Haiphong City in Vietnam Waste to Energy Project

December 24, 2017

HANVIT Power Inc.

Korea District Heating Engineering Co., LTD.

Woowin Keytek Co., LTD.

Agenda

1. Technology

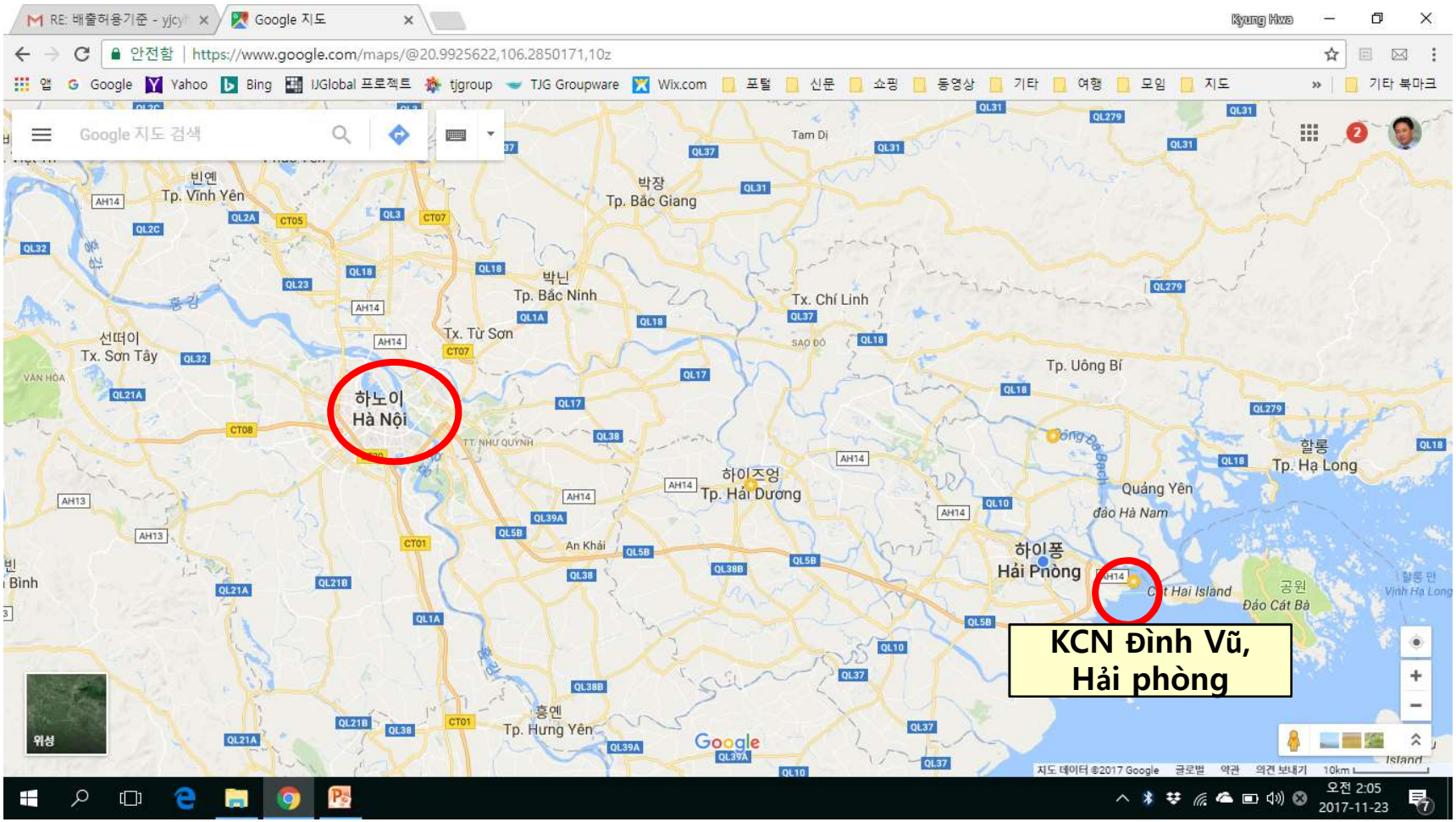
Project Overview

Project Overview

- **Project** : Haiphong City Waste to Energy Project
- **Client** : Haiphong City, Vietnam
- **Location** : KCN Đình Vũ Đông Hải, Hải An, Hải Phòng, Việt Nam
  (N 20.827184, E 106.768315)
- **Capacity** : 23.3 Mwe/hour
- **PPA** : USD 9.5 cents/kwh
- **Contract** : HANVIT Power Consortium
- **Duration** : 35 Months

MSW Plant Site

- **KCN Đình Vũ Đông Hải, Hải An, Hải Phòng, Việt Nam**



Dinh Vu Industrial Park

MSW Plant Site

KCN Đình Vũ Đông Hải

Municipal Solid Waste in Hai Phong City

- **Opening/closing of landfill sites** :
  - Almost 90% of landfill sites have been built within 20 years; many of the sites just closed or will be closing very soon (because of long-lasting effect to the water source and bad smell to the air)
- **Disposal completion rate of landfill:**
  - Over 50% of landfill area are filled with more than 80% of the total.
- **Population/waste volume**
  - Over 80% of URENCOs cover less than 400,000 people, and about 60% of URENCOs collect less than 50,000 ton of waste per year.
  - Till 2016, total population of Hai Phong City is 1.963 million people. Hai Phong Urencos has collected about 80% of total urban solid wastes, and accounting for 60% of total solid wastes generated by Hai Phong people yearly
- **Waste composition**:
  - Average composition of highly organic waste is 72.6%. (55,18~57,60%- data from Jica, Mar 2011)
- **Collection fee**:
  - URENCOs collect on average 14,100 VND/month/household (70US cent) as the waste collection fee.
  - At present, 1 household in Haiphong City has to pay 40,000 VND (1.76$)/month to URENCOs for collection, trans.port and disposal. Factory, office, hotel, restaurant, hospital, school has to pay 324,000 vnd(13,6$)/month (QD:3257/2016/QD-UBND dated 22/12/2016

Ref: MRV designed for NAMAs in Waste Sector in Vietnam, Presented by: Anh Tien Do, Ph.D. , Vietnam Institute of Meteorology, Hydrology and Environment

Composition of MSW

Table 5. Composition of solid waste in Vietnam's cities in 1998 - % in weight

Composition	Hanoi	Haiphong	Halong	Danang	Ho Chi Minh City
Organic compounds	50.1	50.6	40.1- 44.7	31.5	41.3
Plastic, rubber, leather	5.5	4.5	2.7 - 4.5	22.5	8.8
Paper in all kinds	4.2	7.5	5.5 - 5.7	6.8	24.8
Metal	2.5	0.2	0.3 - 0.5	1.4	1.6
Brick, stone, ceramics	1.8	0.6	3.9 - 8.5	1.8	5.6
Soil, cobble & other solids	35.9	36.5	47.5 - 36.1	36	18
Water content	47.7	45 - 48	40- 46	39.1	27.2
Ash content	15.9	16.6	11	40.3	58.8
Density, ton/m^3	0.42	0.45	0.57-0.65	0.38	0.412

Source: Report "State of Environment in Vietnam 2001" - NEA

Woods: 3.7%

Ref: Solid Waste Management in Vietnam, An Industrial Ecology Study by Thao Nguyen School of International and Public Affairs, Columbia University Adviser: Prof. Nickolas J. Themelis, Earth and Environmental Engineering

Heat Value for MSW Haiphong

- **We assume MSW Heat Value data for Haiphong City**
  - We get a data from Dhaka(Bangladesh) and South Tangerang (Indonesia) with similar living culture
- **Reference Report**
  - Prospect of Electric Energy from Solid Wastes of Rajshahi City Corporation: A Metropolitan City in Bangladesh; IPCBEE vol.17 (2011) © (2011) IACSIT Press, Singapore
    - Average Value for Dhaka and Chittagong city : 7.38 MJ/kg -> 1,763 Kcal/kg
    - Rajshahi City is 7.94 MJ/kg -> 1897 Kcal/kg
    - Average Value above two city : 7.66 MJ/kg -> 1,829,87 Kcal/kg
  - Feasibility Study & Basic Design Report for South Tangerang, 2015.12
    - Standard Quality : 1,800 Kcal/kg
- **Assumed Calorific Value in Hai phong: 1,800 Kcal/kg**

Heat Value & Power Generation

Design Criteria for Calorific Value

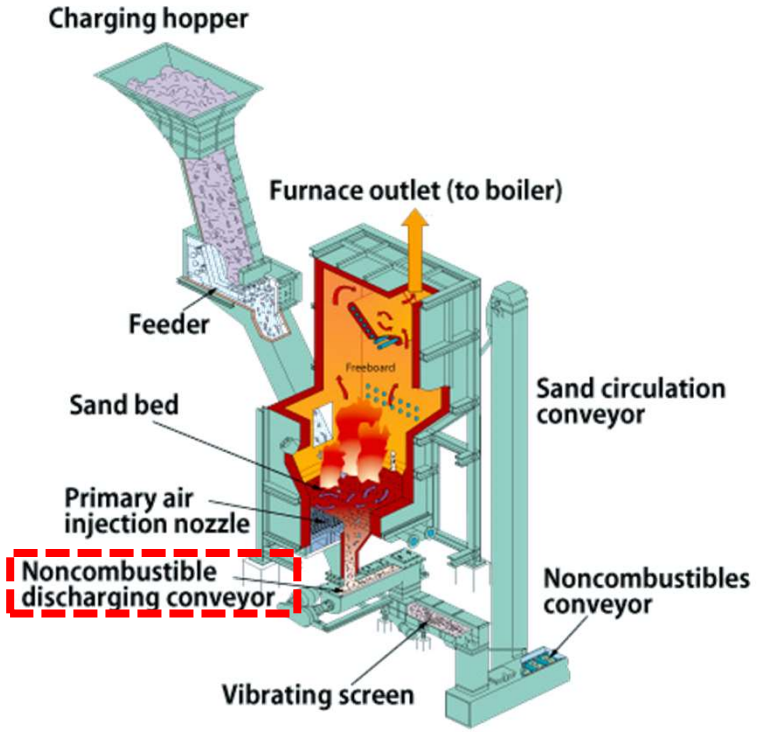
- Waste Receive : **2,000 t/d** (Pre-Treatment Process) -> **1,000 t/d** to Fuel
- Calorific value: **1,800 kcal/kg** (Pre-Treatment Process) -> **2,400kcal/kg**

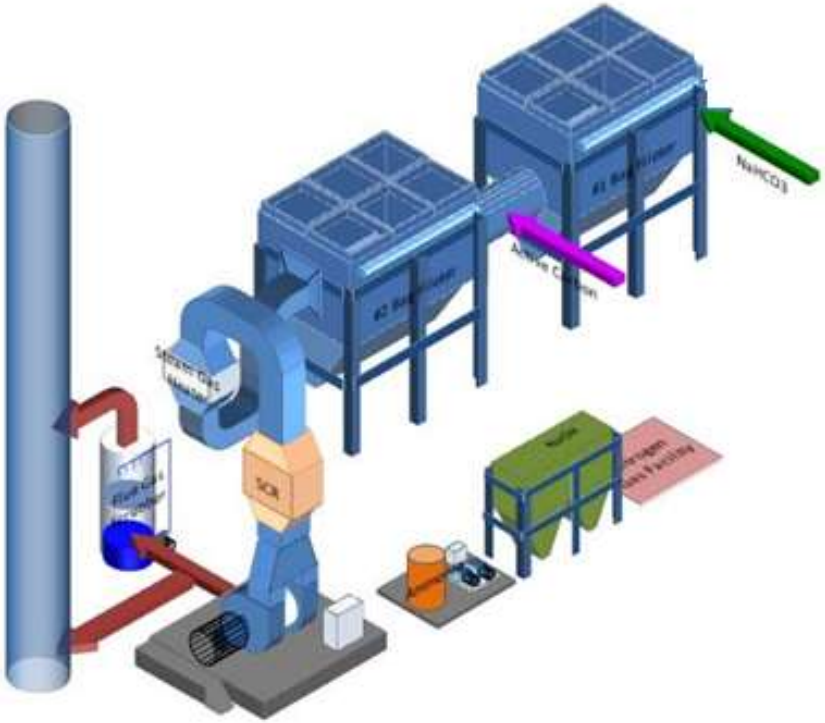
Power Generation Simulation

No.	Item	Value	Unit	Remark
1	MSW Receive	2,000	Ton/day	
2	After Sorting	50.0%		
3	MSW Fuel	1,000	Ton/day	
4	MSW Calorific Value	2,400	Kcal/kg	
5	Boiler Efficiency (CFBC Type)	25%		
6	Power Generation (Gross)	29.070	Mwe/hr	
7	Internal Use	20.0%		5,814 KWe
8	Power Generation (Net)	23.256	Mwe/hr	
9	Remaining Ash	48	Ton/day	< 5%

It is strongly recommend to burn additional fuel to increase heat value for higher power generation output.

Noncombustible Ash Release





48 tpd (<5%)

Ash Quantity and Treatment

- **Emission Quantity**
  - Ash : 2,000 Kg/h x 24 -> **48 tpd (<5%)**
  - Flue Gas : 300 Kg/h
- **Composition of Ash**
  - Incombustible Component (Most)
    - Ca, Mg, Si(silica) Al, Fe
  - Chemistry Component (Extremely small quantities)
    - Hg, Cd, Pb, As, Cr
- **Chemistry Component**
  - Chemistry Component will be landfilled with others
  - This Chemistry was originally existed in Nature and no harmful too extremely small quantity

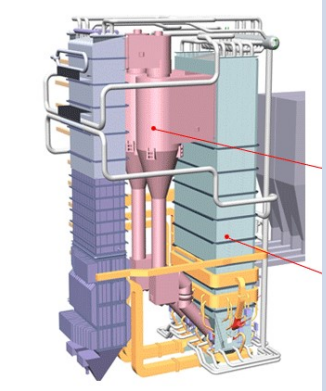
Ref: Naju Project Design Data

Technology and Process Concept

Electrical Power Generation

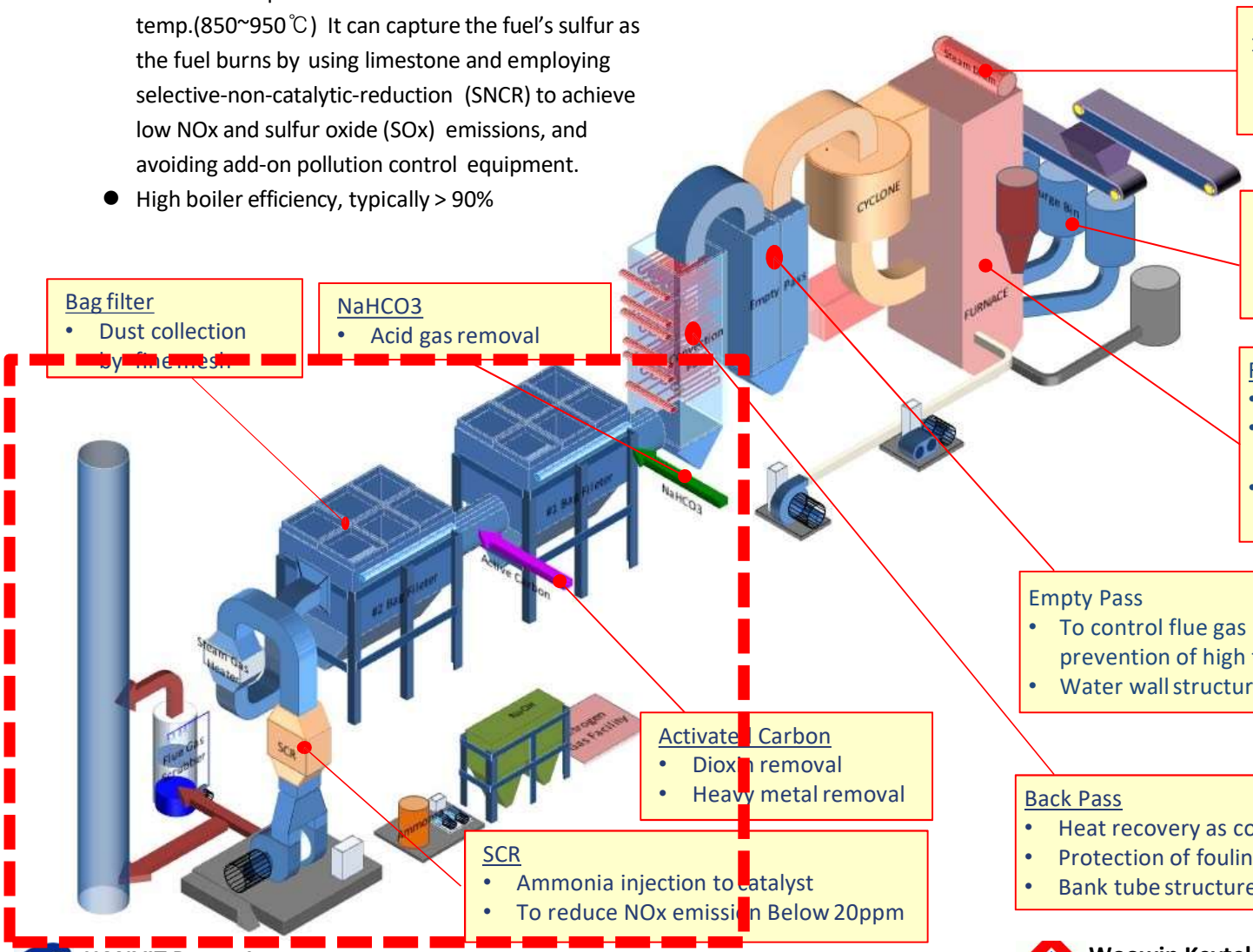
Item	Value	Remark
Steam turbine – gross power output	29.070 MWe/h	
Internal Use	5.814 MWe/h	
Steam turbine – net power output	23.256 MWe/h	
Exhaust steam pressure	Approx. 0,12 bar(a)	
Yearly Average Temperature	30°C	

Comparison Grate & FBC Type

Item	Grate type	FBC type (Our Technology)
Features		
Technical feature	• Mass burning on the moving grate • Drying, combustion, after-combustion process • No need of Pretreatment	• Fluidized Bed Combustion • Fuel flexibility (mixed fuel firing) • Low emissions • Mechanical Pretreatment Required
Furnace Temp	950~1050℃	850~950℃
Useable Fuel	• Bulk MSW • 1000~3500 kcal/kg	• Coal, SRF(RDF), Biomass(Wood chip), etc. • 1600~8000 kcal/kg
Flue gas quantity	100	88 (based on Grate type 100)
Plant Efficiency	10~15%	20~25%
Construction Cost	200,000 USD/ton	220,000~250,000 USD/ton
Operation Cost	60 USD/ton	100 USD/ton

Circulating Fluidized Bed Combustor (CFBC)

- Most effective methods to burn various solid fuels
- Available to operate at low combustion temp.(850~950℃) It can capture the fuel's sulfur as the fuel burns by using limestone and employing selective-non-catalytic-reduction (SNCR) to achieve low NOx and sulfur oxide (SOx) emissions, and avoiding add-on pollution control equipment.
- High boiler efficiency, typically > 90%



Điều kiện hơi
- Trên 80 bar / 450℃
- Hiệu suất nồi hơi > 90%

Surge Bin
- Buffering of fuel feeding
- Capacity : 30min of MCR

Furnace
- Relatively low furnace temp.
- Low emission(NOx, SOx) by SNCR
- Refractory & Water tube wall structure

Empty Pass
- To control flue gas below 650℃ in order for the prevention of high temp corrosion at bank tube.
- Water wall structure

Back Pass
- Heat recovery as convection at bank tube.
- Protection of fouling by Soot blowing
- Bank tube structure

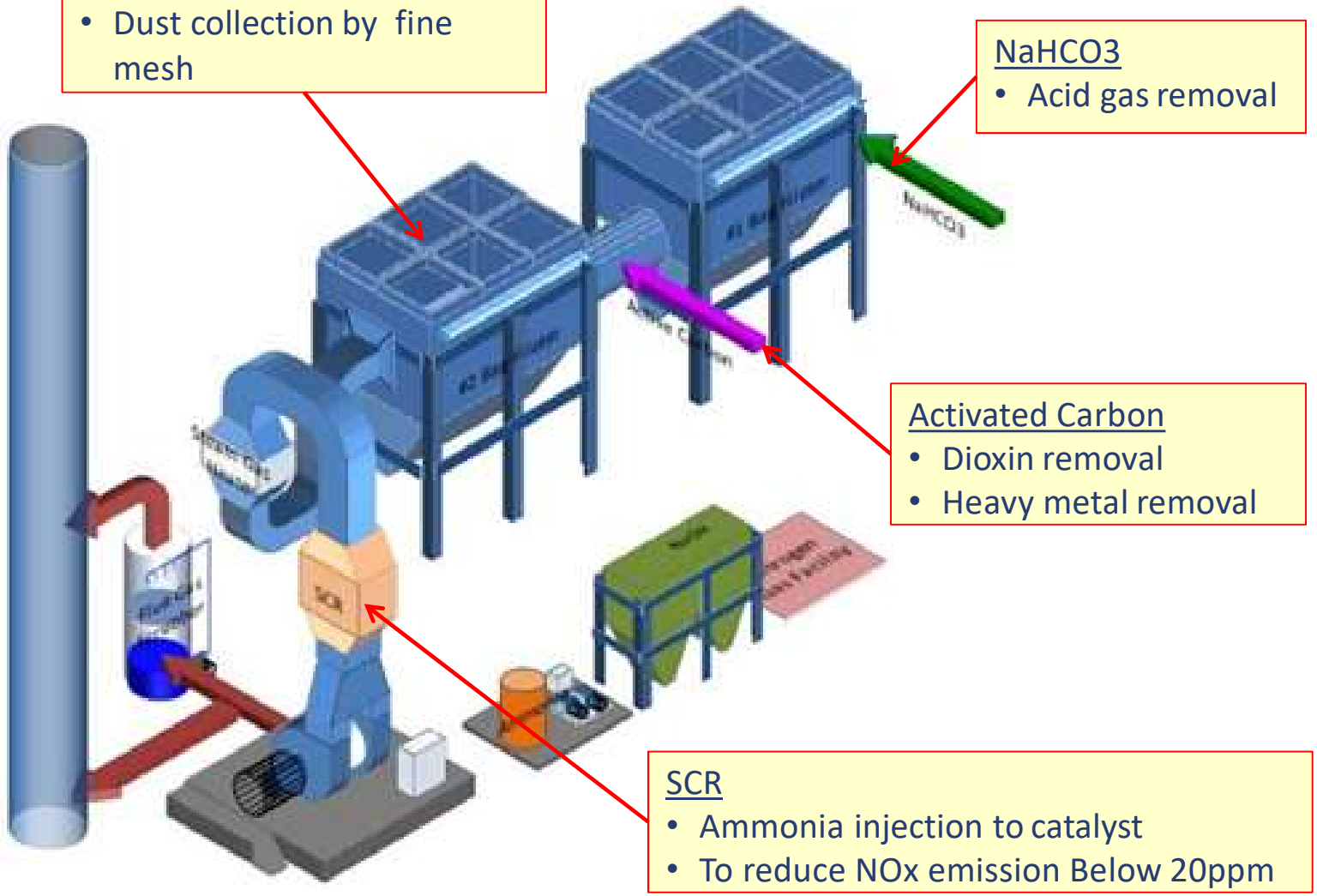
Bag filter
- Dust collection by fine mesh

NaHCO3
- Acid gas removal

Activated Carbon
- Dioxin removal
- Heavy metal removal

SCR
- Ammonia injection to catalyst
- To reduce NOx emission Below 20ppm

Environment Facility for CFBC

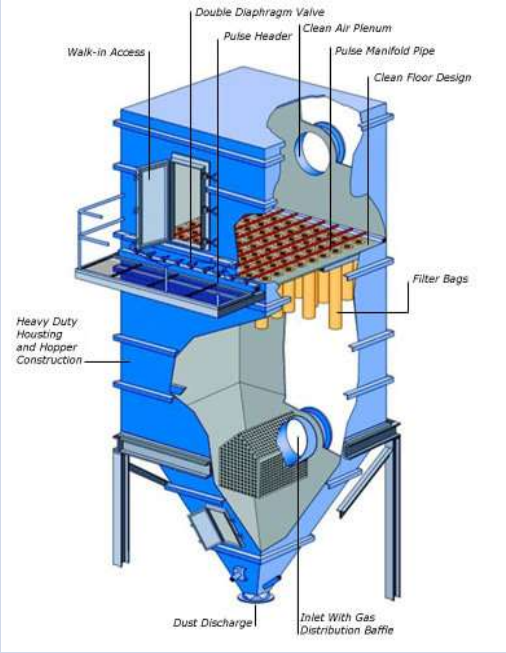
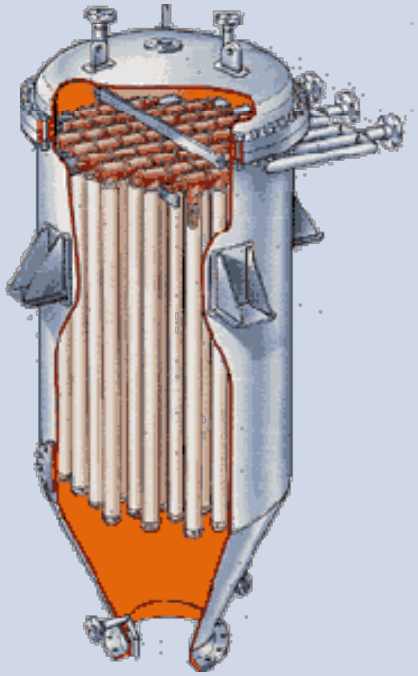
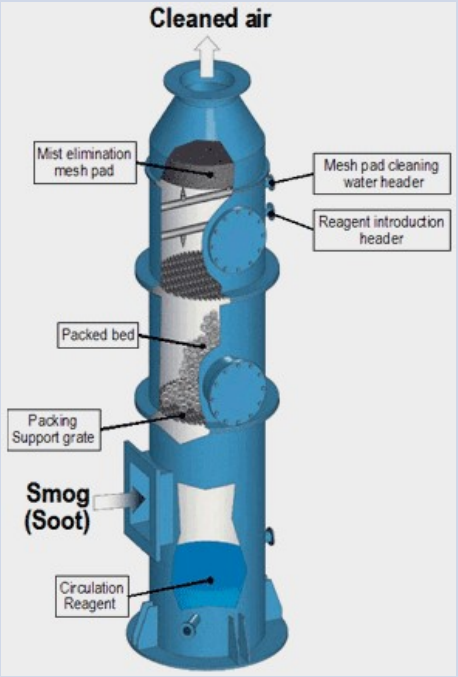


Air Pollutant Emission Standard

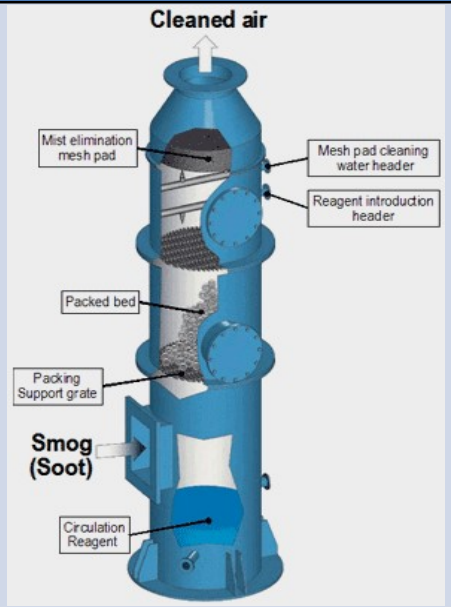
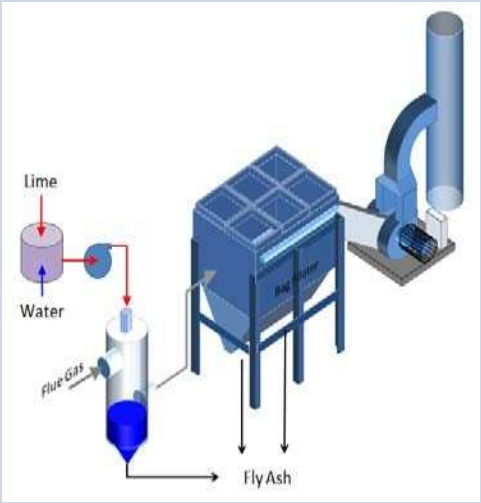
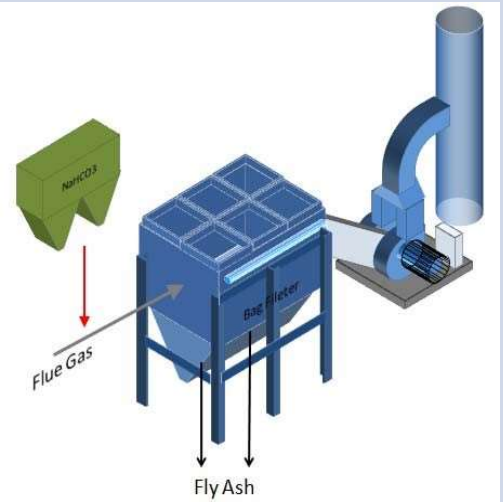
No.	Contamination	Unit	Government Regulation	Korea Regulation	Remark
1	HCl	mg/Nm3	50	15	
2	SO_2	mg/Nm3	250	50	
3	NO_2	mg/Nm3	500	50	
4	CO	mg/Nm3	250	50	
5	Hg	mg/Nm3	0.2	0.03	
6	Cd	mg/Nm3	0.16	0.02	
7	Pb	mg/Nm3	1.2	0.2	
8	Dioxin	(ng-TEQ/Nm3)	0.6	0.1	

Ref: Circular No. 03/2016/TT-BTNMT; March 3, 2016

De-Dust System

	Bag Filter	Ceramic Candle Filter	Wet Scrubber
Picture			
Features	• Effective for removal of solid granules such as dust • Periodic maintenance necessity such as replacement of bag • Pulsation phenomenon due to purge • Additional removal effect by fabric surface cake of chemical reagent	• Effective for removal of solid granules • Limitations on particulate removal • High cost	• Reduction effect of solid granular removal and harmful substance • Relatively low cost • Depending on the target to be removed, chemicals and water are required. Wastewater is generated.
Selection	Our Technology		

Acid Gas

	Wet Scrubber	SDR(Semi-dry Reactor)	Dry Reactor
Picture			
Features	• Exhaust flue gas passes through the chemical solution • High removal efficiency due to direct contact between liquid and gas phase • High initial investment cost • Wastewater is generated and waste water treatment is required.	• Dissolve the absorbent in water and inject it into the exhaust flue gas through a spray device • Relatively low initial investment cost • Waste generation increase • Relatively low efficiency • High O&M cost	• Powdered absorbent is added to the exhaust flue gas. • Simple structure and low initial cost • low treatment efficiency
Reagent	$Ca(OH)_2$, $CaCO_3$, NaOH, $Mg(OH)_2$	$Ca(OH)_2$ $NaCO_3$ $NaHCO_3$	$Ca(OH)_2$ $NaHCO_3$
Selection		Our Technology	

Dioxin System

Activated Carbon

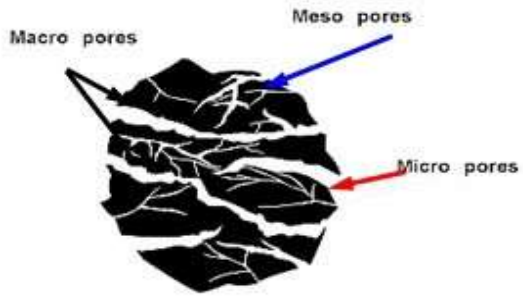


Figure 1: Activated carbon structure - schematic.

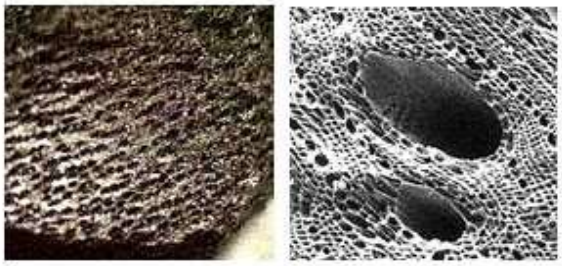
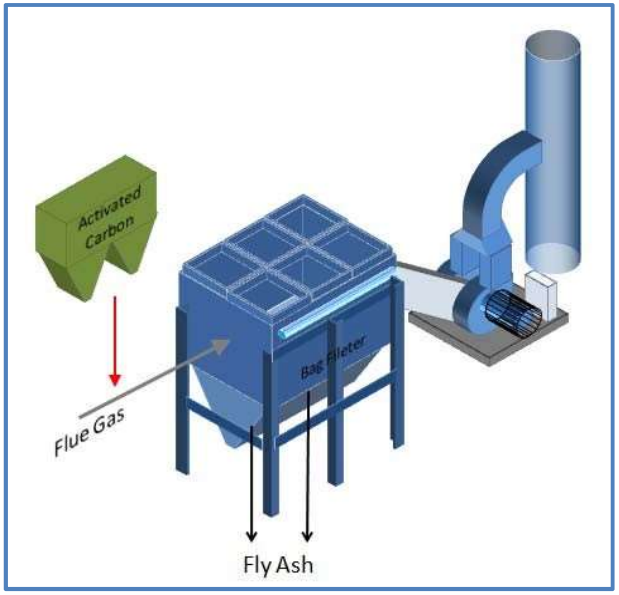


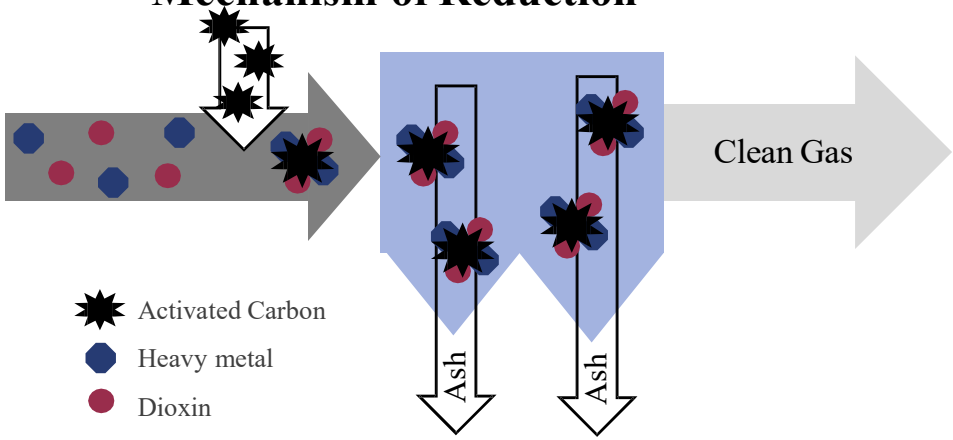
Figure 2: Activated carbon structure – SEM pictures.

- **Activated Carbon is the most effective adsorbent.**
- **Activated Carbon has a porous structure of about 1500 m^2/ gm.**

System Configuration

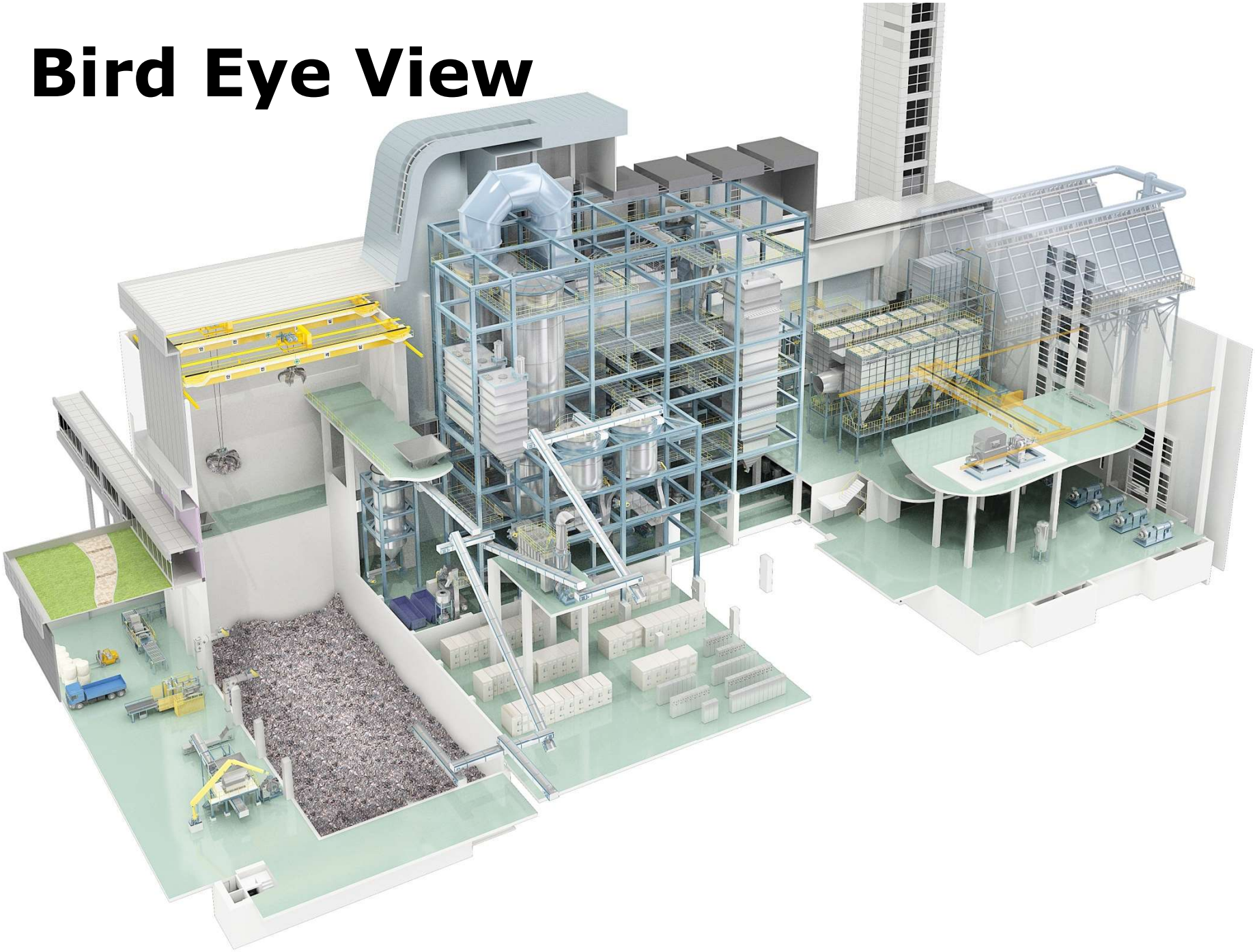


Mechanism of Reduction

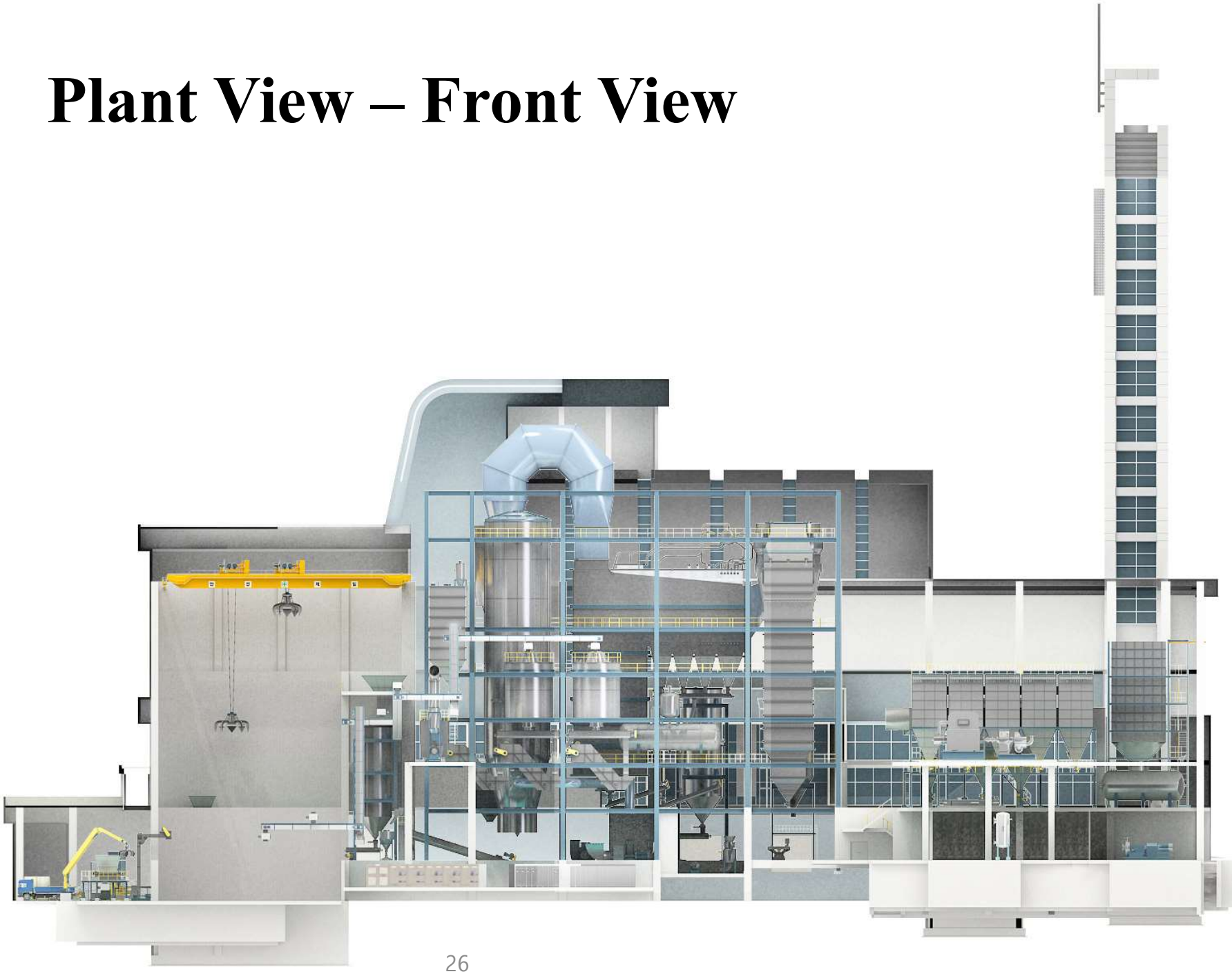


Reference Plant

Bird Eye View

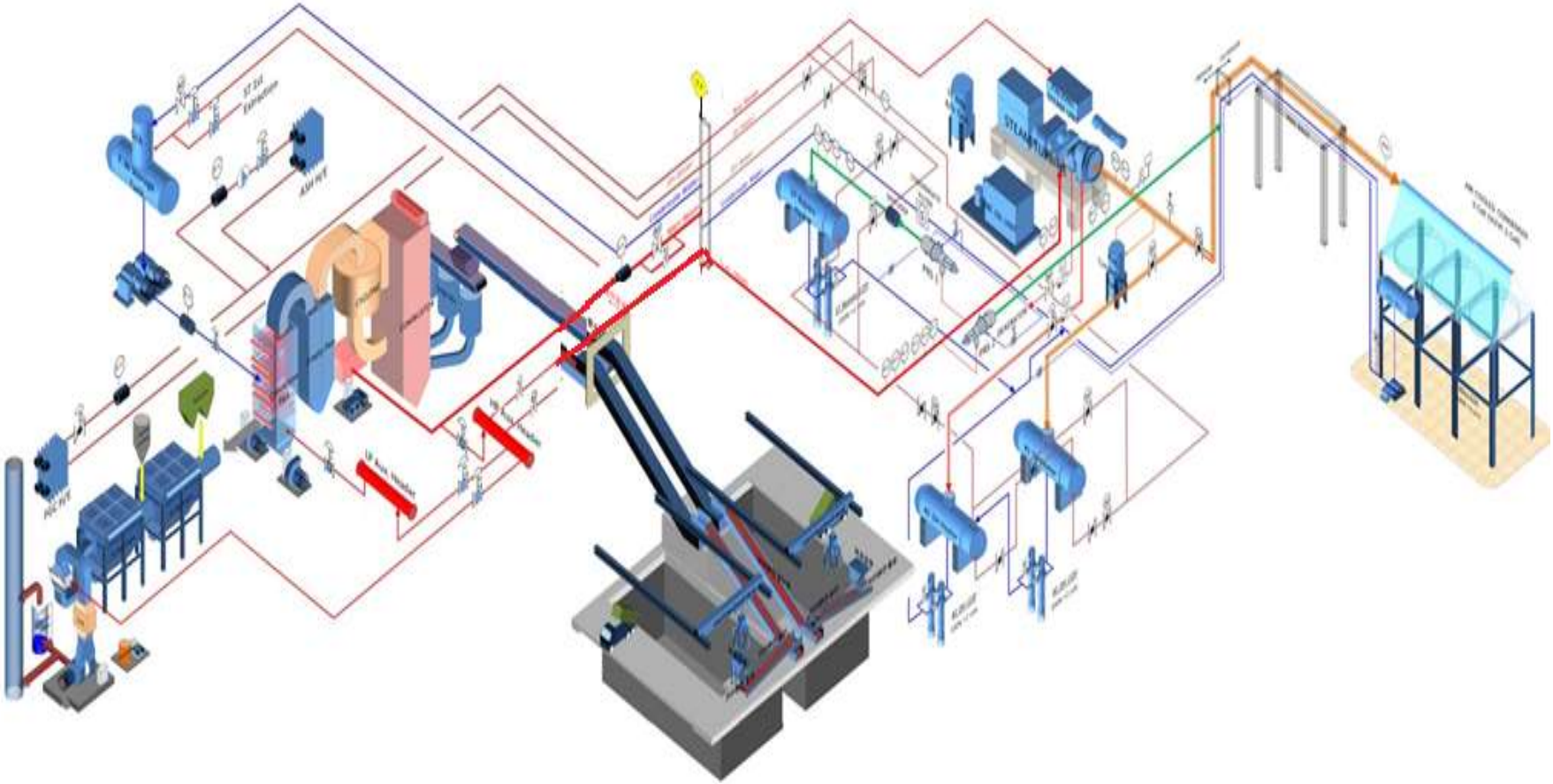


Plant View – Front View

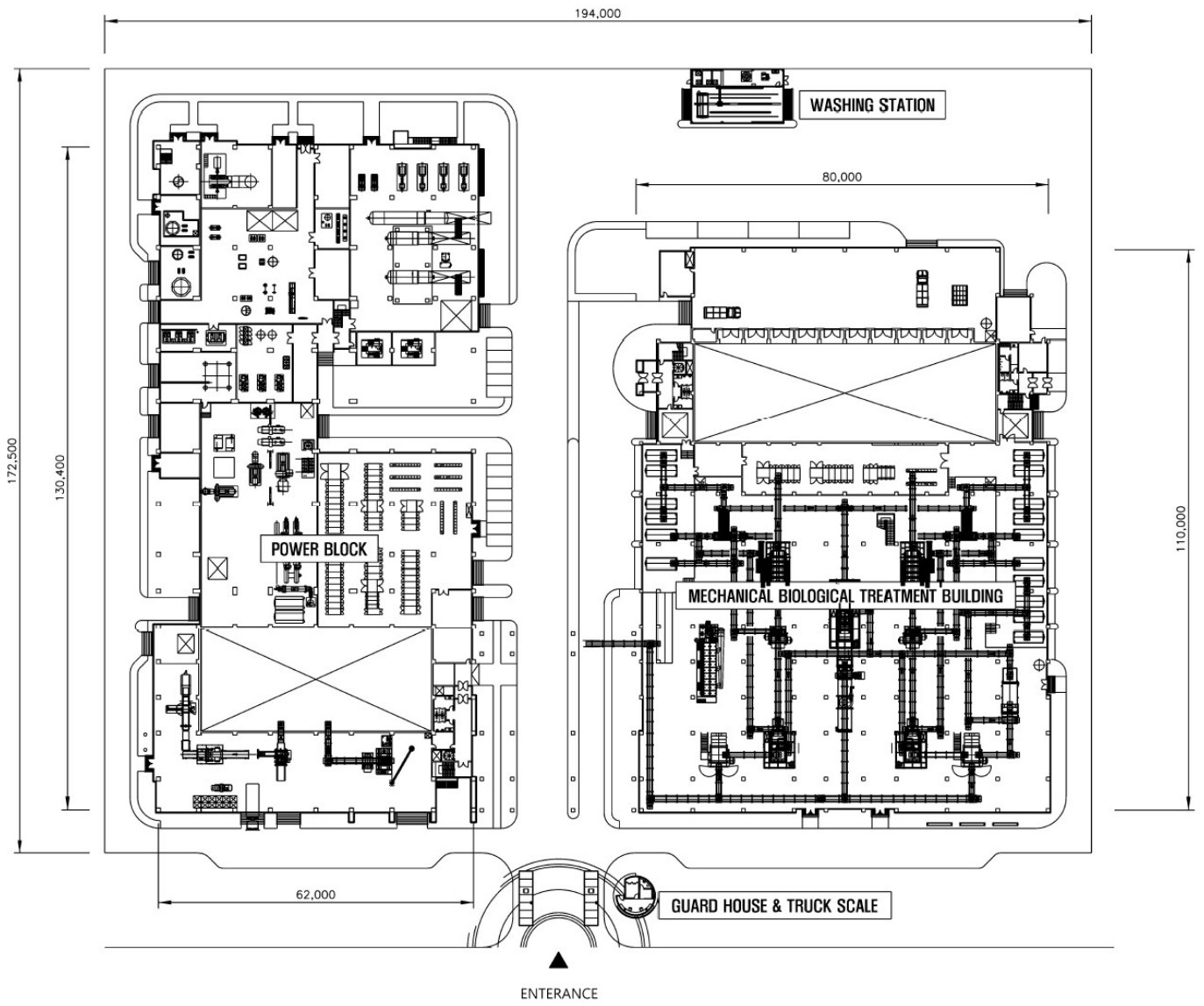


Plant Concept (NAJU WTE, Korea)

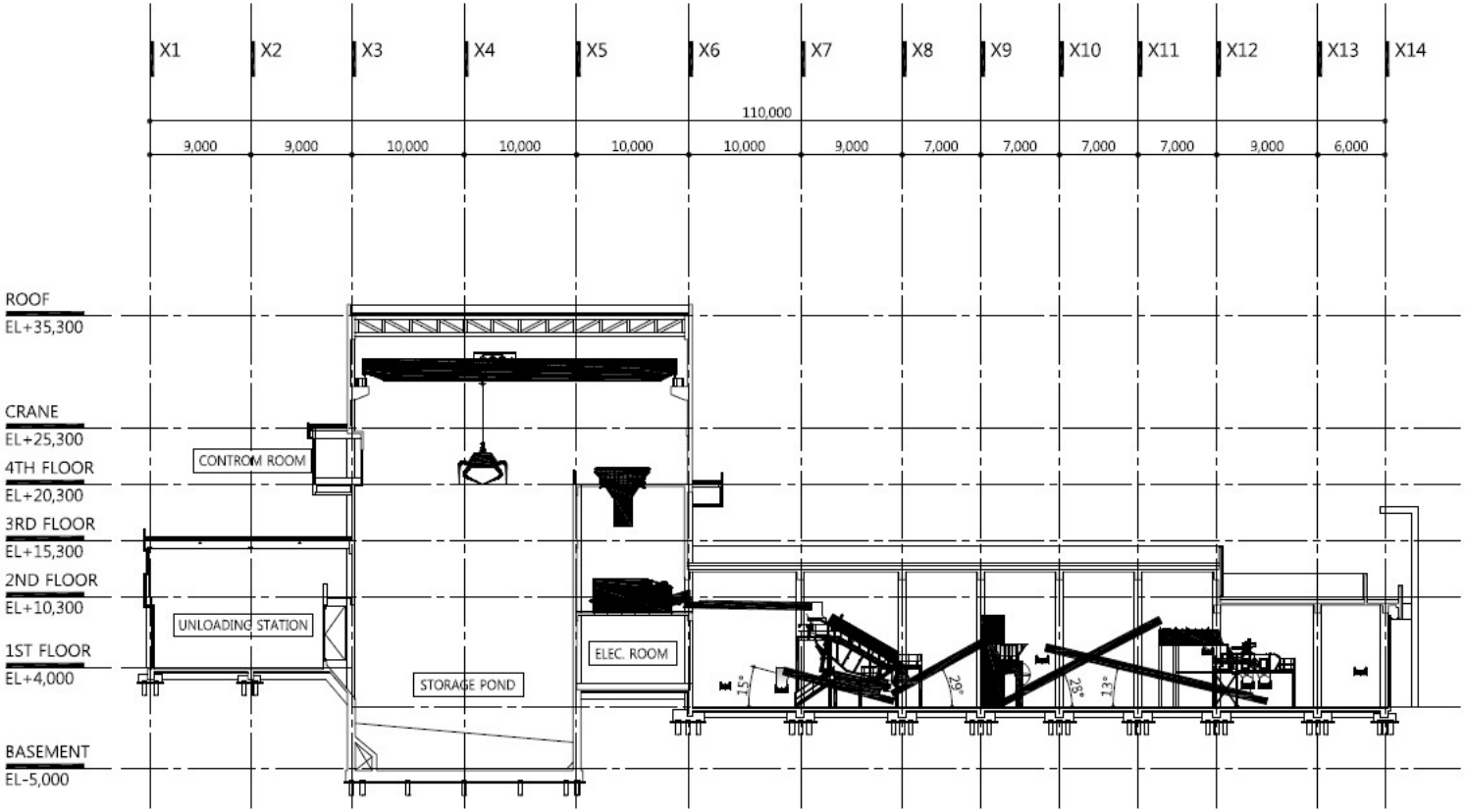
- **Plant Capacity : 19.6MWe**
- **Main Equipment**
  - CFBC Boiler (Hansol SeenTec; Korea), Condensing Turbine (KHI; Japan)



Design - Plan

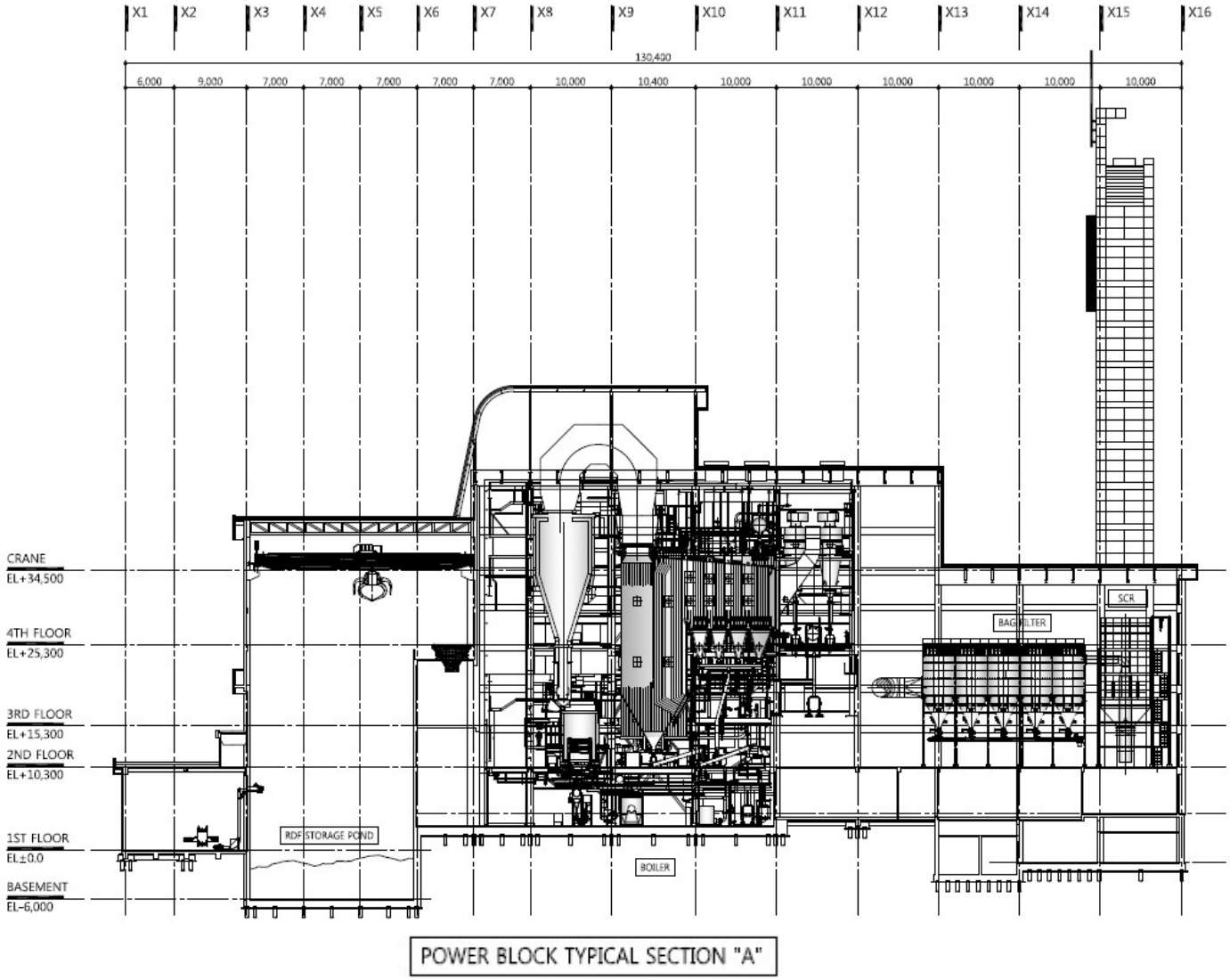

194,000
WASHING STATION
80,000
172,500
130,400
110,000
POWER BLOCK
MECHANICAL BIOLOGICAL TREATMENT BUILDING
62,000
GUARD HOUSE & TRUCK SCALE
ENTERANCE

Design - Section



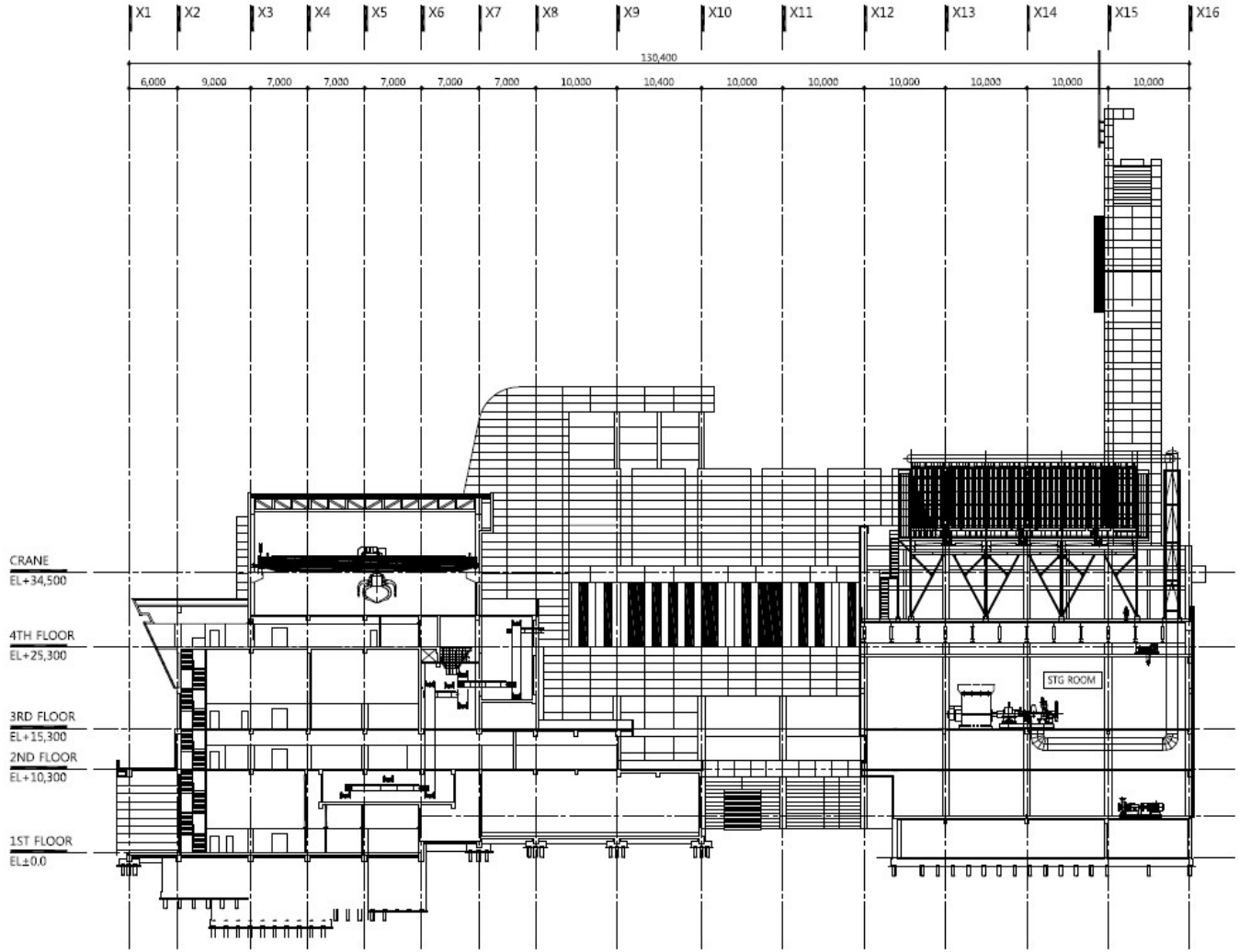
MBT ROOM TYPICAL SECTION

Design - Section

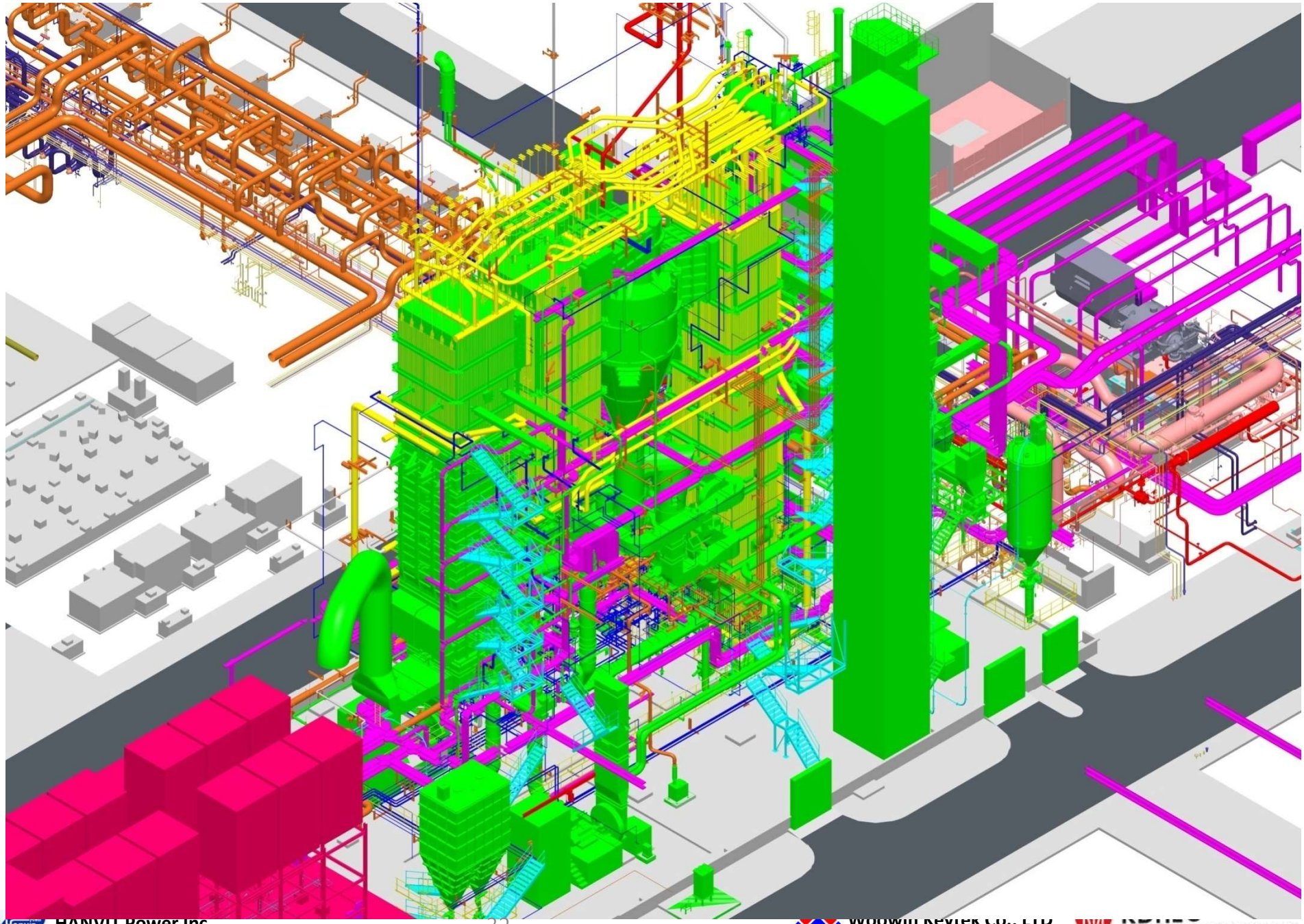


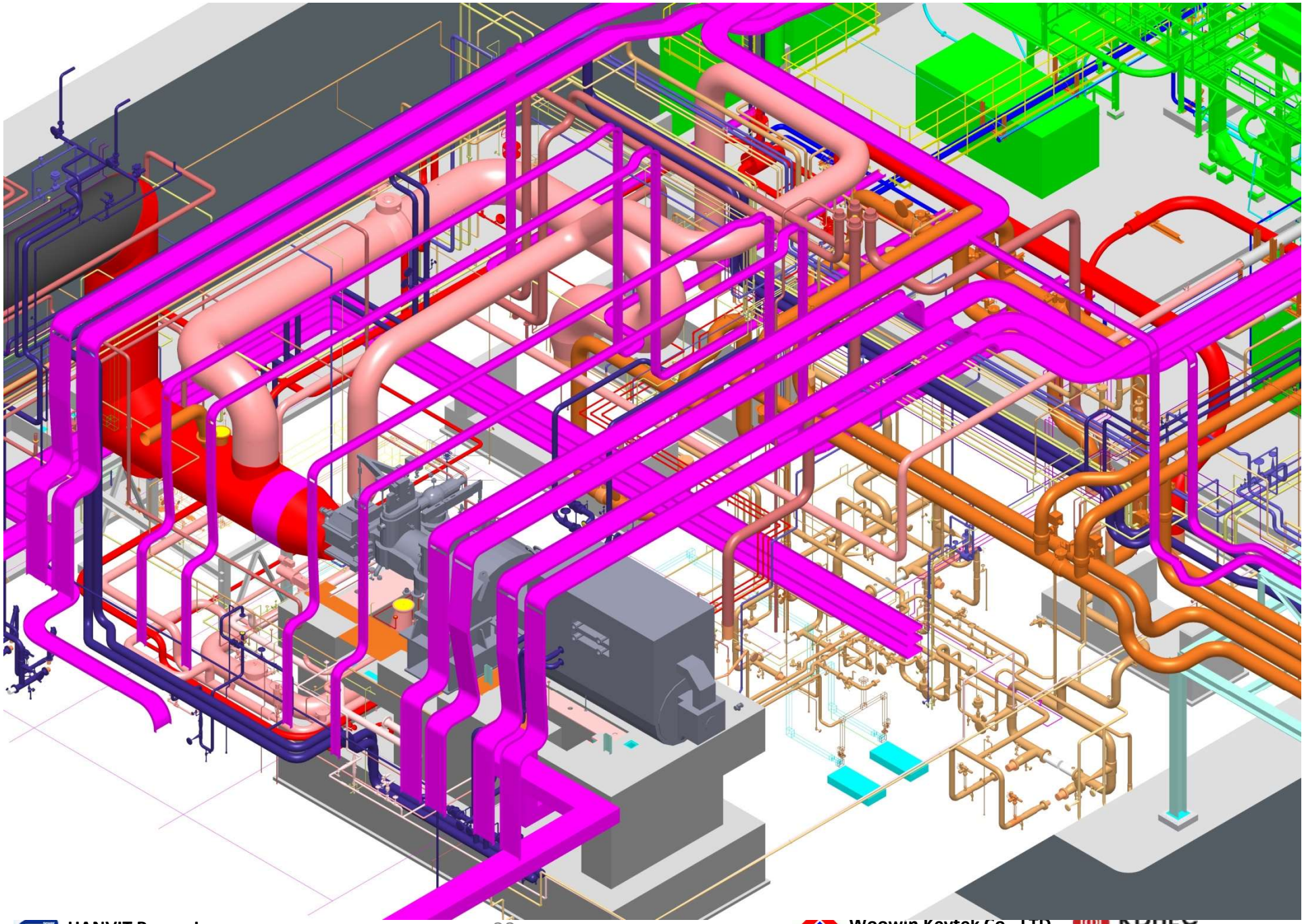
POWER BLOCK TYPICAL SECTION "A"

Design - Section



POWER BLOCK TYPICAL SECTION "B"





Pre-Treatment System

- **The Pre-Treatment system is required for the application of the CFBC Boiler which comprises of the several kinds of mechanical sorting, for instance, magnetic separation, density separation along with the manual pick-up of the recyclable materials.**
- **The Pre-Treatment system should be designed and selected according to the physical characteristics of the MSW in the course of basic design.**
- **It must do so in order to**
  - Reduce the wastes volume; or
  - Reduce its hazardous nature; or
  - Improvement of Fuel Properties : Calorific Value/Segregation of Combustibles
  - Facilitate its handling; or
  - Recovery of the Recyclable Materials

Typical Pre-Treatment System

Pre-Treatment System Process

MSW

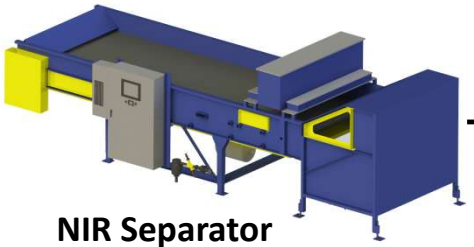
Pre-shredding

Refuse Shredder

Separation of Weight

Air Separator

Optical Sorting



NIR Separator

PVC

Re-shredding

SRF

Separation of Grain-size

Trommel Screen

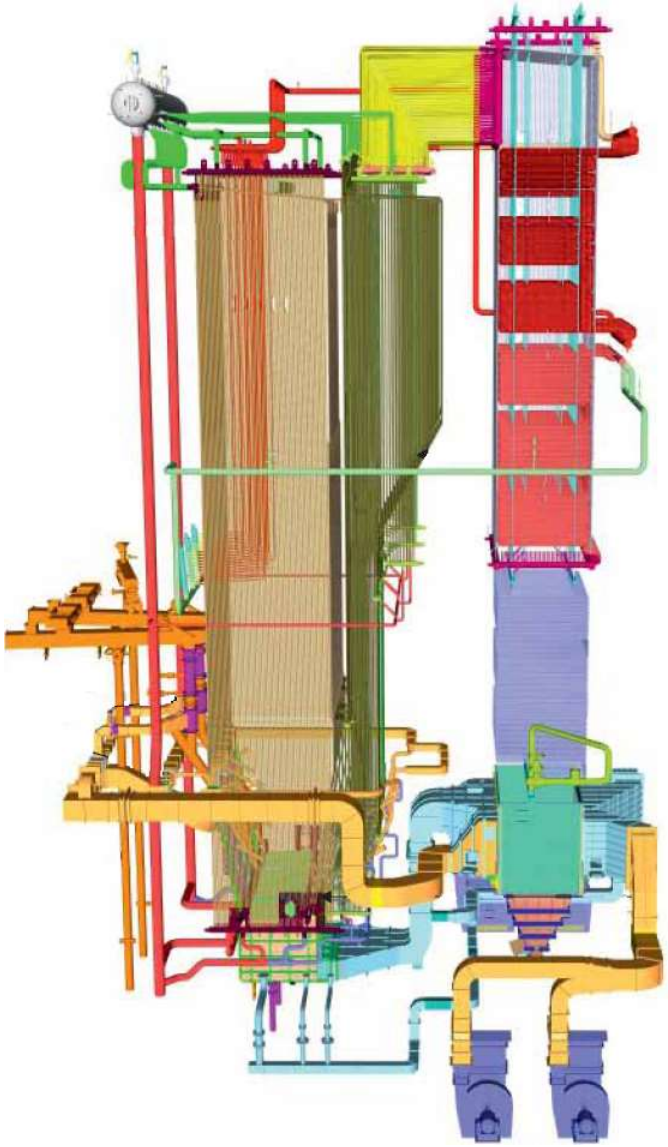
Organic Waste

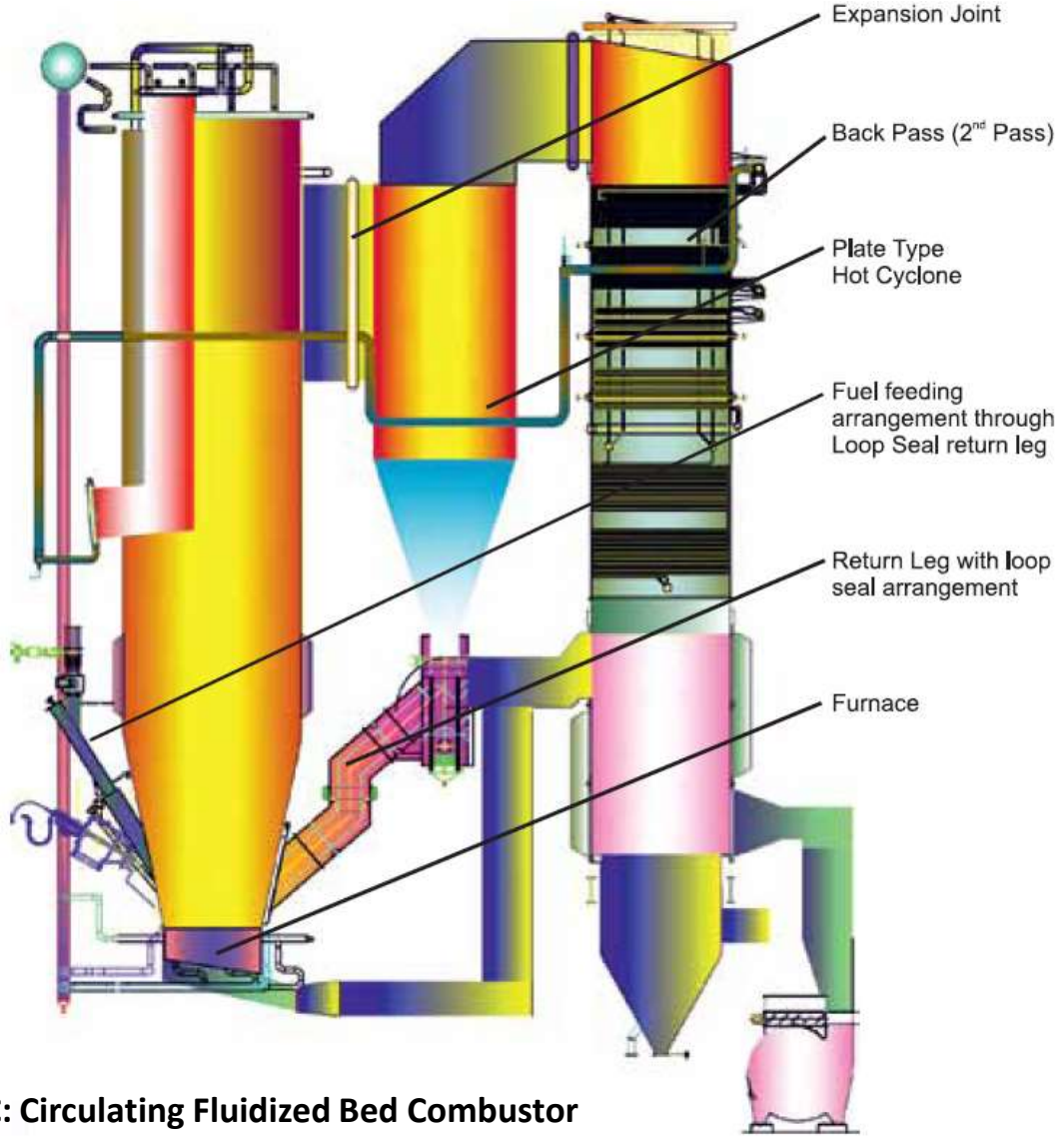
Magnetic Sorting

Magnetic Separator

SRF: Solid Refuse Fuel

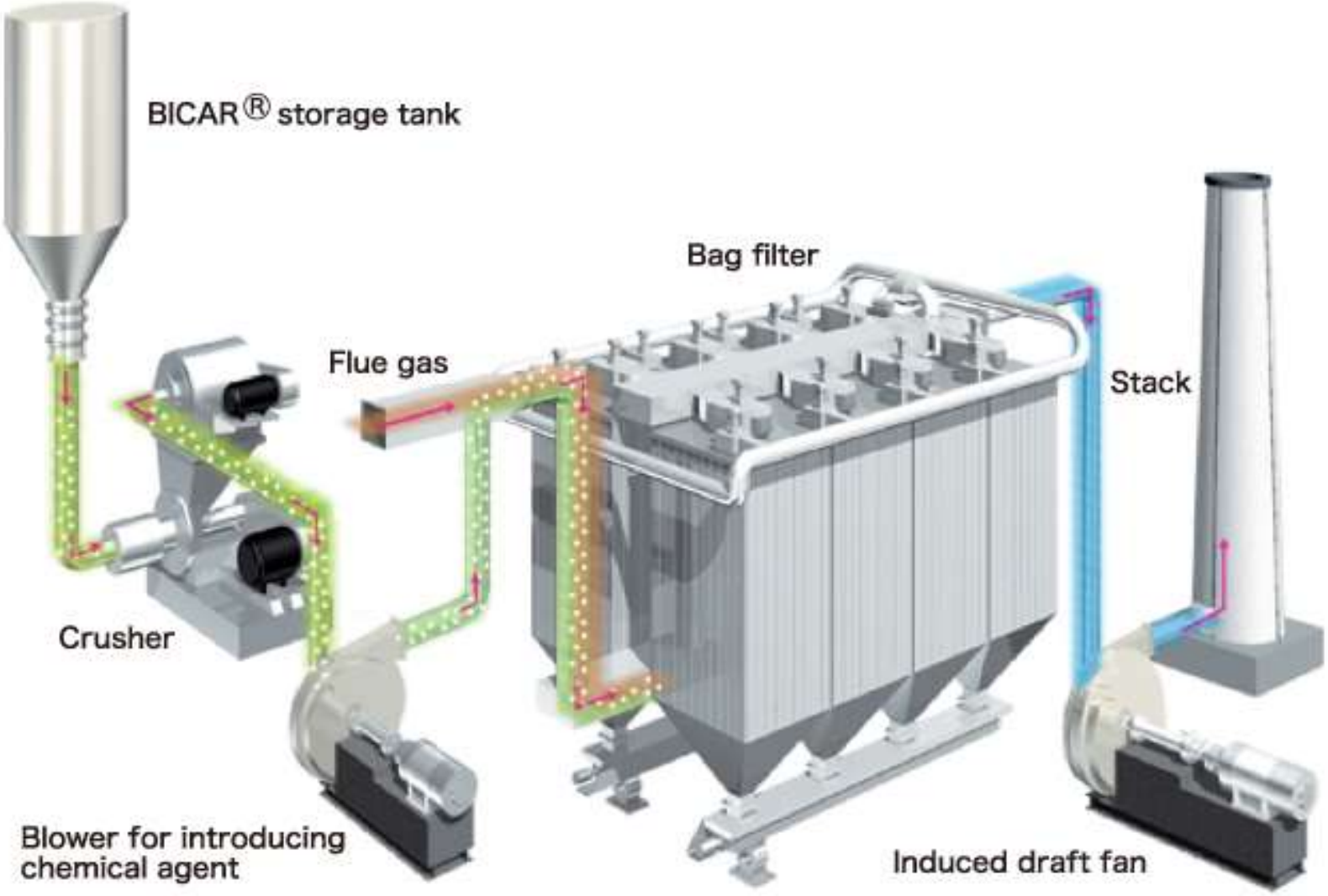
Boiler System – CFBC





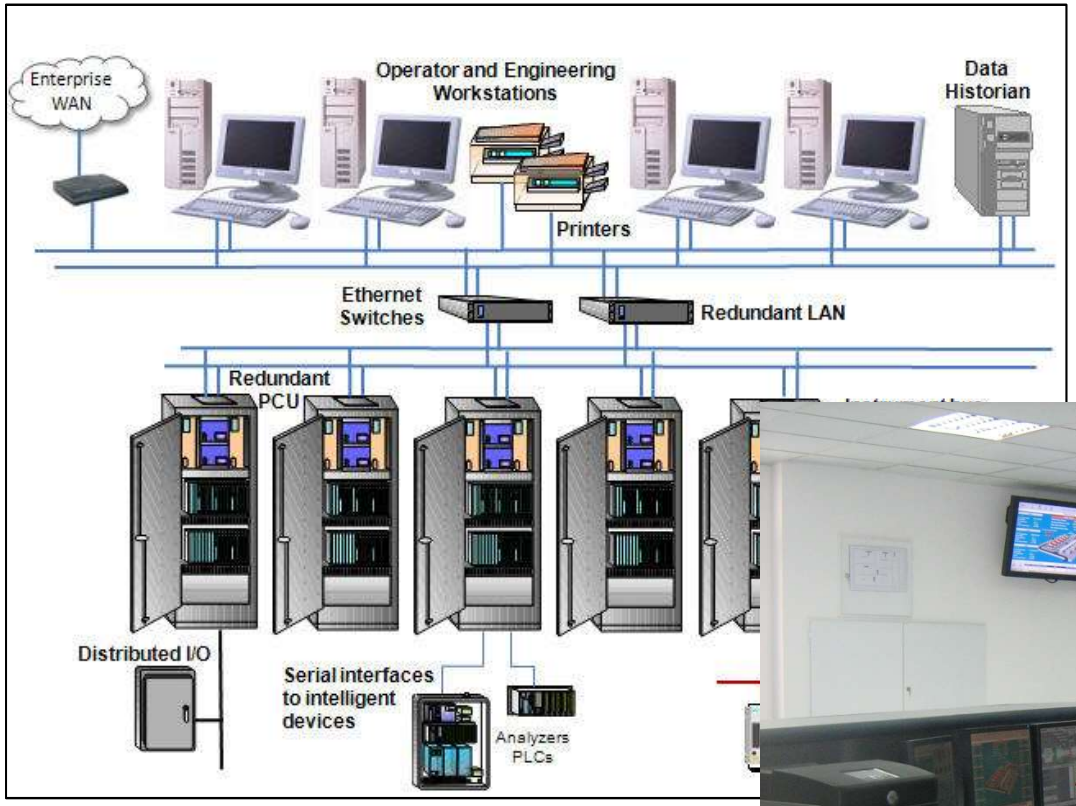
CFBC: Circulating Fluidized Bed Combustor

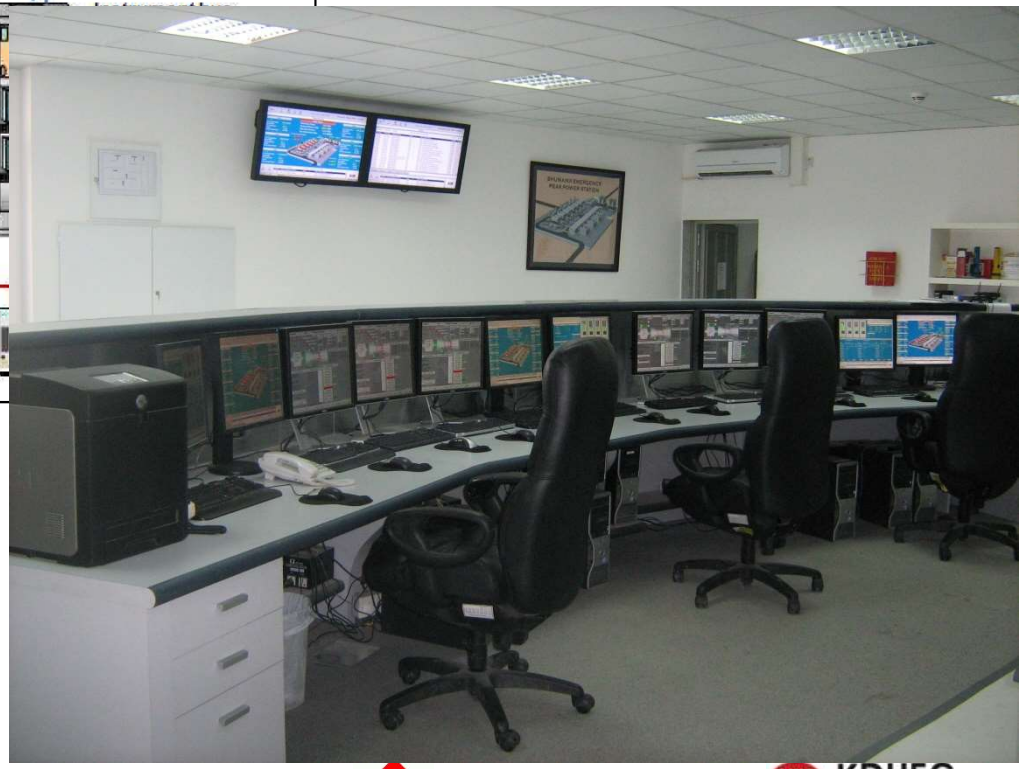
Flue Gas Treatment System



Steam Turbine Generator

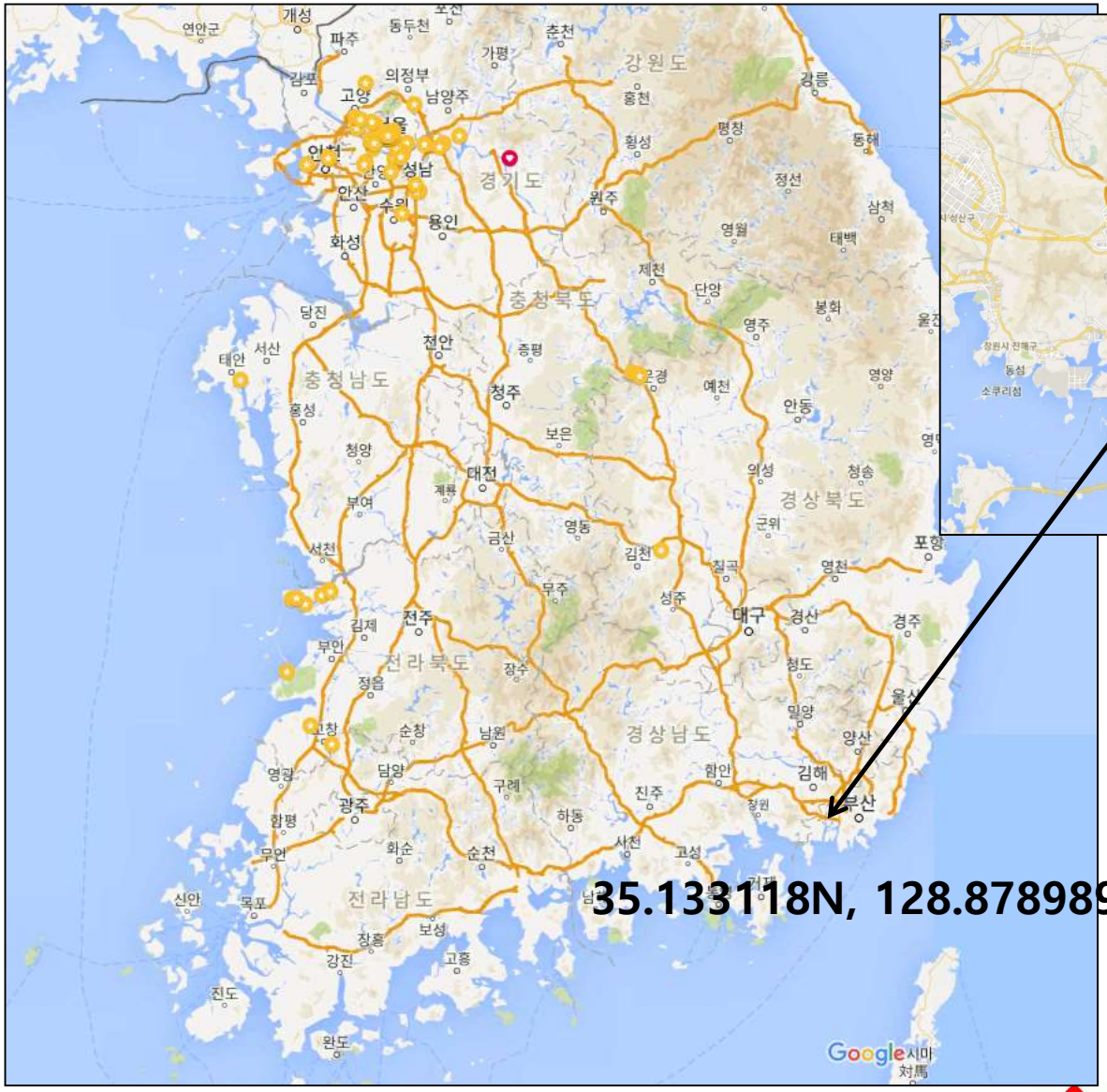
DCS

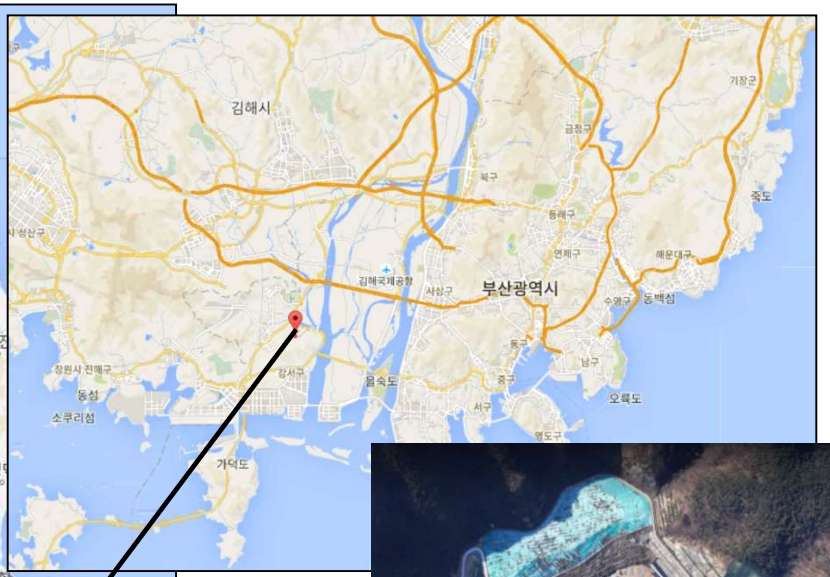

Enterprise WAN
Operator and Engineering Workstations
Data Historian
Printers
Ethernet Switches
Redundant LAN
Redundant PCU
Distributed I/O
Serial interfaces to intelligent devices
Analyzers PLCs



Switch Yard

Location for Sanggok WTE Plant





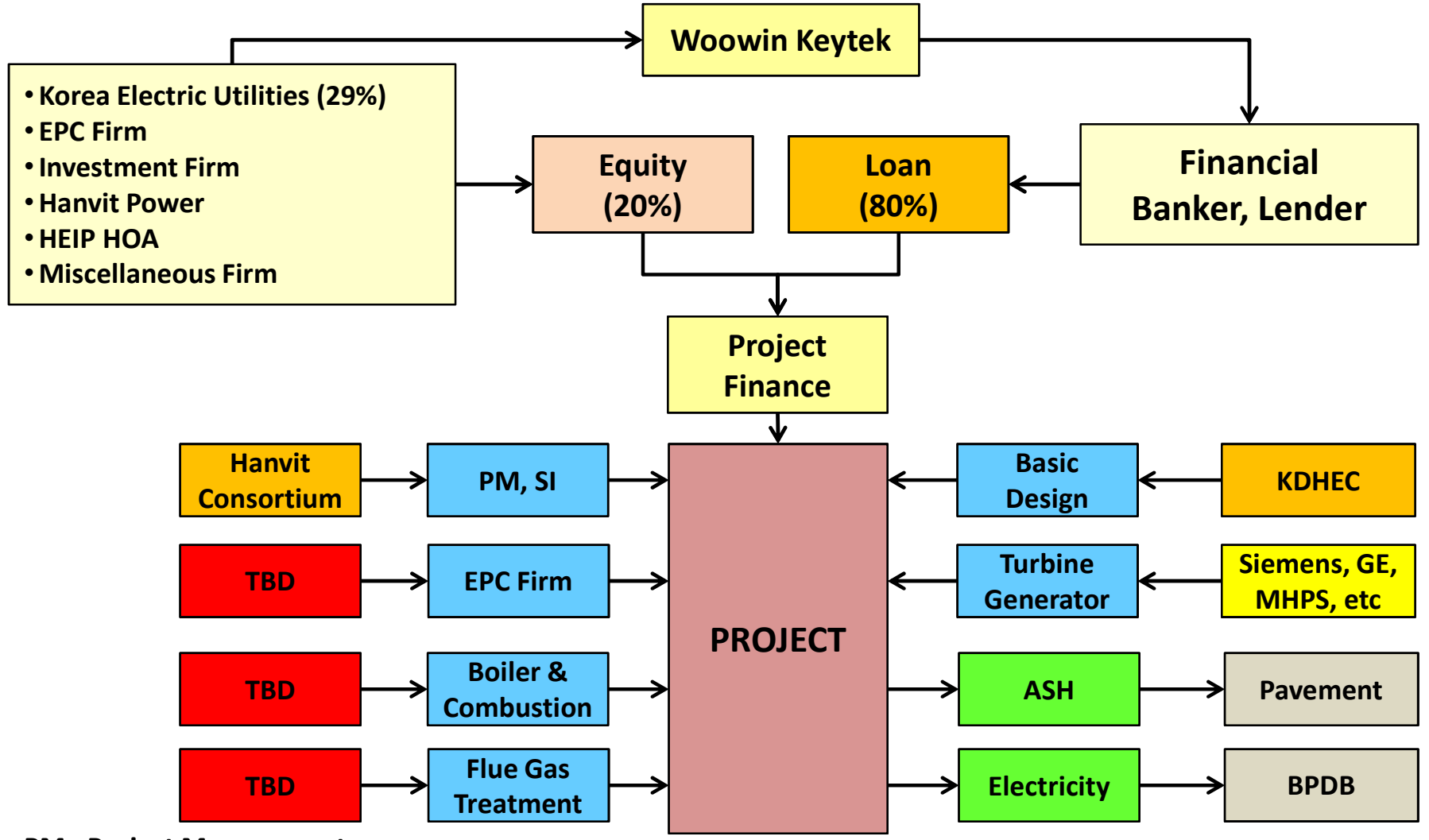
Overview for Sanggok WTE Plant

Pre-Treatment Facility

Boiler, Turbine Building

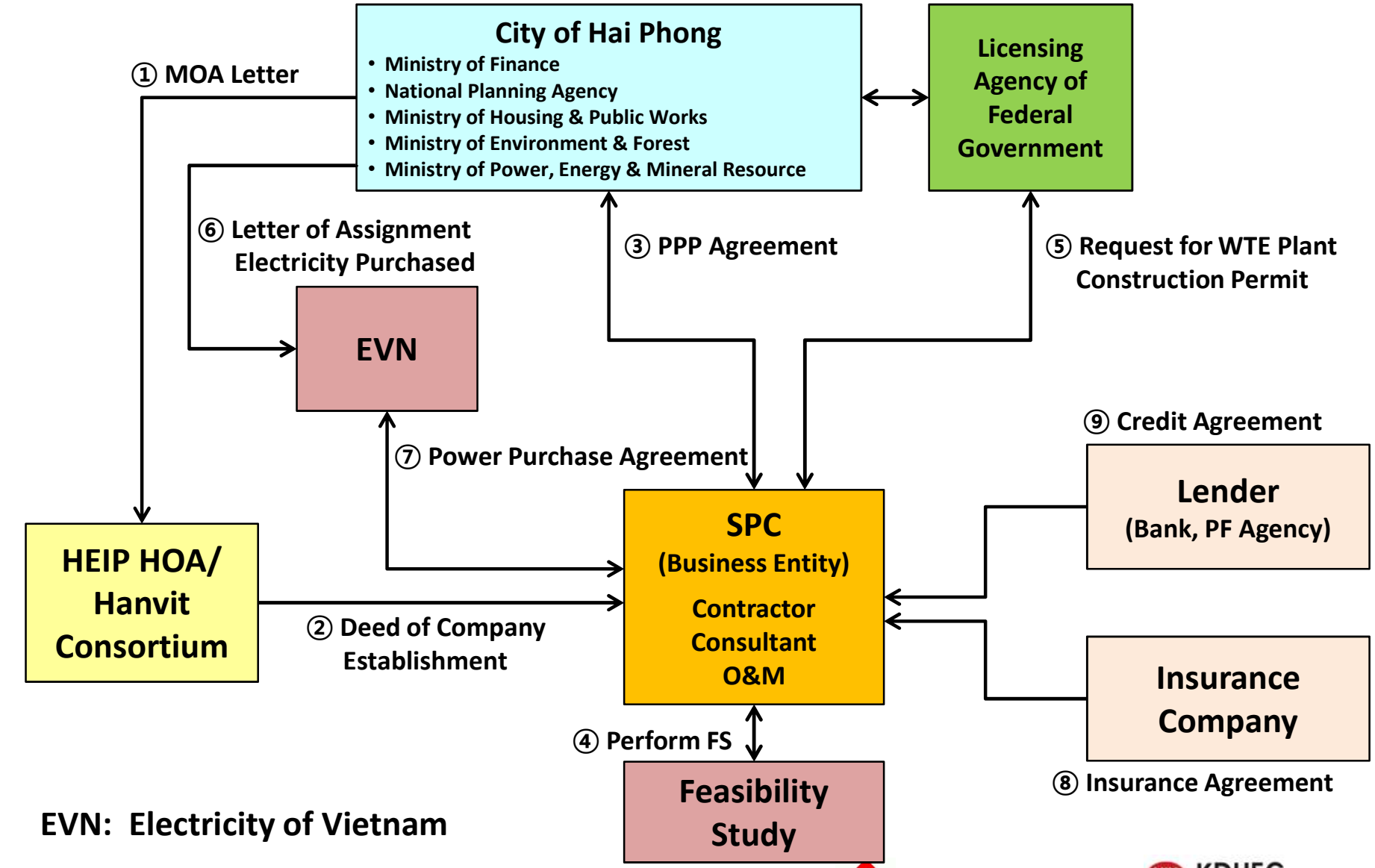
Project Execution Strategy

Project Structure



PM : Project Management
SI : System Integration

PPP & FDI Scheme



EVN: Electricity of Vietnam

Project Overall Time Schedule

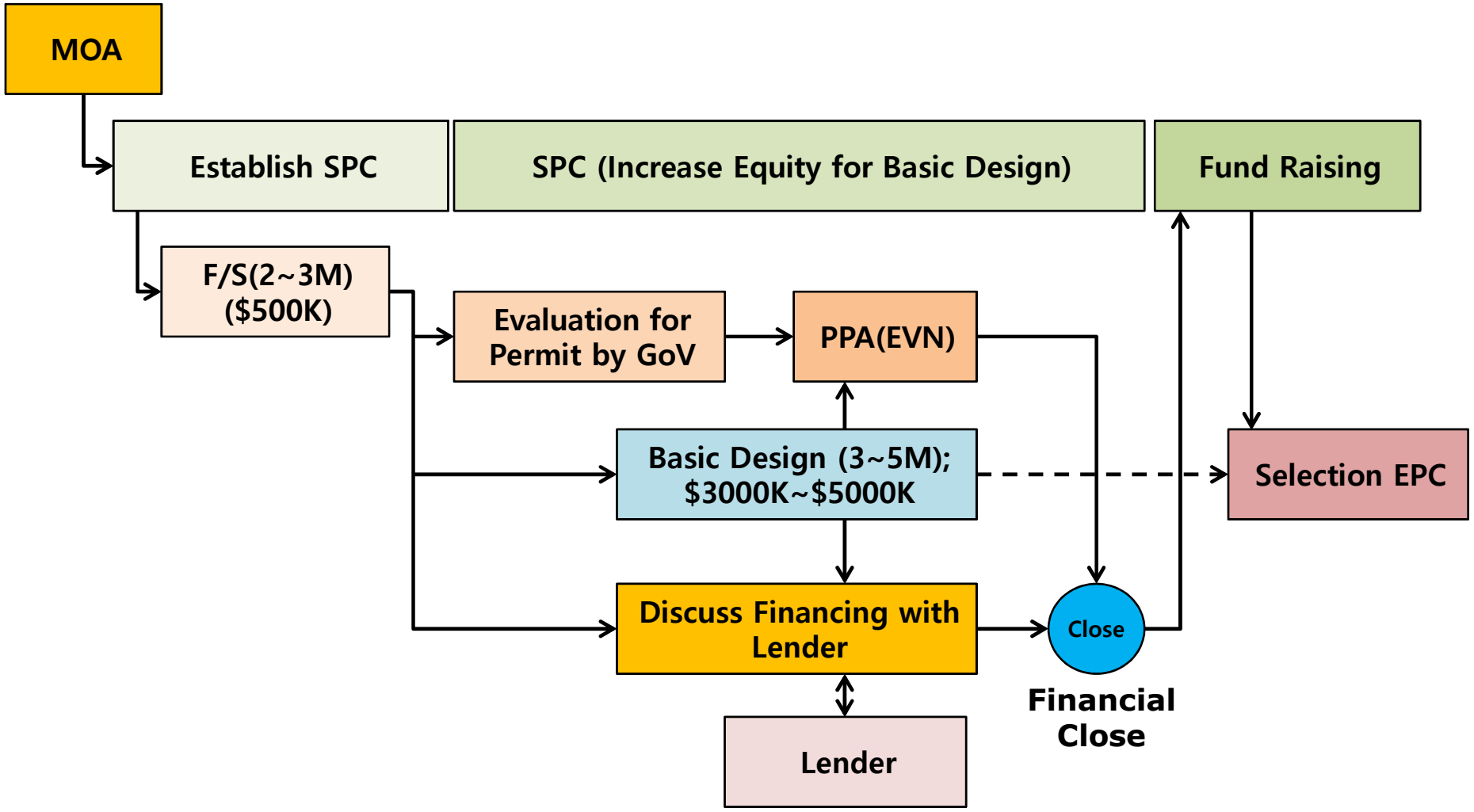
#	Work Activity	Duration	Scope	Remark
1	MOA Letter	1 mon	GoV	
2	Deed of Special Purpose Company Establishment	1 mon	HEIP HOA/Hanvit Consortium	
3	Public Private Partnership Agreement	1 mon	GoV/SPC	
4	Perform Feasibility Study	5 mon	SPC	
5	Request WTE Power Plant Construction Permit	6 mon (TBD)	GoV	
6	Letter of Assignment Electricity Purchased to EVN	1 mon	GoV/EVN	
7	Power Purchase Agreement with EVN	3 mon	EVN/SPC	
8	Waste Supply Agreement	1 mon	GoV/SPC	
9	Insurance Agreement	2 mon	SPC	
10	Credit Agreement (Financial Closing)	3 mon	Lender/SPC	
11	Perform Basic Engineering for EPC Bidding	6 mon	SPC	
12	Bidding EPC and Contract	2 mon	SPC	
13	Start Construction (EPC)	35 mon	EPC	
14	Finish and Commercial Operation	25 years	SPC	

GoV : Government of Vietnam

Project Overall Time Schedule

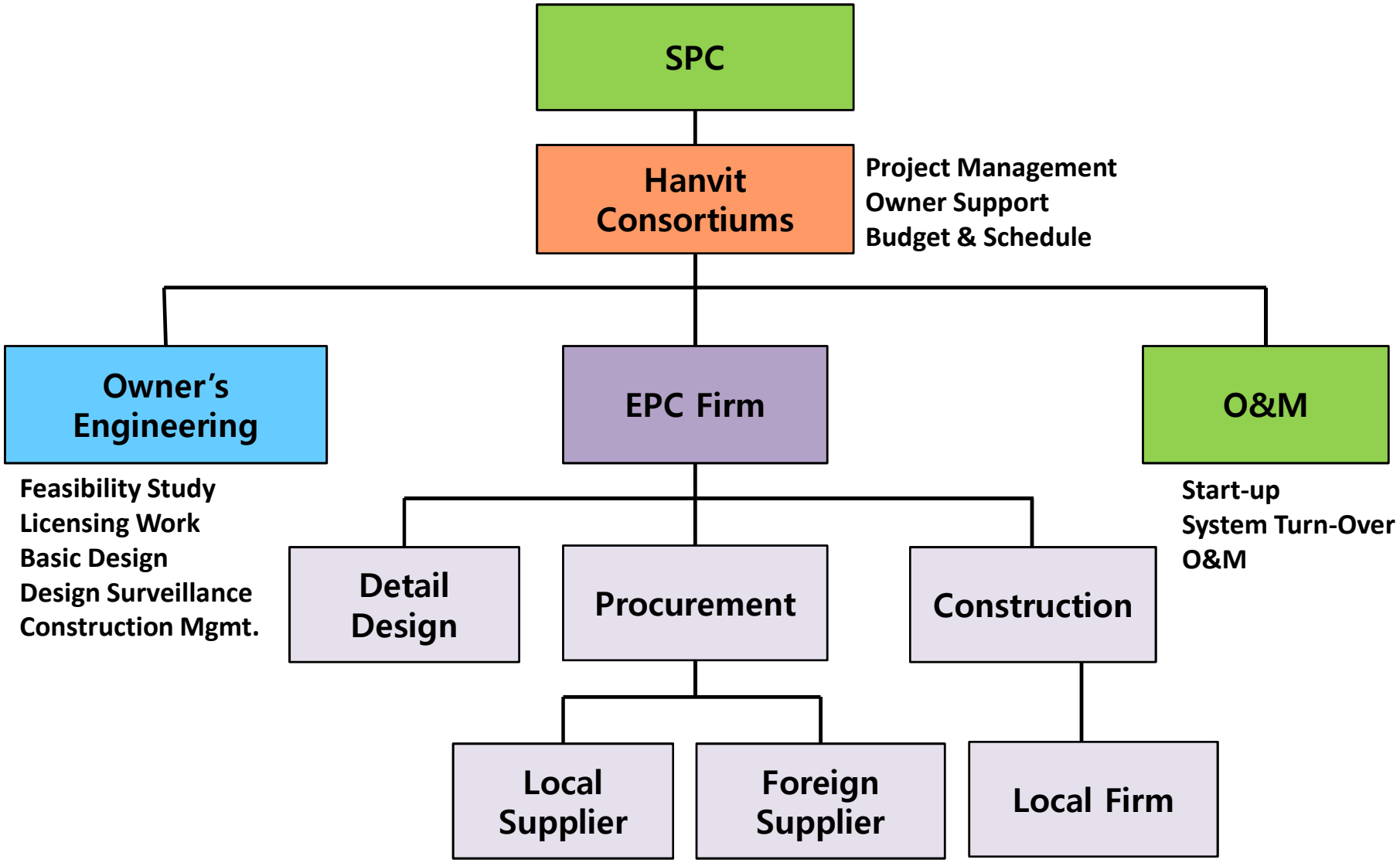
#	Work Activity		1	2	3	4	5	6	7	8	9	10	11	12	3y	25y
1	MOA Letter	1														
2	Deed of SPC Establishment	1														
3	PPP Agreement	1														
4	Perform Feasibility Study & Request Permit	5														
5	Evaluation WTE Construction Permit	6														
6	Letter of Electricity Purchased to EVN	1														
7	PPA with EVN	3														
8	Waste Supply Agreement	1														
9	Insurance Agreement	2														
10	Credit Agreement (Financial Closing)	3														
11	Perform Basic Engineering for EPC Bidding	6														
12	Bidding EPC and Contract	2														
13	Start Construction (EPC)	35														
14	Finish and Commercial Operation	25y														

Licensing and Project Start Process

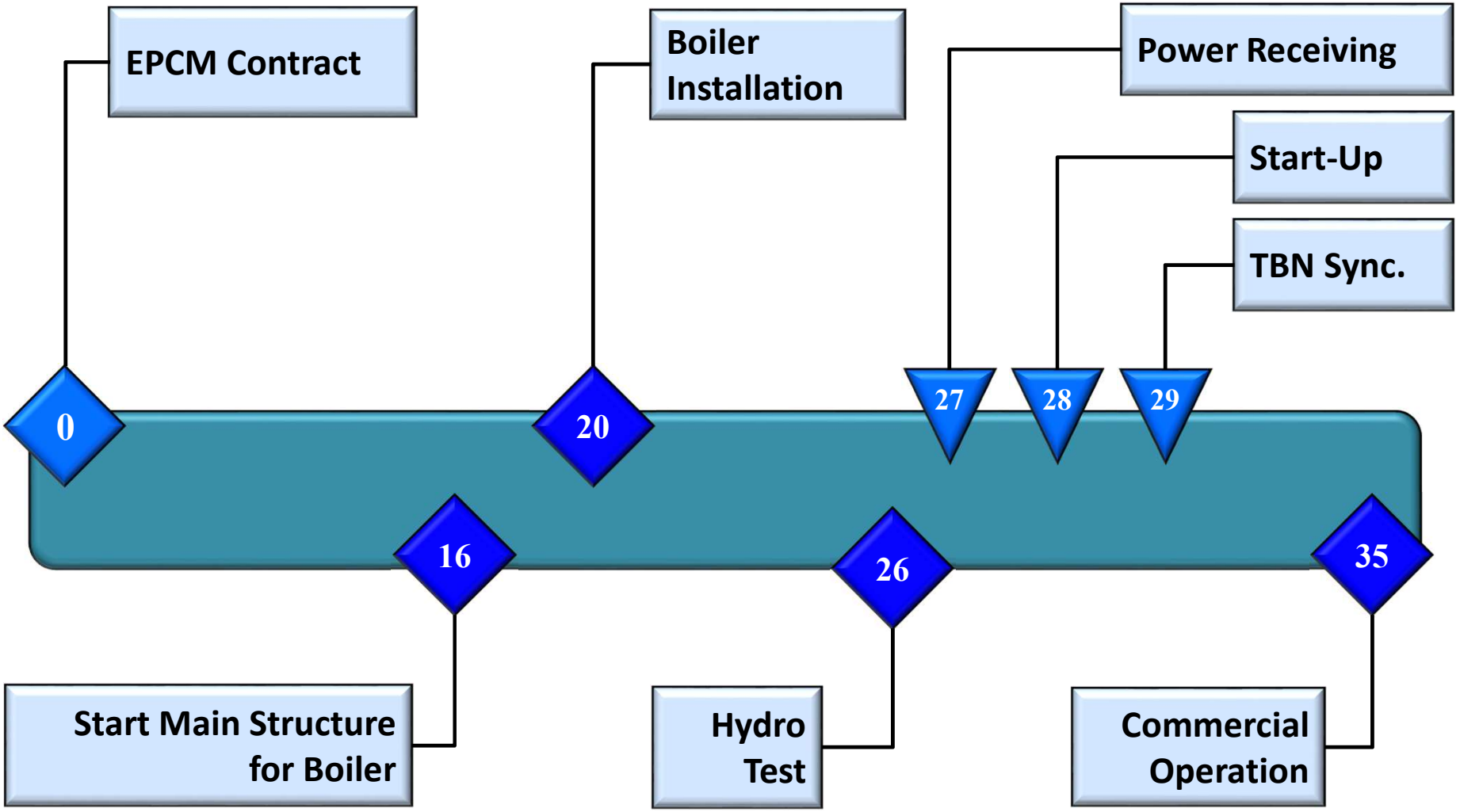


F/S : Feasibility Study
GoV : Government of Vietnam

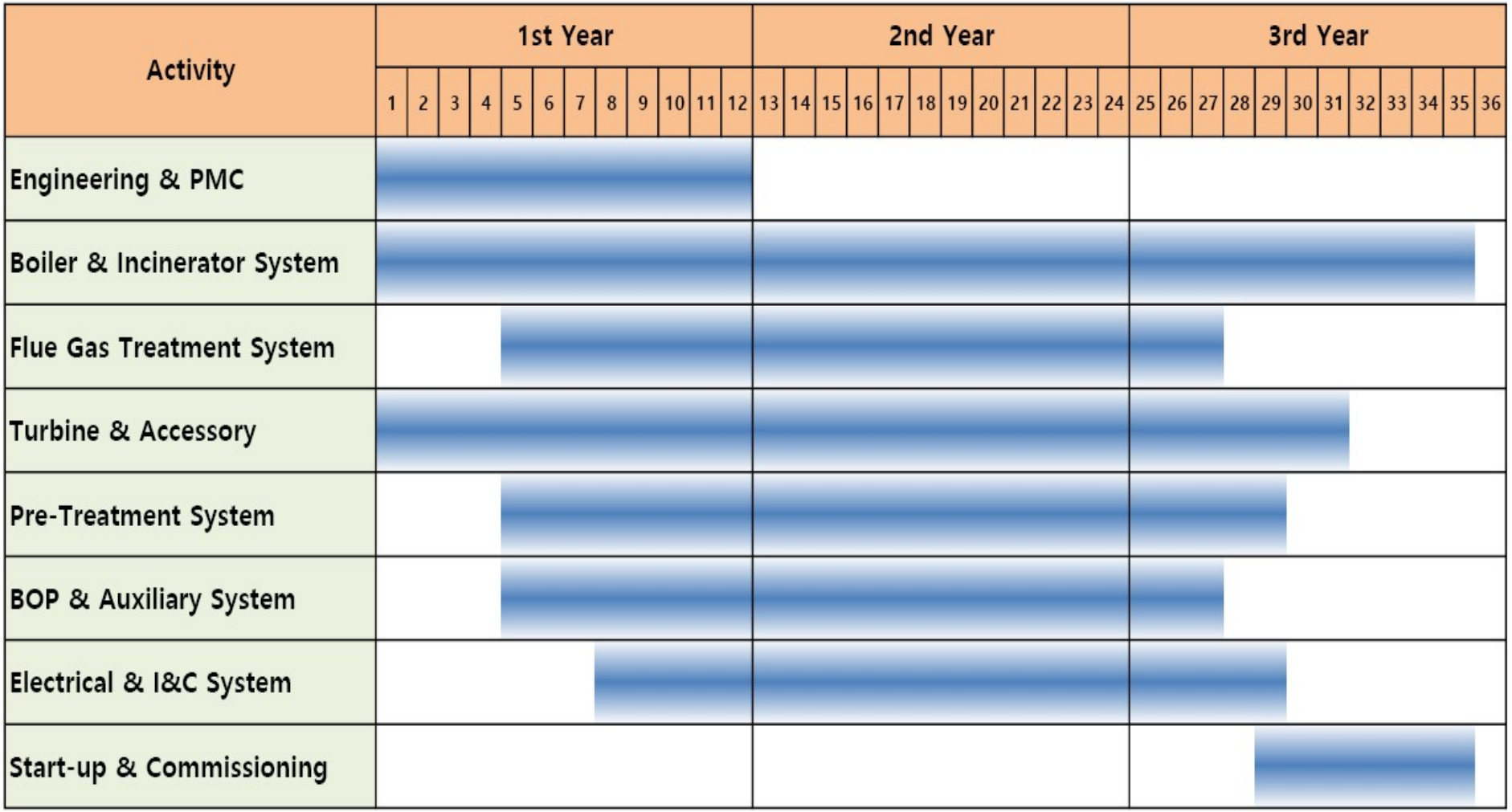
Project Organization



Milestone (35month)



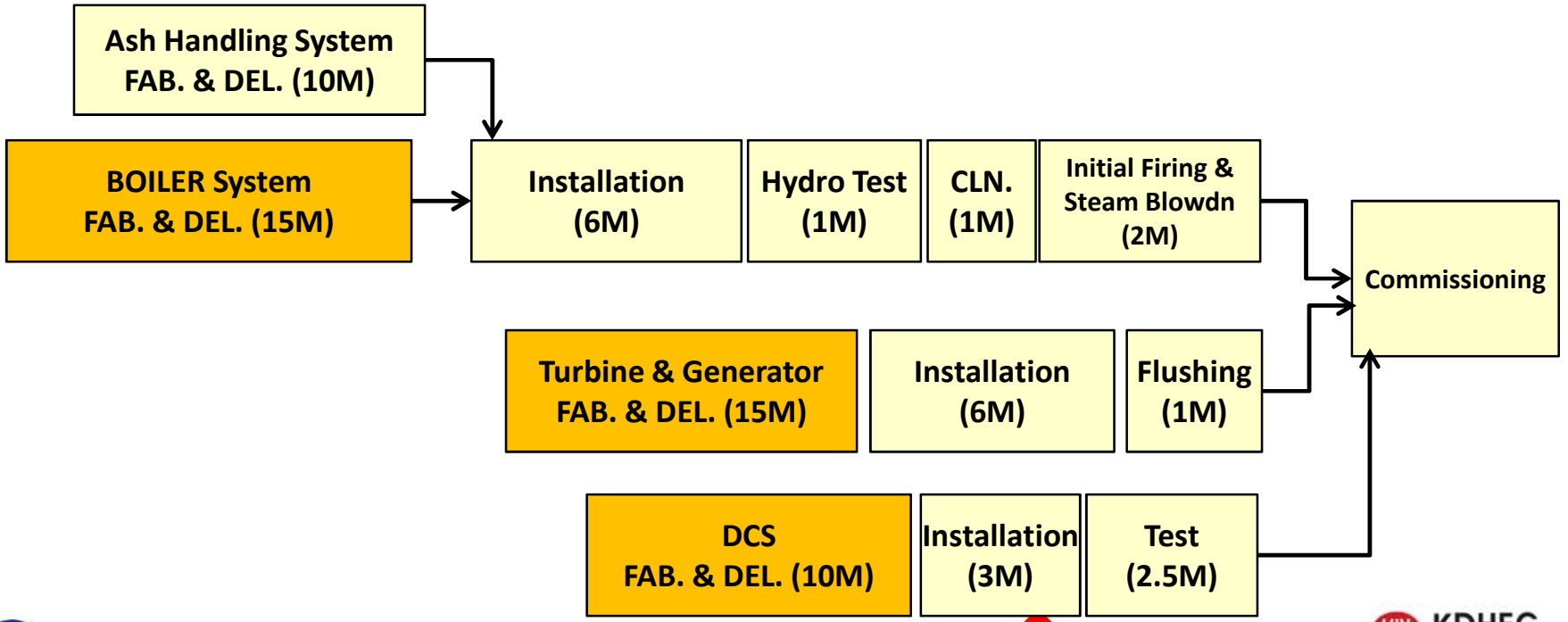
Project Schedule



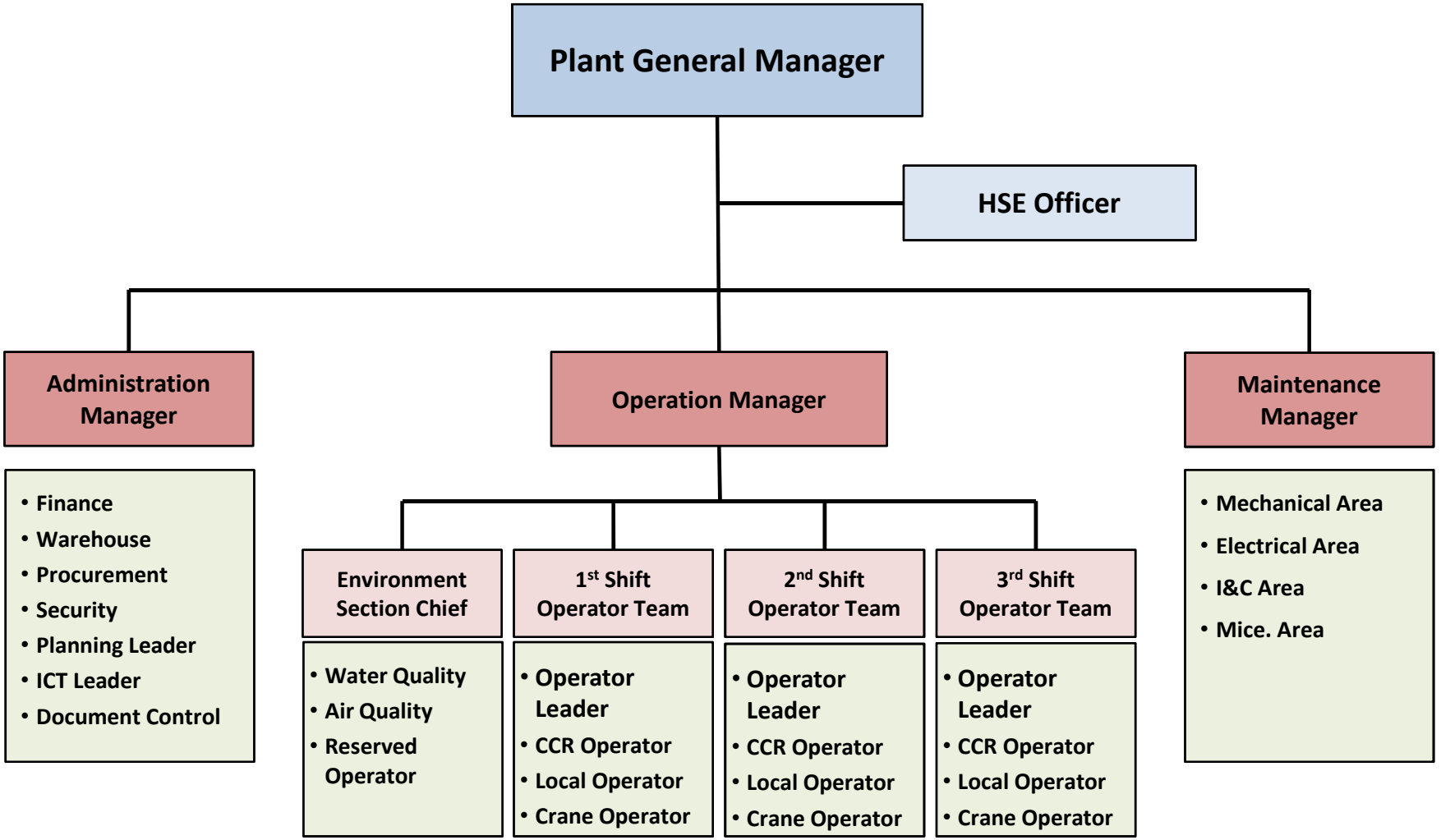
Critical Path

Duration for Major Equipment Manufacturing and Delivery

- Boiler System : 15M (Including Incinerator)
- Ash Handing System : 10M
- Turbine & Generator : 15M
- DCS : 10M



O&M Organization & Staffing Plan



Scope of Supply –SPC

- Any activities for permitting and contact to authorities
- Studies and investigation, like soil, noise, grid study, etc.
- Prepare Waste (fuel), light fuel oil, sorbents, chemicals, water, electricity, etc., for commissioning and operation
- Plant operation and maintenance
- Any taxes, duties, levies in connection with the Project by the relevant tax authorities.
- Custom Clearance

Scope of Supply – Hanvit Consortium

- **Basic & Detail Engineering**
- **Equipment & Material Supply**
  - Reception and Waste Handling, Waste Pre-treatment System
  - Boiler System
  - Turbine System, Generator, Condenser, Water Seam cycle
  - Flue Gas Treatment System and Ash Handling System
  - Electrical, Instrumentation and Control
  - Piping, Steel structure, Insulation, Painting, etc.
  - Spare Parts for 1 years & Transportation
- **Construction**
  - Mechanical & Piping Work
  - Electrical & Instrument Work
  - Civil & Architecture Work
- **Commissioning & Performance Test**
  - Supervision, Personnel training

Key Factor for Successful Project

Financial Perspective Proposal

- The **quantity(2,000tpd) and quality of waste** should be guaranteed, so, after sorting we use 1,000 tpd as fuel for power generation
- Based on preliminary finical analysis, this project is a economically feeble projects, so, the **tipping fee ($12.00/ton) and Electricity Tariff (9.5 cents/kwh)** should be increased for rate of inflation every two years.
- The electricity power tariff and purchasing should be guaranteed.

Critical Issue for Project

- The plant water shall be provided by GoI to the boundary of WTE plant.
- The design and construction task for transmission line are exclude from our budget, the switch yard should be connection point with EVN.
- SPC will performed licensing work for construction of MSW power plant, the active support of city are required
- The various warranty document are required to discuss with financial lender, the aggressive support of city for the warranty document are required

Risk Analysis

- **Risk related to the project**
  - The project does not achieve the MSW calorific value, MSW Quantity, Minimum Annual Availability of Plant
  - ➢ Conduct an **extensive feasibility study** to evaluate the associated risks
- **Risk related to the procurement of critical equipment/material**
  - Critical equipment/material cannot be procured early stage.
  - ➢ Prepare supplier short list
- **Risk related to public resistance**
  - The Success of Project lies in large part the public consensus
  - ➢ The Environmental Impact Assessment should be thoroughly carried out in advance.

Financial Analysis

Plant Basic Data

No.	ITEM	Data	Unit	Remark
1	Operation Year	25	Year	
2	WTE Plant Location	KCN Đình Vũ	-	
3	Land Fill Area	N20.827184, E106.768315	GPS	
4	Electricity Tariff	9.5	USCent/kwh	
5	Waste Tipping Fee	12.00	US$/ton	
6	Waste Quantity	2,000	Ton/day	
7	Waste Composition	-	-	
8	Calorific Value	2,400	Kcal/kg	Assumed
9	Land Acquisition	$20/m^2	50 years	
10	Local Government Invest to SPC	N/A	-	BOO
11	Cooperate Tax	20	%	
12	Estimate Interest Rate for Loan	7.0	%	
13	Estimate Discount Rate for Loan	12.0	%	
14	Average Worker Salary (1year)	5,000	US$	

Financial Analysis

(25 Years)

ITEM	Value	Unit	Remark
Total Investment	$171,085,000	USD	(for 3 Years)
Total Sales Electricity	$411,694,535	USD	
Total Waste Tipping Fee	$109,500,000	USD	
Fixed O&M Cost	$6,600,360	USD	
Variable O&M Cost	$94,465,573	USD	
Financial Cost (Debt + Interest)	$231,948,489	USD	(for 10 Years)
Cooperate Tax	$57,359,428	USD	
Net Income	$161,358,357	USD	
Net Present Value(NPV)	$480,583	USD	
Internal Rate of Return(IRR)	6.63%	%	

Reference Document

- The Potential of Coprocessing Municipal Solid Waste – MSW in Clinker Kilns to Cements; February 2016, Vietnam institute for building materials
- MRV designed for NAMAs in Waste Sector in Vietnam; Presented by: Anh Tien Do, Ph.D.; Vietnam Institute of Meteorology, Hydrology and Environment; August, 2016
- MRV designed for NAMAs in Waste Sector in Vietnam, Presented by: Anh Tien Do, Ph.D. , Vietnam Institute of Meteorology, Hydrology and Environment; February, 2006
- Composition and Generation Rate of Household Solid Waste: Reuse and Recycling Ability A case study in District 1st, Ho Chi Minh City, Vietnam; Dieu T. M.; Department of Environmental Technology and Management; June, 2014
- Vietnam Environment Solid Waste; World Bank, MONRE, CIDA; 2004
- Study on the Industrial Waste Treatment and Waste-to-Energy Project in BINH DUONG Province, the Socialist Republic of Vietnam; February, 2013

2. Additional Discussion

<Precondition>

We use assumed data to answer your question.
Real Project data can be identified after Feasibility Study and our assumed data can be changed.

Pre-treatment Process

Assumption

- Waste Transportation Truck : 10 ton Truck
- Working Hour : 10 hour/day
- The Pre-treatment Capacity : 95 ton/hour (24hour Operation)

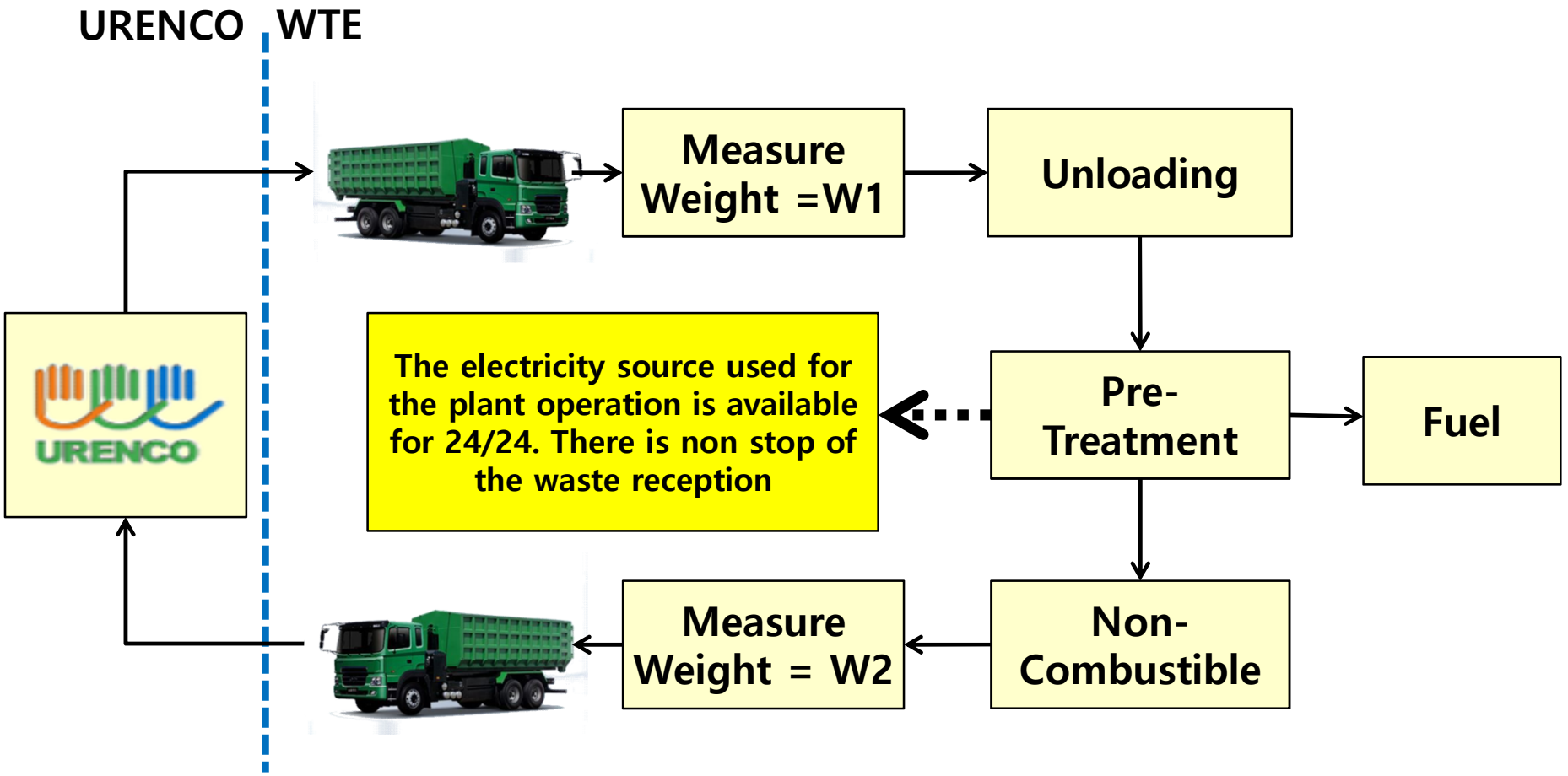
※ **Real Project data identified after Feasibility Study**

Proposal (Preliminary)

- Waste Reception Process
- Truck coming in and coming out (including Washing Truck)
- Odor Problem
- Fuel Storage Concept (3day Storage capacity)

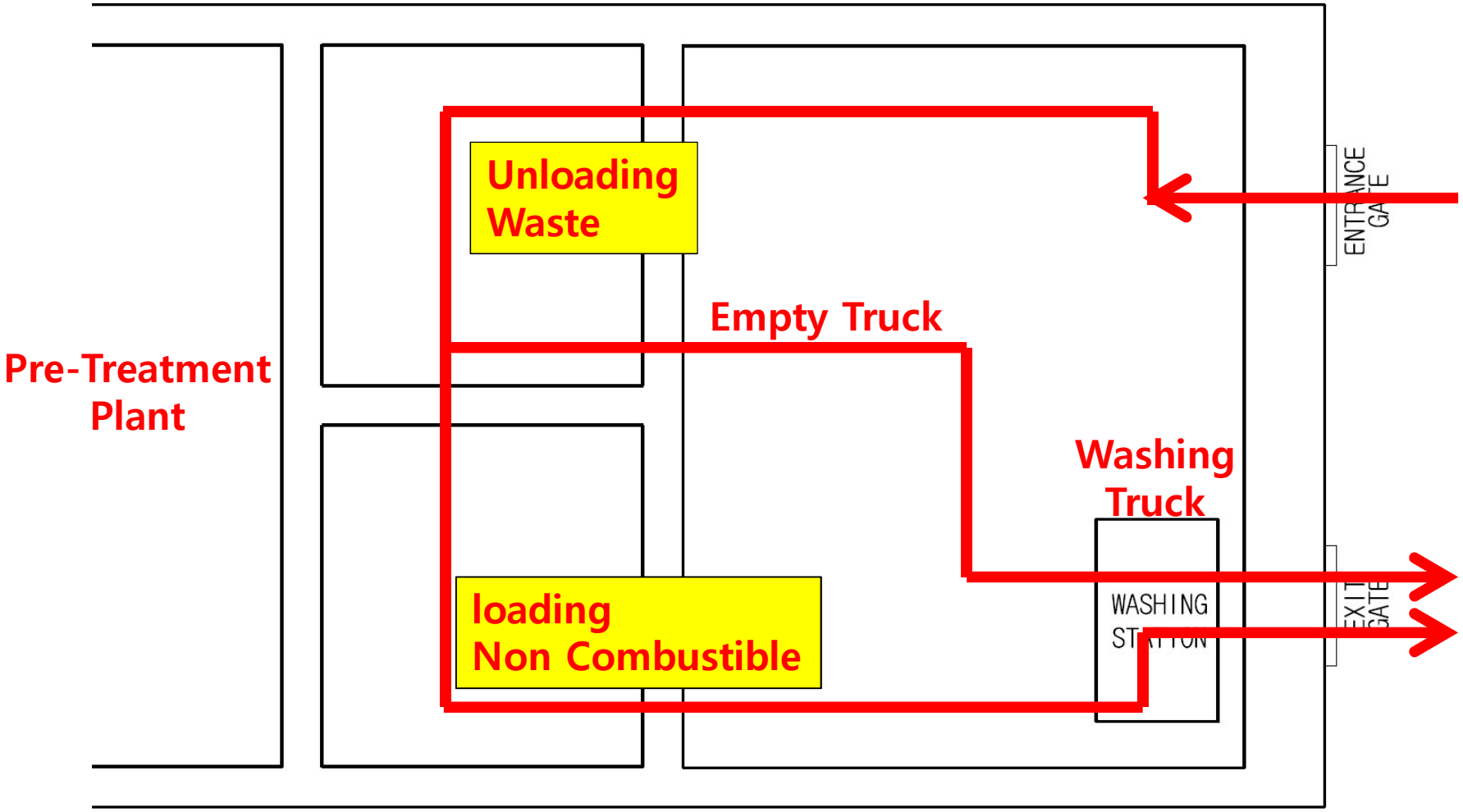
Waste Reception Process

Waste Supplier : URENCO



Waste Truck

- **Without Washing, Truck cannot out from the Plant.**



Odor and Fuel Storage

Areas that smell are in principle sealed

- Air curtains are installed to prevent the odor from discharging to the outside.
- Chemical solution cleaning tower will be installed where high concentrations of odors such as waste storage, leachate storage, and organic sorter areas
- In areas where low concentrations of odor in fuel storage and fueling facilities are install dust removal equipment and activated carbon odor removal tower

Fuel Storage Area

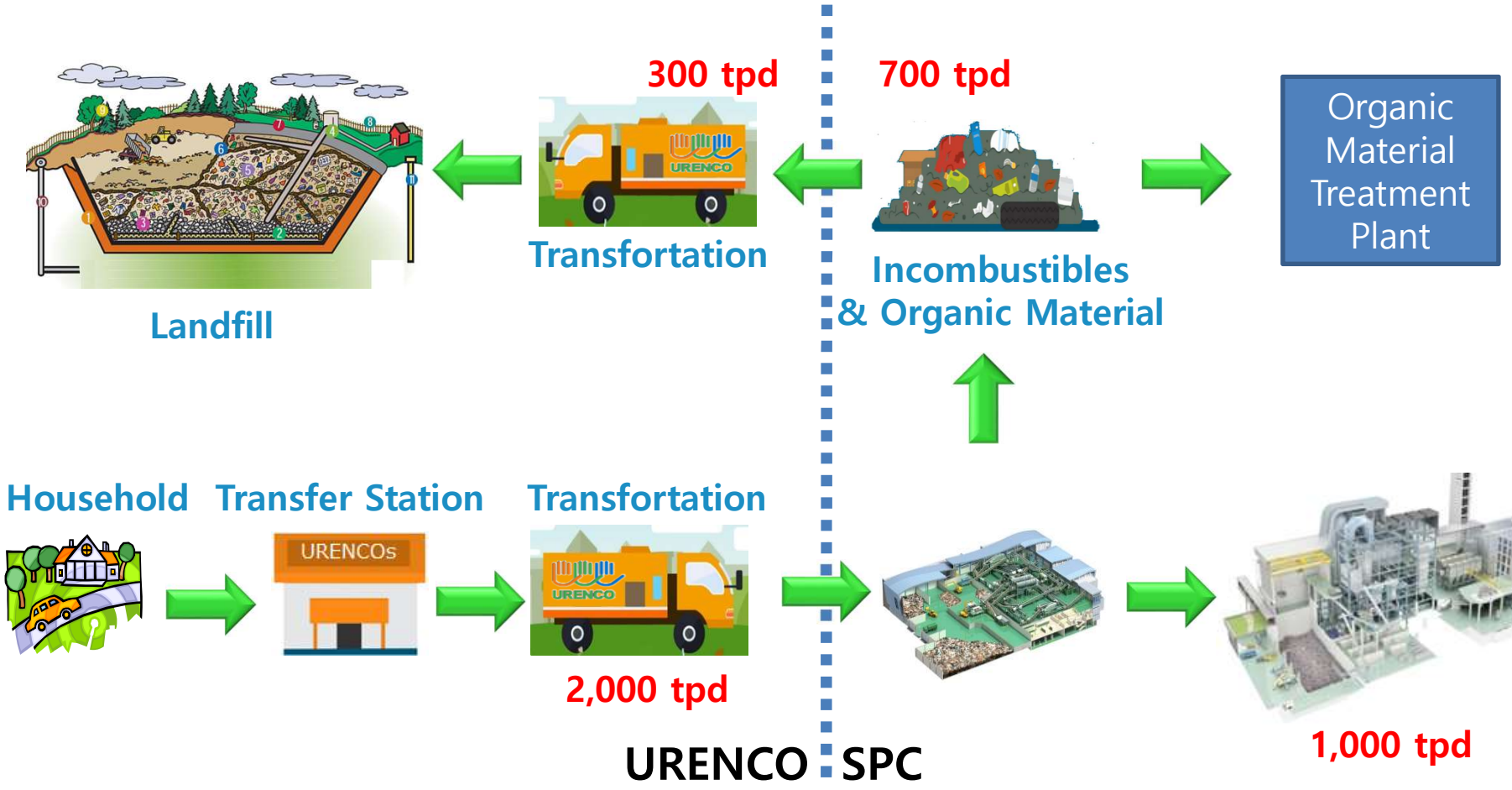
- The fuel reservoir is made of concrete pits, and the facility that stores the final fuel after processing the waste from the fueling plant
- Storage tank capacity is calculated based on the storage of 3 days of fuel capacity

Organic Material Treatment

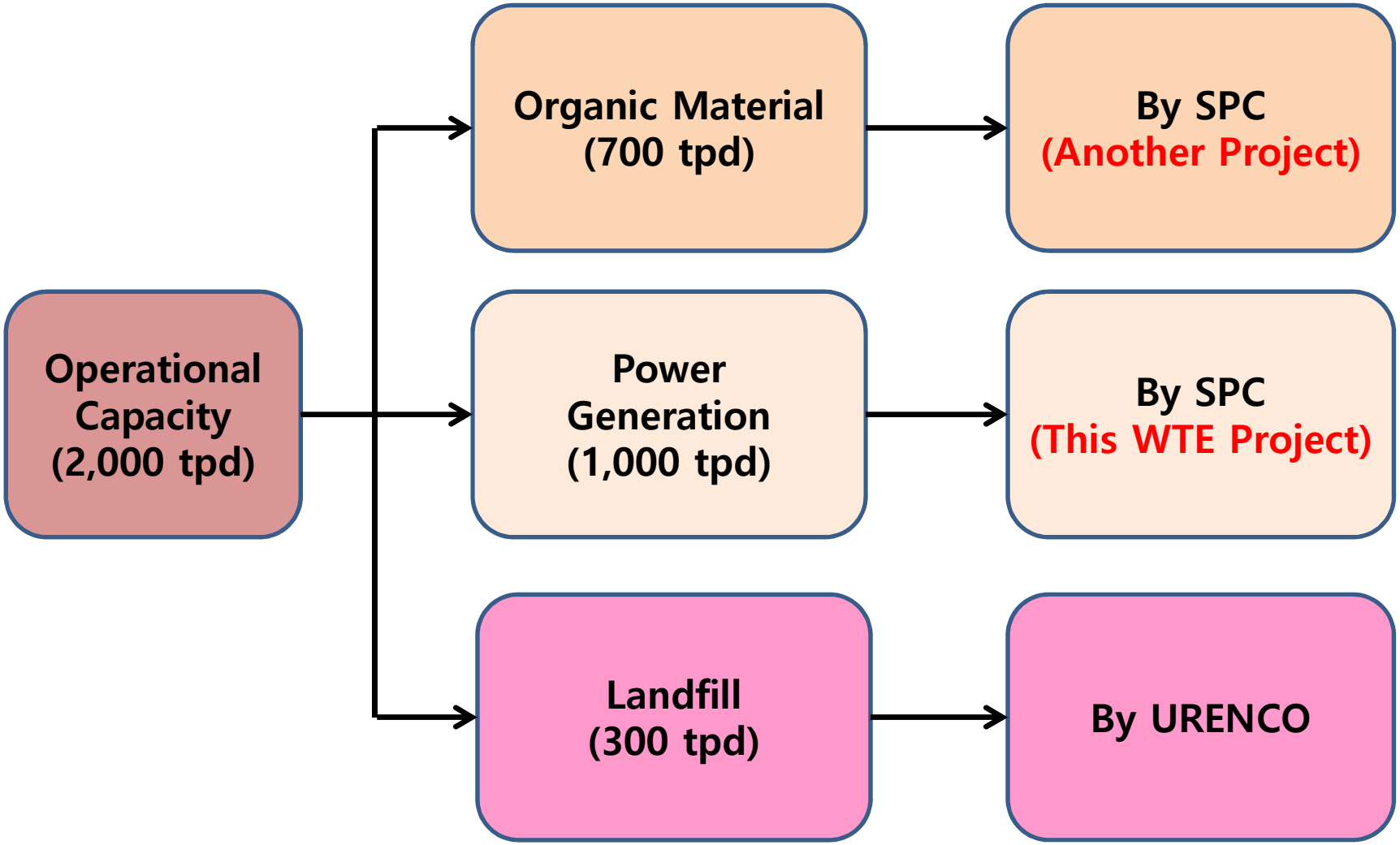
- **Basic principles of Waste disposal**
  - There is no way to completely dispose of the waste.
  - Just the flammable wastes are used as fuel
  - Low-calorific waste like organic waste that lowers power plant efficiency excludes fuel use.
  - Food waste can be transported to sanitary landfill and then used as landfill gas, or it can be treated compost, feedstuff with separate facilities
- **Non-flammable waste estimated as follows**
  - Iron, nonferrous metal, valuable goods: sale
  - Incombustibles, PVC: landfill
  - Bed ash : landfill
  - Fly ash: Consignment processing

Waste Treatment Process

- **We estimate the quantity of waste without landfill survey, after Feasibility Study it will be fixed.**



Waste Operational Planning



Status in Korea for Organic Treatment

	Treatment Method	Plant	Remark
1	Feedstuff	173	
2	Compost	78	
3	Feedstuff, Compost	3	
4	Incineration	54	
Total		308	

by December 31, 2015

Organic Treatment Option

- **Feedstuff : Re-Clean Co., Ltd.**
  - Location: 793, Heolleung-ro, Songpa-gu, Seoul, Korea
  - Product : Raw Materials of Feedstuff
  - Bio Oils: <1%
  - Tipping Fee : $100/ton (Private Company)
- **Compost : Saenggok Organic Waste to Recycling Plant**
  - Location 76, Saenggok sandan-ro, Gangseo-gu, Busan, Korea
  - Product : Compost
  - Waste Water : Discharge to Sea after Treatment
  - Tipping Fee : $55/ton (Busan City owned Company)
- **Separate Project Execution**
  - Hanvit can support Hai Phong City with Separate Project

Plant Area

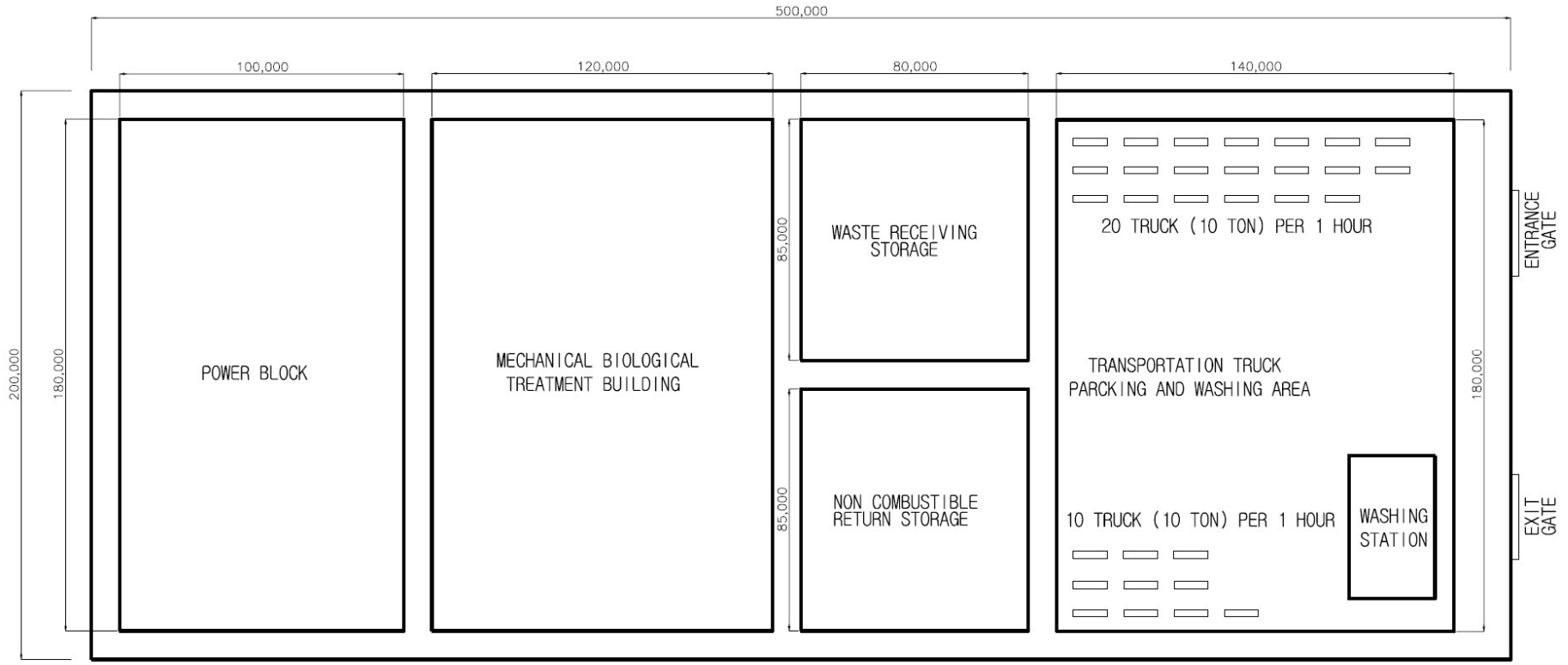
- **Total Area : 10 Ha**

	Area Name	Width (M)	Length (M)	Area (Ha)
1	Power Block	100	180	1.80
2	Pre-Treatment	120	180	2.16
3	Waste Receiving Storage	80	85	0.68
4	Non-Combustible Return Storage	80	85	0.68
5	Transportation Truck Parking & Washing	140	180	2.52
6	Miscellaneous Area	-	-	2.00
Total				9.84

Plant Area

Site Plan Concept

- Two Gate for Entrance and Exit
- Separate receiving and return waste storage



3. Past Performance & Financial Status

Major Performance for HANVIT

Major Performance

Plant Construction

No	Project Name	Year
1	GS Dangjin Combined Cycle Power Plant (CCPP) Commissioning	1999
2	Secondary System Piping Insulation for KHNP Wolsong NPP Unit 3	2001
3	K-Power Kwangyang LNG CCPP Commissioning	2004
4	Electrical Power Facility Construction Work of Kori NPP In-House Power Outage Prevention System	2005
5	Developed the Asset Management System for all Korean Standard NPPs	2009
6	Korea Hydro & Nuclear Power (KHNP) Shin-Wolsong NPP Units 1&2 Commissioning	2010
7	KHNP Shin-Kori NPP Units 3&4 Commissioning	2011
8	Developed the Asset Management System for Korea Western Power (KOWEPO) Taean TPP Units 9&10	2013
9	Developed the Asset Management System for Korea Southern Power Samcheok TPP Units 1&2	2014
10	Supervision for Piping Installation of KOWEPO Taean TPP Units 9&10	2015

Major Performance

Plant Operation/Maintenance

NO	Project Name	Year
1	Developed the Operation Simulator for KHNP Korean Standard NPP	1999
2	Plant Performance Analysis and Improvement Plan for KHNP Kori NPP Unit 1	2000
3	Developed the Operation Guidebook for Kori NPP Units 1&2	2000
4	Plant Performance Analysis and Improvement Plan for Korea Midland Power Seoul TPP Unit 5	2001
5	Plant Performance Analysis and Improvement Plan for KHNP Uljin NPP Unit 2	2001
6	Developed the Operation Guidebook for Uljin NPP Units 1&2	2001
7	Test and Verification for KHNP Hanbit NPP Unit 1&2 Operation Simulator	2004
8	Nuclear Reactor and Steam Generator Maintenance for KHNP NPPs	2006 ~
9	Test and Verification for Operation Simulator for KHNP APR (Advanced Power Reactor) 1400 NPPs	2007
10	Motor Operated Valve and Air Operated Valve Inspection and Maintenance for KHNP NPPs	2008 ~
11	Electrical System Test and Verification for KHNP Kori NPP Units 1,2,3&4	2010
12	Test and Verification for Operation Simulator for Barakah NPP in UAE	2012
13	Final Acceptance Test and Verification for Power Plant Electric System of Shoaiba II CCPP in SA	2013
14	Final Acceptance Test and Verification for Power Plant Electric System of Takoradi T2 in Ghana	2013
15	Developed the Operation Simulator for CCPP (Combined Cycle Power Plant)	2015
16	Electrical System Test and Verification for Barakah NPP in UAE	2016

Major Performance

Engineering

No	Project Name	Year
1	Periodic Safety Review(PSR) for Kori NPP Unit 1 & Wolsong NPP Unit 1	2000
2	Radioactive Environmental Qualification (EQ) for KHNP NPPs (Kori, Shin-Kori, Hanbit, Wolsong etc.)	2002~
3	Soundness & Reliability Evaluation for Equipment/Component of KHNP Wolsong NPP Units 2,3 & 4	2002
4	Heating & Ventilation Air Control System Design for KHNP Hanbit NPP Units 3&4	2002
5	Feasibility Study for Georgia 100 MW Hydro Power Plant	2006
6	Developed the Configuration Management System for System-Integrated Modular Advanced Reactor	2007
7	BOP (Balance of Power Plant) Equipment Procurement for KHNP Shin-Kori NPP Units 3&4	2008
8	Feasibility Study for Balephi Hydro Power Plant in Nepal	2008
9	Electrical Equipment Procurement for Samcheok Green TPP Units 1&2	2014
10	Preliminary Feasibility Study for 180MW Coal Fired Combined Heat Power Plant in Kazakhstan	2016
11	Preliminary Feasibility Study for Simanggo II 90MW Hydro Plant in Indonesia	2016
12	Feasibility Study for Rehabilitation of Fenchuganj CCPP in Syhlet, Bangladesh	2017
13	Preliminary Feasibility Study for TPA Cipeucang Waste to Energy Plant in Tangerang Selatan, Indonesia	2017

Major Performance

Quality Management/Control

No	Project Name	Year
1	Quality Surveillance for Construction and Equipment Manufacturing for Korea Radioactive Waste Agency (KORAD) Radioactive Waste Disposal Facility	2007
2	Quality Surveillance for Equipment Manufacturing for KHNP Shin-Uljin NPP Units 1&2	2010
3	Quality Surveillance for Construction and Equipment Manufacturing for Barakah NPP in UAE	2012
4	Quality Surveillance for Manufacturing & Replacement of Nuclear Steam Generator for Hanbit NPP Units 3&4	2015

Training and Education

No	Project Name	Year
1	Qualification and In-Service Training for Nuclear Quality Inspectors	2000~
2	Qualification Training for Nuclear Quality Auditors/Lead Auditors	2000~
3	Inspection and Diagnosis Training for Nuclear Facilities Maintenance	2000~
4	Training on the Operation of a Nuclear Power Plant for Hyundai, Daewoo, Daelim, Samsung, Doosan, POSCO, and other corporations.	2005~
5	Training on Nuclear Quality Assurance and Codes/Standards to DSK Engineering, SWI Valve, ENSCO, Geonwoo Lighting, Byeoksan ENG, Dowha General Engineering, and other corporations	2008~
6	Training on the Operation of a NPP for Guangdong Thermal Power Engineering Corporation of China	2008

Major Performance

Quality Assurance

No	Project Name	Year
1	Developed Nuclear Quality Assurance Optimization Program for KHNP	2000
2	Study on Alteration of Quality Class System for Operating Nuclear Power Plants	2006
3	Operation of Quality Management System of Korea Electric Power Research Institute (KEPRI)	2007~
4	Consulting to DSK Engineering for Quality Assurance System Qualification and Registration	2008
5	Consulting to SWI Inc. for the Registration as Qualified Valve Supplier to KHNP	2008
6	Consulting to Byeoksan Engineering for KEPIC (Korea Electric Power Industry Code) Qualification	2010
7	Consulting to Dowha General Engineering Co, for KEPIC Qualification	2010
8	Developed Q/A Program for Operation and Maintenance of Heavy Water Nuclear Power Plants	2012
9	Developed KEPIC-MD (Material Standard) 2012 Annex	2012

Major Performance

Research and Development

No	Project Name	Year
1	Participated in Integral Reactor Research and Development	2002
2	Development of Standardized Technology for Nuclear Power Plant In-service Test	2003
3	Developed Pneumatic Valve Performance Test Equipment and Assessment System	2005
4	Development of a Automatic Flushing and Sludge Removal Facility for Nuclear Steam Generators	2006
5	Developed Combined Cycle Power Plant Operation Simulator	2015
6	Technology Development to Convert Low Grade Coal into High Calorific Coal	2017

Other Services

NO	Project Name	Year
1	Repair Works for Valves, Heat Exchangers, etc. for KHNP Nuclear Power Plants	2000~
2	Developed the Integrated Radioactivity Management System for Nuclear Power Plants	2001
3	Assessment & Control of Radiation Exposure	2002~
4	Radiation Protection System Improvement	2002~
5	Providing Nuclear Technology Data/Documents of IAEA, WANO, INPO and EPRI for Corporate	2004~
6	Radiation Protection Training	2004~
7	Treatment of Radioactive Waste : Collection, Disposal, Shipping and Storage of Radioactive Waste	2006~

Financial Statements - Hanvit

- **Separate Documents**

Major Performance for KDHEC

Major Performance

Project Name	Client/ Location	Plant Capacity	Work Scope	Project Period
Daegu Woodchip Power Plant	KDHC	3MW x 1 (Woodchip) (9Gcal/h)	F/S, B, OE	2006~2009
Naju Power Plant	KDHC/ Lotte E&C	20MW x 1 (RDF) (40Gcal/h)	F/S, B, D	2008~2017
Donghae Biomass Power Plant	Lotte E&C	30MW x 1 (Wood pellet)	Proposal	2010~2011
POIC Biomass CHP Plant	STX HI/ Malaysia	25MW x 1 (PKS)	D	2010~2012
Wonju Biomass Power Plant	Lotte E&C	10MW x 1 (Wood pellet)	Proposal	2011
Saemangum CFBC Power Plant	OCI	151MW x 2(Coal+Tail Gas)	F/S, B	2011~2013
Gimcheon CFBC Power Plant	Kimcheon Energy	59MW x 1(Coal)	OE	2011~2013
Colombia Termo Ecopetrol Petcoke Power Plant	Posco E&C/ Colombia	360MW x 1, 240MW x 1 (Petcoke)	Proposal	2012~2013
Dangjin Biomass CFBC Power Plant	GS EPS	105MW x 1 (PKS+Coal)	OE	2012~2015

F/S : Feasibility Study, B : Basic Engineering, D : Detail Engineering, OE : Owner's Engineering

Major Performance

Project Name	Client/ Location	Plant Capacity	Work Scope	Project Period
Seakmoon Biomass CFBC Power Plant	Seakmoon Energy	40MW x 1 (Wood pellet)	D	2013~2016
Pocheon CFBC Power Plant	STX Energy	160MW x 1(Coal+Biomass)	B	2013~2015
Naepo SRF CFBC Power Plant	Lotte E&C	33.7MW x 2(SRF)	B, D	2014~2018
Venezuela PetCoke Thermal Power Plant	Hyundai E&C/ Venezuela	300MW x 7 (PetCoke)	B	2015~2016
Gunsan CFBC Power Plant	KOMIPO Bio Energy	100MW x 2 (Wood Pellet)	B, OE	2015~2020
Poseung Biomass CFBC Power Plant	Poseung Green Power	43.2MW x 1 (Wood Pellet)	OE	2015~2018
Yeosu Biomass Boiler Power Plant	Yeosu Bioenergy	43.2MW x 1 (Wood Pellet & Chip)	B, D	2016~2019
Busan Myung-Ji Biomass Boiler Power Plant	Kolon Global	9.9MW x 1 (Wood Chip)	B, D	2016~2018

F/S : Feasibility Study, B : Basic Engineering, D : Detail Engineering, OE : Owner's Engineering

Major Performance

Project Name	Client/ Location	Plant Capacity (Fuel)	Work Scope	Project Period
Goseong Hai #1, #2 Coal Fired Power Plant	Korea South-East Power	1040MW x 2 (Coal)	OE	2016~2021
Gangneung Anin #1, #2 Coal Fired Power Plant	Korea South-East Power	1040MW x 2 (Coal)	OE	2016~2020

F/S : Feasibility Study, B : Basic Engineering, D : Detail Engineering, OE : Owner's Engineering

Major Performance

Project Name	Client/ Location	Plant Capacity (Fuel)	Work Scope	Project Period
Daegu CHP Plant	KDHC	44MW x 1 (LSWR) (275Gcal/h)	F/S, B, OE	1993~1997
CheongJu CHP Plant	KDHC	44MW x 1 (LSWR) (150Gcal/h)	F/S, B, D, OE	1994~2000
Songpa CHP Plant	KDHC	12MW x 1 (INC's STM, 136Gcal/h)	F/S, B, OE	1995~2000
Yeongjong-Do CHP Plant	HHI	127MW x 1 (LNG) (306Gcal/h)	F/S, OE	1997~1999
Ansan CHP Plant	ASUDI	63MW x 1 (LSWR) (306Gcal/h)	F/S, B, OE	1998~2000
Hwasung CHP Plant	KDHC	515MW x 1 (LNG) (601Gcal/h)	F/S, B, D	2003~2007
Songdo CHP Plant	ITEC	200MW x 1 (LNG) (376Gcal/h)	F/S, B, D	2004~2009
Paju CHP Plant	KDHC	515MW x 1 (LNG) (599Gcal/h)	F/S, B, D	2004~2011
Pangyo CHP Plant	Lotte E&C	146MW x 1(LNG) (326Gcal/h)	F/S, B, D	2005~2010

F/S : Feasibility Study, B : Basic Engineering, D : Detail Engineering, OE : Owner's Engineering

Major Performance

Project Name	Client/ Location	Plant Capacity (Fuel)	Work Scope	Project Period
Suwan CHP Plant	Suwan Energy	109MW x 1 (LNG) (165Gcal/h)	F/S, B, OE	2006~2009
Samsong CHP Plant	KDHC	100MW x 1(LNG) (303Gcal/h)	F/S, B, D	2006~2011
Homaesil CHP Plant	HUCES	60MW x 1 (LNG) (275Gcal/h)	F/S, B	2007~2008
Gwanggyo CHP Plant	KDHC	141MW x 1(LNG) (306Gcal/h)	F/S, B, D	2007~2012
Yangju CHP Plant	KECC	560MW x 1 (LNG) (460Gcal/h)	F/S, B, D	2007~2014
Byulnae CHP Plant	Byulnae Energy	107MW x 1 (LNG) (240Gcal/h)	F/S, B, D	2007~2013
Nuevo PEMEX Co-Gen power plant	Samsung ENG/Mexico	300MW x 1 (LNG)	Proposal	2008
Hakha CHP Plant	SK E&C	37MW x 1 (LNG) (130Gcal/h)	F/S, B	2008~2010
Therme's Combine Cycle Power Plant	GS E&C/ Brazil	400MW x 1 (LNG)	Proposal	2009

F/S : Feasibility Study, B : Basic Engineering, D : Detail Engineering, OE : Owner's Engineering

Major Performance

Project Name	Client/ Location	Plant Capacity (Fuel)	Work Scope	Project Period
ChilcaUNO Combine Cycle Power Plant	GS E&C/ Peru	270MW x 1 (LNG)	Proposal	2009~2010
Yangsan Sasong CHP Plant	Gyeongnam Energy	120MW x 1(LNG) (120Gcal/h)	F/S, B	2009~2010
Hanam Misa CHP Plant	SK E&S	350MW x 1(LNG)	F/S, B, OE	2009~2014
Wirye CHP Plant	SK E&S	400MW x 1(LNG)	F/S, B, OE	2009~2016
ILO Peaky Simple Cycle Power Plant	Posco E&C/ Peru	200MW x 2 (LNG)	Proposal	2010
Daegu Innovation City CHP Plant	Lotte E&C	400MW x 1 (LNG) (276Gcal/h)	F/S, B, D	2010~2014
ChilcaUNO Power Station Add-on Project	Posco ENG/ Peru	277MW x 1 (LNG)	D	2010~2013
Chuncheon CHP Plant	Posco E&C	500MW x 1 (LNG) (400Gcal/h)	F/S, B	2011~2012

F/S : Feasibility Study, B : Basic Engineering, D : Detail Engineering, OE : Owner's Engineering

Major Performance

Project Name	Client/ Location	Plant Capacity (Fuel)	Work Scope	Project Period
Dangjin #5 Combine Cycle Power Plant	GS EPS	900MW x 1(LNG)	B	2012~2013
Pyengtaek #2 Combine Cycle Power Plant	KEPCO E&C	947MW x 1 (LNG)	D	2012~2015
Osan CHP Plant	KEPCO E&C	400MW x 1 (LNG) (200Gcal/h)	Proposal, B, D	2012~2015
Dongtan #2 CHP Plant	KDHC	900MW x 1 (LNG) (600Gcal/h)	F/S, B, D	2012~2017
CIPREL IV Power Plant Add-on Project	KEPCO E&C/ Cote d'Ivoire	110MW x 1 (LNG)	D	2013~2015
Bismayah IPP–Simple Cycle Power Plant	Hanwha ENC/ Iraq	110MW x 1 (LNG)	Proposal, D	2013~2016
Anyang CHP plant	GS Power	964MW x 1 (LNG) (550Gcal/h)	B	2014~2015
	GS E&C		D	2015~2021

F/S : Feasibility Study, B : Basic Engineering, D : Detail Engineering, OE : Owner's Engineering

Major Performance

Project Name	Client/ Location	Plant Capacity	Work Scope	Project Period
Sangam DMC Project	KDHC	Turbo Chiller : 1,500USRT x 7 Absorption Chiller : 1,500USRT x 7 Ice Storage : 12,600USRT	B,D	2001~2006
Sangam IT Center	KDHC	Turbo Chiller : 810USRT x 4	B,D	2006
Garak/Mungjeong CES Power Plant	KDHC	Gas Engine : 1.4MW x 1 (LNG) (1.5Gcal/h)	F/S, B	2006~2007
South East Logistics Center CES Project	KDHC	Turbo Chiller : 2,000USRT x 4 Absorption Chiller : 1,500USRT x 8	B,D	2006~2009
Goyang CES Project	KDHC	Turbo Chiller : 2,000USRT x 2 Absorption Chiller : 1,000USRT x 4 Ice Storage : 32,700RT	B,D	2007~2010
Sangam2 CES Power Plant	KDHC	Gas Engine : 3MW x 2 (LNG) PLB : 8Gcal/h x 2	F/S, B, D	2007~2010
D-Cube CES Project	KDHC	Turbo Chiller : 1,600USRT x 3, 500USRT x 1 Absorption Chiller : 1,200USRT x 4 Gas Engine : 9MW x 1 (LNG)	F/S, B,D	2008~2011
Sangam DMC Extension Project	KDHC	Turbo Chiller : 1,500USRT x 7 Absorption Chiller : 800USRT x 7	B,D	2013~2015

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Major Performance

Project Name	Client/ Location	Plant Capacity	Work Scope	Project Period
Suwon Homesil DH Plant Construction	HUCES	138Gcal/h	Supervision	2011~2013
POSCO #7,#8,#9 CCPP Construction	Posco Energy	1200MW x 1	Supervision	2012~2015
Danggin Biomass Power Plant Construction	GS EPS	105MW x 1	Supervision	2013~2015
Hwasung Hyangnam 2 DH Plant Construction	HUCES	68Gcal/h	Supervision	2014~2015
Goseong Hai #1, #2 Power Plant Construction	Korea South-East Power	1040MW x 2	Supervision	2016~2021

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Financial Statements - KDHEC

- **Separate Documents**

感恩 Cảm ơn

Cảm ơn bạn

Answer for FBC Boiler

- **Why the FBC Type Boiler Operation Cost high?**
  - It is required Sand for fluidizing. (More efficiency)
    - The operation of Fan for fluidizing use additional Electricity.
  - So, more Operation Cost than Grate type
- **The operation cost for our project**
  - O&M cost for FBC Boiler = $100/ton/day
  - We use 1000ton/day as fuel
  - So, 1000 x $100 = $100,000/day
  - **This cost consider as O&M cost in our Financial Analysis**
- **Despite the FBC Boiler use higher O&M Cost, it generate more electricity and better benefit to business**