

*NEDO's R&D Activities
and
International Collaborative Activities
on Clean Coal Technology*

March 10, 2011

*Environment Department
NEDO*

NEDO's Activities Related to Clean Coal Technologies

1. Coal-fired Power Generation Technology Development
2. Coal Gasification Technology Development (EAGLE)
3. Innovative Zero-emission Coal Gasification Power Generation Project
 4. Development of Environmental Technology for Steelmaking Process
 5. International Collaborative Basic Research
6. New Upstream Collaboration with Australia

(1) Current & Past Activities (1), 2), 3))

- 1) CO₂ separation and capture technology development after coal gasification (EAGLE STEP 2)**
Chemical absorption method
- 2) Innovative Zero-emission Coal Gasification Power Generation Project**
FS on a comprehensive system, from power generation to CCS
Basic R&D, e.g. Oxyfuel IGCC and Hydrogen Gas Turbine
- 3) Innovative technology for steelmaking process**
Hydrogen reduction in blast furnace and CO₂ separation and capture from blast furnace gas

(2) New Activities (4), 5), 6))

- 4) Technology development for CO₂ separation and capture from coal gasification**
EAGLE STEP 3 (CO₂ capture technology: physical absorption method, etc.)
Demonstration of EAGLE is being planned
(Osaki COOLGEN, 1,100 tons/d, 170 MWh)
- 5) International collaborative clean coal technology development project**
- 6) New Upstream Collaboration with Australia**

1. Coal-fired Power Generation Technology Development

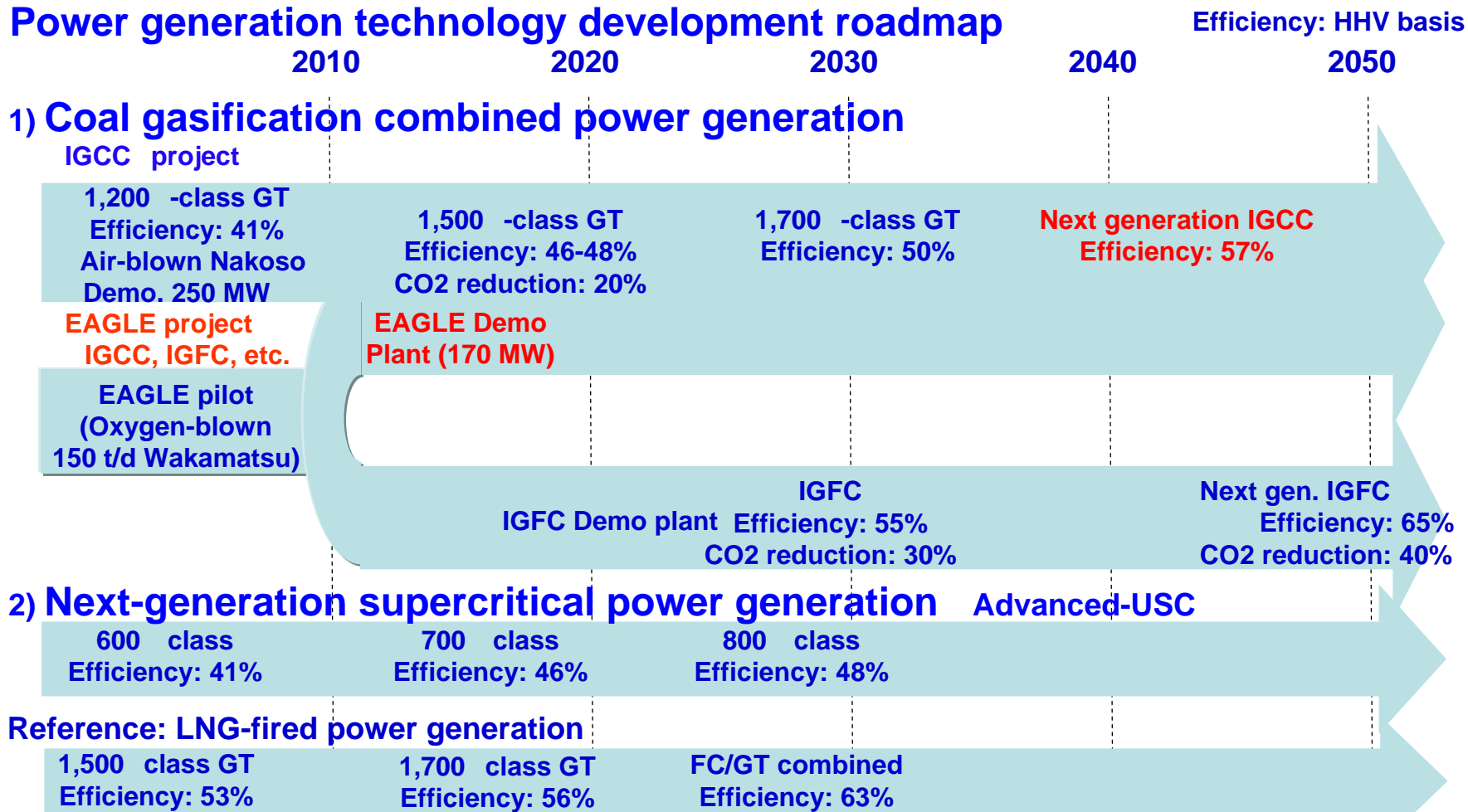


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(1) Present status in Japan

Efficiency of ultra supercritical power plant (USC): 40.6% (HHV)

(2) Power generation technology development roadmap



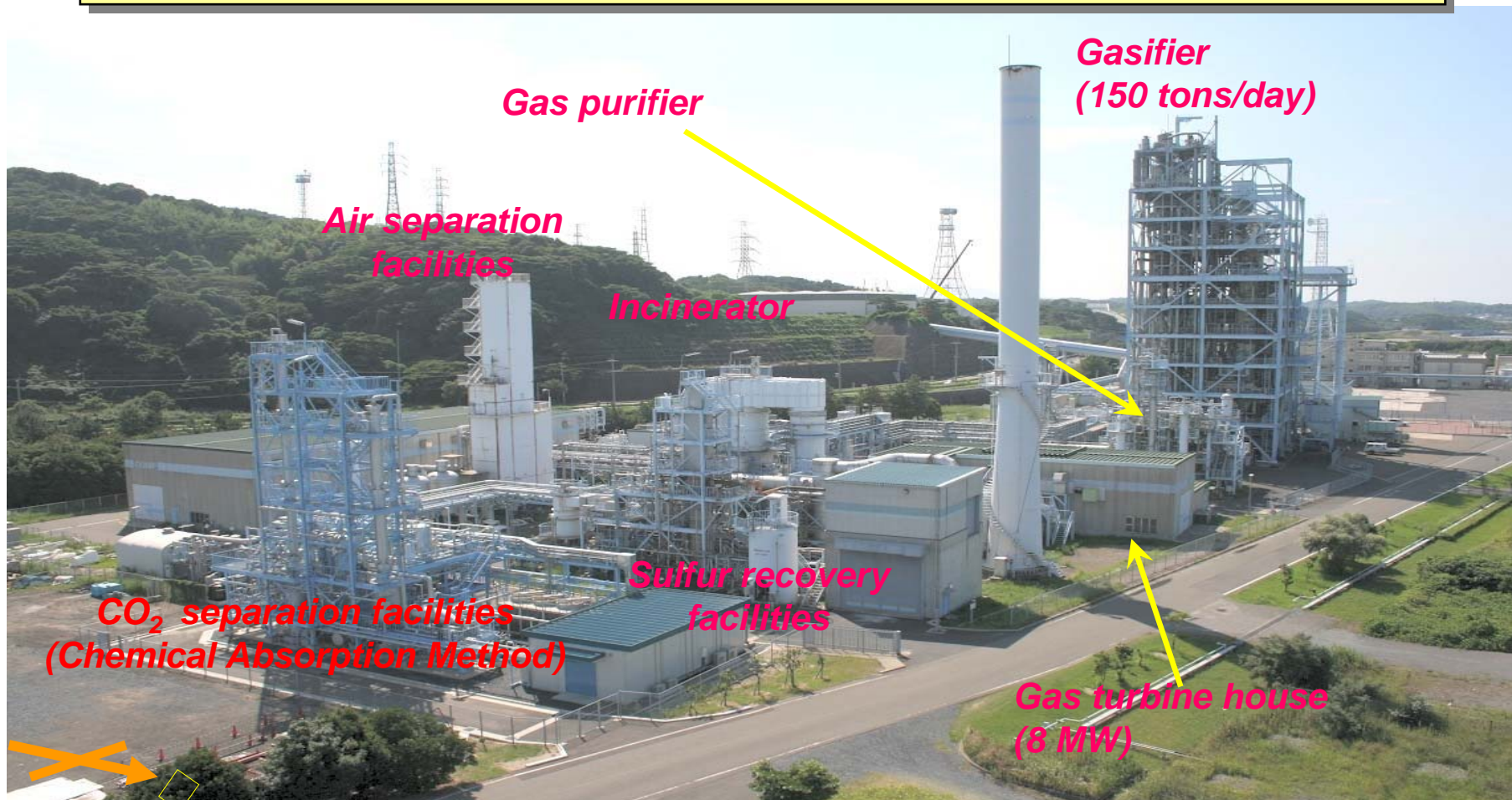
Next generation IGFC output efficiency is expected to reach 65% by 2050. That would exceed the 63% FC/GT efficiency LNG-fired power generation is expected to reach in 2030.

2. Coal Gasification Technology Development (EAGLE Project)

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EAGLE (Coal Energy Application for Gas, Liquid & Electricity)

Photograph of EAGLE Pilot Plant (150 tons/day)



150 tons/day pilot plant located in J-Power's Wakamatsu Laboratory

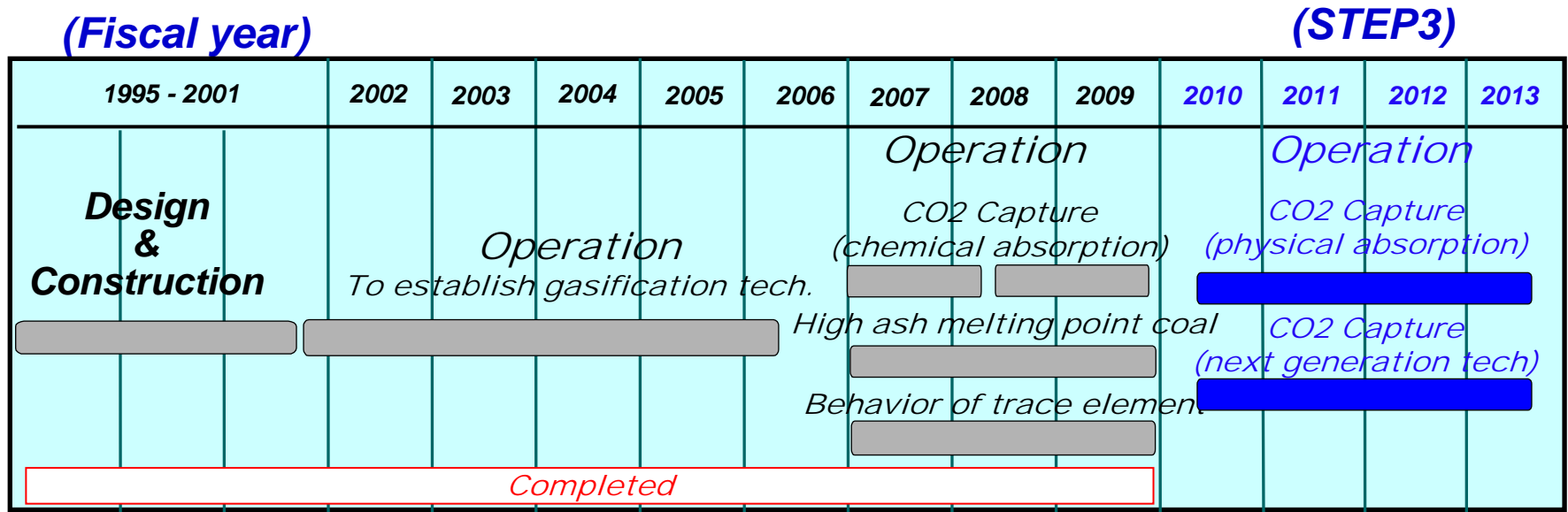
2-1 CO2 Capture Technology Development from IGCC System



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Objectives & Schedule for **EAGLE STEP 3 Project** (2010-2013)

1. Coal Gasification Technology
2. CO2 Capture Technology
Physical absorption technology for 1,500□ class IGCC
3. Next generation CO2 capture technology
(e.g.) CO2 separation by membrane



2-2 IGCC Technology Development (2010-2011)



EAGLE Demonstration Plant

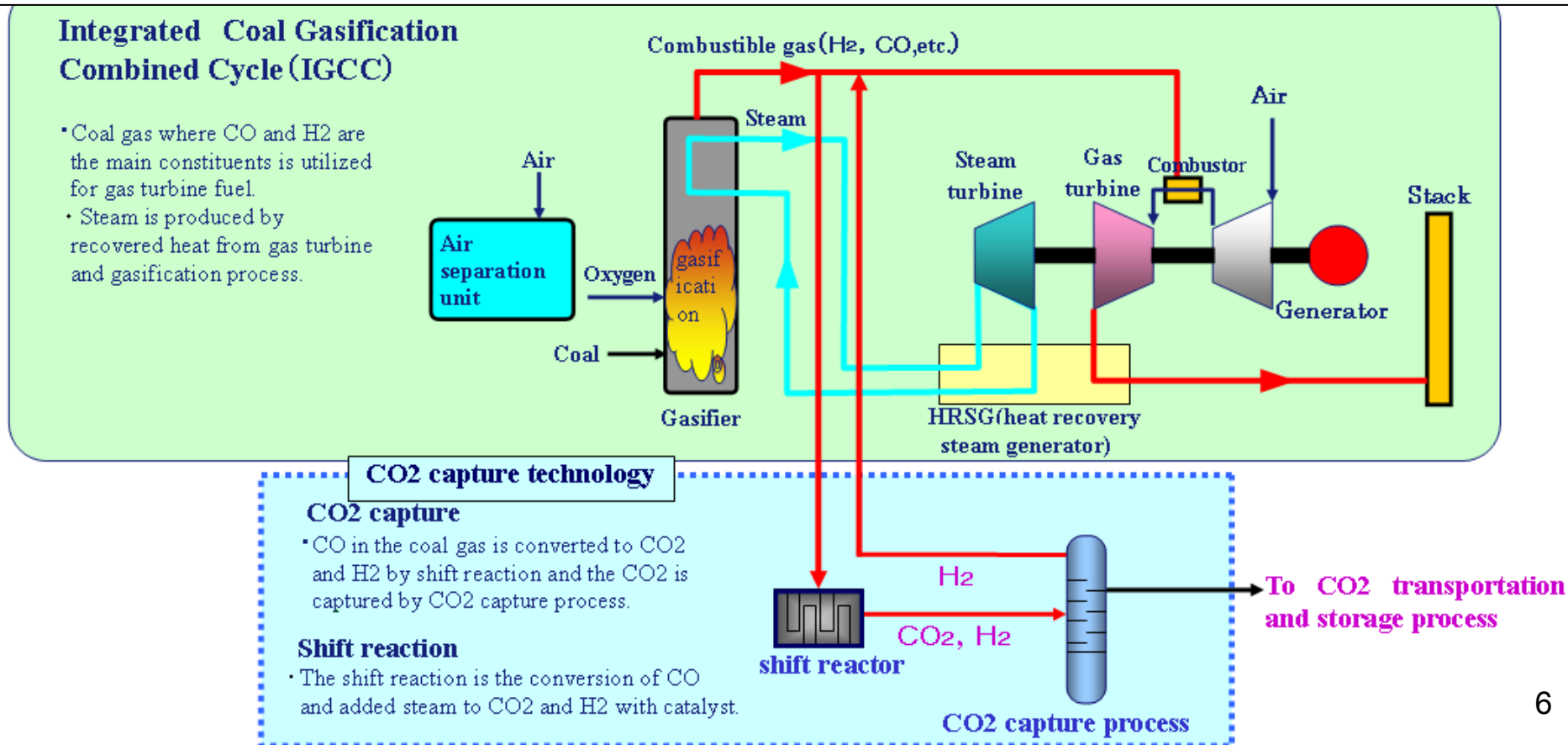
- (1) Based on the achievements of EAGLE technology development, an optimal model for integrated coal gasification combined cycles (IGCC) and CO₂ capture technology will be evaluated.
- (2) A detailed plan for verification tests will be developed and the future commercial viability of the system will be assessed.

[Osaki demonstration plant (constructed at the Osaki Power Station operated by Chugoku Electric Power)]

Power generation : 170,000 kW-class

Construction period : 2012-2016

IGCC verification tests will commence from March, 2017



3. Innovative Zero-emission Coal Gasification Power Generation Project



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1. Objective

It is extremely important to reduce CO₂ emission from coal-fired thermal power plants. The target for CO₂ reduction can't be achieved by improving power generation efficiency alone. Innovative technology such as CCS is needed.

2. Project details

(1) Assess the feasibility of deploying a total system from power generation to CCS in Japan from an economic point of view.

1) Several envisioned sites in Japan 2) Nakoso site

(2) Project period: FY2008 - FY2012

3-1 Study on Technology Elements through FS

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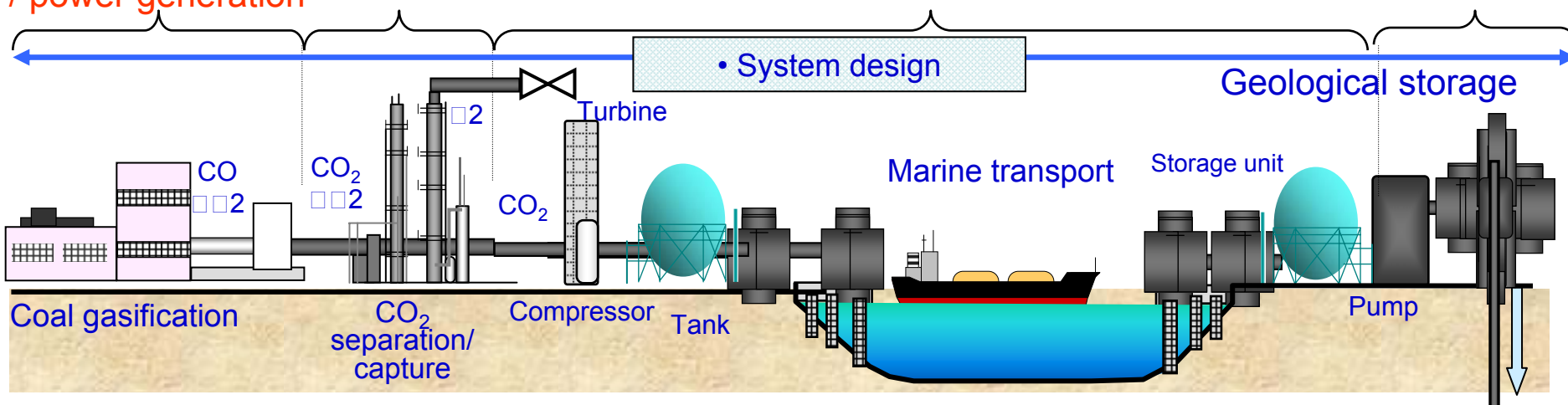
Feasibility study □ on total system from power generation to CCS □

(1) Coal □ asification / power generation

Capture/Storage

(2) Transport

(3) Storage

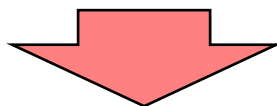


Review a total system from power generation to CO2 storage

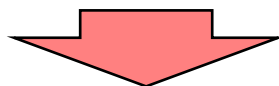
- (1) Concept design of CO2 separation and capture system
- (2) Concept design of CO2 transport system
- (3) Concept design of CO2 storage system and review of the potential of CO2 storage
- (4) Review a total system from power generation to CO2 storage
- (5) Concept design of a total system at a specified site (Nakoso area)

3-2 Expected Outcomes from FS

- Conceptual design of technology elements
- Prepare economic evaluation model using data obtained from the FS
- Review the potential of CCS realization based on its estimated cost



- Establish an economic evaluation model and cost evaluation model for CCS
- Assess effect on energy supply and demand system
- Evaluate the potential of deploying a CCS system



- Evaluation for a CCS total system
- Proposal on the potentiality of deploying a CCS system

3-3 Study of the Potential of CO₂ Storage using IGCC

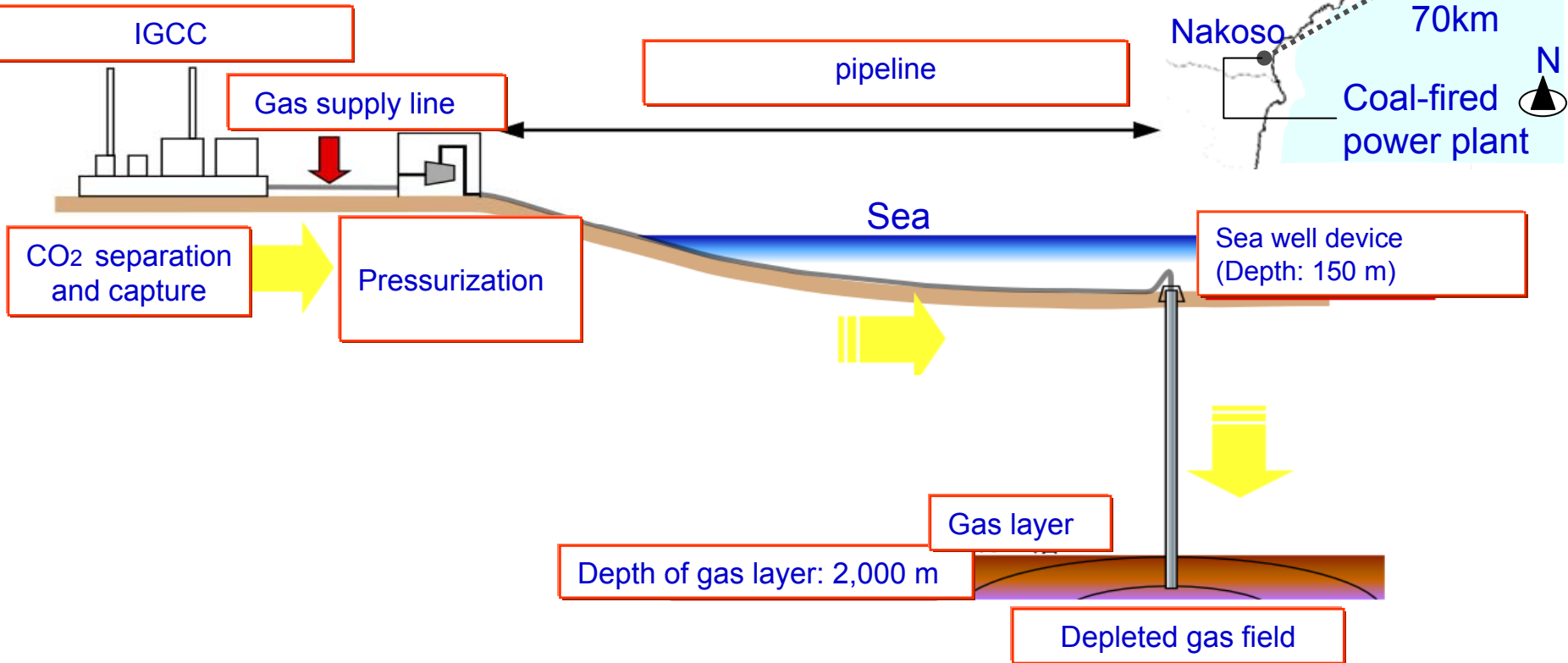
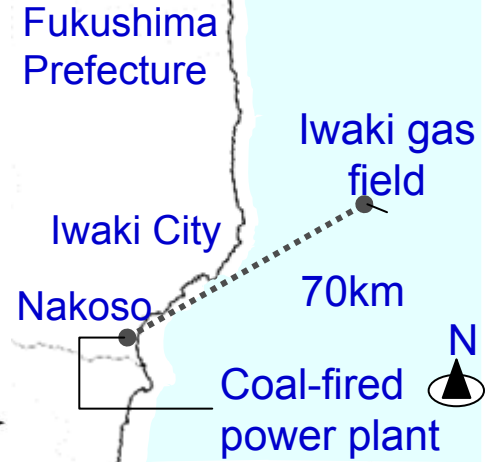
Demonstration Plant at Nakoso Site (FS to Study a Total System)



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CCS storage: Off the coast of Nakoso

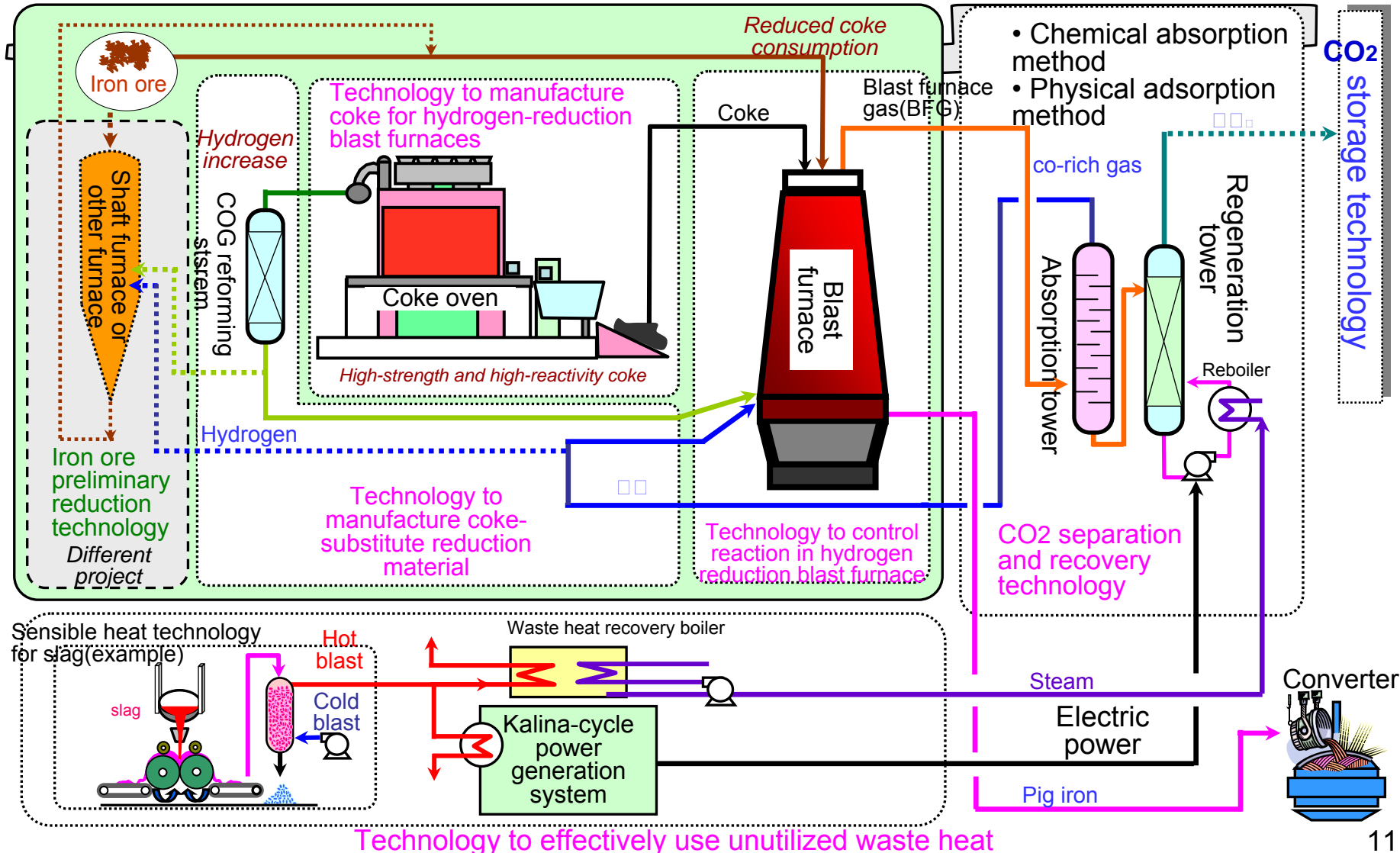
CO₂ separated and collected from the Nakoso IGCC plant will be transported through a pipeline and stored in the depleted Iwaki natural gas field located about 70 km off the coast of Nakoso.



4. Development of Environmental Technology for Steelmaking Process

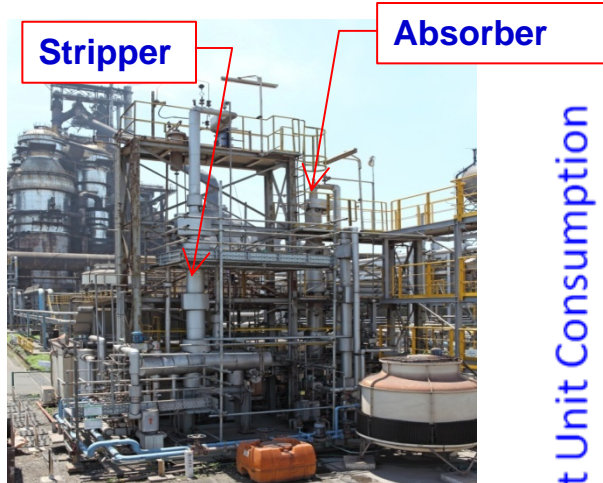
(1) Development of technology to reduce CO₂ emissions from blast furnaces

(2) Development of technology to separate and recover CO₂

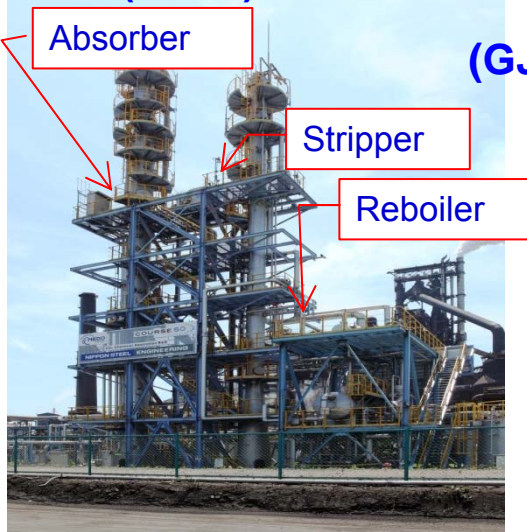


4-1 CO₂ separation and capture from blast furnace gas (BFG)

**Bench Test Plant (1 t/D)
CAT-1**

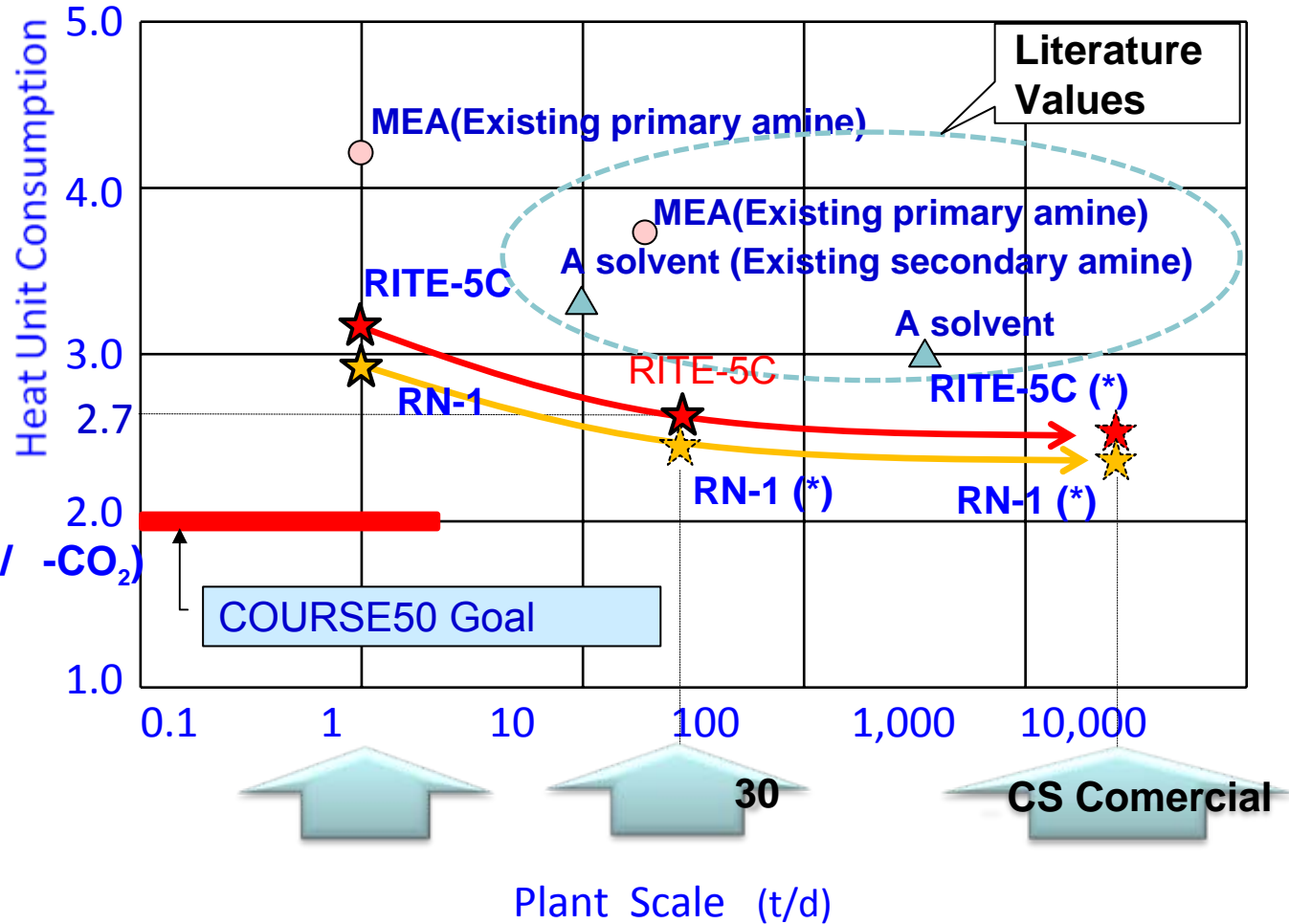


**Process Evaluation Plant
(30 t/D) CAT-30**



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RITE-5C Existing Absorbent
RN-1 family New Absorbents (under investigation)



5. International Collaborative Basic Research (Australia, Canada, U.S.)



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Objective

(1) This research program was designed to contribute to early establishment of a CCS system in Japan using coal power, through international collaborative research in CCS-related technology fields with leading countries, such as Western countries.

(2) With the aim of achieving practical application or a technology breakthrough, collaborative research in basic and fundamental technology fields will be carried out with research organizations, etc. in Western countries.

5-1 International Collaborative Basic Research (Australia, Canada, U.S)



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(1) Number of research themes : 7

(2) FY2010 budget : 150 million yen

(3) Project period : FY2010 - FY2012

(4) Counterparts

**Australia: Monash University,
HRL, CSIRO, CO2CRC**

Canada : PTRC

U.S. : NETL, LBNL, PNNL, NOBLIS

5-2 Bilateral Collaboration between Australia and Japan

Themes	Australia	Japan
1. International Collaborative Research on Advanced Utilization Technology Based on the Gasification of Victorian Brown Coal	Monash Univ.	Kyushu Elec. Kyushu Univ.
2. Feasibility Study to Realize a Future Energy System (Hydrogen Supply Chain) Using Carbon-free Fuel Derived from Low Rank Coal	HRL, CSIRO, CO2CRC	KHI*

*Kawasaki Heavy Industries, Ltd.

5 3 Feasibility Study to Realize a Future Energy System (Hydrogen Supply Chain) Using Carbon-free Fuel Derived from Low Rank Coal (PLAN)

• **Objective** □ In order to address energy and environmental issues related to coal utilization, this project aims to deploy a hydrogen energy supply chain system, promoting hydrogen produced from low rank coal and used as carbon-free fuel.

• **Counterparts: HRL, CSIRO, CO2CRC**

• **Overview of possible joint project:** Hydrogen would be produced from Australian brown coal using coal gasification technology. Basic technologies to capture and safely store CO2 generated during hydrogen production would be examined. Moreover, a new hydrogen supply chain for storing, transporting and utilizing hydrogen in Japan would be created. With the promotion of a new hydrogen supply chain in mind, a study on fundamental technologies, required facilities and economical efficiency would be conducted.

Topics

1. Verification tests (brown coal gasification, CO2 separation/capture)
2. Optimization of overall energy system (hydrogen supply chain)
3. Review of economic evaluation methods

• Division of responsibilities

Japanese side (KHI) □ project management, basic design of equipment

Australian side:

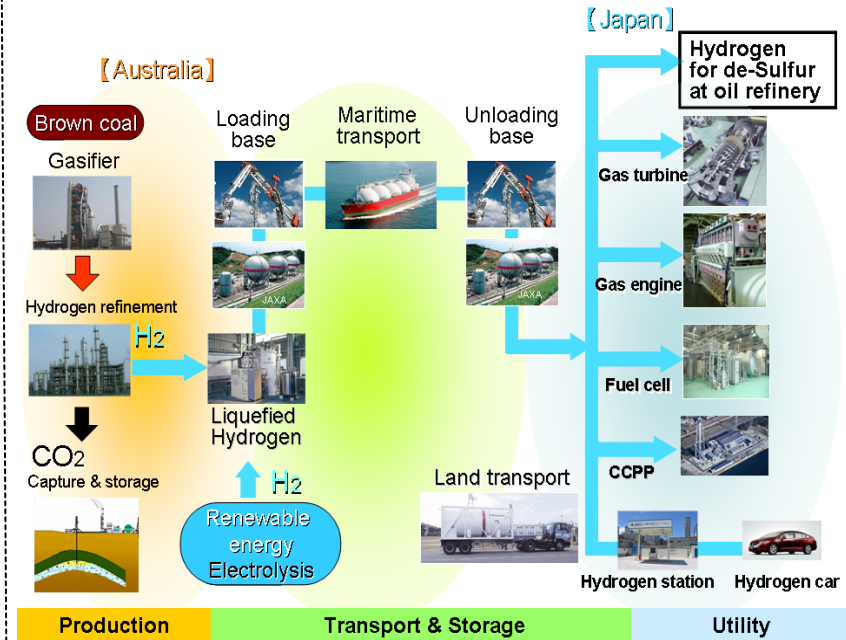
HRL: Australian project leader, provision of infrastructure,

etc.

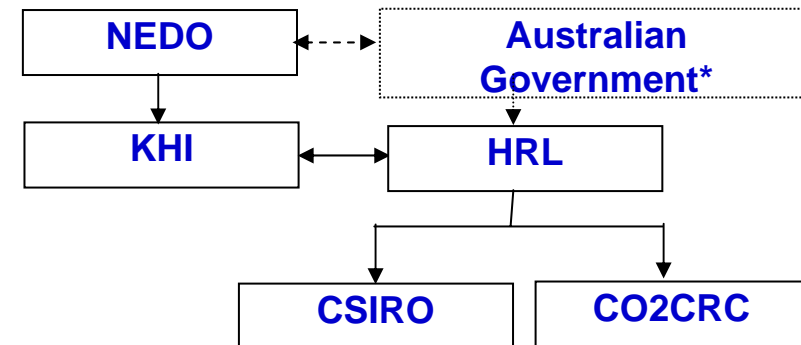
CSIRO: development of new gas purification technology

CO2CRC: review of CCS technologies

• Carbon-free Hydrogen Supply Chain



• Organizational Structure



*Cooperation from Australian government will be requested when necessary.

5 4 Feasibility Study to Realize a Future Energy System (Hydrogen Supply Chain) Using Carbon-free Fuel Derived from Low Rank Coal

1. Verification test (brown coal gasification)

(by KHI)

- (1) Gasification of Australian brown coal (Loy Yang coal) was successfully conducted at KHI's Works.
- (2) The possibility of hydrogen production from brown coal was confirmed.



2. Verification test (CO2 capture/separation and recovery) (by KHI)

- (1) CO2 capture/separation from coal combustion gas with KHI's propriety innovative solid adsorbent was confirmed.
- (2) CO2 desorption from the adsorbent with low energy was confirmed.



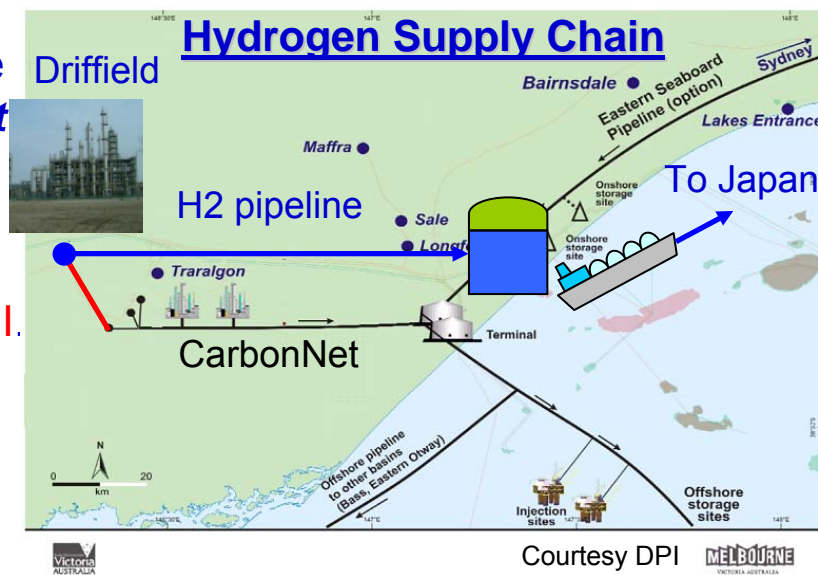
5 4 Feasibility Study to Realize a Future Energy System (Hydrogen Supply Chain) Using Carbon-free Fuel Derived from Low Rank Coal

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3. Optimization of overall energy system (hydrogen supply chain)

(by HRL, CSIRO, CO2CRC and KHI)

- (1) Capacity of hydrogen plant was determined to be “700 t/day-H₂ (based on loading capacity)” by KHI.
- (2) Possible process schemes for hydrogen supply chain were addressed by KHI and HRL.
- (3) Each proposed process scheme was investigated, characterized, and cost of each was estimated by HRL.
- (4) The most suitable plant sites for brown coal gasification-purification plant and export port were investigated and selected to “**Driffield and a port in Gippsland**” respectively by HRL.
- (5) The most feasible process scheme was selected to “**Oxygen Blown Gasification – H₂ transportation by gas pipeline**” by HRL and KHI.
- (6) Basic engineering for the selected scheme is proceeding by KHI and HRL.
- (7) Review of gas purification technology was completed by CSIRO.
- (8) Review of transportation & storage of CO₂ from the Latrobe Valley was completed by CO2CRC.



4. Refinement of cost structure for hydrogen supply chain

Will be conducted in 2011 by KHI and HRL

5 5 International Collaborative Research on Efficient Utilization Based on Victorian Brown Coal Gasification (PLAN)

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1. Objective

It is intended to research the potential of Victoria-Japan joint project based on efficient utilization of Victorian coal under the corporation of KEPCO and Victoria State Government to develop new industries in Victoria and to secure energy resource for Japan.

2. Project Outline

The Japanese research entity (KEPCO, Kyushu University) study jointly technologies of the CCS ready high-efficiency brown coal gasification power generation and synthesis of chemical feed stocks toward commercializing Victorian brown coal-derived energy and chemical complex with the Victorian research entity for the purpose of high-efficiency utilization of Victorian brown coal which counts one-third of the world brown coal reserve

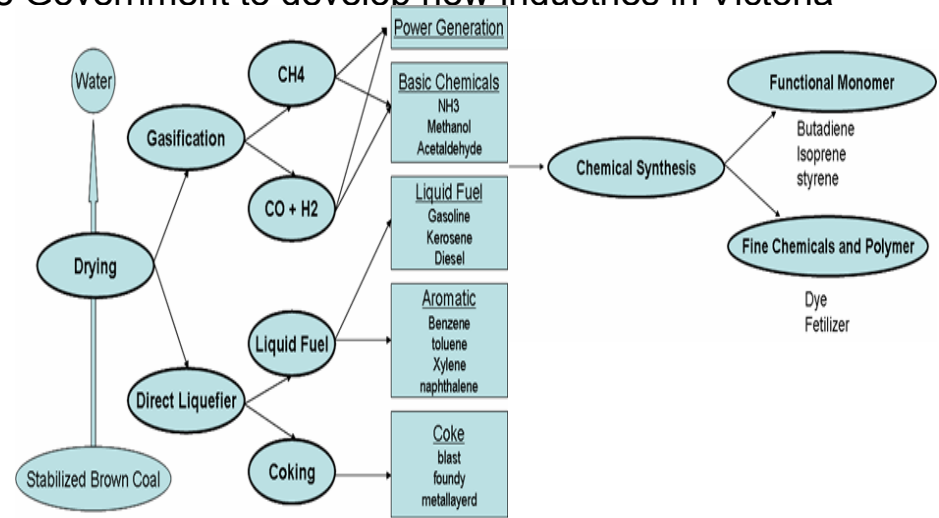


Fig.1 Victorian brown coal-derived energy & chemical complex

3. Implementation List

- (1) Surveying elemental technologies including drying brown coal
- (2) Designing the concept of the CCS-ready gasification power generation process
- (3) Technical study on the chemical complex with Victorian brown coal
- (4) Feasibility study of Victoria-Japan energy & chemical complex based on Victorian brown coal

4. Collaboration Japan Victoria

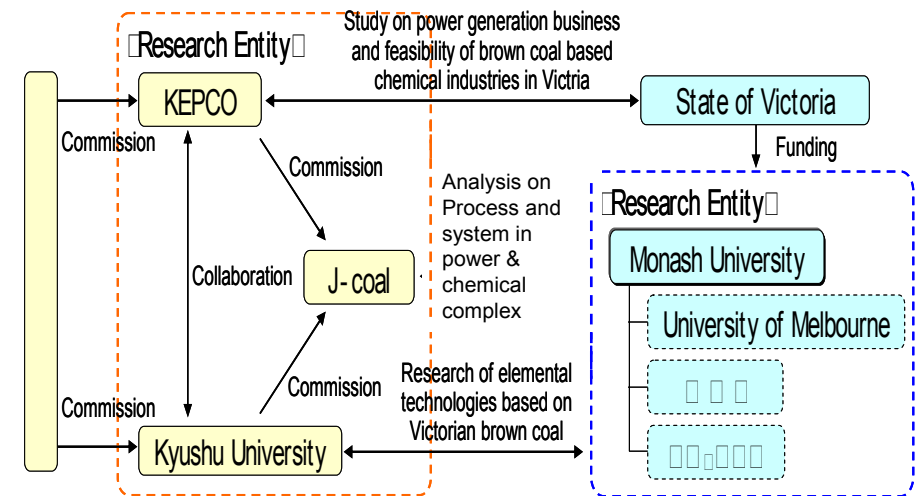


Fig.2 International Collaboration between Victoria and Japan 19

5-6 The International Collaborative Research of Advanced Utilization Based on Victorian Brown Coal Pyrolysis & Modification



New Energy and Industrial Technology Development Organization

1. Objective

It is intended to research the potential of Victoria-Japan joint project based on the advanced utilization of Victorian brown coal in order to **develop new industries in Victoria and secure the energy resource for both Victoria and Japan.**

2. Project Outline

The Japanese research entity (KEPCO, Kyushu University and J-coal) co-researches technologies of the process of **the CCS - ready Victorian brown coal-derived energy and chemical complex** with the Victorian research entity for purpose of utilizing Victorian brown coal of one-third of the world brown coal deposit efficiently.

3. Current Research

Fundamental co-research oriented to the feasible design on supposed operating the complex in Victoria.

Fundamental research

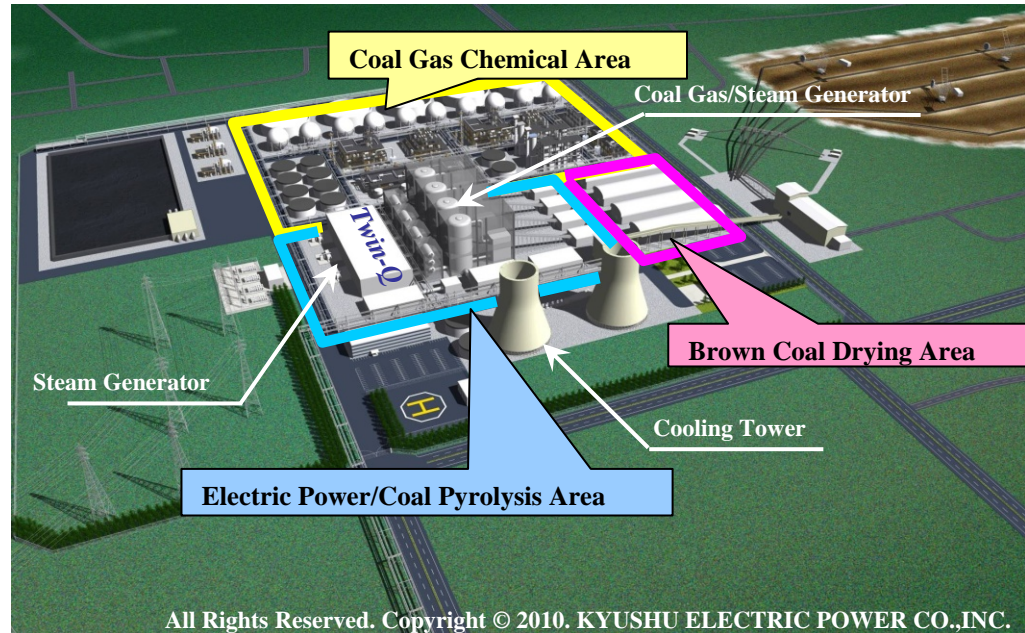
- (1) **Pre-drying with low heat** (by Kyushu Univ.)
- (2) **Modification and Pyrolysis** (by Kyushu Univ.)
- (3) **Synthesis Application** (by Monash Univ.)
- (4) **Combustion** (by Monash and Kyushu Univ.)

Feasibility Study

- (1) **Coal gases market study**
(J-coal)
- (2) **Economical evaluation and integration of each sector such as power generation, manufacturing alternate fuel, chemicals etc.**
(Kyushu Electric Power)

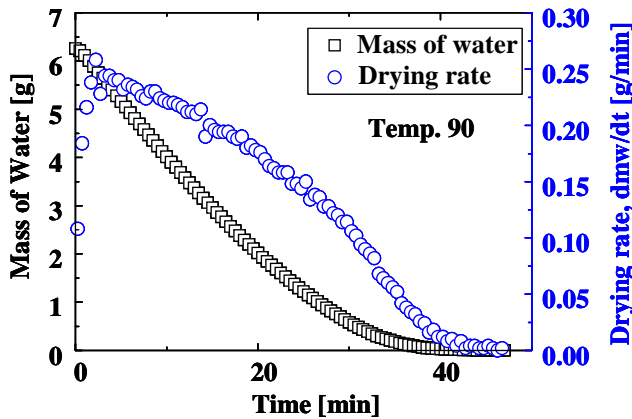


Expectation of Brown Coal Energy/Chemical Complex

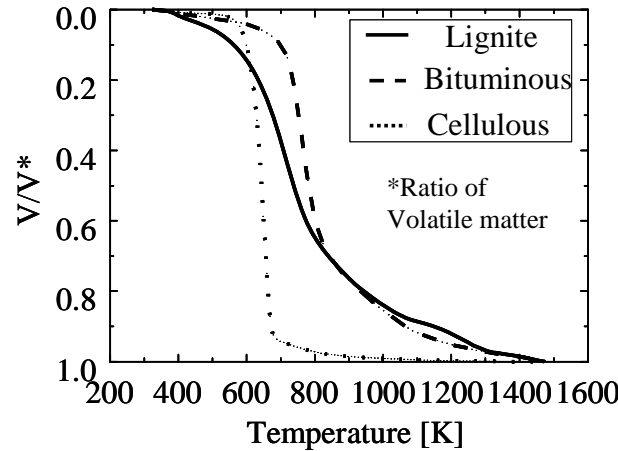


5-7 Fundamental Research toward Victorian Brown Coal Advanced Utilization

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Pre-drying Characteristics



Pyrolysis Characteristics



Photo. Halogen Moisture Analyzer

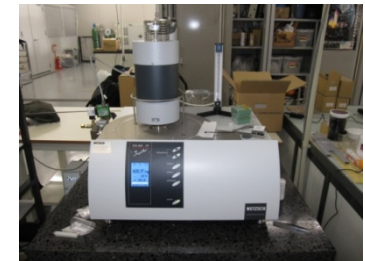
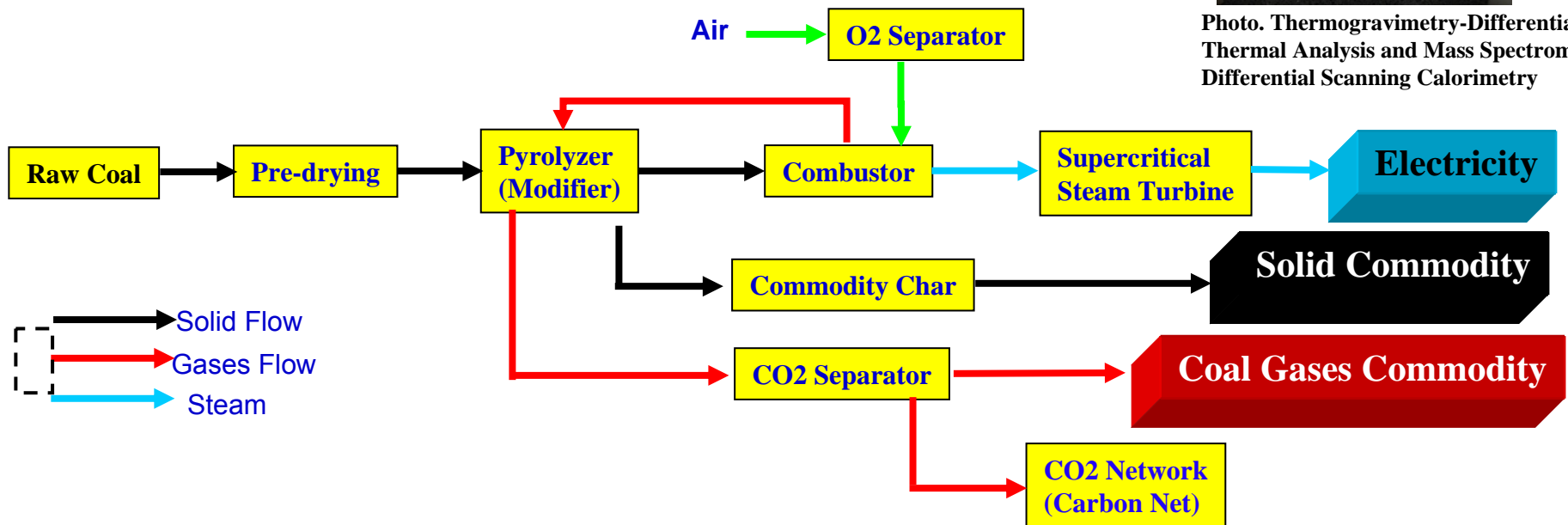


Photo. Thermogravimetry-Differential Thermal Analysis and Mass Spectrometry Differential Scanning Calorimetry



Flow Diagram of the CCS - ready Victorian brown coal-derived energy and chemical complex

5 8 New Upstream Collaboration with Australia



Study of mine methane extraction & utilization

1. Objective

In order to reduce GHG emissions and improve mine safety and productivity in underground coal mines, a survey is conducted to study the potential for introducing extraction and utilization technology for mine methane (CMM/VAM).

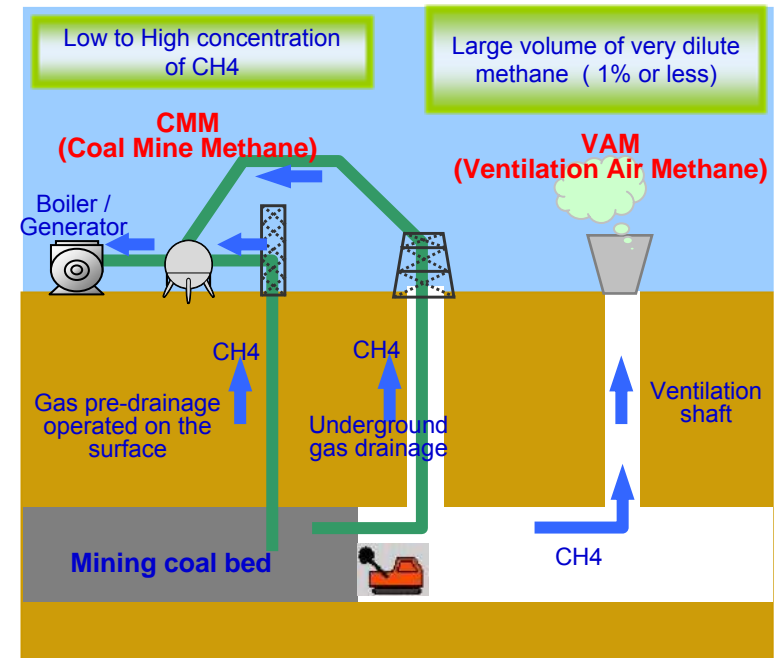
2. Project outline

- (1) Joint study proposed between NEDO and CSIRO
- (2) Survey method details will be determined based on the results of a feasibility study (F/S)

- ▣ To evaluate a suitable method for enhanced pre-drainage, post-drainage, utilization and mitigation of drained methane and ventilation air methane.
- ▣ To assess mine geological conditions and gas reservoir characteristics and to preliminarily estimate total mine methane emissions or production rates.
- ▣ To evaluate the potential for reducing mine methane as of GHG emissions, which has 21 times greenhouse effect than carbon dioxide.

3. Schedule

- JFY2010 F/S (preliminary survey) (by June,2011)
- JFY2011 - Mine site survey (about 2 years)



Thank you.