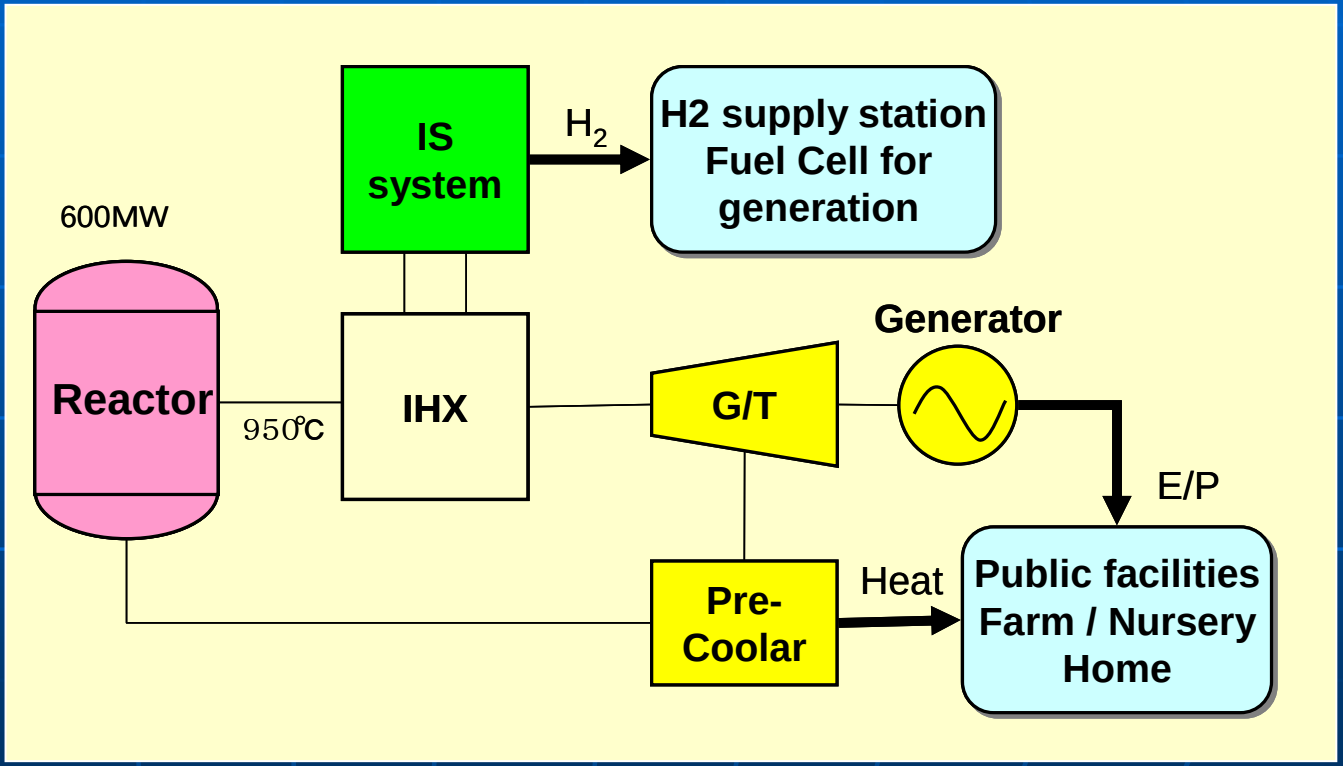
Use of VHTR in the industrial sector, to be a “Nuclear Boiler”, can contribute greatly to environmental protection and energy security

# The Scenario for “Hydrogen Town”

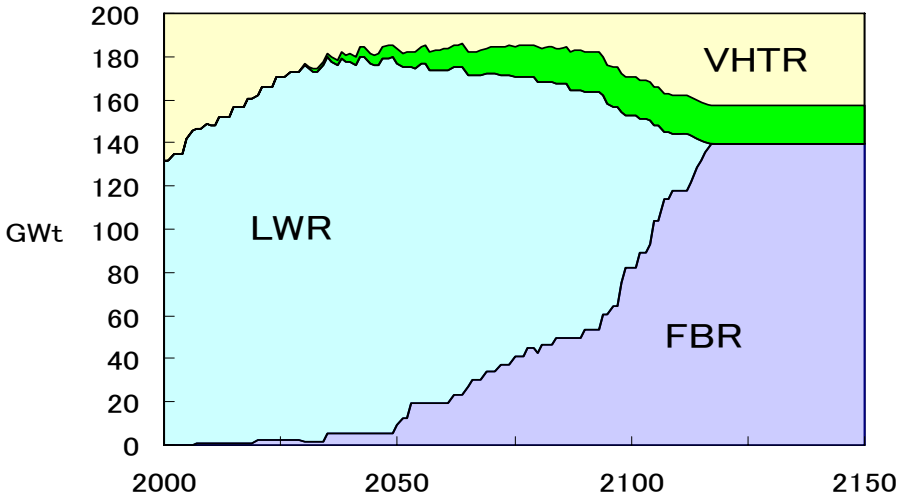
## 1. Deployment Schedule

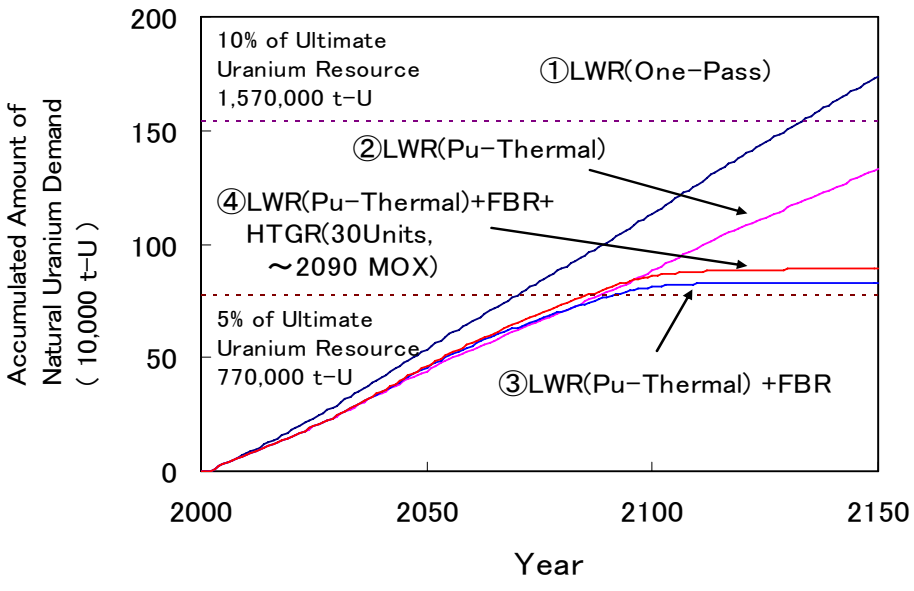
- Aomori Prefecture has a strategic plan to promote local use of hydrogen.
- 2030 ～ : VHTR demonstration plant for hydrogen production

## 2. System Concept



# The Scenario for Super-long-term Fuel



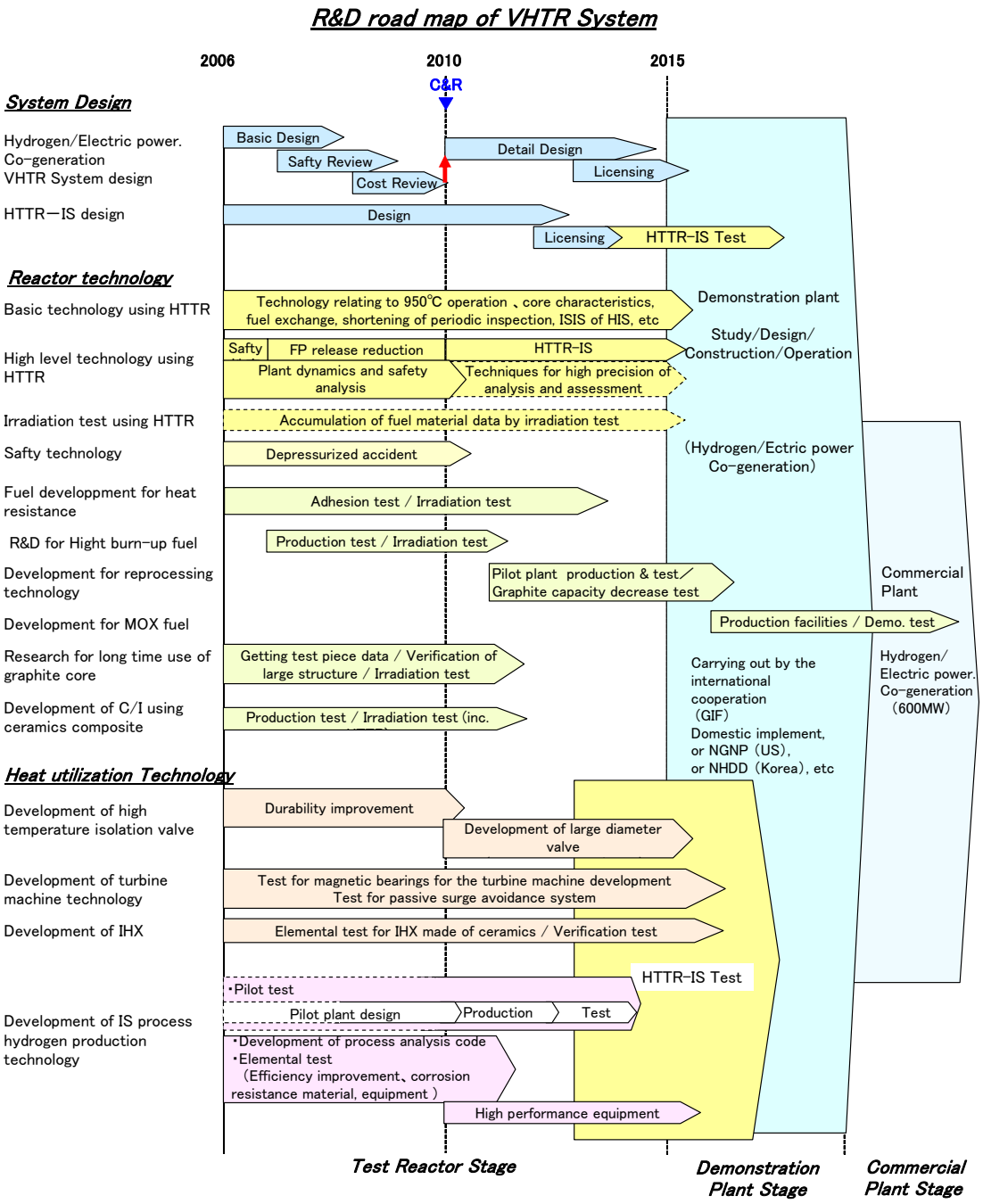

## Condition

- Hydrogen production scenario
- 2040 – 2100 : U-fuel
- 2100 – : MOX-fuel

( Plutonium is produced by LWR/FBR)

30 VHTRs do not affect future Japanese uranium demand much

⇒ no deviation from the official fuel cycle policy of Japan.

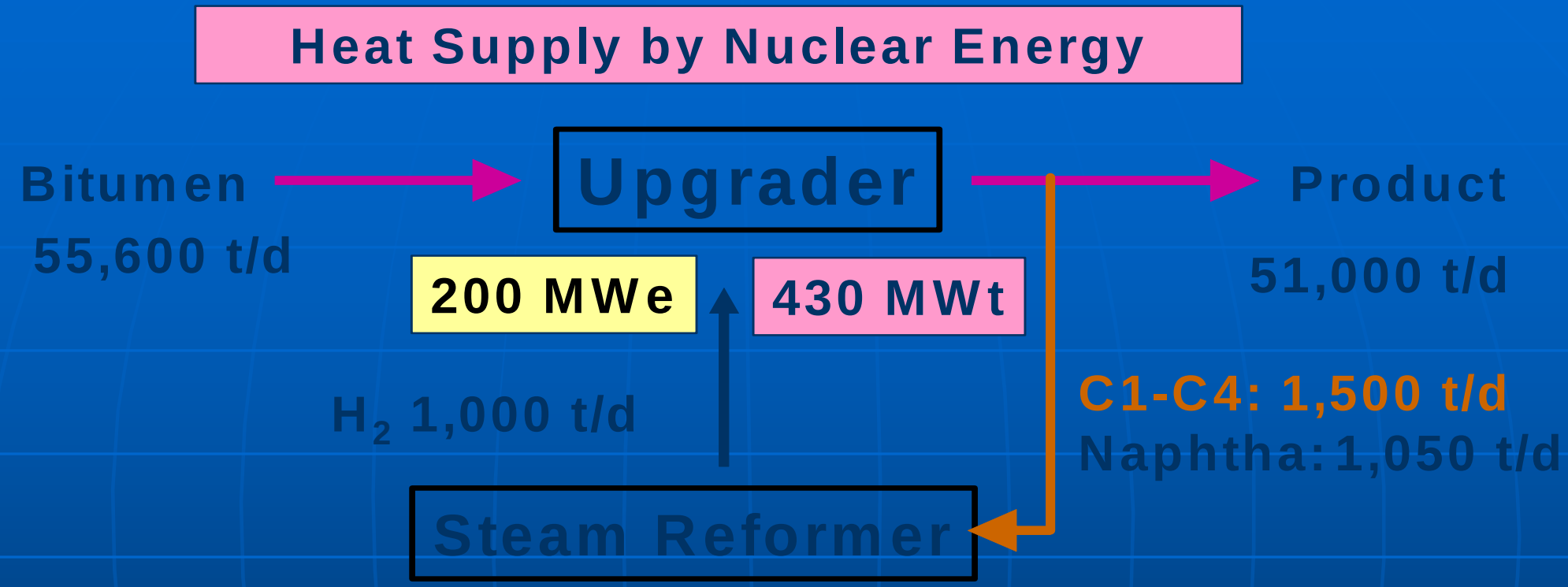



# R&D Roadmap

- Technological subjects necessary to realize the VHTR deployment scenarios have been submitted from the industry.
- JAEA should take an initiative for steady promotion of VHTR research and development.

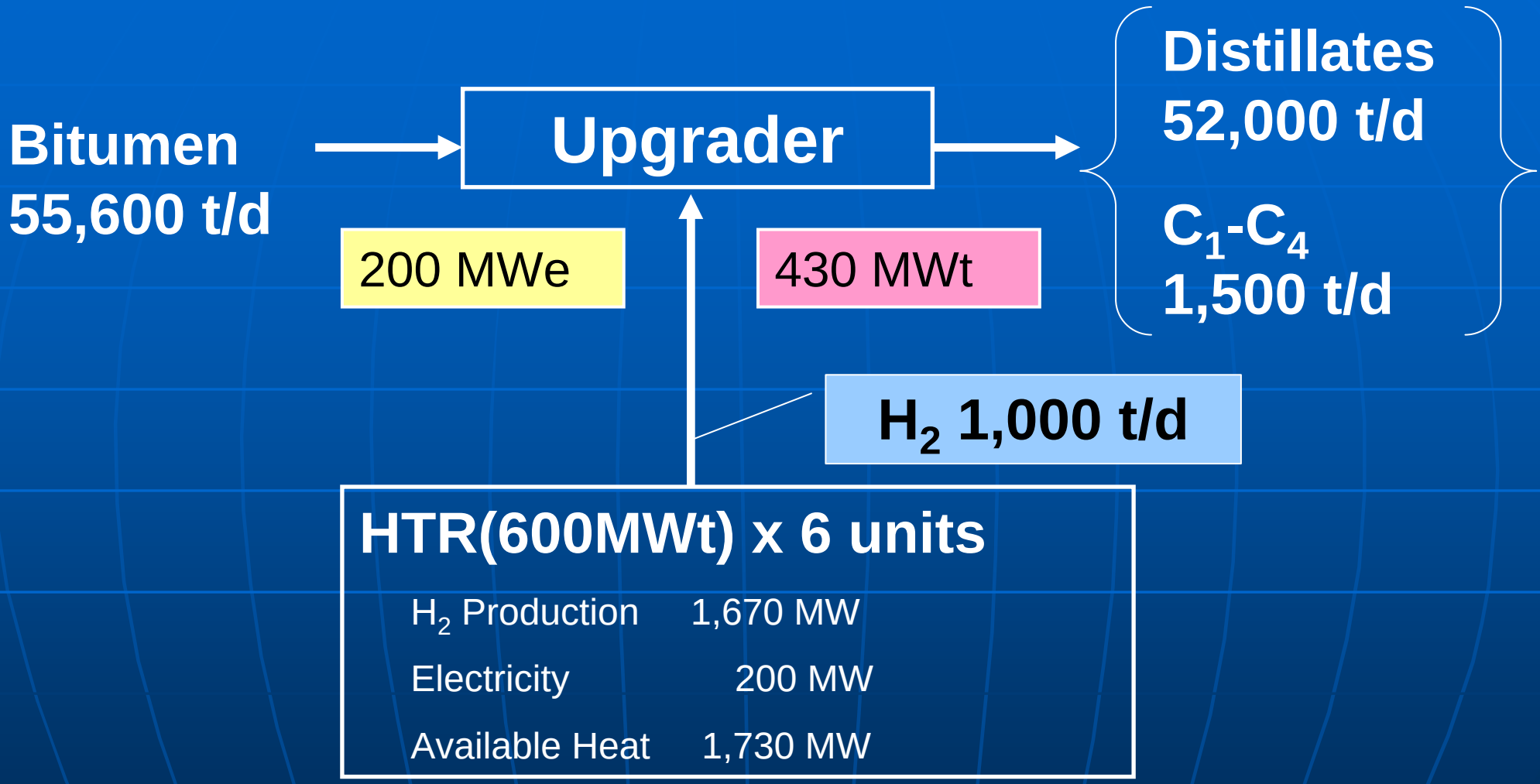
# Making Distillates from Ultra Heavy Oil Hydrogenation

- Ultra heavy oils equivalent to vacuum residue, of Orinoco tar (Venezuela), Oil sand (Alberta, Canada) to be processed at 100 thousand barrel / day
- Hydrogen consumption of 4 wt.% corresponds to 7.2 million Nm3 / day
- Four HTR of 600 MWt to produce H2
- Distillates of 6 million ton annually, equal to 8 % of transportation or 15 % of residential fuels in Japan




# Nuclear Energy to Bitumen Upgrading

M. Numata, et. Al. “Application of Nuclear Energy to Bitumen Upgrading and Biomass Conversion”, ICONE14, Miami, Florida, USA July 17-20, 2006

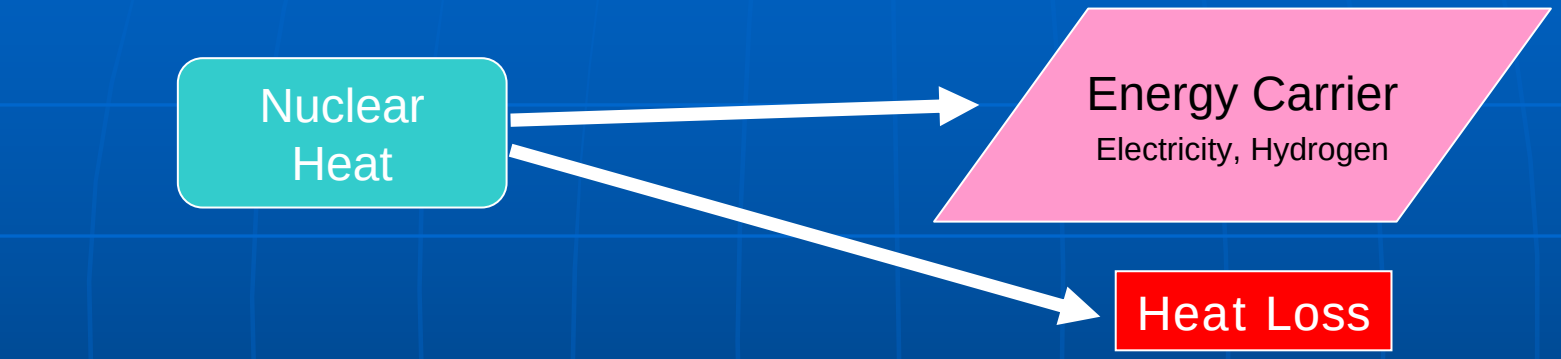



# Nuclear Energy to Bitumen Upgrading

**An Extension by Nuclear Hydrogen**

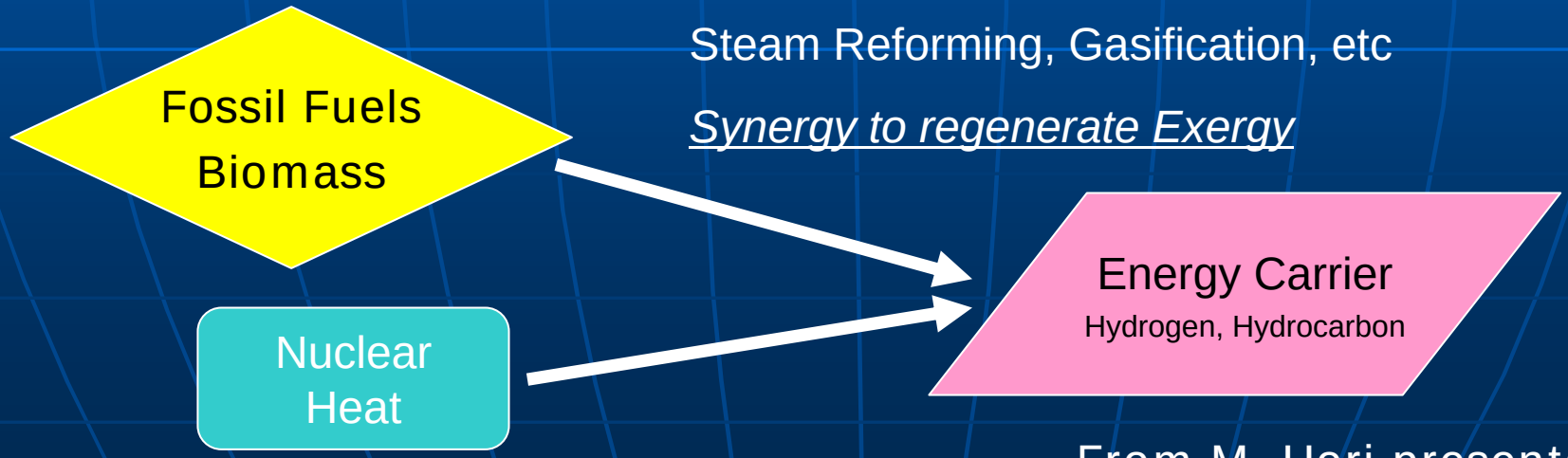
# From Nuclear to Energy Carrier

Turbine Electricity Generation, Water Splitting for Hydrogen, etc.




Steam Reforming, Gasification, etc

*Synergy to regenerate Exergy*




From M. Hori presentation

# Remarks

- Nuclear heat application has been said for long, long time, but not so much succeeded
- Effective and practical measure to climate change / green house gas reduction
- Nuclear technology and its related institutions should advance and address to the real world as other technologies and environments do
- Practical application would be possible based on experiences and further international collaboration

I have a dream.
Someday we can develop fully nuclear capacity for human survival on this planet.