International Conference
“Green Hydrogen for the Chilean Energy Transition”

Large-Scale Hydrogen Storage and Transportation System

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Chiyoda Corporation
Hydrogen Supply Chain Concept

“SPERA Hydrogen” System (Liquid Organic Hydrogen Carrier)

Methylcyclohexane (MCH)

Toluene

H₂ is fixed to toluene through the hydrogenation and convert to MCH. At the use point, H₂ is generated from MCH and toluene is reused.

Renewable Energy

<table>
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<tr>
<th>Power generation</th>
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<tr>
<td>H₂</td>
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<tr>
<td>FCV Feed stock</td>
</tr>
</tbody>
</table>

Gas Field

[CCS EOR]

Reforming Shift

CO₂ Separation

H₂

[CCS (ECBM)]

Gasification

[CH₄ Recovery]

Coal

[Hydrogenation plant]

Electrolyzer

Nuclear

Wind

Hydraulic

Solar

Geothermal
“SPERA Hydrogen” System
(Liquid Organic Hydrogen Carrier)

H₂ Production Site

Resources

Hydrogenation

MCH : Methylcyclohexane

Transportation

Storage

Toluene

MCH

H₂ Utilization Site

Utilization

Dehydrogenation

MCH

Toluene

H₂

☆ Liquid state storage and transportation
☆ Under the ambient temperature and pressure
☆ Hydrogen energy can be treated as easy as potential risk of gasoline.
☆ Conventional infrastructure can be utilized. (storage tanks, chemical tanker and chemical tracks has been well commercialized.)
### Features of SPERA Hydrogen® System

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
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<tbody>
<tr>
<td>Easy to handle</td>
<td>Liquid state under ambient temperature and pressure. 1/500 in volume, approximately.</td>
</tr>
<tr>
<td>Use of existing oil infrastructure</td>
<td>Physical properties of toluene and MCH are similar to petroleum oils, gasoline fractions.</td>
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<tr>
<td>Combination of Proven technologies</td>
<td>Combination of conventional equipment except for new catalyst for dehydrogenation.</td>
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</table>

Physical properties of toluene and MCH are similar to petroleum oils, gasoline fractions.
Demonstration plant

Dehydrogenation (H₂ Utilization Site)

Dehydrogenator

Hydrogenation (H₂ Production Site)

Hydrogenator

MCH Tank

Toluene Tank

Tanks for hydrogenation unit

Tanks for dehydrogenation unit
Development of “SPERA H₂” System

(Note) MCH: Methylcyclohexane  TOL: Toluene

H₂
50Nm³/h

Dehydrogenation Section

Hydrogenation Section

Feed MCH

Product MCH

Feed TOL

Product TOL

Process Section (50Nm³-H₂/h)

Tank Area

Demonstration plant at Chiyoda R&D Center, Yokohama, Japan
Demonstration Performance
(April, 2013 – Nov. 2014)

☆ Capacity：50Nm³/h (H₂ storage & generation)

☆ Hydrogenation（H₂ storage reaction）
  Conversion：> 99 %  Selectivity：> 99%
  Yield（H₂ storage ratio）：> 99%

☆ Dehydrogenation（H₂ generation）
  Conversion：>95%  Selectivity：> 99%
  Yield（H₂ generation ratio）：> 95%

☆ H₂ storage & generation ratio：> 95%

Demonstration operation
The World’s First Global Hydrogen Supply Chain Demonstration Project

Using LOHC Technology, Chiyoda and our partners established the Advanced Hydrogen Energy Chain Association for Technology Development (AHEAD), and started the world’s first global hydrogen supply chain demonstration project toward 2020 when the Tokyo Olympic and Paralympic Game takes place.

Advanced Hydrogen Energy Chain Association for Technology Development

<table>
<thead>
<tr>
<th>Year</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
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<tr>
<td>Phase 1: FS &amp; Basic Design</td>
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The World’s First Global Hydrogen Supply Chain Demonstration Project

**Project Outline**

**Project Scale**
Supply of 210 tons (max) of gaseous hydrogen in 2020, equivalent to filling 40,000 FCV.

**Hydrogen Supply**
Hydrogen will be produced by steam reforming from the processed gas derived from the natural gas liquefaction plant of Brunei LNG Sdn. Bhd.

**Hydrogen Demand**
Fuel for the Keihin refinery thermal power plant, an affiliate of TOA OIL Co., Ltd.
TOA OIL Co Ltd. is owned by SHOWA SHELL SEKIYU K.K.

**NEDO Support**
2/3 of this project is funded by NEDO (New Energy and Industrial Technology Development Organization, Funding agent of Ministry of Economy, Trade & Industry).
The World’s First Global Hydrogen Supply Chain Demonstration Project

Brunei Hydrogen Production & Hydrogenation Plant (Image)

Kawasaki Dehydrogenation Plant (Image)
Acknowledgement

Part of this presentation is based on results obtained from following projects commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

・Demonstration of the Hydrogen Supply Chain by Organic Chemical Hydride Method Utilizing Unused Energy

We express words of gratitude to NEDO.
Thank you very much for your kind attention.