Overview of NEDO's High-efficiency Clean Coal Technology Development

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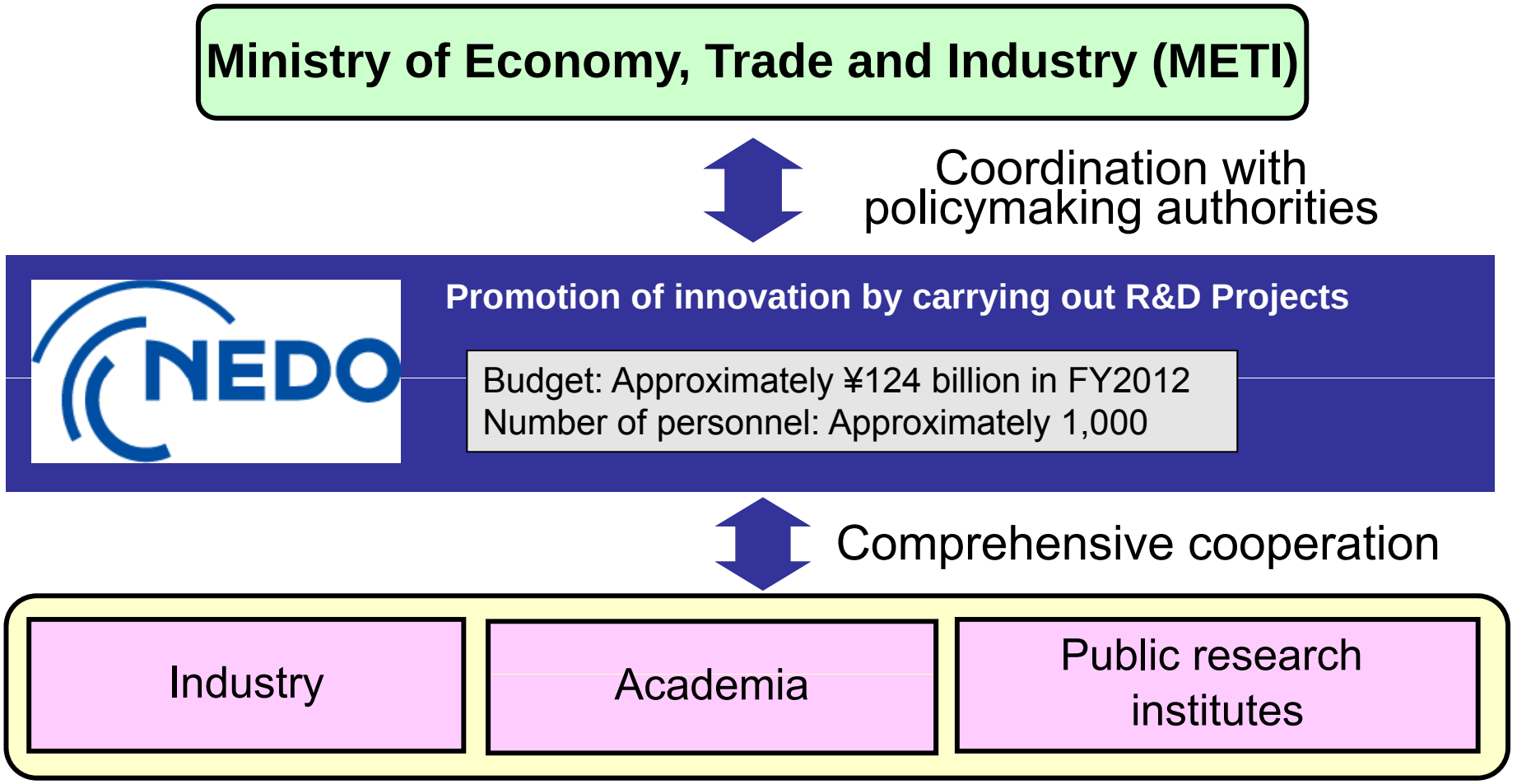
1. About NEDO

– ***NEDO, an independent administrative agency under METI, promotes R&D as well as the dissemination of industrial, energy and environmental technologies.***



2. NEDO Policy on CCT Development

Current situation:

・Coal accounts for one fourth of global primary energy consumption and its consumption is expected to increase.

・ As a result of continued R&D and effective O&M, Japan has achieved the highest efficiency levels of coal-fired thermal power generation efficiency in the world. However, there are many low-efficiency coal thermal power stations around the world.

・Based on a review of Japan's Basic Energy Plan in the wake of the Great East Japan Earthquake, coal-fired thermal power generation will likely be a primary power source in the future, as a result of reductions of the dependence on nuclear power and adjustments to supply and demand through the introduction of renewable energy sources.

Policy:

・NEDO promotes R&D on high-efficiency clean coal technology (CCT) that contribute to CO_2 emissions reductions and high-efficiency CO_2 capture technology as part of CCS.

・NEDO aims to utilize Japanese high-efficiency CCT to maintain Japan's industrial competitiveness as well as promote and disseminate CCT overseas, particularly in developing countries in Asia, in order to stabilize energy supply and demand and contribute to the establishment of a low-carbon society.

Priority activities:

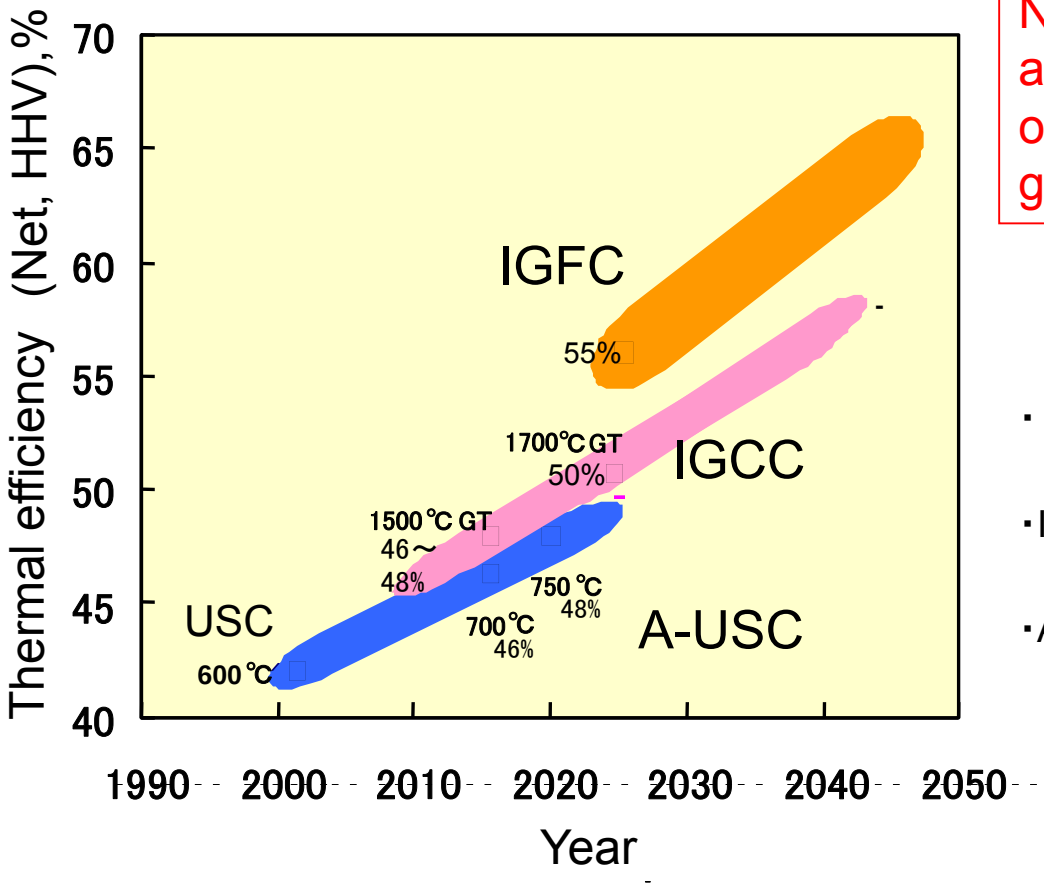
① Improvement of Coal-fired Power Generation Efficiency
② Feasibility Study on CCS in Japan
③ Dissemination of High-efficiency Clean Coal Technology

3. Improvement of Coal-fired Power Generation Efficiency

(1) Present status in Japan

Efficiency of USC power plant: approx. 41% (HHV, net)

(2) Power generation technology development roadmap



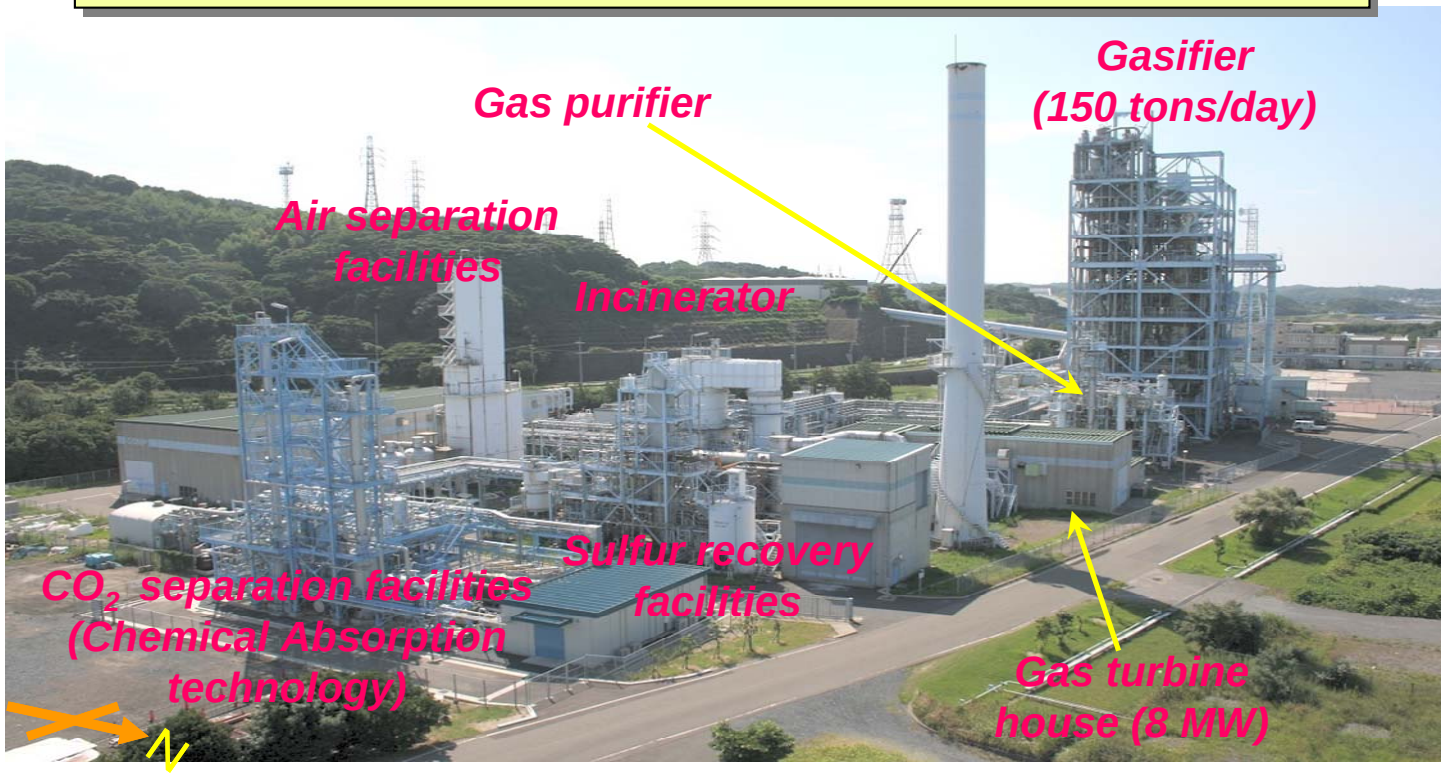
NEDO is promoting IGCC and IGFC development in order to improve power generation efficiency.

- Integrated Coal Gasification Combined Cycle (IGCC)
- Integrated Coal Gasification Fuel Cell Combined Cycle (IGFC)
- Advanced Ultra Super Critical Steam Condition (A-USC)

Source: Cool Earth - Innovative Energy Technology Program

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

Photograph of EAGLE Pilot Plant (150 tons/day)



■Stage 1 (2002 - 2006) Oxygen-blown entrained-flow gasifier was developed.
Gas cleanup technology was established.

■Stage 2 (2007 - 2009) CO_2 capture technology (chemical absorption) was developed.
Coal type diversification (high ash fusion temperature coal) was carried out.
Trace elements behavior was investigated.

■Stage 3 (2010 - 2013) Development of CO_2 capture technology (physical absorption)
Survey of innovative CO_2 capture technology

EAGLE Stage 3: Survey of innovative CO_2 capture technology

- Development of CO_2 capture technology (physical absorption) -

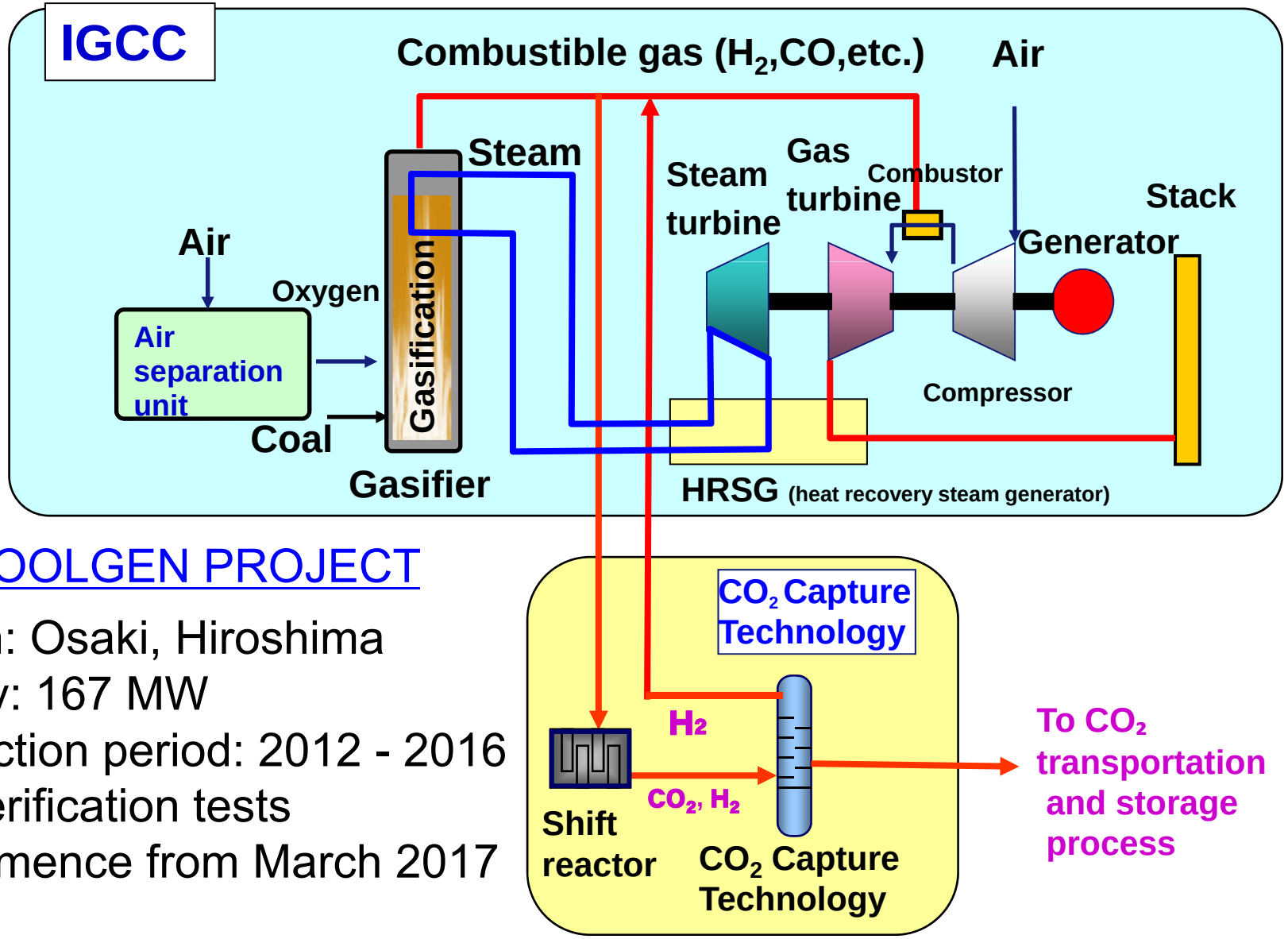
A survey on innovative CO_2 capture technology is being carried out in order to develop optimal CCS technology to be used in combination with higher pressure systems in next generation IGCC. The EAGLE pilot plant is being utilized to conduct an oxygen-blown entrained-flow gasifier, CCS test using mainly physical absorption technology.

Gasifier →①→ Shift Reactor →②→ CO_2 absorber →Gas turbine

(Desulfurizer) (Desulfurizer)

CO Shift Reactor	CO_2 Absorber	
Sour shift (location of Desulfurizer: ②)	Physical absorption	Stage 3 Currently testing
Sweet shift (location of Desulfurizer: ①)	Chemical absorption	Stage 2 Reference test

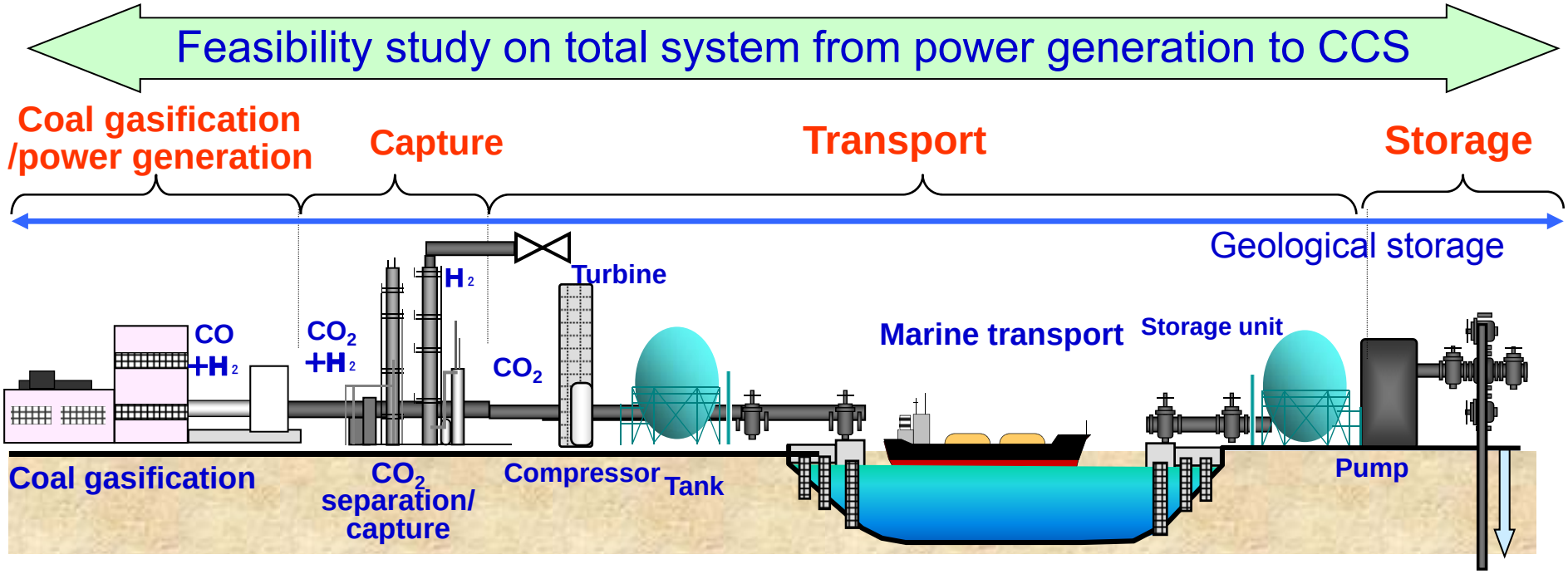
Feasibility Study on IGCC Technology Development (2010 – 2011)



OSAKI COOLGEN PROJECT

Location: Osaki, Hiroshima
Capacity: 167 MW
Construction period: 2012 - 2016
IGCC verification tests will commence from March 2017

4. Feasibility study on CCS in Japan



Feasibility study

(1) CO_2 separation and capture system
(2) CO_2 transport system
(3) CO_2 storage system and review of the potential of CO_2 storage

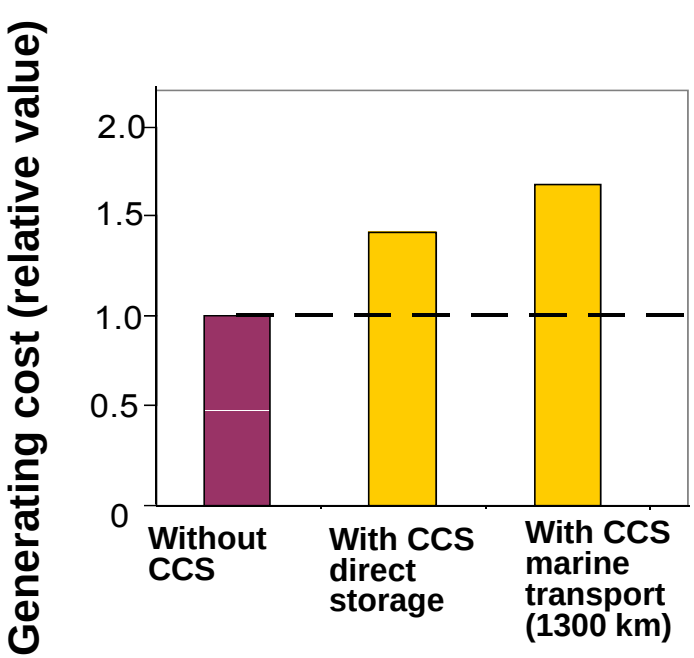
Conceptual design

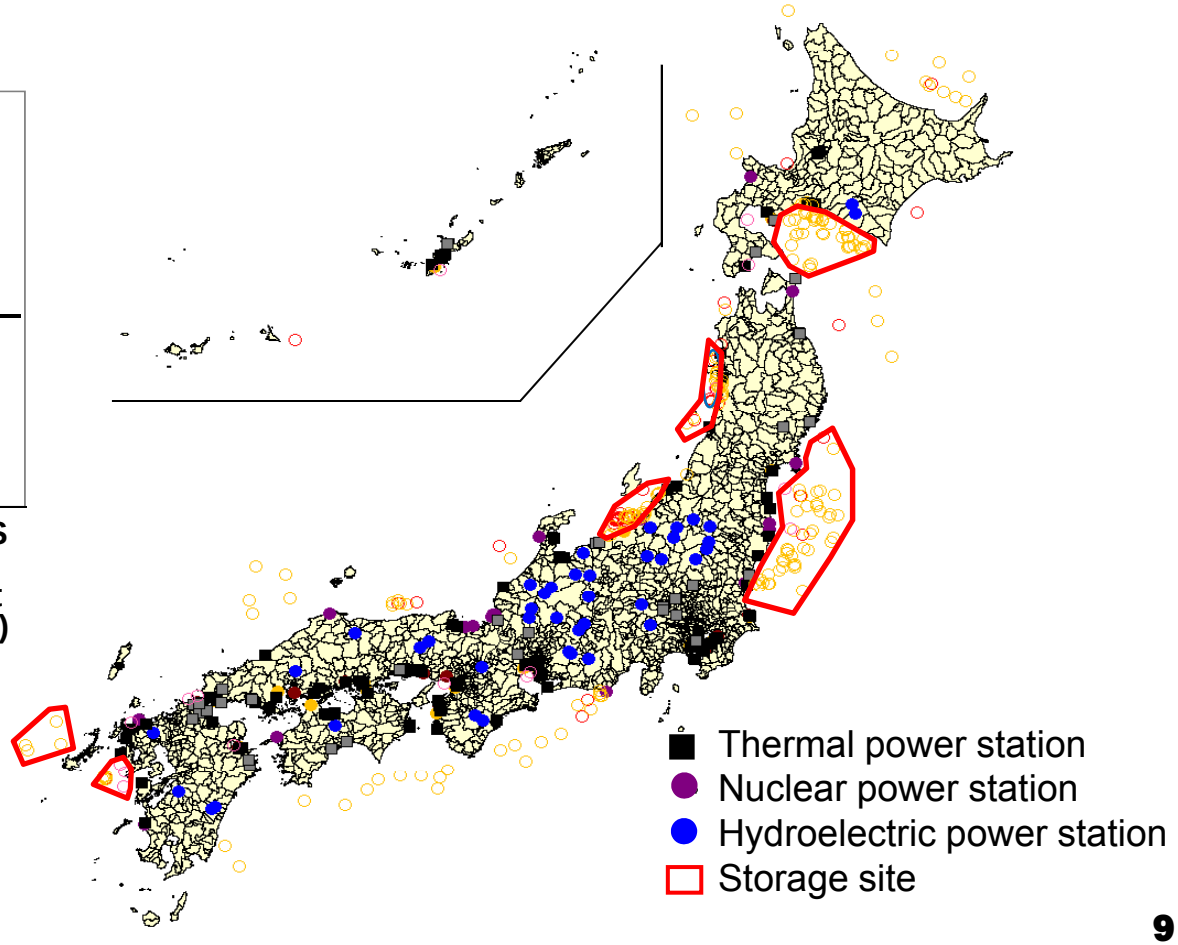
(4) Review on a total system from power generation to CO_2 storage
(5) Total system implemented at a specified site

Conceptual design

Feasibility study on CCS in Japan
FS Results (Interim)

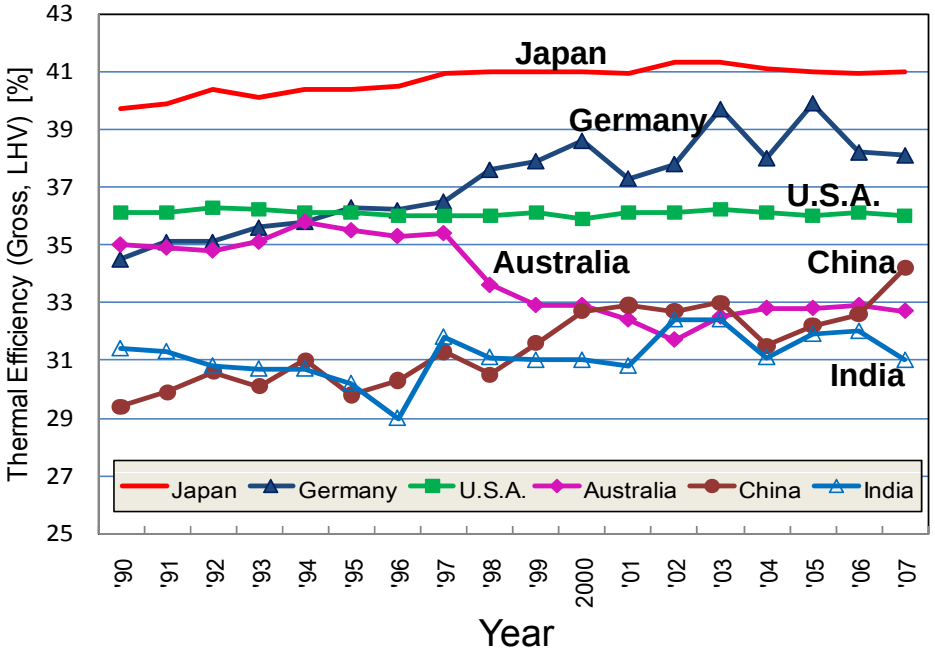
- CO_2 storage sites are located in coastal waters. CO_2 storage sites and large-scale CO_2 emission sites such as coal-fired power stations are shown below.
- Based on the interim FS results, generating costs would increase by 40% in the case of direct storage and by 70% in the case of marine transport.





5. Dissemination of High-efficiency Clean Coal Technology

As Japan has achieved the world's highest efficiency levels for coal-fired thermal power generation technology, project feasibility studies are currently being conducted on high-efficiency CCT, such as USC and IGCC in order to disseminate the technology worldwide and reduce global CO_2 emissions.



International comparison of fossil fuel power generation efficiency (ECOFYS) (2010)

Feasibility studies on the following projects:

- USC , USC + CCS
- IGCC , IGCC + CCS
- Coal gasification
  (SNG, H_2 , Clean synthetic fuel, etc.)
- Upgrading or drying of low rank coal
- Operation know-how
  (Combustion simulation, etc.)

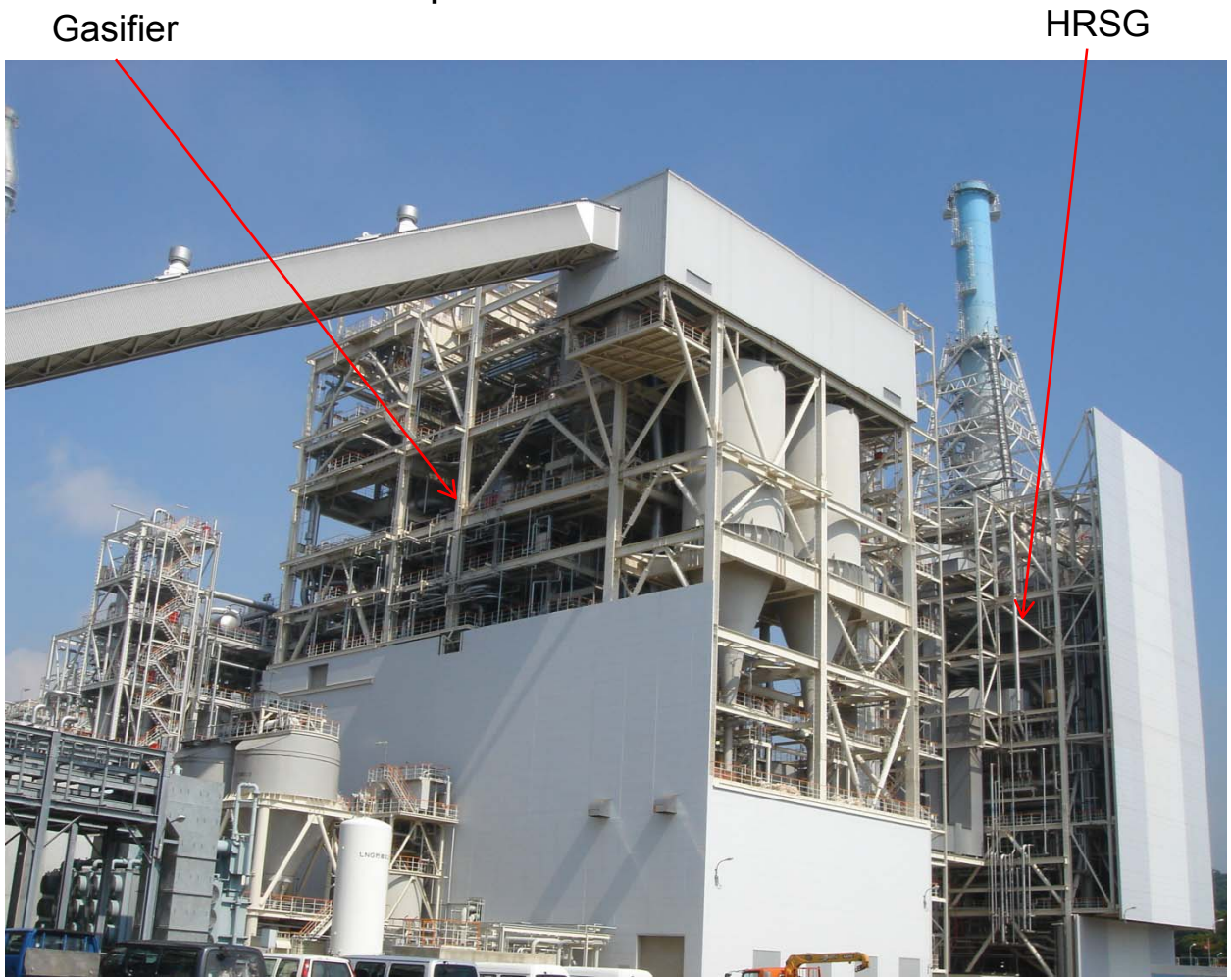
USC Power Plant

Isogo thermal power plant: maximum output - 600 MW x 2,

- New No. 1: 25 MPa x 600℃/610℃, operation started in 2002
- New No. 2: 25 MPa x 600℃/620℃, operation started in 2009

IGCC Plant

Nakoso IGCC demonstration plant
250 MW operation started in 2007



NEDO Project Formation Research on High-efficiency CCT in 2011 - 2012

★ 2011: Advanced operation know-how using coal-fired boiler simulation in China
★ 2011: IGCC project in Lang Fang, China
★ **2012: Advanced operation know-how using low rank coal-fired boiler simulation in China**

★ 2011: Clean synthetic fuel using coal project in Mongolia

★2011-**2012: High-efficiency coal power plant (USC) in Poland**

★ **2012: High-efficiency coal power plant (USC) in Bosnia and Herzegovina**

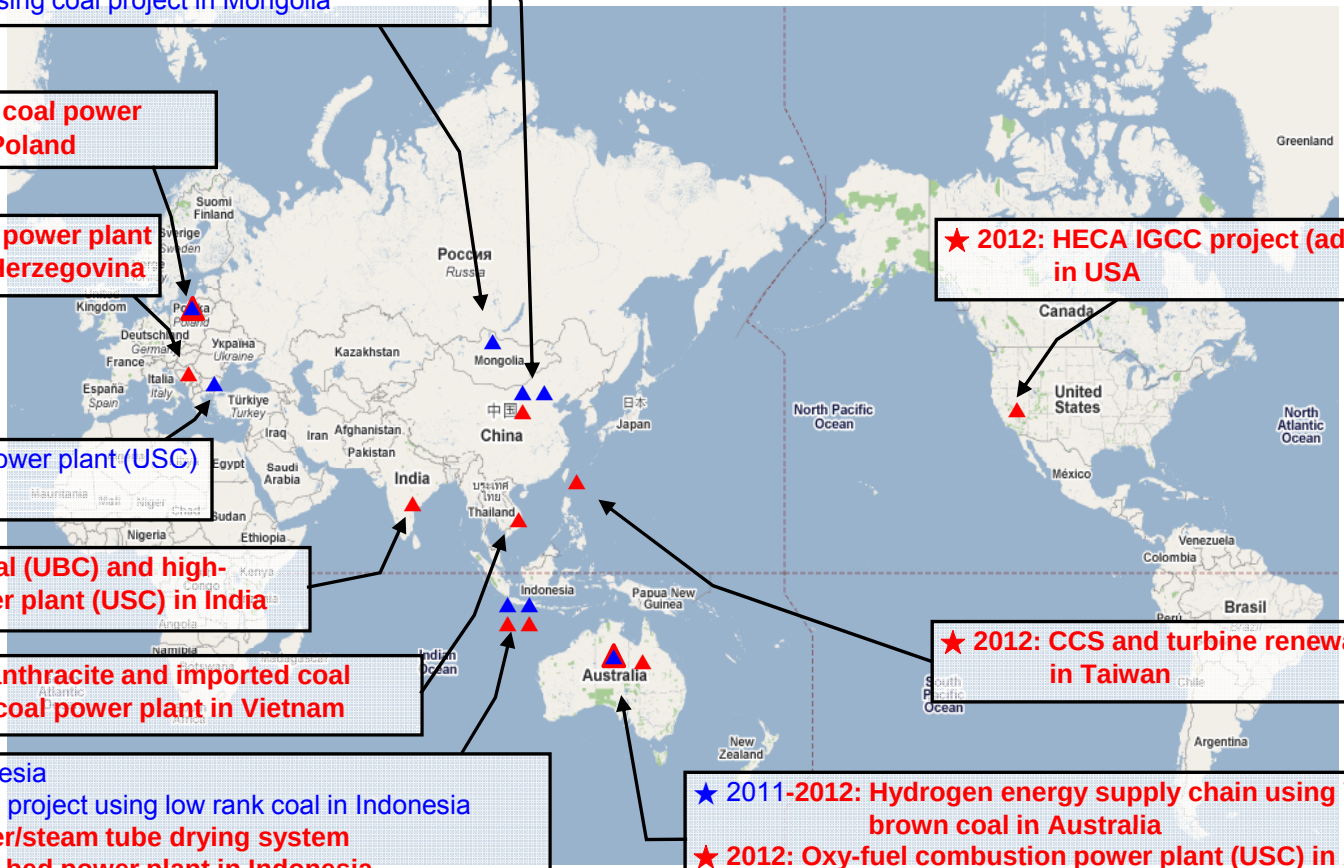
★ 2011: High efficiency coal power plant (USC) and CCS in Bulgaria

★ **2012: Upgraded brown coal (UBC) and high-efficiency coal power plant (USC) in India**

★ **2012: Co-firing domestic anthracite and imported coal at a high-efficiency coal power plant in Vietnam**

★ 2011: IGCC project in Indonesia
★ 2011: Substitute coking coal project using low rank coal in Indonesia
★ **2012: Low rank coal power/steam tube drying system**
★ **2012: Circulation fluidized bed power plant in Indonesia**

▲ 2011 project formation research
▲ 2012 project formation research



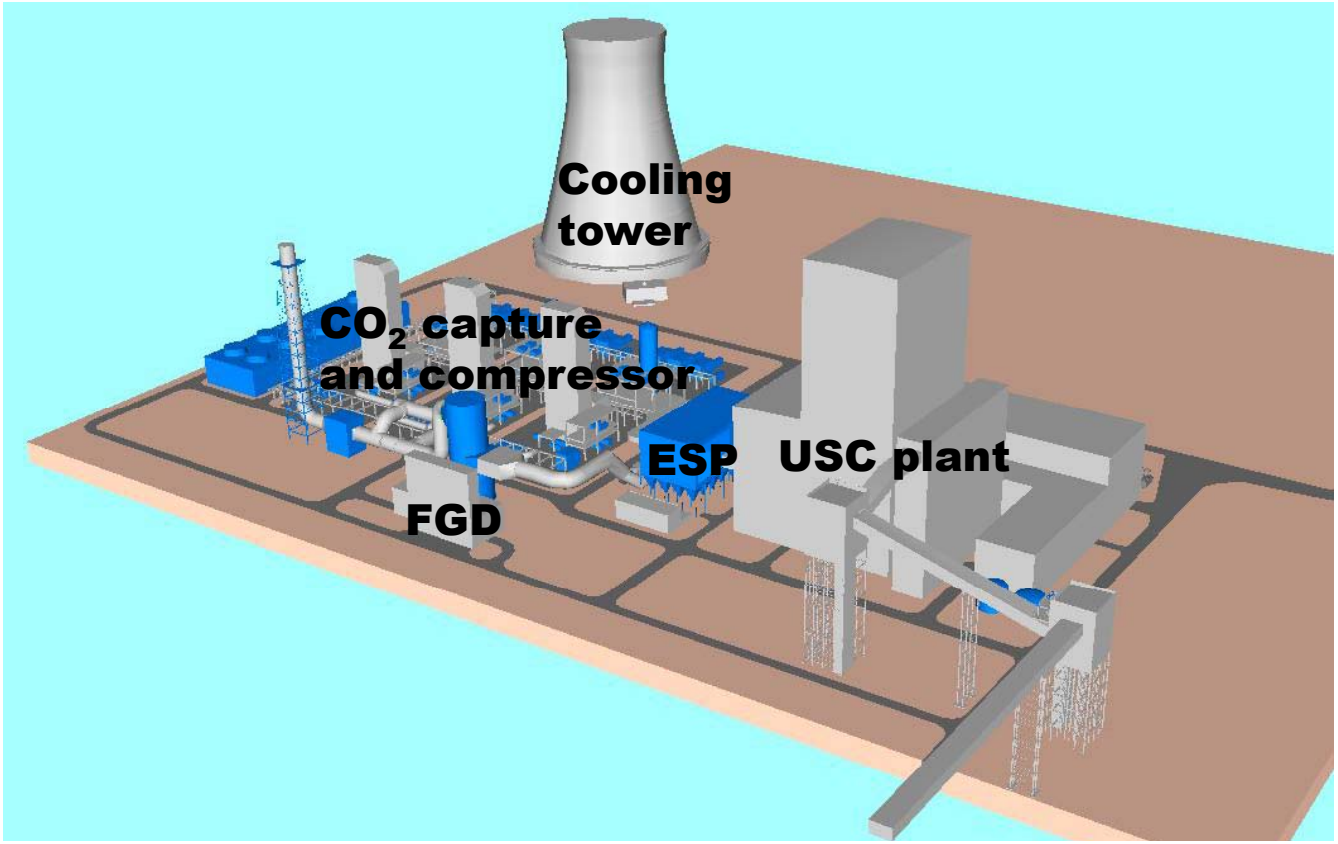
★ **2012: HECA IGCC project (additional FS) in USA**

★ **2012: CCS and turbine renewable project in Taiwan**

★ 2011-**2012: Hydrogen energy supply chain using Victorian brown coal in Australia**
★ **2012: Oxy-fuel combustion power plant (USC) in Australia**

USC + CCS plant

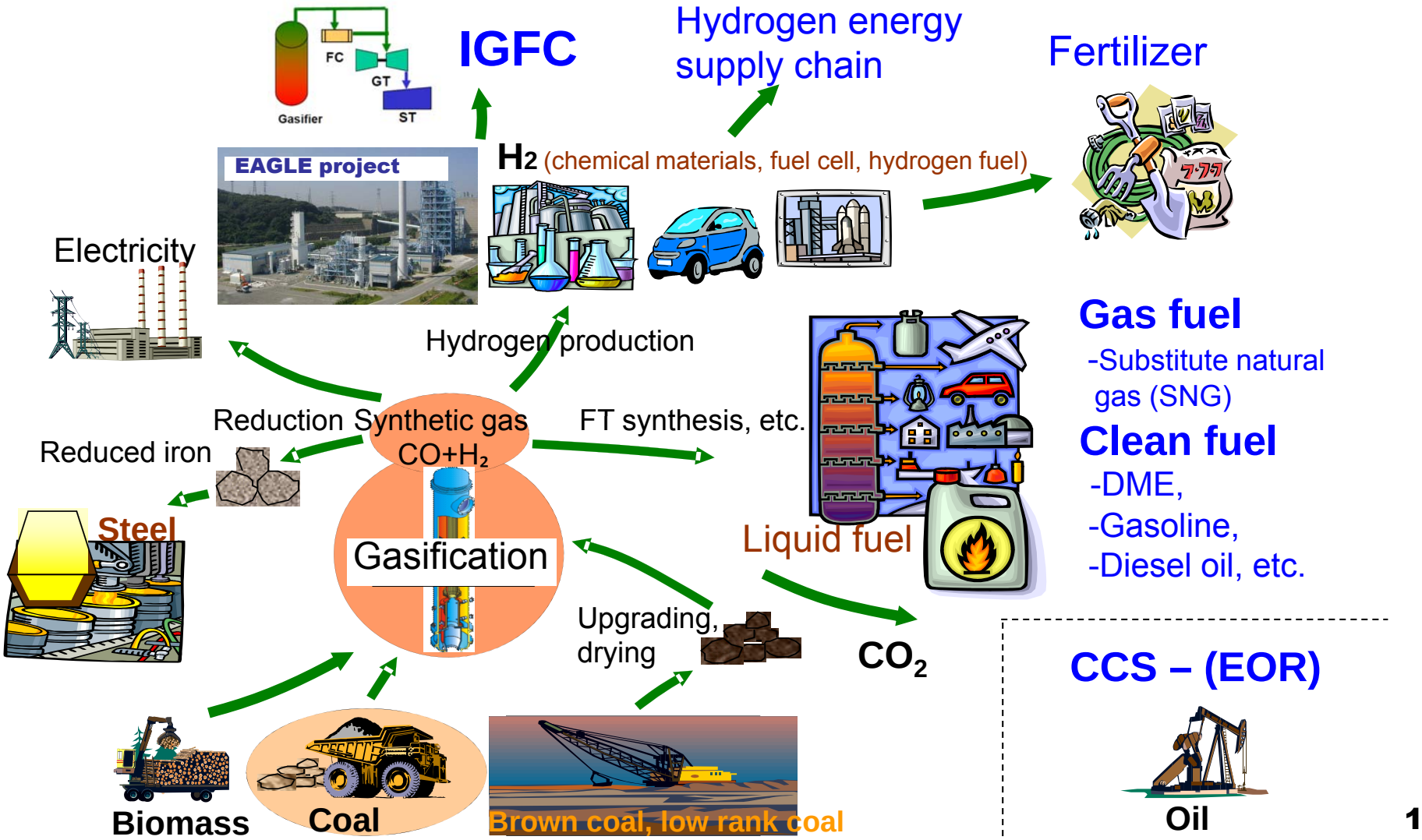
FS results on 500 MW class USC + CCS plant



The results of the FS show that one high-efficiency USC unit of 500 MW class would be much more suitable as efficiency would increase by 6% (32%→38%) and construction costs would be the same compared to construction plans for two subcritical 225 MW units.

Technology for Sustainable Use of Coal

State-of-the-art gasification technology accelerates the establishment of coal-based low carbon societies.



Thank you!