Achievements and Future Activities in Operation of Clean Coal Technology

TEPCO

Tokyo Electric Power Company – Fuel & Power Company

November, 20th, 2015

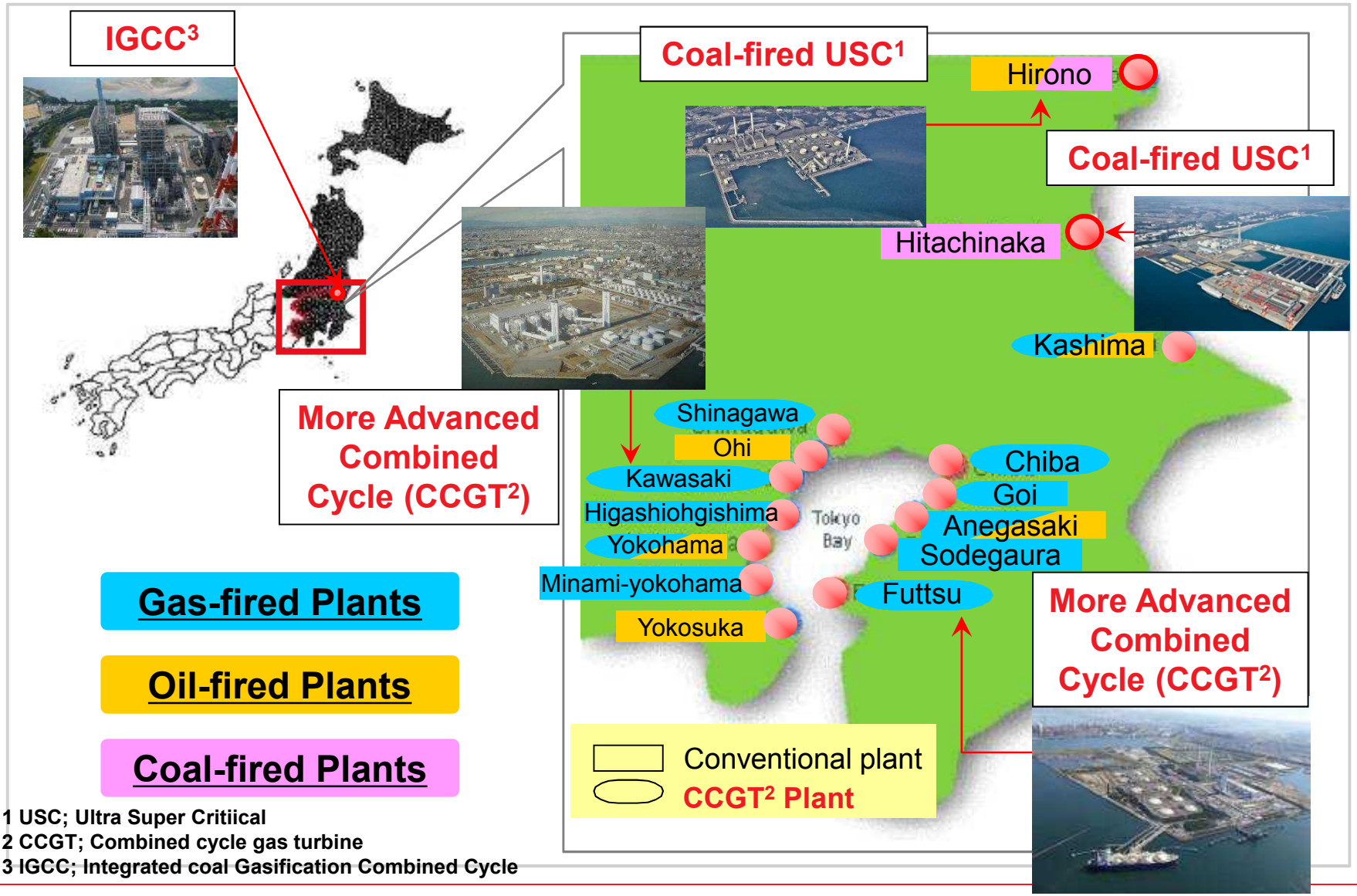
Outline

1. Thermal Power Plants of TEPCO

2. User’s expertise and experienced O&M know-how

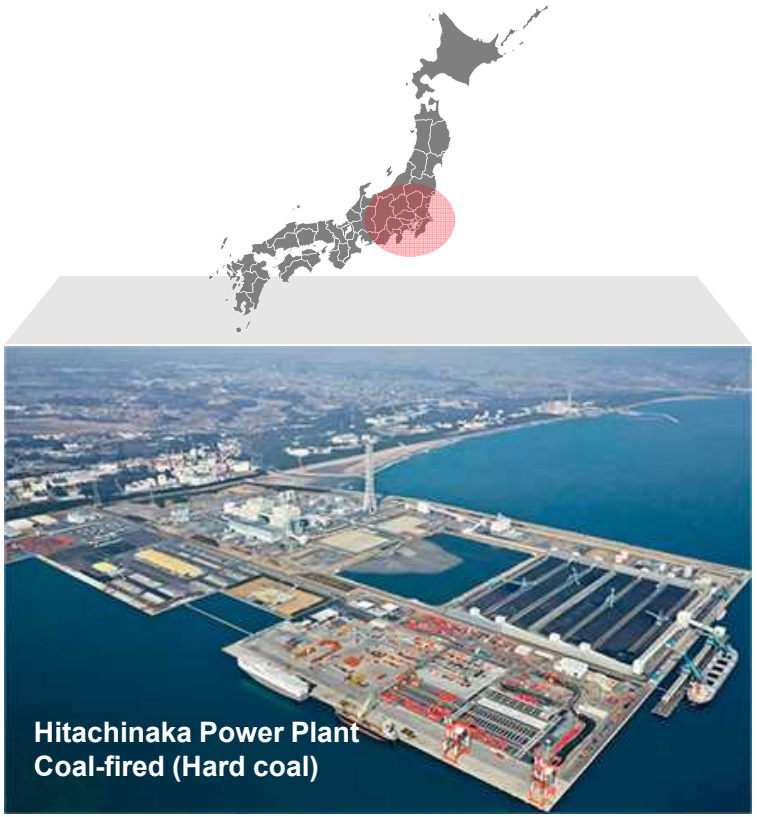
3. IGCC Technology

TEPCO is Japan's largest utility, supplying power to the Tokyo metropolitan area for over 60 years



1 USC; Ultra Super Critiical
2 CCGT; Combined cycle gas turbine
3 IGCC; Integrated coal Gasification Combined Cycle

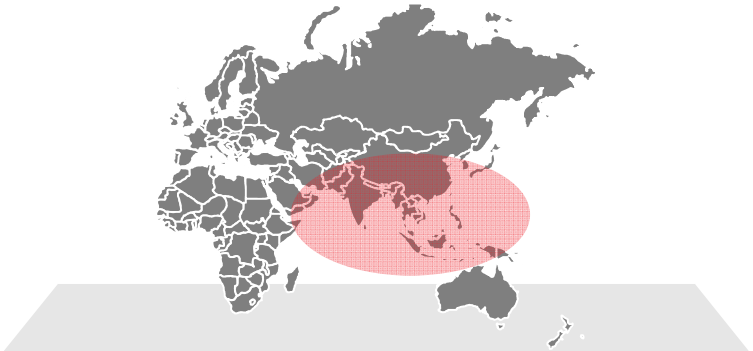
TEPCO runs power plants of various fleet types with large capacity (Domestic)



Fleet		Units[1]	Total capacity[1] MW	OEM
Coal		4 (6)	3,200 (5,025)	▪ MHPS ▪ MHI ▪ Hitachi ▪ Toshiba ▪ GE ▪ IHI ▪ MELCO ▪ Fuji
CC GT	1500℃	10	5,021	
	1300℃	26 (3)	9,600 (753)	
	1100℃	14	2,000	
Gas (Conventional)		23	12,761	
Oil (Conventional)		19	10,750	
IGCC		(1)	(250)	
Total		**96** **(10)**	**43,332** **(6,028)**	**Annual Output** **~211.6** TWh

1 Values in brackets include joint operation plants

TEPCO runs power plants of various fleet types with large capacity (Global)



Investment in power plant SPC			Total capacity MW	Owner-ship ratio Percent
Fleet	Plant name			
Gas	The Philippines	Irijan	1,251	50.0
	Taiwan	Star Buck	490	22.7
	UAE	Umm Al Nar	2,200	20.0
	Vietnam	Phu My 2-2	715	15.6
	Taiwan	Fong Der	980	19.5
	Taiwan	Chang Bin	490	19.5
Coal	The Philippines	Sual	1,218	50.0
	The Philippines	Pagbilao	735	50.0
	Indonesia	Paiton III	815	14.0
	Indonesia	Paiton I	1,230	14.0
Total			**10,124**	

Power generation corporation investment

Thailand	EGCO GROUP	5,150	12.3

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User's expertise and experienced O&M know-how lead TEPCO for the Low Carbon Society

The Best Available Technology

CCGT / USC

Experienced O&M method

Operation and Maintenance

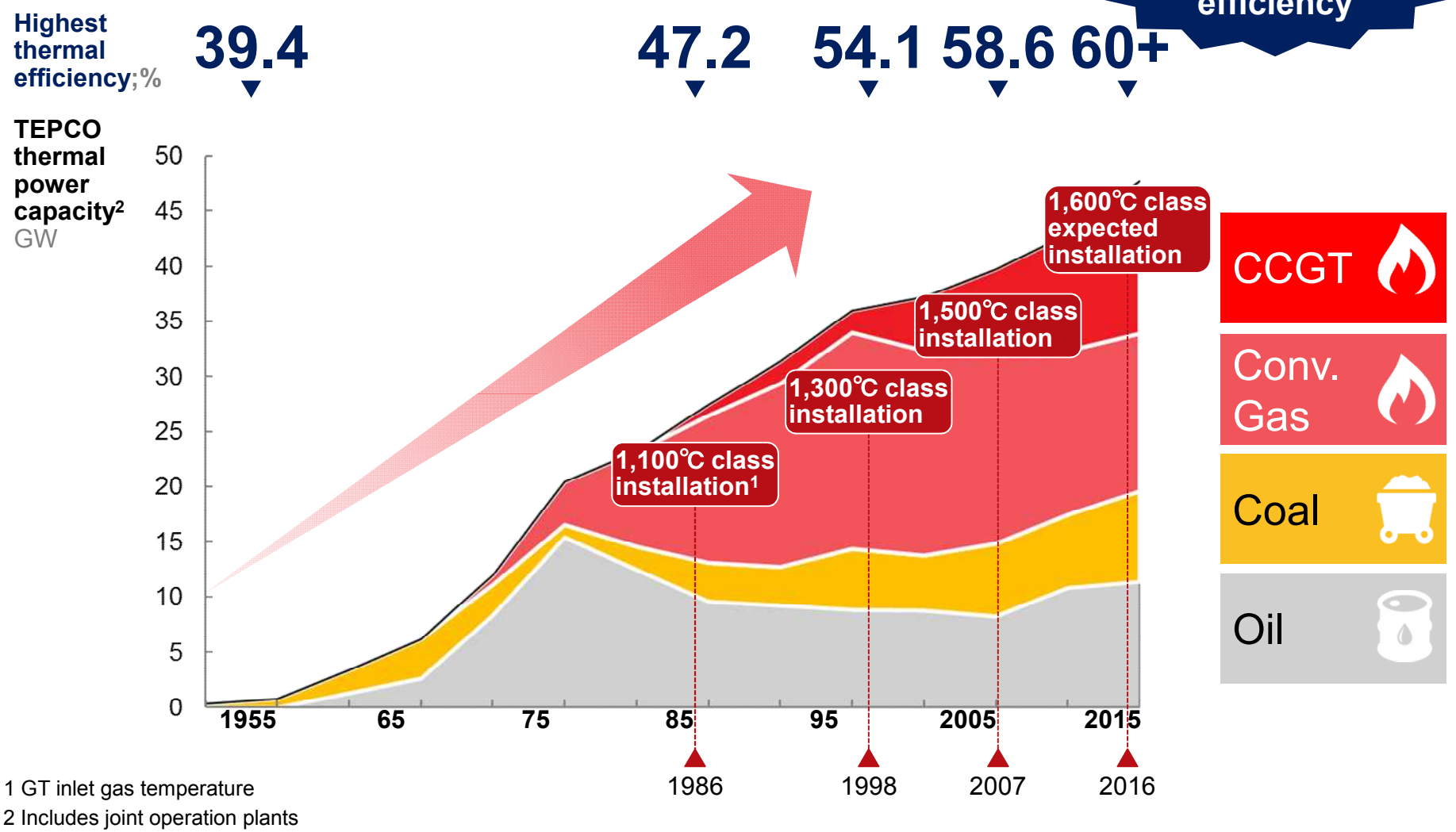
- Plant monitoring
- Early detection
- Plant diagnosis
- Efficiency management

Next-Generation Technology

IGCC / A-USC

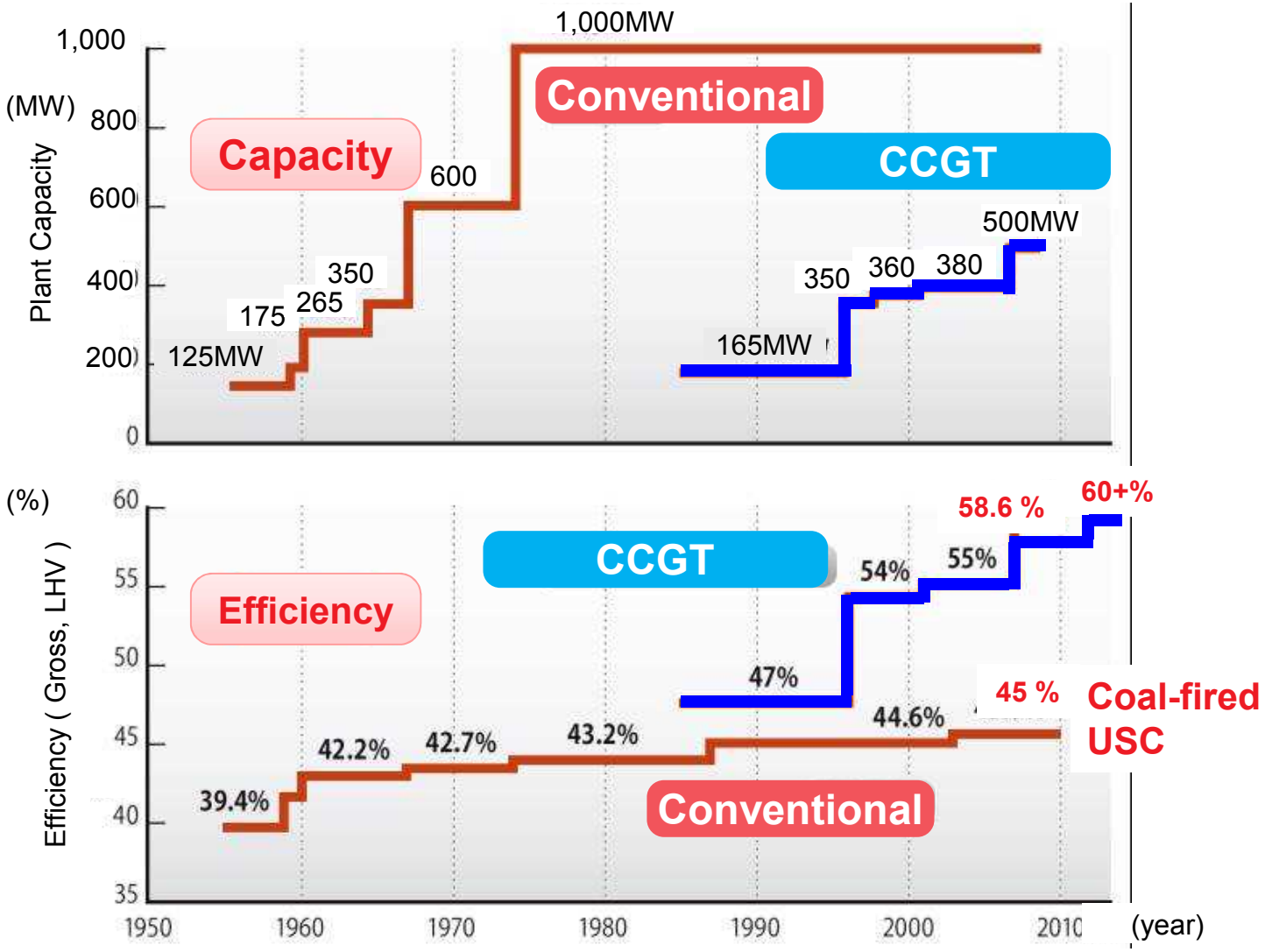
TEPCO has been maximizing power plant performance with the best available and cutting-edge CCGT technologies …

One of the world's highest thermal efficiency



1 GT inlet gas temperature
2 Includes joint operation plants

TEPCO has been adopting the best available technologies also as to conventional plant.



Appropriate types of flue gas treatment system are installed from following options to coal-fired power plant

NO_2

Type	Method
Dry	Selective Catalytic Reduction (SCR)
Dry	Selective Non-Catalytic Reduction (SNCR)
Dry	Activated Carbon Injection (ACI)
Wet	Oxidation-Reduction

PM (Particulate Matter)

Method	
Scrubber	
Fabric Filter (FF)	
Electrostatic Precipitator (EP)	Dry
	Wet
:	

SO_2

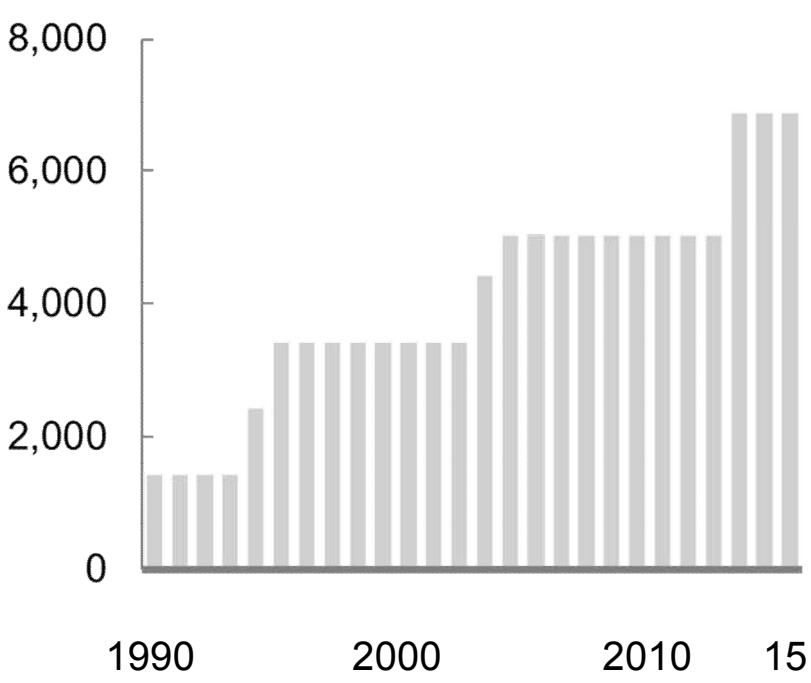
Type	Method	
Dry	Dry Sorbent Injection (DSI)	
Semi-Dry	Spray Dryer	
:		
Wet	Wet Scrubber	Sorbent
	Limestone or Lime - Gypsum	
	$Mg(OH)_2$	
	NaOH	
	Sea Water	
	:	

TEPCO adopted

TEPCO build trust in environment by introducing environmental friendly equipment with accumulated know-how

TEPCO has developed and maintained coal power plants

TEPCO's coal plant[1]



1 incl. joint operation plants

Example: Strong commitment to environmental compliance

- **Set strict environmental standards with the municipality**.1/6 level of legal regulation
- **Promote local area benefits** from plant construction and operation
- **Proactive communication** with local government
- **Real-time transfer** of environmental data to the municipality
- **Keep regular touch points** with the municipality and surrounding cities
- **Provide detailed data sets and hold public hearings**

TEPCO has built strong connection with every stakeholder for long terms in any phases

Before environmental impacts assessment	Environmental impacts assessment	Under construction and after COD
▪ **Consensus and communication building** with and locals ▪ Repetitive **information sessions** of a project for locals ▪ Other **contact points**	▪ **Strict steps of environmental impacts assessment** – Through 50 months, **4 major steps** of assessment before construction	▪ **Real time reporting** of environmental data to the municipality ▪ Keep **regular touch** points

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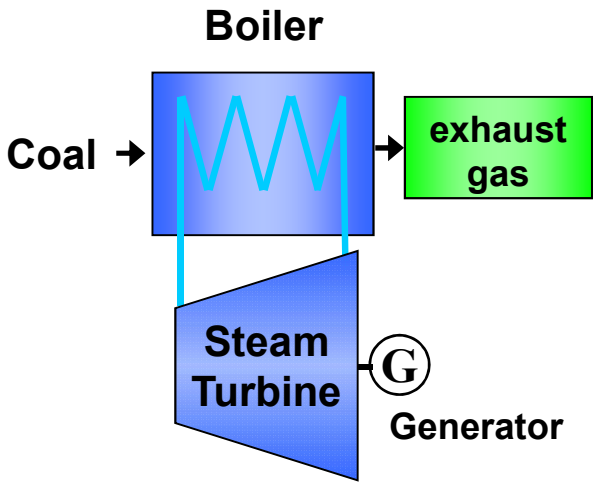
3. **IGCC Technology**

Conventional and Combined Cycle power plant

Conventional

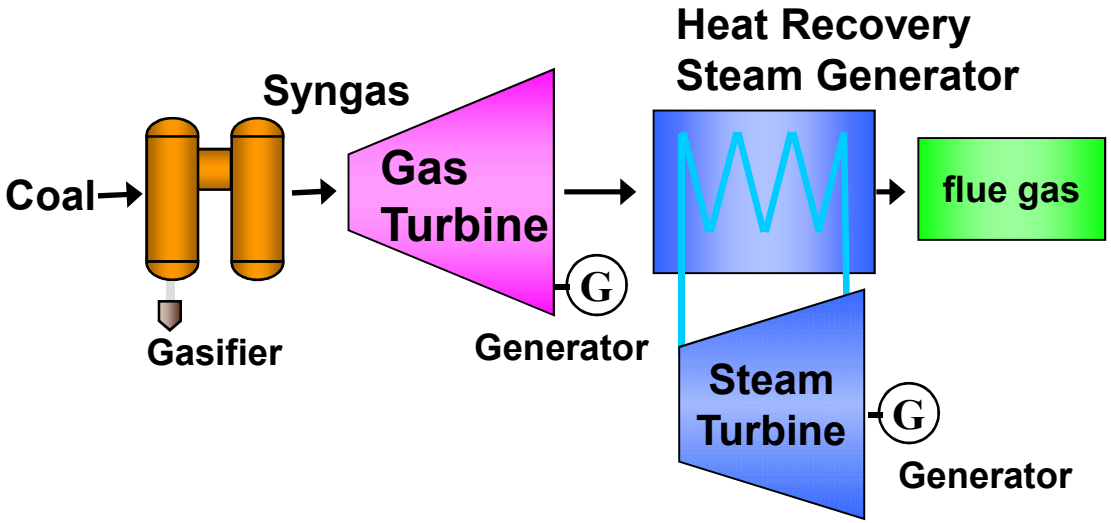
Boiler＋Steam turbine



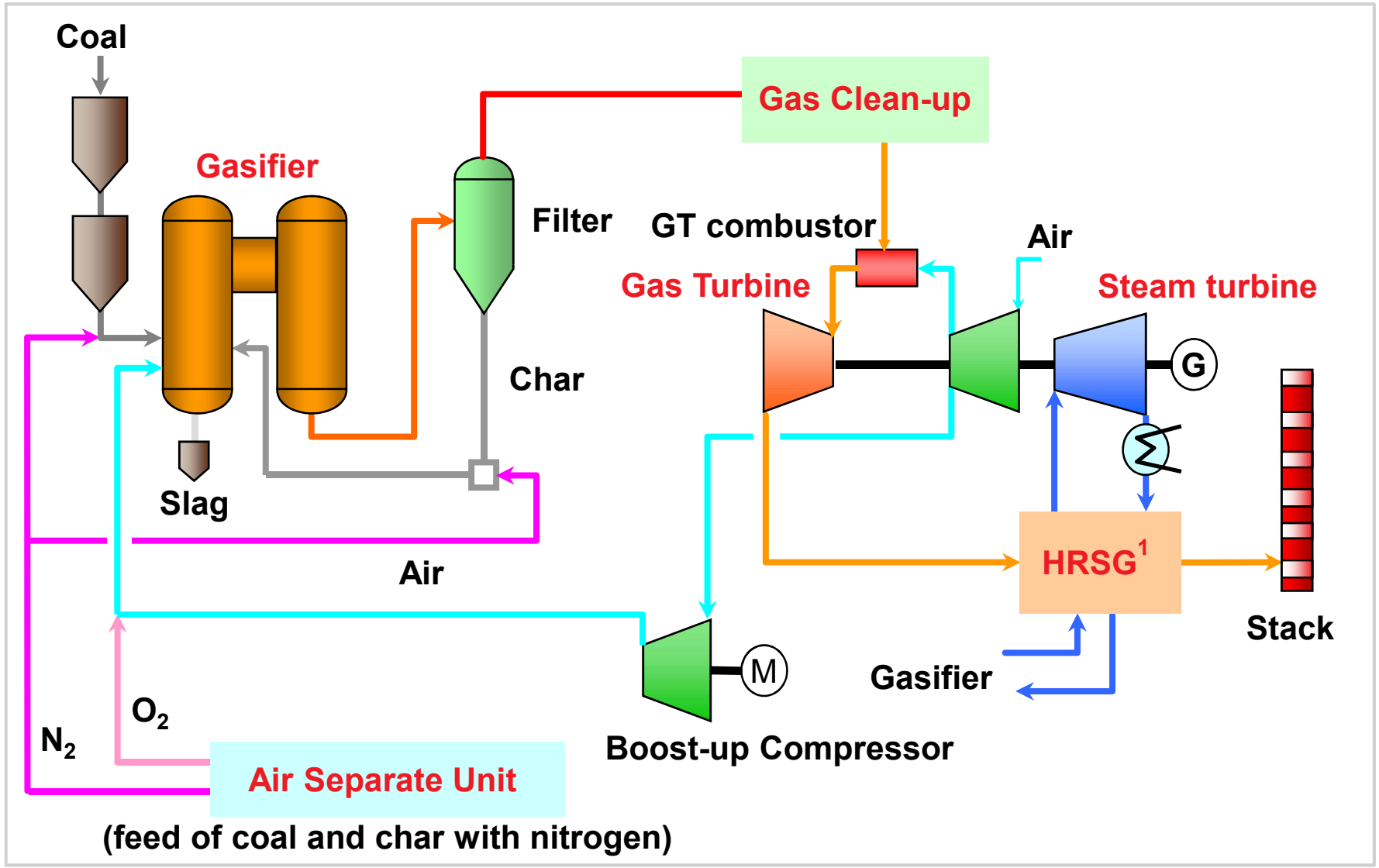
Combined cycle (IGCC)

Boiler＋Steam Turbine

＋Gas Turbine



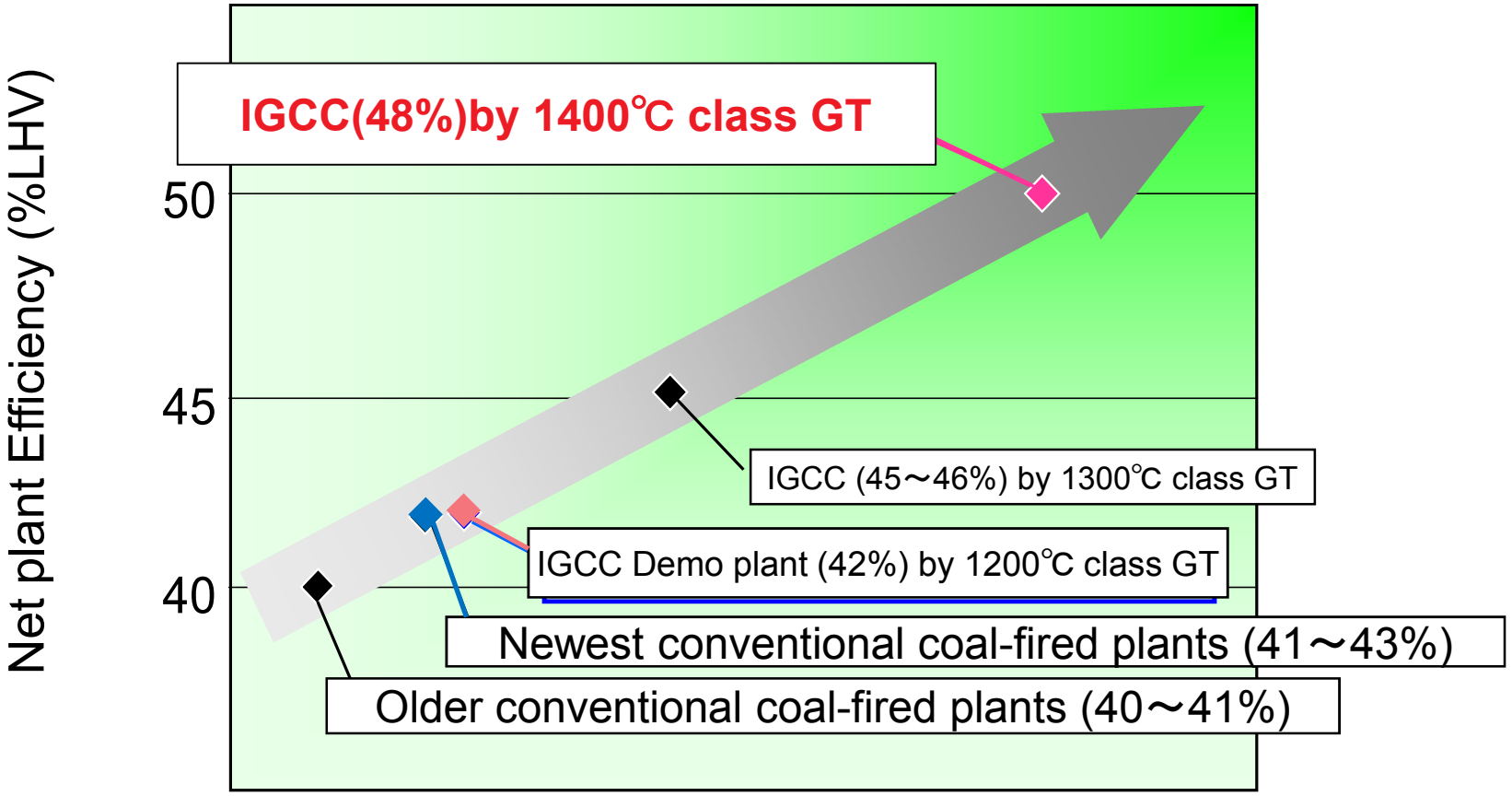
Integrated coal Gasification Combined Cycle (IGCC)



1 HRSG;Heat Recovery Steam Generator

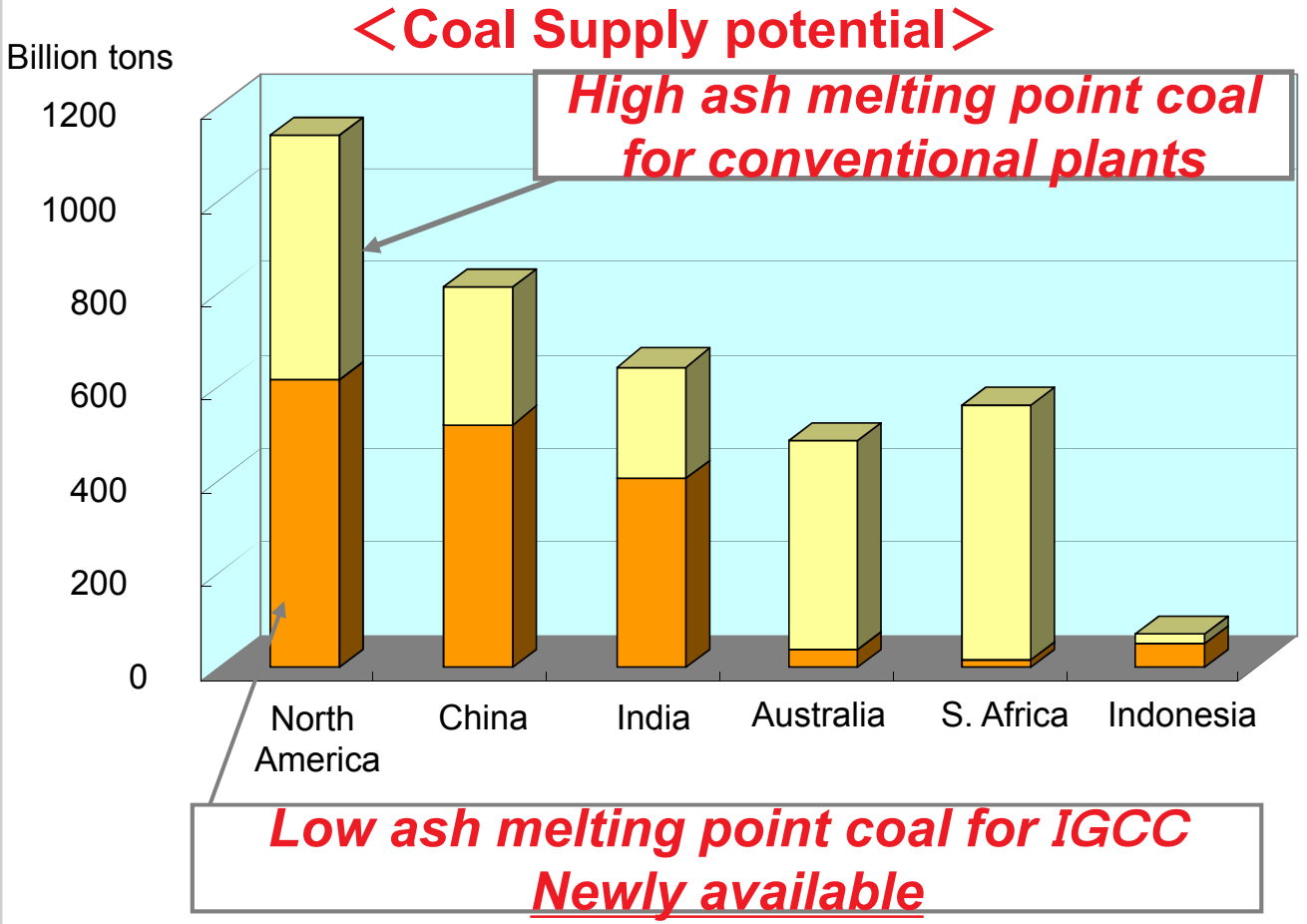
Advantages of IGCC (1/3)

❶ Efficiency improvement with increase in gas turbine temperature



Advantages of IGCC (2/3)

❷ Expansion of the available coal class (use of low ash melting point coal)



Advantages of IGCC (3/3)

❸ Reduction of the coal ash throughput （Approximately 50% reduction）

Coal ash

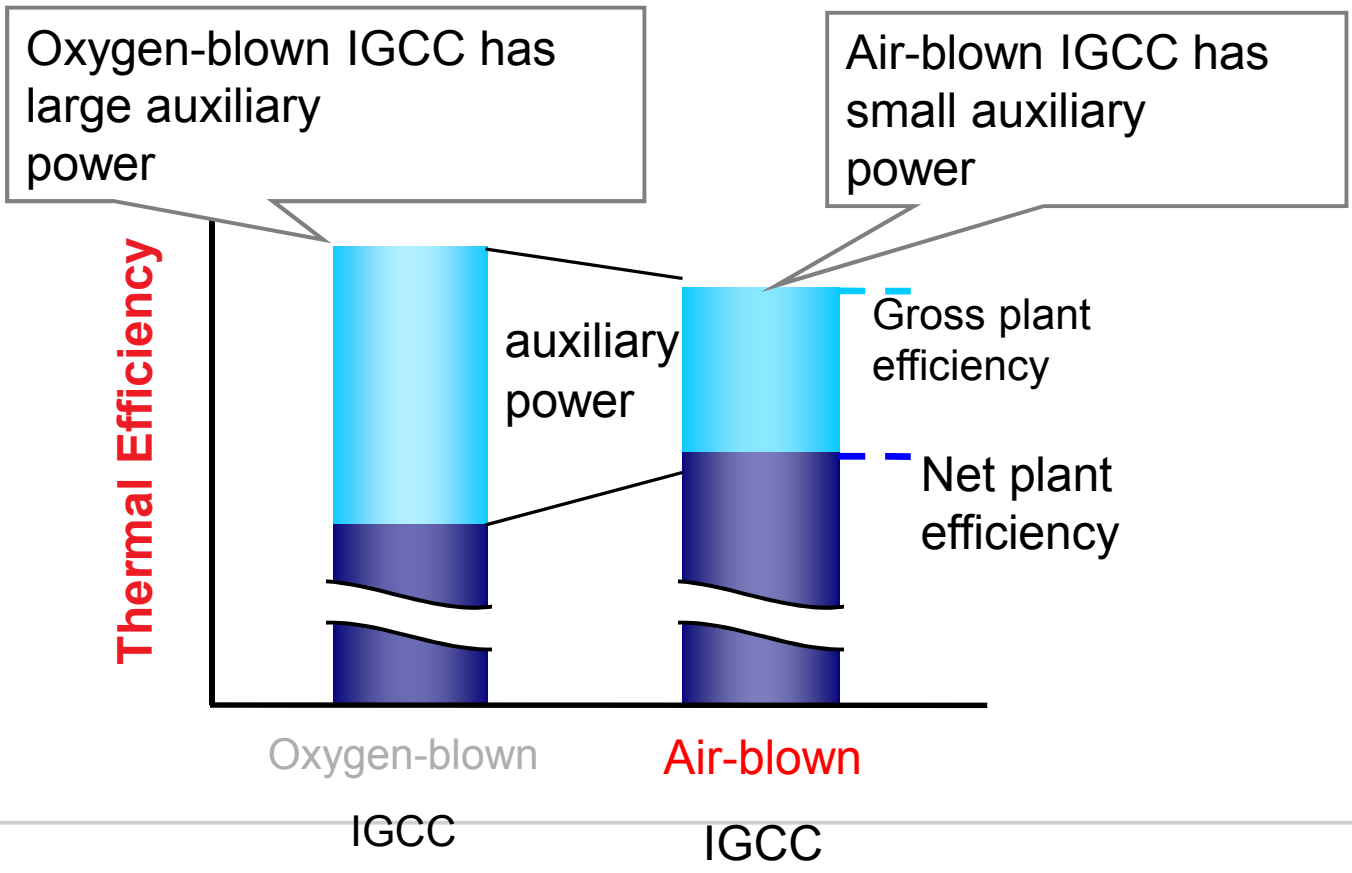
（conventional coal-fired plants）

Glassy slag

（IGCC）

TEPCO is the originated developer and leading company that has been operating Air-blown IGCC.

Thermal efficiency comparison between Air-blown IGCC and Oxygen IGCC



TEPCO's IGCC Technology – History and Experience

1983-1995
Process Development unit

2t/day of coal consumption

100 times

1991-1996
Pilot Plant

200t/day (Equivalent to 25MW)

8.5 times

2007-2013
Demo Plant※

※Commercialization from April, 2013

1700t/day, 250MW

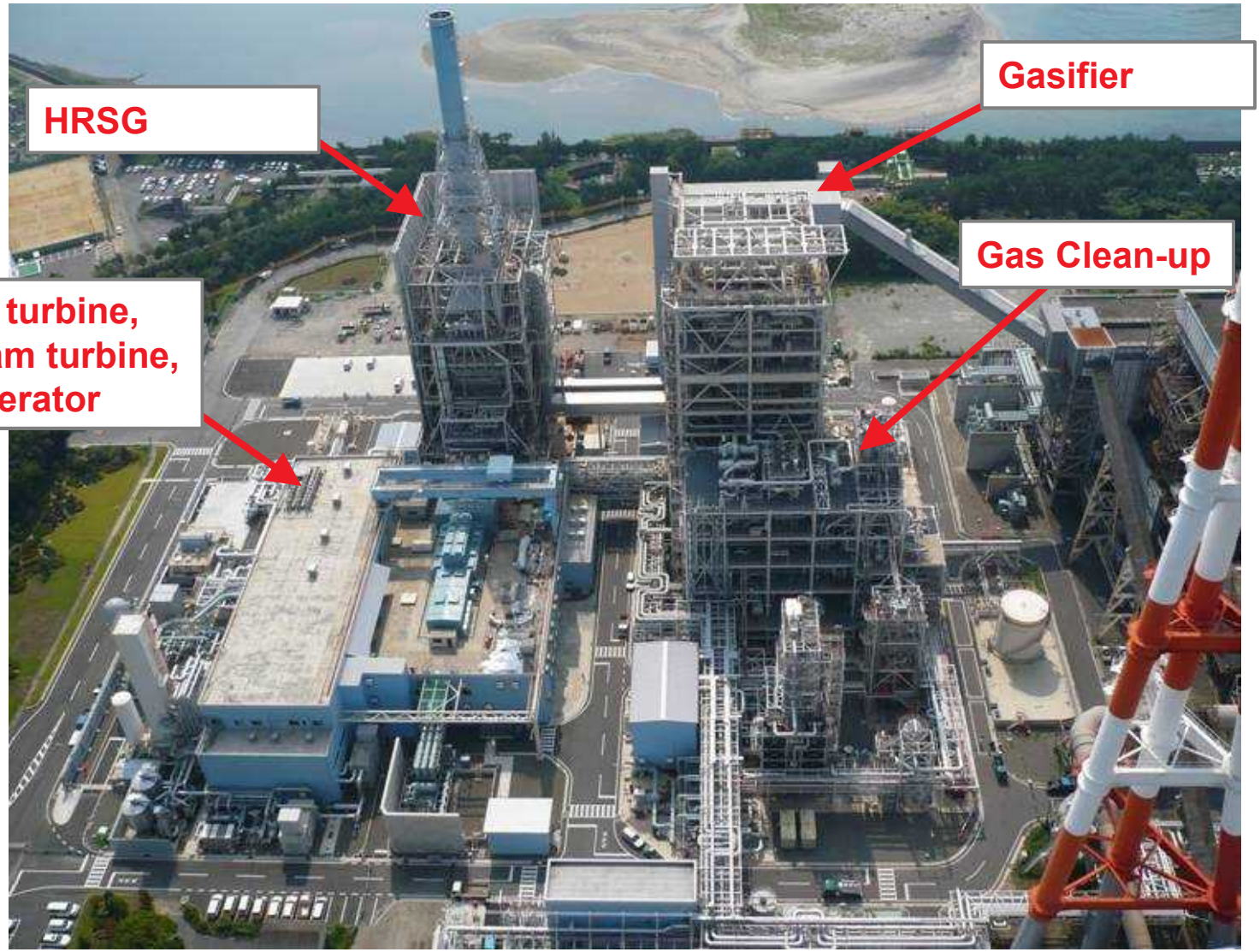
2 times

2020-
IGCC Commercial Plant (Hirono, Nakoso)

3700t/day, 540MW

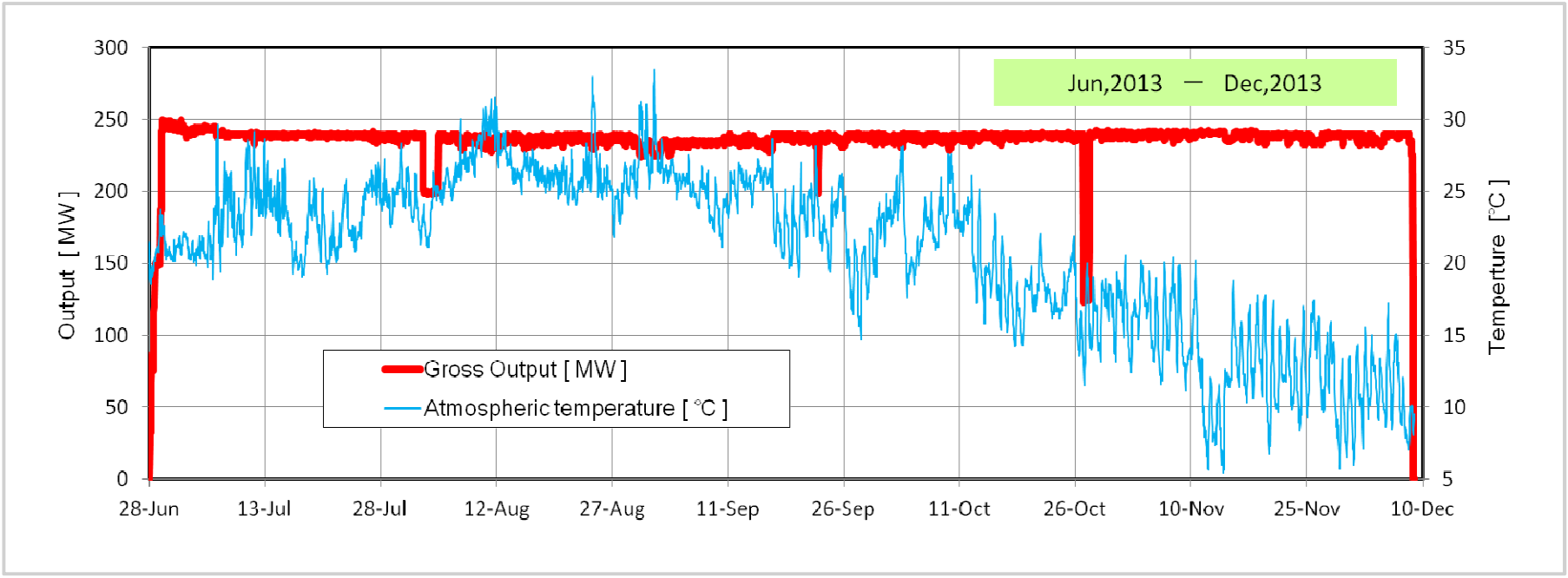
- Diversification for energy security
- Reduction of greenhouse gas emissions

Bird's-eye view of Nakoso IGCC demonstration plant



About 4,000h's continuous running time has been achieved in test

World record of IGCC Plant continuous operation : 3,917h



SOURCE: Joban Joint Power Co., Ltd.

Results of demonstration performance test in Nakoso

		Design Values	Results
Gross Output		250 MW	250.0 MW
Gas Turbine Output		128.9 MW	124.4 MW
Steam Turbine Output		121.1 MW	125.8 MW
Atmospheric Temperature		15 degC	13.1 degC
Net Efficiency (LHV)		42 %	42.9 % [1]
Syngas Composition	LHV	4.8 MJ/m^{3}N	5.2 MJ/m^{3}N
	CO	28.0 %	30.5 %
	CO2	3.8 %	2.8 %
	H2	10.4 %	10.5 %
	CH4	0.3 %	0.7 %
	N2etc.	57.5 %	55.5%
Environmental Performance (16%O2 Corrected)		<Target >	
	SOx	8 ppm	1.0 ppm
	NOx	5 ppm	3.4 ppm
	Particulate	4 mg/m^{3}N	<0.1 mg/m^{3}N

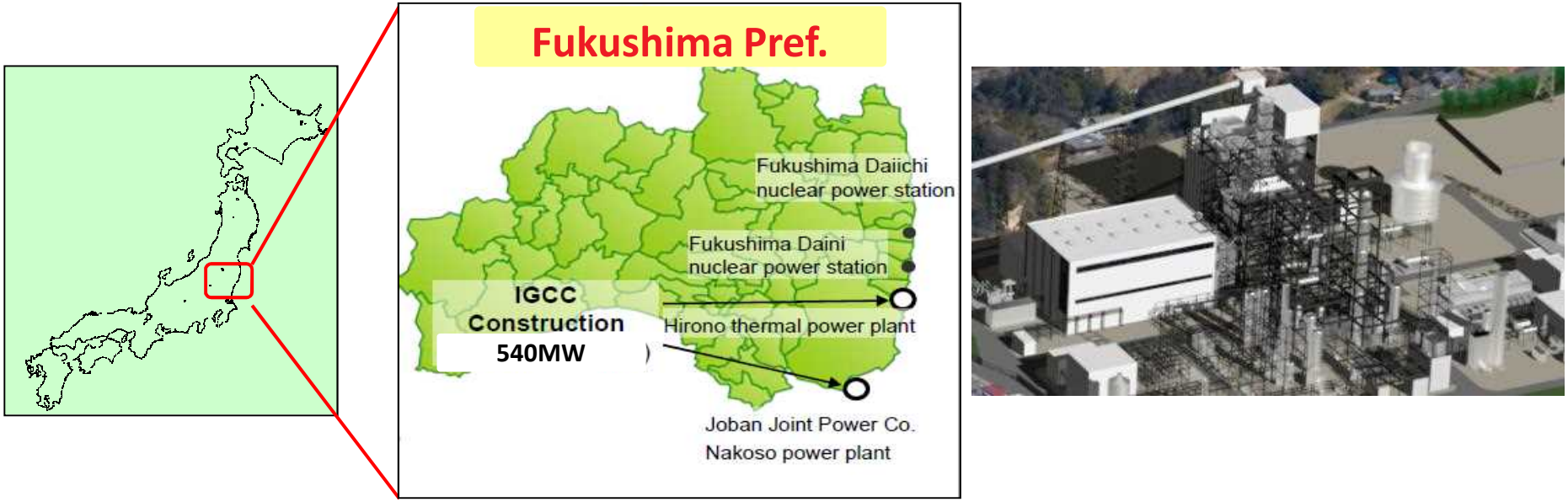
1 Correction value at 15 ºC

SOURCE: Joban Joint Power Co., Ltd.

Summary of IGCC Commercial Plant in Hirono and Nakoso

Principal specification	
Output	540MW
Gasifier	Air-blown &Dry Feed
Plant Efficiency	48%(LHV)

Project schedule
EIA (Environmental Impact Assessment)
May, 2014-
Operation Start(Scheduled)
July, 2020



We believe that our clean coal plants operational achievements contribute to high-quality infrastructure in Asia.

TEPCO

Contract：report@tky.ieej.or.jp