January, 2013

Reliable & Proven Design for Circulating Fluidized Bed Boiler CFB Power Plant by Sumitomo Heavy Industries Co., Ltd.

1. Sumitomo Heavy Industries in brief
2. Principals of CFB technology
3. Reliable design
4. Track Records
5. Modular CFB Boiler

1. Sumitomo Heavy Industries Co., Ltd. in brief

Corporate Profile

Head Office: Tokyo, Japan

President: Yoshinobu Nakamura

Founded: November 20, 1888

Incorporated: November 1, 1934

Capital: JPY 30,872 million (as of March 31, 2012)
= **MNT : 463,075 million**(*JPY1 = MNT15)

Number of Employees: Consolidated, 18,139 (as of March 31, 2012)

Annual Revenue: Consolidated, JPY 624,100 million (for the 2011 Fiscal Year)
= **MNT : 9,361,500 million** (*JPY1 = MNT15)

Sumitomo Group in brief

A Member of Sumitomo Group

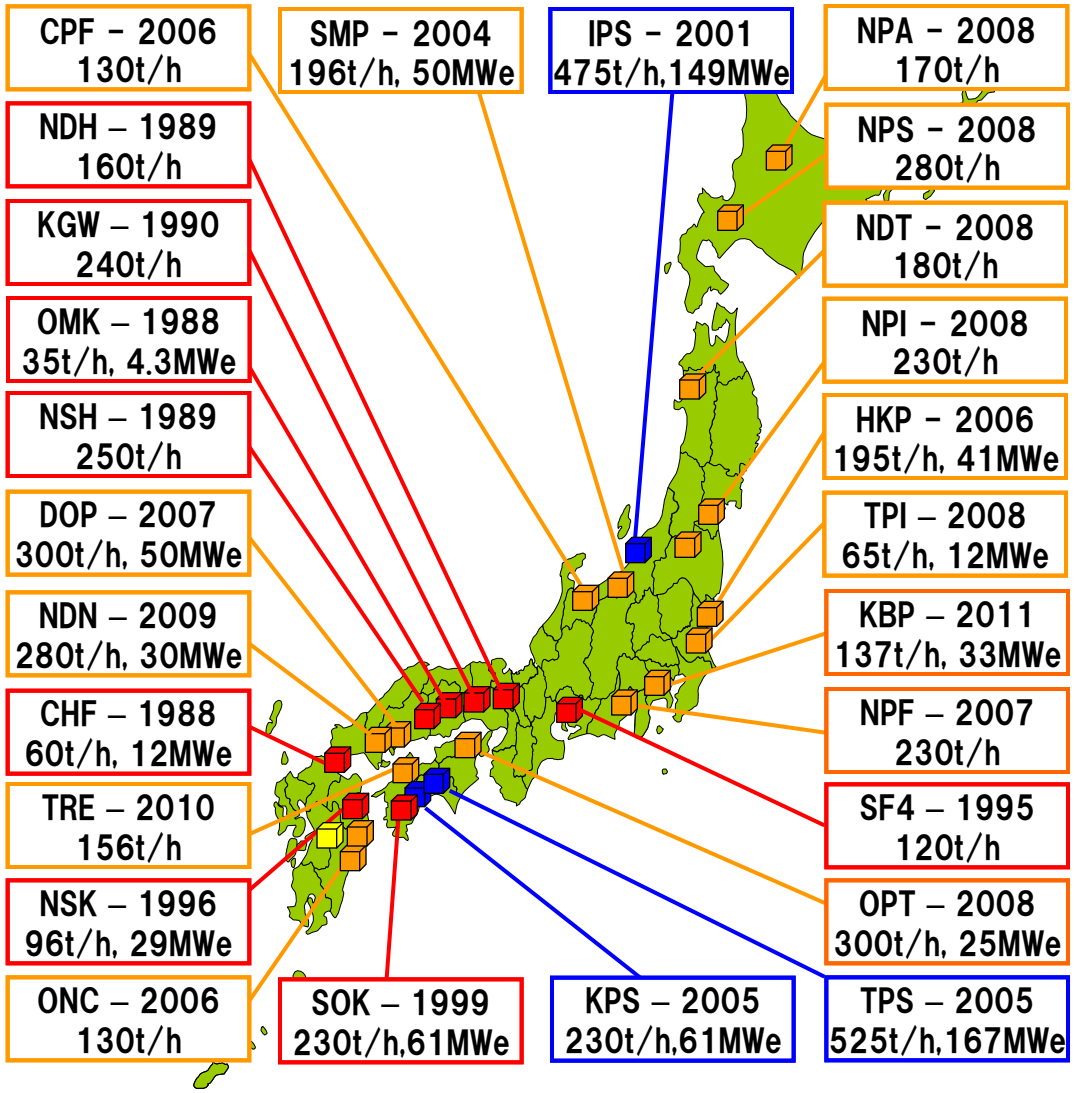
・Sumitomo Heavy Industries(SHI)	--Industrial Machinery & Engineering
・Sumitomo Chemical	--Fine Chemicals
・Sumitomo Metal	--Steel
・Sumitomo Mitsui Banking Co.	--Banking & Financing
・Sumitomo Corporation	--Corporation
・Sumitomo Electric	--Electrical/Optical Cable
・NEC	--Electronics
・Sumitomo Osaka Cement	--Cement & Ceramics
・Sumitomo Warehouse	--Logistics
・Mazda	--Automobile
・Asahi Beer	--Brewery
・Meidennsha	--Heavy Electrical
・Nippon Sheet Glass	--Glass
・Sumitomo Mitsui Construction	--General Construction

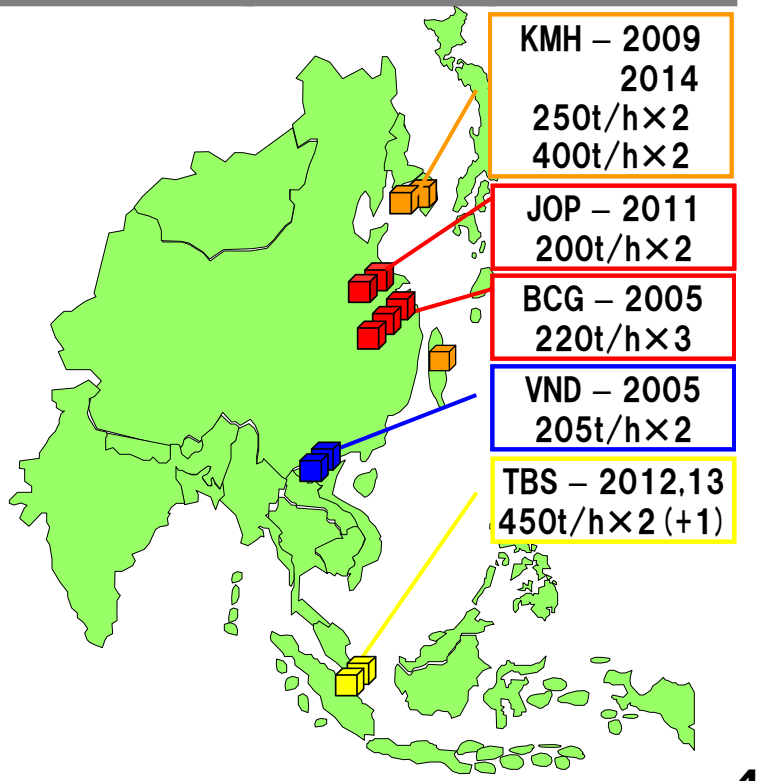
Total 47 companies, 266 thousand employees

Delivery Record of SHI's CFB Power Plant

- Coal Fired Cogeneration × 15
- Coal Fired IPP × 5
- Biomass / Waste Fuel × 20
- Biomass / Waste Fuel (Under Construction) ×3

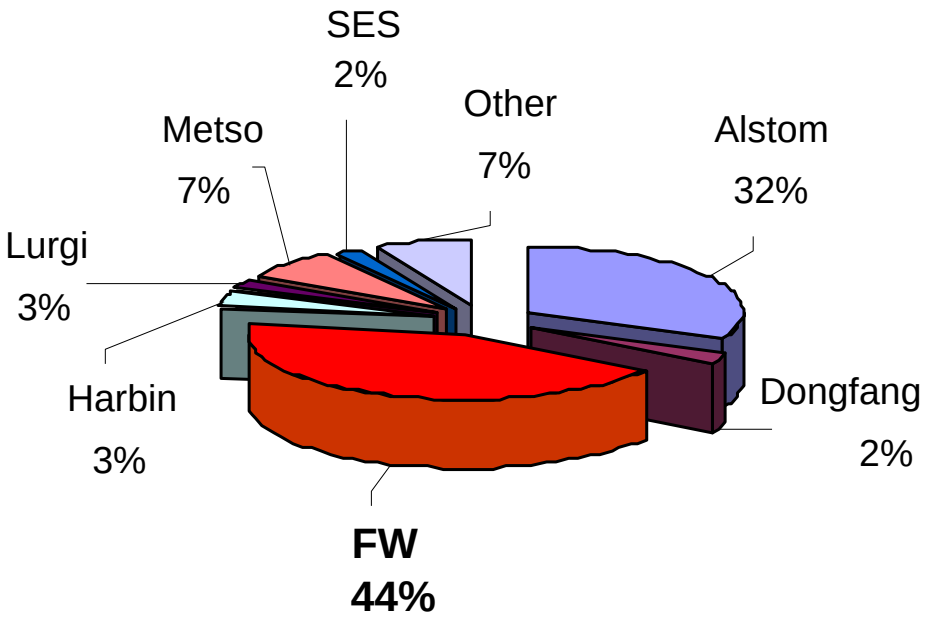
Operation Year	JAPAN	Other Countries
-1990	5 units	0 units
1991-2000	3 units	0 units
2001-2010	17 units	9 units
2011-	4 units	5 units
Total	29 units	14 units





Foster Wheeler CFB Market Share

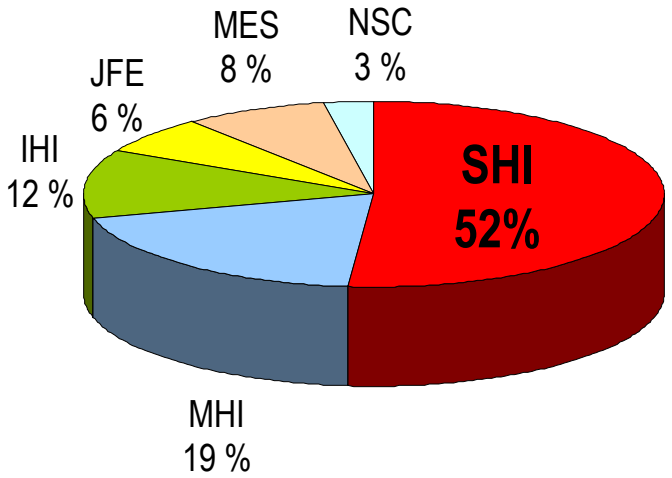
Foster Wheeler
CFB Market Leader in the world



Total 25.1 GWe, 260 Units

(1996-2006)

Sumitomo - Foster Wheeler
CFB Market Leader in Japan



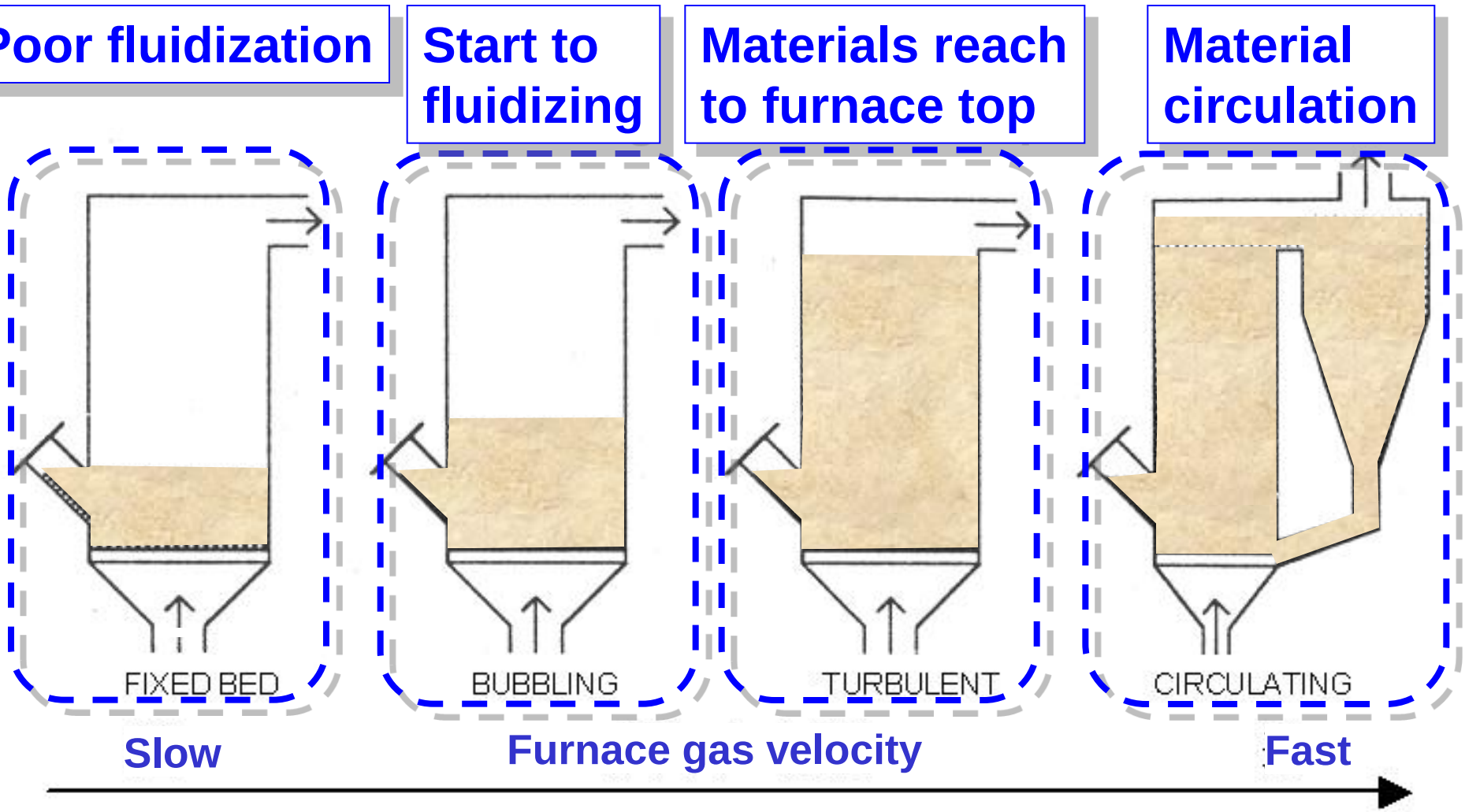
TOTAL 52 units

Source: 2007 McCoy Power Reports, All boiler types and sizes, Excludes domestic orders provided by domestic suppliers in China, India, Japan, and S. Korea, Other includes suppliers with less than 2% market share, Market Share based on MWe

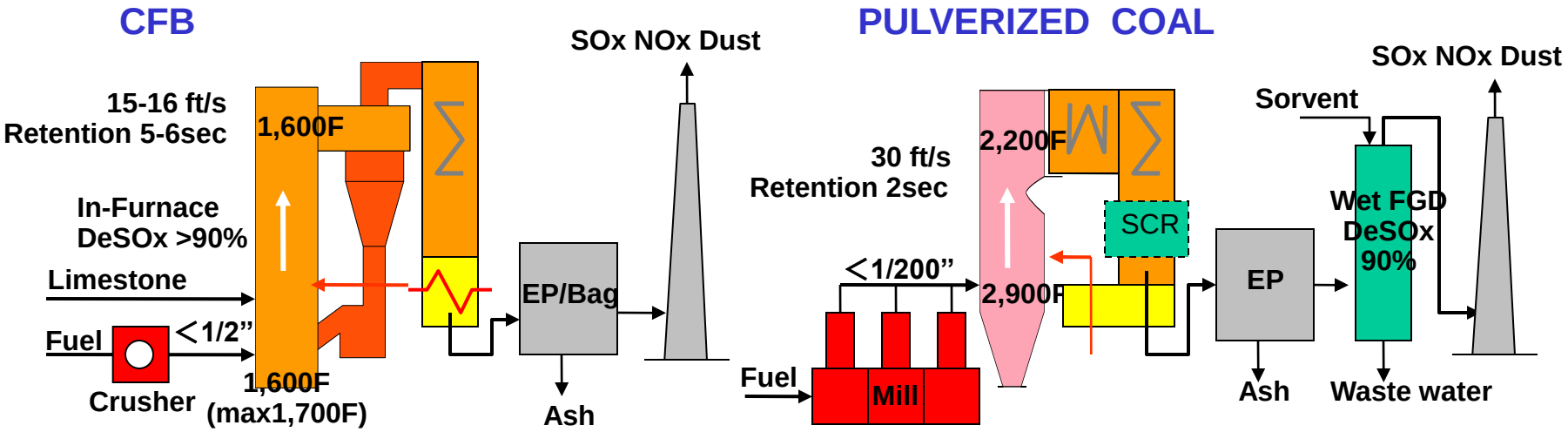
2. Principals of CFB technology

Bed Material circulation

Material behavior in each flue gas velocity phase



CFB Advantage against PC Boiler



FUEL Flexibility	**Low Volatile, High Ash** **Low Melting temp, Low Grindability**	**High Volatile, Low Ash** **High Melting temp, High Grindability**
Coal	Anthracite–Bituminous--Lignite	High Cost Bituminous Only
Waste	Biomass, TDF, RPF, Sludge	Not Available
SOx Emission	**No DeSOx System** Limestone Injection Available(DeSOx>90%)	**Required Wet Scrubber FGD** Not Available
NOx Emission	**No DeNOx System** SNCR(Urea Injection) Available (DeNOx>50%)	**Requires SCR** Not Available
Maintenance	**No Pulverizer, Slugging, Wet FGD** **Less Wearing, Long Life Refractory**	**Required for Pulverizer, DeSlugging FGD, (SCR)**
Installation Cost	**Even to PC with FGD**	

3. Reliable design

3-1. CFB pilot combustion test -Test facility

CFB PILOT TEST FACILITY OVERVIEW

SHI Niihama Laboratory
Ehime pref. , Japan

-Outline-

Thermal input 1 MWth Furnace φ600 x 20mH

-All fuels are tested by the pilot facility before actual commercial boiler design

-Every single fuel & co-combustion technology are developed by means of this facility

-More than 100 combustion tests were held in past 9 years

3. Reliable design

3-2. CFB pilot combustion test –Getting Information

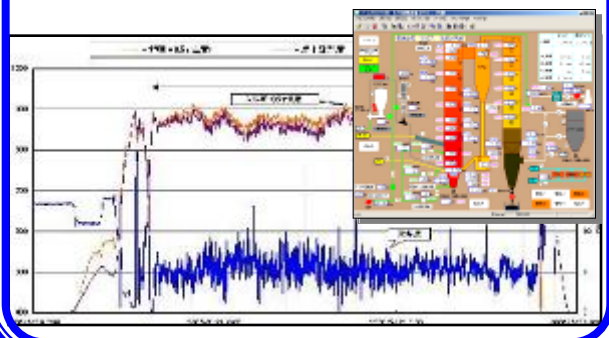
CFB PILOT COMBUSTION TEST

After basic lab. Analysis
SHI perform pilot test all PJ

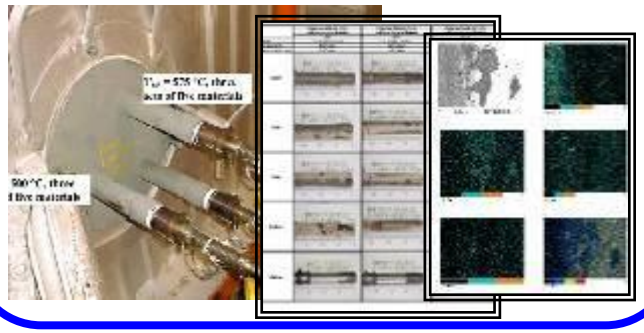
Real Fuels

Fouling and fluidization

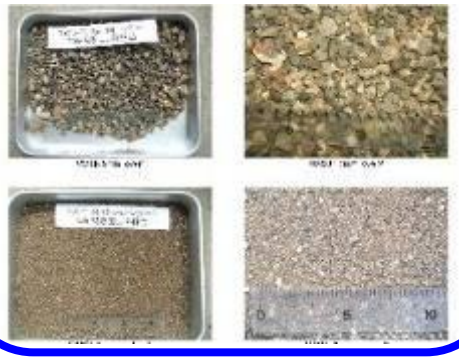
Combustion and emission



Corrosion information



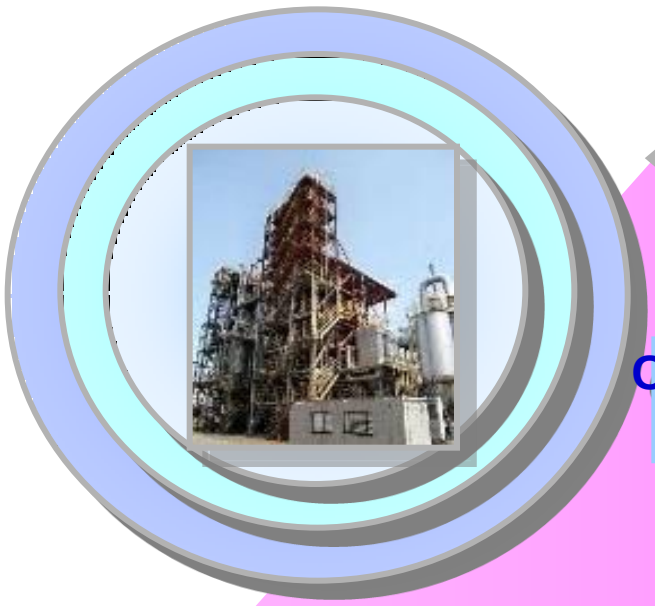
Ash property



3. Reliable design

3-3. Design feed back – Together with Customers

SHI cares Customers continuously through Service Work.
Operation Advise and Service with Customers



Reflect to Design

Commercial plant operation data

Combustion test results with real fuel

After service

Operation years

Delivery

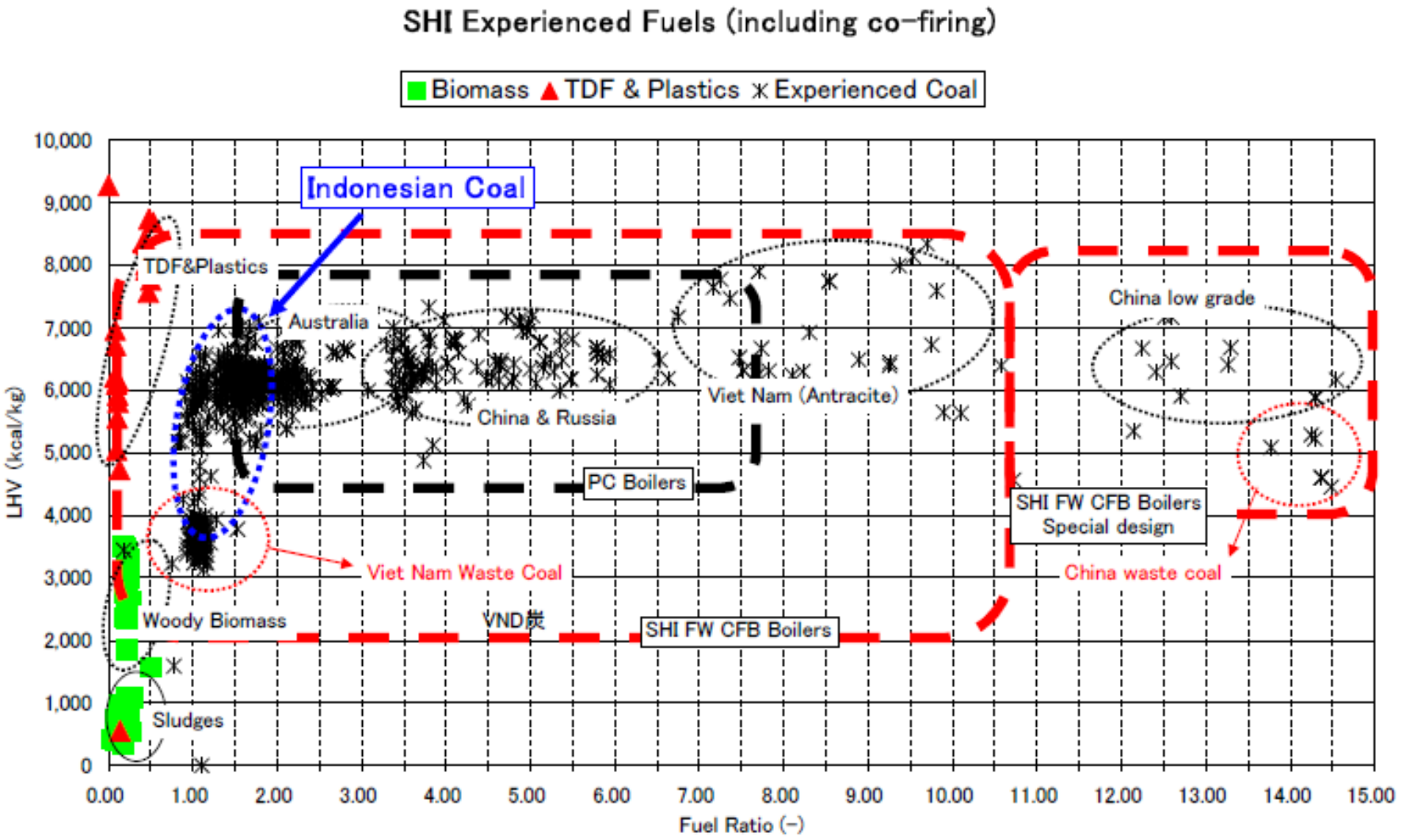
SHI's experiences in commercial plant

Numerical simulation & evaluation

Foster Wheeler experiences & technical exchange meeting

4. Track Record

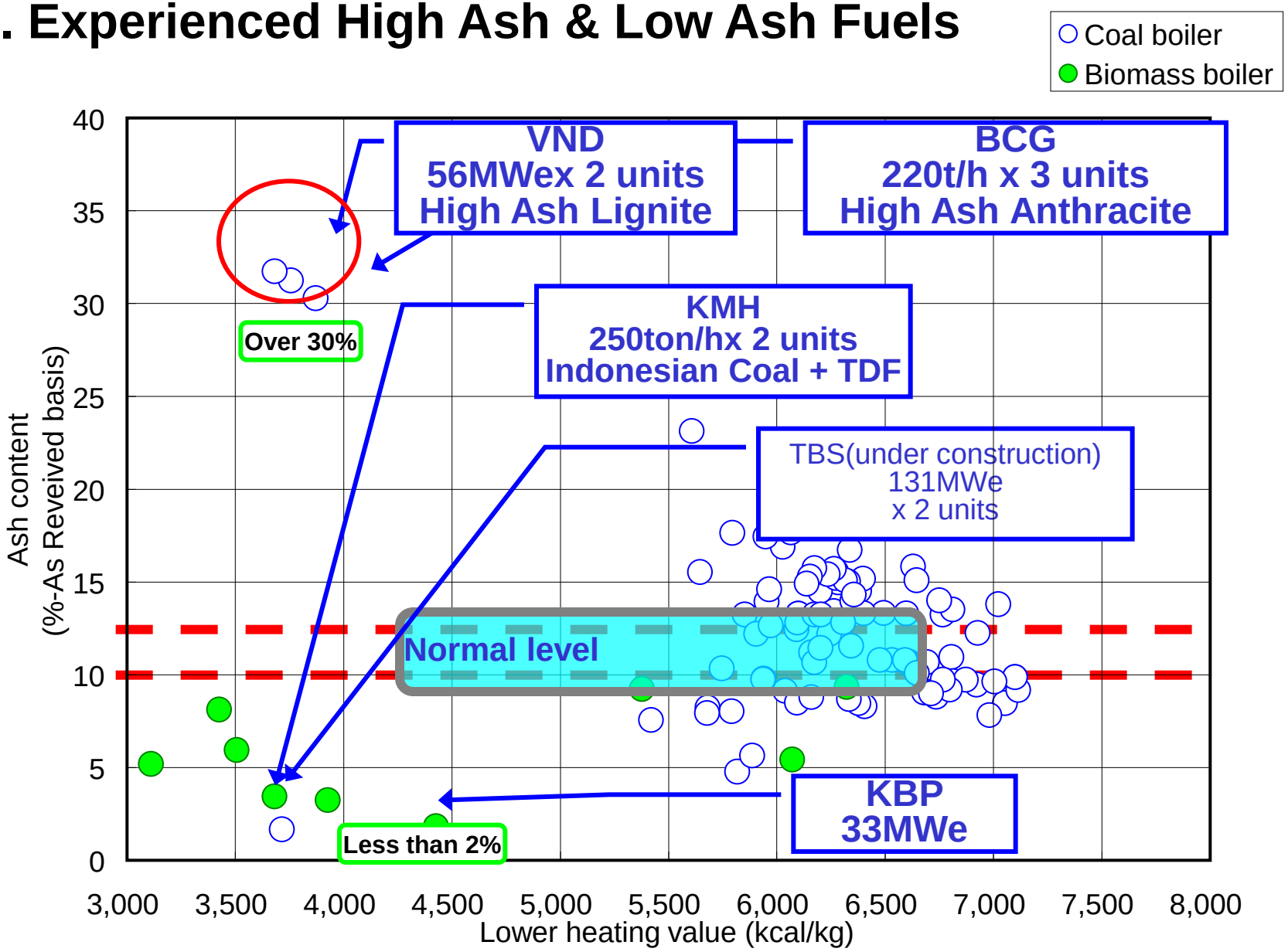
4-1. SHI experienced Fuels (Including co-firing)



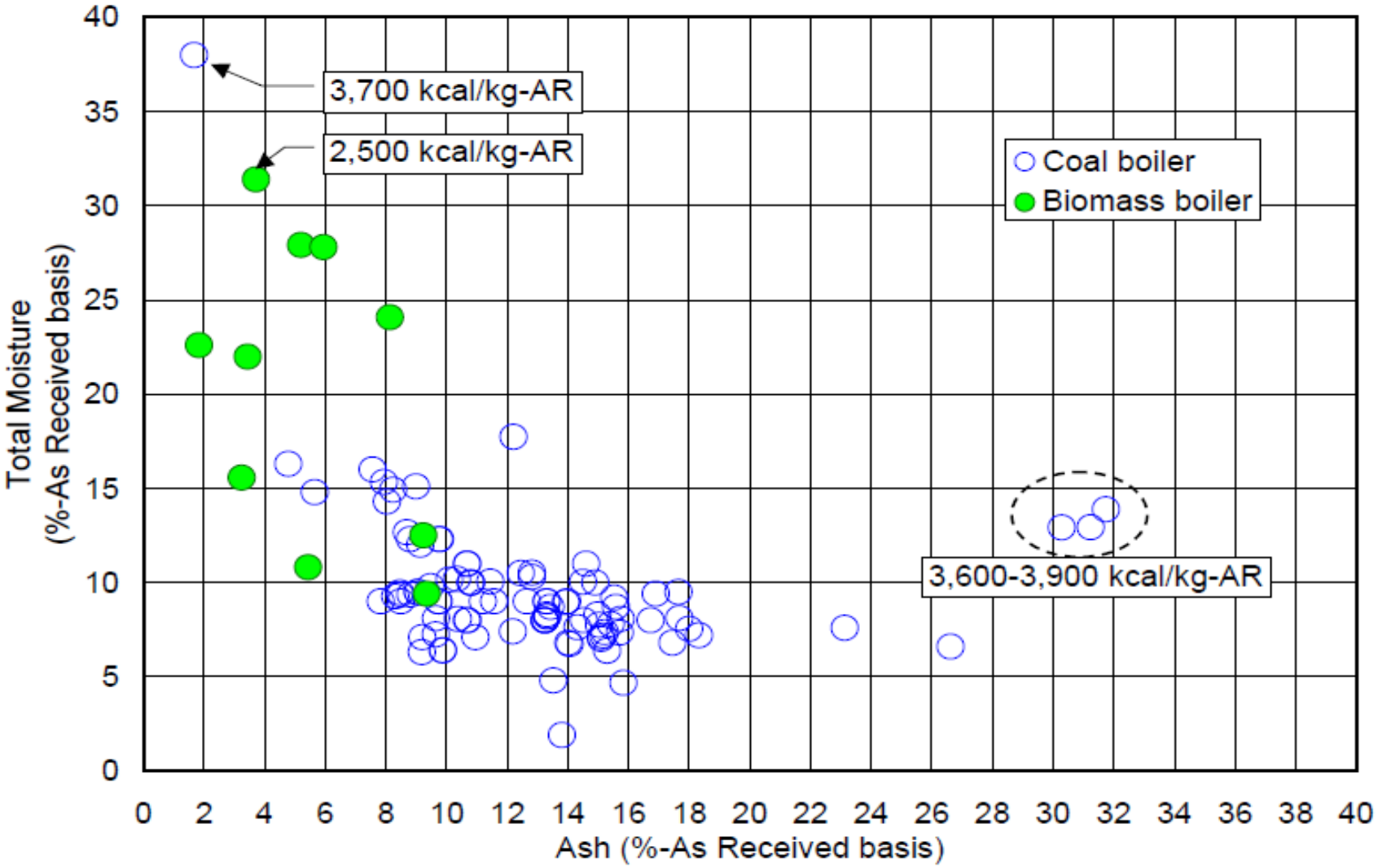
*LHV = Lower Heating Value
*Fuel Ratio = Volatile Matter(%)/Fixed Carbon(%)

4. Track Record

4-2. Experienced High Ash & Low Ash Fuels



4-3. Experienced Coal (Moisture & Ash content)



*Heating value is LHV basis

4. Track Record

4-4. SHI Reference List

	Boiler No.	Start Up	Customer	Mill	Boiler Spec			Fuel						CO2 Reduction	
					Capacity	Temperature	Pressure	Fossil Fuel		Wood	Recycle			Biomass	Renewable
					ton/h	℃	kg/cm2	Coal	Petcoke	Biomass	TDF	RPF	Sludge	ton-CO2/y	ton-CO2/y
Coal Fired Cogeneration	1	88.08	OMIKENSHI	KAKOGAWA	35	485	60	○						-	-
	2	88.09	KOBE STEEL	CHOFU	54	500	110	○						-	-
	3	89.04	NIPPON STEEL	HIROHATA	250	571	130	○						-	-
	4	89.06	KOBE STEEL	KOBE	150	541	130	○						-	-
	5	90.10	KOBE STEEL	KAKOGAWA	225	543	110	○				Max:15%		-	70,000
	6	95.02	OJI PAPER	SOBUE	120	540	120	○				Max:25%		-	17,800
	7	96.04	TAIHEIYO CEMENT	SAIKI	96	541	110	○						-	-
	8	99.08	SUMITOMO OSAKA CEMENT	KOCHI	230	541	130	○		○				35,800	-
	9, 10, 11	05.08	DRAGON SPECIAL RESIN	CHINA	220x3	540	100	○						-	-
	12, 13	10.06	OJI PAPER	CHINA	200x2	540	120	○						-	-
Coal Fired IPP	14	01.06	TAIHEIYO CEMENT	ITOIGAWA	475	569/541	173/37	○						-	-
	15	05.04	TAIHEIYO CEMENT	TOSA	525	569/541	173/36	○						-	-
	16	05.10	SUMITOMO OSAKA CEMENT	KOCHI	237	541	130	○		○				35,800	-
	17, 18	03.04	VINACOAL	VIETNAM	205x2	540	130	○						-	-
Biomass / Recycle Fuel	19	04.10	SUMMIT MYOJYO POWER	ITOIGAWA	196	513	100	30%		Demolition Wood 70%				221,300	221,300
	20	06.05	OJI PAPER	NICHINAN	130	541	120			Demolition Wood 13%	83%		4%	44,700	223,700
	21	06.09	HOKUETSU PULP	KATSUTA	195	513	100	40%		Demolition Wood 60%			3%	192,600	192,600
	22	06.10	CHUETSU PULP	FUTATSUKA	130	530	120	10%		Demolition Wood 15%	60%	15%		30,600	183,400
	23	07.12	DAICEL CHEMICAL	OTAKE	300	541	130	70%			30%			0	158,300
	24	08.03	TAKASAGO PAPER	IBARAKI	65	450	60			Demolition Wood 70%	30%			75,000	107,100
	25	07.10	NIPPON PAPER	FUJI	230	505	100	20%		Demolition Wood 60%		20%		223,200	297,700
	26	07.11	NIPPON PAPER	IWANUMA	230	505	100	40%		Demolition Wood 40%		20%		168,000	252,000
	27	08.04	NIPPON DAISHOWA PAPERBOAD	AKITA	180	480	80	90%		Demolition Wood 10%		(10%)		33,300	33,300
	28	08.11	NIPPON PAPER	ASAHIKAWA	170	510	100	22%		Bark 54%	20%	3%	1%	152,000	215,500
	29	08.09	NIPPON PAPER	SHIRAOI	280	536	130	85%		Roots 9%		5%	1%	45,800	68,600
	30	09.01	OJI PAPER	TOMIOKA	300	485	70	49%		30%		21%		145,300	247,000
	31	09.06	NIPPON DAISHOWA PAPERBOAD	HIROSHIMA	280	535	110	99%					1%	0	-
	32, 33	09.05	KUMHO PETRO CHEMICAL	KOREA	250x2	540	130	100%			Max:30%			0	111,100
	34	09.11	TORAY	EHIME	150	541	105	90%		Demolition Wood 10%				25,700	25,700
	35	11.02	KAWASAKI BIOMAS POWER	KAWASAKI	137	513	102			Wood Chip 100%				203,900	203,900
	36	12.07	ASAHI KASEI	NOBEOKA	80	493	63	30%		Demolition Wood 60%		10		81,700	95,300
	37	12.11	TUAS POWER LTD	SINGAPORE	450	510	105	80%		PKS 20%				146,700	146,700
	38	12.12	CHENG LOONG PAPER	TAIWAN	130	541	128	82%			16%		2%	under estimate	under estimate
	39	12.4	Green Thermal	AIZU	25	453	55			Wood Chip 100%				37,200	37,200
	40	13.11	TUAS POWER LTD-2A	SINGAPORE	450	510	105	80%		PKS 20%				146,700	146,700
	41	12.11	NIPPON GOHSEI	KUMAMOTO	28	453	55	40%		60%				28,800	28,800
	42, 43	15.05	KUMHO PETRO CHEMICAL-II	KOREA	400x2	541	130	100%			Max:30%			under estimate	under estimate

4. Track records

205 t/h x 2 Lignite-Fired CFB
VND-PROJECT, Vietnam

Steam flow		2 x 205 t/h
Steam press.		13 MPa
Steam temp.		540 ℃
Power Output		56 MWe x 2units
Fuel		Lignite Ash(30%), S(6%) T.M.(19%)
Emission	SO_2	<191 ppm(6%O_2)
	NOx	<490 ppm(6%O_2)

<Outstanding Features>

- First CFB Boiler operated in Vietnam
- First coal-fired IPP project in Vietnam
- First power business by VINACOAL
- Minemouth project using high ash(30%), high sulfur(6%) lignite

4. Track records

Tire Derived Fuel (TDF)-fired CFB
OJI Paper, Nichinan, Japan

Steam flow		**130 t/h**
Steam press.		**11.9 MPa**
Steam temp.		**541 ° C**
Fuel	**83%**	**TDF**
	13%	**Biomass**
	4%	**Sludge**
Emission	**SO_2**	**<90 ppm(6% O_2)**
	NOx	**<250 ppm(6% O_2)**

Low ash

<Outstanding Features>

1. **The highest TDF mixing ratio in CFB**
2. **Special Design for TDF/Biomass**
   - **Step-grid type furnace bottom for wire contained TDF**
   - **TDF, Biomass feeding system**
   - **INTREX Superheater**

4. Track records

33 MWe 100% Woody biomass-fired CFB
Kawasaki Biomass Power, Kawasaki, Japan

Start-up	**February 2011**
Steam flow	**137 t/h**
Steam press.	**10.2 MPa**
Steam temp.	**513℃**
Power output	**33 MWe**
Fuel	**Woody biomass**
	Ash(2.2%-AR)
Emission SOx	**3ppm(Act. O_2)**
NOx	**30ppm(6% O_2)**
Service	**PPS**

<Outstanding Features>

1. 1st 100% biomass firing CFB in Japan

2. Meet stringent Emission Requirements

DeNOx with ammonia gas injection (SNCR) + Catalyst (SCR)

DeSOx with Wet type flue gas scrubber

4. Track records

World Largest Tropical Biomass Fired CFB

Tuas Power Ltd., Tembusu BMCC Project
(Biomass & Clean Coal Cogeneration), Jurong Island, Singapore

-Plant Spec Summary-

Completion of Works:	**Dec 2012**
Steam Generation:	**450 t/h**
Steam Pressure:	**10.5 MPa**
Steam Temperature:	**510 ° C**
Power Output:	**100MWe+Steam**
Fuel:	**Biomass(PKS*)**
	Coal

***PKS=Palm Kernel Shell**

TUAS POWER
A member of China Huaneng Group

Sumitomo Heavy Industries

Sumitomo- Foster Wheeler
Introduction of Modular CFB Boiler

5. Modular CFB Boiler

SHI Sumitomo Heavy Industries

Sumitomo - FW Modular CFB Basic Concept

1. Boiler Specification

Type	Sumitomo-FW CFB
Capacity	25t/h
Steam Pressure	5.4 ~ 6.4 MPaG
Steam Temperature	450 ~ 480℃

2. Design

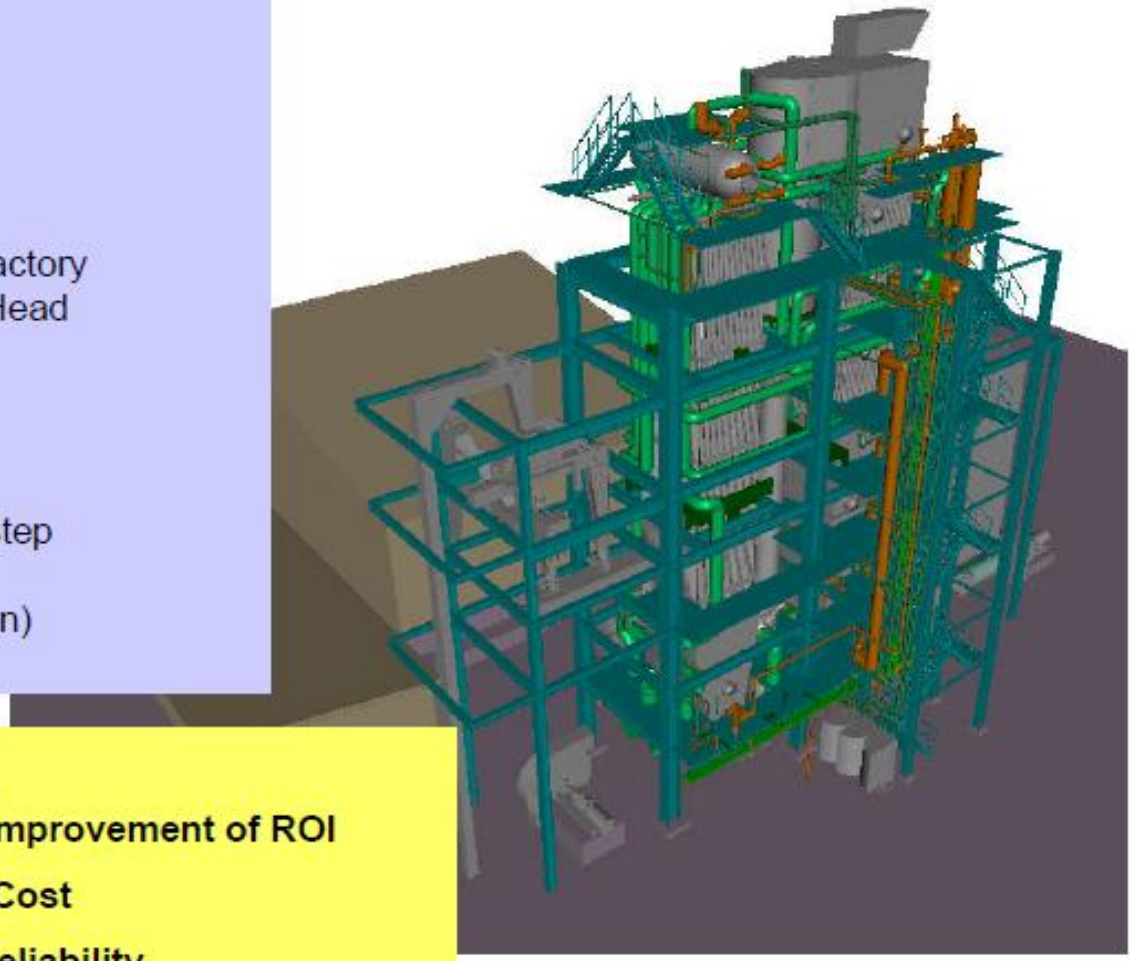
Furnace:	Water tube with Kick-out Design
Separator:	Water tube with refractory
Furnace Bottom:	Step grid or Arrow Head

3. Fuel

Coal, Biomass

4.Emission

SOx	In furnace de SOx
NOx	Low temperature 2 step combustion SNCR (Urea injection)
Dust	Bag filter



Concept and Effect

1. Shorter Delivery Time → Improvement of ROI
2. Reduction of Construction Cost
3. High performance & High Reliability

5. Modular CFB Boiler

An Example of GHG Emission Reduction Project in a Local Area

Advantages:

(1) Producing Heat and Electricity
(2) Mitigating Air Pollution (NOx and SOx)
(3) Possibility of Using Biomass and Waste
(4) Reducing Consumption of Coal

A local Heat Only Boiler (HOB)
in Tuv Aimag, Mongolia

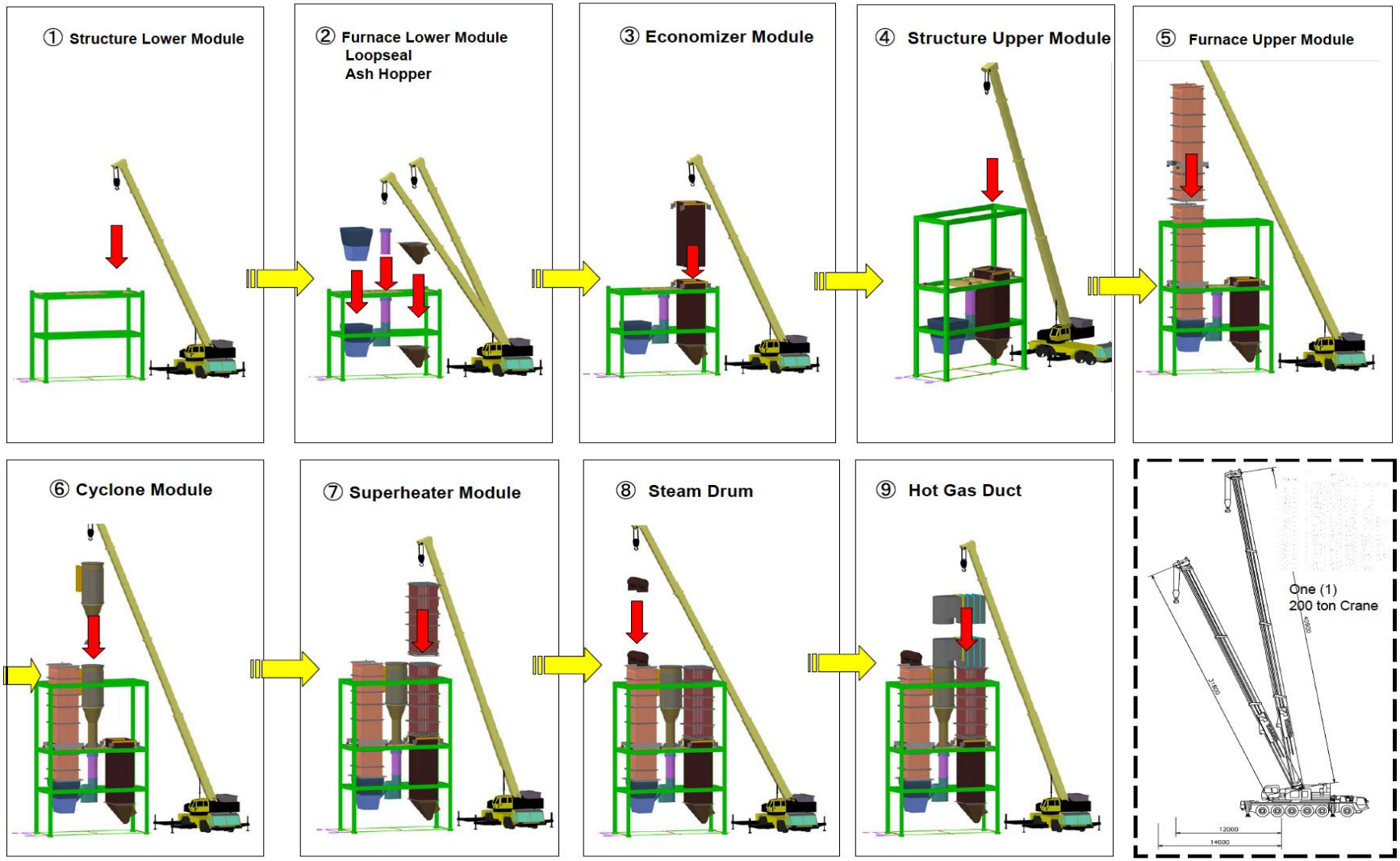
Replace
ment

A Modular CFB Boiler
(Capacity: 1MB- 10MB)

5. Modular CFB Boiler

Sumitomo Heavy Industries

Shorter Delivery (Site Construction)



5. Modular CFB Boiler

Shorter Delivery (Project Schedule)

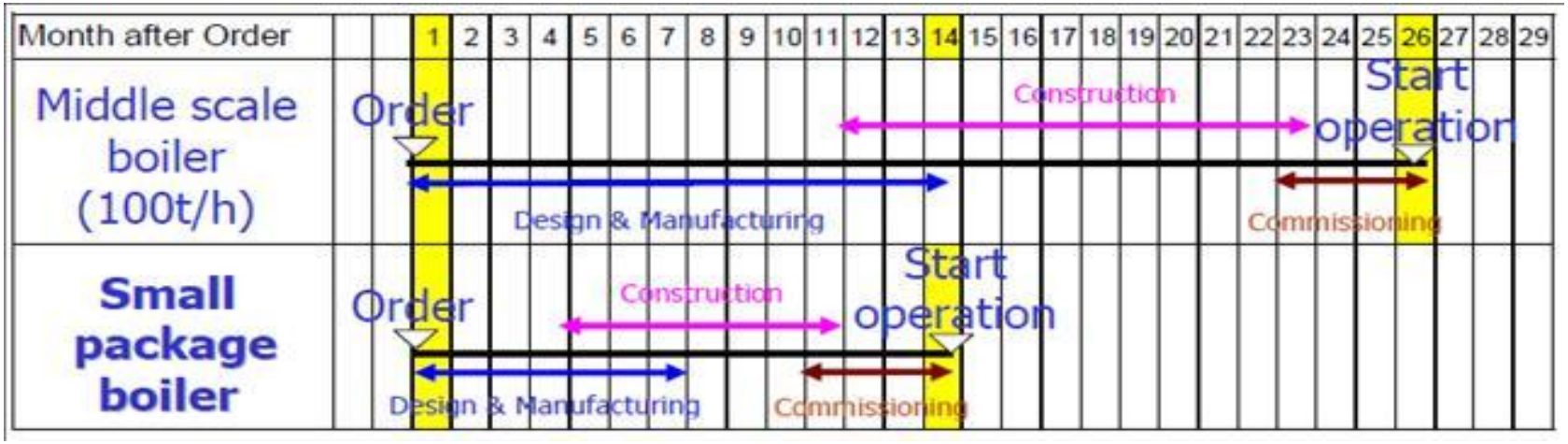
Design innovations

- Boiler size 25t/h package design
- Module construction

Impact for construction

	unit	Large scale boiler	Small package boiler
Period	day	239	103
Man-hour	man	32,330	9,525

Typical Project schedule



5. Modular CFB Boiler

SHI Sumitomo Heavy Industries

Modular CFB (Performance Design)

Operating Condition			Biomass 100%	Coal 100%
Weather Condition			(Japan)	(Japan)
Boiler Capacity		t/h	25	25
Boiler Load		% MCR	100	100
Fuel Calorific Value (LHV)		kcal/kg(AR)	2,706 (TM 35%)	6,375
Fuel Consumption	Coal	t/h	0	3.0
	Biomass	t/h	6.8	0
Fly Ash		t/h	0.20	0.54
Bottom Ash		t/h	0.02	0.06
Sand Feed		t/h	0.05	0.05
Emission	SOx	ppm(O2 6%)	100	190
	NOx	ppm(O_2 6%)	150	130
	Dust	mg/Nm^3(O_2 6%)	20	20

Баярлалаа !!

Thank You for Listening !!

ご清聴有難うございました !!