

# ***Progress in NAKOSO 250 MW Air-Blown IGCC Demonstration Project***

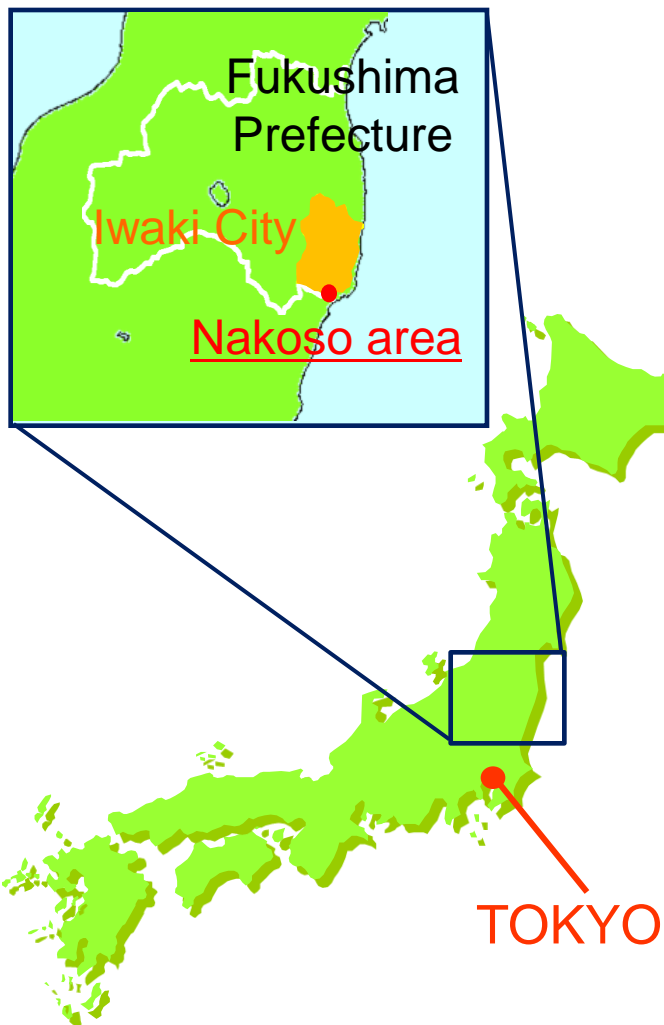
*International Conference on  
Power Engineering-2013 (ICOPE-2013)*

*October 24, 2013*



**Makoto Nunokawa**  
**Joban Joint Power Co., Ltd.**

# Location of NAKOSO IGCC Demonstration Plant

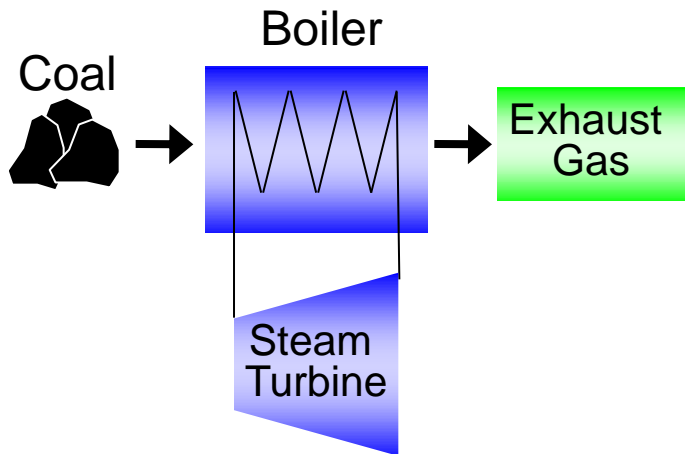


Located on the Nakoso Power Station of  
Joban Joint Power Co., Ltd.

# System Feature of IGCC

## Conventional PCF

Boiler + Steam Turbine

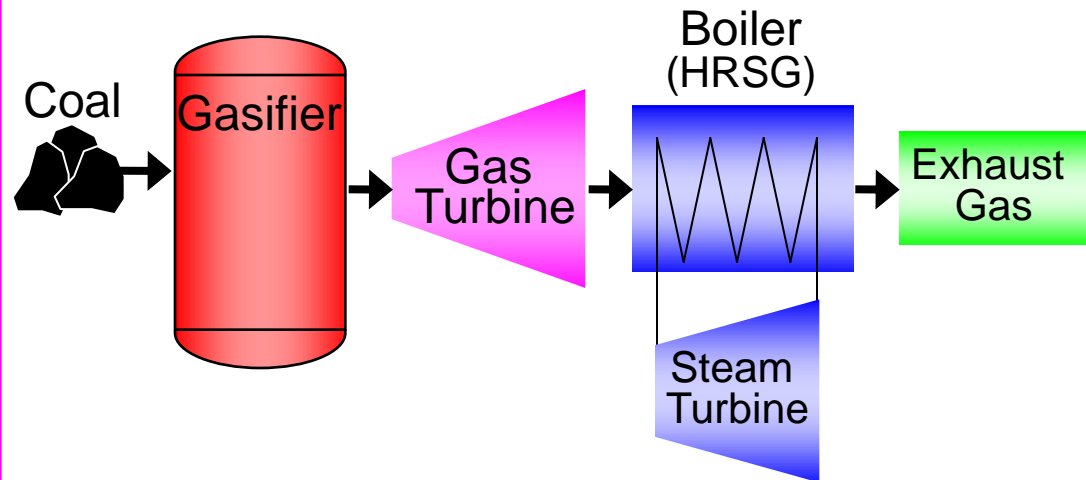


PCF : Pulverized Coal Firing

## IGCC Integrated coal Gasification Combined Cycle

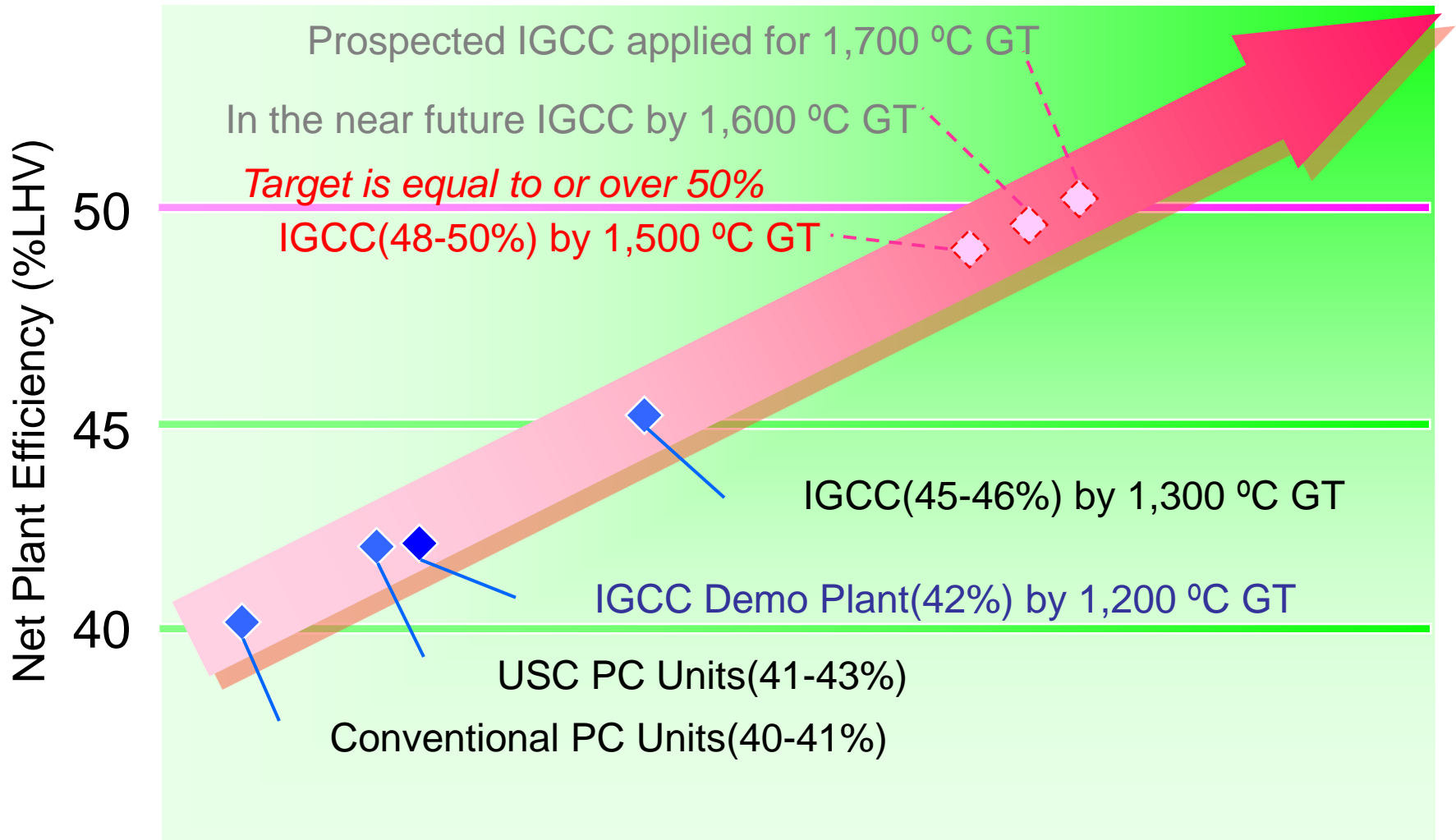
Boiler + Steam Turbine

+ Gasifier + Gas Turbine



**IGCC is a new power generation system aiming at higher efficiency than conventional coal-fired systems by integrated coal gasification with combined cycle power generation technology.**

# Thermal Efficiency Improvement



**Thermal efficiency improves in cope with high temperature gas turbine combined cycle technology.**

# Development History of Air-blown IGCC in Japan

Shareholders of CCP are  
10 major Utilities in Japan

← **Demonstration plant**  
Clean Coal Power R&D Co., Ltd.  
1700t/d 250MW (2007-2012)

**Pilot plant**  
IGC Research Association  
200t/d Equivalent to 25MW (1991-1996)



**Process development unit**  
CRIEPI-MHI 2t/d(1983-1995)



CRIEPI: Central Research Institute of  
Electric Power Industry

**Confirmation test plant**  
MHI Nagasaki 24t/d (1998-2002)



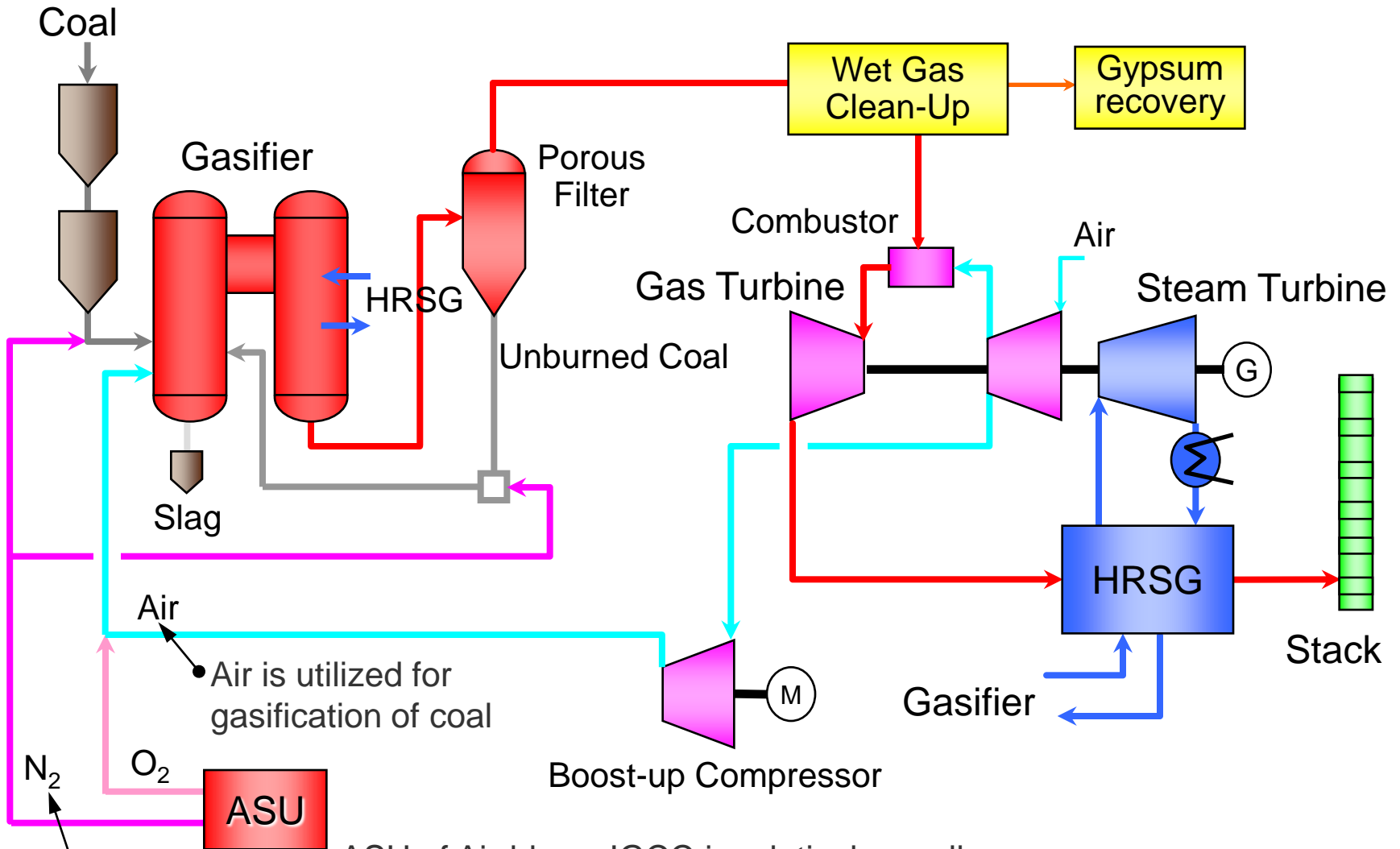
# Demonstration Project Schedule

FY	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12
Preparatory Verification Study	[Hatched bar]													
Design of Demo Plant			[Orange bar]											
Environmental Impact Assessment			[Green bar]											
Construction of Demo Plant						[Yellow bar]								
Demo Plant Operation									[Red bar]					

*Clean Coal Power R&D Co., Ltd.*

▽ *was established*

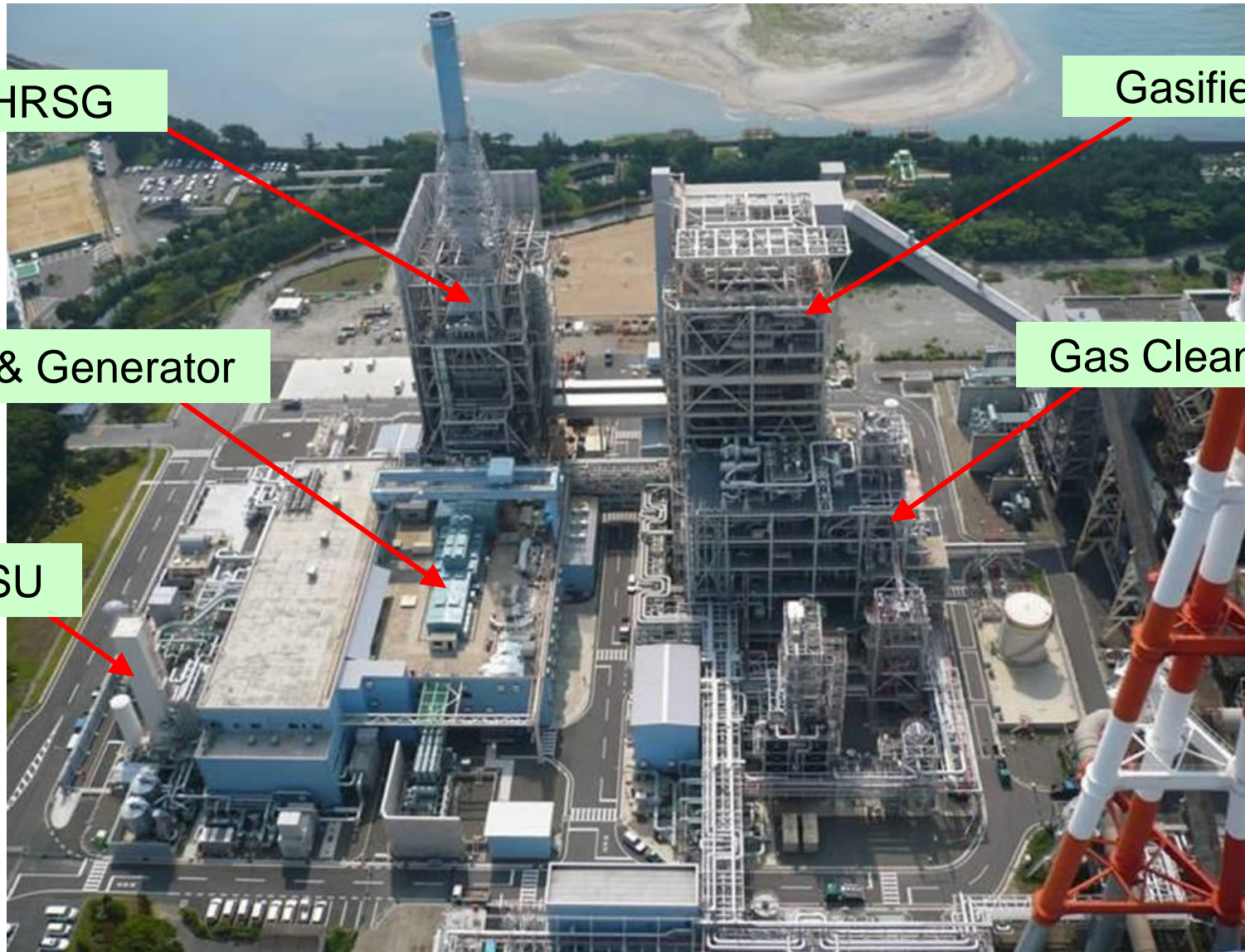
# Schematic Diagram of NAKOSO IGCC Plant



ASU of Air-blown IGCC is relatively small.

Mainly N<sub>2</sub> is utilized for coal and char transport

# Bird's-eye view of NAKOSO IGCC Plant



HRSG

Gasifier

GT, ST & Generator

Gas Clean-up

ASU



# Specification of NAKOSO IGCC Demonstration Plant

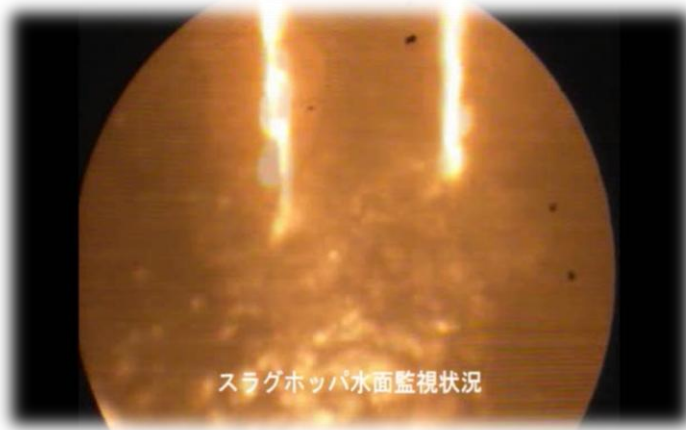
<b>Capacity</b>	<b>250 MW gross</b>		
<b>Coal Consumption</b>	<b>approx. 1,700 metric t/day</b>		
<b>System</b>	<b>Gasifier</b>	<b>Air-blown &amp; Dry Feed</b>	
	<b>Gas Treatment</b>	<b>Wet (MDEA) + Gypsum Recovery</b>	
	<b>Gas Turbine</b>	<b>1200 °C class (50Hz)</b>	
<b>Efficiency (Target Values)</b>	<b>Gross</b>	<b>48% (LHV)</b>	<b>46% (HHV)</b>
	<b>Net</b>	<b>42% (LHV)*</b>	<b>40.5% (HHV)</b>
<b>Flue Gas Properties (Target Values)</b>	<b>SOx</b>	<b>8 ppm</b>	<b>(16%O<sub>2</sub> basis)</b>
	<b>NOx</b>	<b>5 ppm</b>	
	<b>Particulate</b>	<b>4 mg/m<sup>3</sup>N</b>	
<b>EPC</b>	<b>Mitsubishi Heavy Industries (MHI)</b>		

\* While target net thermal efficiency is 48~50% in commercial IGCC plant applying 1500 °C class gas turbine, 1200 °C class gas turbine was adopted to reduce the capacity of plant for economy as a test plant.

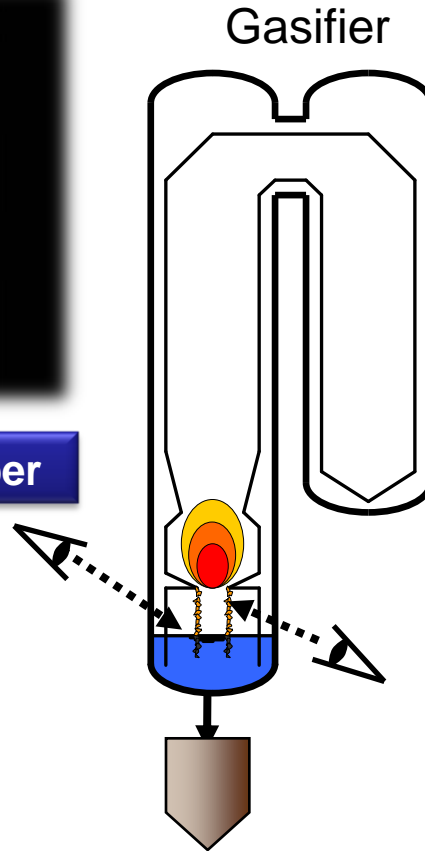
# Verification Items of Demonstration Test

Item	Goal
<b>System Safety and Stability</b>	<b>Demonstrate safe shutdown when plant malfunctions, and safe handling of coal gas.</b>
<b>Reliability</b>	<b>Run continuously for at least 2,000 hours (equivalent to 3 summer months) to confirm reliability.</b>
<b>Coal Type Flexibility</b>	<b>Collect data while running coal types outside of the design specs. Data is to be used to support future commercial design.</b>
<b>High Efficiency</b>	<b>Achieve targeted thermal efficiency, to show that system delivers the high efficiency that is said to be IGCC's greatest advantage.</b>
<b>Durability</b>	<b>Run for long period, then conduct overhaul inspection to demonstrate durability.</b>
<b>Economy</b>	<b>Use operational performance as a basis for comprehensive evaluation of costs (construction costs, operating costs, maintenance costs etc.), and evaluate economic feasibility.</b>

# Stable Slag Flow from Bottom of the Gasifier



Surface of water in Slag Hopper



Slag Hole view from lower side

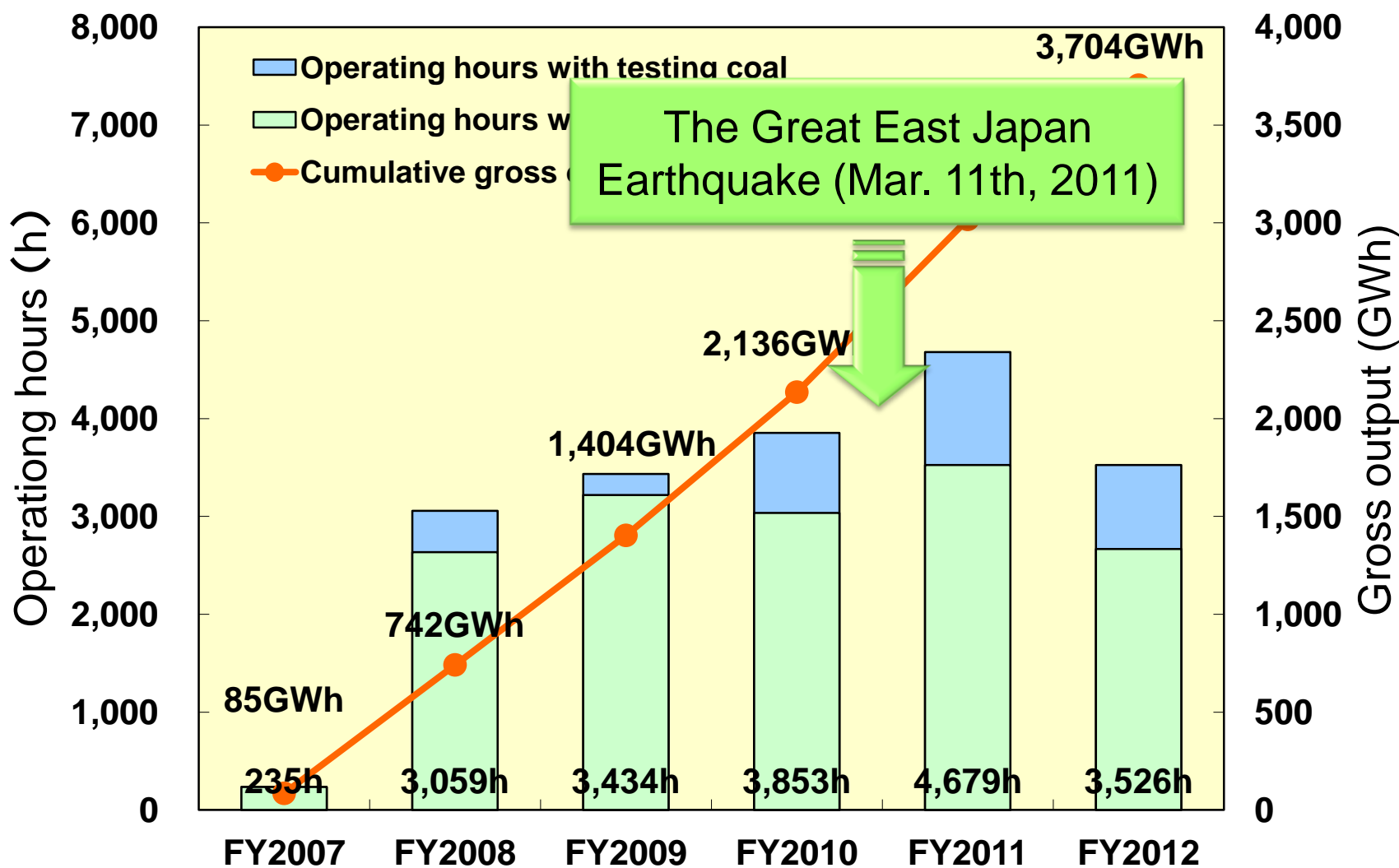
The two streams of molten slag from the bottom of the gasifier are constant, which means that the gasifier is operating in a very stable condition. This image is always monitored in the main control room.

# Results of Plant Performance Test

	Design Values	Results
Atmospheric Temperature	15 °C	13.1 °C
Gross Output	250 MW	250 MW
Gas Turbine Output	128.9 MW	124.4 MW
Steam Turbine Output	121.1 MW	125.8 MW
Net Efficiency (LHV)	42%	42.9%*
Syngas LHV	4.8 MJ/m <sup>3</sup> <sub>N</sub>	5.2 MJ/m <sup>3</sup> <sub>N</sub>
Composition CO	28.0%	30.5%
CO <sub>2</sub>	3.8%	2.8%
H <sub>2</sub>	10.4%	10.5%
CH <sub>4</sub>	0.3%	0.7%
N <sub>2</sub> etc.	57.5%	55.5%
Environmental Performance (16%O <sub>2</sub> Corrected)	<Target>	
SOx	8 ppm	1.0 ppm
NOx	5 ppm	3.4 ppm
Particulate	4 mg/m <sup>3</sup> <sub>N</sub>	<0.1 mg/m <sup>3</sup> <sub>N</sub>

\*Correction value at 15 °C

# Operating Hours and Cumulative Gross Output



# *Earthquake Situation*

- On March 11th, 2011, a magnitude 9.0 earthquake occurred off northeastern Japan. The plant operating at 225MW shut down safely.
- Following tsunami rushed toward the plant and almost all equipments on the first floor were submerged by seawater and covered by a large amount of mud.

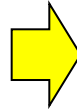
Time	Situation
2:46 p.m.	<ul style="list-style-type: none"><li>• The earthquake occurred.</li><li>• Plant operation was stopped by increased vibration of gas turbine bearing #2.</li><li>• Station blackout occurred.</li></ul>
3:30 p.m.	<ul style="list-style-type: none"><li>• The first tsunami wave arrived.</li><li>• All facilities were flooded between 1 to 2 meters above the ground.</li><li>• The second and the third tsunami wave arrived afterward.</li></ul>
3:35 p.m.	<ul style="list-style-type: none"><li>• Emergency power was restored.</li></ul>

# *Tsunami Rushed Toward the IGCC Plant*



# Tsunami situation (just coming)

## Plant premises





# *Tsunami situation (just coming)*

## Plant premises

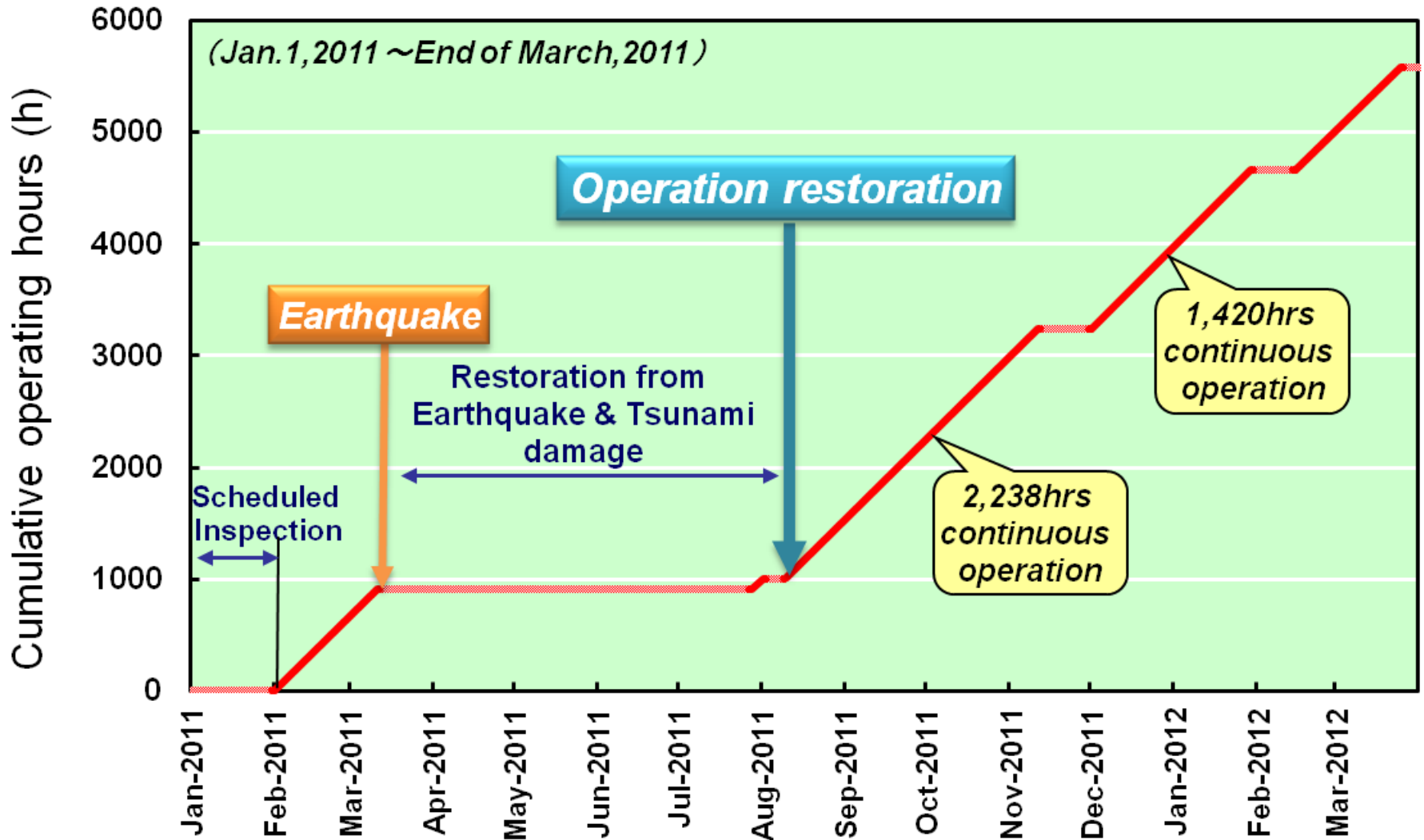


# Post-tsunami Situation

## Plant premises



# Operation of NAKOSO IGCC after the Earthquake



**After the restoration, NAKOSO IGCC realized high availability.**

# Status of Targets and Achievements

	Targets	Results	Status of Achievement
Safe and Stable Operation	250 MW	250 MW	Achieved
Long Term Continuous Operation	>2,000 hrs	2,238 hrs	Achieved
Net Thermal Efficiency	>42% (LHV basis)	42.9%	Achieved
Carbon Conversion Rate	>99.9%	>99.9%	Achieved
Environmental Performance	SOx <8 ppm NOx <5 ppm Dust <4 mg/m <sup>3</sup> <sub>N</sub>	1.0 ppm 3.4 ppm <0.1 mg/m <sup>3</sup> <sub>N</sub>	Achieved
Coals	Bituminous (B) Sub-bituminous (SB)	Chinese (B) USA (B, SB) Indonesian (B, 2SB) Colombian (B) Russian (B) Canadian (B)	Achieved
Start-up Time	<18 hrs	15 hrs	Achieved
Minimum Load	50%	36%	Achieved
Load Change Rate	3%/min	3%/min	Achieved
Durability, Reliability and Maintainability	Evaluate during 5,000 hrs test	5,013 hrs in one year, No serious damage	Same as conventional PCF
Economy estimation	Less than or equal to PCF power generation cost	Construction cost and operation cost was estimated.	Could be compatible with PCF

# *Conclusion*

The Air-blown IGCC investigated in Japan was demonstrated the performance and functionality with NAKOSO Demonstration Plant since 2007.

Reliability was confirmed by 18,788 hours of accumulated operation with 3,704GWh power supply, and the resulting net thermal efficiency was achieved to 42.9% at LHV basis.

The demonstration project was finished in March 2013, and the NAKOSO IGCC plant is operated commercially by Joban Joint Power Company as high efficiency power generating station.

# Takeover from CCP to Joban Joint Power Co.

## Before March 31<sup>st</sup>, 2013



*NAKOSO IGCC plant was owned and operated by Clean Coal Power R&D Company as a demonstration test plant.*

*The demonstration test was carried out for five and a half years, and was completed successfully.*



## After April 1<sup>st</sup>, 2013

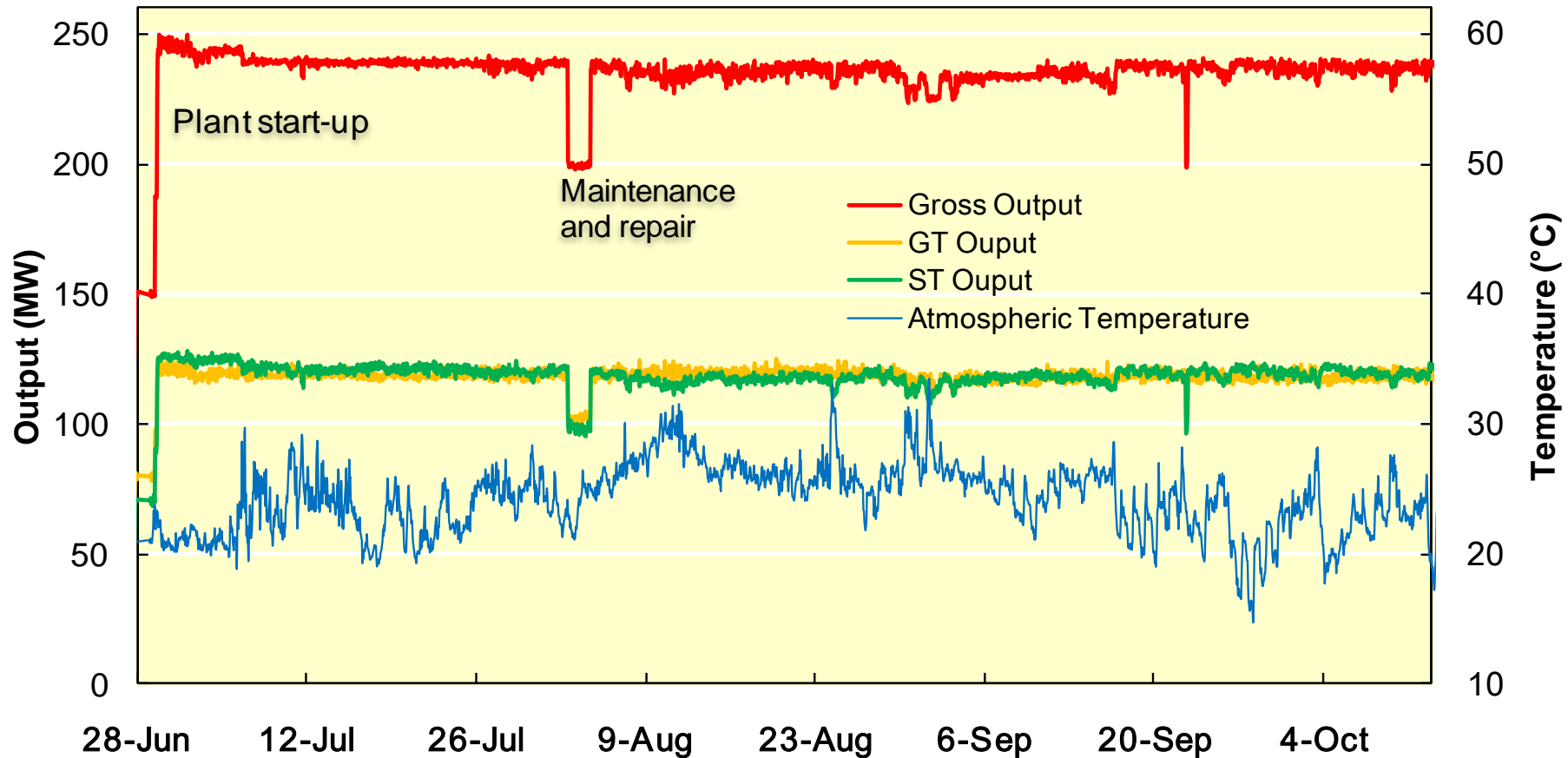


*NAKOSO IGCC plant is owned and operated by Joban Joint Power Company as a commercial plant.*

*After three month's inspection and repair work for commercial use, it has been operated continuously at rated load since June 28<sup>th</sup>, 2013.*

# Operation Result after Commercial Use

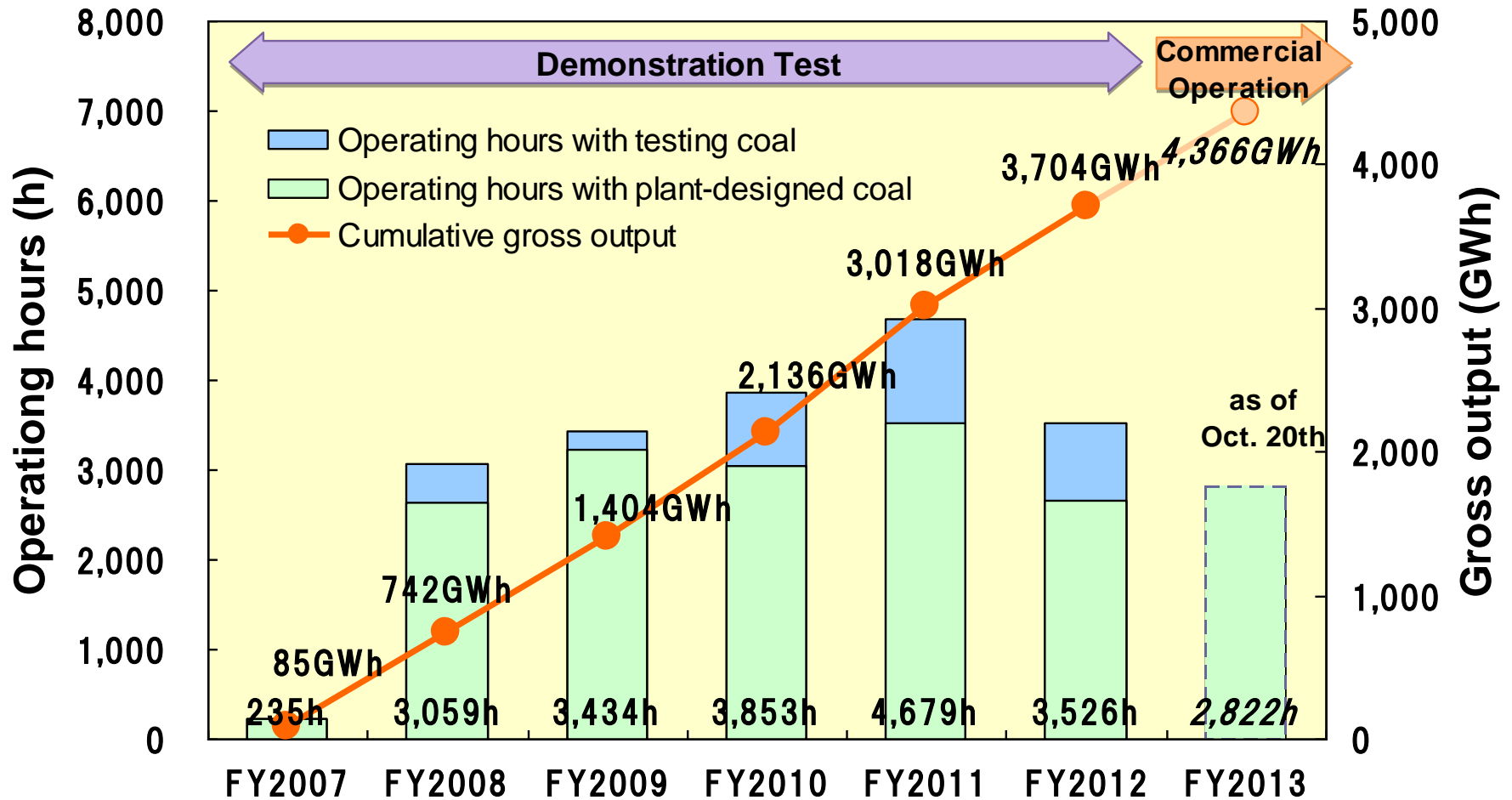
as of Oct. 20<sup>th</sup>



**NAKOSO IGCC Plant has been operated in good condition at rated power since June 28th, 2013 as a commercial plant.**

**Continuous operation hours has exceeded 2,750hrs.**

# Operation Result after Commercial Use



**It will pursue a further progress in high efficiency coal power generation technology with the Air-blown IGCC.**



Thank you!

