Commercialization of Mitsubishi IGCC/Gasification Technology

October 10, 2011

Photo :
250MW IGCC Demonstration Plant
@Nakoso, Japan

MITSUBISHI HEAVY INDUSTRIES, LTD.

MHI's Business Portfolio

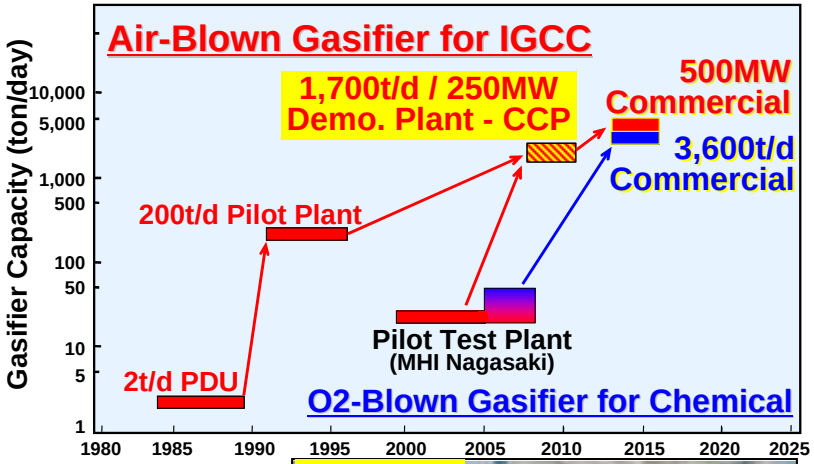
MITSUBISHI HEAVY INDUSTRIES, LTD.

Contribute to Both

the Power Generation and

the Chemical Industries through

Proven Gasification Technology



- **Air-Blown Gasifier with H-T GT for IGCC i.e. for Power :**

  World Highest Plant Efficiency and Economy

  ex. 250MW IGCC Demonstration Project

- **O2-Blown Gasifier for Chemical Products i.e. for SNG, CTL, NH_3, etc. :**

  High Efficiency and Minimum Utility Consumption including Aux. Power

MHI's Approach to the Market - Formation of Single Point Responsibility

MITSUBISHI HEAVY INDUSTRIES, LTD.

Gasifier

(Air-blown for Power / O2 Blown for Chemical)

- ✓ **The World Highest Plant Efficiency**
  - Minimum ASU
  - Dry Coal Feed System
- ✓ **Wide Variety Coal Applicability**
- ✓ **High Reliability Membrane Waterwall Structure (same as conventional boilers)**

Low Calorie Gas Firing Gas Turbine

- ✓ **Abundant Supply Record of BFG/COG Firing Gas Turbine**
- ✓ **Operation Flexibility for Calorific Change of Fuel Gas**

AGR

- ✓ **World-wide Abundant Experience of Chemical Plants**

GTCC Plant

- ✓ **World-wide Abundant Experience of EPC Contracts**

OEM／R&D Capability
＋
System Integration Capability

Realizing High Efficiency – High Reliability
IGCC / Gasification Plant

MHI's Typical Business Scheme for Commercial Projects

MITSUBISHI HEAVY INDUSTRIES, LTD.

MHI executes projects step by step in order to make commercial plants come true reliably and economically.

Evaluation of Coal by MHI 24T/D Pilot Plant

Owner's Request

Scoping Study
Guesstimate Plant Cost & Performance

Primary Evaluation of Candidate Coal Properties
FEED Proposal
Emission Data
FS
Plant Layout
Project Schedule
Estimate Plant Cost & Performance

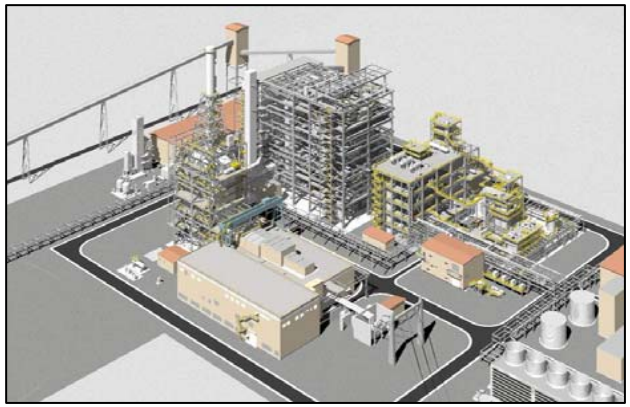
FEED or EPC (LNTP)
Basic Engineering as Real Projects

EPC
Engineering (Detail)
Procurement
Construction

C.O.D

Commissioning
Support by Supervisors or Technical Advisors

L.T.S.A
Long Term Maintenance Support



IGCC Commercial Plant

MHI Air-Blown IGCC System

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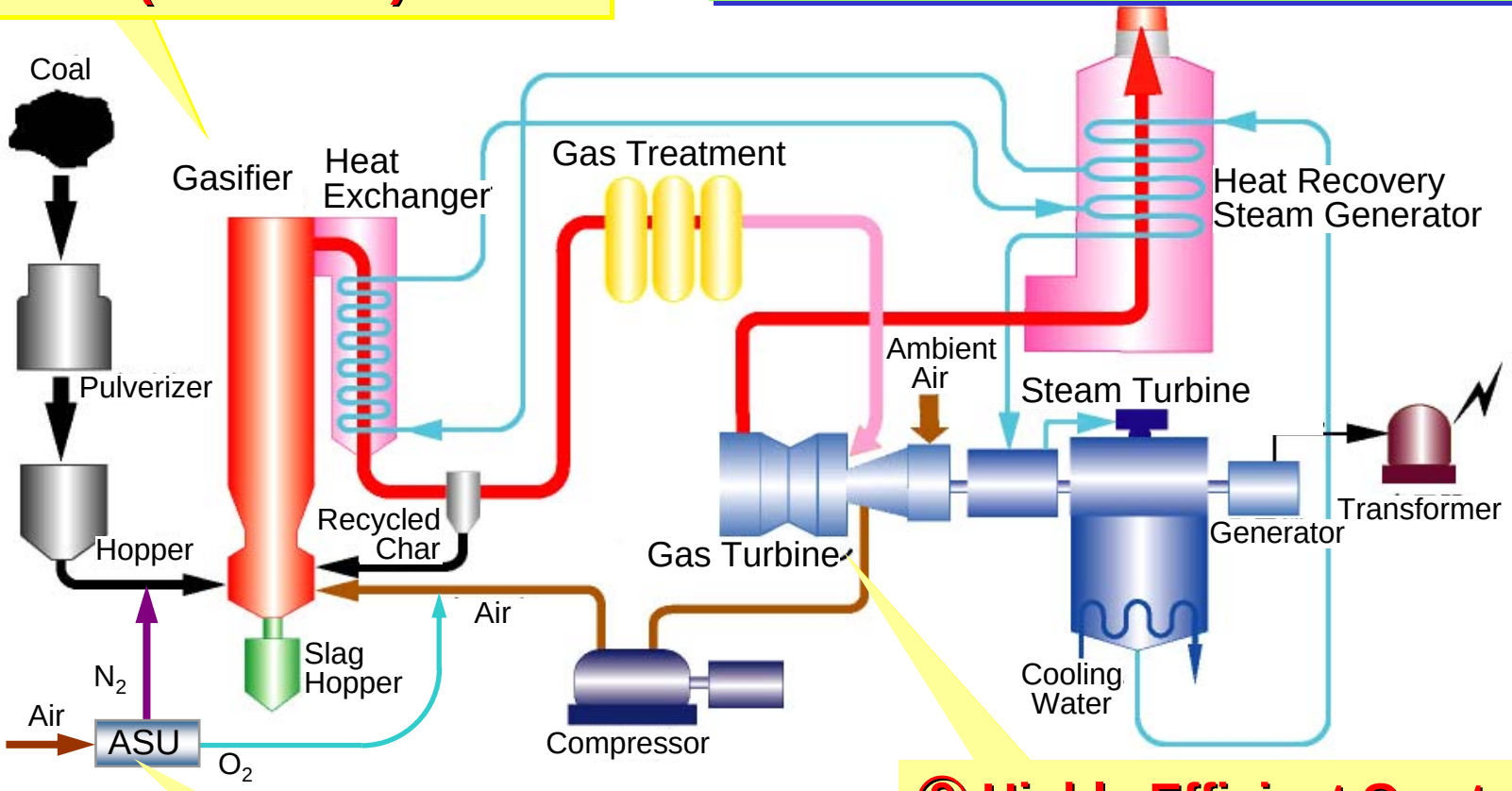
① Highly Efficient Gasifier (Air-Blown)

④ System Integration capability is MHI's key factor of strength.



② Highly Efficient Gas turbine (High Temperature)

③ Small ASU for N2 Production (for Coal Transportation and Inerting)

Essentially different from the other Oxygen-blown technologies.

Why IGCC ?

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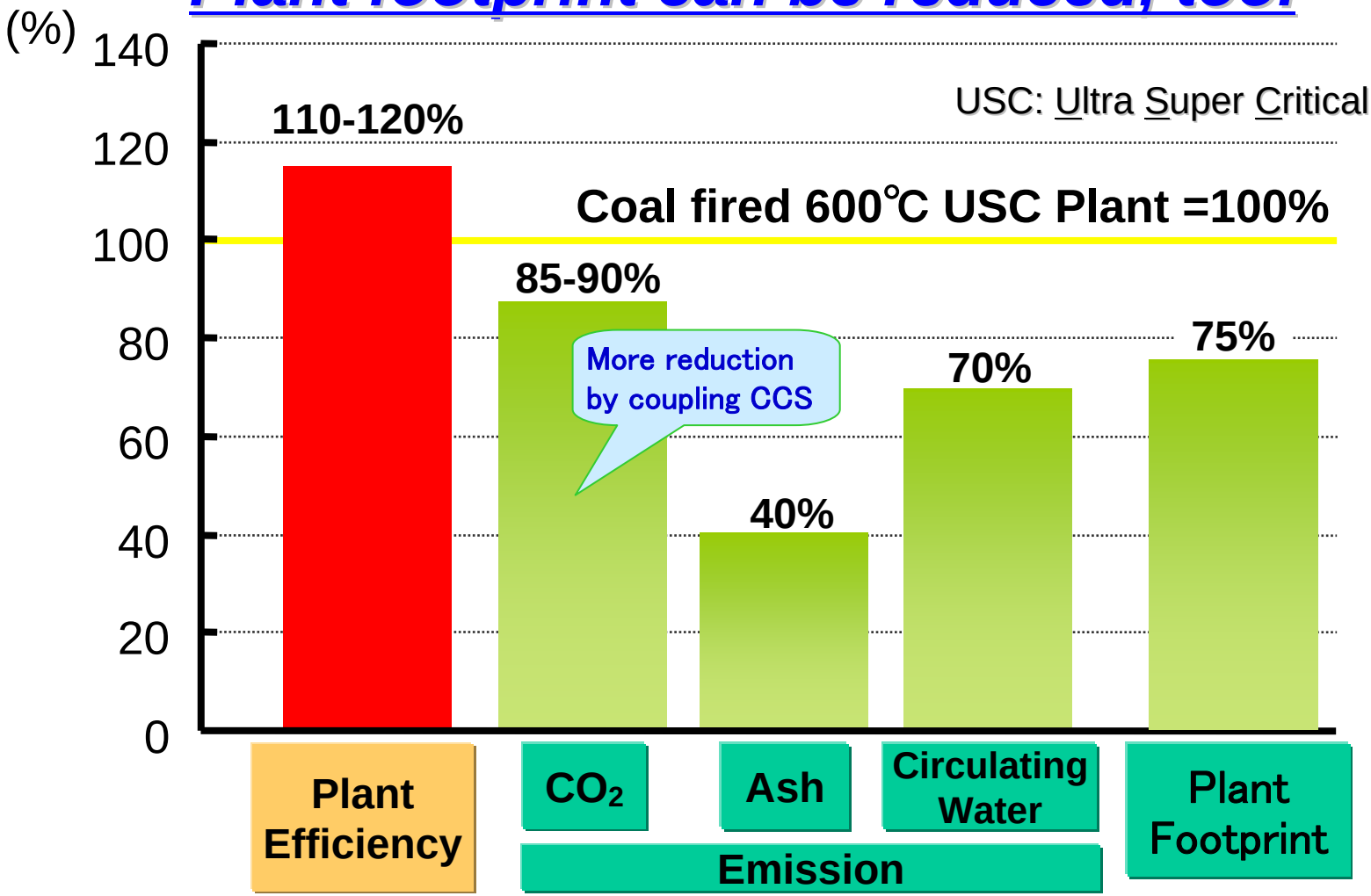
The World Highest Efficiency and Lowest Emission
Plant footprint can be reduced, too.



Features of MHI Air-Blown IGCC

MITSUBISHI HEAVY INDUSTRIES, LTD.

Realize the Lowest Cost with Various Advantages

- **Highest Plant Efficiency Because of Air-Blown Gasifier for IGCC**
- **Flexibility for Variety of Coal Including Brown Coal Because of 2-Staged Dry Coal Feed and "Fine" Coal Pulverizing System**
- **Higher Reliability & Easier Maintainability with Membrane Waterwall Configuration**
- **Effective Utilization of By-Product like Discharged Molten Slag, Recovered Sulfur, etc.**
- **High Plant Efficiency by "F" or "G" Type High Temp. GT and High Reliability from Abundant "Low Calorie Gas Firing" GT**

Efficiency of MHI Air-Blown IGCC

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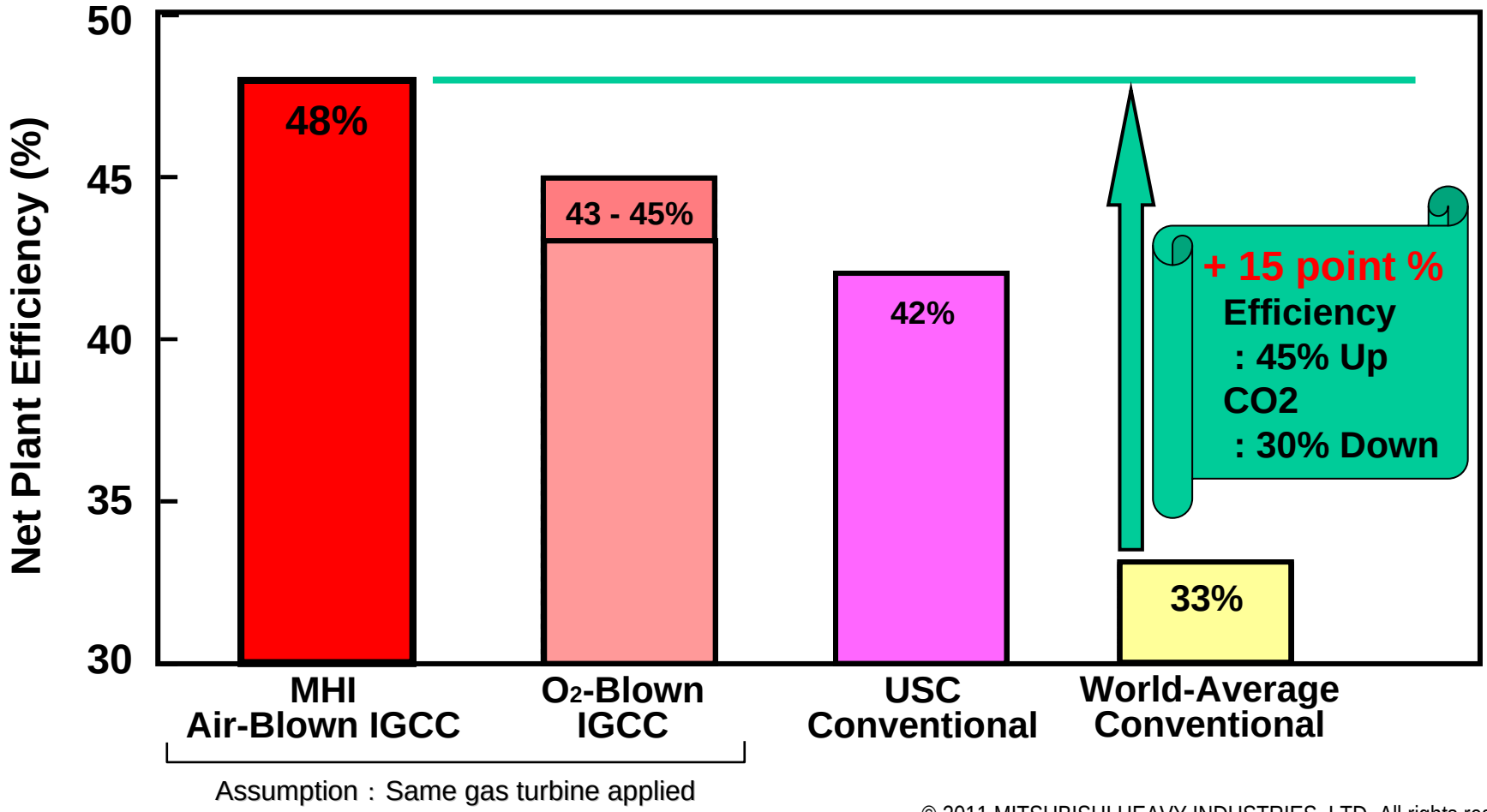
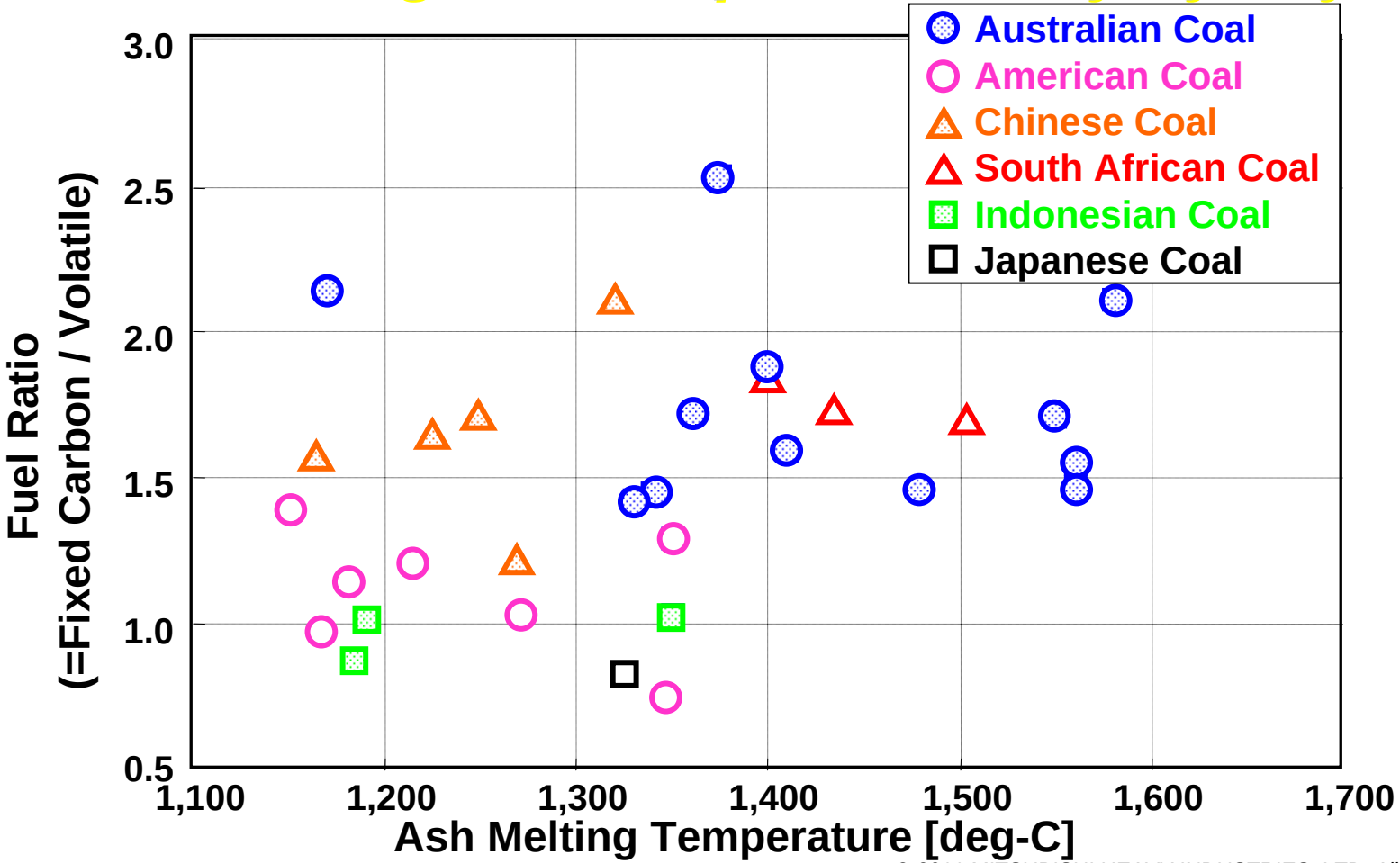
- The world highest efficiency is achieved by Air-Blown IGCC.
- The Air-Blown IGCC is MHI's original technology.



"Variety of Coal" Experience

MITSUBISHI HEAVY INDUSTRIES, LTD.

MHI Gasifier successfully gasified all coals including Lignite, accumulating more experience day by day !



Comparison in CAPEX w/ CO2 Capture

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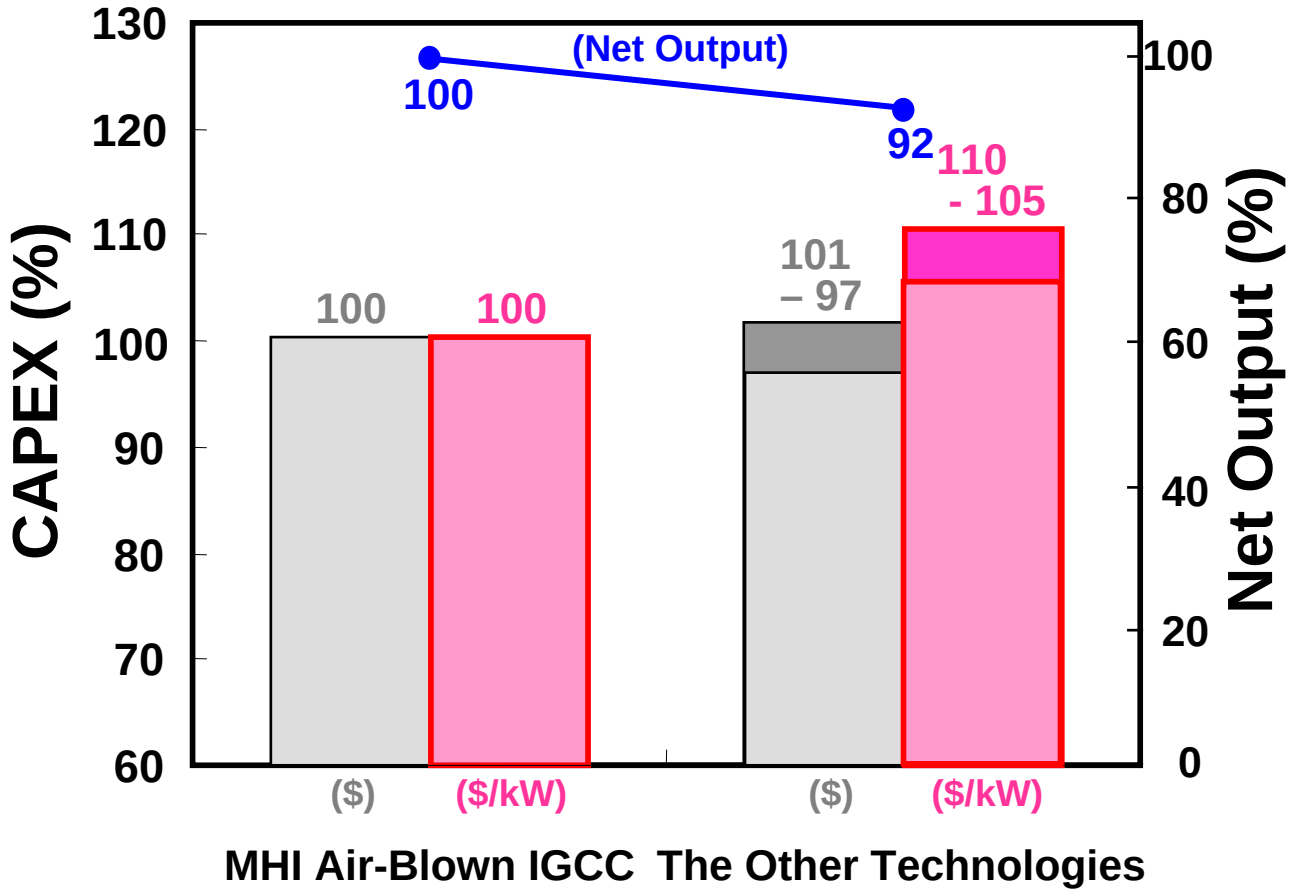
CAPEX of MHI Air-Blown IGCC with CO2 Capture is the lowest!!



Present Status of 250MW IGCC Demonstration Project (Nakoso)

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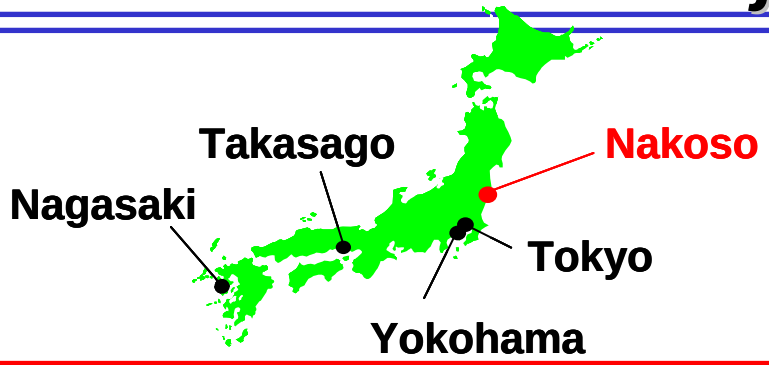

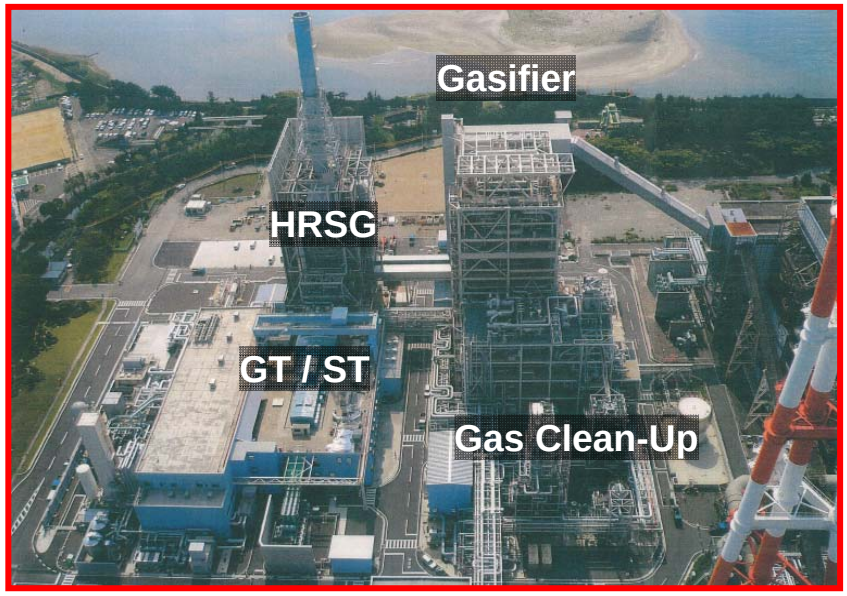

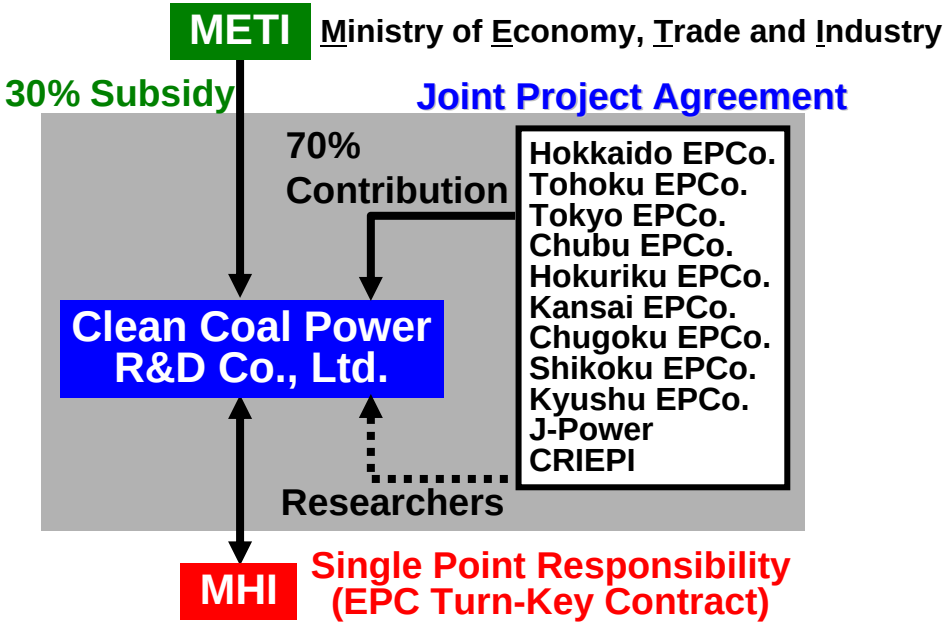

- Project is going on Schedule.
- Operation started Sep. 2007
  - 100% Load
  - 2,000hrs. Continuous Operation finished
  - Coal Change / Load Swing / Efficiency Improvement, etc.
  - 5,000hrs. Durability Test finished
    ⇒Subsidy from METI ended

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Engineering				Construction			Operation					

Present Status of 250MW IGCC Demonstration Project (Nakoso)

- The earthquake (@M9) and tsunami attacked the Demo. Plant on Mar. 11, 2011.
- All facilities flooded 2 m above the ground level and piping, etc. damaged, but the plant shut down quite in safe, with neither dangerous situation like syngas leakage nor explosion.
- No fatal damage due to the earthquake-resistant design of main equipments.
- After 4.5 months restoration, the plant came back on July 28, continuously operating at full load for 1,500 hrs..

Tsunami Flooding

IGCC

Demo. Plant in Operation after Restoration (September)

250MW IGCC Demonstration Project (Nakoso)

- Targets & Accomplishments -

MITSUBISHI HEAVY INDUSTRIES, LTD.

		Targets	Achievements	Note
Performance	Output	250MW	250MW	
	Efficiency (Net, LHV)	> 42.0%	42.9%	
	Carbon Conversion	> 99.9%	> 99.9%	
Emission	SOx NOx Dust	< 8 ppm < 5 ppm < 4 mg/m^{3}N	1.0 ppm 3.4 ppm < 0.1 mg/m^{3}N	
Operational Flexibility	Coal Kinds	Bituminous Sub-bituminous	Chinese, PRB 2 Indonesian Subs Colombian	Continuously expanding
	Start-up Time	< 18 hr	15 hr	
	Minimum Load	50%	Less than 50% (36%)	
	Ramping Rate	3%/min	3%/min	
Reliability	Long-term Continuous Operation	2,000 hr	2,039 hr	
	Long-Term Reliability Run	5,000 hr	5,013 hr	

- All of the demonstration targets have been achieved.
- Future plan focuses on the further improvement of operational flexibility.

Contribution of Mitsubishi CCT for CO2 Reduction

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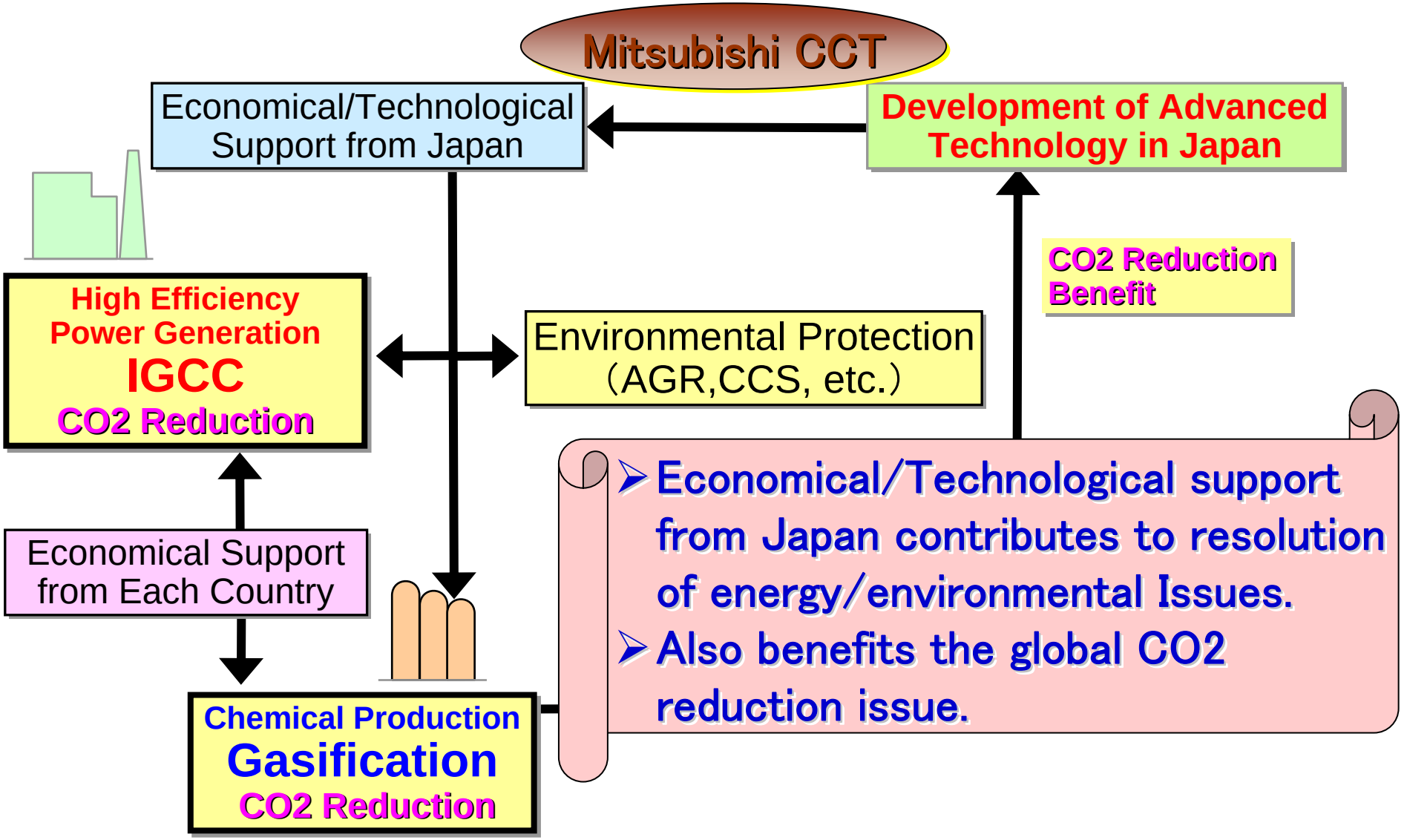


Contribution of Mitsubishi CCT for CO2 Reduction

MITSUBISHI HEAVY INDUSTRIES, LTD.

CCT Supporting and Nearby Coal Producing Countries

CCT Supporting Schemes

- Japan — System Infrastructure Export
  Bi-lateral CO2 Off-set
- Australia — Energy Transformed Flagship
- USA — DOE Loan Guarantee Program
- EU — NER (New Entrants' Reserve) 300

CCT Promoting Countries

- Australia
- USA
- EU
- China
- Indonesia
- India
- Asian Countries

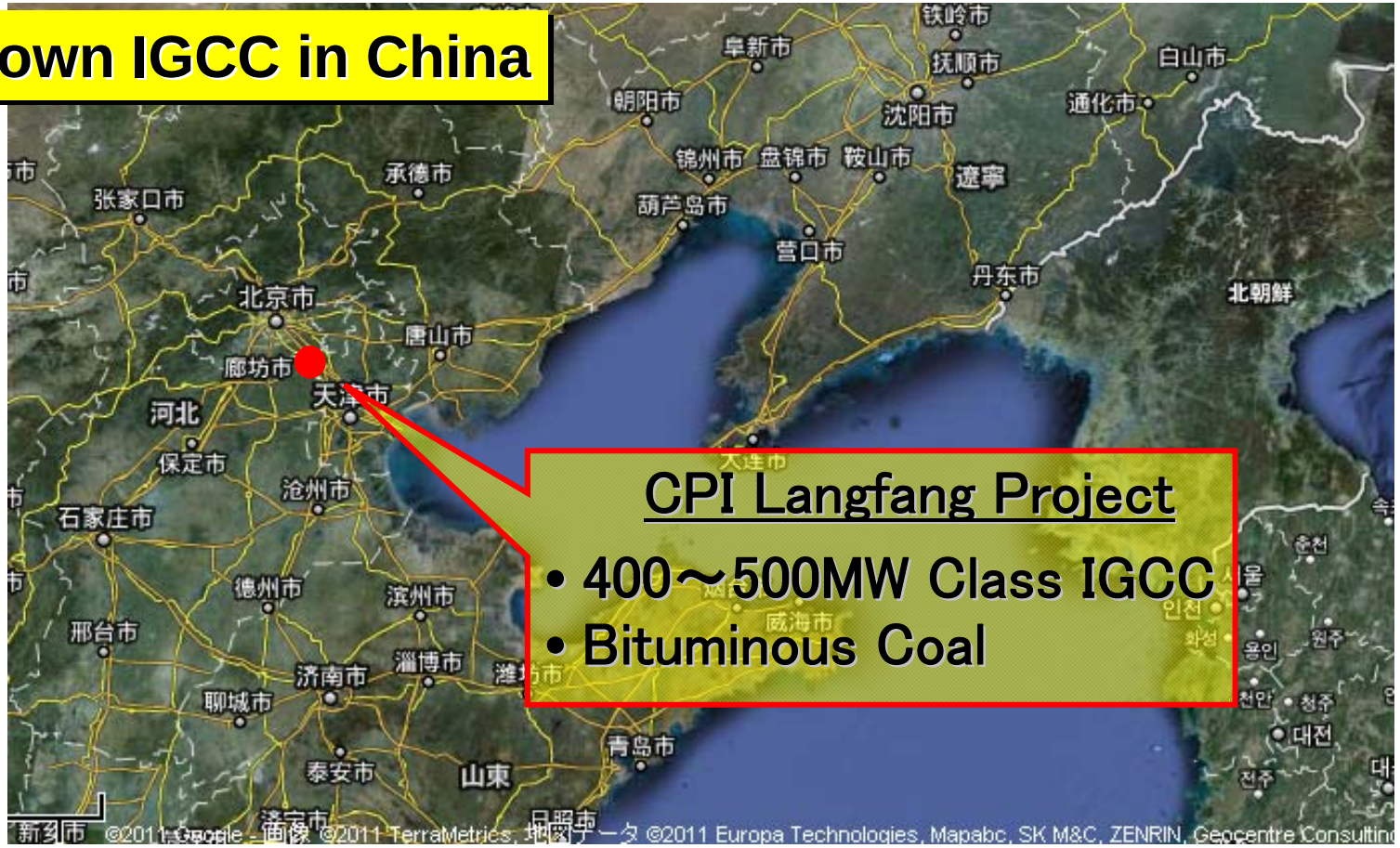
Milestone for Commercial Plant Projects Development by MHI

- Feasibility Study : 2011
- FEED* or EPC** Contract : 2012
  - * Front End Engineering & Design
  - ** Engineering, Procurement & Construction
- COD of Commercial Plants : 2016～17

Clean Coal Projects MHI is undertaking

MITSUBISHI HEAVY INDUSTRIES, LTD.

Air-blown IGCC in China



Project Development Schedule

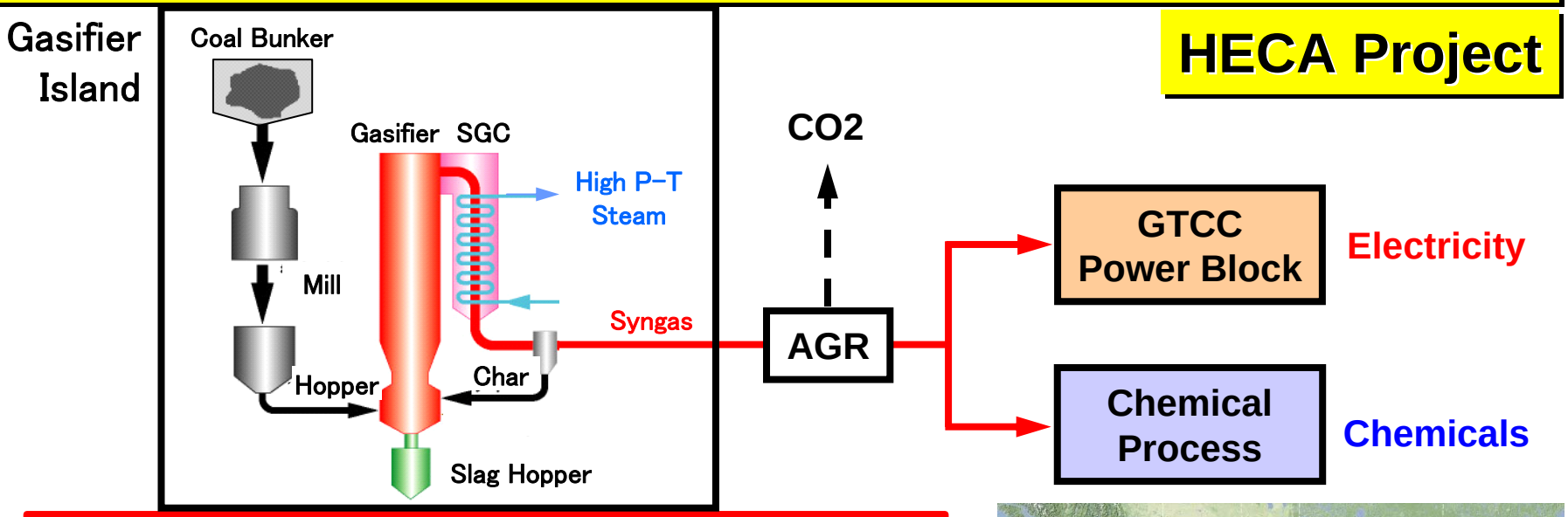
2010	MOU Agreed
2011	Feasibility Study
2012～	Commercialization

Clean Coal Projects MHI is undertaking

MITSUBISHI HEAVY INDUSTRIES, LTD.

Oxygen-blown IGCC and Gasification for Chemicals in USA

HECA Project



Such polygeneration provides the 400 MW Integrated Gasification Combined Cycle (IGCC) plant operational flexibility to better match market demand. For instance, the plant will produce more fertilizer in the evening when less electricity is needed, which optimizes the economic use of the facility.

The plant will capture 90% of the CO2 produced and transport it to an adjacent oil field, where it will be used for enhanced oil recovery and sequestered in deep, underground geological formations, furthering California's low carbon power policies, adding to domestic oil production, and replacing imported high-carbon fertilizer with domestic low-carbon fertilizer.

The project has selected Fluor as its Engineering, Procurement and Construction contractor and has also selected the Oxygen-Blown Gasification technology of Mitsubishi Heavy Industries, Ltd.

Extraction from "marketwatch.com"

Clean Coal Projects MHI is undertaking

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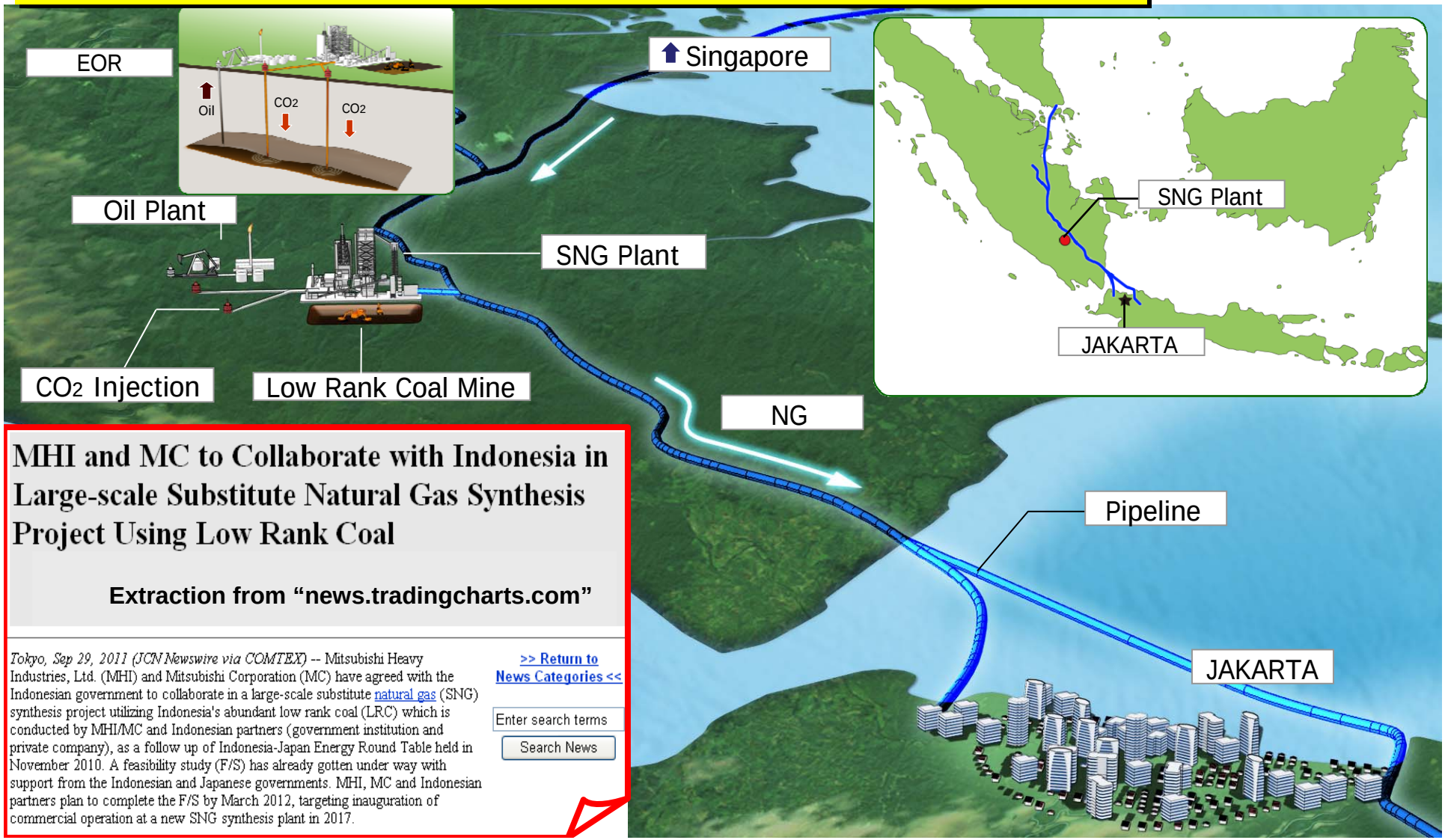
Oxygen-blown Gasification for SNG in Indonesia



MHI and MC to Collaborate with Indonesia in Large-scale Substitute Natural Gas Synthesis Project Using Low Rank Coal

Extraction from "news.tradingcharts.com"

Tokyo, Sep 29, 2011 (JCN Newswire via COMTEX) -- Mitsubishi Heavy Industries, Ltd. (MHI) and Mitsubishi Corporation (MC) have agreed with the Indonesian government to collaborate in a large-scale substitute natural gas (SNG) synthesis project utilizing Indonesia's abundant low rank coal (LRC) which is conducted by MHI/MC and Indonesian partners (government institution and private company), as a follow up of Indonesia-Japan Energy Round Table held in November 2010. A feasibility study (F/S) has already gotten under way with support from the Indonesian and Japanese governments. MHI, MC and Indonesian partners plan to complete the F/S by March 2012, targeting inauguration of commercial operation at a new SNG synthesis plant in 2017.

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Enter search terms

Search News

Technological Innovation Coming Very Soon

MITSUBISHI HEAVY INDUSTRIES, LTD.

- **Further Efficiency Improvement**
  - Adopting Higher Temperature Innovative Gas Turbine, **J-Class and more**
  - Applying Newly Developed **Energy Conservation System**
- **Utilization of Lower Grade – Higher Moisture – Coal**
  - From Bituminous and Sub-bituminous to **Lignite and Brown Coal**

Scenario of Efficiency Improvement

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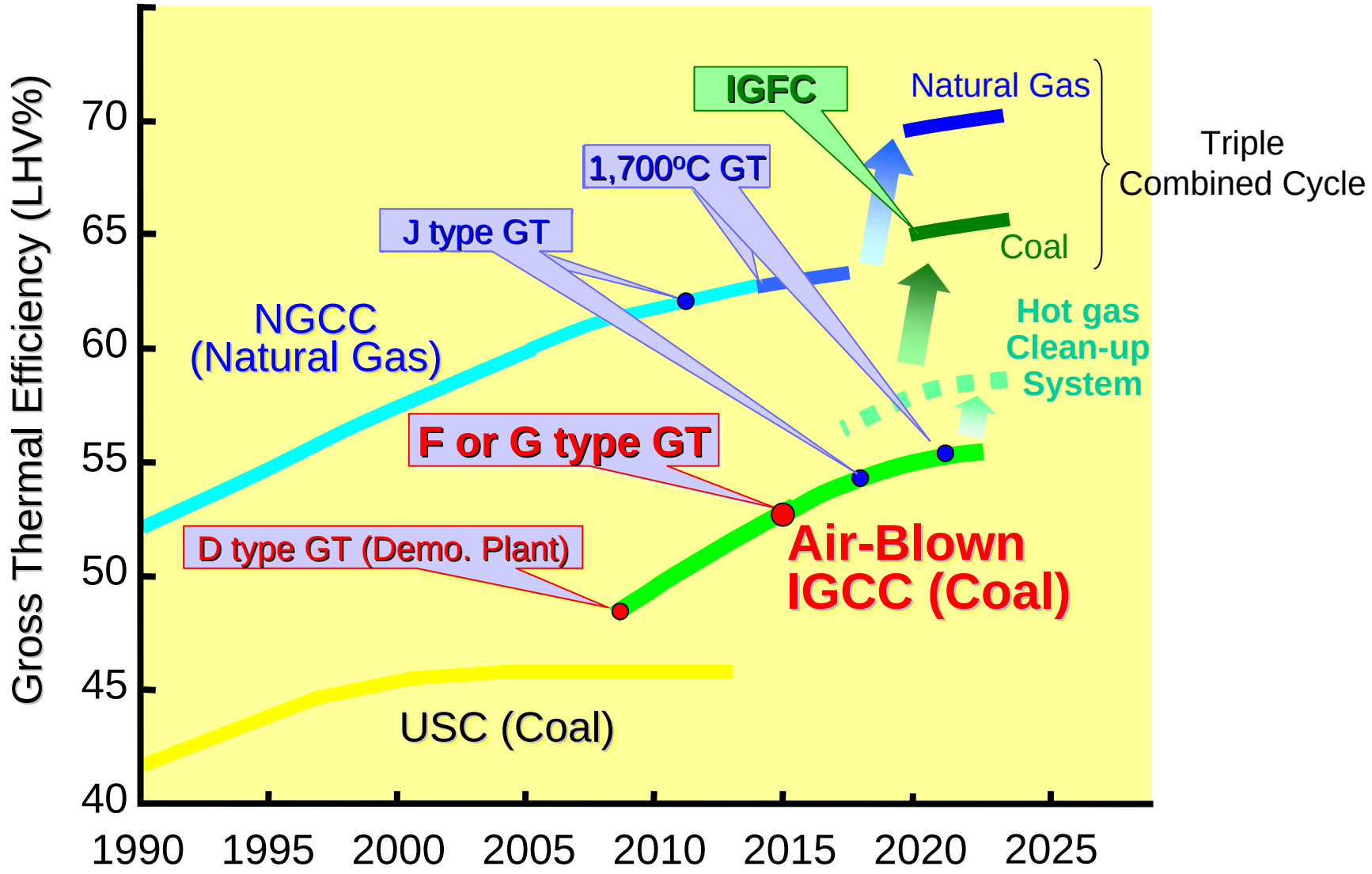


J Class Gas Turbine Market Introduction

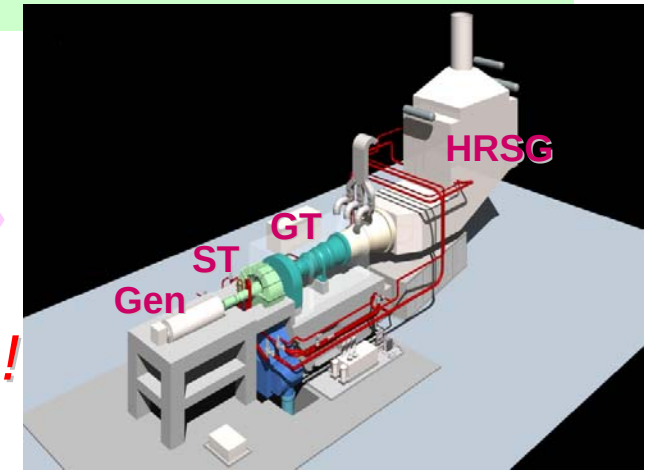
MITSUBISHI HEAVY INDUSTRIES, LTD.

Delivery of Commercial Units to Begin in 2011. (60Hz)
First Commercial operation Unit in 2013 for 2,900MW (M501J ×6)
Kansai Electric Power Company.

[T-Point Verification]

Strategic Planning → R&D / Design → Design Implementation → Verification Test

2011
Operation Started !



[60Hz] Commercial Plant

Strategic Planning → R&D / Design → Design Implementation → Ready for FOB → Commercial Operation

2009 2011 2013

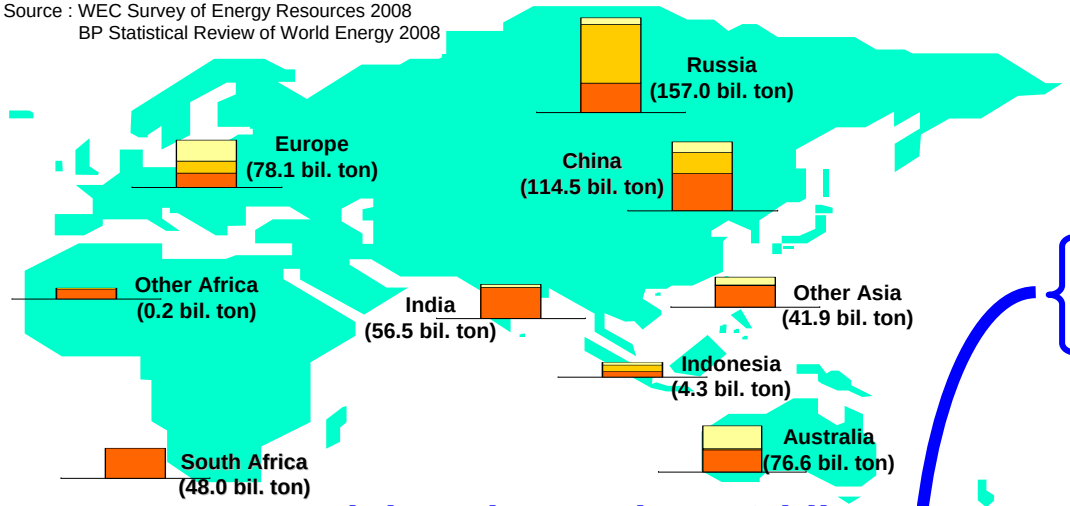
IGCC Application

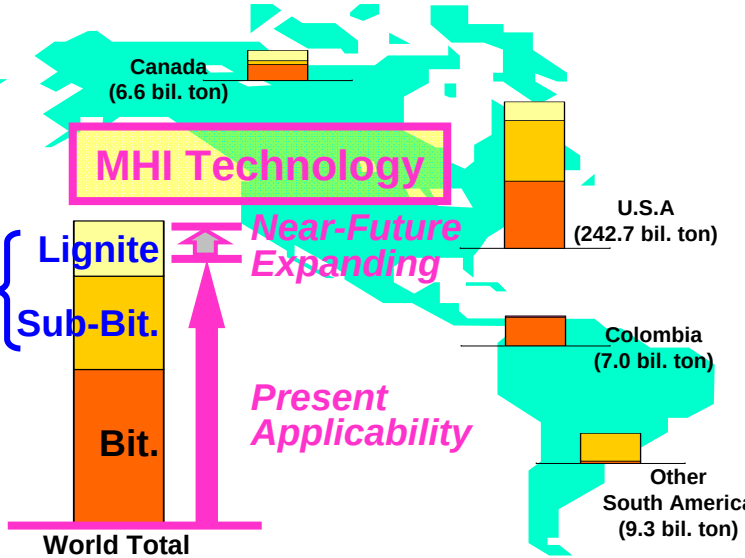
G type IGCC Commercialization → Development of J type IGCC

Scenario of High Moisture Coal Utilization

MITSUBISHI HEAVY INDUSTRIES, LTD.

Source : WEC Survey of Energy Resources 2008
BP Statistical Review of World Energy 2008





High moist. coal : 41.2 bil.ton
- Scenario of utilization -

Mine-mouth IGCC

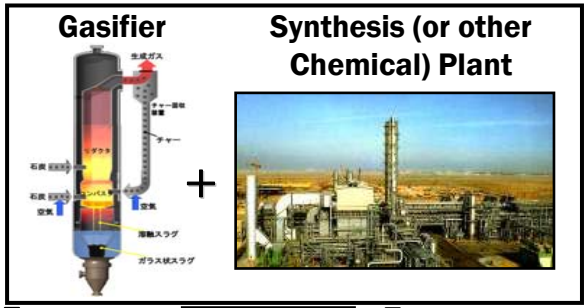
Pre-Drying*

+

Mine-mouth Synfuel/Chemical Production

Pre-Drying*

+



Synfuel

GTCC
Diesel Engine

NH3, etc.

*Pre-Drying may be applied to the future expanding part, to more moistened lignite.

Scenario of High Moisture Coal Utilization

MITSUBISHI HEAVY INDUSTRIES, LTD.

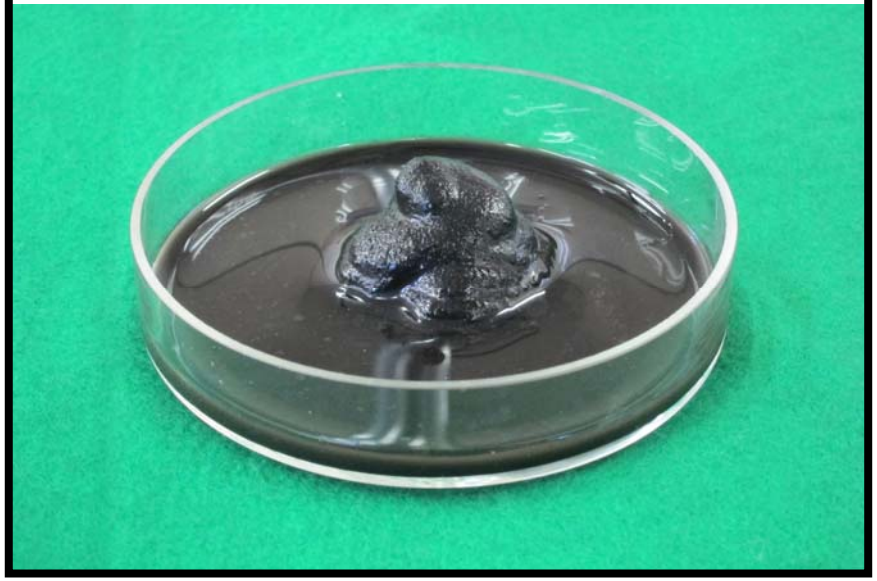
Managing moisture is the "Key."

Lignite

@60% Moisture Content

Bituminous Coal

@60% Moisture by Wetting



Pre-drying characteristics are different!

Summary

MITSUBISHI HEAVY INDUSTRIES, LTD.

- *Air-Blown 250 MW IGCC demonstration plant has successfully achieved targets and been proving commercial serviceability.*
- *Dry feed, 2 stage O_2-Blown Gasifier achieved minimizing oxygen and auxiliary power consumption.*
- *Based on the results, MHI has started undertaking commercial projects for the Air-Blown IGCC with F or G type Gas Turbine and O_2-Blown Gasifier.*
- *Further efficiency improvement is planned by applying innovative Gas Turbine (J type and 1700degC Class) and newly developed energy conservation systems.*
- *Lower grade, higher moisture coal comes to be effectively utilized very soon.*


“Mitsubishi’s Contribution for
Energy and Environment Solutions”