Clean Coal Demonstration Plant Of 250MW Air-Blown IGCC in Japan

日本的250MW空气吹入IGCC实证项目的进展情况

June 8, 2011

Tsutomu Watanabe

Clean Coal Power R&D Co., Ltd.

渡辺　勉

洁净煤发电研究所

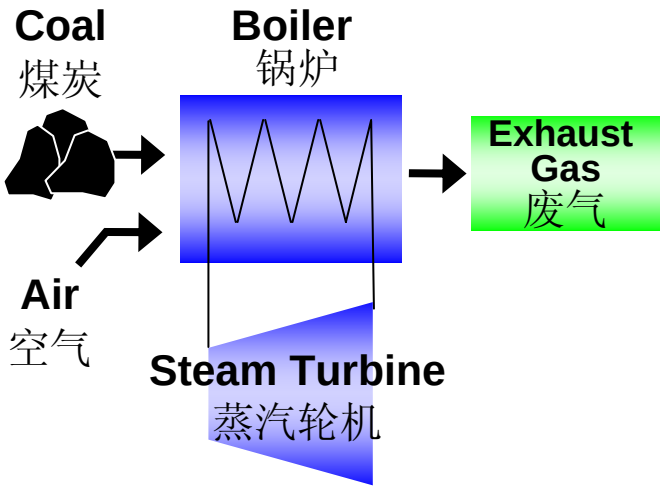
Location of demonstration plant（试验地点）

Located within the NAKOSO Power Station
of JOBAN JOINT POWER CO.,LTD.
建设在常磐共同电力公司 勿来火电厂内

System Feature of IGCC（IGCC的特征）

Conventional PCF
以往的燃煤火力发电

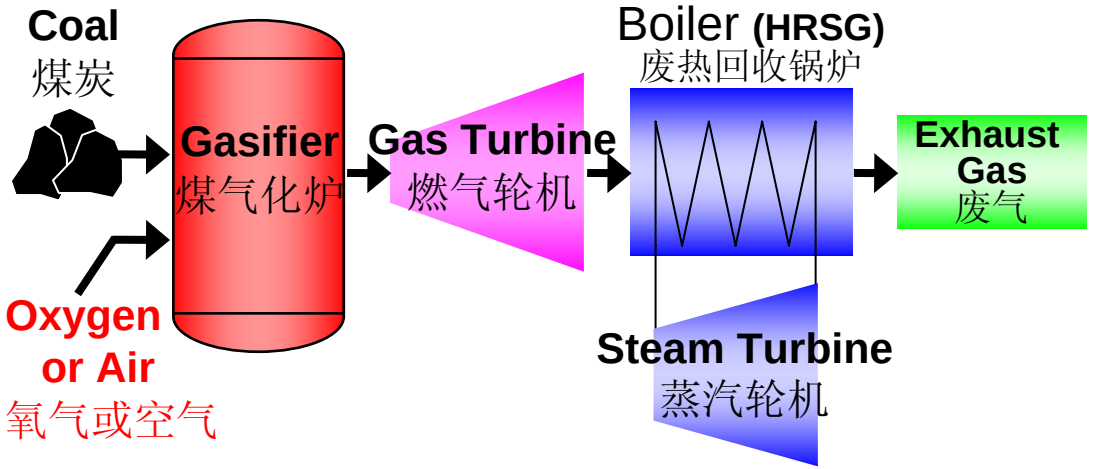
Boiler + Steam Turbine
锅炉＋蒸汽轮机



PCF : Pulverized Coal Firing

IGCC
煤气化联合循环发电

Boiler+Steam Turbine + Gasifier+Gas Turbine
锅炉＋蒸汽轮机+煤气化炉＋燃气轮机



IGCC : Integrated coal Gasification Combined Cycle

The thermal efficiency of IGCC is higher than that of PCF by using combined cycle power generation technology.
There are two types of IGCC, Oxygen-blown type and Air-blown type.

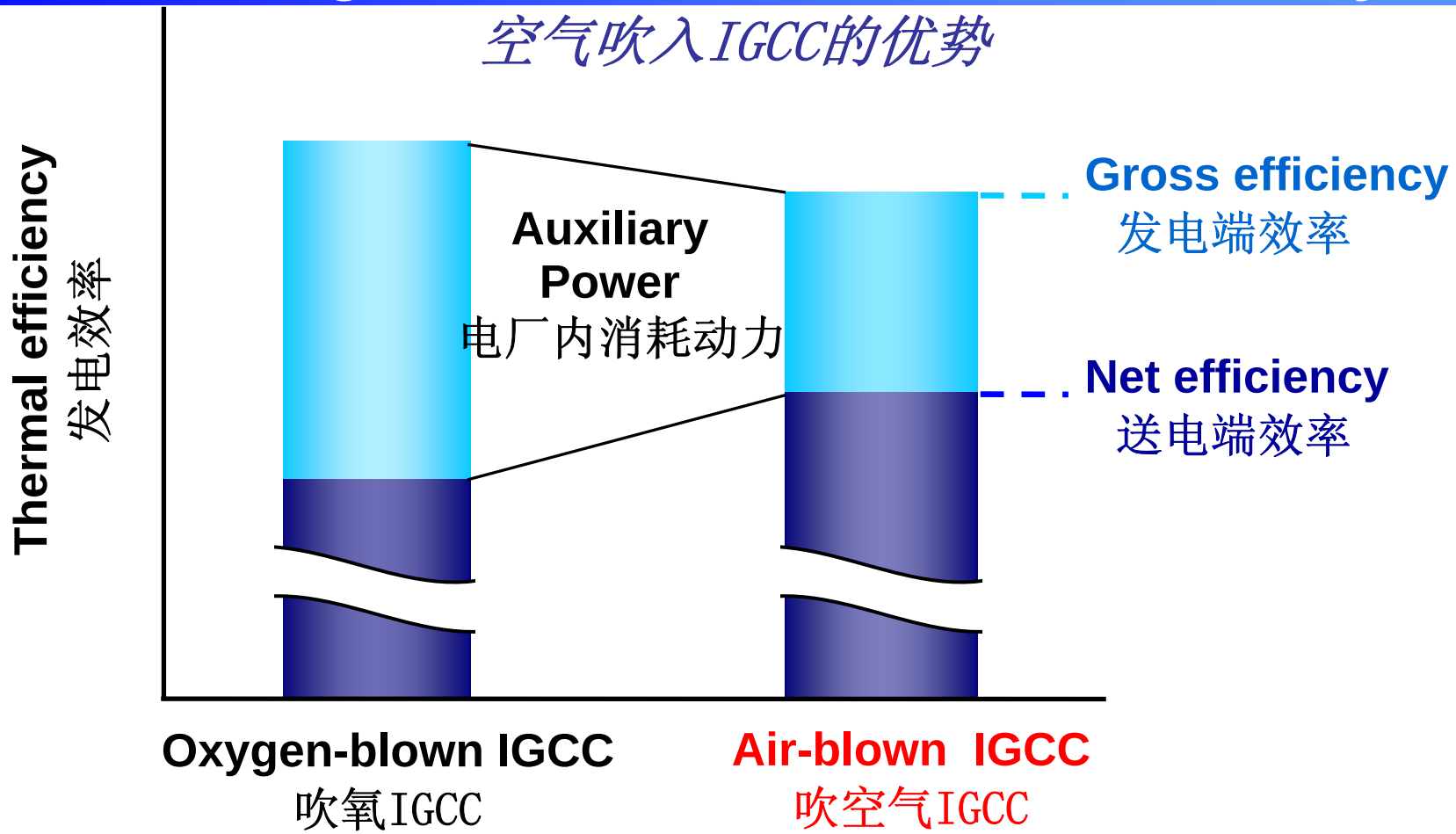
IGCC采用联合循环发电技术，与以往的煤炭火力发电相比，发电效率较高。
IGCC有氧气吹入和空气吹入的两种方式。

Coal IGCC Projects（煤炭IGCC项目）

Projects Site 各国的比较	Buggenum Netherland 荷兰	Puertollano Spain 普埃托利亚诺 西班牙	Wabash River USA 沃巴什河 美国	Tampa USA 坦帕电气 美国	Nakoso 勿来 Japan 日本
Gasifier type 煤气化炉形式	O_2-blown Dry-feed 吹入氧气 干式供煤 Shell	O_2-blown Dry-feed 吹入氧气 干式供煤 Penflo	O_2-blown Slurry-feed 吹入氧气 湿式供煤 E-Gas™	O_2-blown Slurry-feed 吹入氧气 湿式供煤 GE	Air-blown Dry-feed 吹入空气 干式供煤 MHI
Coal consumption 煤炭使用量	2,000 t/d	2,600 t/d	2,500 t/d	2,500 t/d	1,700 t/d
Gross output 发电端功率 (GT：燃气轮机)	284 MW 1,100degC-class	335 MW 1,300degC-class	297 MW 1,300degC-class	315 MW 1,300degC-class	250MW 1,200degC-class
Demonstration test start 实证试验的开始时期	Jan. 1994	Dec. 1997	Oct. 1995	Sep. 1996	Sep. 2007

Advantage of Air-blown IGCC in Efficiency

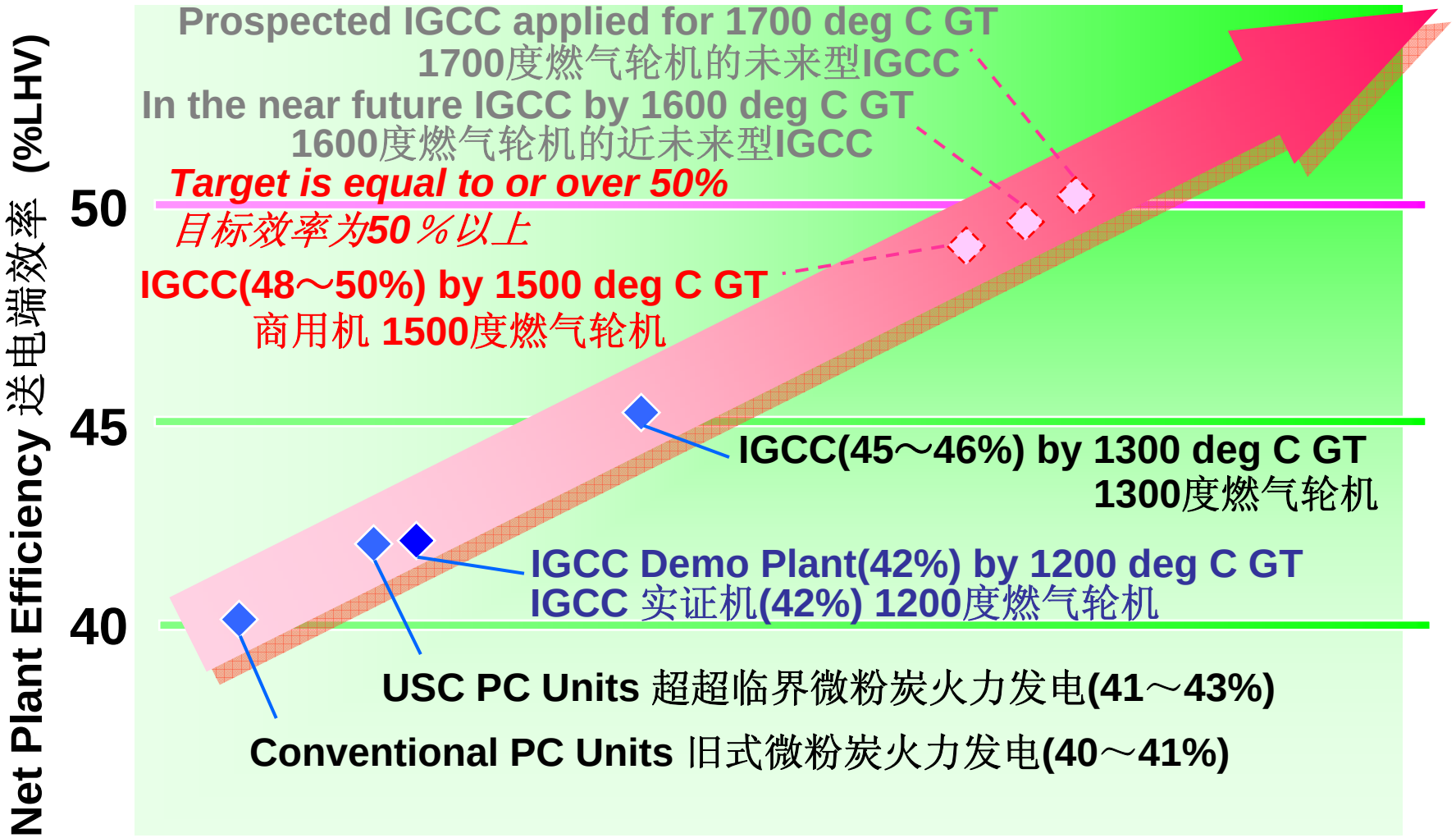
空气吹入IGCC的优势



Air-blown IGCC applied in Nakoso is expected to realize high thermal efficiency compared with oxygen-blown IGCC.

勿来采用的吹空气IGCC方式与吹氧IGCC相比，预计可以实现更高的热效率。

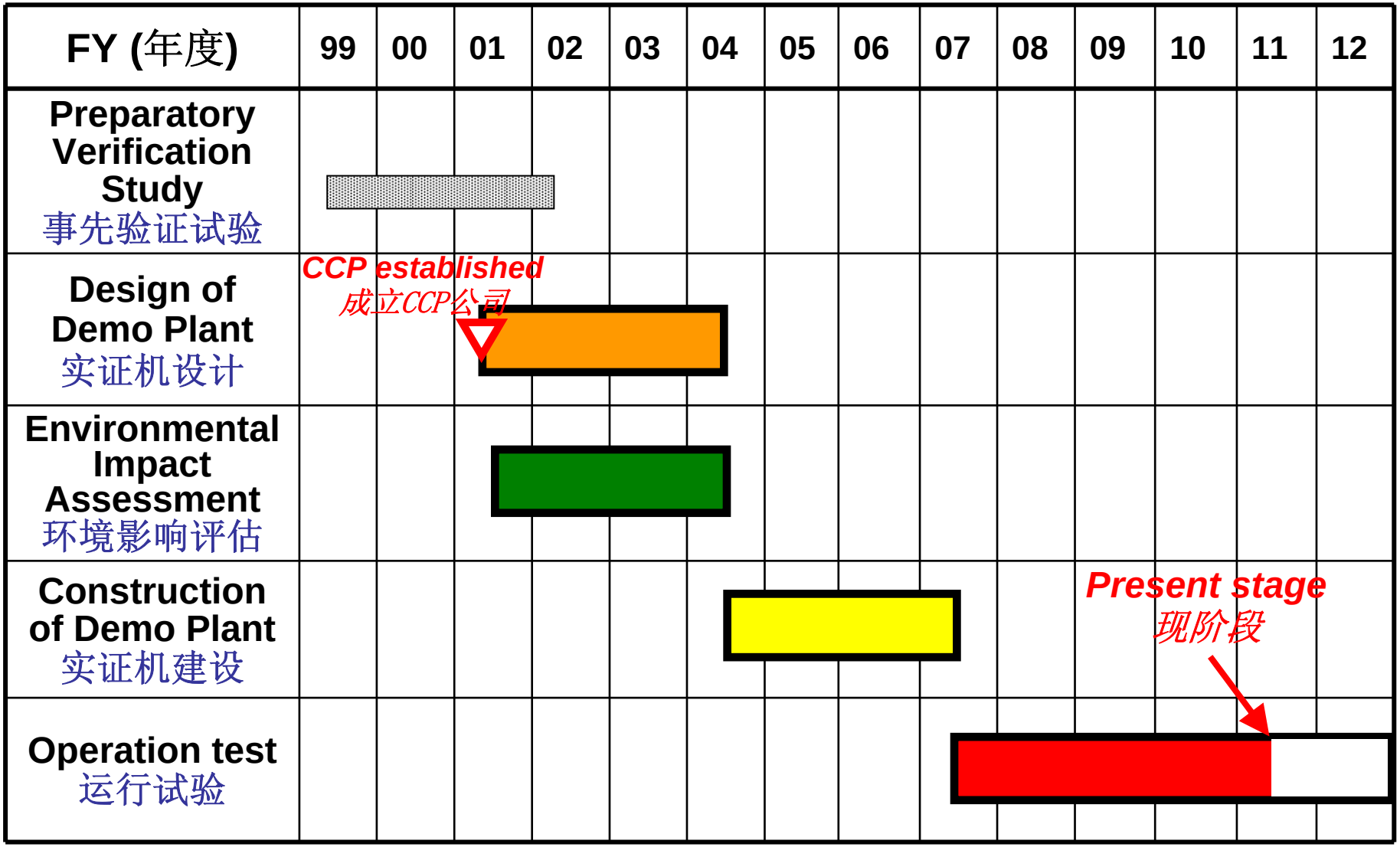
Thermal efficiency Improvement（效率改善）



Thermal efficiency improves with the advancement of high temperature gas turbine combined cycle technology.

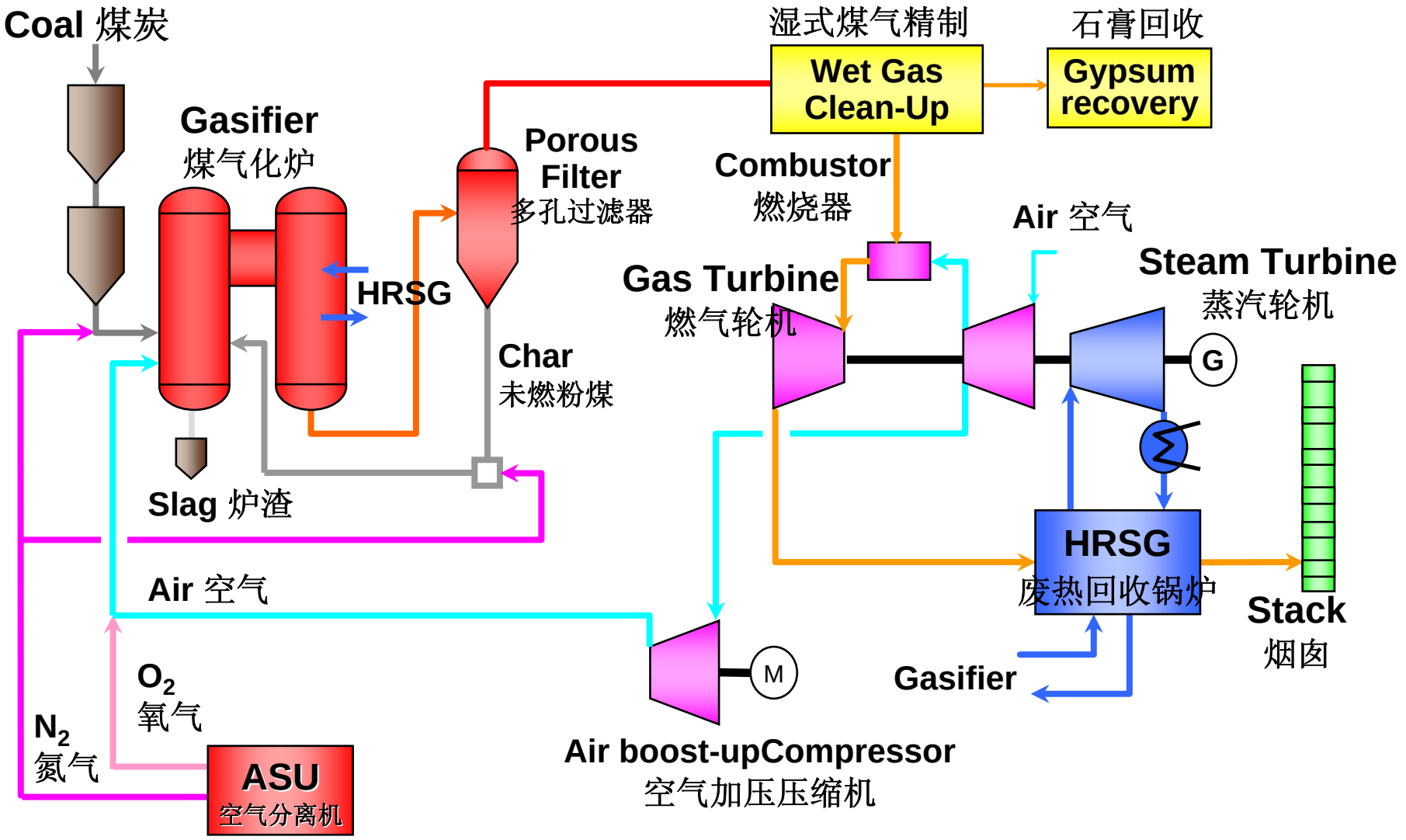
随着高温燃气轮机联合循环技术的进步，发电效率会进一步提高。

Demonstration Project Schedule（实证计划概要）



Operation test was started from September, 2007.
运行试验始于2007年9月。

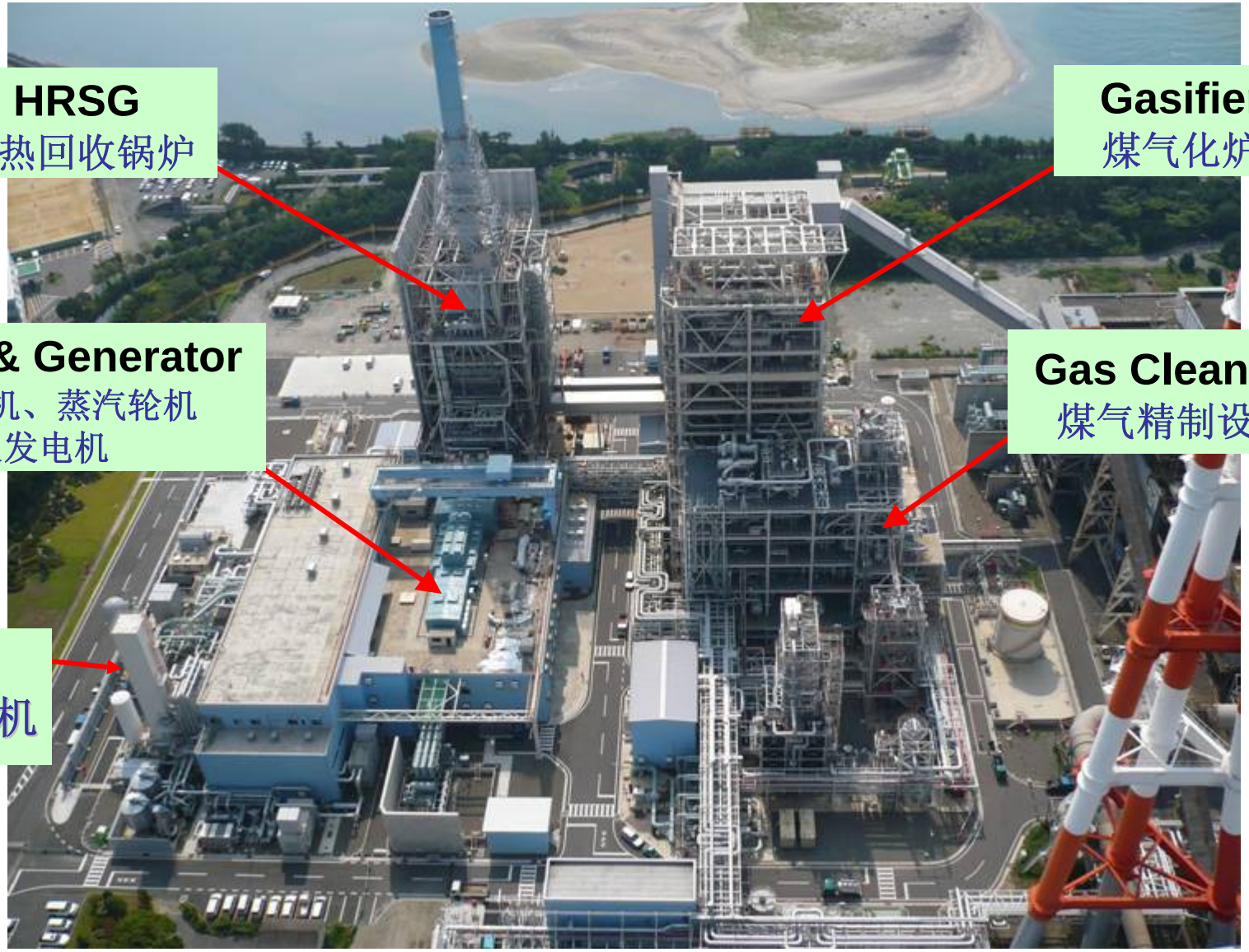
Schematic diagram of Demonstration Plant （系统图）



Purpose of ASU is to produce N_2 to pressurizing and transporting Coal and Char, and the ASU is very small.

空分的目的是用于生产对煤炭和未燃粉煤进行加压或搬运时使用的氮气，所以空分装置的体积非常小。

Bird's-eye view of IGCC Demonstration Plant（俯瞰图）



Specification of Nakoso IGCC（勿来IGCC的规格）

Capacity 容量	**250 MW gross**		
Coal consumption 煤炭使用量	**approx. 1,700 metric t/day 约1,700 吨/天**		
System 方式	**Gasifier 煤气化炉**	**Air-blown & Dry Feed 空气吹入＆干式供煤**	
	Gas Treatment 煤气精制	**Wet (MDEA) + Gypsum Recovery 湿式(MDEA)+石膏回收**	
	Gas Turbine 燃气轮机	**1200 deg C-class (50Hz)**	
Efficiency (Target Values) 目标热效率	**Gross 发电端**	**48% (LHV)**	**46% (HHV)**
	Net 送电端	**42% (LHV) ***	**40.5% (HHV)**
Flue Gas Properties (Target Values) 排气目标值	**SOx 硫氧化物**	**8 ppm**	**(16%O_2 basis)**
	NOx 氮氧化物	**5 ppm**	
	Particulate 粉尘	**4 mg/m^{3}N**	

*** While target net thermal efficiency is 48～50% in commercial IGCC plant applying 1500 deg C class gas turbine, 1200 deg C-class gas turbine was adopted to reduce the capacity of the Demo plant as a research facility.**

IGCC商用机拟使用1500度的燃气轮机，送电端效率可以达到48～50％。

IGCC实证机作为研究用设备，为了降低示范电厂容量，使用了1200度燃气轮机。

Outline of Demonstration Test Program 实证试验的项目和目标

No.	Item 项目	Goal 目标
1	**System Safety and Stability** 安全性和稳定运行	**Safe and stable operation to be verified during start-up, operation and shutdown** 验证设备启动、运行、停机时的安全性和稳定性。
2	**Reliability** 可靠性	**2,000 hours continuous operation (equivalent to 3 months operation)** 实现2000小时连续运行（相当于3个月）。
3	**Fuel Flexibility** 炭种适用性	**Several types of coals to be used for the design of future commercial IGCC** 为了今后设计商用机，确认各类炭种的稳定运行。
4	**High Efficiency** 高效率性	**Achievement of target efficiency** 实现目标热效率。
5	**Durability** 耐久性	**Durability of components and auxiliaries to be examined by inspection after long-term operation** 运行5000小时后进行点检，验证设备仪器的耐久性。
6	**Economy** 经济性	**Evaluation of economy of commercial IGCC by the results of construction, operation and maintenance of Demonstration Plant** 根据实证机的建设、运行及维护结果，评估IGCC商用机的经济性。

Summary of Targets & Achievements 目标&成就总结

	Targets 目标	Results 结果	评价Status of Achievement	Future plan未来计划
Safe and Stable Operation	250MW	250MW	Achieved 达到	—
Long Term Continuous Operation	>2000hr	2039hr	Achieved 达到	—
Net Thermal Efficiency	>42% (LHV basis)	42.9%	Achieved	—
Carbon Conversion Rate	>99.9%	>99.9%	Achieved	—
Environmental Performance	SOx <8ppm NOx <5ppm Dust <4mg/m3N	1.0ppm 3.4ppm <0.1mg/m3N	Achieved 达到	—
Coals	Bituminous (B) Sub-bituminous (SB)	Chinese (B) USA (SB) Indonesian (SB)	Achieved 达到	Increase in coal Types 扩大煤种
Start-up Time	<18hr	15hr	Achieved	—
Minimum Load	50%	36%	Achieved 达到	Decrease in minimum load
Load Change Rate	3%/min	3%/min	Achieved	—
Durability & Reliability & Maintainability	Evaluate during 5000hr test	5013hr in one year, No serious damage	Almost achieved 基本达到	Maintenance interval Evaluation, Higher availability
Economy estimation	Less than or equal to PCF power generation cost	Construction cost and operation cost was estimated.	Under study 评价中	Maintenance cost Evaluation etc.

No.1: System Safety and Stability 系统的安全性和稳定性（1）

Result of plant performance test in March 2008 性能试验的结果

	Design values 设计值	Results 试验结果
Atmospheric Temperature 空气温度	15degC	13.1degC
Gross Output 发电端功率	250 MW	250.0 MW
Gas Turbine Output 燃气轮机功率	128.9 MW	124.4 MW
Steam Turbine Output 蒸汽轮机功率	121.1 MW	125.8 MW
Net Efficiency (LHV) 送电端效率	42 %	42.4 %(42.9%)
Syngas LHV 煤气发热量	4.8 MJ/m^{3}N	5.2 MJ/m^{3}N
Composition 组成成分 CO	28.0 %	30.5 %
CO2	3.8 %	2.8 %
H2	10.4 %	10.5 %
CH4	0.3 %	0.7 %
N2和其他	57.5 %	55.5%
Environmental Performance 环境性能	<Target 目标值>	
(16% O2 Corrected) SOx	8 ppm	1.0ppm
NOx	5 ppm	3.4 ppm
Particulate 粉尘	4 mg/m^{3}N	<0.1 mg/m^{3}N

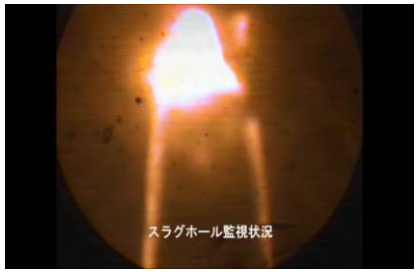
Full load (250MW) operation was achieved in March 2008. Stable and continuous full load operation as well as design plant performance was confirmed.
2008年3月达到额定负荷(250MW)，确认了在额定负荷状态下的稳定运行和设计性能。

No.1: System Safety and Stability 系统的安全性和稳定性(2)

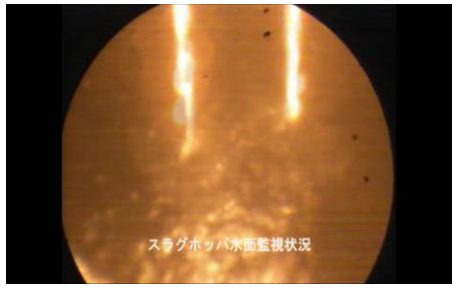
Example : Development of the slag condition monitoring system
开发煤渣状况监测系统

Slag hole blockage has never been experienced.
The flow of molten slag is constant, keeping the gasifier in very stable condition.
迄今为止没有发生过煤渣孔堵塞的现象。
煤渣稳定地落下，可以证明煤气化炉在非常稳定的状态下运行。

<Stable streams of molten slag 煤渣的稳定落下>

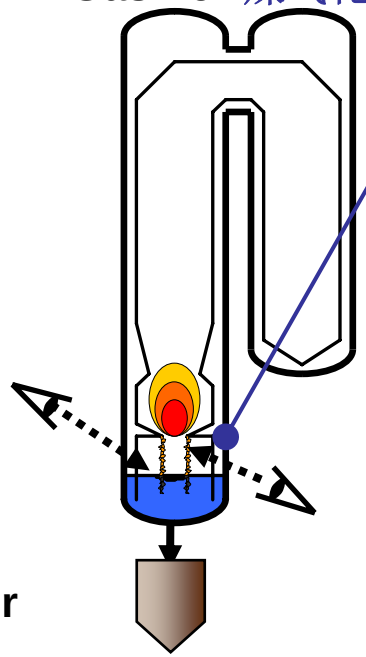


Slag hole view from lower side
煤渣从煤渣孔落下

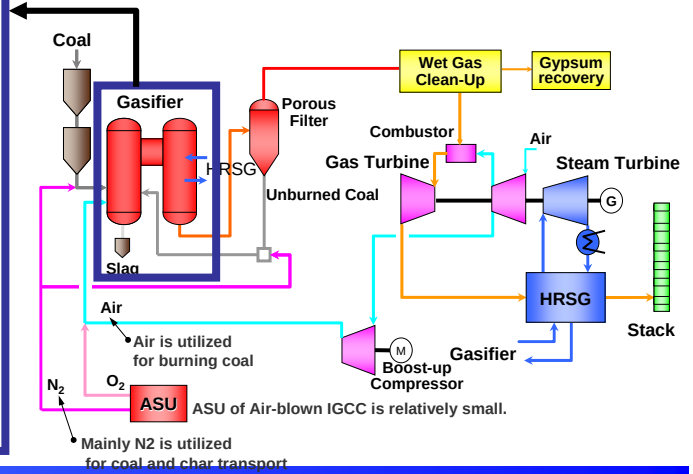


Surface of the water in slag hopper
煤渣落入煤渣仓的水中

Gasifier 煤气化炉



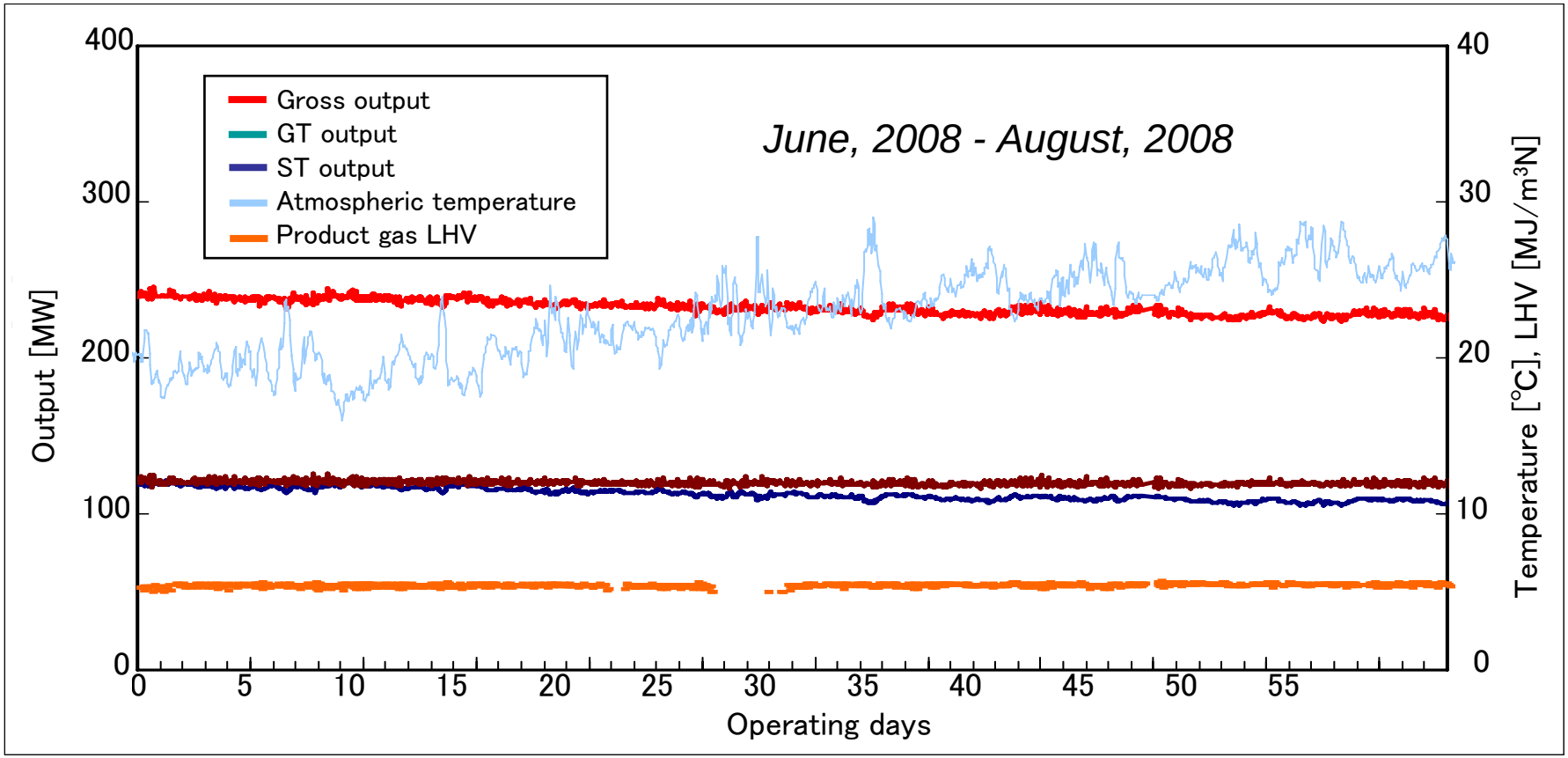
Slag condition monitor
>Image analysis device
>Sound monitoring system
煤渣落下监测装置
>图像分析装置
>音响监测装置



No.2: Reliability 可靠性

Trend data of long term reliability test conducted in 2008 summer

长期可靠性验证试验过程的经时变化数据（2008年夏天）



- Capability of stable power generation at rated power was confirmed.
  已经确认可以在额定负荷状态下稳定运行。
- 2000hours continuous operation was achieved in the first year.
  在试验运行的第一年就实现了2000小时连续运行。

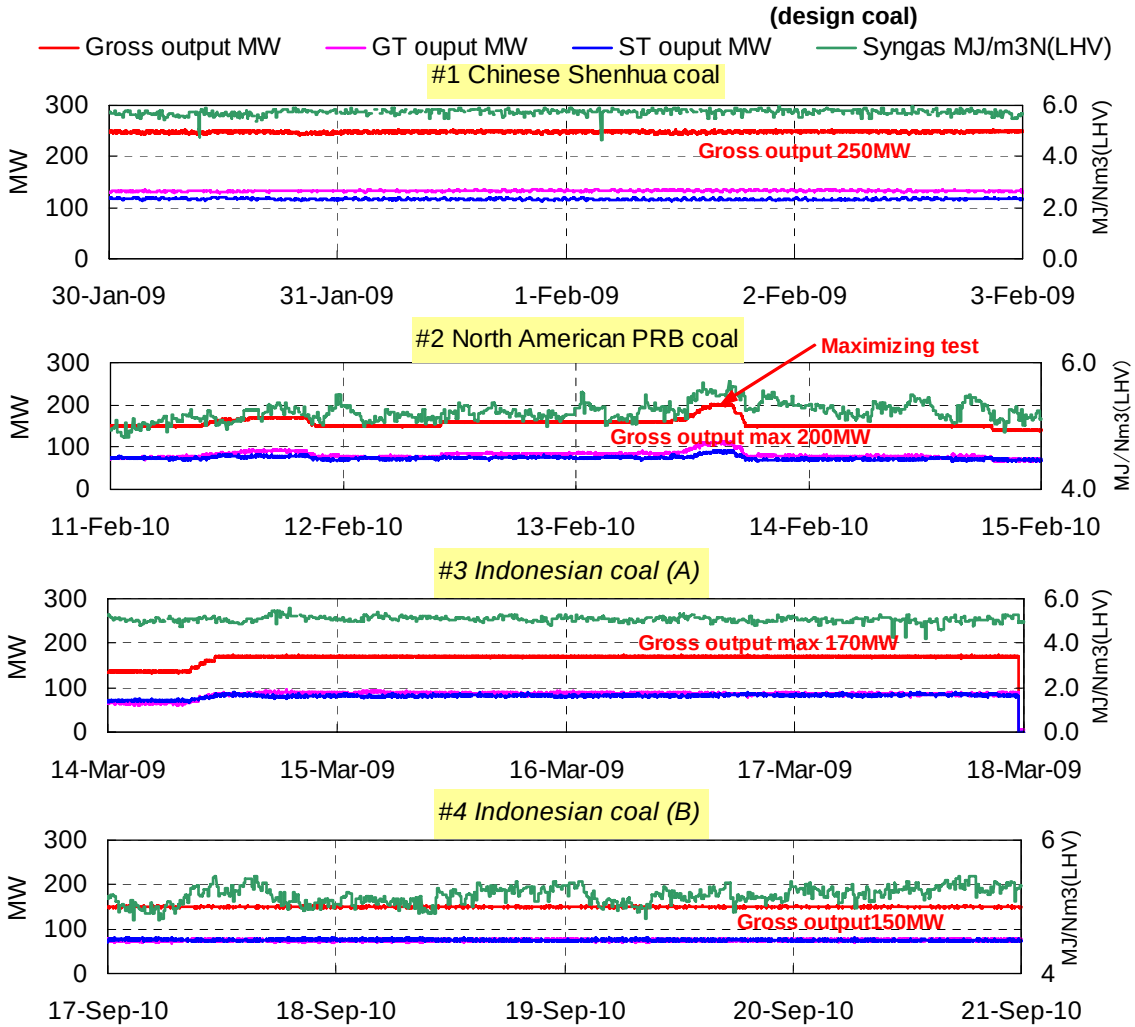
No.3: Fuel Flexibility 炭种适用性（1）

Properties of coal used in 2009, 2010 使用炭的性状（2009- 2010年）

		#1 (design coal) Chinese Shenhua 中国神华炭 Jan, 2009	#2 North American PRB 北美PRB炭 Feb, 2010	Indonesian Coal 印度尼西亚炭	
				#3 (A) Mar, 2009	#4 (B) Sep, 2010
Gross Calorific Value 热量 (air dry)	kJ/kg	27,120	26,670	26,370	23,010
Total Moisture 含水量 (as received)	wt%	15.4	25.3	21.7	29.7
Total Sulphur 含硫量 (air dry)	wt%	0.25	0.39	0.25	0.12
Proximate Analysis 工业分析(air dry)					
Inherent Moisture 固有水分	wt%	7.5	8.0	7.9	17.1
Fixed Carbon 固定碳素	wt%	51.3	47.4	45.2	37.8
Volatile Matter 挥发成分	wt%	32.3	39.1	42.5	41.6
Ash 灰分	wt%	8.9	5.5	4.4	3.5
Fusibility of Coal Ash 灰熔融性					
Flow Temperature 流动温度	deg C	1225	1420	1260	1230

Bituminous coal and sub-bituminous coal have been used at the Demo Plant.
实证机既可以使用烟煤（#1）也可以使用次烟煤（#2～4）。

No.3: Fuel Flexibility 炭种适用性(2)；Test result 试验结果



Stable power generation using various coals was confirmed.

确认了不同煤种都可稳定发电。

Other coal types are going to be tried . *其它煤种正在验证.*

No. 4: Durability 耐久性

The durability test was executed from June, 2009 to June, 2010.
>Total operating hours reached 5,013hours *年运行时间达**5,013**小时*

- Some shut-downs during durability test were experienced mainly by the auxiliary facilities' incidents as shown below.
***耐久性**试验时经历**了一些停机过程, 主要原因是下述的一些辅机事故造成.*

-Their causes were categorized as initial trouble mode.*按始发状态分类.*

-Countermeasures were applied and no recurrence afterwords.
-采取措施后无再发现象.

-Result of inspection on major facilities after the durability test showed no unexpected deterioration or damage, still further inspection is under way while checking the earthquake damage.
***耐久性**试验后主设备检查结果显示无非预期老化和损坏,正在检查地震造成损坏*

Item of Incident 事故项目	System
①Leakage from Gland packing of Rotary Valve below Porous Filter 阀门密封漏气	Char Recycle System
②Trip of Slag Discharge Conveyor 排渣传送带故障停运	Slag Treatment System
③Leakage of Coal from the Pulverized Coal Collector 粉煤集煤器漏煤	Pulverized Coal Supply System
④Leakage of No.2 Extraction Air Cooler Tube 2号抽气冷却器泄漏	Gasifier Air Supply System
⑤Leakage of Char Gasifier Burner Cooling Tube 气化炉未燃煤燃烧器冷却管泄漏	Gasifier

No. 5: Economy 经济性

Evolution on economy of commercial IGCC is under way based on the results of construction, operation and maintenance of demonstration plant.*经济性正在评价中*

Power generation cost/kWh =

construction cost + operating cost + maintenance cost +carbon-emissions tax

①IGCC > PCF

②IGCC < PCF

③IGCC ≒ PCF

④IGCC < PCF

Economy estimation 经济评价

①Construction cost is to be almost 20% higher than conventional PCF at commercial stage. *商用阶段建设费比常规要高约**20%**。*

Cost-reduction in facility is under study such as reducing the components, reflecting the various test results. *正在研究降低设备成本, 如减少部件,反映各种试验结果*

②Fuel cost mainly consisting operating cost could be almost 20% lower than PCF at commercial stage because of higher efficiency.*燃料费用可降低约**20%**。*

③Maintenance cost is under study while conducting maintenance work in the plant. *维修费用正在研究中。*

Next year, we will conduct maintenance outage by law, which would bring about the information for the estimation. *明年将进行法定检修，会带来可供评价的有益信息。*

No.5: Economy (Example of the required space)经济性(例占地面积)

Space of IGCC Demonstration plant
IGCC示范电厂占地面积

250MW

Space of IGCC Commercial plant
商用IGCC电厂占地面积

About 1140MW
(570MW ×2 unit)

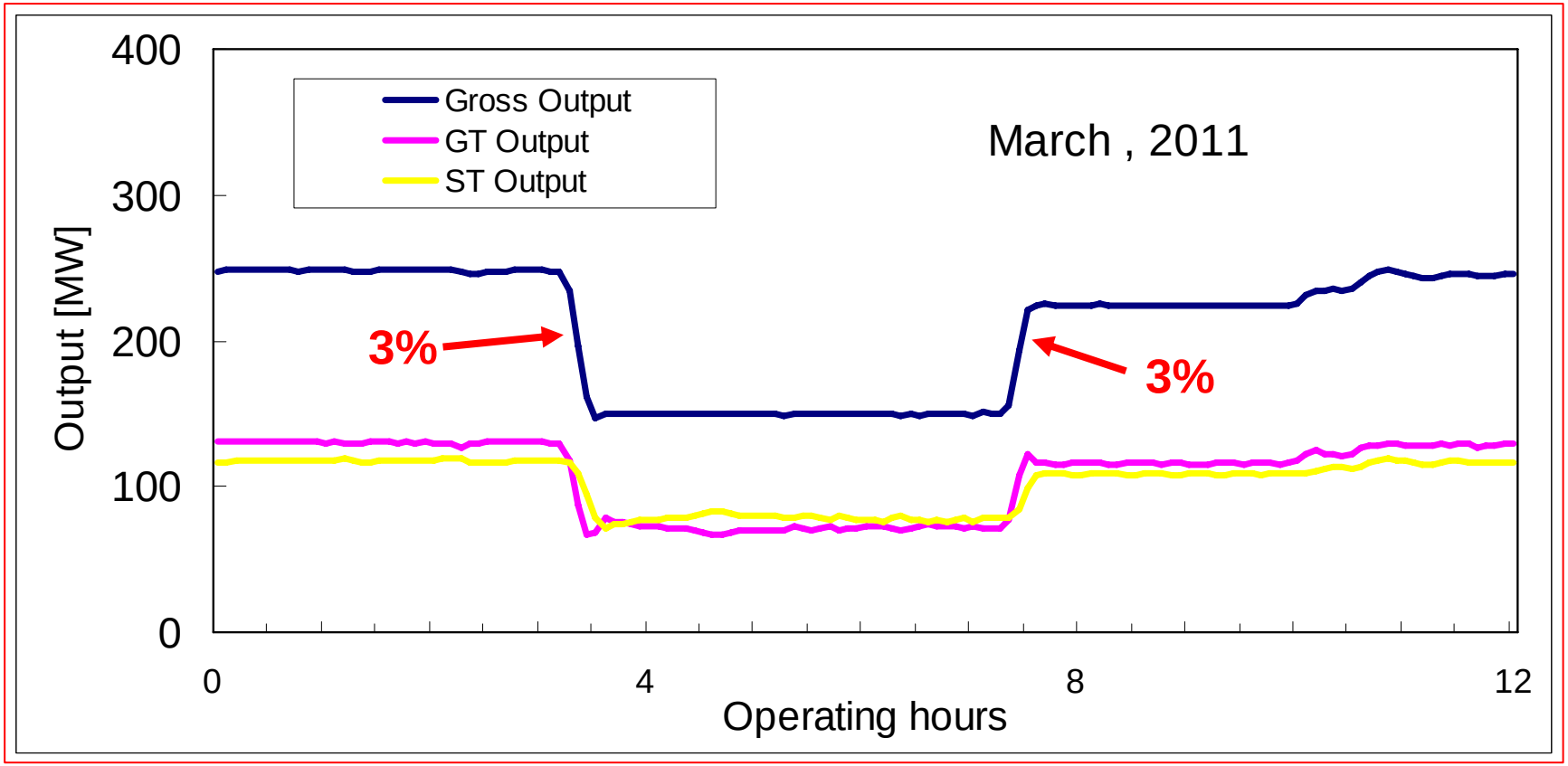
Space of PCF plant
常规燃煤电厂占地面积

1000MW
(1000MW ×1 unit)

The space of IGCC at commercial stage is expected to be equal or smaller than that of conventional PCF plant.
商用阶段IGCC电厂的占地面积预期等于或小于常规燃煤电厂

No.6: Other item : operational capability 运行能力

Load Change Rate 负荷变化率



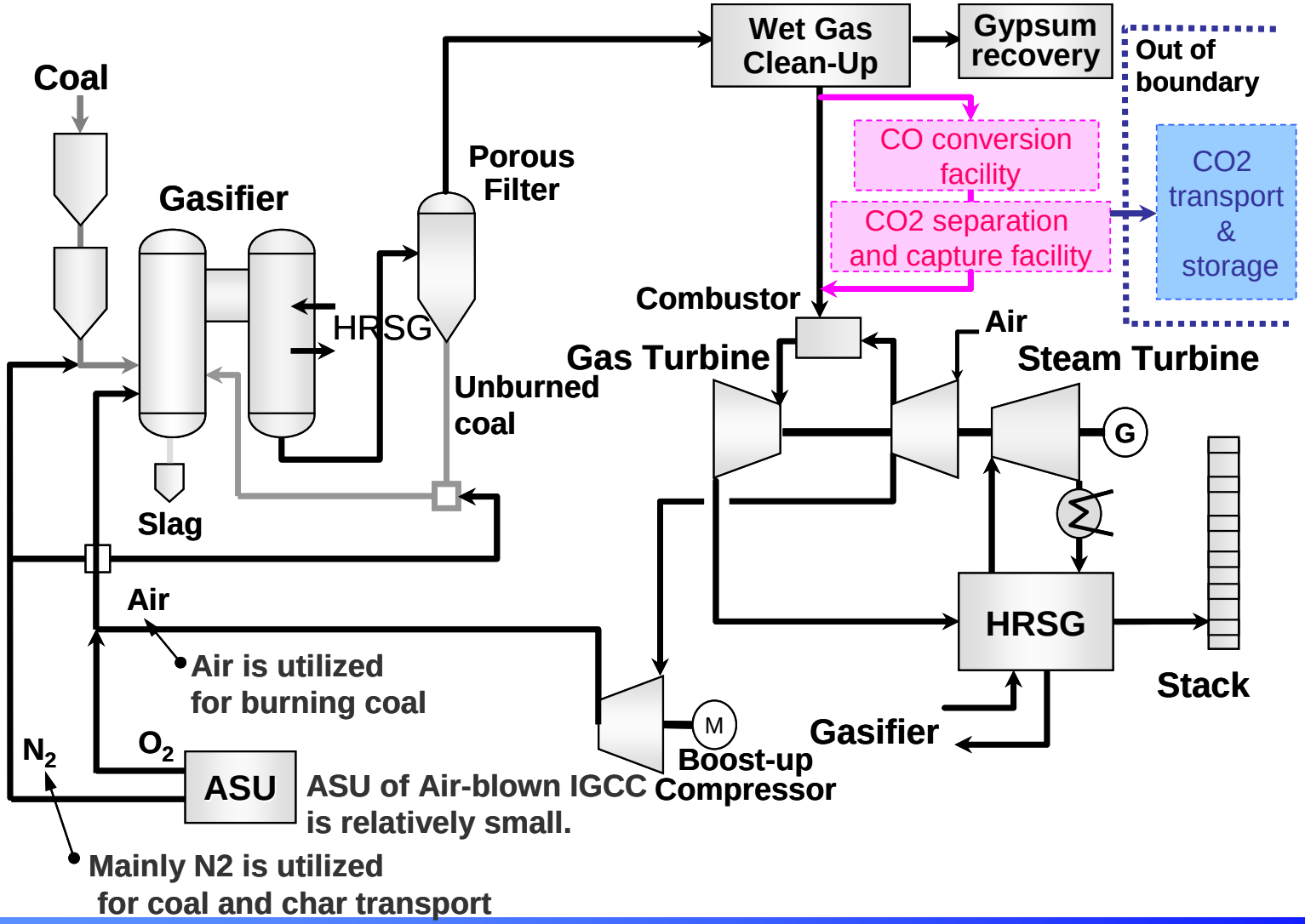
Load change rate of 3%/min which is compatible with conventional PCF in Japan, was realized by adjusting the operation parameters.

通过调整运行参数，负荷变化率已经达到了日本常规火电厂的水平3%/分。

New Subject under consideration 正在考虑的新课题

Japanese government is now conducting feasibility study of CCS application utilizing the Nakoso IGCC plant.

日本政府目前正在开展利用勿来IGCC电厂，开展CCS实证试验的可行性研究。



Concluding Remarks 结束语

- ***Demonstration test has been proceeded almost on schedule. Net thermal efficiency(42.9%) higher than design value was confirmed, and 2000hr continuous operation test and 5000hr durability test was finished.***

  目前，我们的实证试验基本按计划进展。送电端效率已经超过设计的数值，实现了2000小时连续运行，并完成了5000小时的耐久性运行。通过实证试验，我们积累了诸多经验，以期用于IGCC商用机。

- ***Carbon dioxide Capture and Storage (CCS) is in the spotlight recently. Although CCS is one of effective countermeasures against global warming, the costs of CCS are still quite high and applicable locations for storage are to be limited.***

  最近CCS（Carbon dioxide Capture and Storage、二氧化碳回收与存积）越发受到关注。ＣＣＳ虽然是应对地球变暖问题的有效措施之一，但其成本还很昂贵，而且用于储存的地点受到限制。

- ***Air-blown IGCC is to be a practical coal-fired power generation system with the highest net thermal efficiency at this time.***

  空气吹入ＩＧＣＣ是现阶段可以商用的、且送电端发电效率最高的煤炭火力发电系统。将这一技术用于改建陈旧的低效燃煤火力厂，可以有助于防止地球变暖以及节约资源，可谓是比较现实，有效的解决办法。

Nakoso IGCC incurred severe damages mainly because of the tsunami

勿来IGCC电厂受到的严重损坏主要来自于海啸的冲击

(strong jolts did not bring about fatal damages to the facilities)

*(强**震没有**给设备带**来致命**损**坏**)*

Repair work is under way to resume the generation by middle of this July

Accident in Hukushima No1 Nuclear Plant 福岛第一核电站事故

IGCC plant is located about 50km south to the Nuclear Plant

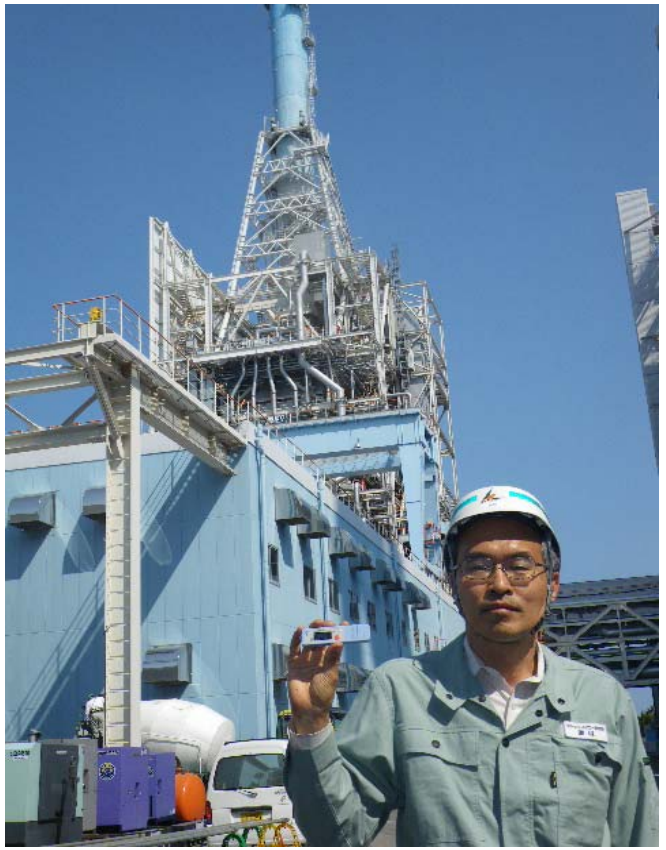
We continuously monitor the radiation level

勿来位于核电站南50km处，我们在连续监测放射线水平，到目前为止，几乎对IGCC区域没影响

So far, almost no effect around IGCC area

(The value is around 0.1 μ sievert/hour)

Radiation indicator
放射线检测仪



Attachment 1: Information on Clean Coal Power R&D Co., Ltd

附件 1: 关于洁净煤发电研究所

1. **Date of Establishment** 创立日期： **June 15, 2001** 2001年6月15日

2. **Business Activities** 事业内容：

Test and Research of IGCC through Design, Construction and Operation of Demonstration Plant.

使用实证设备对煤气化联合发电技术的设计、建设和运行进行试验和研究。

3. **Shareholders** 股东名单：

Hokkaido EPCo 北海道电力株式会社
Tohoku EPCo 东北电力株式会社
Tokyo EPCo 东京电力株式会社
Chubu EPCo 中部电力株式会社
Hokuriku EPCo 北陆电力株式会社
Kansai EPCo 关西电力株式会社
Chugoku EPCo 中国电力株式会社
Shikoku EPCo 四国电力株式会社
Kyushu EPCo 九州电力株式会社
Electric Power Development Co. 电源开发株式会社

4. **IGCC Development Coalition** IGCC 开发联盟：

Above EPCOs + Central Research Institute of Electric Power Industry (CRIEPI)

上述电力公司 + 电力中央研究所（CRIEPI）

Attachment 2: Development history of air-blown IGCC in Japan

空气气化IGCC技术在日本的发展历史

Demonstration plant

CCP R&D Co.,Ltd.
1700t/d 250MW (2007-2010)

Pilot plant

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

Process development unit

CRIEPI-MHI 2t/d(1983-1995)

Confirmation test plant

MHI Nagasaki 24t/d (1998-2002)

CRIEPI: Central Research Institute of Electric Power Industry