Nuclear Hydrogen Production Project in Korea

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Young-Joon Shin, Jong-Ho Kim, Jong-Hwa Chang
Won-Suk Park, Jong-Kyun Park

Korea Atomic Energy Research Institute
GDP vs Energy Demand

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP (Billion $, 1996 Value)</th>
<th>Energy Consumption (MTOE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>7.5</td>
<td>50</td>
</tr>
<tr>
<td>1985</td>
<td>7.8</td>
<td>55</td>
</tr>
<tr>
<td>1990</td>
<td>8.6</td>
<td>60</td>
</tr>
<tr>
<td>1996</td>
<td>6.1</td>
<td>65</td>
</tr>
<tr>
<td>2001</td>
<td>7.5</td>
<td>70</td>
</tr>
<tr>
<td>2006</td>
<td>6.1</td>
<td>75</td>
</tr>
<tr>
<td>2011</td>
<td>7.5</td>
<td>80</td>
</tr>
<tr>
<td>2015</td>
<td>6.1</td>
<td>85</td>
</tr>
<tr>
<td>2020</td>
<td>7.5</td>
<td>90</td>
</tr>
</tbody>
</table>

Growth Rate (%/yr)

<table>
<thead>
<tr>
<th>Period</th>
<th>GDP</th>
<th>Energy Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘80-'90</td>
<td>8.6</td>
<td>7.8</td>
</tr>
<tr>
<td>‘90-'00</td>
<td>6.1</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Data from Korea Energy Economics Institute
Data from Korea Energy Economics Institute
Simple expansion of the current energy system for the sustainable development is not possible because of

- Limitation of fossil (especially) energy resources
  - Unaffordable price

- Climate change (Kyoto protocol)
  - Korea is expected to ratify Kyoto protocol in the year 2007

- Energy security
  - Most of oil is being imported from middle east
  - Vulnerable to international energy crisis

Transition to “Hydrogen Economy”
NHDD Project Targets

- Complete the development and demonstration of the nuclear based hydrogen production technology by the year 2021.
  - Period: 2004 – 2021 (18 years)
  - Budget: ~ US$ 1.0 Billion

- Start producing commercial hydrogen by using nuclear power from the middle of 2020s
  - Production cost: ~ 1,500 won/kg (~$1.5/kg)
In order to commercialize the developed technologies as soon as possible, the industries are required to participate from early development stage.

The industries will lead the construction and operation of the demonstration facilities while Government will lead the program in the design stages.

In order to assure cost-effective research, international collaboration will expand and be promoted continuously.

Cooperation through the GIF-VHTR/HP and the on-going bilateral collaboration would be fostered.
NHDD Project Structure & Management

- VHTR Design Tech.
- Nucl. Fuel Tech.
- Waste Management
- Material Tech.
- Equip. Tech.
- I & EC Tech.

Subcontract:
- 1 research institute
  - 3 univ. research teams

Partner Institution:
- KIER, KIST
  - 1 research institute
  - 5 univ. research teams

Subcontract:
- 6 univ. research teams
- 2 research institutes
  - 4 univ. research teams

On-going work scope

Later work scope

Slide 7
International Cooperation

- NUKEM, FZJ
- INET
- CEA
- INL
- GA

NHDD-KAERI
Development of the NHPT

Assessment of NHPT

- Three top-ranked cycles to be evaluated:
  - Sulfur Iodine (SI) Cycle
  - High Temperature Electrolysis (HTE)
  - Methane-Methanol-Iodomethane (MMI) Cycle

- Evaluation Activities
  - Collection and production of technical data
  - Development of the flowsheet
  - Comparison of thermal pathway and efficiency

Development of an Advanced SI Cycle

- Membrane-based high technology
  - HI concentration by electrodialysis
  - Membrane reactor for hydrogen separation

- High temperature materials
  - Screening test for equipment material selection
  - Coatings and fabrication technology

- Scale-up and engineering
  - Key technologies
  - Lab-scale test (~1,000NL/hr)
  - Pilot-scale test (~100Nm³/hr)
  - Demonstration facilities (~10,000Nm³/hr)
Technological Criteria for Assessment

- Thermal efficiency
- Availability and cost of chemicals, materials and equipment
- Economics of scale-up
- Hazard and operability
- Conversion of chemical reactions and side reactions
- Separation of materials and phases
- Corrosion problems
- Materials handling (continuous or semicontinuous operation)
NHDD-HP Research System

Evaluation of alternatives

- H₂
- HTES
- Electrolyser
- AC/DC Converter
- Condenser
- Separator
- H₂O
- O₂

Priority tech.; advanced SI

- H₂
- I-S Process
- H₂SO₄ Decomposition
- HI Decomposition
- Bunsen Reaction
- H₂O
- H₂SO₄ Evaporator

IHX

VHTR

1000°C

970°C

1/2 H₂ + 1/2 O₂ → H₂O
Advanced SI Cycle Development Schedule

- Basic R&D for SI cycle
  - Tests of catalysts and high temp. materials
  - Test of atm. OpC
  - Test of press. OpC

- Construction of lab. scale (~1000 NL/h)
- Operation of lab. facilities
- Development of pilot equipment
- Design of pilot process
- Construction of pilot scale (~100 Nm³/h)
- Operation of pilot facilities
- Design of demonstration process
- Construction of demo. scale (~10,000 Nm³/h)

Timeline:
- 2008
- 2012
- 2016
UPTNC : Unit process test at normal pressure condition
CLTNC : Closed loop test at normal pressure condition
CLTPC : Closed loop test at prototypical condition

**NHDD-KAERI**

**Evolutionary Path of SI Technologies**

- **UPTNC(Glass)**
  - USA(1977)
  - Japan(1997)
  - Korea(2004)

- **CLTNC(Glass)**
  - Japan(2004)
  - Korea(2005)

- **CLTPC(Lab scale)**
  - USA/Fr(2008)
  - Korea(2009)

**Construction of Pilot Plant**
- Japan(30 m³/h, ’10)
- USA(120 m³/h, ’11)
- Korea(~100 m³/h, ’12)

**VHTR/HP Collaboration**
- SI process
- HTES process
- Alternatives

**Collaboration with GA**
- signed MOU(August 2005)
- opening ceremony of NHJDC-San Diego (12 Sep. 2005)
- Under discussion for work proposals.

**Catch up with SI process technology gaps by 2009**

**Collaboration with domestic AE & industry**
- Design technology
- Fabrication of equipment and reactors

**Technology Threshold**

- VHTR(1000 °C)

**Slide 13**
Korea launched nuclear hydrogen program in the year 2004. The program’s target is to develop and demonstrate the nuclear based hydrogen production technology by the year 2021.

Large part of R&D activities are currently focused on:
- development of the VHTR,
- TRISO fuel fabrication technology development,
- high temperature material development,
- development of an advanced SI process.

KAERI is very open and positive to the international collaboration.
Thank You.

http://www.hydrogen.re.kr/