

Biomass Utilization Status and Example in Fluidized Bed Boiler in Korea

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- I** Renewable fuel in power plant
- II** Experimental data in pilot CFB reactor
- III** Experience in commercial CFB boiler
- IV** Direction of power generation technology

● RPS (Renewable Portfolio Standard)

- Introduced in 2012 to promote the use and supply of renewable fuel and to activate renewable energy industry in Korea
- **Selected suppliers must supply a certain percentage** of total power generation capacity using renewable energy
 - ✓ 18 suppliers : KEPCO subsidiary 6, Private company 10, Public company 2
 - ✓ 2012 (2%) ⇨ 2017(4%) ⇨ 2018(5%) ⇨ 2020(7%) ⇨ 2023(10%)

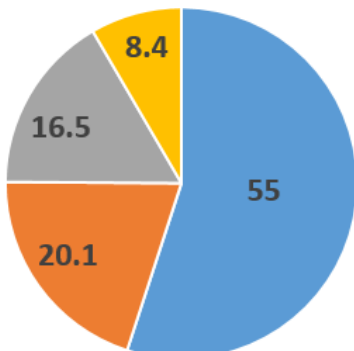
● REC weight factor for different renewable energy source

✓ REC : Renewable Energy Certificate

REC factor	Target energy
0.25	IGCC
0.5	Waste , Landfill gas
1.0	Bioenergy, RDF(100%) , Hydropower, Onshore wind power, Tidal power
1.5	Woody biomass(100%) , Offshore wind power (<5km)
2.0	Offshore wind power (>5km), Fuel cell

● Status of renewable fuel (Bio or Waste) application in domestic power plant

	Fuel		REC factor	Co-firing ratio (Period)	Power plant
Bio energy	Wood Pellet		1	< 4% ('13~present)	Standard PC boiler
				~ 15% ('13~present)	Yeosu CFB boiler Samcheok CFB (ready)
	Bio-oil (Vegetable)		1	100% ('14~present)	Jeju oil boiler
	Bio-oil (Animal)		1	100% ('14~present)	Namjeju oil boiler
Waste energy	SRF	RDF	0.5	1~5% ('10~'11)	Donghae CFB boiler
	Bio-SRF	Wood chip	0.5	3~12% ('14~present)	Donghae CFB boiler
		Cashew Nut Shell	0.5	5~10% (ready)	Yeosu CFB boiler
		Coffee Residue	0.5	5~10% (ready)	Standard PC boiler



The amount of wood pellet imported ('16, 1.7million tons) is increasing year to year

- Market share : 3 countries account for more than 90% of the total market ('17.5)

Vietnam (55%) > Canada (20%) > Malaysia (17%)

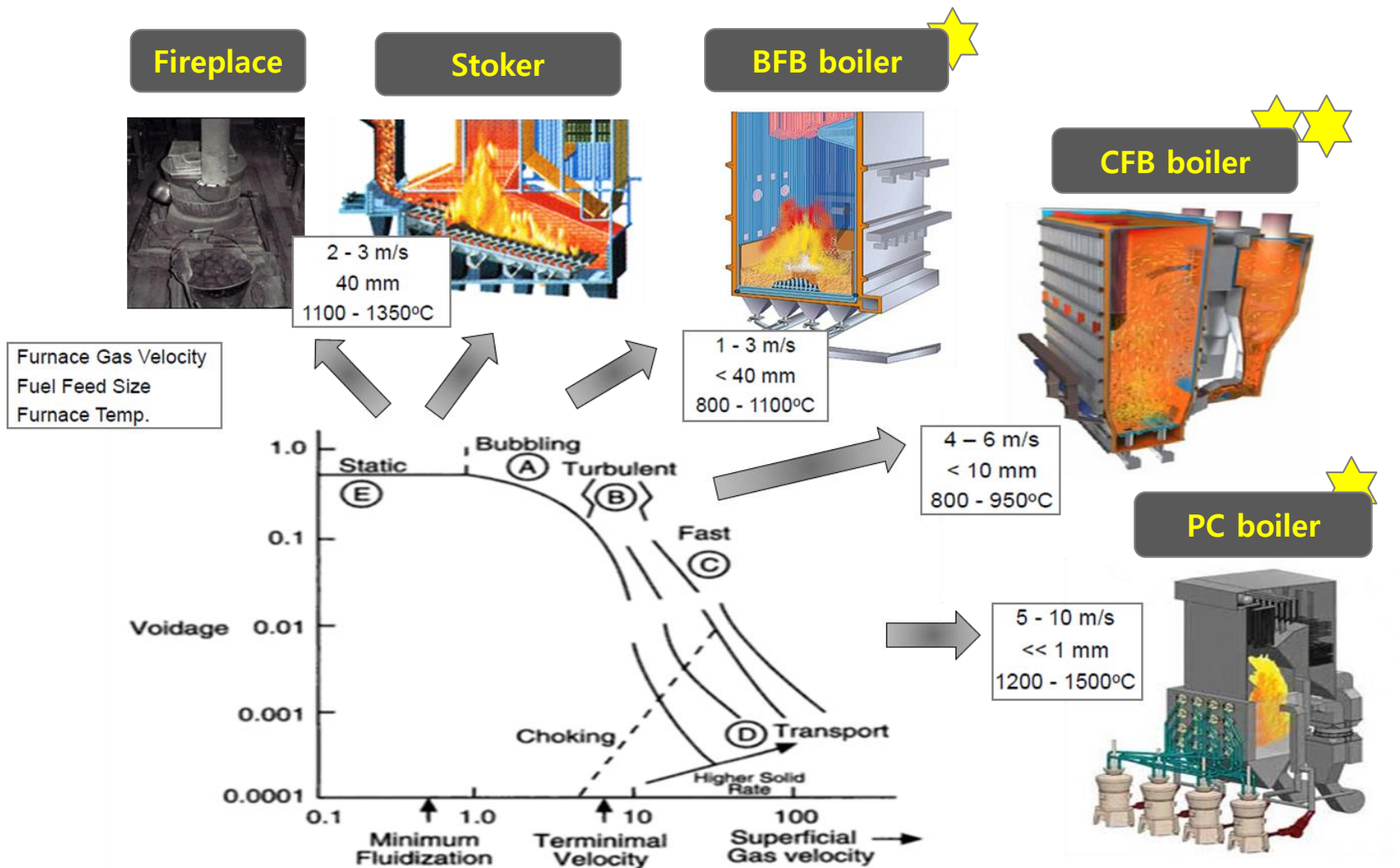
- Average import price of wood pellet ('17.5) : 252,670 won/ton (190 Euro/ton)

Try to adjust the RPS weight factor in case of co-firing of wood pellet

I. Renewable fuel

Biomass combustion boiler (1)

● Different commercial combustion boilers



I. Renewable fuel

Biomass combustion boiler (2)

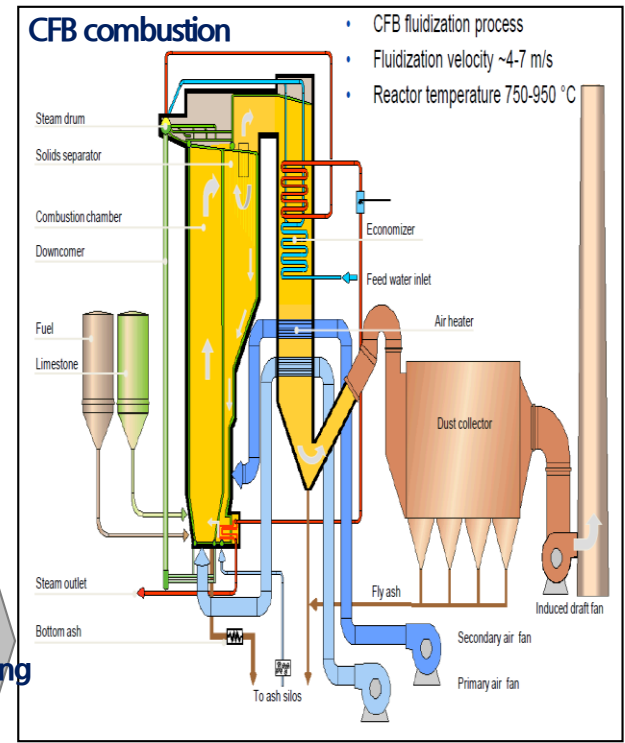
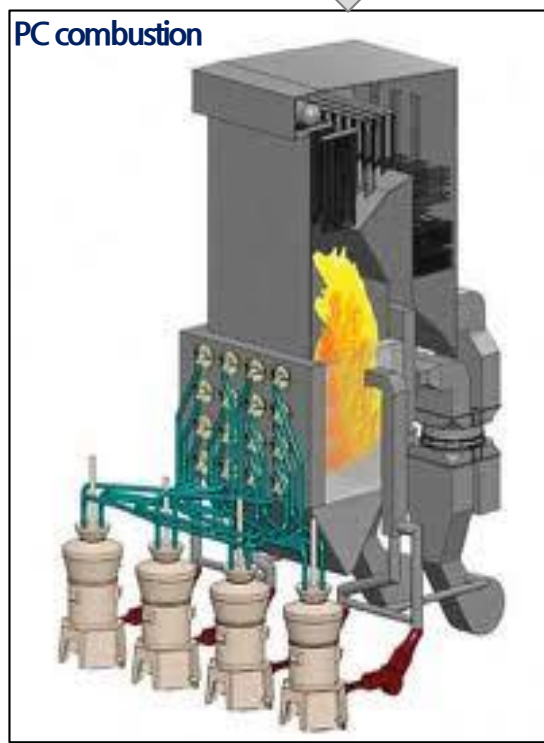
Fuel application characteristics according to combustion type of existing facilities

Limited to < 4 %
due to
- low degree of pulverization
- unstable operation status in boiler



Need pretreatment

Direct application



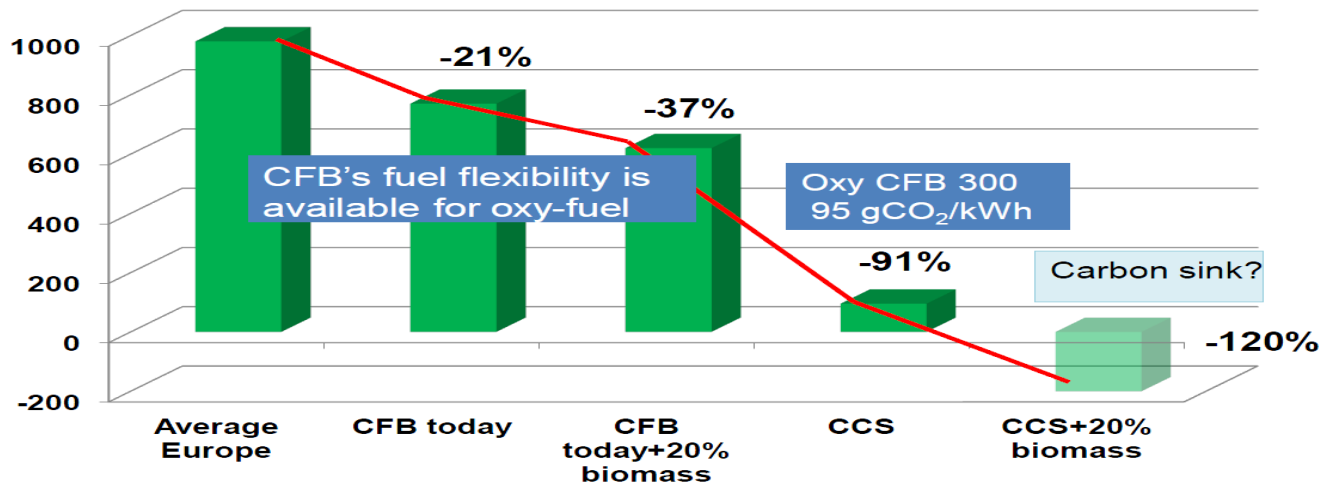
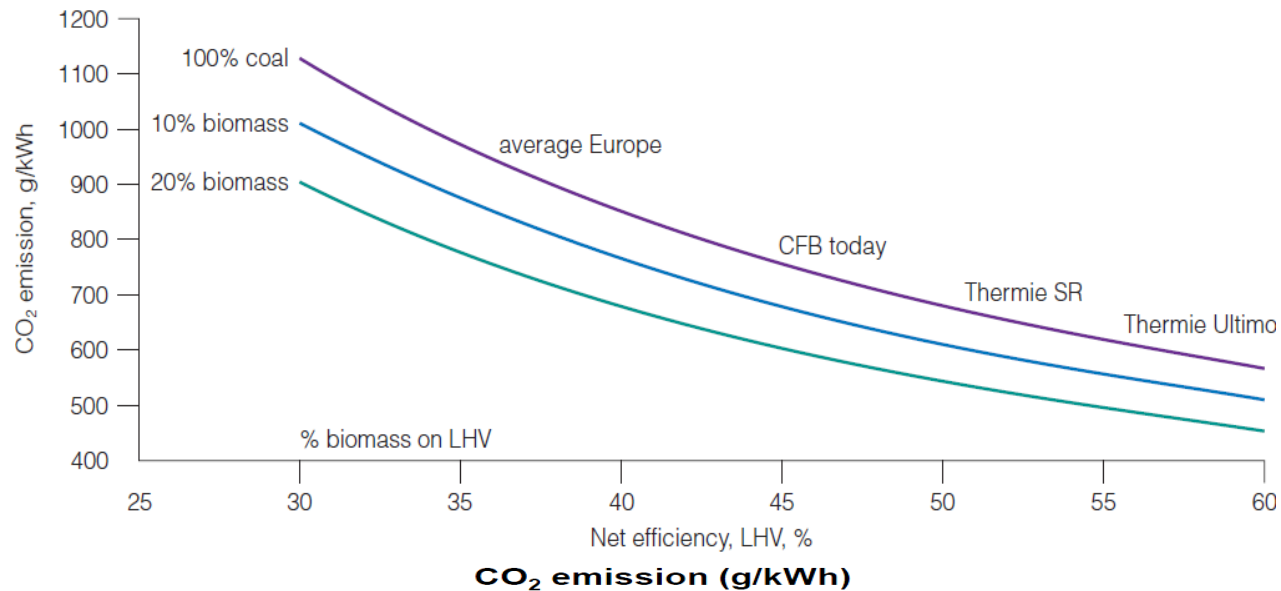
Milling

No milling

I. Renewable fuel

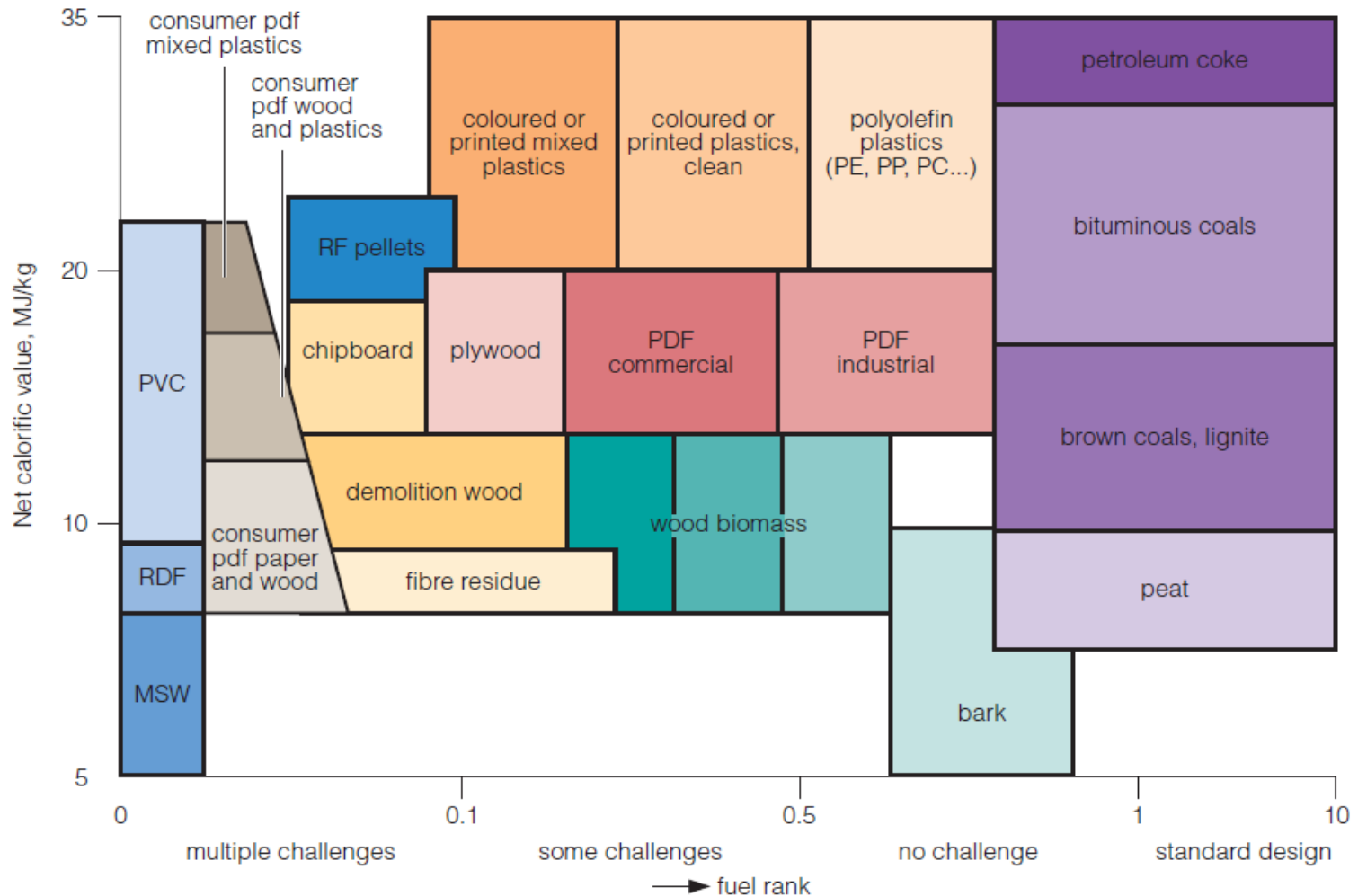
CO₂ emission reduction method

● Benefits of co-combustion in a CFB system and CCS-Biomass integrated system



I. Renewable fuel

● Technology challenges according to fuel diversification (Fluidized Bed)



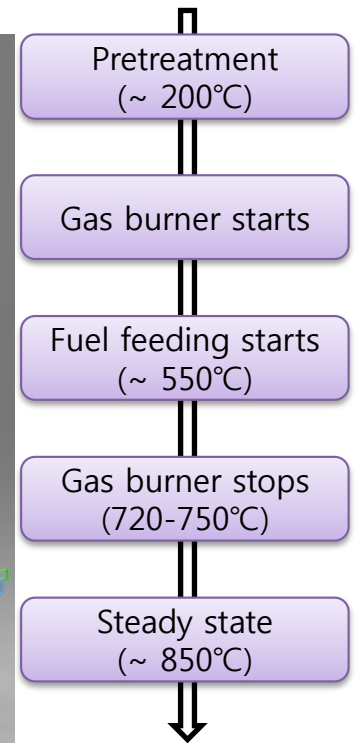
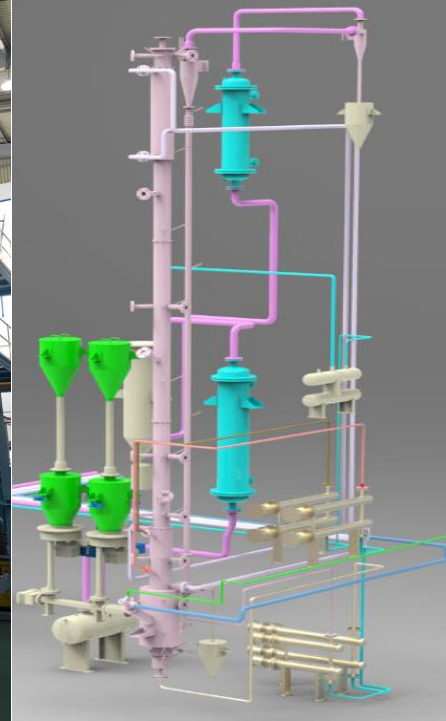
II. Pilot scale CFB reactor

Set up

Existing



Newly installed

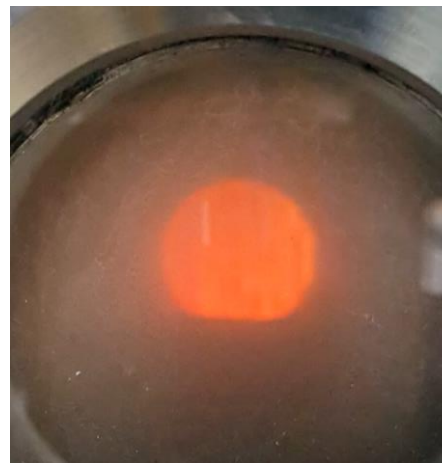
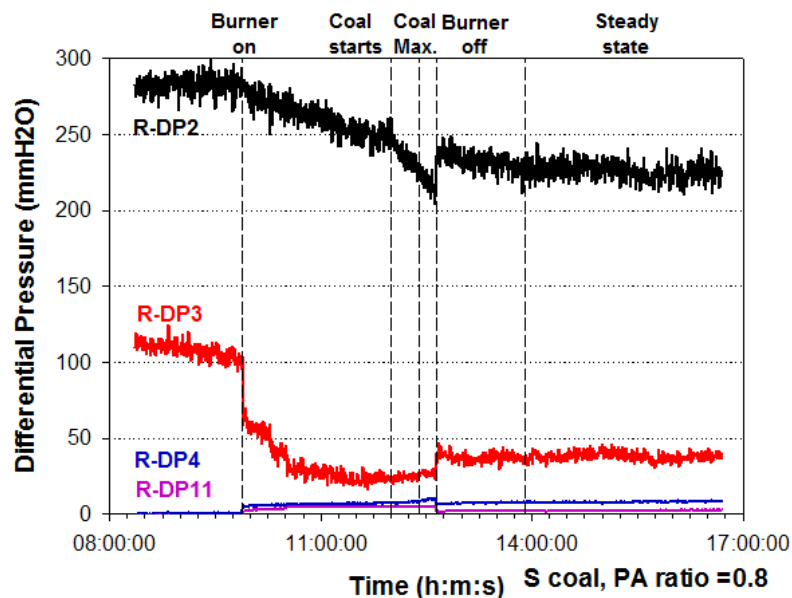
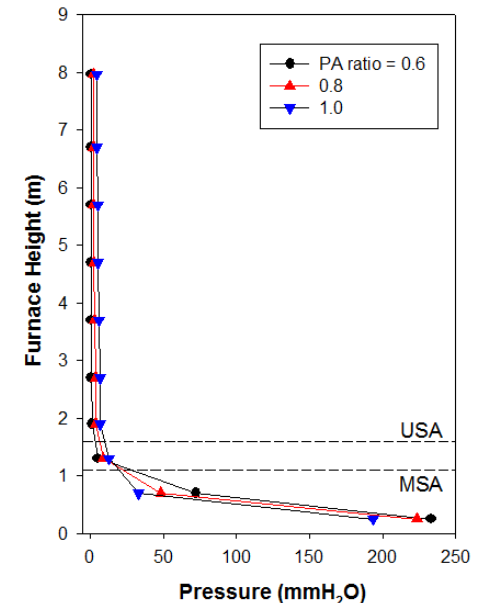
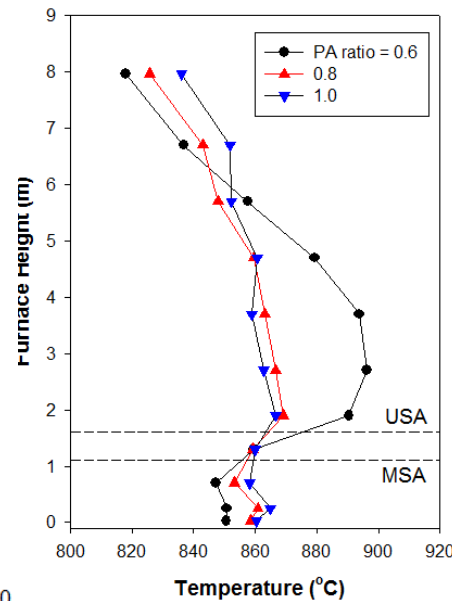
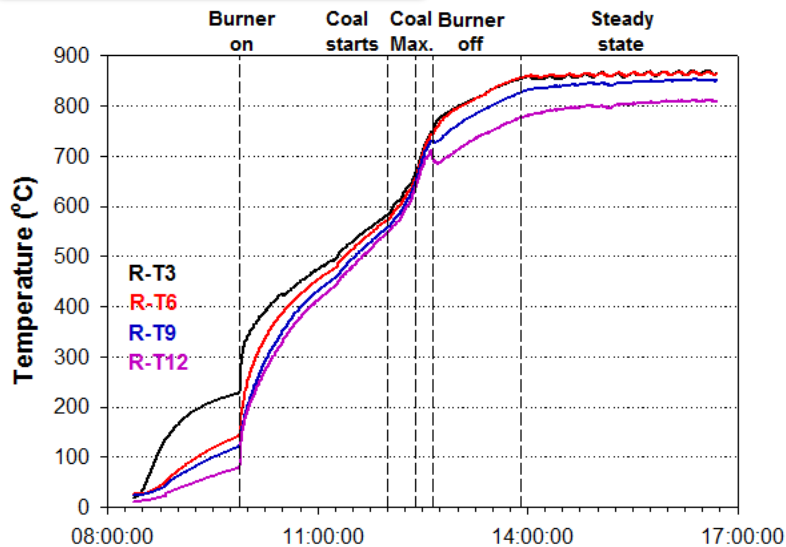


Item	Existing	Newly installed
Heating method	External Heater	Gas Burner + Direct Combustion Heat
Combustor Material	SUS 310	Refractory (Bottom) and Inconel
Configuration	1 combustor, 1 cyclone	1 combustor, 1 cyclone (+ extra cyclone)
Combustor Size	0.15m (Dia.) × 8m (Height)	0.15m × 8m
Gas Sampling Port	Cyclone (1ea), Bag filter (1)	Axial (6), Cyclone (2), Bag filter (1)
Fuel feeding rate	3-5 kg/hr	Max 15 kg/hr

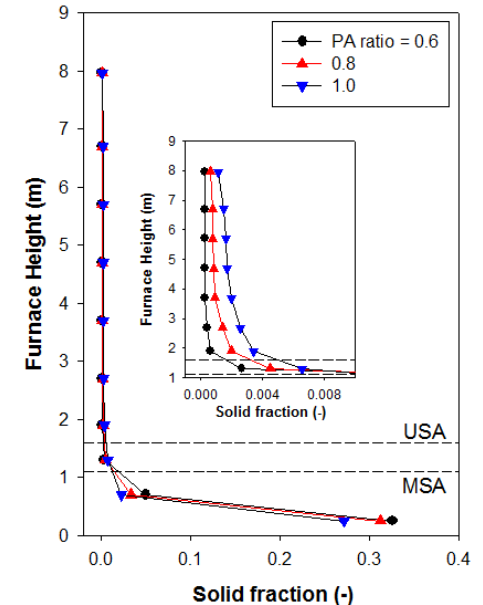
II. Pilot scale CFB reactor

Experimental data

Fundamental test



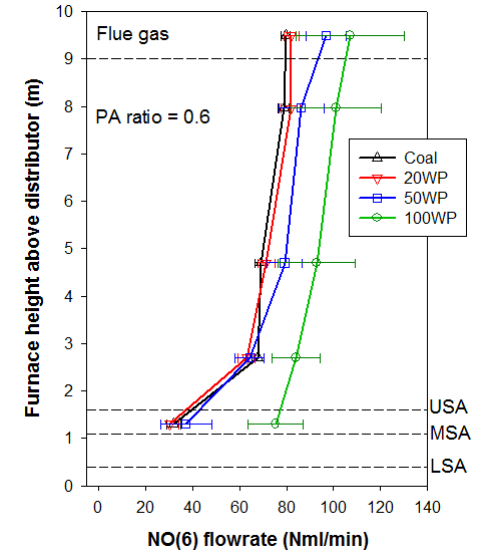
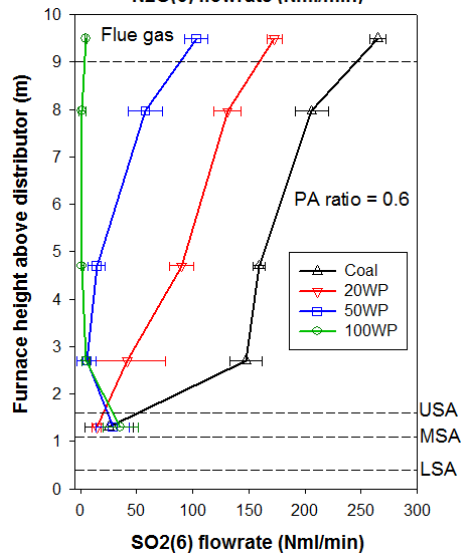
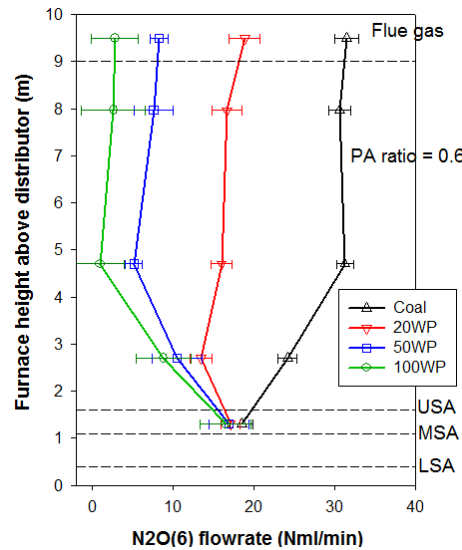
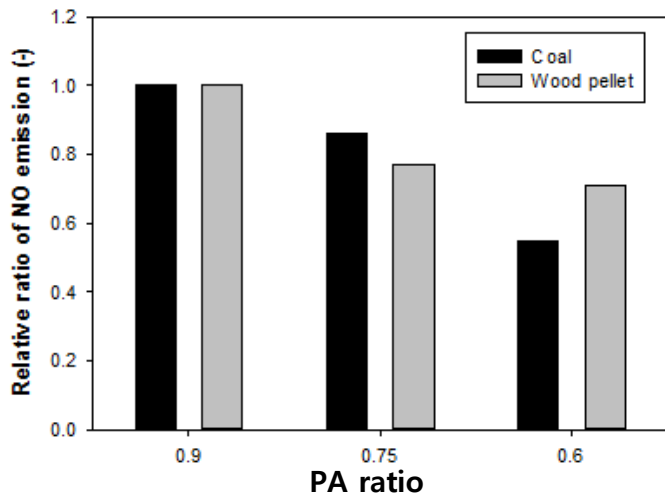
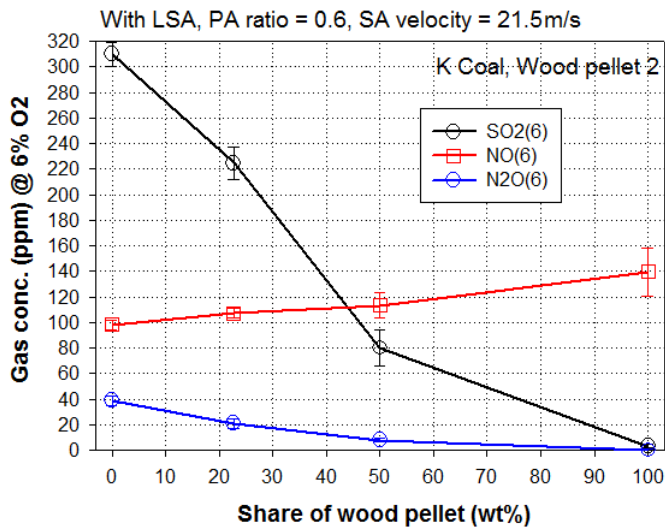
These follow the main features of CFB



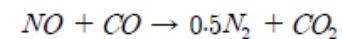
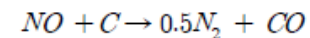
II. Pilot scale CFB reactor

Experimental data

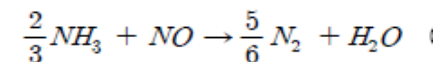
NO_x and SO₂ in case of co-firing of wood pellet (0%, 20%, 50%, 100%) with coal



SO₂ & N₂O ↓, NO ↑



(Char, CaO in ash)



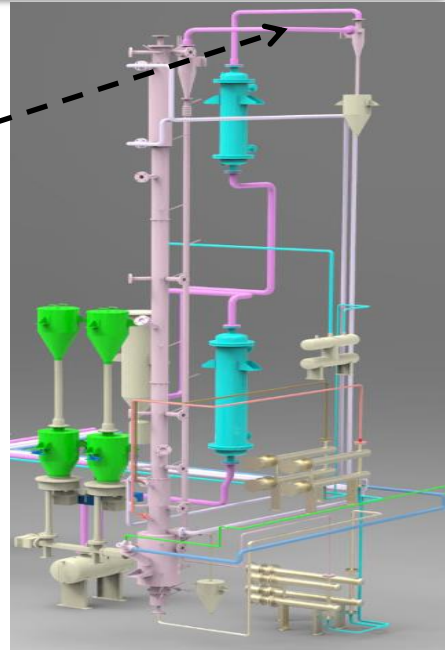
II. Pilot scale CFB reactor

Experimental data

Comparison of components in fine fly ash (6nm - 10 μ m)



Solid sampling (6nm-10 μ m)
(FPS-4000+ELDI, Dekati)



connected after 1st cyclone



Main 2 components among Na, K, Cl, Ca, S, P (by XRF)

Avg. Size (μ m)	Coal combustion	Wood pellet combustion
0.0098	S, Ca	Cl, K
0.0221	S, Ca	
0.0408	S, Ca	
0.0720	S, Ca	
0.1214	S, Ca	
0.1996	Ca, S	
0.3137	S, Ca	
0.4814	S, Ca	S, Ca
0.7589	S, Ca	S, Ca
1.2495	Ca, S	Ca, S
2.0167	Ca, S	Ca, S
3.0169	Ca, S	Ca, S
4.4476	Ca, S	Ca, S
7.3112	Ca, S	Ca, S

Alkali chloride is dominant in fine particle when wood pellet fired

III. Biomass application

Overview (1)

● Operation status of CFB boiler in Korea (include uses of bio and waste energy)

Company / Location(City)	Year	Capacity (steam t/h or MWe)	Fuel	Category	Supplier /Design
EWP/ Tonghae	1998/99	693 t/h x2 (200 MWe x2)	Anthracite /Biomass	Electric	Doosan/ Alstom
Hansol²⁾ / Jeonju	2010	10 MWe	Biomass/ RPF	Co-Gen	AF Sweden
Gunjang Energy #3, #4 / Gunsan	2011/ 2014	250 t/h x 2	Coal /Pet. Coke	Co-Gen	Hyundai HI
KOSEP / Yeosu	2011 / 2016	1040 t/h x 2 (340MWe x 2)	Coal/Biomass	Electric	Doosan
Yeosu Co-gen Plant / Yeosu	2012	350 t/h x 2	Coal	Co-Gen	Hyundai HI
Hyundai Oil Bank #8, #9, #10 / Daesan	2012/2014 /2017	220 t/h x 2 330 t/h x 1	Pet. Coke	Co-Gen	Hyundai HI
Gimcheon Community Energy / Gimcheon	2012	330 t/h	Coal	Co-Gen	Hyundai HI
Han Ju Corp. / Ulsan	2015	250 t/h	Coal	Co-Gen	Hyundai HI
GS EPS / Dangjin	2015	105 MWe	Biomass	Electric	FW
KOMICO / Wonju	2015	10 MWe	RDF	Co-Gen	Hansol Seentec / KIER
OCI/ Gunsan	2015	150MWe x 2	Coal	Co-Gen	Doosan /FW
KOSPO / Samcheok	2016	1,572 t/h x 4 (500MWe x 4)	Coal/ Biomass	Electric	Hansol Seentec /FW
Hansol³⁾ / Jeonju	2017	30 MWe	Biomass/ RPF	Co-Gen	Kawasaki
Hanhwa Energy / Gunsan	2018	100MWe	Coal	Co-Gen	FW

III. Biomass application

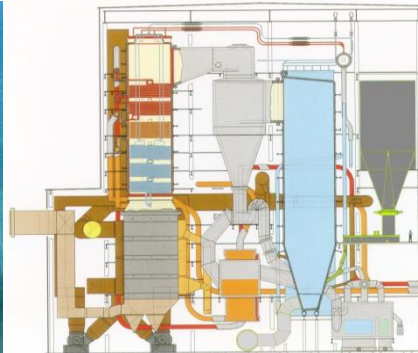
Overview (2)

Cebu CFB



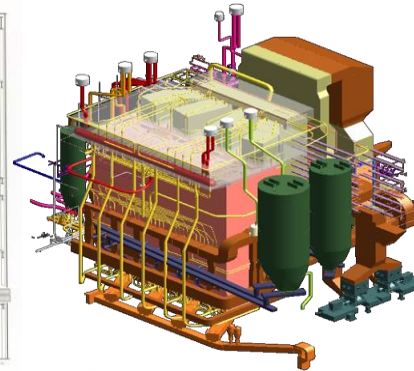
- **Capacity**
 - 100MW x 2units
- **Commercial Op.**
 - #1 : '11. 2
 - #2 : '11. 5
- **Designer**
 - Foster Wheeler
- **Feature**
 - Compact Cyclone
 - INTREX
 - Sub-bituminous
 - **No co-firing**

Donghae CFB



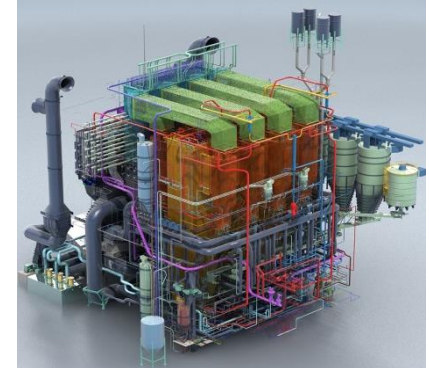
- **Capacity**
 - 200MW x 2units
- **Commercial Op.**
 - #1 : '98. 9
 - #2 : '99. 9
- **Designer**
 - Alstom
- **Feature**
 - FBHE
 - FBAC
 - Korean Anthracite
 - **RDF, WCF**

Yeosu CFB



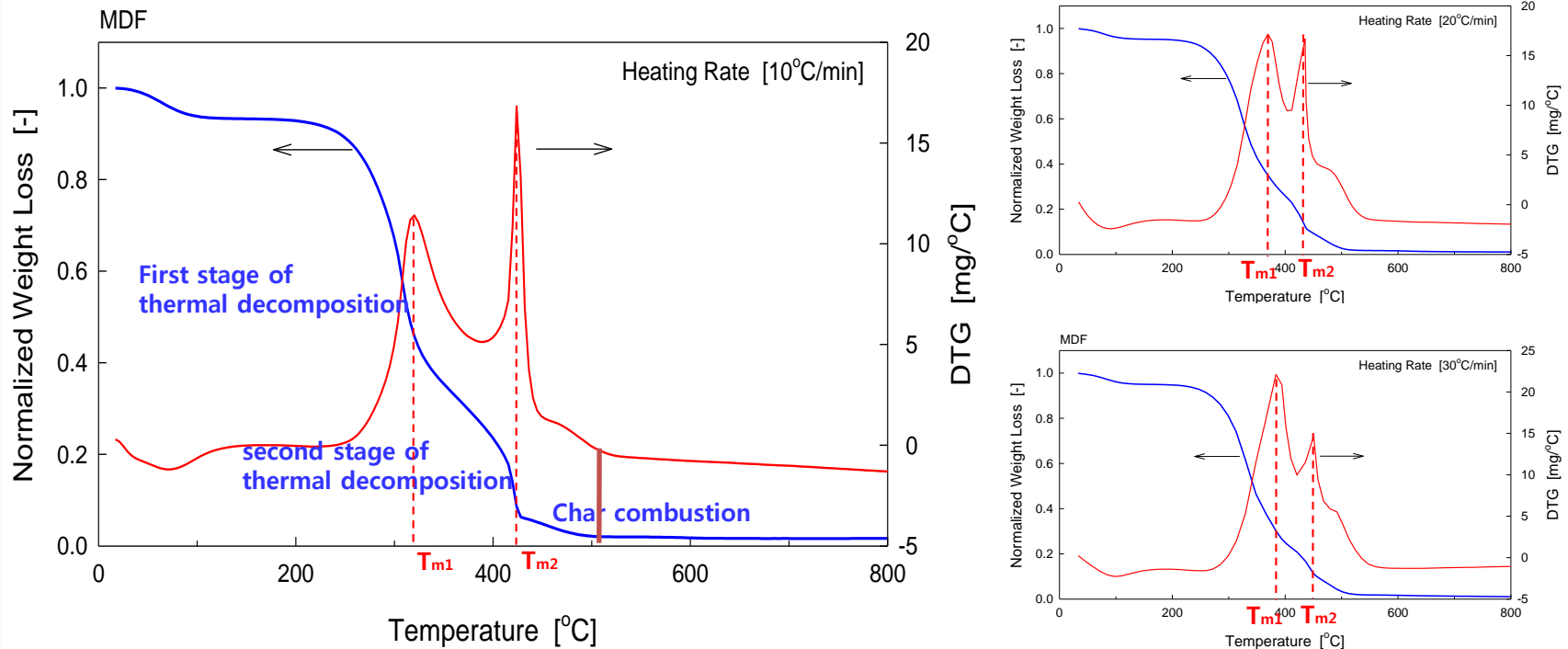
- **Capacity**
 - 300MW x 2units
- **Commercial Op.**
 - #1 : '16. 9
 - #2 : '11. 10
- **Designer**
 - Foster Wheeler
- **Feature**
 - Compact Cyclone
 - w/o INTREX
 - Wingwall Tube
 - **Wood pellet**

Samcheok CFB



- **Capacity**
 - 2units [550MW x 2-CFB x 1-Turbine]
- **Commercial Op.**
 - #1 : '16. 12
 - #2 : '17. 6
- **Designer**
 - Foster Wheeler
- **Feature**
 - SC-CFB type
 - 257bar/603°C
 - **Wood pellet (ready)**

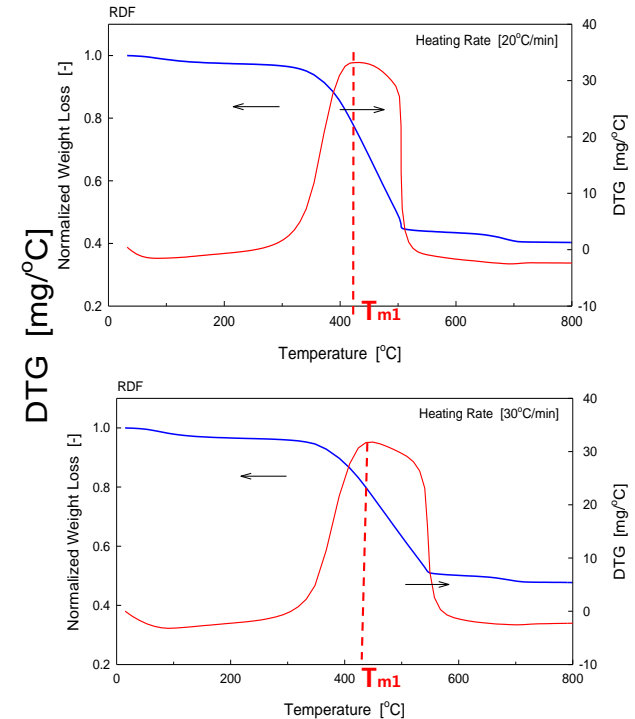
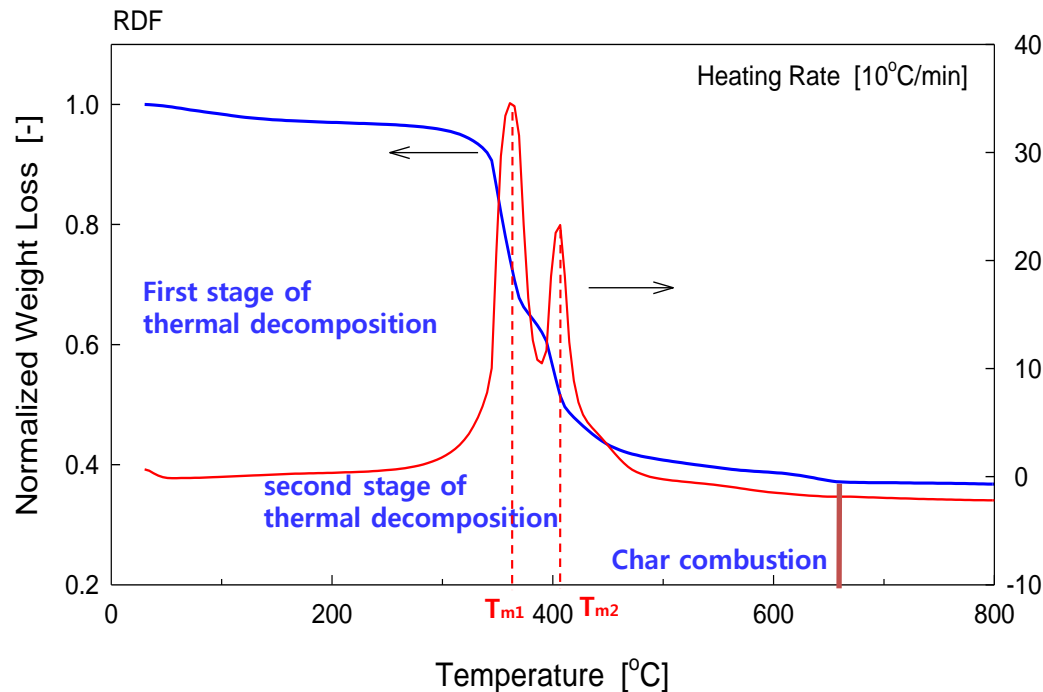
Combustion characteristics of MDF according to temperature rise condition (TGA vs DTG)



- First stage of thermal decomposition (230 ~ 370 °C) : Hemi-cellulose, Cellulose, Partially Lignin
- Second stage of thermal decomposition (370 ~ 420 °C) : Remaining Lignin
- Char combustion (420 ~ 500 °C): Char Residues

**** Although the temperature (T_{m1} , T_{m2}) at the maximum pyrolysis rate increases with increasing heating rate, secondary pyrolysis process becomes weaker and weaker**

Combustion characteristics of RDF according to temperature rise condition (TGA vs DTG)



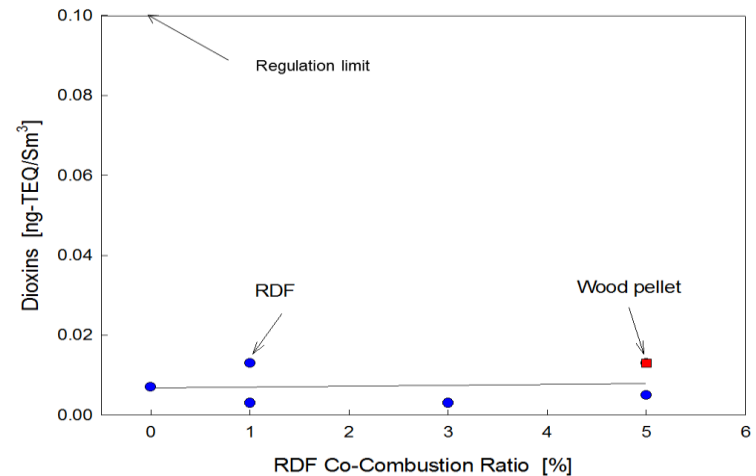
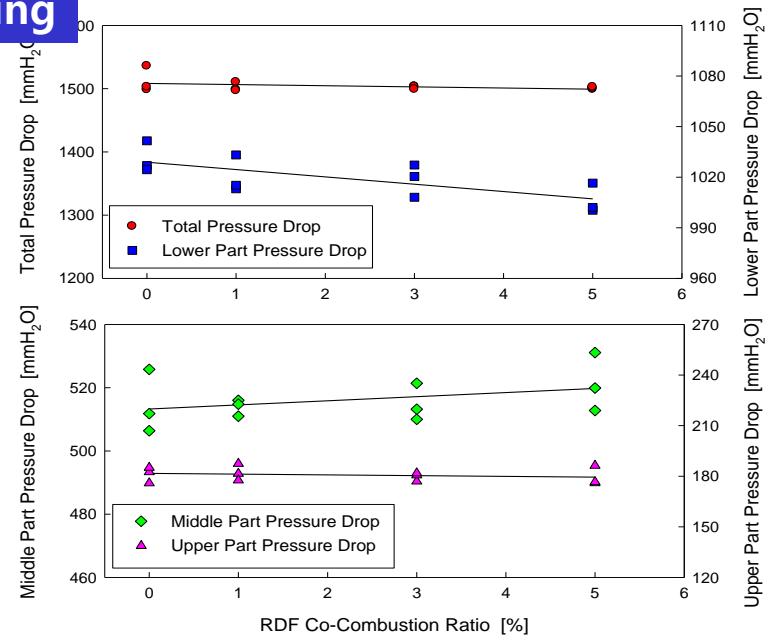
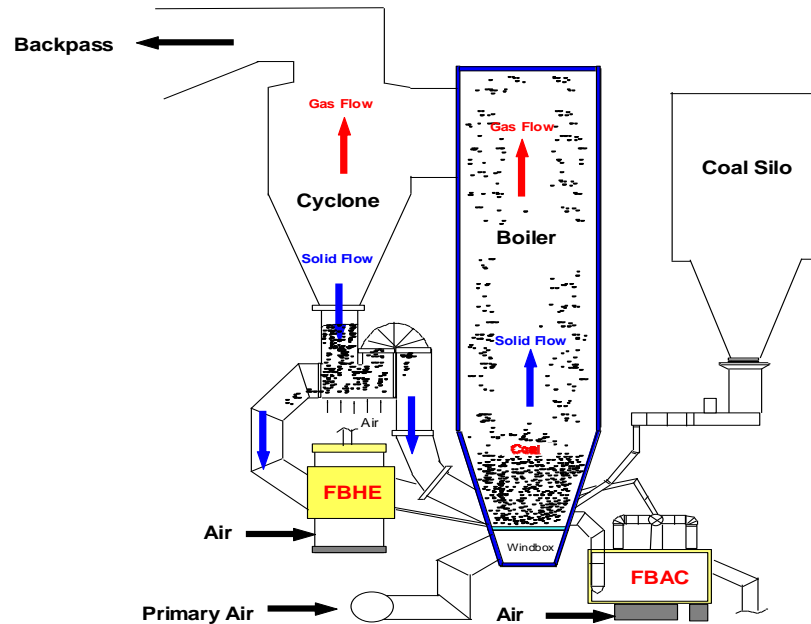
- First stage of thermal decomposition (330 ~ 370 °C)
- Second stage of thermal decomposition (370 ~ 420 °C)
- Char combustion (420 ~ 650 °C): Char Residues

**** Although the temperature at the maximum pyrolysis rate increases with increasing heating rate, secondary pyrolysis process is eliminated**

III. Biomass application

Commercial CFBC boiler(1)

Donghae CFB (200MW) – Biomass/RDF cofiring



RDF/wood pellet feeding site



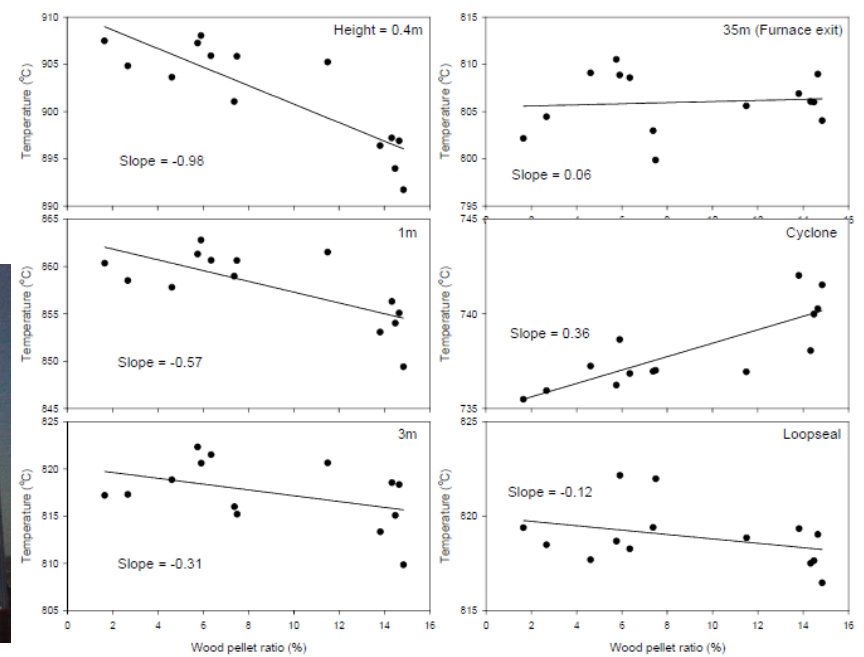
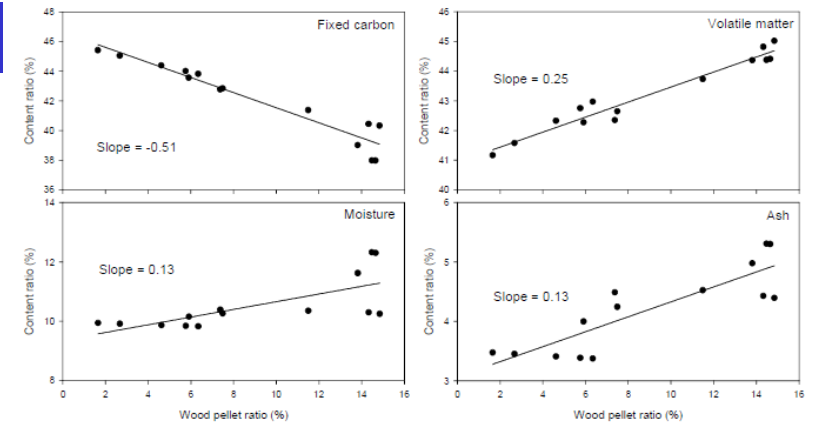
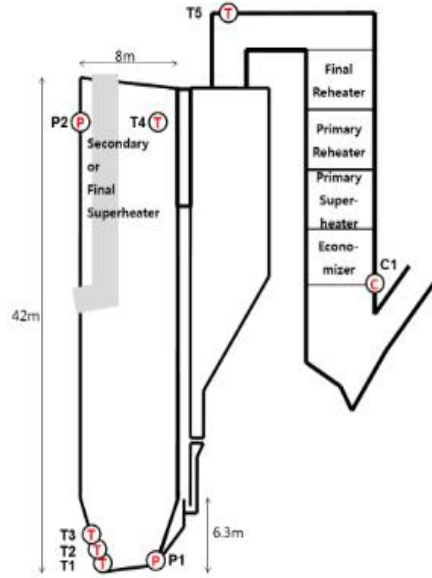
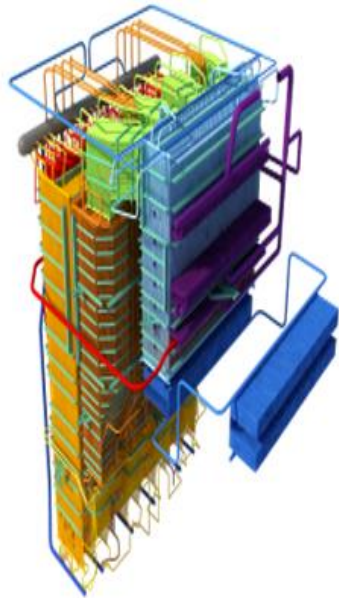
RDF/wood pellet feeding system



III. Biomass application

Commercial CFBC boiler(2)

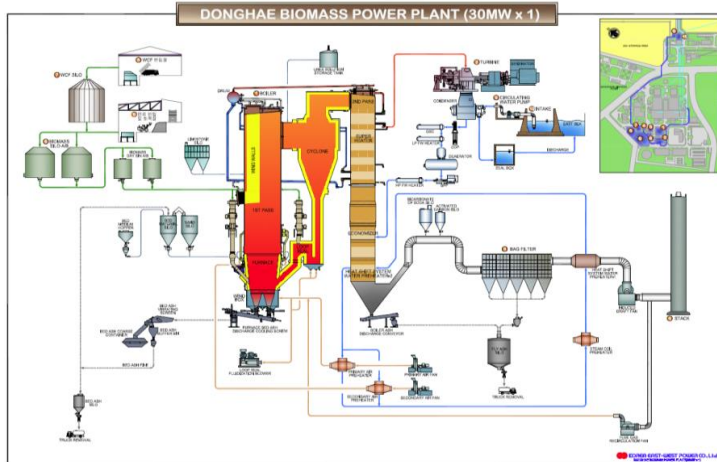
Yeosu CFB (340MW)– Biomass cofiring



III. Biomass application

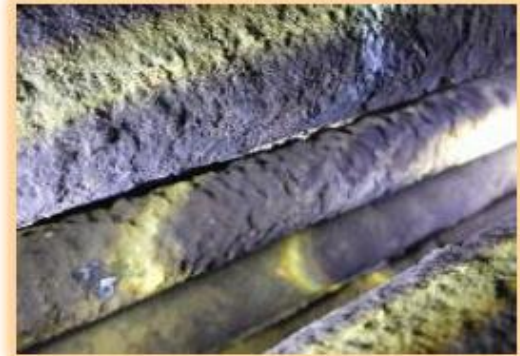
Commercial CFBC boiler(3)

Donghae CFB (30MW)– Only Biomass



Boiler	Andritz /POSCO CFB, constant Pr. Operation 107 ton/hr (84.5% efficiency) 96kg/cm ² , 510°C
Turbine	SIEMENS / POSCO HP TBN-LP TBN Rating 30MW 93kg/cm ² , 507°C
Fuel	100% Domestic Bio-SRF 2,400-4,285 kcal/kg(Design 3,952) 600ton/day (3,000kcal/kg basis)
Total Efficiency	28.4% (Output 100% basis) Station service consumption 14%
Problem	Tube leakage (HT corrosion)/Fouling Poor fluidization due to clinker formation / Fuel transport

Donghae CFB (30MW) – High temperature corrosion by KCl

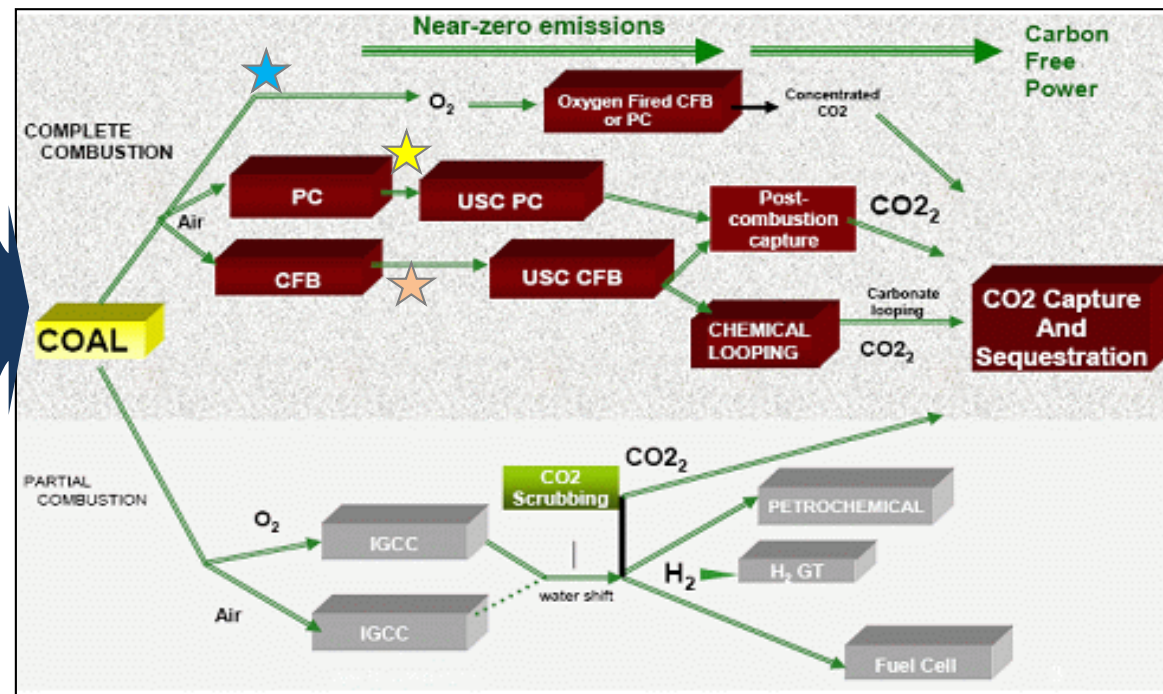
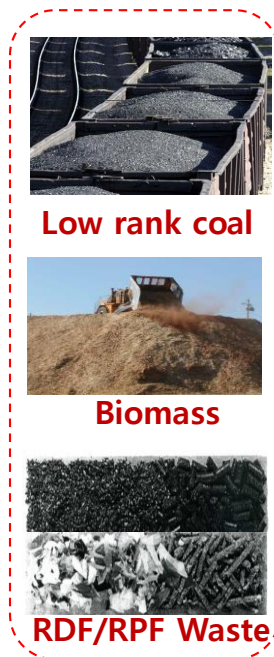


Reduction of high temperature corrosion after injection of ammonium sulfate

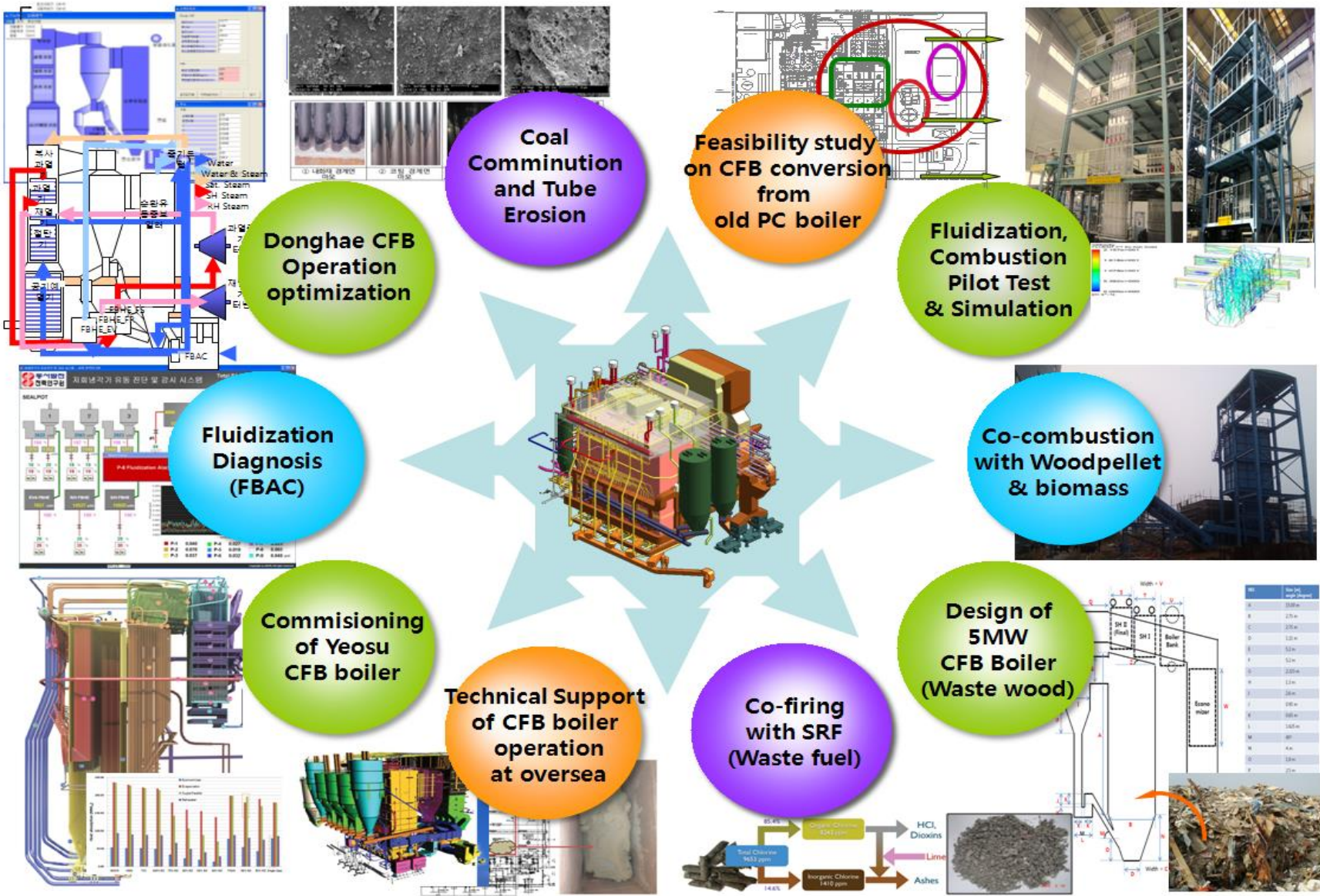
cf) Sometimes coal can be used to mitigate high temperature corrosion in biomass-fired boiler.

IV. Direction of power generation technology

- Clean power through co-firing of renewable fuel, high efficiency, and CCS
 - Large capacity power plant ; co-combustion (PC < 4%, CFB > 10%)
 - Middle & small (<100MW) ; combustion (FB and stoker boiler)
 - Forecast of fuel usage for co-firing/combustion : 1.4million tons after 2020
: Need to find and develop cheap domestic/overseas forest resources



KEPCO's Research Experience



Thank you