

MHPS IGCC Power Plant

IGCC: Integrated coal Gasification Combined Cycle

June 2, 2014



MITSUBISHI HITACHI POWER SYSTEMS, LTD.

Product of MHPS IGCC

IGCC Plants in Japan :

- 250MWe IGCC*¹ @Nakoso(TK) : Commercial Operation since June 30,2013 (Demo. started 2008)
- 166MWe IGCC*² @Osaki : Demonstration, Now under Construction (Demo. will start 2016)
- 540MWe x2 IGCC*¹@Fukushima(TK): Now under Project Development

*1: Air-blown ,*2: Oxygen-blown TK : Turn Key project



TEPCO develops 500MW class IGCC Plants in Japan

Tokyo Electric Power Company

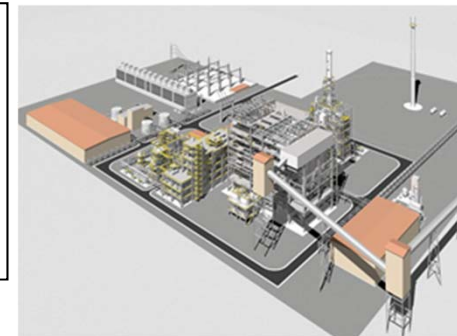
New Comprehensive Special Business Plan (extract)

- **Creating industry and employment through the construction of the world's most advanced high-efficiency coal-fired power plant**

In Fukushima, the large-scale IGCC* facility, employing Japanese clean coal technology, leads the world in proving the technology and attracts global acclaim as a source of clean coal technology and as a symbol of Fukushima's revitalization

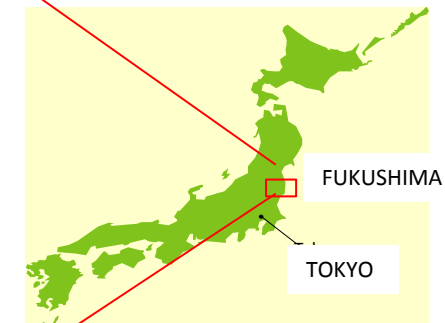
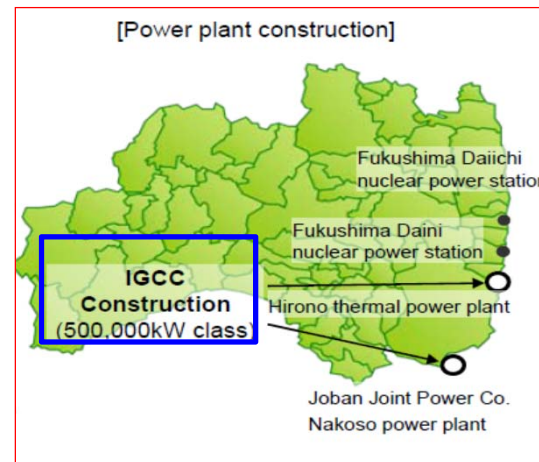
- On the premises of the Hirono thermal power plant (Futaba-gun) and the Nakoso power plant run by the Joban Joint Power Co.(Iwaki City) , a 500,000 kW-class trial project involving the construction and operation of a coal-fired thermal power plant using world-leading high-efficiency technology (IGCC)

Source: Tokyo Electric Power Company HP Press release on 15 Jan.2014
Detailed Report of the New Comprehensive Special Business Plan



Project Schedule Plan

- Environmental Impact Assessment 2014 (started)
- Start of Construction 2016
- Start of Operation Beginning of 2020s



Learned form Nakoso 250MW IGCC Plant



Nakoso 250MW Demonstration Project finished in end of March 2013 after achieving all the targets.

- Excellent Performance
(**Highest Efficiency**, Less Environmental impact)
- Higher Reliability
World record of continuous operation
- Fine Operability
- Fuel Flexibility (9kinds of coal used)
Bituminous coal(China, Indonesia, Colombia,Russia)
Sub-bituminous coal(USA, Indonesia)

⇒ **540MW Commercial Plants**
have become "Ready."

The plant was converted to the **First Commercial Plant** in Japan and restarted operation **from the summer of 2013**



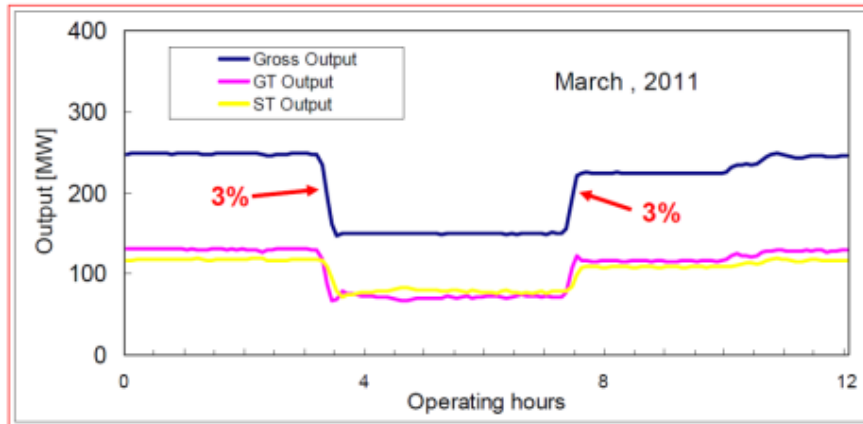
JSME Medal for Technology
Awarded
(JSME : Japan Society of Mechanical Engineering)

Achievements of Nakoso 250MW IGCC Plant



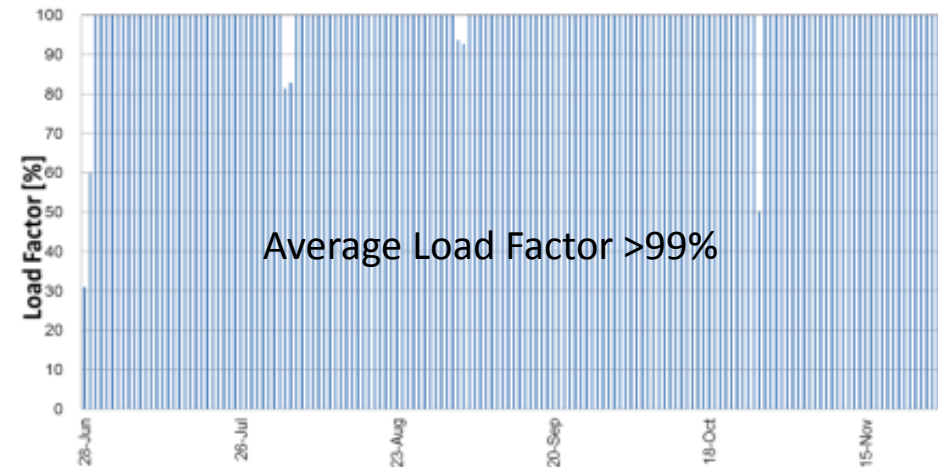
Operability (Load Change)

Verified at 3%/min load change operation which is required as middle range operation

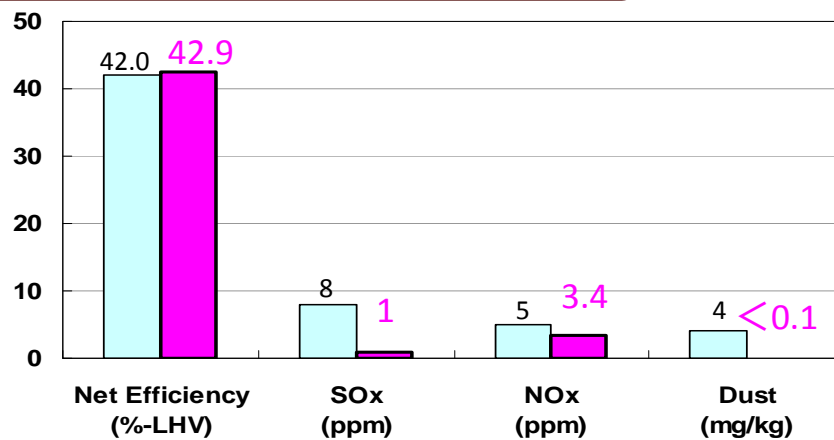


Reliability

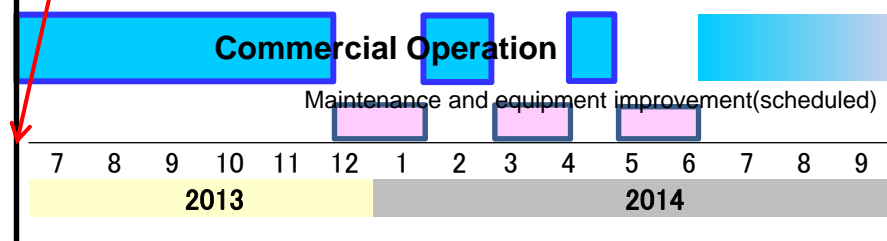
Continuous full load operation from July to December of 2013 without any forced outage



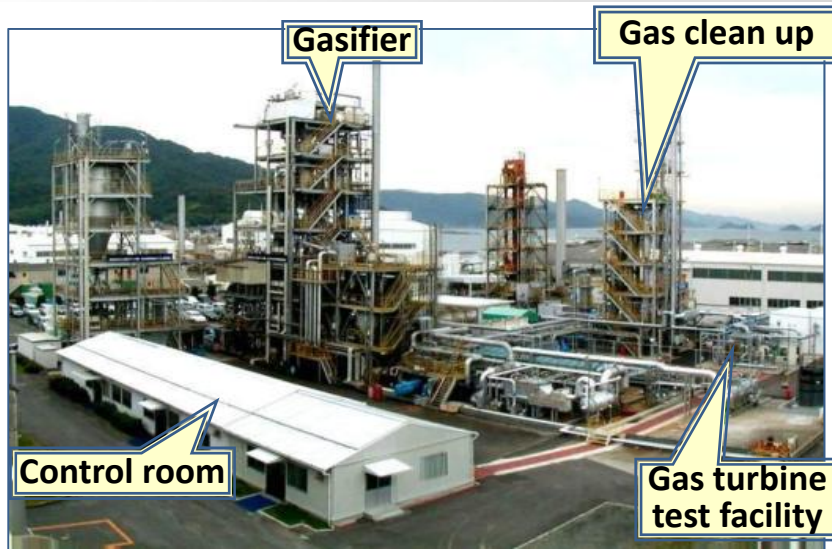
Environmental Performance



Operation history and schedule after the start of commercial operation (June 30, 2014).



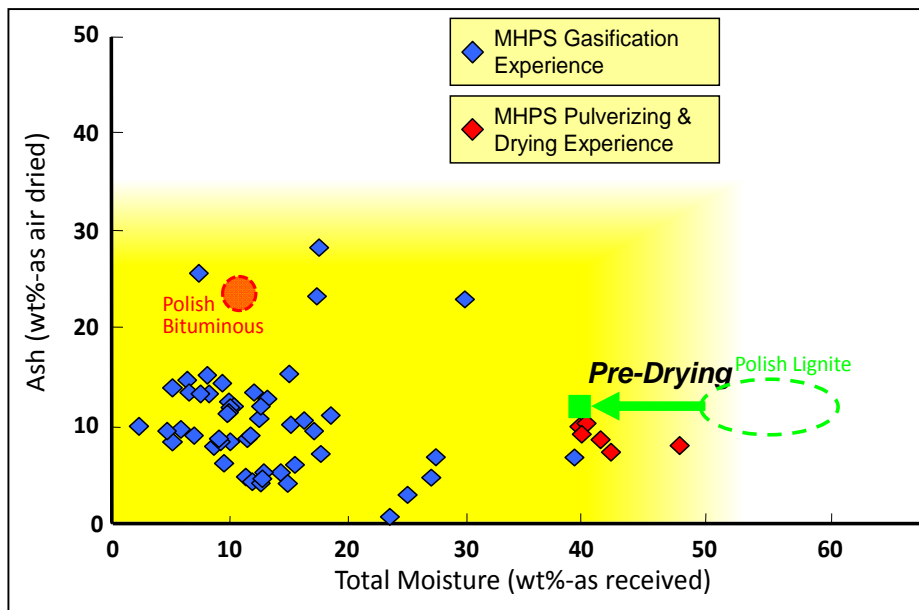
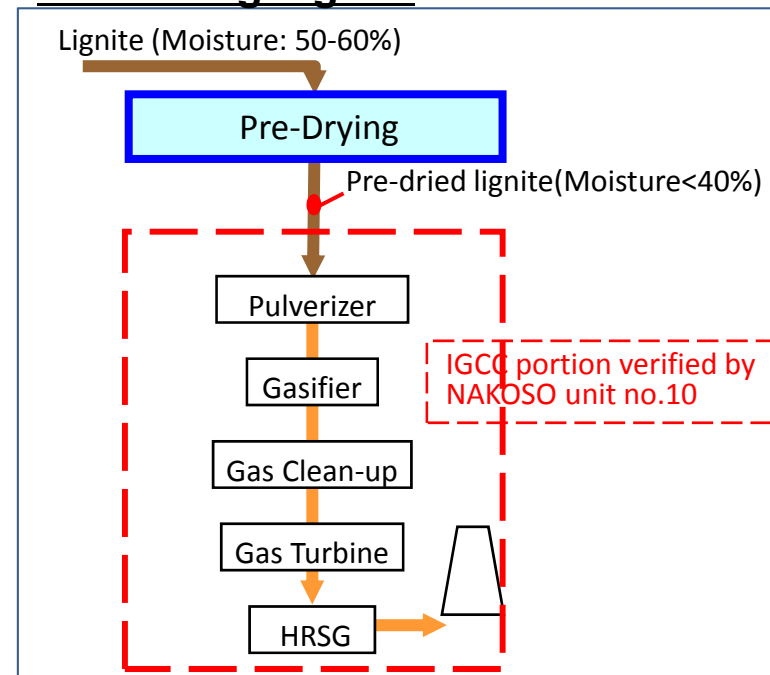
Verification of Fuel Flexibility in Nagasaki



Many kinds of coals had been tested in Nagasaki IGCC verification Plant.

- Bituminous coal
- Sub-bituminous coal
- Lignite (USA/ Texas Lignite , Indonesian Lignite
Australia /Victoria Brown coal)

IGCC firing Lignite



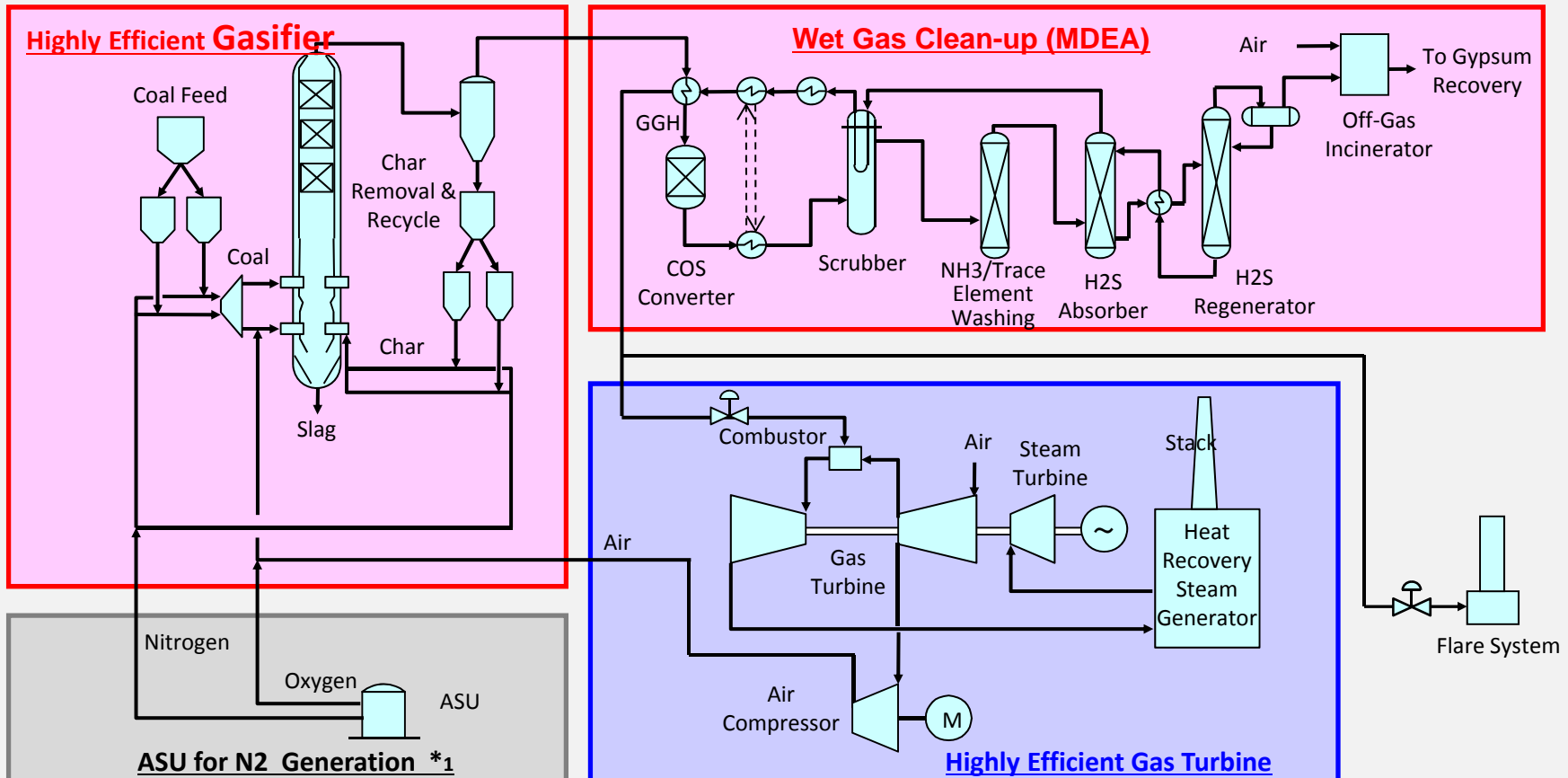
Polish bituminous is well within the MHPs gasification experience.
Polish lignite up to approx. 50wt% total moisture can be applied for IGCC **without** pre-drying.
Polish lignite more than 50wt% total moisture also can be applied for IGCC **with** pre-drying.

Air-blown IGCC System Configuration

540MW IGCC plant system configuration is same as Nakoso 250MW plant.

MHPS can supply whole IGCC plant with single point responsibility

Gasifier / Gas Clean-up : Clean fuel gas generation from coal with high efficiency

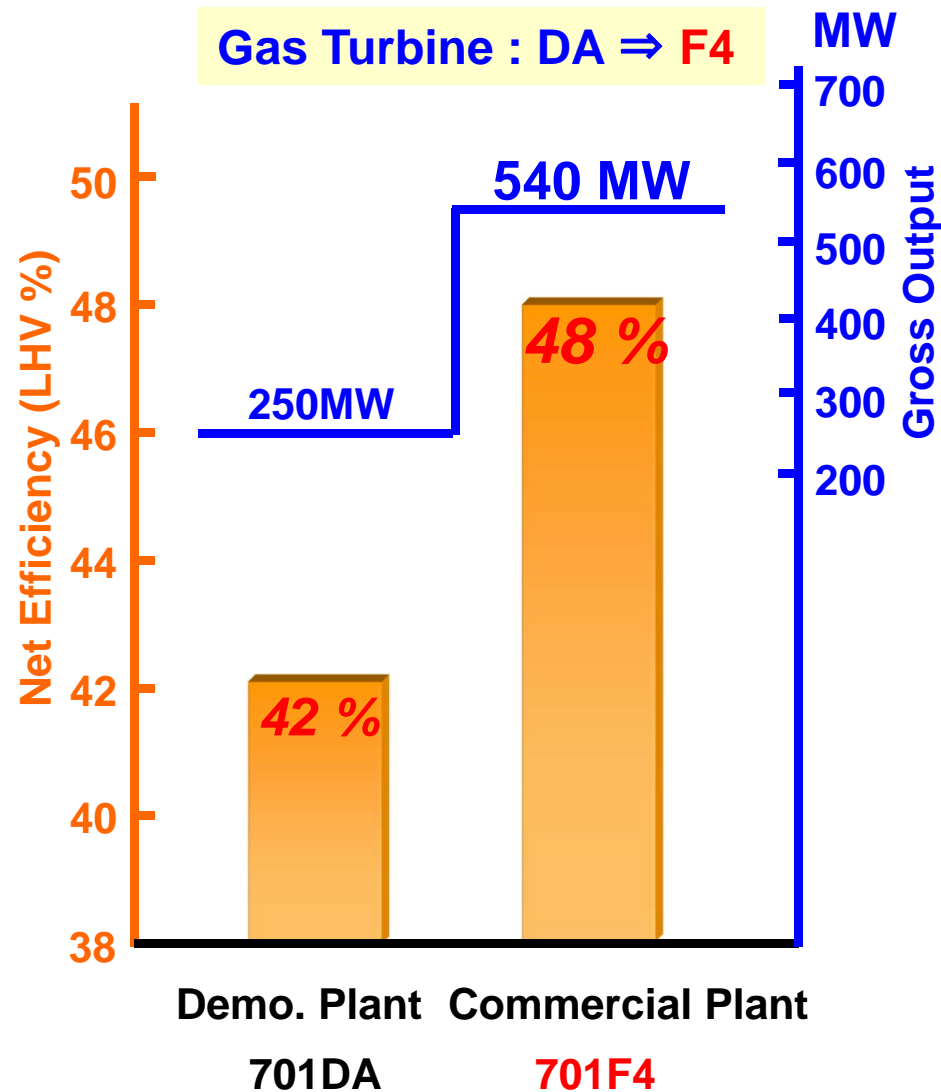


*** 1 : ASU for N2 Generation :**

- Inerting N2 for coal transportation is produced.
- O2 as a by-product is mixed with air and efficiently utilized as gasification reaction enhancer.

Combined Cycle : Efficient Power Generation by fuel syngas

Principal Specification of MHPS 540MW IGCC Plant



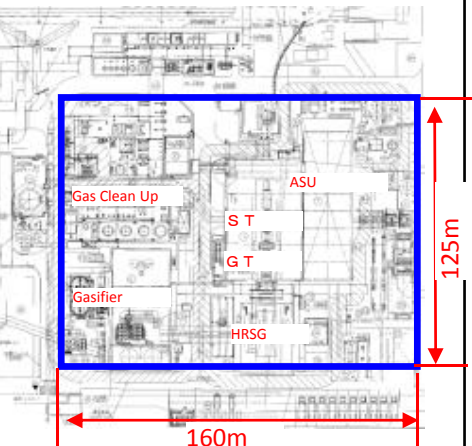
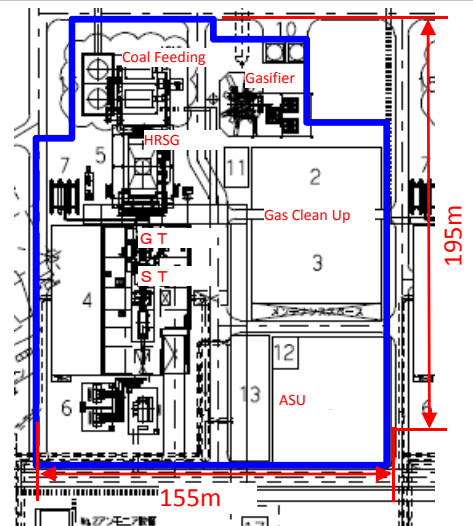
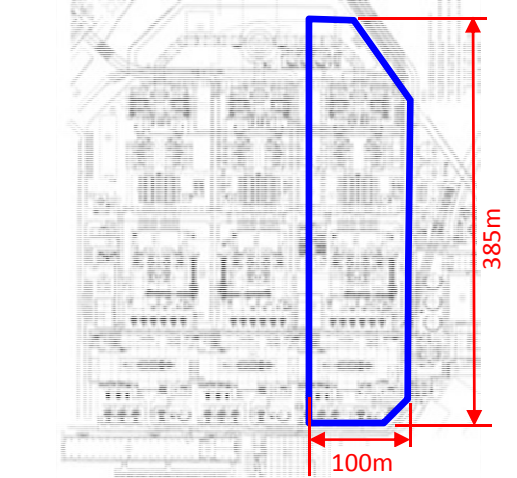
Item	Major Specification
	50Hz
Coal	Bituminous Coal & Sub-bituminous Coal
Output	Gross
	540 MW
	Net
	480 MW
Gasifier Oxidizer	Air (O2 Enriched)
Coal Feed	Dry
Acid Gas Clean-up	Wet MDEA* 1
Gas Turbine	M701F4 \times 1 (1 on 1)
Net Efficiency (LHV)	48 %

Note: Plant performance like output and efficiency depends on site conditions including coal properties.

** 1 MDEA: Chemical absorption method using methyldiethanolamine.*

M701F4 The Most Experienced Gas Turbine

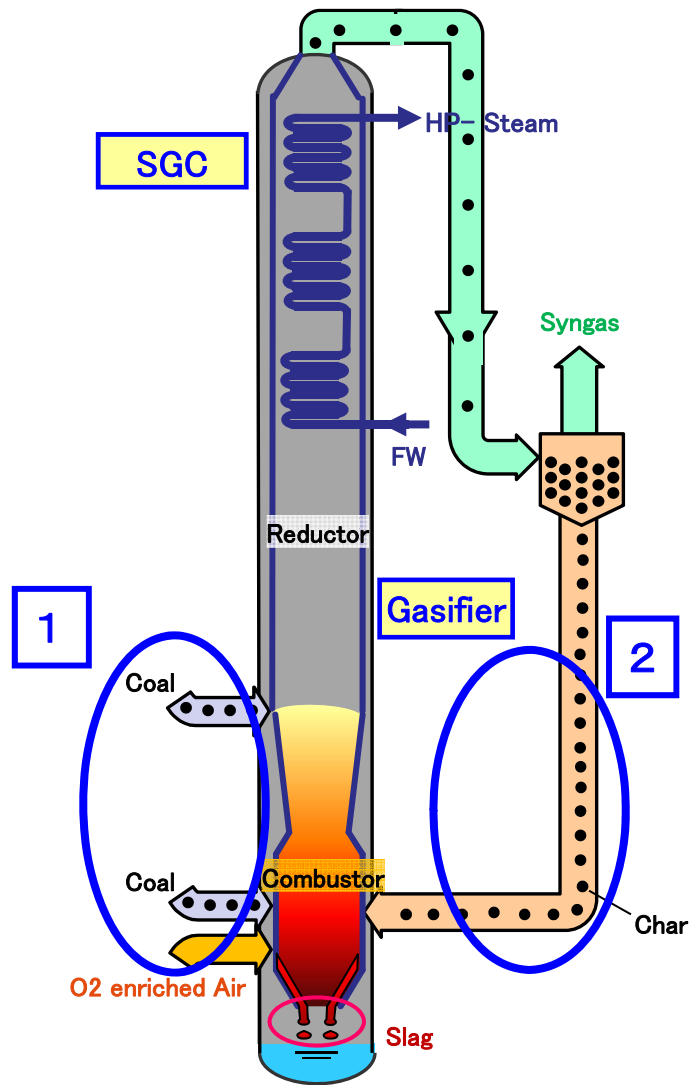
Plot Area Comparison

Item	Nakoso 250MW IGCC	540MW IGCC	800MW USC
Plot Plan			
Plant Area ※1	20,000m ²	30,200m ²	47,600m ² ※2
Plant Area (per MW)	80m ² /MW [Base]	56m ² /MW [70%]	63m ² /MW [79%]

※1 : Excluding Utility equipment

※2 : Power Block : 35,500m² FGD Aeration(not indicated) : 12,100m²

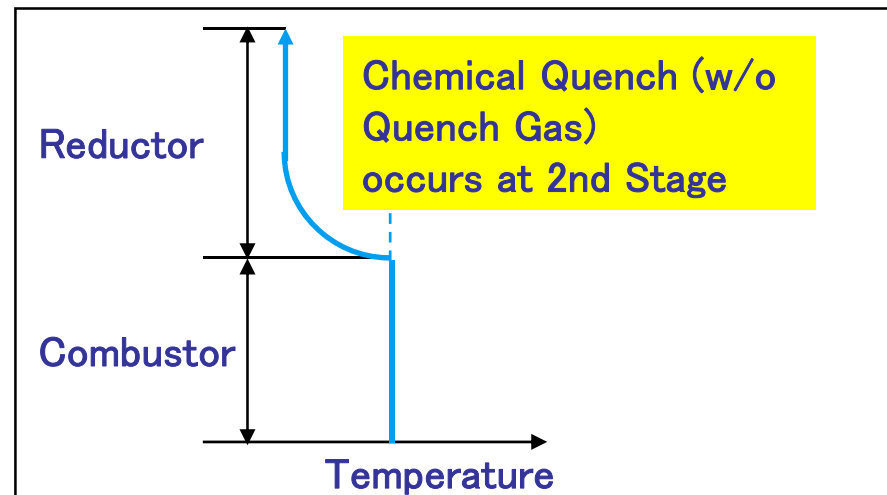
High Reliability Gasifier Concept



1. 2-Staged Gasification

– Combustor / Reductor Configuration

- ① Stable Syngas Production for Wide Variety of Coal
- ② Smooth Slag Discharge Capability
- ③ No Necessity of Quench Gas



2. Char Recycling System

- ① Minimize Unburnt Carbon in Slag
- ② No Black Water from Gasifier

Proven Design Methodology for Gasifier

The scale-up of the gasifier follows the established scale-up law from the 200T/D pilot plant. No critical issues expected.

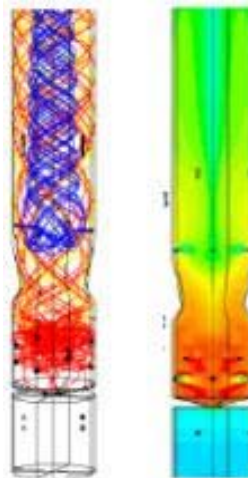


200T/D Pilot Plant

Scale-up 8.5 times



MHPS Verification Plant

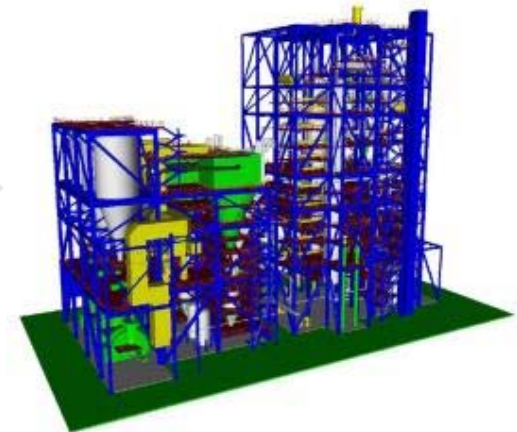


3D-CFD
Simulation



250MW (1700T/D) Nakoso #10
(former Demo. Plant)

2 times



Gasifier for 540MW IGCC Commercial Plants

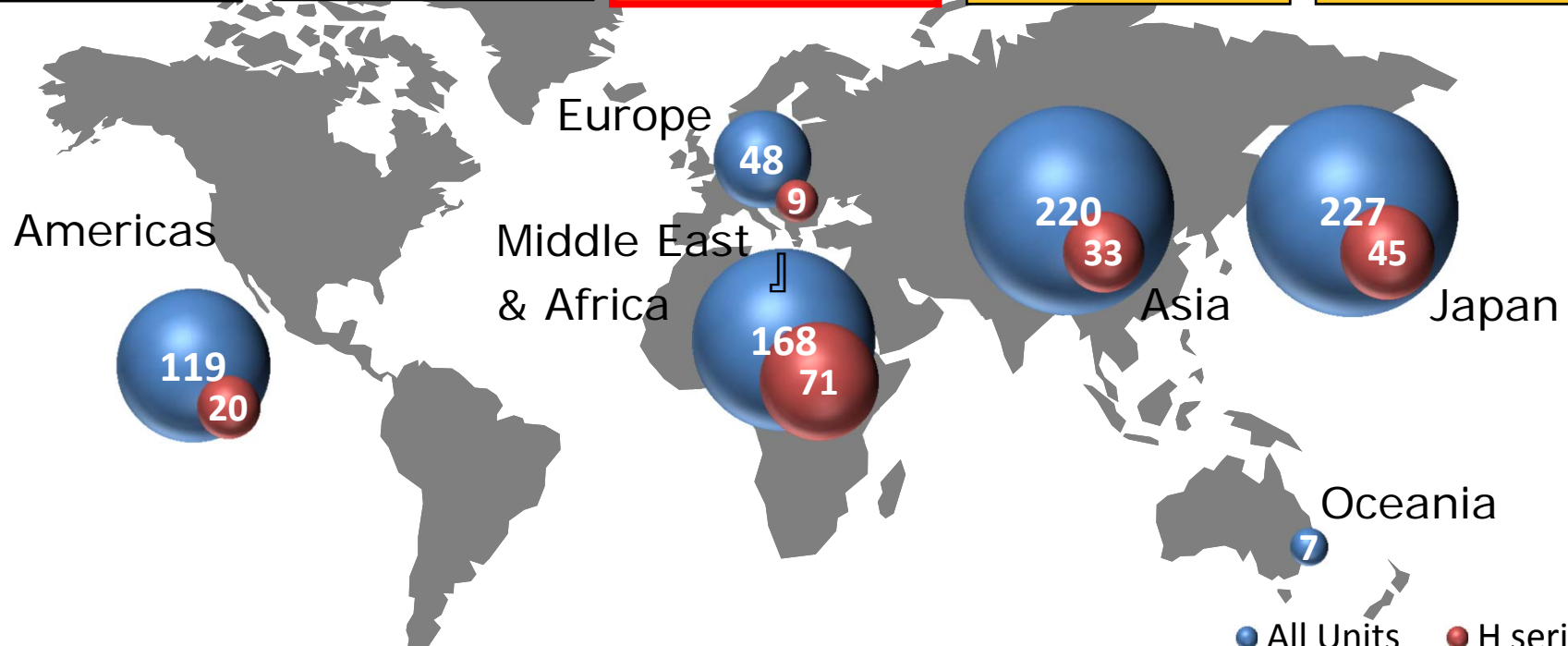
As the result of successful demonstration,

- Scale-up methodology was validated.
- Same methodology is applied to the 500MW IGCC commercial plants at lower scale-up factor.

MHPS Gas Turbine Global Experience



M501J × 26 M701J × 2 Total: 28 units	M501G × 69 M701G × 11 Total: 80 units	M501F × 73 M701F × 124 Total: 197 units	M501D × 25 M701D × 92 Total: 117 units	H-15 × 6 H-25 × 159 H-80 × 13 Total: 178 units
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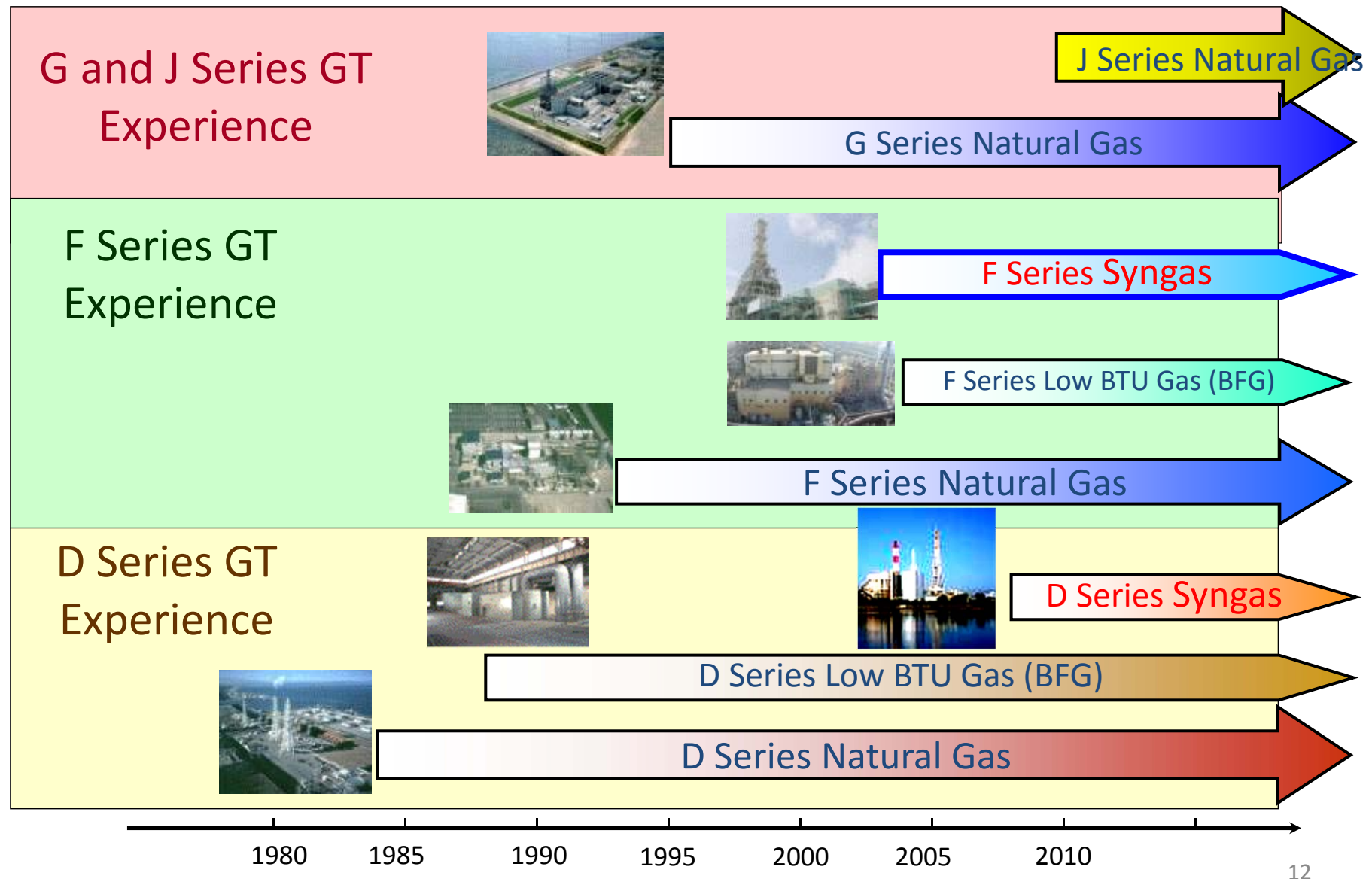
● All Units ● H series
 (*) As of April 2014

All Units – 789 units

(including 189 units of Takasago Mfd. Mid&Small Class GTs)

M701F4 : The Most Experienced Gas Turbine.

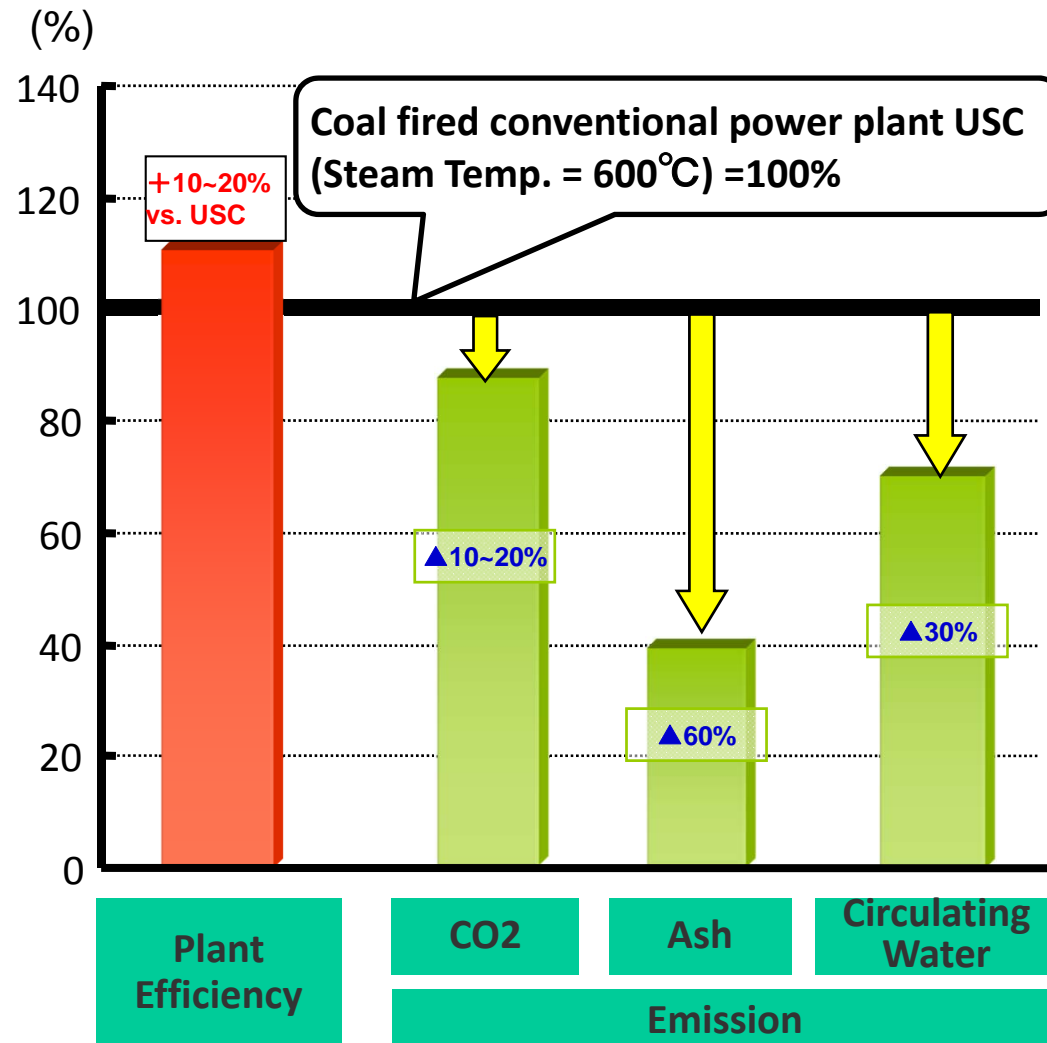
Gas Turbine Trend for Fuel Gas Application



Environmental Performance of 540MW IGCC Plant



The World Highest Efficiency and Lowest Emission for coal can be achieved by MHPS IGCC.



Flyash
(Conventional Boiler)

Grassy Molten Slag
(IGCC)

Approx. 60% decrease in volume



Utilization as a
pavement material



Utilization as a
concrete aggregate

are possible.

Conclusion



- The 250MW IGCC demonstration plant has been successfully completed by achieving all of its purpose and targets , and was converted to the Commercial Plant in Japan as Nakoso unit No.10 of Joban joint Power Co. and restarted operation from the summer of 2013.
- Based on the experience in the demonstration plant, MHPS is now capable of realizing 540MW-class IGCC commercial plants with high reliability (availability) and economy by reflecting all the accumulated data and lessons learnt.
- A lot of IGCC's advantages like higher plant efficiency and applicability of coal of lower rank are taken into account.
In addition, reduction of CO2 emission, ash discharge and circulating water is envisioned, too.



***“MHPS’s Contribution for
Energy and Environment Solutions”***

Appendix.1

MHPS Technology and Products for Power Generation and Chemicals

POWER PLANT & EQUIPMENT



Combined Cycle Power Plant



Steam Turbine



Boiler



Gas Turbine

MHPS is a technology provider and OEM of key components like gasifiers, gas turbines and steam turbines. Also supplies chemical plants and equipments.



Gasifier



CO₂ Recovery Plants



Compressor for Ethylene Plant



Refuse Incineration Plant

Methanol synthesis plant etc

CHEMICAL PLANT & EQUIPMENT



IGCC

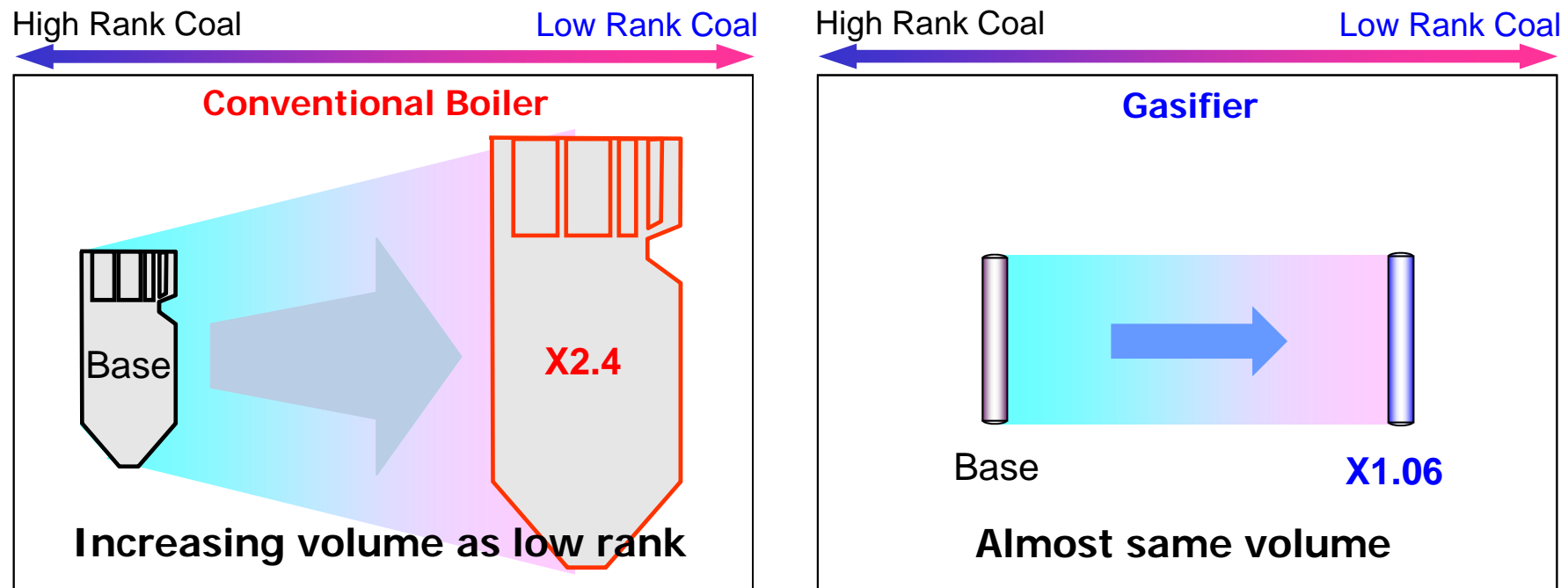
MHPS plays a role of the most reliable system integrator for IGCC based on our overall experience and technology.

Appendix.2

Lignite Coal Firing IGCC Plant

Lignite Coal Firing Boiler is relatively expensive as larger volume due to lower ash melting temp.

IGCC is suitable for Lignite Coal as the volume of the gasifier is almost same as the bituminous coal firing gasifier.



Appendix.3 Low Calorific Gas Firing Projects Progress

