The 33rd JCCP International Symposium

Innovations in Petroleum Refining Industry and Role of Japanese Refining Technology

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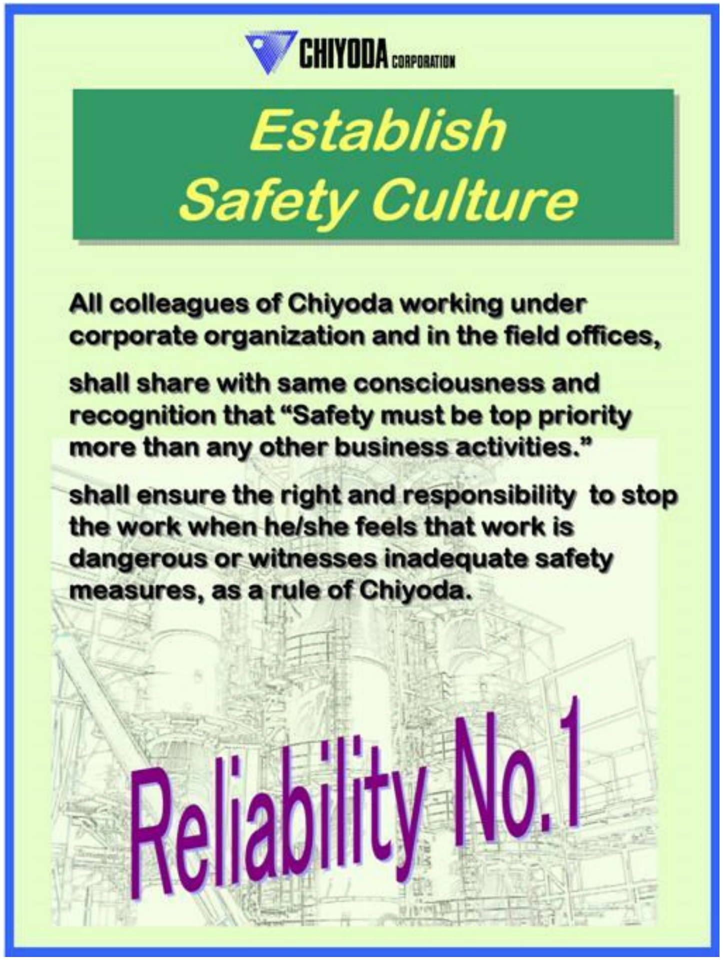
Contents

CHIYODA at a Glance

- Founded on January 20, 1948
- Integrated Engineering & Construction Service Provider
- Employees : 8,300 (Global Basis)
- Capital : USD 425 Million (for 2013)
- Revenue : USD 4.4 Billion (for 2013)
- New Orders : USD 5.8 Billion (for 2013)
- Global Headquarters @ Yokohama, Japan

*1 USD=102 JPY(as of 2014/03)

Safety as our Core Value



Our Corporate Philosophy

"Energy and Environment in Harmony"

- Safety is our Core Value.
- We all make and implement personal safety plans individually.
- Our 2014 TRIR target for overseas projects is **0.15.**

Business Fields

Offshore & Upstream

- Integrated Offshore & Upstream Services

Gas

- Gas Processing
- LNG
  - Liquefaction
  - Regasification
  - Floating
- Synthesis gas

Petroleum Refineries

- Heavy oil upgrading
- Chemical Refinery Integration

Petrochemicals & Chemicals

- Methanol
- Fertilizer
- Olefins
- Aromatics

Pharmaceuticals & R&D

- Pharmaceuticals
- R&D Center

Green Energy

- Solar Energy
  - CSP / PV Power
  - PV Module Production
- Hydrogen Supply Business

Water Management

- Industrial Water
  - Waste Water Treatment + Recycling
  - Produced Water Treatment

Environmental Protection

- Flue gas desulfurization
- Acid gas/CO_2 capture and storage
- Energy conservation

Metals & Mining

- Metallurgical Refining and Smelting

Infrastructure

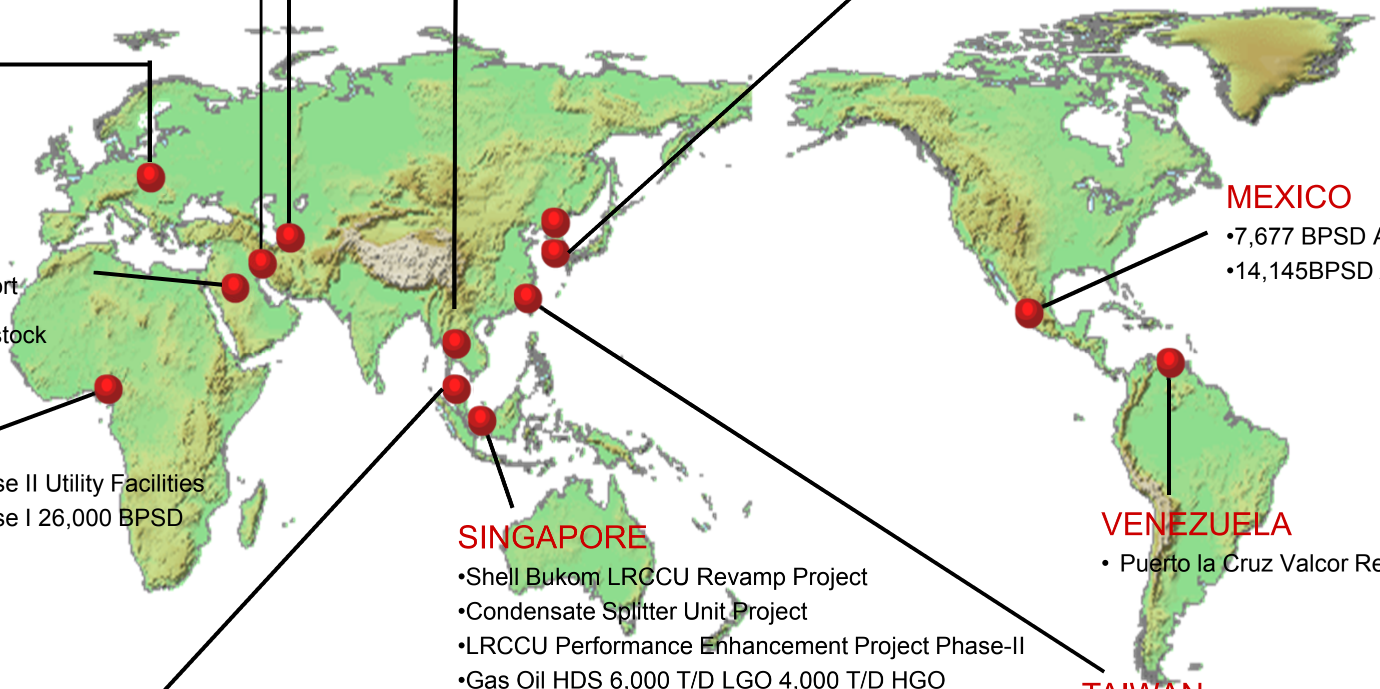
- Airport
- Transport

General Industry

- Electronic materials
- Food processing

CHIYODA CORPORATION

Major Refinery Experiences (recent 15 years for overseas)



TURKMENISTAN
- 750,000 T/Y Hydrotreater
  750,000 T/Y Catalytic Reformer

IRAN
- 232,000 BPSD No.8 Petroleum Refinery

SLOVAKIA
- 106,000 T/H VGO Hydrotreater
  38,000 NM3/Hr Hydrogen Plant

SAUDI ARABIA
- Coker Unit) for Jubail Export Refinery Project
- 2,000,000 B/Y Lube Basestock Refinery

NIGERIA

Refinery Rehabilitation Phase II Utility Facilities

Refinery Rehabilitation Phase I 26,000 BPSD FCC Unit

LPG Merox for Refinery

MALAYSIA

•100,000 BPSD Melaka Refinery Project Stage-1

•6,500 BPSD Catalytic Reformer

THAILAND
- 5,000 T/D x2 Gas Oil HDS
- 3,300 T/D Hydrocracking Project
- 2,250 T/D Isomerization
- 100,000BPSD (Stage II) Refinery Project
- 40,000 BPSD Petroleum Refinery Revamping

SINGAPORE

•Shell Bukom LRCCU Revamp Project

•Condensate Splitter Unit Project

•LRCCU Performance Enhancement Project Phase-II

•Gas Oil HDS 6,000 T/D LGO 4,000 T/D HGO

•17,000 BPSD Catalytic Reformer

•CD-3 Revamp Project 60,000 BPSD Mild Vacuum 18,0000 BPSD Kerosene Merox

•23,000 BPSD Hydrocracking Complex

•4,000 T/D Long Residue Catalytic Cracker

KOREA
- 200,000 BPSD Petroleum Refinery
- Heavy Oil Upgrading
  30,000 BPSD Hydrocracker
  30,000 BPSD RHDS

MEXICO

•7,677 BPSD Alkylation Plant

•14,145BPSD Alkylation Plant

VENEZUELA
- Puerto la Cruz Valcor Refinery Project

TAIWAN
- 30,000 BPSD Residue HDS
- 25,000 BPSD Residue Oil Cracking Unit

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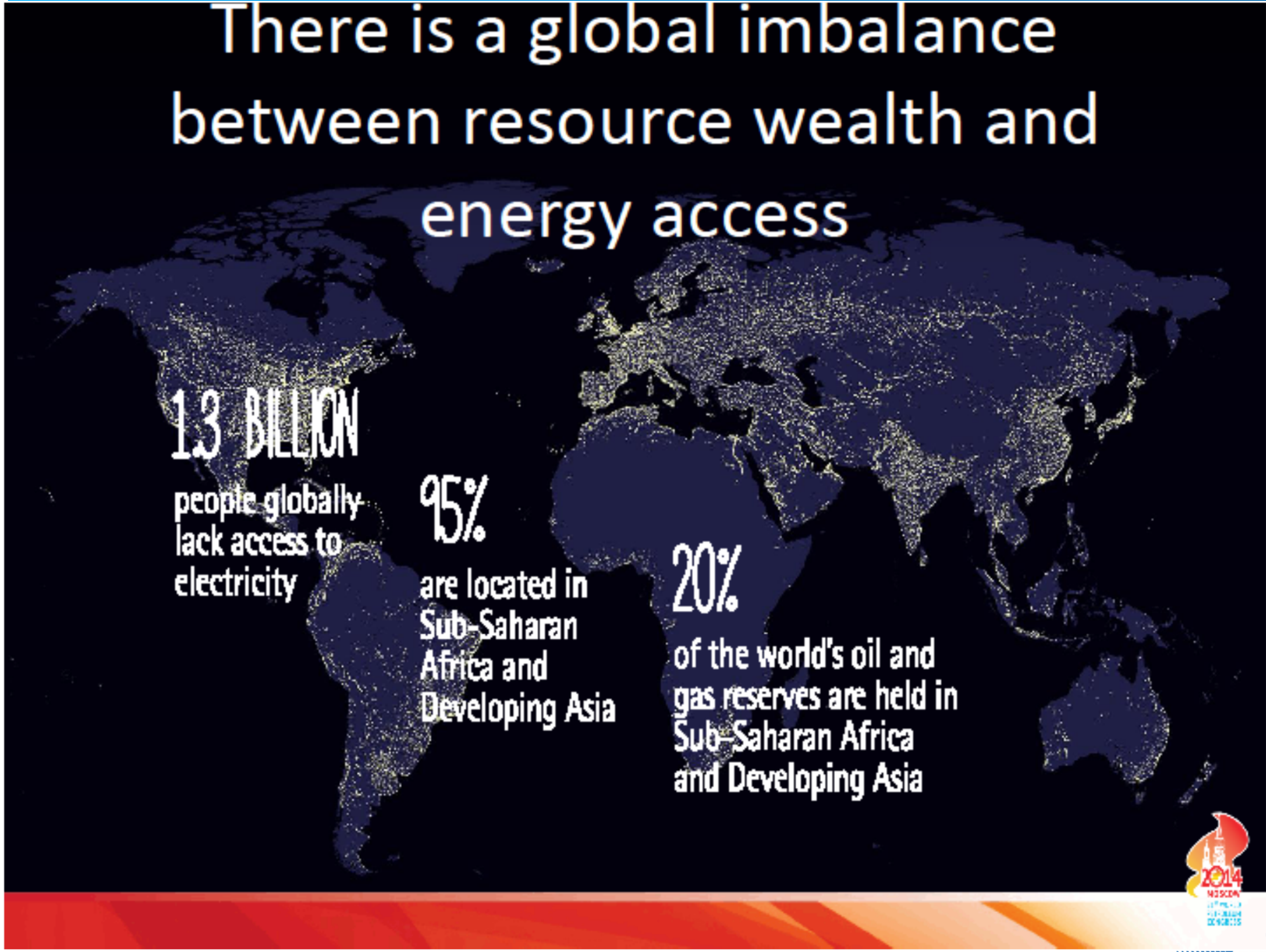
Energy Poverty



Source: 20th World Petroleum Congress

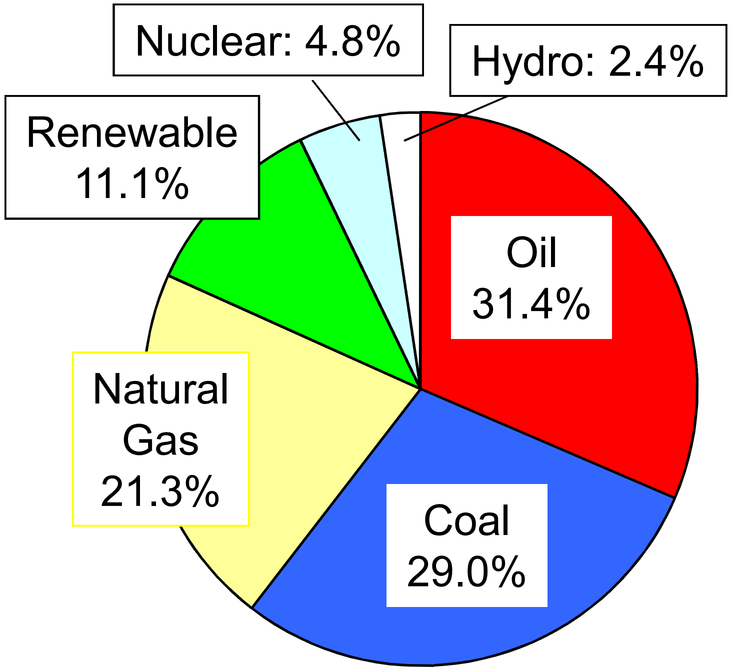
Increasing World's Population and Energy Consumption

1. The world's population will increase of 8 billiion in 2025 from current 7 billion.
2. The world's energy will increase from current 13 Btoe to 16 Btoe in 2025.

Source: IEEJ Energy Outlook 2014

3. This increase of energy consumption will enlarge CO_2 emission that accelerates global warming and also leads to serious environmental problems worldwide.

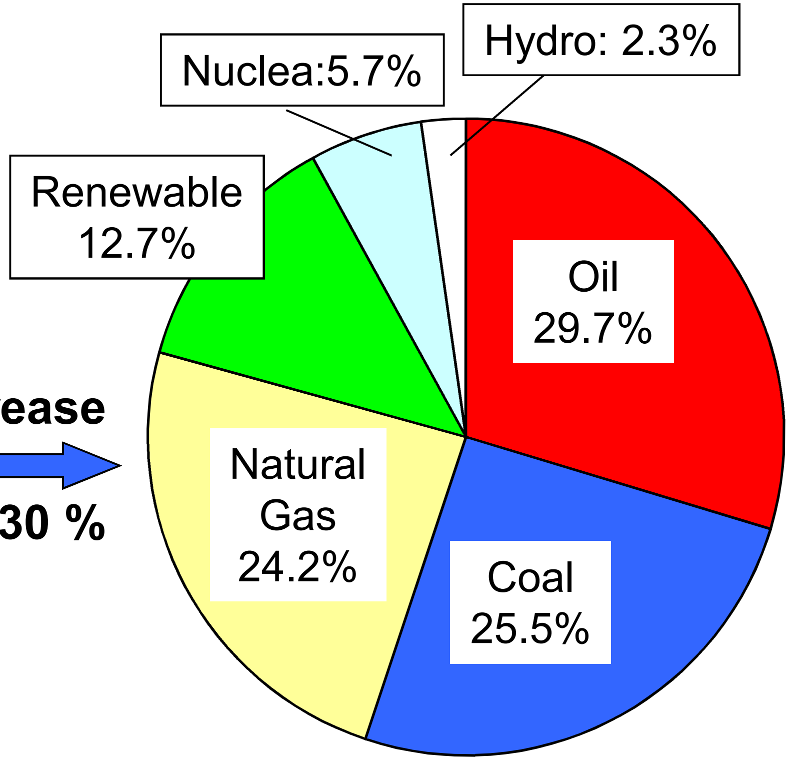
Oil will still be the Primary Energy Source in 2030



13,371 Million Tons of Oil Equivalent

2012

Increase By 30 %

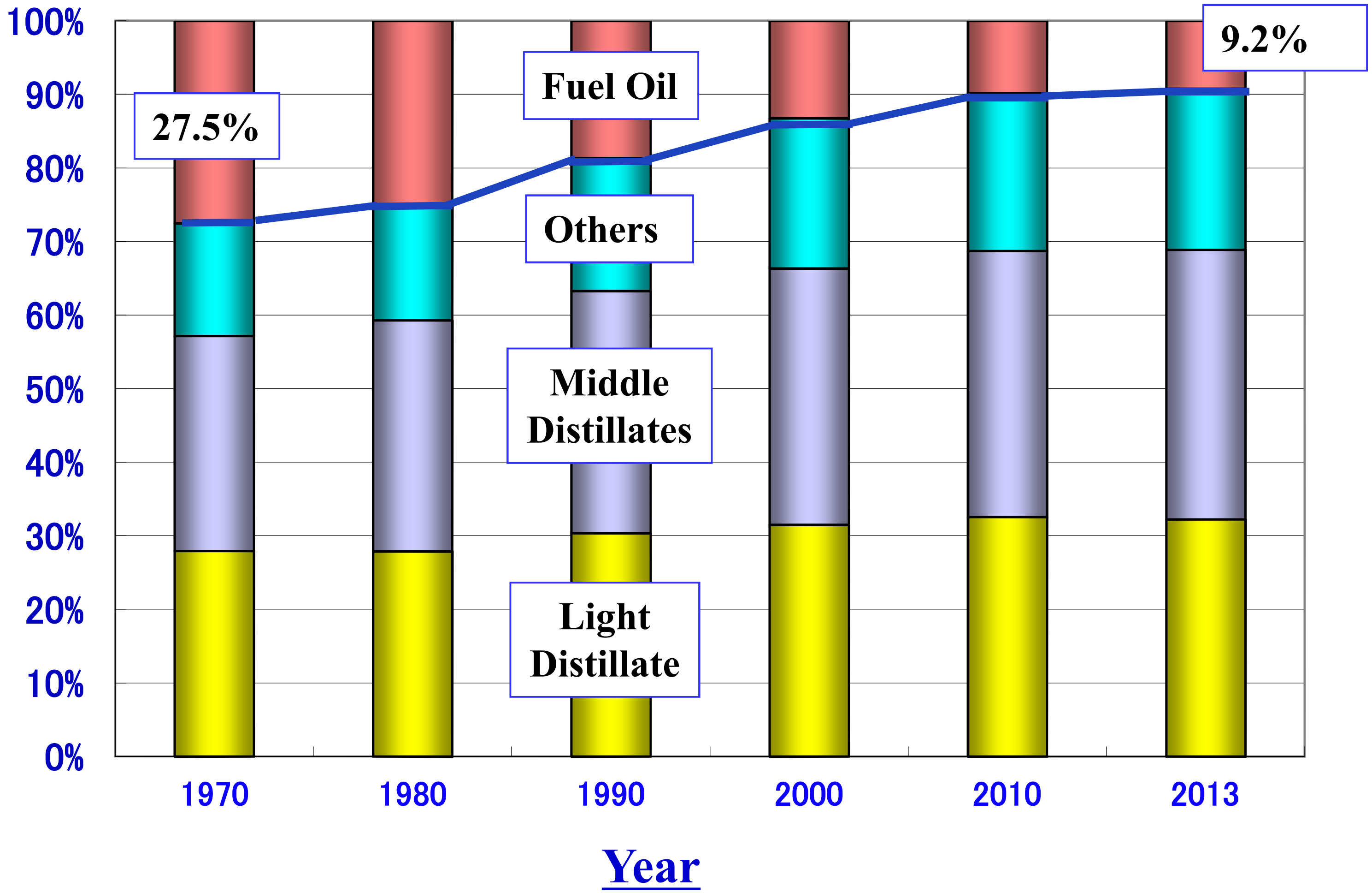


17,413 Million Tons of Oil Equivalent

2030

Source: IEEJ World Energy Outlook 2014

Trend of Consumption by Product Group in the World

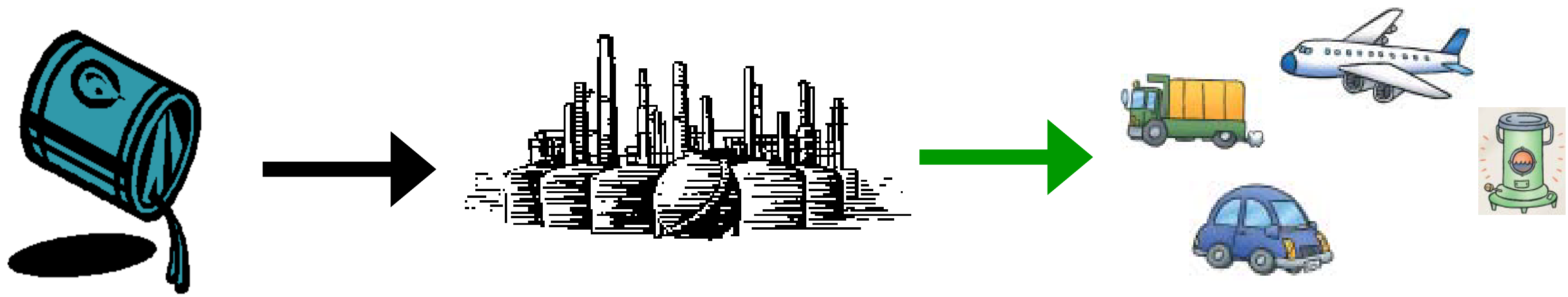


Source: BP Statistical Review of World Energy 2014, excluding FSU till 1990

Mission of Petroleum Refinery

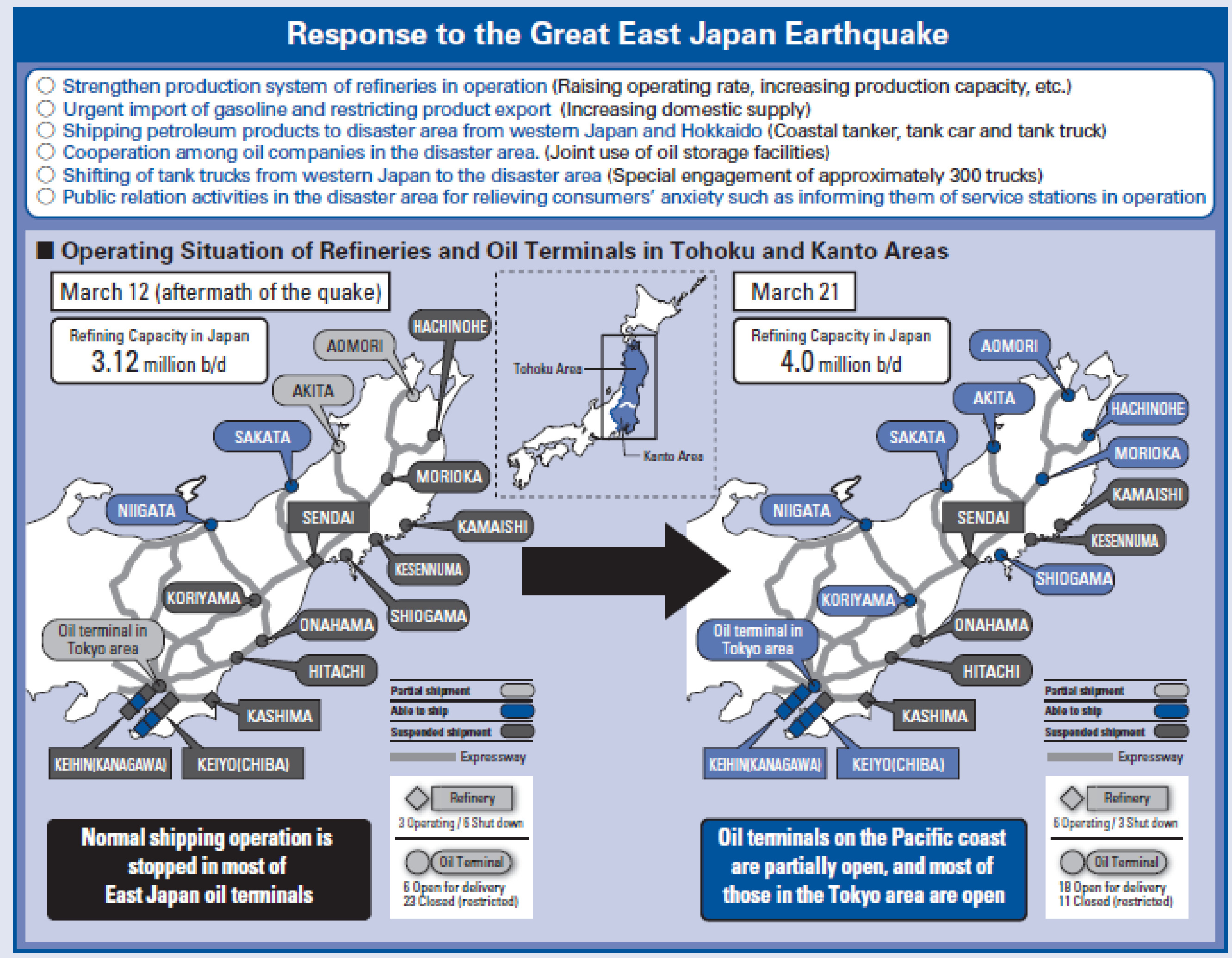
- ✓ To produce clean & high quality petroleum products
- ✓ To maximize the utilization of petroleum, or Noble Use of Crude
- ✓ To deliver petroleum products at any circumstance

Reliable, Efficient, and Competitive Refinery



Role of Refining Industry

Sustainability by Deliver Petroleum Product at Any Circumstance



Source: **PAJ** Petroleum Association of Japan

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Role of Refining Industry

Sustainability by Delivering Petroleum Product at Any Circumstance

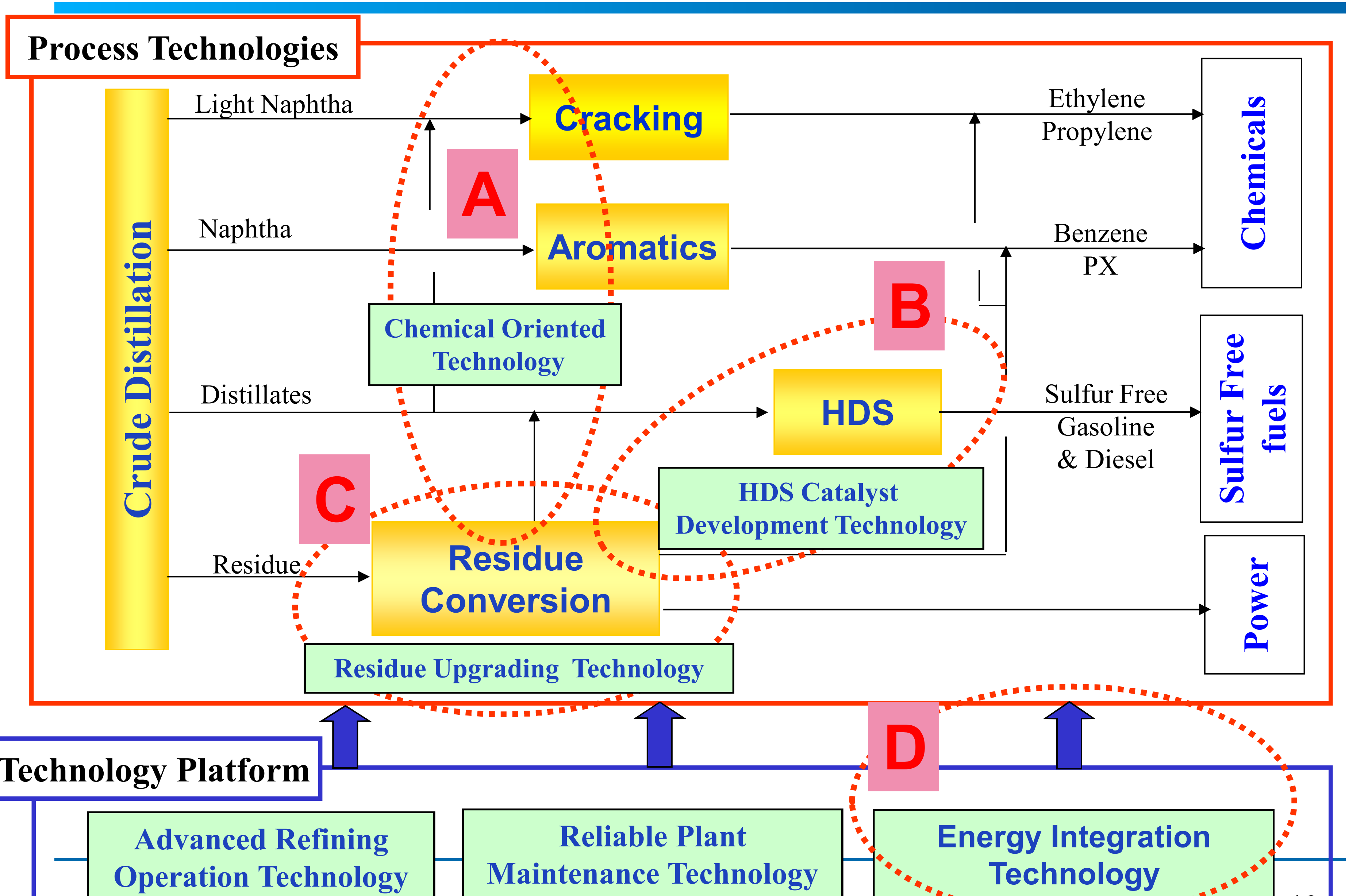
Source: **PAJ** Petroleum Association of Japan

Contents

Focused Areas for Refinery

- ✓ More Demand for lighter Distillate products
- ✓ Stringent Environmental Requirements/Regulations
- ✓ Improve refining Margin by Heavy Oil Cracking
- ✓ Energy Saving by Energy Integration Technology

Focused Areas



Contents

A Example of Chemical-Oriented Technology

High-Severity FCC (HS-FCC)

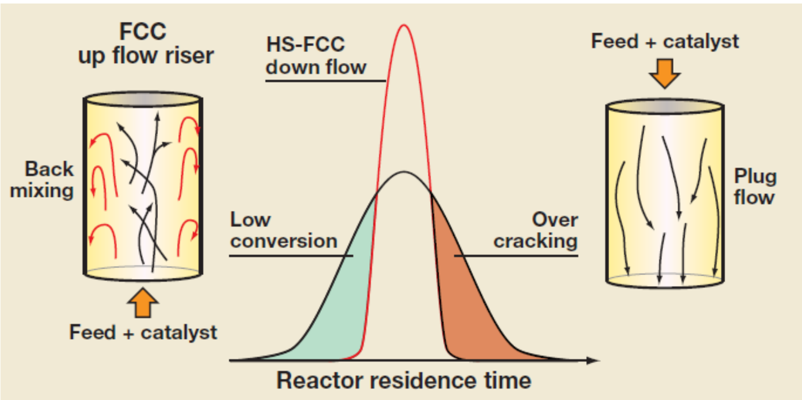
HS-FCC has been developed to convert heavy oil into valuable chemicals.

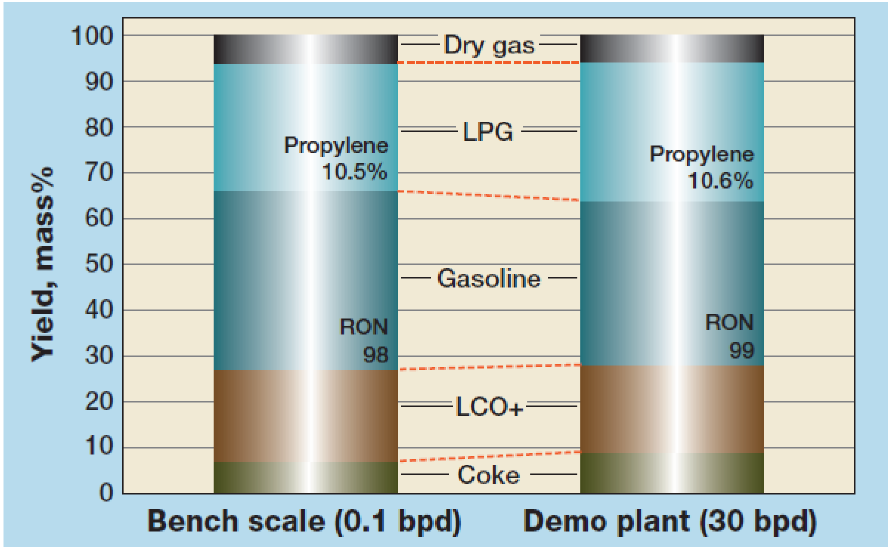
Compared to conventional FCC, higher propylene and butane yield are expected.

3,000 BPSD semi-commercial plant was constructed at Mizushima refinery of JX Nippon Oil & Energy Corporation.

Typical operating conditions for FCC and HS-FCC

	FCC	HS-FCC
Reaction T,°C	500-550	550–650
Contact time, s	2–5	0.5–1.0
Catalyst/oil, wt/wt	5-8	20–40
Reactor flow	Up flow	Down flow

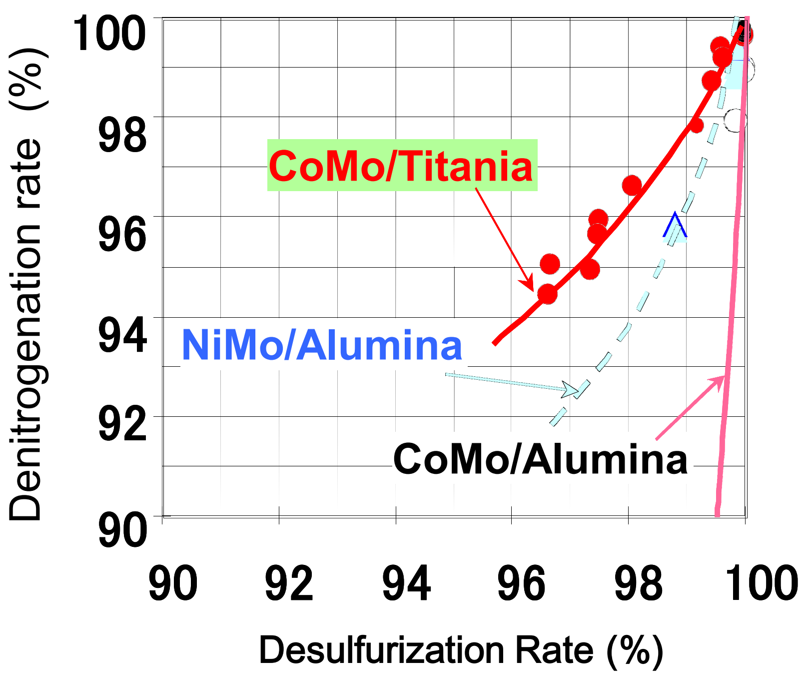




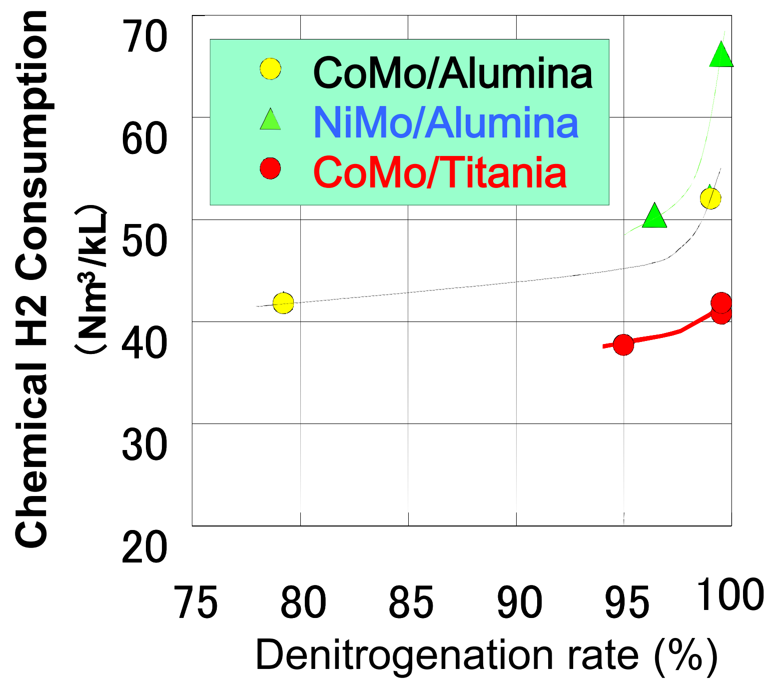
Source: Axens Homepage

B Sulfur-Free Fuel by Hybrid Titania Catalyst

High Denitrogenation Selectivity



Low Hydrogen Consumption



Hybrid Titania Catalyst : Alumina Supported and Titania Layered

C Heavy Oil Cracking by Petroleomics Technology

Detailed Chemical Composition Analysis of Heavy Oil

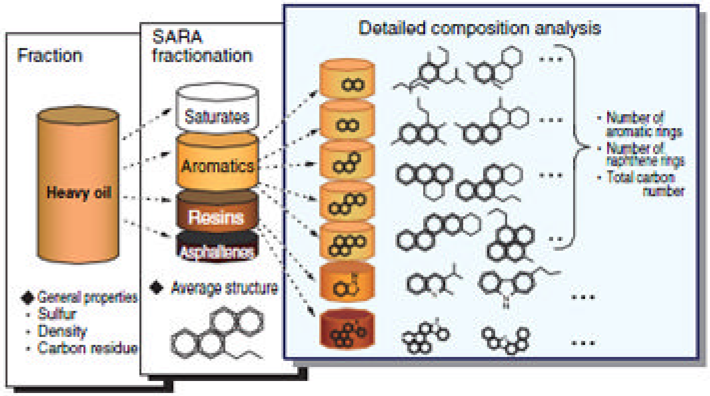


Figure 1 Pre-fractionation processing for detailed composition analysis of heavy oil

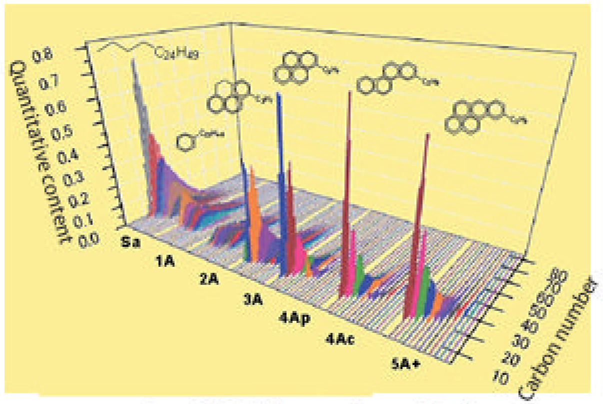


Figure 2 Detailed composition analysis of atmospheric residue (by way of example)

Molecule-based Reaction Modeling Technology

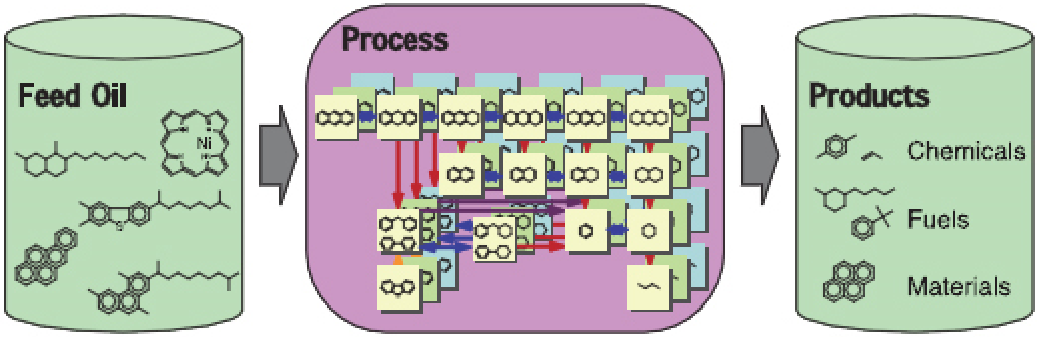


Figure 3 Molecule-based Kinetic modeling for molecular-level analysis of heavy oil (Basic concept)

Source: JPEC Homepage

C Technological Development of Petroleomics

(a) Development of Technologies for Heavy Oil Cracking Processes Utilizing Advanced Pre-treatment Processing and Hydrotreating

(b) Analysis of the Catalyst Deactivation Mechanism for Developing Optimum Technologies for Processing Feedstocks with Low Reactivity

(c) Development of Advanced Residue Cracking Technologies for Processing Extra-heavy Oils

(d) Development of Advanced Slurry Phase Hydrocracking(SPH) Process for Extra-heavy Oil Upgrading

(e) Development of Innovative Upgrading Process for Light Cycle Oils and Others

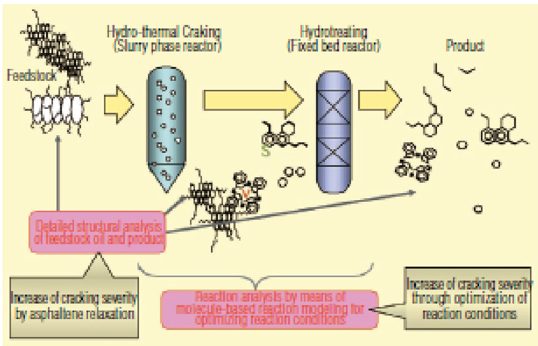
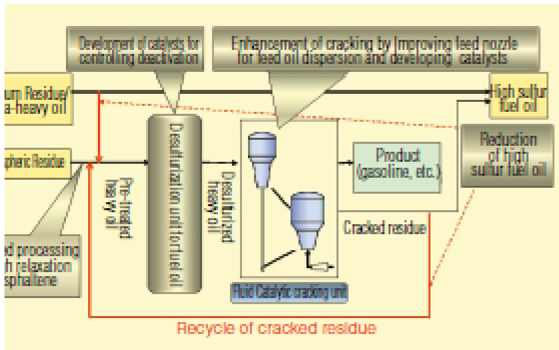


Figure 6 Concept of Advanced Slurry Phase Hydrocracking (SPH) Process for Extra-heavy Oil Upgrading



4 Concept of the technologies for heavy oil cracking process

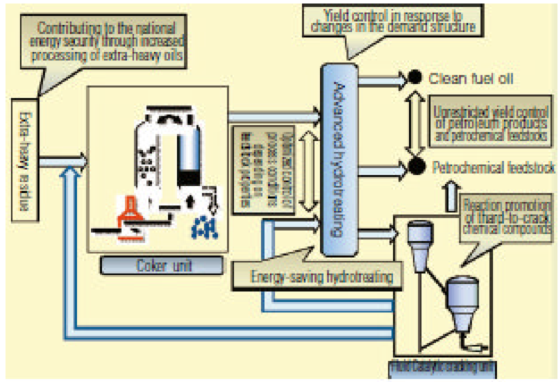
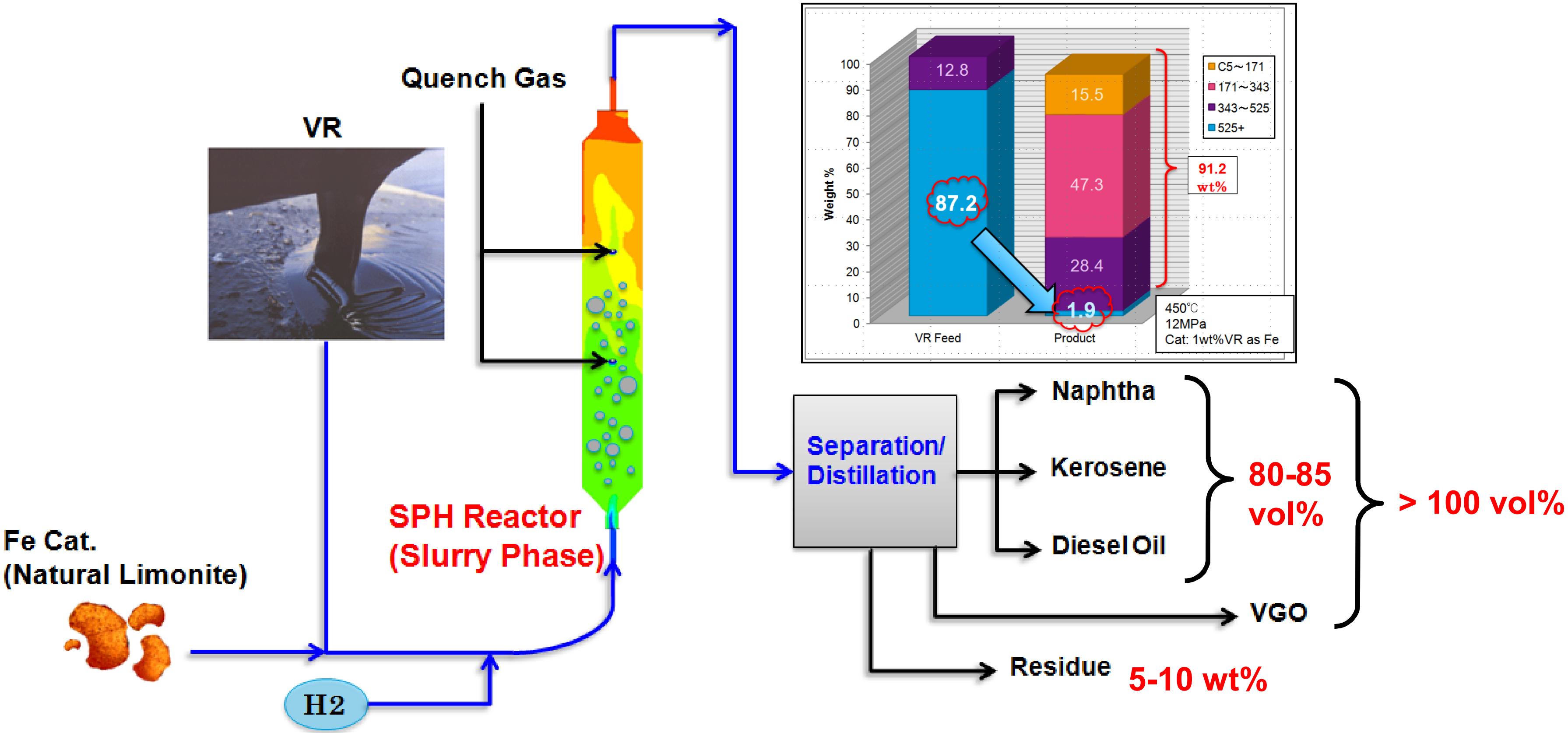


Figure 5 Concept of Advanced Residue Cracking Technologies

Source: JPEC Homepage

C SPH Features: High Yield, Less Residue



Advantages:

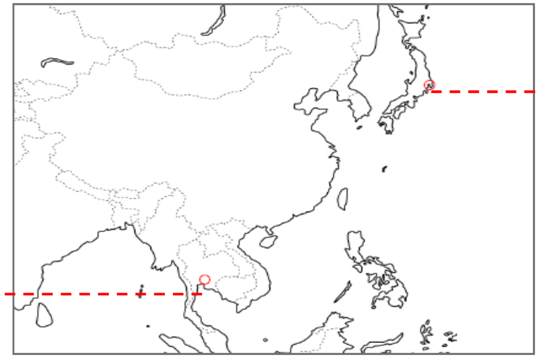
1. High Oil Yield : > 80-85 vol% (> 100vol% including VGO)
2. High Conversion : > 95 % on Feed VR
3. Good economics : Cheap limonite catalyst (more 10 times cheaper than other synthetic catalysts

D

Energy Integration Technology (Area-wide pinch technology analysis)

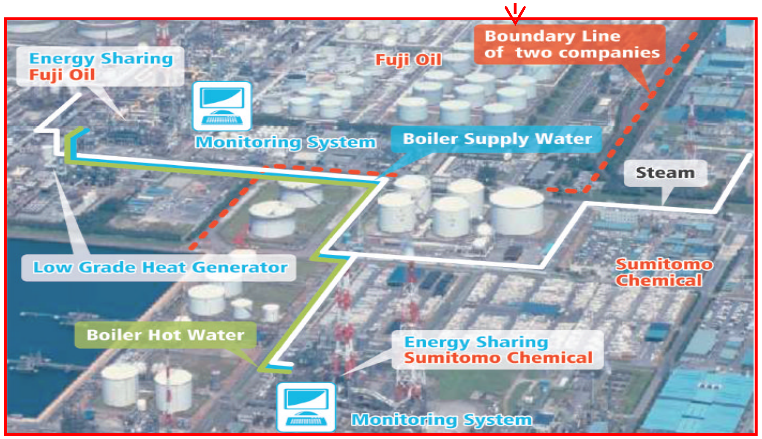
Map Ta Phut Industrial Complex in Thailand

15 chemical, petrochemical and refinery sites in Map Ta Phut participated for optimizing total energy systems including heat and electricity in multiple sites.



Tokyo Bay Industrial Area in Japan

23 chemical, petrochemical and refinery sites in Tokyo Bay industrial area participated in the analysis study



Topics

Solutions for Heavy Oil Upgrading

<u>Experiences in Residue Conversion</u>

EUREKA 2 units (Japan, China)

Delayed Coker 2 units (Malaysia、Middle East)

SDA/PDA 3 units(*) / 6 units

***: including pre-feed unit**

<u>Experiences in Hydrocracker / Residue HDS</u>

RDS	**18 units (Chevron/Unocal/Shell)**
H-Oil	**1 unit**
Chevron OCR	**3 units**
Hydrocracker	**12 units (UOP/Chevron/Axens/Shell)**

- **Keeping in touch with the latest RDS & Hydrocracker technology since 1970**
- **Sales-agreement made for SDA with KBR under the name of ROSE™ process.**
- **EUREKA is a thermal cracking process developed by Chiyoda & Fuji Oil to produce cracked oil and aromatics pitch from vacuum residue.**

Conversion of CO_2 into Chemical Resources

Chiyoda's CO2 Reforming is an effective solution for environmental friendly synthesis gas production.

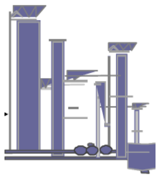
Natural Gas

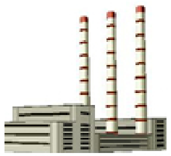
C1

CO2

CCS
Carbon Capture Storage

Flue Gas





Refinery
Chemical Plant

Power
Plant

CO2 Reforming Process

$CH_4 + CO_2 \rightarrow H_2 + CO$

$CH_4 + H_2O \rightarrow 3H_2 + CO$

H2/C=2.0

- GTL
- Methanol
- DME

H2/C=1.0

- Oxo –synthesis
- MMA

CO separation

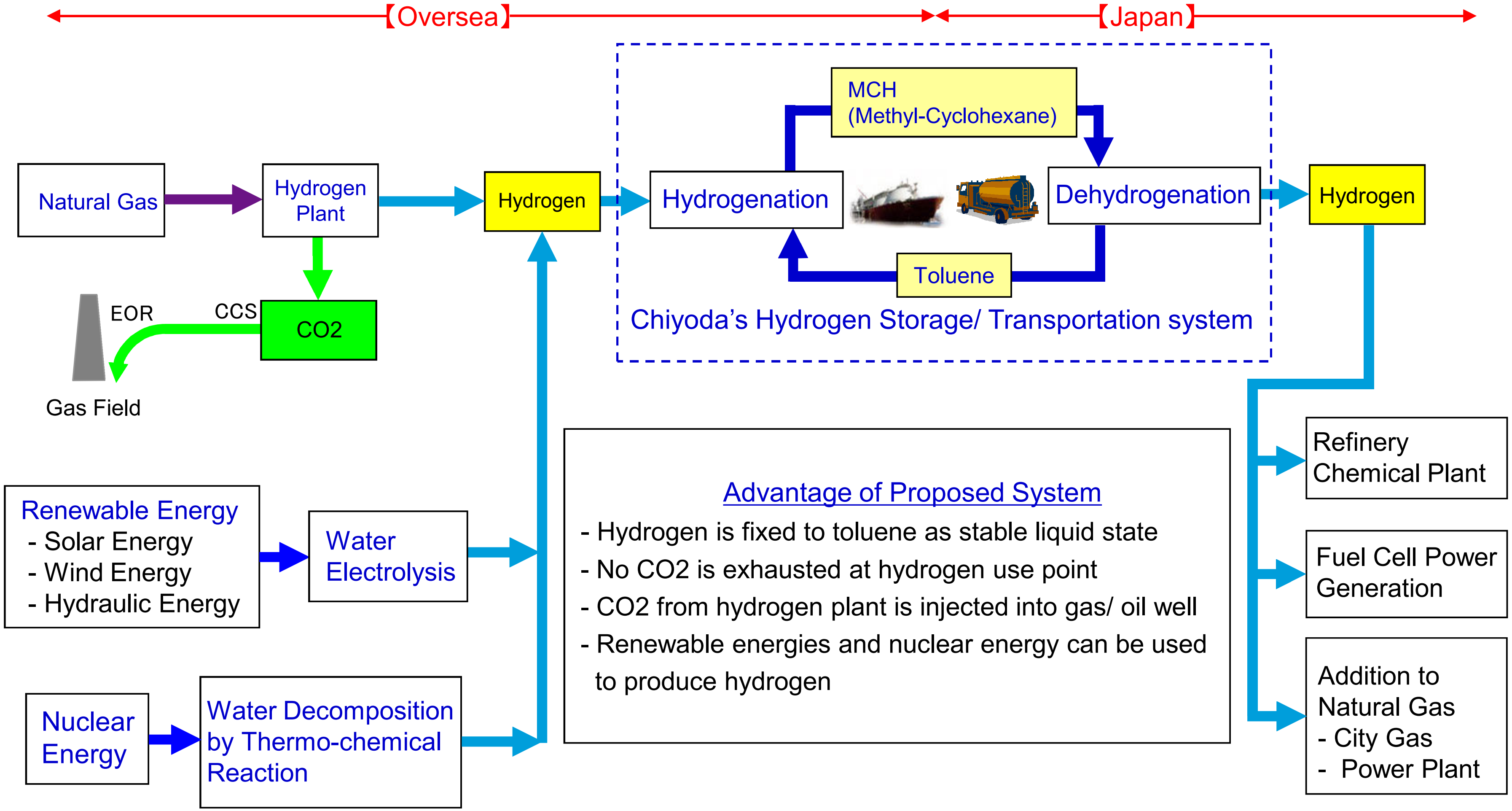
- Acetic Acid

500BPSD GTL Demonstration Plnat
Chiyoda's CO2 Reforming Process is used for synthesis gas production in National GTL project by JOGMEC and Nippon GTL Technology Research Association.

Chiyoda's CO2 Reforming can convert CO2, a greenhouse gas, into raw chemical material. Wide range of H2/CO ratio is efficiently accomplished. Synthesis gas with a H2/CO ratio of 2.0 is used as feed gas for GTL, methanol, and DME. Synthesis gas with a H2/CO ratio of 1.0 is used as feed gas for Oxo-synthesis and MMA (Methyl Methacrylate).

CO2 contained in flue gas from refinery, chemical plant, or power plant can be used as feedstock for CO2 Reforming.

Hydrogen Supply Chain for Clean Energy Utilization



Advantage of Proposed System

- Hydrogen is fixed to toluene as stable liquid state
- No CO_2 is exhausted at hydrogen use point
- CO_2 from hydrogen plant is injected into gas/ oil well
- Renewable energies and nuclear energy can be used to produce hydrogen

Rejuvenation of Existing Column by Partial Regression Method

- Partial regression method is developed by Chiyoda group to update the corroded area of existing column into clad material
- New shell clad plate is fabricated and divided in shop
- After removing corroded shell plate, new shell plates are welded in two diagonal points
- The method could reduce cost and duration
- It could be applied where a large crane is not available

Mock-up Test