The Korean Activities of Oxy-Fuel Combustion

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KEPCO RI

Oxyfuel Combustion Conference 2

순산소연소연구단
OXY-FUEL COMBUSTION
R&D ORGANIZATION

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The Korean activities of Oxy-Fuel Combustion

1. Project Outline

Project Outline

Project Goal: **Demonstration of 100MWe Class Oxy-PC Power Plant**

Conceptual Design → **Basic Design** → **Detail Design & Construction**

Conceptual Design & Test Bed Construction

- Development of Process Analysis Tool
- Development of key technology of Oxy-PC Combustor
- Construction of Test Bed

Phase Ⅰ (2007~2010)

Basic Design of Oxy-PC Plant

- Feasibility Study of Plant Retrofit
- Development of key technology of Process Control & Operation
- Optimization of Process Analysis Tool
- Basic Design Oxy-PC Power system

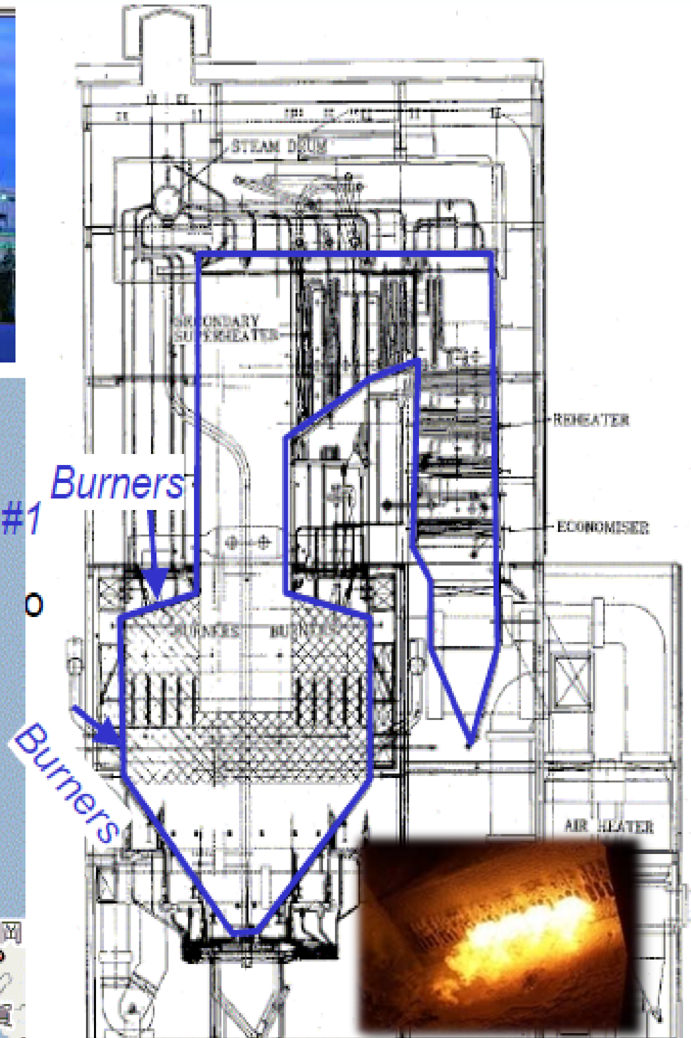
Phase Ⅱ (2010~2012)

Detailed Design & Construction of Demo. Plant

- Construction of Demo. Plant
- Detailed Design
- Test Running

Phase Ⅲ (2012~2015)

Tentative Demo. Site (Youngdong TPP)



Plant output	125MWe
Boiler type	Single-drum radiant heat type
Operation start	1973
Maker	Boiler : BHK T/G : Hitachi
Main steam	Flow rate : 420t/h Temp. : 541deg-C Pressure : 12.85MPa
Burner type	Circular type × 16 Bent type × 12
Mill type	Tube type × 6 (Standby × 1)
Fuel	Anthracite(FR*=14)
Efficiency	36%

* Fuel Ratio= Fixed Carbon/Volatile

Organization

Project Coordinator

- Role : Managment/Adjustment/Guide)
- Organization : KEPCO RI

Project 1

- Role
  - Development of Technology of Process Control & Operation for Oxy- PC Power System
  - Basic Design of Demo. Plant
- Organization : KEPCO RI
- Consortium : KOSEP, DIGC, DHIC, KITECH

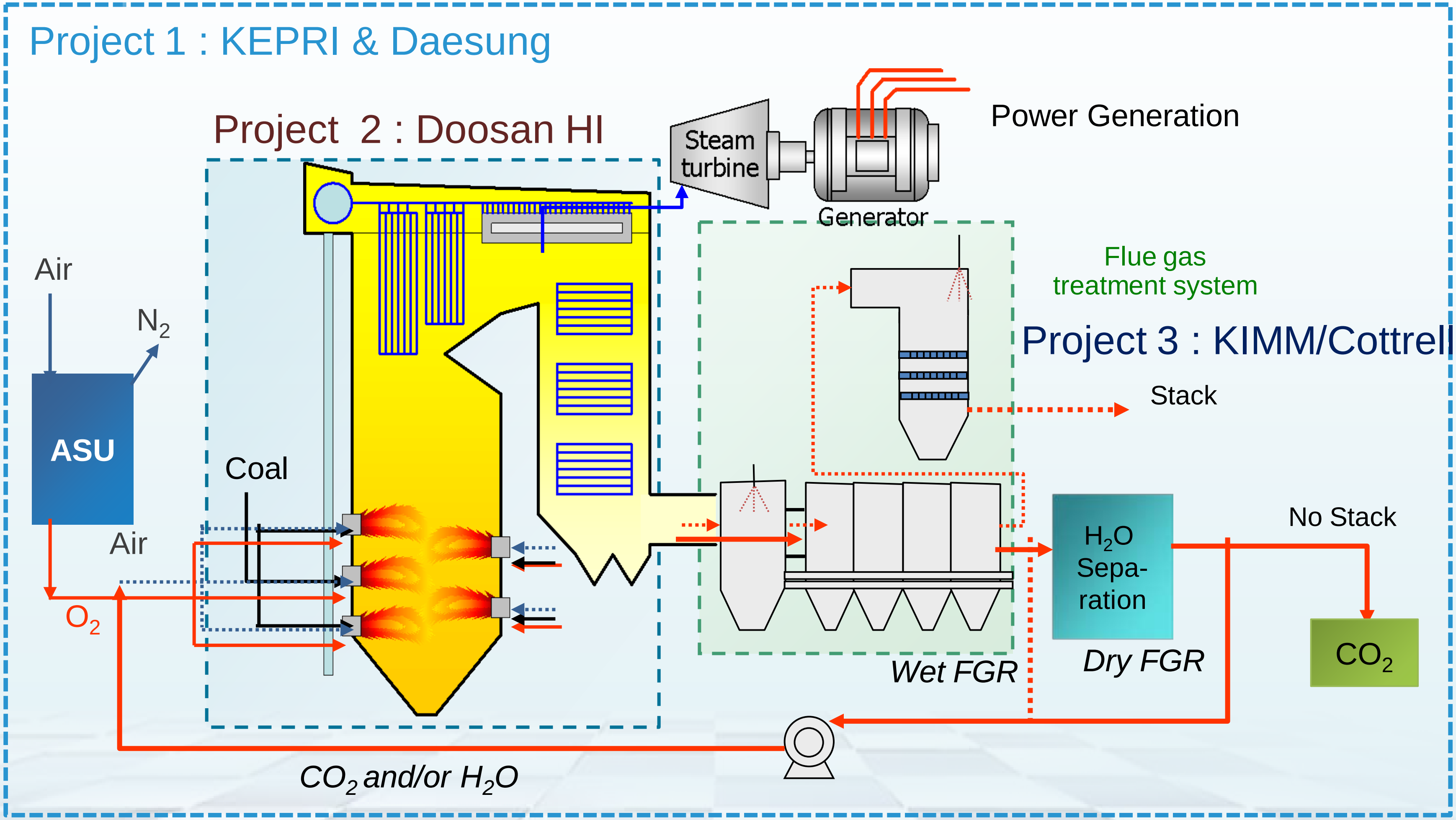
Project 2

- Role : Basic Design of Oxy-PC Boiler
- Organization : DHIC

Project 3

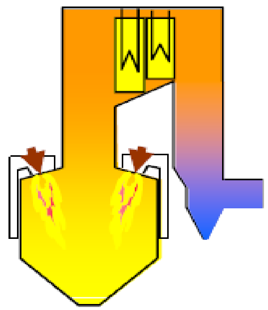
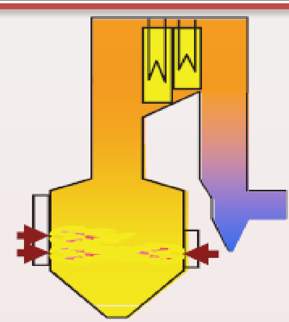
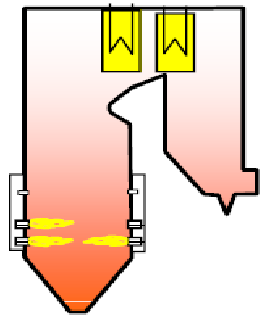
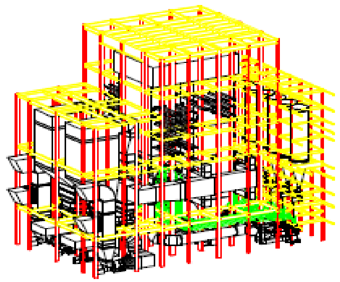
- Role : Development of Environmental Control System for Oxy-PC Power System
- Organization : KIMM
- Consortium : KC-Cottrell, Yonsei Univ. KAIST

Scope of Basic Design



2. What We Have Done

Feasibility Study Result (Boiler)

Feasibility Cases				
	Case 1	Case 2	Case 3-1	Case 3-2
	Retrofit	Retrofit	Retrofit	Brownfield
Boiler	Existing Downshot	Existing Downshot	New Boiler	
Firing System	Downshot-Fired Circular Burners	Wall-Fired Circular Burners & New Windbox		
Mill & PF Ducting	Vertical Mill & New PF Piping, New PAF			
Boiler Plant Layout	Maximum use of boiler / boiler island components & layout New PAH & refurbished SAH			New
Boilerhouse Primary Steelwork	Existing			New

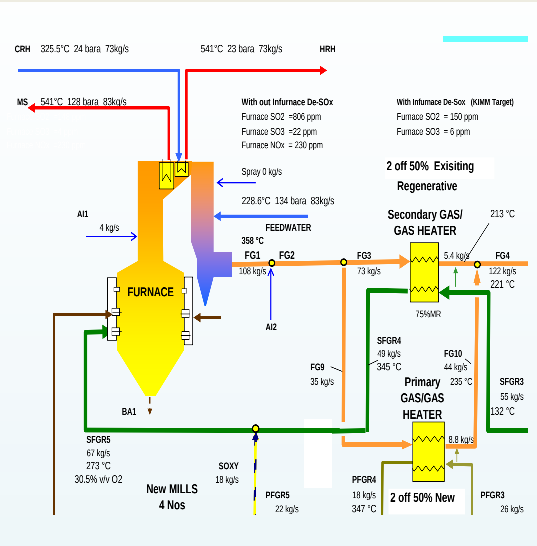
The Retrofit Case was selected to apply for verified Oxyfuel technology maximizing use of exiting boiler components & layout

Performance & Indicative Capital Cost(Boiler)

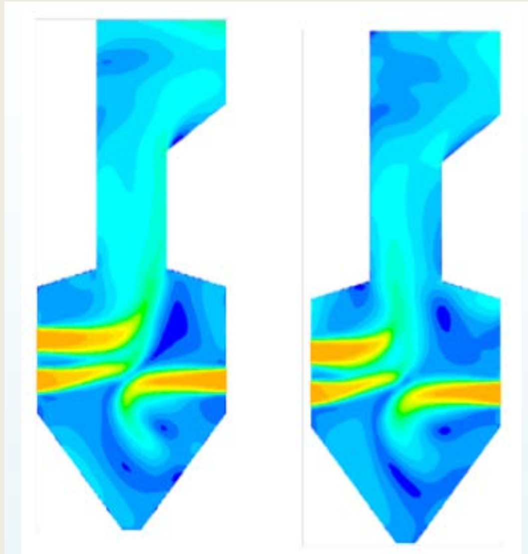
Feasibility Study		Performance (100% MCR)		Emissions			Capital Cost[4] (MUSD)	Total Expected Period (months)
		Capacity[1] (t/h)	Efficiency (% GCV)	NOx (mg/MJ)	SOx (mg/MJ)	Dust (g/Nm^3)		
Case 0	Air-firing	372 t/h	82.0 %	tbc	305	19.4	-	-
Case I	Air-firing	372 t/h	83.3 %	Approx 120	340	2.9	27.0	26
	Oxy-firing	297 t/h	86.9%	Approx 60	650[2] 120[3]	3.7		
Case 2	Air-firing	372 t/h	83.4 %	90	340	2.9	27.7	28
	Oxy-firing	297 t/h	87.1 %	45	650[2] 120[3]	3.7		
Case 3-1 (3-2)	Air-firing	372 t/h	83.6 %	90	340	2.9	77.4 (87.2)	36 (44)
	Oxy-firing	297 t/h	87.3 %	45	650[2] 120[3]	3.7		

Notes :
1) Boiler Capacity was considered based on 372 t/h equivalent to 125 MWe gross for Air Firing and 297 t/h equivalent to 100 MWe gross for Oxy firing condition.
2) Uncontrolled SOx
3) In-furnace De-SOx (as proposed by KIMM)
4) Capital Cost was estimated as a results of Feasibility Study and is not guaranteed.

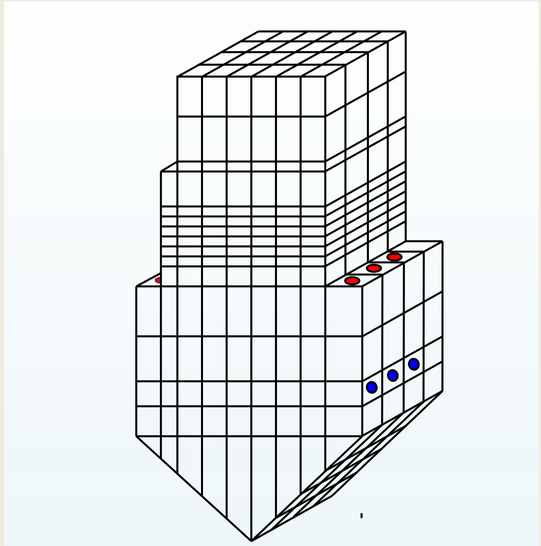
Thermal Performance Modeling & Prediction



Boiler Island Process Flow Diagram
Heat & Mass Balance



CFD Modelling Isothermal Flow
Field Staged & Un-staged



Heat Transfer Performance

- Boiler plant designed for air-firing can operate under oxyfuel firing conditions, without significant heating surface pressure part modifications

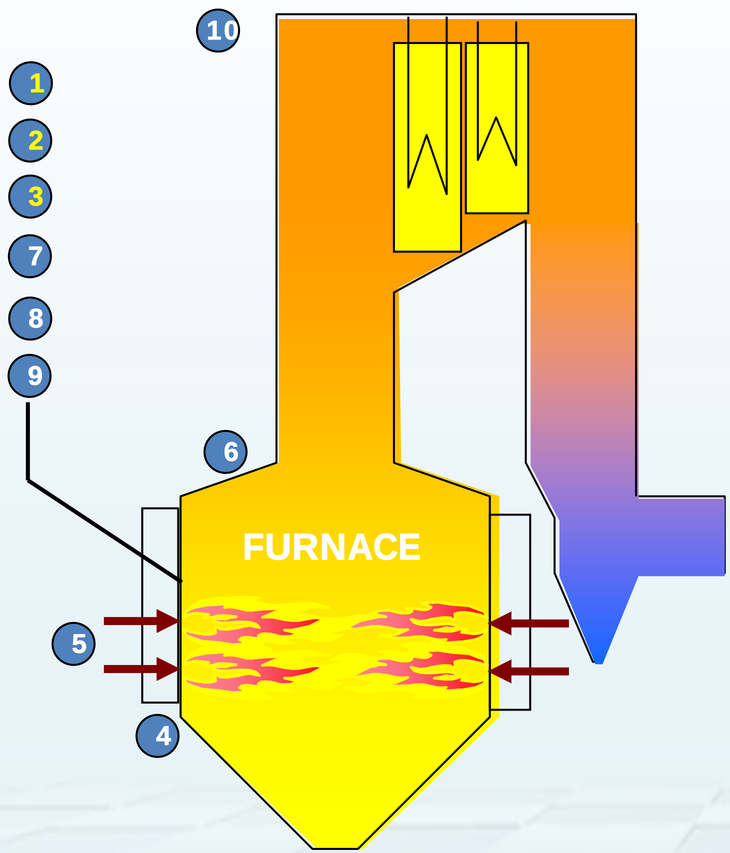
- Low utilisation of lower furnace leading to high SH spray demand & high carbon-in-ash (short residence times).

Furnace
– Radiant heat transfer dominates
– Radiant heat transfer dominated by particulate material
– Impact of non-luminous gases radiation (CO_2, H_2O) small compared to particles
– Impact of oxyfuel compared to air is therefore expected to be small

Convective pass
– Heat transfer based on gas properties, velocities
– Radiation has diminishing importance
– Performance is predictable using conventional design rules

Minimal thermal impact of oxyfuel verified by pilot scale testing

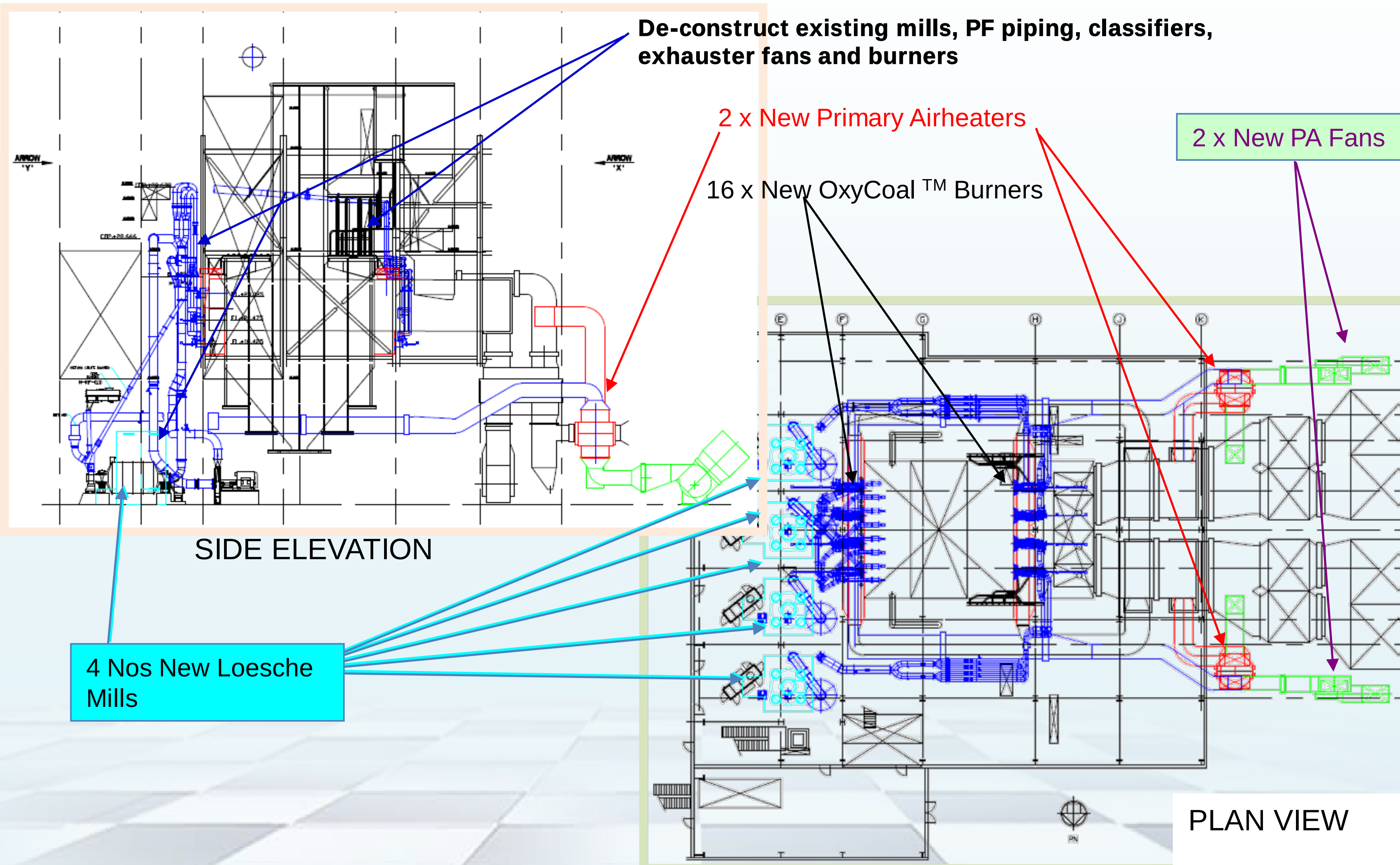
Mechanical Design



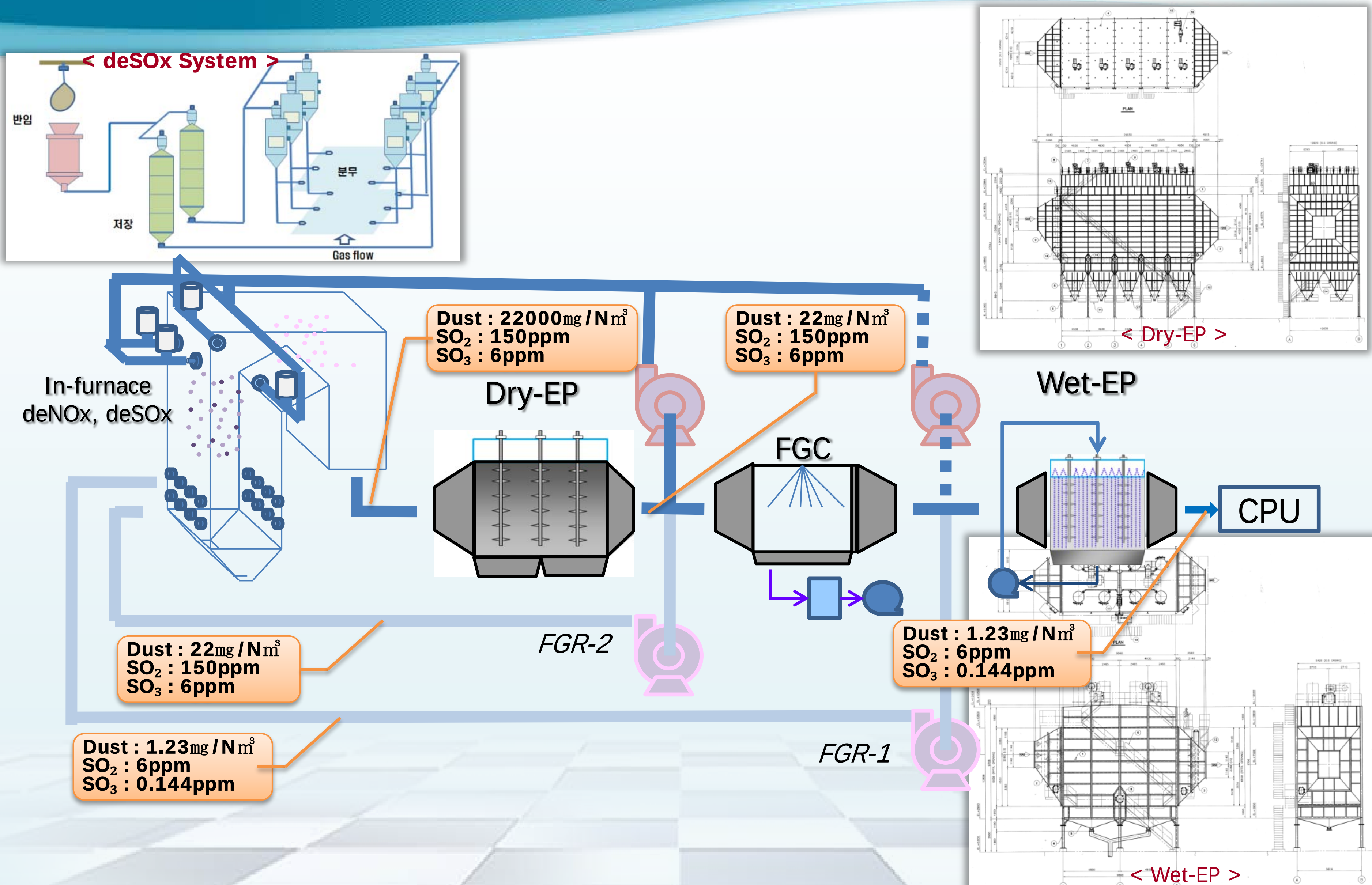
Retrofitted Boiler : WALL FIRED		
Detailed Review:-		(to accommodate new burner loads)
Sling Tubes*	1	New, Rows 'A' & 'D' material upgrade
Furnace Wall Tubes	2	No strength mods other than redundant tubeset replacement
Framing & Attachments	3	New replacement 'hot' buck stay at one level
New Scope:-		
Burner Windbox	4	New
Burners & Burner Openings	5	New OxyCoal™ Burner
Arch Pressure Parts	6	New (ribbed bore tube or alternative tube)
Seal Casing	7	New
Overturning Posts & Buckstays	8	New (or strengthened)
Pressure Part Attachments	9	New
Supports*	10	New, Row 'B' sling rod material upgrade

*Sling row definition - Refer Drg No.: KU1-122-601 Boiler Loading Plan

Conceptual GA



Environment Control System



Environment Control System

1) Design Condition

	Type	Specification	Remarks
De-SOx	In-Furnace De-Sox(Dry Type)	limestone, 1t/hr, dry flue gas spray	New Build
Dry EP	Dry, Full Sealed	510,000m3/hr, Temp. 210℃, Eff. 99.96%	New Build
FGC	Spray	200,000m3/hr, Temp.120℃/30℃	Incl. cooling tower
Wet EP	Water Film	200,000m3/hr, Temp.30℃, Eff. 95%	New Build
FGD	Wet Type FGD	200,000m3/hr, Temp. 30℃, Eff. 98%	Reuse
Aux. filter	Filter	10,000m3/hr, Temp. 30℃, Eff. 95%	New Build

2) Capital Cost

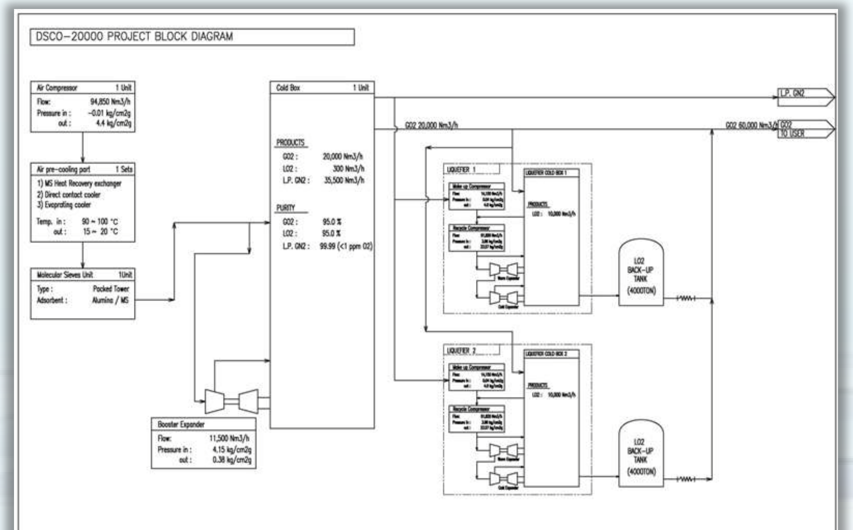
(MUSD)

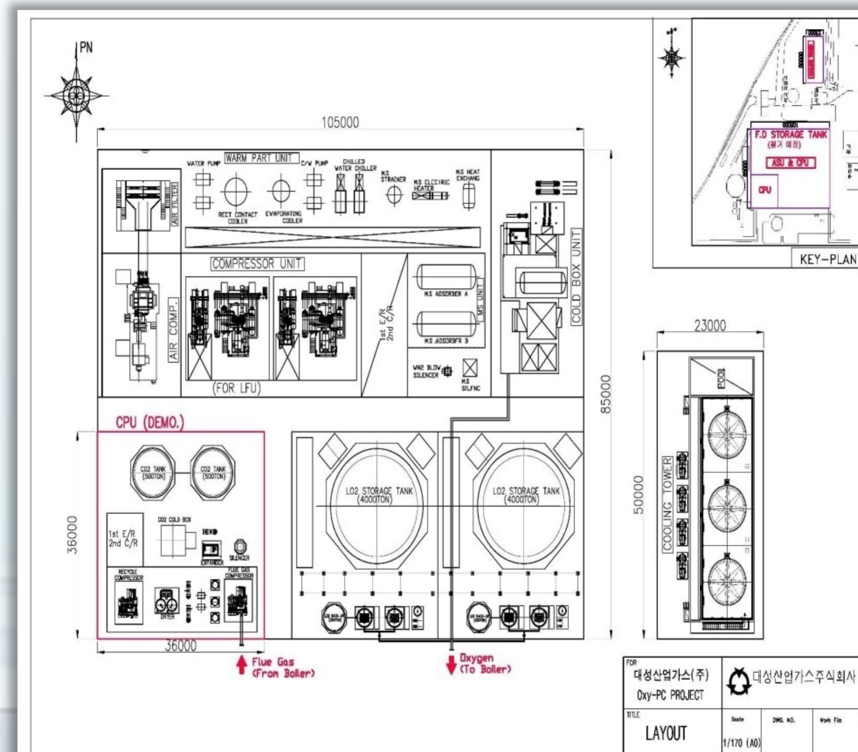
	CASE 1	CASE 2	CASE 3
De-SOx	1.5	N/A	1.5
Dry EP	5.0	5.0	5.0
FGC	1.2	1.2	1.2
Wet EP	2.0	N/A	N/A
FGD	N/A	5.0	5.0
Aux. filter	N/A	0.3	0.3
Total	9.7	11.5	13.0

ASU & CPU

	Basic Design Conditions for ASU	Remarks
ASU Type	Double Column	Cryogenic
O2 Purity	95%	
Oxy mode	GO2 Producing, 20,000 Nm3/h LO2 Back-up, 40,000 Nm3/h	1/3 Vs Full Load Demand
Air Mode	20,000 Nm3/h	LO2
Capacity of LO2 Tank	8,000 m3	For 6days Oxy mode Operation
Time for LO2 production	11 ~ 12 days	For During Air Mode

	Basic Design Conditions for CPU	Remarks
CPU Type	Cryogenic	
Capacity	10% Vs Full Load Demand	
CO2 Phase	GCO2, LCO2	Depend on Operation Mode





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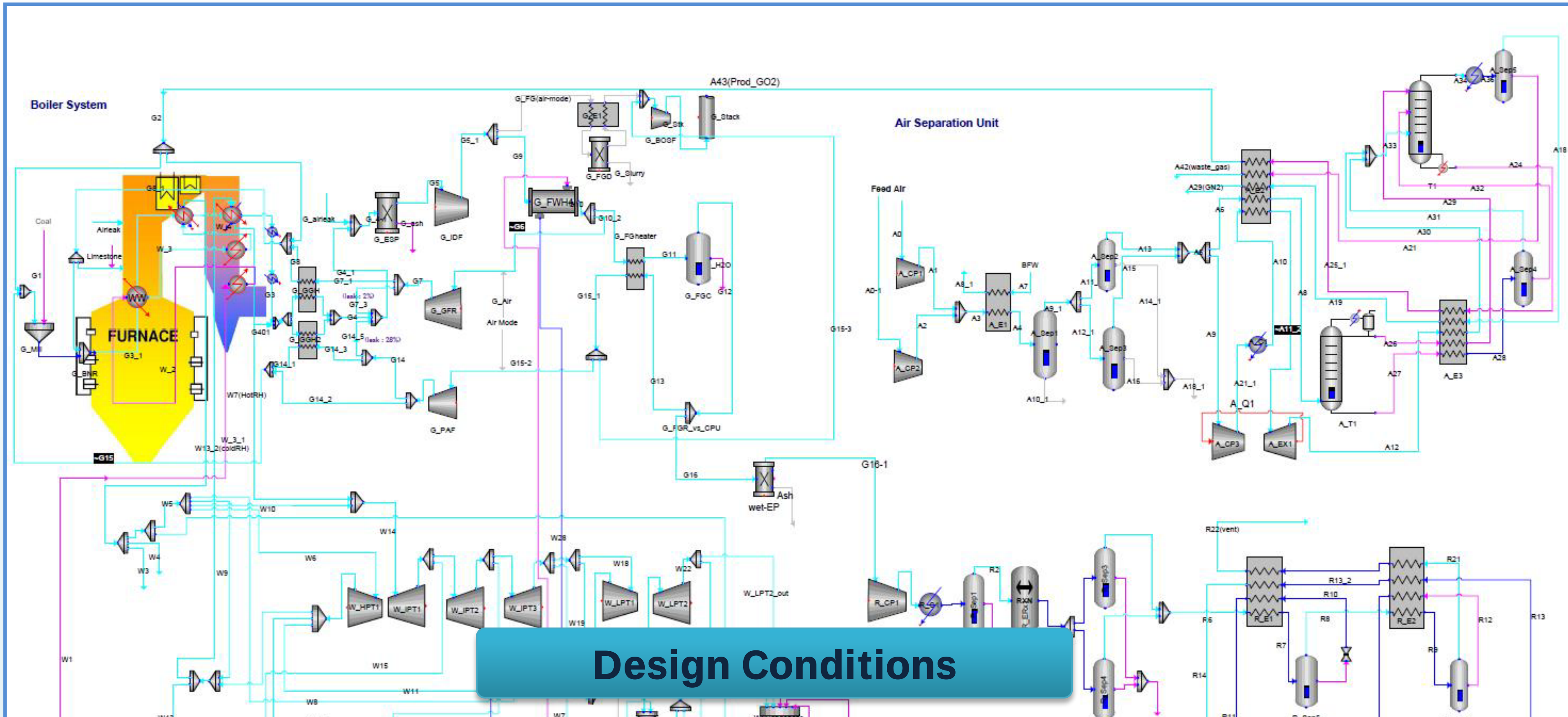
Process Diagram of Oxy-PC Power Plant



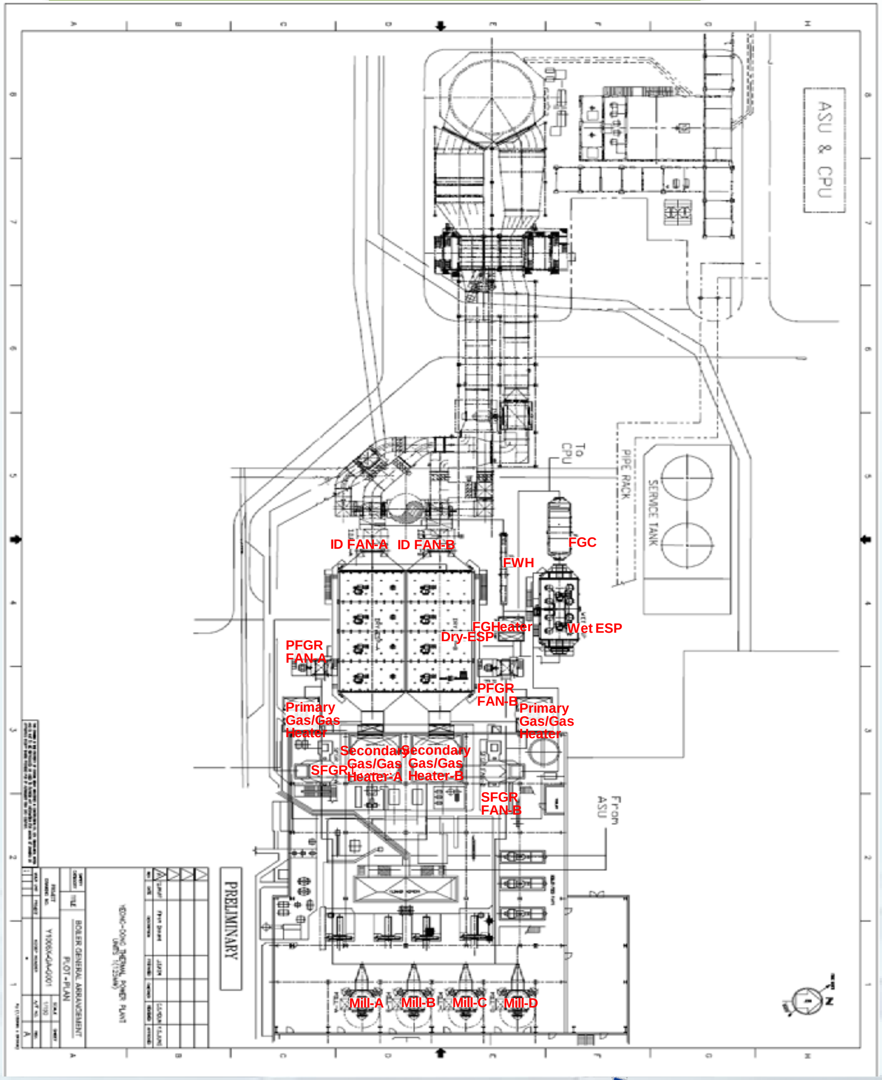
Design Conditions

Process	O_2 Purity	Excess O_2	FGR Rate	CO_2 Capture Rate	CO_2 Purity	Air Ingress Rate
Operation Condition	95%	3%	67.4%	90 %	95%	3.5%

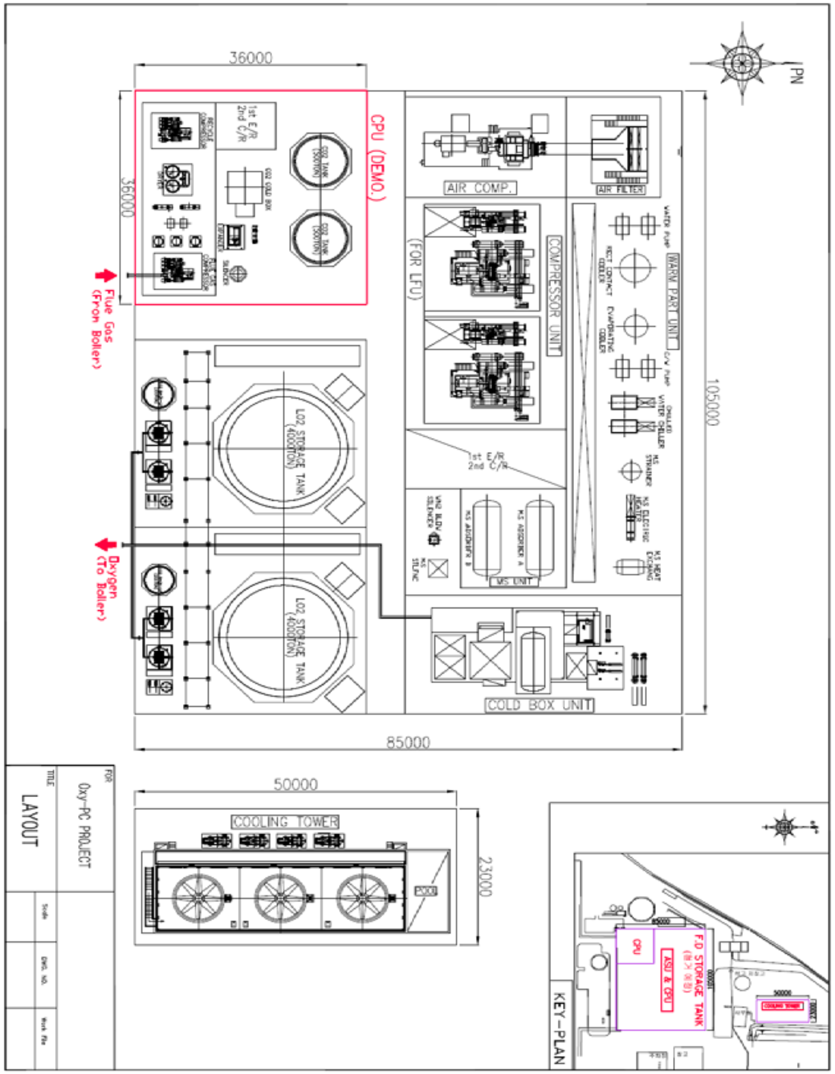
Arrangement Plan of Main Facilities

General Arrangement

Boiler Island



ASU & CPU



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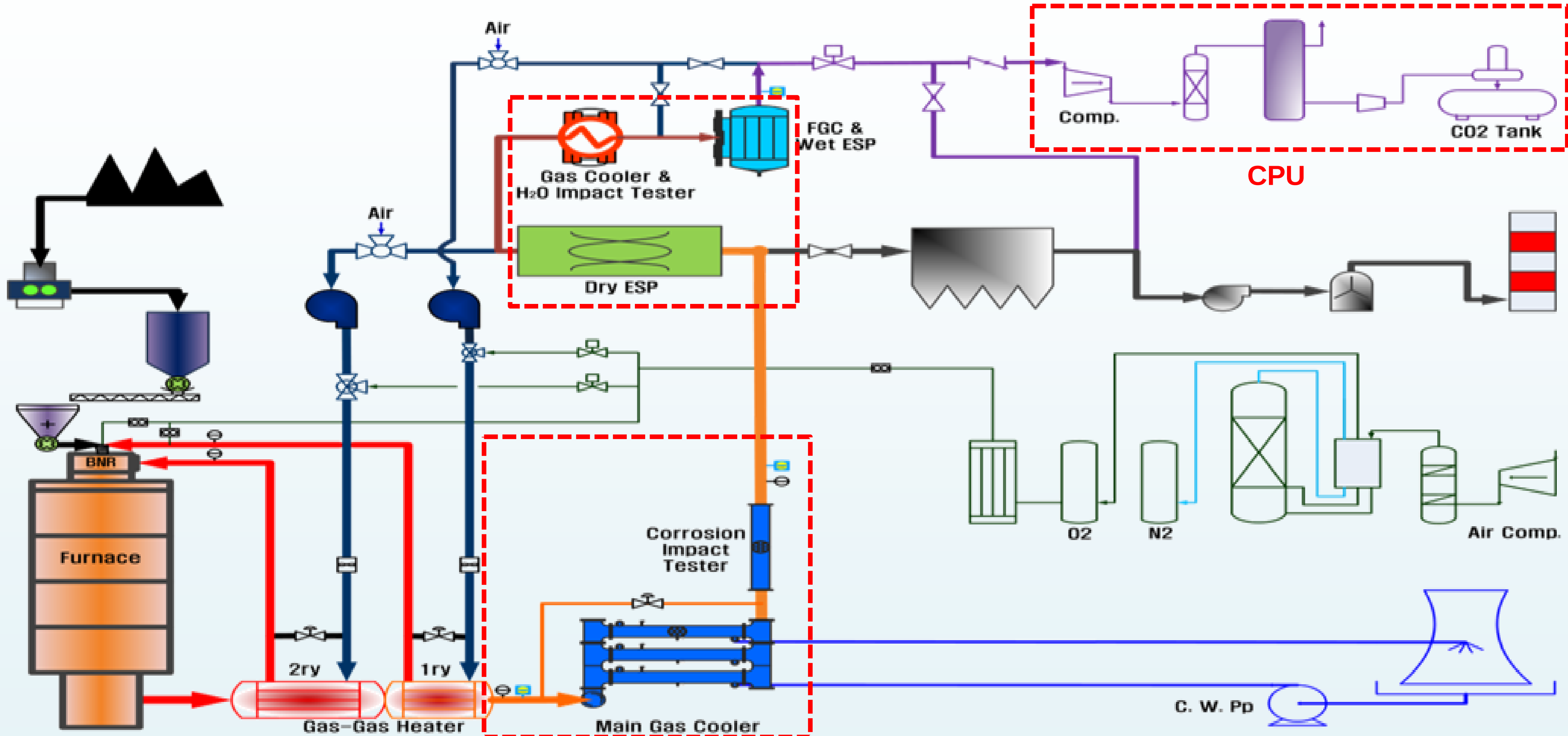
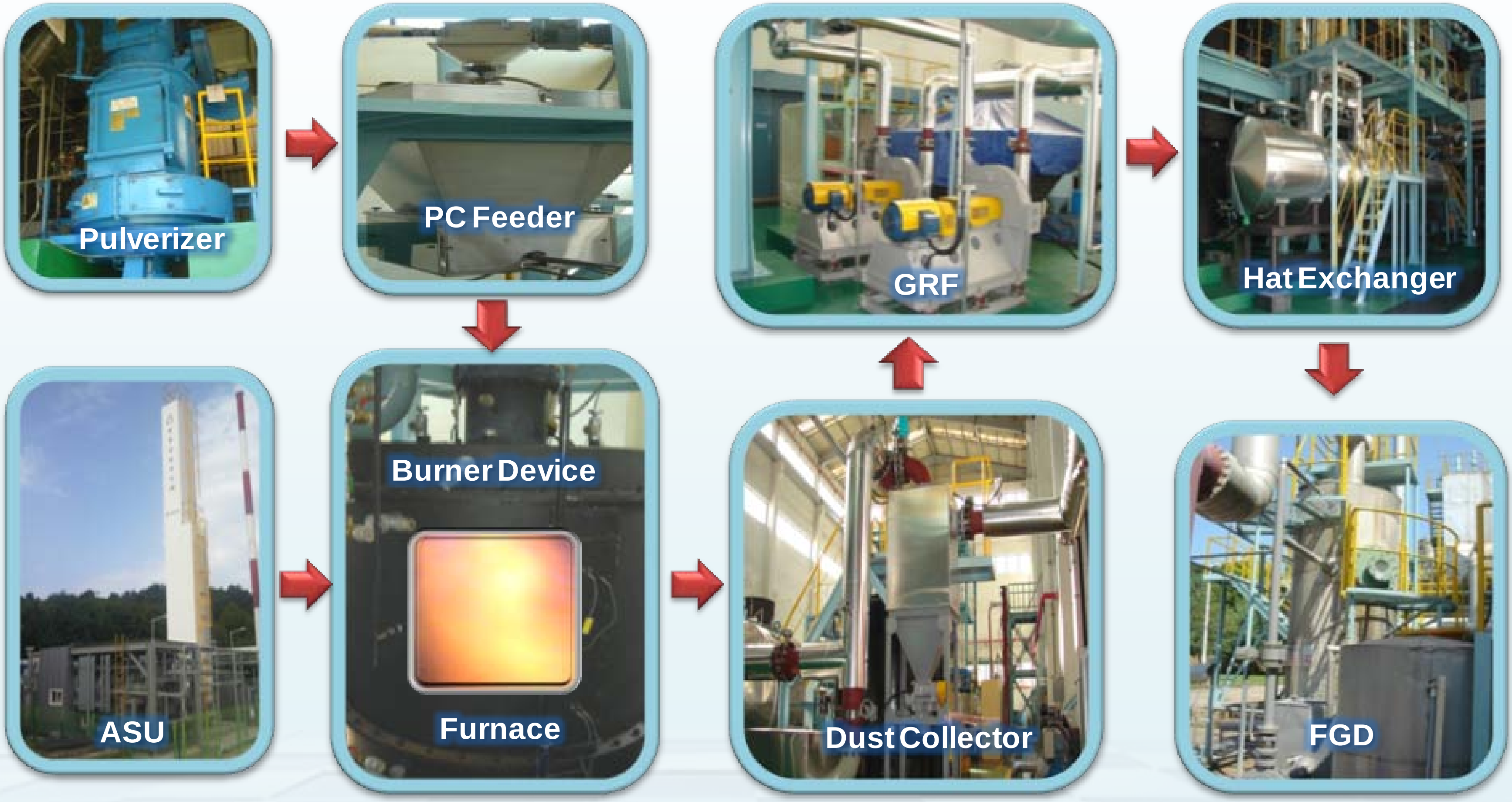
Schematic Diagram of Test Bed



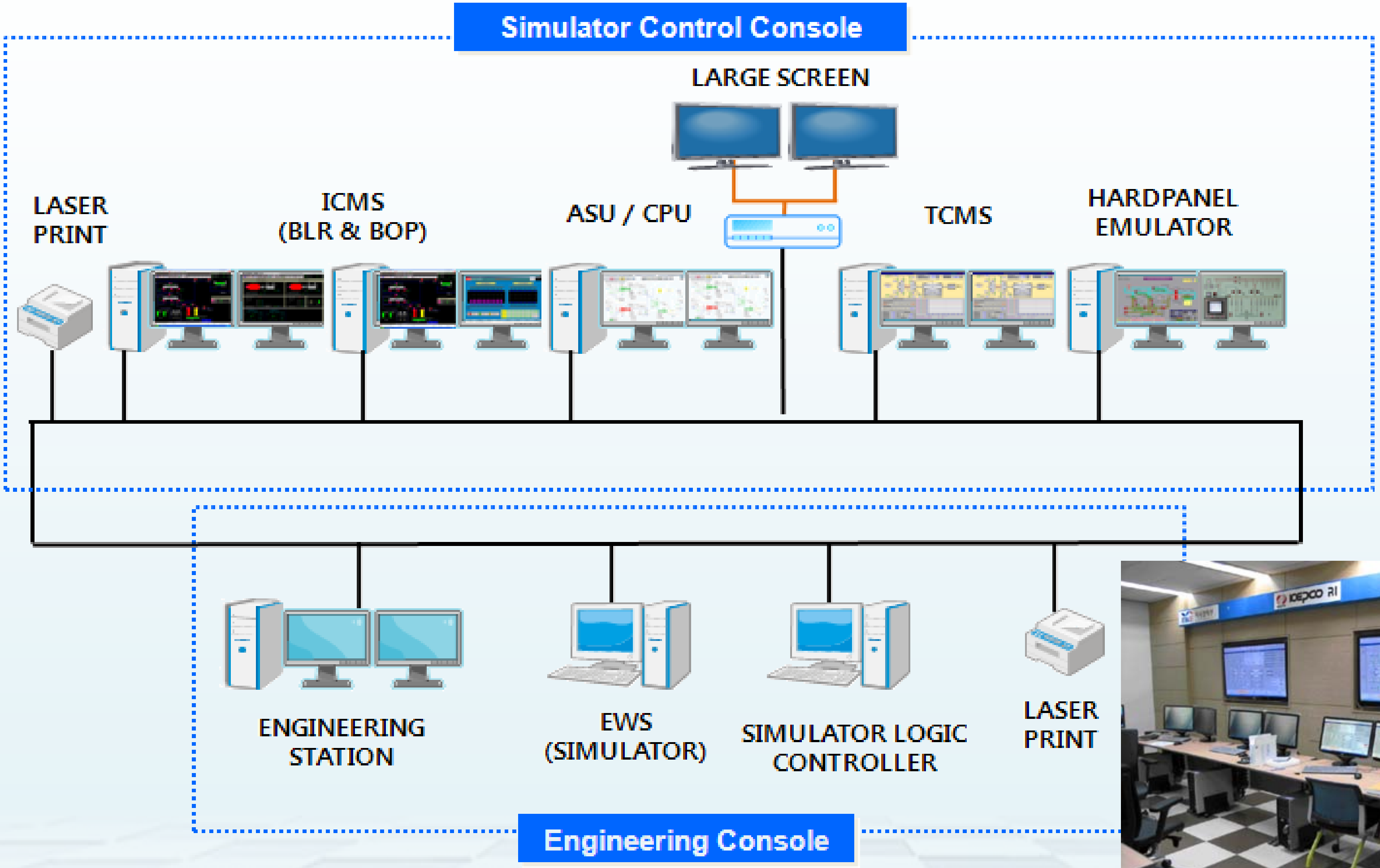
- Oxy-PC Test Bed 100kg/hr(Coal),(0.7MWth)
- Dual Mode Operation (Air & Oxy Mode)

Test Bed – Combustion System

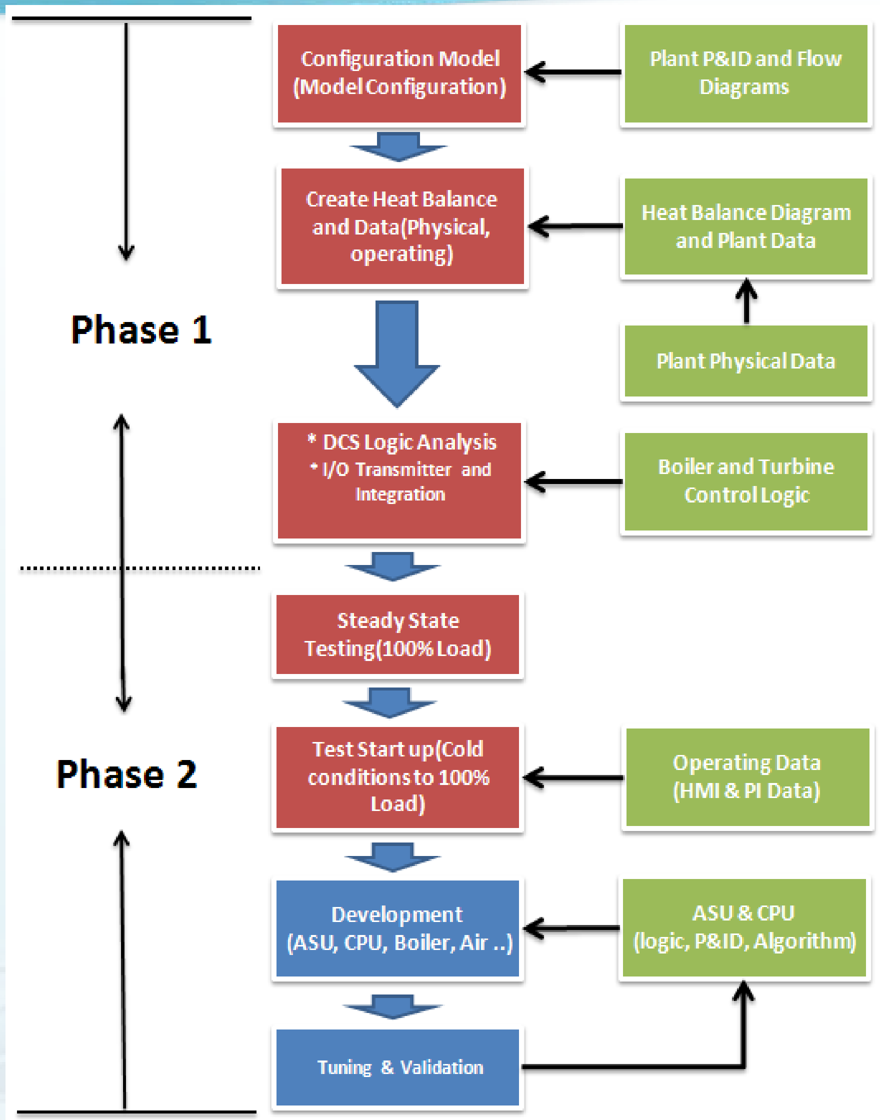


Test Bed -Environment Control System

Developing of Dynamic Engineering Simulator



Developing of Dynamic Engineering Simulator



Phase 1) YEONGDONG Unit 1 Engineering Simulator

- Developing YEONGDONG Unit 1 Engineering Simulator
- Performance Verification of YEONGDONG Unit 1 Engineering Simulator

Phase 2) Oxy-PC Dynamic Engineering Simulator

- Modifying YEONGDONG Unit 1 Engineering Simulator to Oxy-PC Dynamic Engineering Simulator
- Developing Boiler and Air/Gas System Model for Oxy-PC Dynamic Engineering Simulator
- Developing ASU and CPU System Model
- Verifying Boiler and Air/Gas System Control Logic

Developing of Dynamic Engineering Simulator

YEONGDONG Engineering Simulator

- YD Simulator Tuning & Test

ASU&CPU System

- Module Development
- Control Logic Emulation
- HMI Screen Emulation

Oxy-PC Boiler System

- Boiler Model
- Boiler Control Logic
- Boiler HMI Screen

Oxy-PC Simulator Integration

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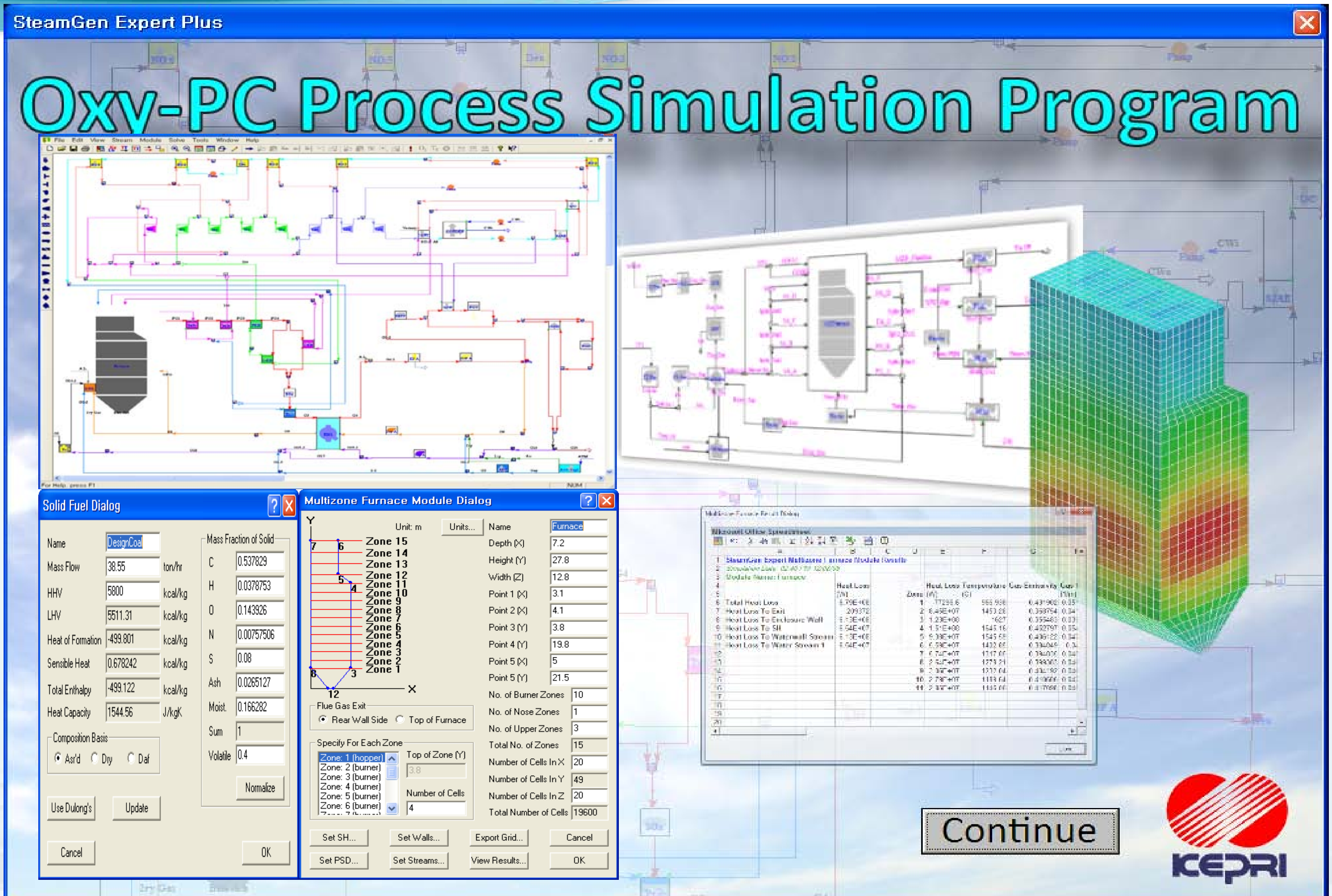
Developing of Process Analysis Tool



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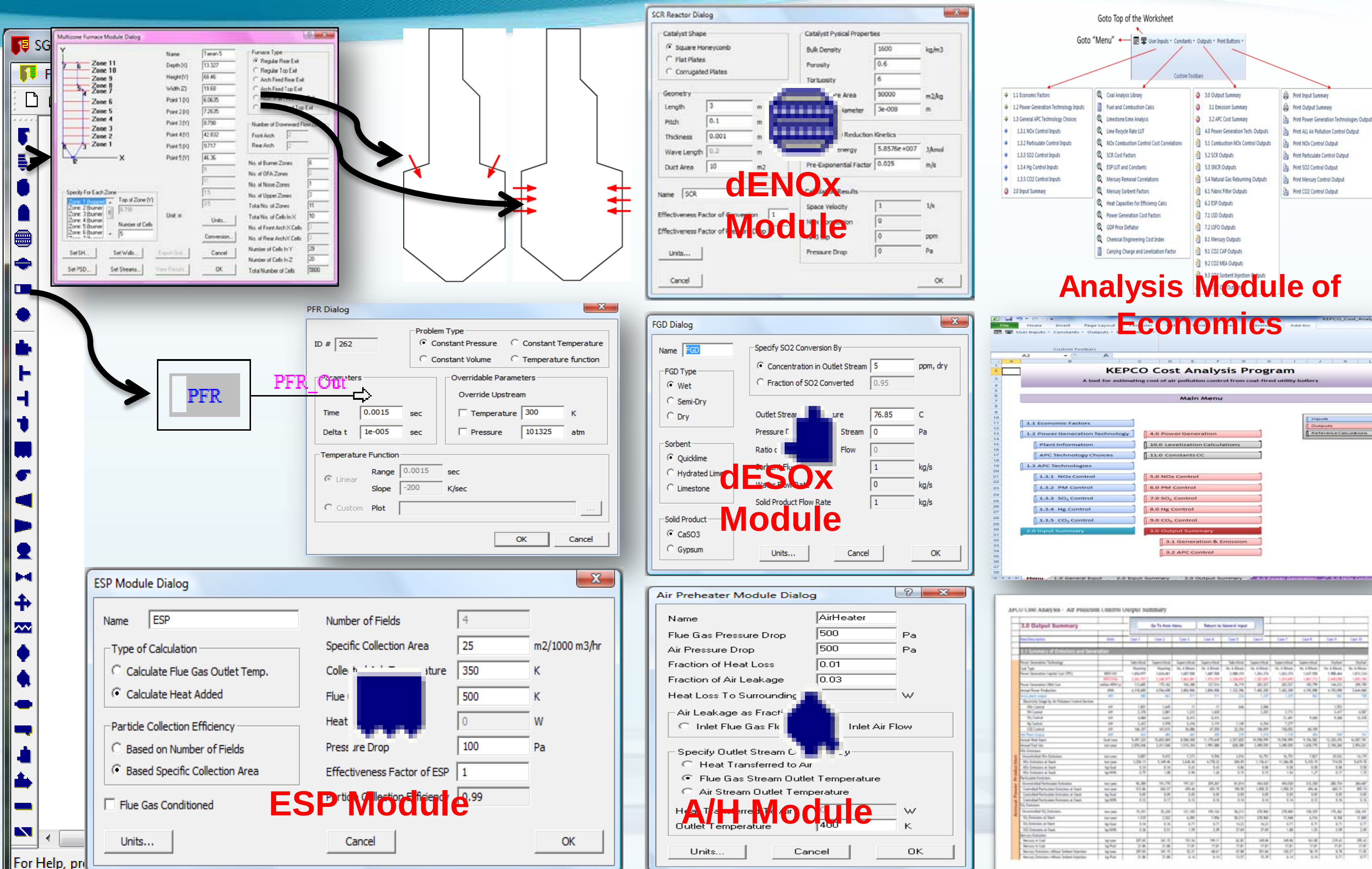
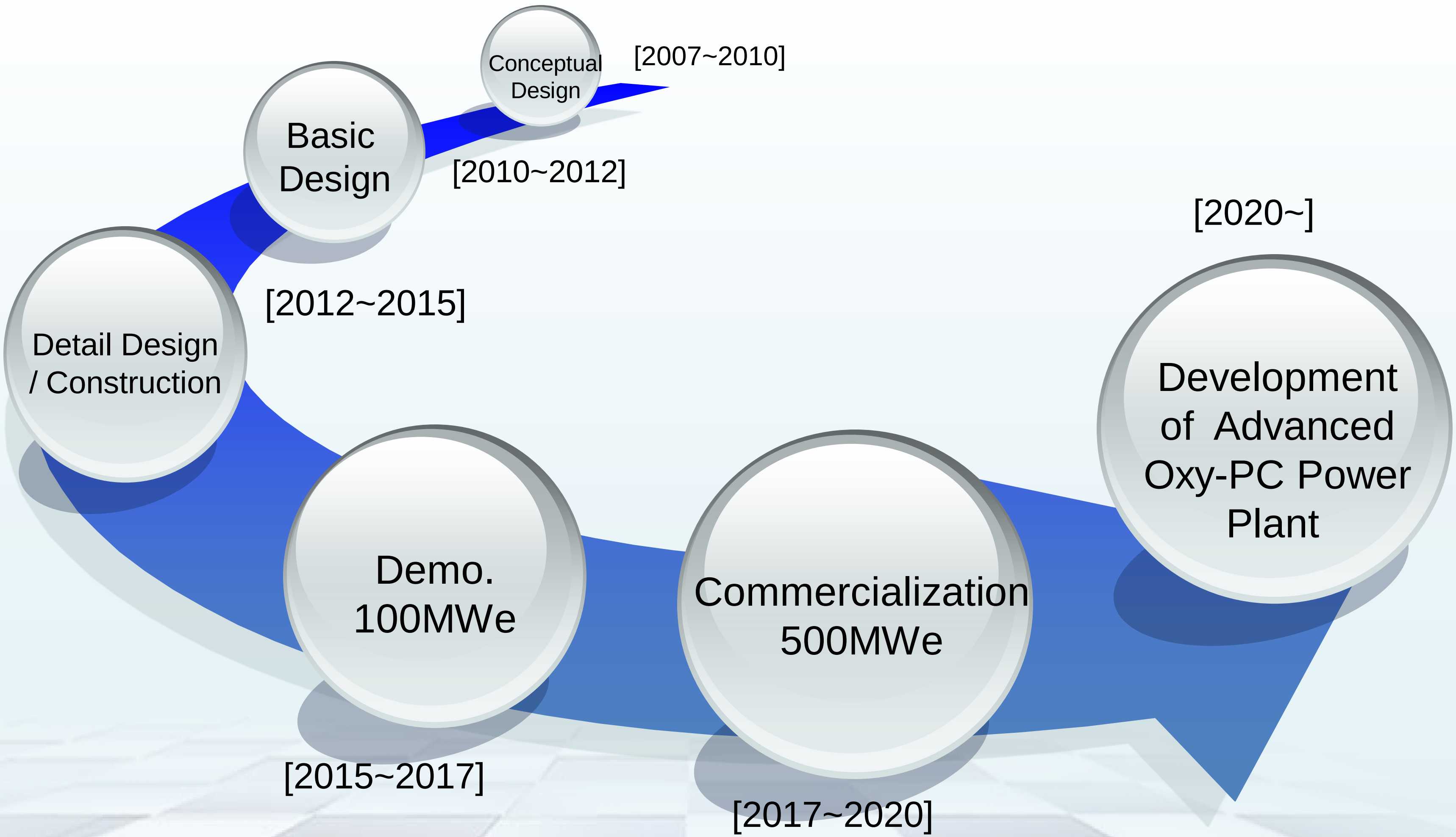
Developing of Process Analysis Tool



3. What We Will Do

KOCRO Plan



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Capital Investment

Total Capital Investment : 130M USD

Cost Share

- Power Company : KEPCO, KOSEP
- Private Sector : Doosan, Daesung, KC Cottrell
- Korean Government

Preliminary Feasibility Study

- **Every public project with over 50M USD MUST pass the preliminary feasibility study by the Ministry of Treasury.**
- We will enter the 2012 PFS to get the 2013 budget allocation fr om the National Assembly

Operational Cost

Dual Combustion Operation

- Expect to have 100day/year Oxy-Fuel Mode Operation
- Minimum 3 years operation
- Can be extended if additional needs (testing new technologies)arise

Operation Cost

- Need to compensate the loss of revenue by Oxy-Fuel Operation
- 10M USD per year

Potential Compensation Methods

- RPS
- CTS
- Adjustment of Power Whole Sale Price

Conclusions

Conclusions : Technical & Political

Technical Front : Sailing Smooth

- Ready to complete the Demonstration Plant Construction by 2015
- Dual Combustion Mode Allows Us A Very Flexible Operation
  - Test Different Technological Options
  - Can Go Back to Air-Firing Mode until the Technical Problems are Fixed if they arise
- There is a Window of Opportunity to Deploy Brand-New Commercial Scale Oxy-Fuel Power Plant in Korea After 2020

Political Front : Foggy

- Much of the Driving Force for Global Climate Change Mitigation Has Been Evaporated
- We Do Not Know Whether the Korean Government Is Willing to Move Ahead in This Circumstance.

Storage

- Lagging behind the Capture Technology Development
- Yet to Hear from the National Geological Institute and Korea National Oil Corporation about the Commercial Scale Off-Shore CO2 Storage Sites

Thank You

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