Status & Perspective of Commercial-Scale Gasification Project in Korea

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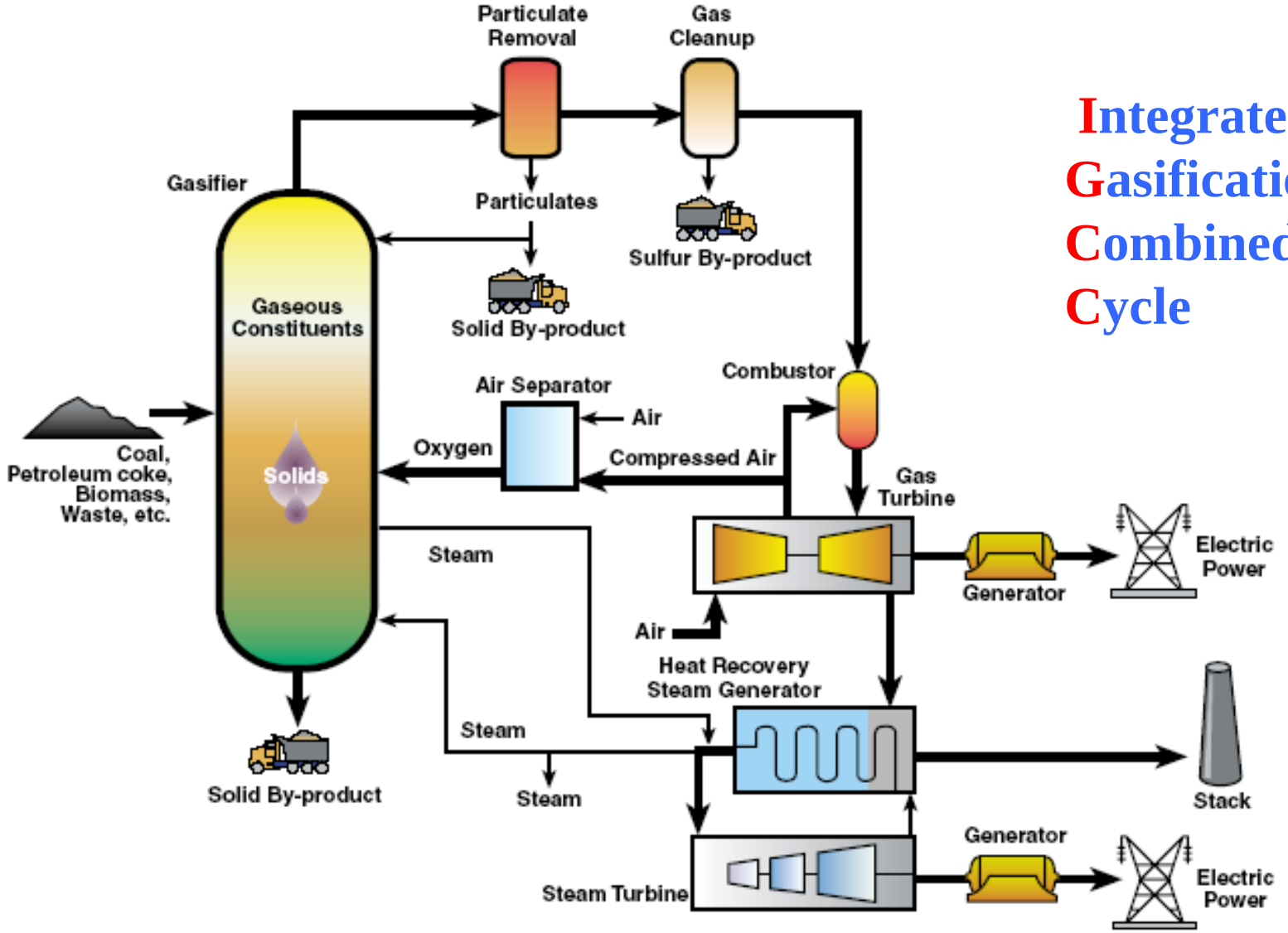
Energy situation in Korea

- Import most of the primary energy source (more than 95%)
- Require adequate portfolio scenario including coal since coal has relatively stable price market
- Must utilize high-efficiency technology such as gasification (IGCC, SNG)

Gasification Related R&D and Demonstration Project in Korea

1. Taean 300 MW IGCC Power Plant
2. Gwangyang 500,000 ton SNG Plant
3. Namhae IGCC Plant
4. 20 TPD Pilot Gasification System
5. Current Gasification R&D Program

IGCC Power Plant



Integrated Gasification Combined Cycle

Background of Taean IGCC Project

- **Needs for reducing greenhouse gas emissions**
  - ✓ **Setting the goal of greenhouse gas emissions reduction in Korea in June. 2015**
  - ✓ **Reducing 37% against forecast of greenhouse gas emissions in Korea in 2030 (BAU, 850.6million CO_2 tons)**

- **Achievement government policy goal for promoting new and renewable energy use in electric power generation from 2% in 2012 up to 10% by 2024**
  - ✓ **IGCC is regarded into new energy in Korea**

Year	`12	`13	`14	`15	`16	`17	`18	`19	`20	`21	`22	`23	`24
%	2.0	2.5	3.0	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0

Construction of 300MW IGCC Demo plant by 2016 according to "*Korea Electric Power Development Basic Plan(2010-2024)*"

Taean IGCC Plant in Korea(Korea western power co.)

Project summary

- Title : Design and construction of 300MW IGCC Demo Plant for the Development of Korea IGCC Technology
- Background : To development Korean Standard model of gasification plant using engineering results through the national project and construction of IGCC demonstration plant .

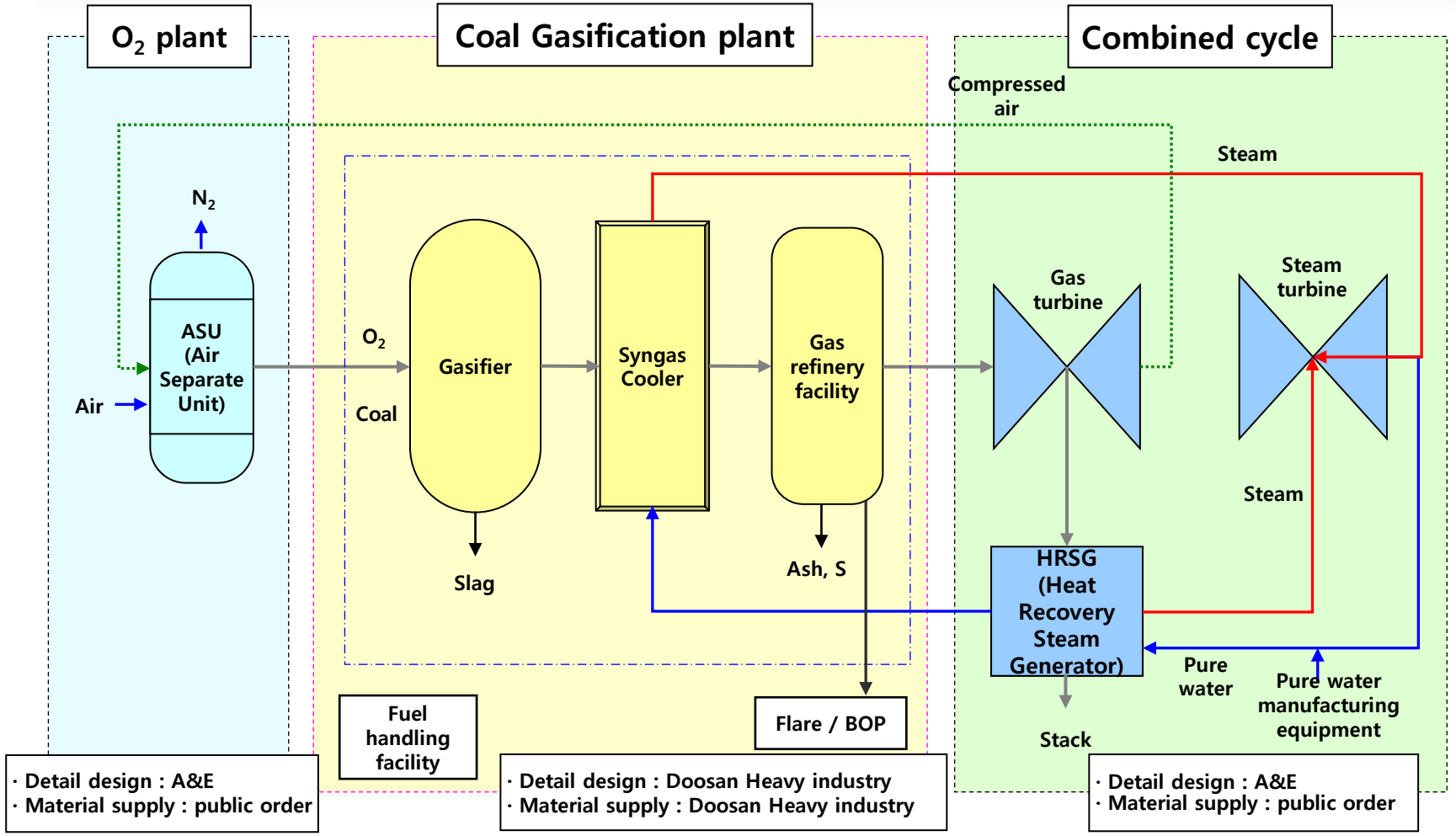
  - The 3rd Basic Plan for Long-term electricity supply and demand('06.12)

- R&D cost: Government(8%) + Participant(92%)
  - Period : 2011. 2 ~ 2016. 11.(70 months)
  - Prime contractor : Korea western power co.
  - Sub contractor : IAE, KIER, Doosan, Hyundai heavy industries, Universities(Ajou, Hongik, Suwon)
- Ultimate goal

To secure 300MW IGCC technology through engineering, manufacturing, construction & operation.

Gasification Plant Characteristics

Comprehensive design of plant



Gasification Plant Characteristics

Condition of Gasifier and cooling system

Classification	Temperature (℃)	Pressure (MPag)
Gasifier	about 1,550	4.2
Outlet temperature	about 900	4.2
Hot gas cooling system outlet	about 250	4.16
High pressure feed water	220	16.4
Intermediate pressure feed water	216	7.4
High pressure steam	338	14.1
Intermediate pressure steam	268	5.2

Gasification Plant Characteristics

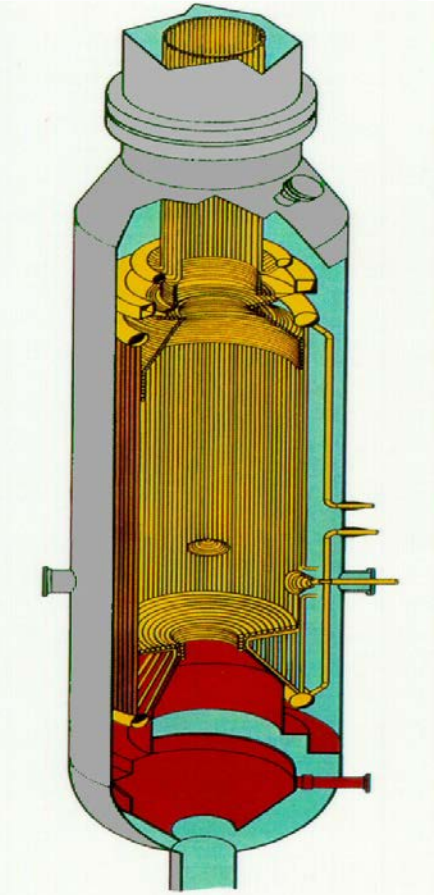
Gasifier

Performance

- Carbon conversion : ≥ 99.5
- Operating pressure : 25~45 bar
- Operating temperature : 1300~1600 ℃
- 70% bottom slag + 30% fly ash

Gasifier and burner

- single stage, dry type, cylindrical
- Membrane wall : recovery of reaction heat and reduction heat loss of external wall
- Structure: Refractory lining + Solid/Liquid slag
- Consist of Fire brick at the bottom
- Counter flow, circling(4set), duration is longer than wet type burner(1~2yr)



SCGP gasifier

Taean IGCC Plant : Site

[Taean Powr Plant Site]

Taean IGCC Plant : Characteristics

Division	Characteristics		Remark
Power Output	Gross	Net	GT : 230 MW ST : 150 MW (Base : HHV)
	380 MW	305 MW	
Feed Stock	Subbit. ~ bit.coal (Ignition fuel : LNG)		
Plant Efficiency	Net 42%		Base: HHV
Coal Flow	2,670 ton/day		As received basis
Air Pollutant Emission	SOx : < 15ppm NOx : < 30ppm Dust : < 3㎎/S㎥		@15% O_2

Plant Area : 81,500㎡

Taean IGCC Plant : Syngas Composition

Component	Concentration	
H_2S	< $20ppm_{vd}$	
COS	< $5ppm_{vd}$	
CO	0.5819	
N_2	0.0868	
H_2	0.2360	
Particle	< 3㎎/N㎥	
HHV	3,306 kcal/kg, ($CO+H_2+CH_4$)	
Syngas Flow	159,947kg/h, ($CO+H_2+CH_4$)	

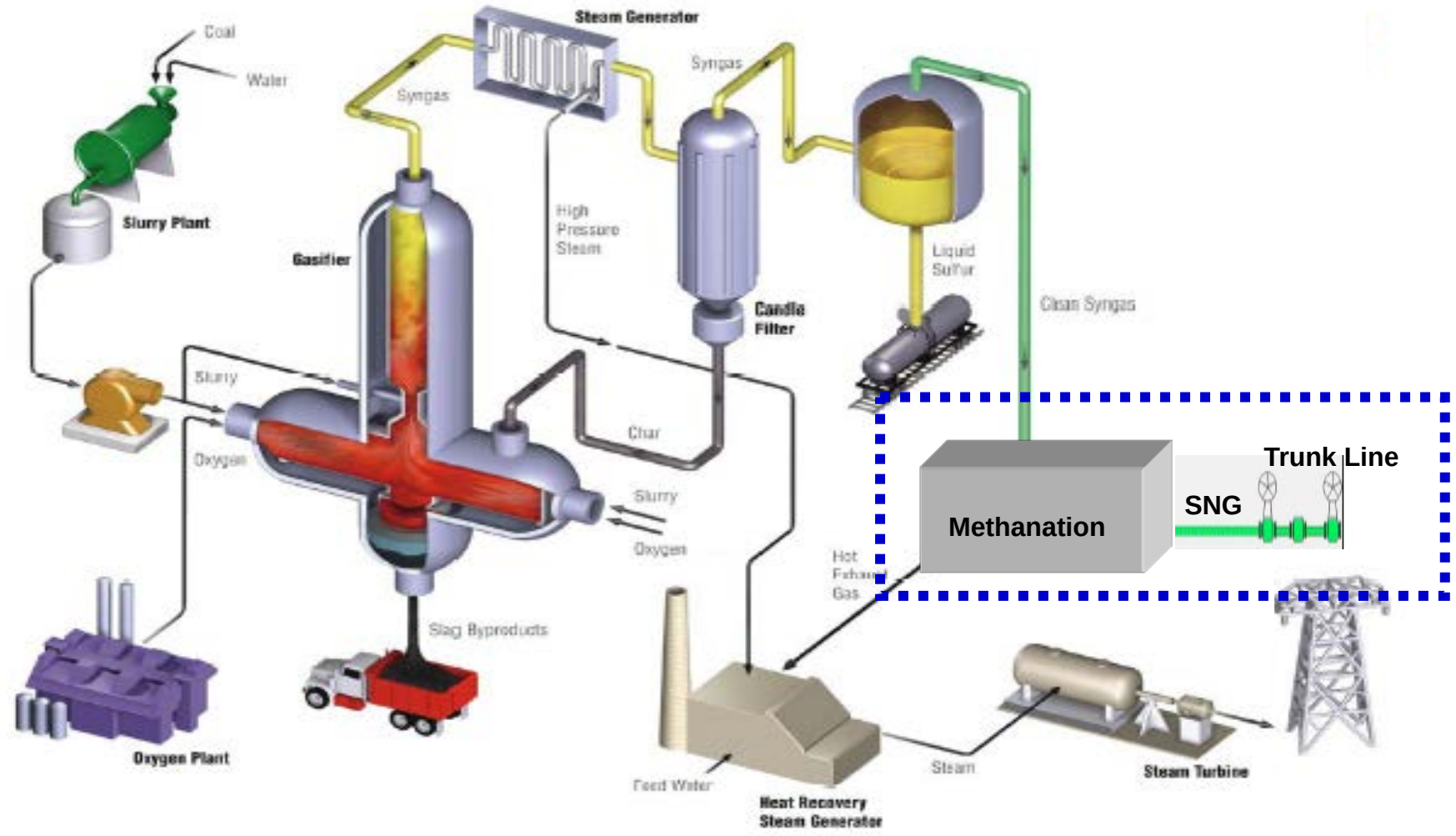
Construction Status of Taean IGCC Plant

Yr	’07	’08	’09	’10	’11	’12	’13	’14	’15	’16
	1st Phase(40months)				2nd Phase(70Months)					
Mile-stone	Basic Design Start 3	Enviro. Impact Assess. 5	BDP Finish 10	Const. Master Plan 11	Excavation Con. Start 11		Gasifier Install 6	Power Receiving 7	Test Run 10	Demo Oper. Start 3 / R&D Finish 11
Accum. Progress (%)	Basic Desigin (Completed)				7.97	30.61	66.07	91.80	99.29	100

※ Progress Status : 96% (@Sep. 2015)

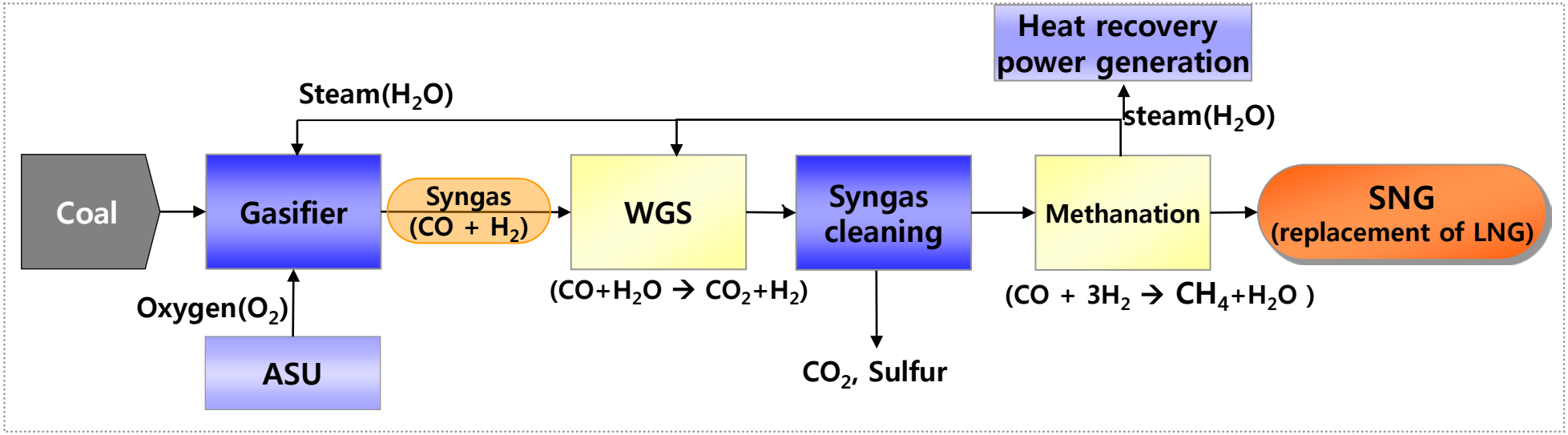
POSCO SNG project status

□ SNG process overview



SNG plant design considerations

□ SNG Process



- Gasification : Syngas(mainly CO, H_2) is produced by partial oxidation of coal
- WGS(water gas shift reaction) : Increasing hydrogen content ($CO + H_2O \rightarrow H_2 + H_2O$)
- Syngas cleaning : Removal of acid gases(H_2S, COS, CO_2) in syngas
- Methanation : Reaction of CO and H_2 to produce SNG ($CO + 3H_2 \rightarrow CH_4 + H_2O$)

SNG plant design considerations

□ Requirement : consider SNG quality since using natural gas pipe line of KOGAS)

KOGAS natural gas pipe line using system)

- Related regulations : Urban Gas Business Act.
- Progress
  - '05.7~'08.12 : Conclusion of contract of using pipeline with POSCO and KOGAS
    - section : Gwangyang LNG terminal→ Pohang steelwork
    - amount of resources : 200,000~300,000 ton/year
  - after '08.12 : Fulfillment of national policy

※ But, SNG is currently conducted research services for national quality standards set for using pipe line.

※ SNG quality

classification	Composition (%)	Heating value (㎉/㎥)
LNG	Methane (>85%), Ethane (2%), others (propane, N_2)	9,700~10,800
PNG	Methane (>90%), others (CO_2, N_2)	9,000~10,200
SNG	Methane (>98%), others (H_2, N_2, CO_2)	9,000~9,500

* LNG (Liquefied Natural Gas), PNG (Pipeline Natural Gas), **SNG (Synthetic Natural Gas)**

POSCO Gwangyang SNG Project (1)

· **Location: Gwangyang, Korea**

- Site Size: 100 Acre

· **Capacity: 500KTA of SNG**

- **5,500 TPD Sub-bituminous Coal**
- **ConocoPhillips:** Gasifiers 2 + 1
- **Linde:** Rectisol for Acid Gas and CO2 Separation
- **HaldoTopsoe:** Methantion Process
- **Jacobs:** Feed Contractor
- **POSCO E&C:** EPC Contractor
- **Daewoo Eng.:** Detail Eng. Contractor

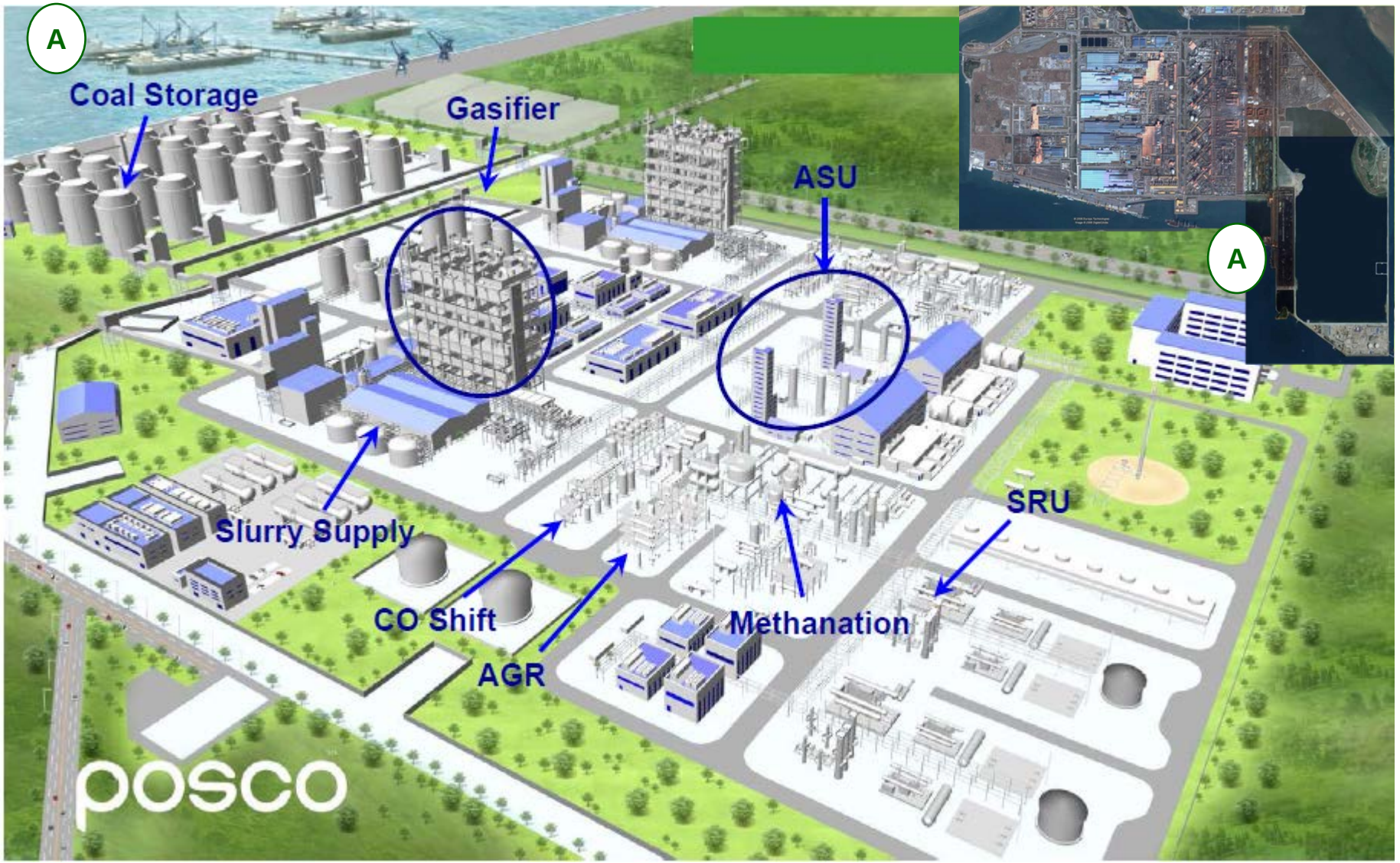
· **Schedule: ’08.11 ~ ’16.12**

- ’11.6.7 **Groundbreaking Ceremony**

◆ **Present: Under Start-up and Commissioning**

Source : 2011 GTC conference, “Status of Gwangyang SNG Project”

POSCO Gwangyang SNG Plant Overview (1)



Source : 2011 GTC conference, “Status of Gwangyang SNG Project”

POSCO Gwangyang SNG Plant Overview (2)

Source : 2014 GTC conference, “Updates on POSCO SNG Project”

Namhae IGCC project Background

○ **Alternative Power Plant Technology compared coal-fired or NGCC plant**

- **IGCC is categorized in the NRE in Korea**
- **relatively low emission of the pollutants**
  - *** Comparing with p.c power plant SOx 90%, NOx 30%, Dust 60% reduction**
- **economically superior when CCS is introducing in the power industry**

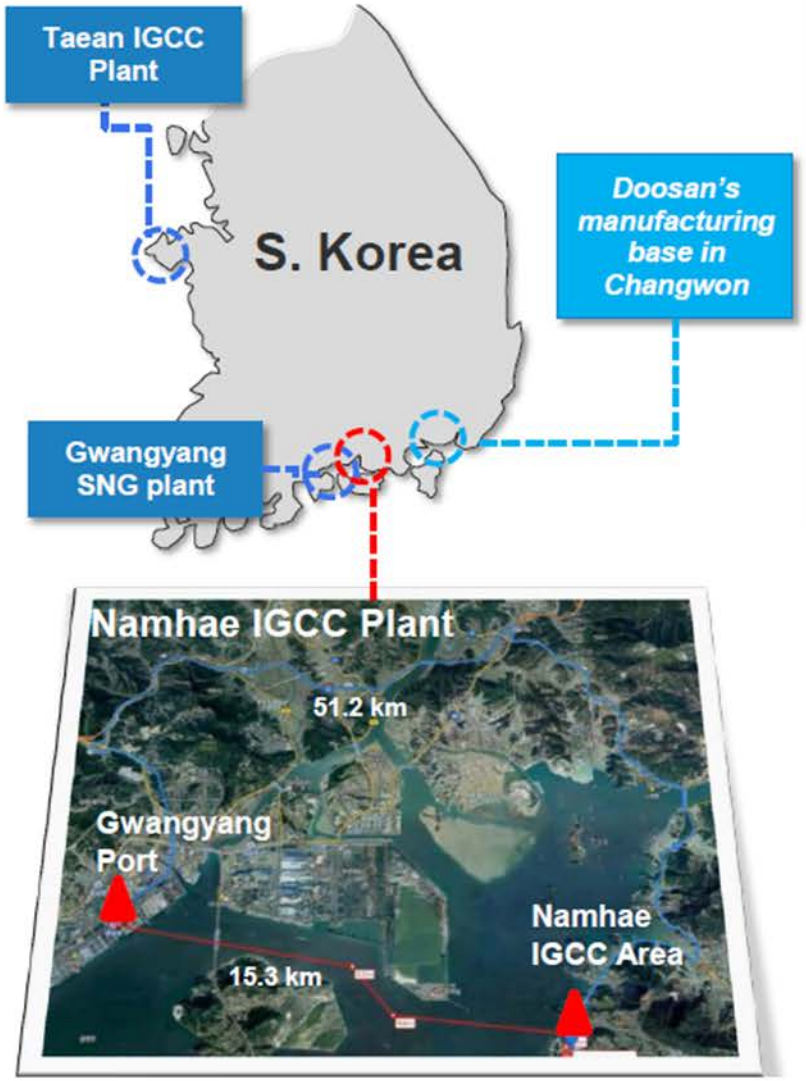
○ **Include in the 5th national power plant construction plan**

※ **Comparison of candidate power generation technology**

	P.C	LNG-CC	IGCC
Facility	Boiler + S/T	G/T + HRSG + S/T	Gasifier + G/T + HRSG + S/T
Fuel Cost	Coal (42,000 KRW/Gcal)	LNG (15,000 KRW/Gcal)	Syngas [Feed: Coal]
Investment Cost	2,000 KRW/kW	1,200 KRW/kW	3,000 KRW/kW
Plant Efficiency	43% (USC)	55%	46%
Capacity factor	Base Load (85%)	Peak to Medium Load (> 60%)	Base Load (85%)

✓ **Business Choice : p.c > IGCC > LNG-CC**

Namhae IGCC Project



- √ Location: Namhae-gun, Gyeongsangnam-do
- √ Developer : POSCO E&C
  Doosan Heavy Industries & Construction
- √ Plant Capacity: > 300MWe (Net, HHV)
- √ Project Schedule
  - Feb.2015 : MOU with Namhae-gun
  - Jul. 2015 : List-up of Gov.'s 7th *Basic Plan* for long term electricity supply and demand of South Korea
  - 4Q. 2015: Pre-feasibility study completion
  - 1Q. 2019: Ground Breaking
  - 1Q. 2023: Commercial operation

Source : 2015 GTC conference

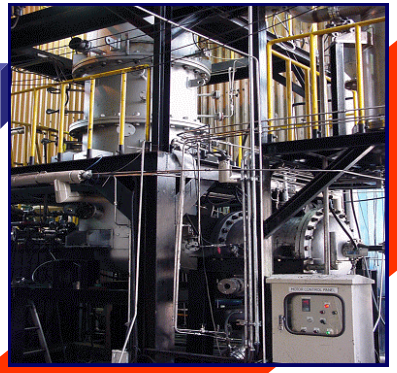
20 TPD Gasification Test Facility (in Taean IGCC Plant) (1)

IAE's Coal Gasification Scale-up History

1-stage coal gasification (3 TPD)

1994 - 2011

Waste oil gasification (1 TPD)



2000 - 2005

2-stages gasification (3 TPD)

2009 - 2011

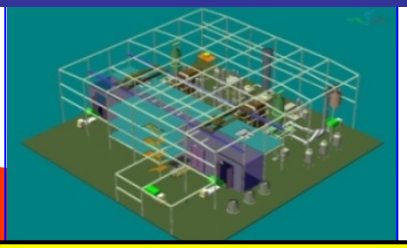
Compact gasification (3 TPD)

2009 - present

Partial or Non-slagging gasification (3 TPD)

2011 - present

100 TPD Gasification



Demo. plant (~100 TPD) in planning

20 TPD Test-bed (Non/Partial slagging)

2015-present

Test-bed (20 TPD)

Pilot-scale (1~3 TPD) gasification research for 20 years

Source : IAE

20 TPD Gasification Test Facility (in Taean IGCC Plant) (2)

- Coal Preparation, Gasifier, Quench-type Cooling System

- Syngas Treatment/Cleaning System
  - COS Hydrolysis Unit
  - Wet Desulfurization System
  - Dry Desurfurization System

- Non / Partial-slagging entrained-bed type

- Suitable for low rank coals
  (moisture in dried coal : 7-18%)

- Constructed in 2015

20 TPD Gasification Test Facility

Application Areas of Test-bed Facility

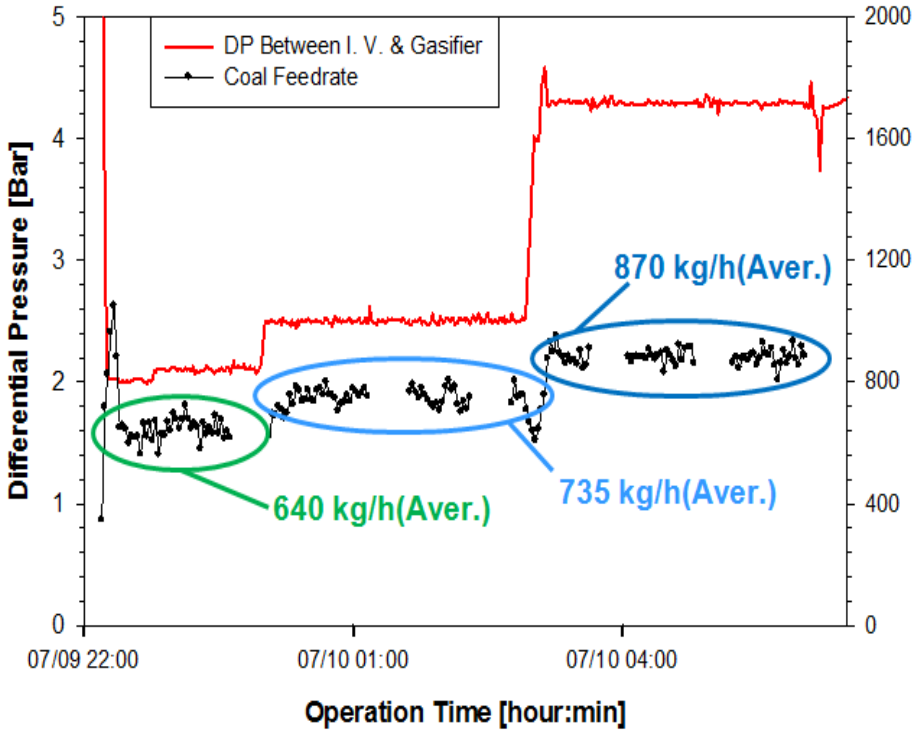
- ❖Design of 200 TPD Korea-developed IGCC system
- ❖Validation of Scale-up Concept of Newly developed Gasifier
- ❖Development of Operation Strategy of 300 MW IGCC Demonstration Plant
- ❖Experiment of Gasification Characteristics and develop database of candidate Coal
- ❖Trouble Shooting of 300 MW IGCC Demonstration Plant
- ❖Test unit of domestically developed gasification parts or components
- ❖Test unit of newly conceped technology or process related with gasification

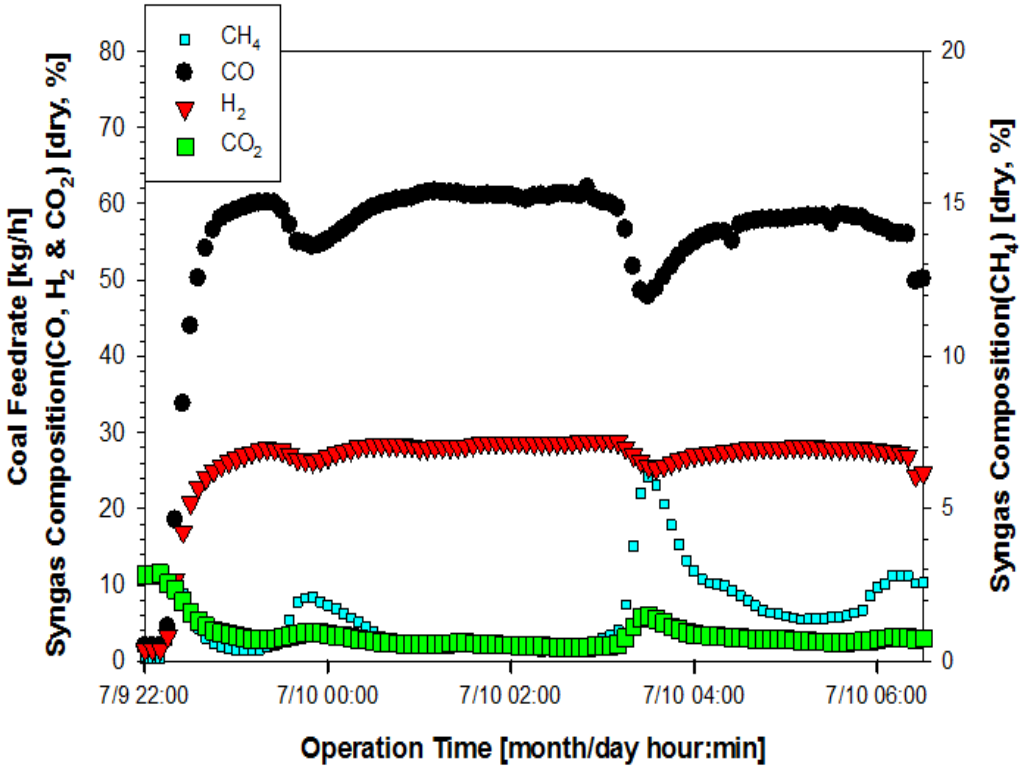
Results of 20 TPD Gasification Test

■ Feed Rate & Corresponding Syngas Composition

Feed Coal: **Australian White Haven Bituminous Coal**

Gasification Condition: **~1,200℃, 19.8 ~ 20.1 bar**





Source : IAE

Results of 20 TPD Gasification Test: Slag

■ **Total produced amount is small**

Slag : Australian White Haven coal (2015/7)

Slag : Indonesian KCH-mixed coal (2016/7)

Source : IAE

Mission Innovation Energy Program in Korea

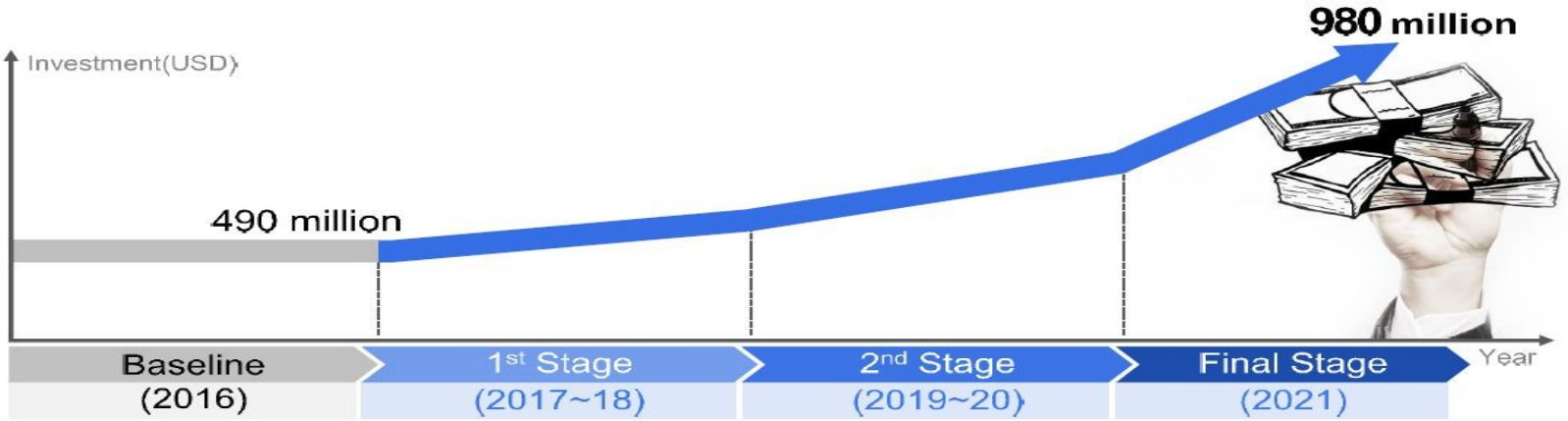
Establishment of low carbon economic society in the future :

- **distributed clean energy**
- **energy prosumer**
- **reduction of greenhouse gas**

청정에너지기술 R&D 투자 계획

KETEP

(투자규모) 청정에너지기술 중점투자분야에 해당하는 정부·공기업 사업을 선별,
'16년 규모를 합산하여 기준금액 약 5,600억원*(490백만 달러) 산정, `21년까지 배 확대
* 정부: 4,500억원, 공기업 1,100억원



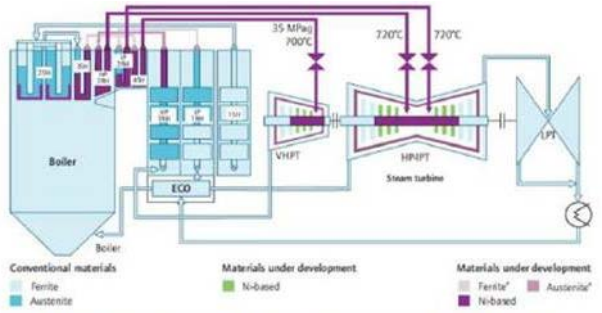
Mission Innovation program for Power Generation Industry

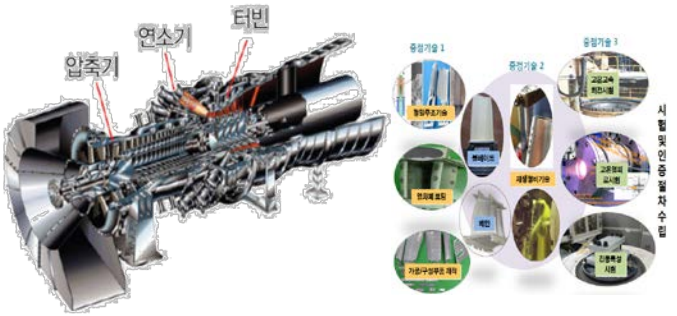
Concept

Future of clean fuel technology for the power generation plant will have been accomplished high efficiency, low CO_2 emission, and flexibility of feedstocks.

Strategic projects

①Development of clean coal technology as A-USC 700℃ for low CO_2 emission ②Development of high-efficiency next generation GT ③Development of co-firing system at large power plant using low carbon fuel ④Development of supercritical CO_2 of new power generation system ⑤IGFC ⑥Development of domestic technology of low cost and high efficiency compact process for CO_2 mitigation using coal gasification generation





Strategy

Furtherance Direction ① High Efficiency

· Deal with environmental regulations through retrofit of power plant.
· Development of technology as A-USC, supercritical CO_2, and IGFC

→ strategic project 1,4,5

Furtherance Direction ② Domestic Technology

· Increasing demand of GT and IGCC, according to power sector
· Expanding export industrialization through domestic technology of eco-friendly / high efficiency

→ strategic project 2,6

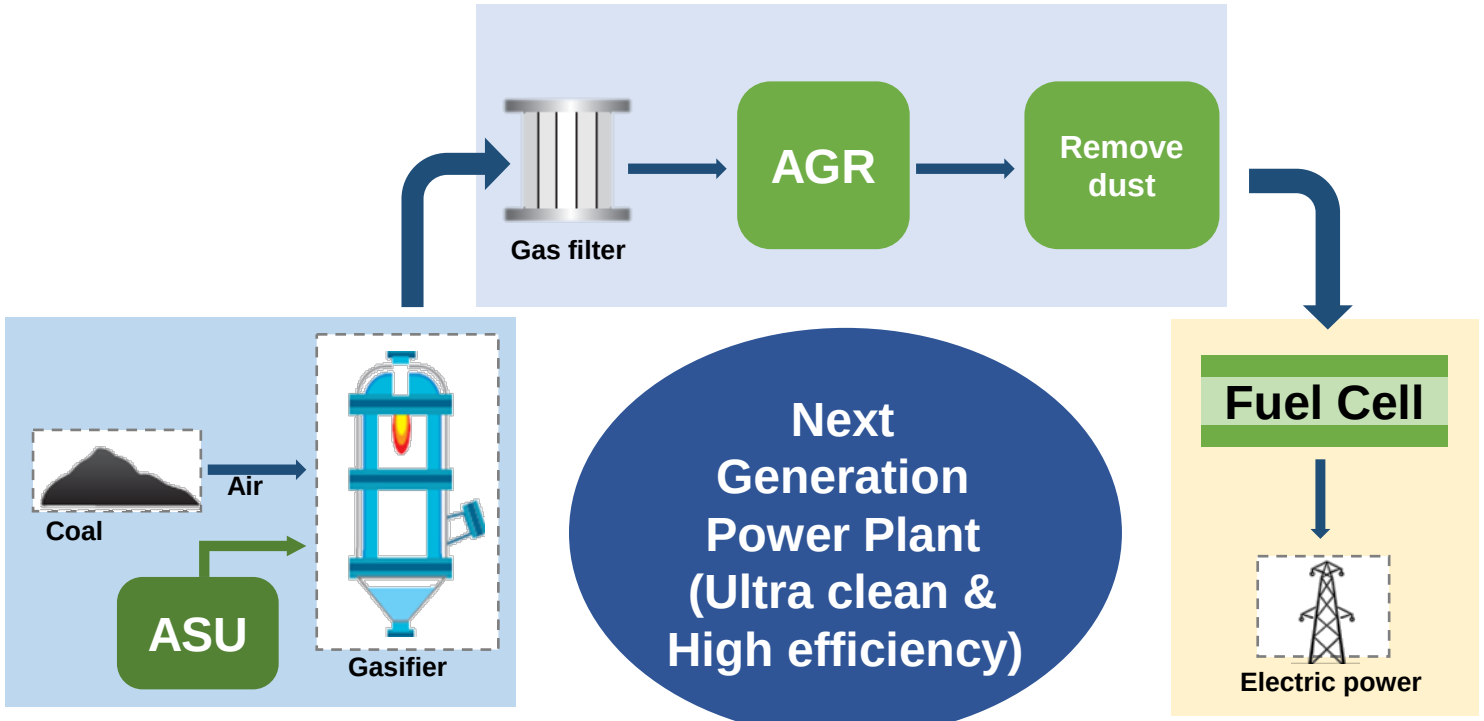
Furtherance Direction ③ Flexibility of Feedstocks

· Fuel change: biomass or renewable resource
· Development of response technologies not only RFS, RPS but also global petroleum dependency

→ strategic project 3

Source : KETEP

Gasification related R&D Plan : IGFC

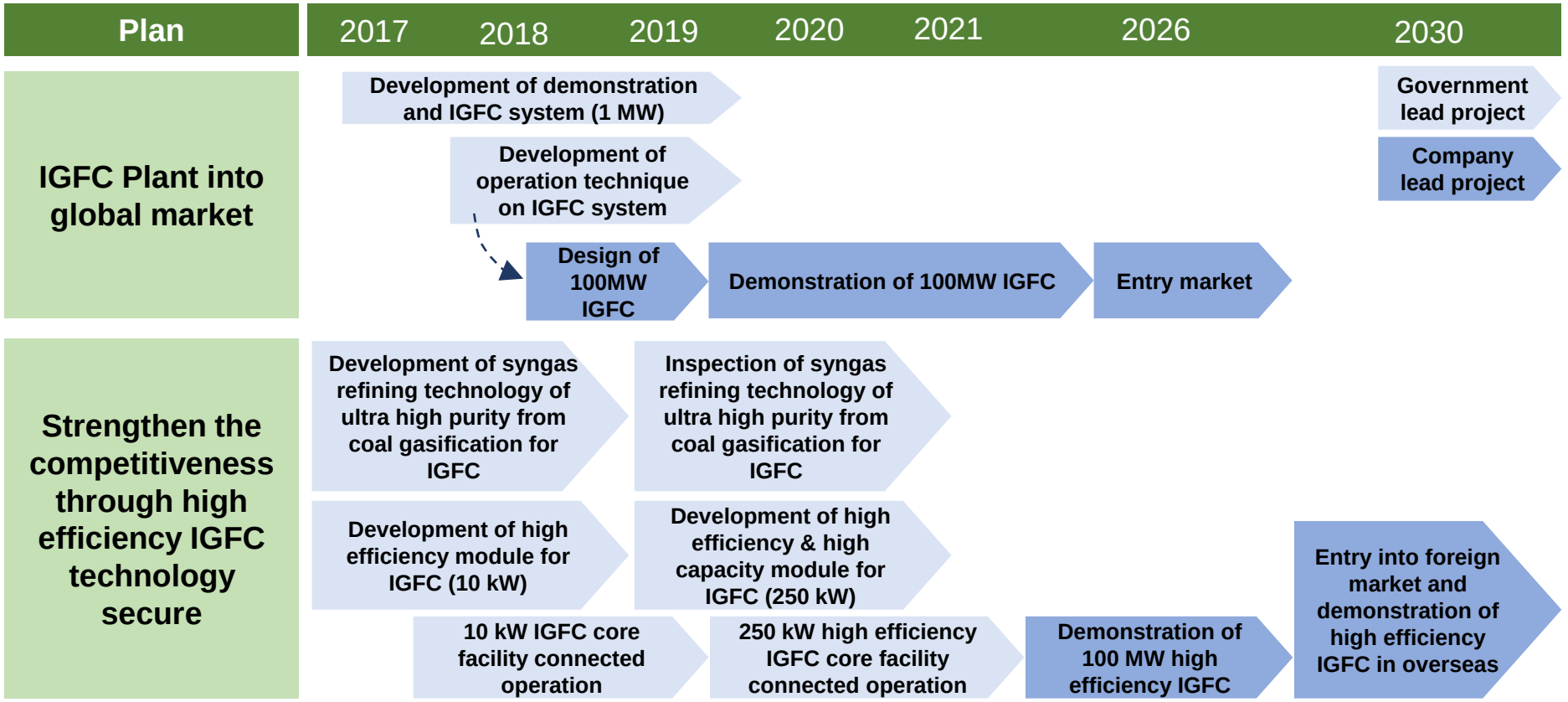


Coal Gasification

High efficiency Power Plant integrated with Fuel Cell

Source : KETEP

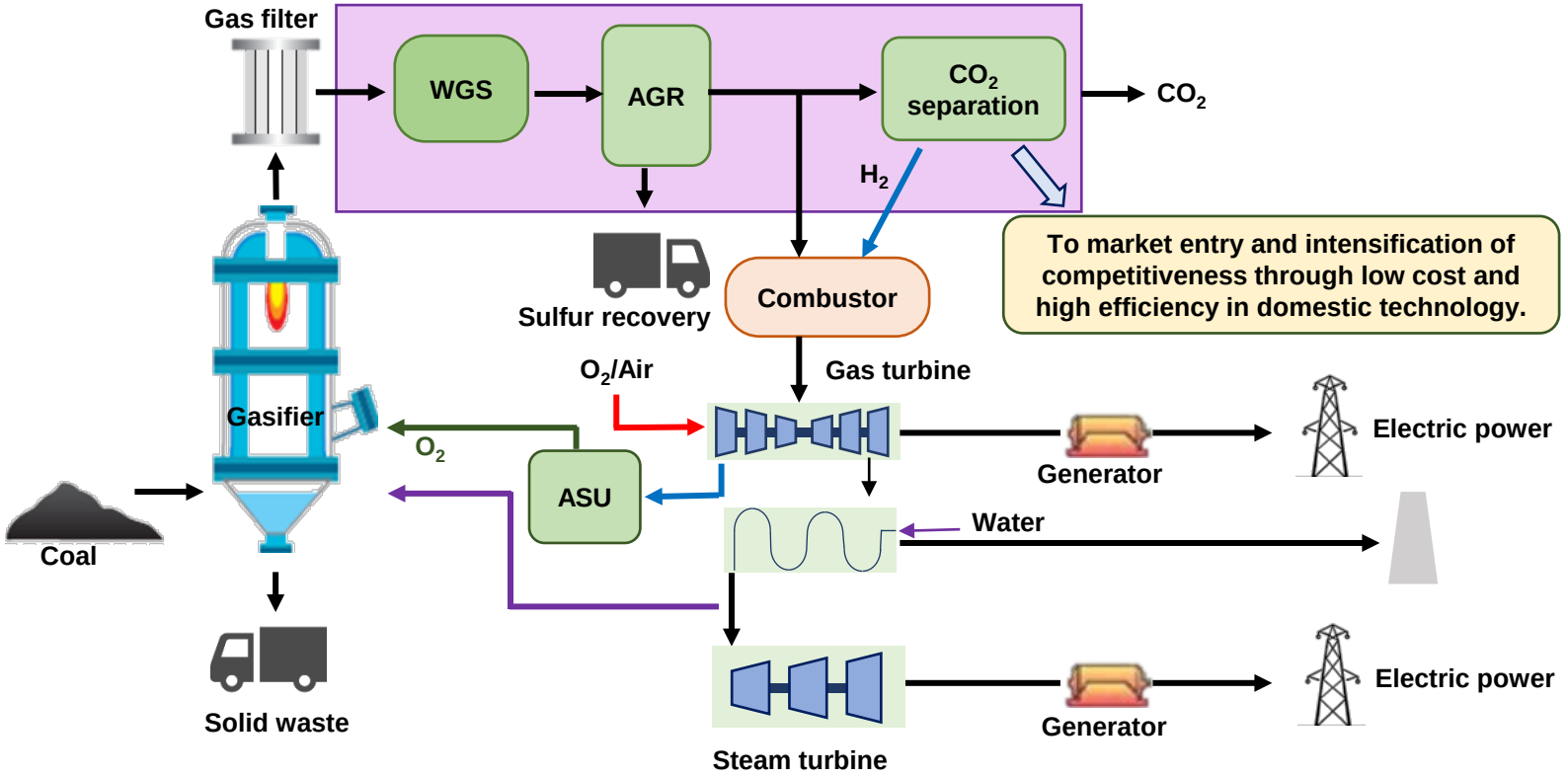
Roadmap of IGFC in Korea



Source : KETEP

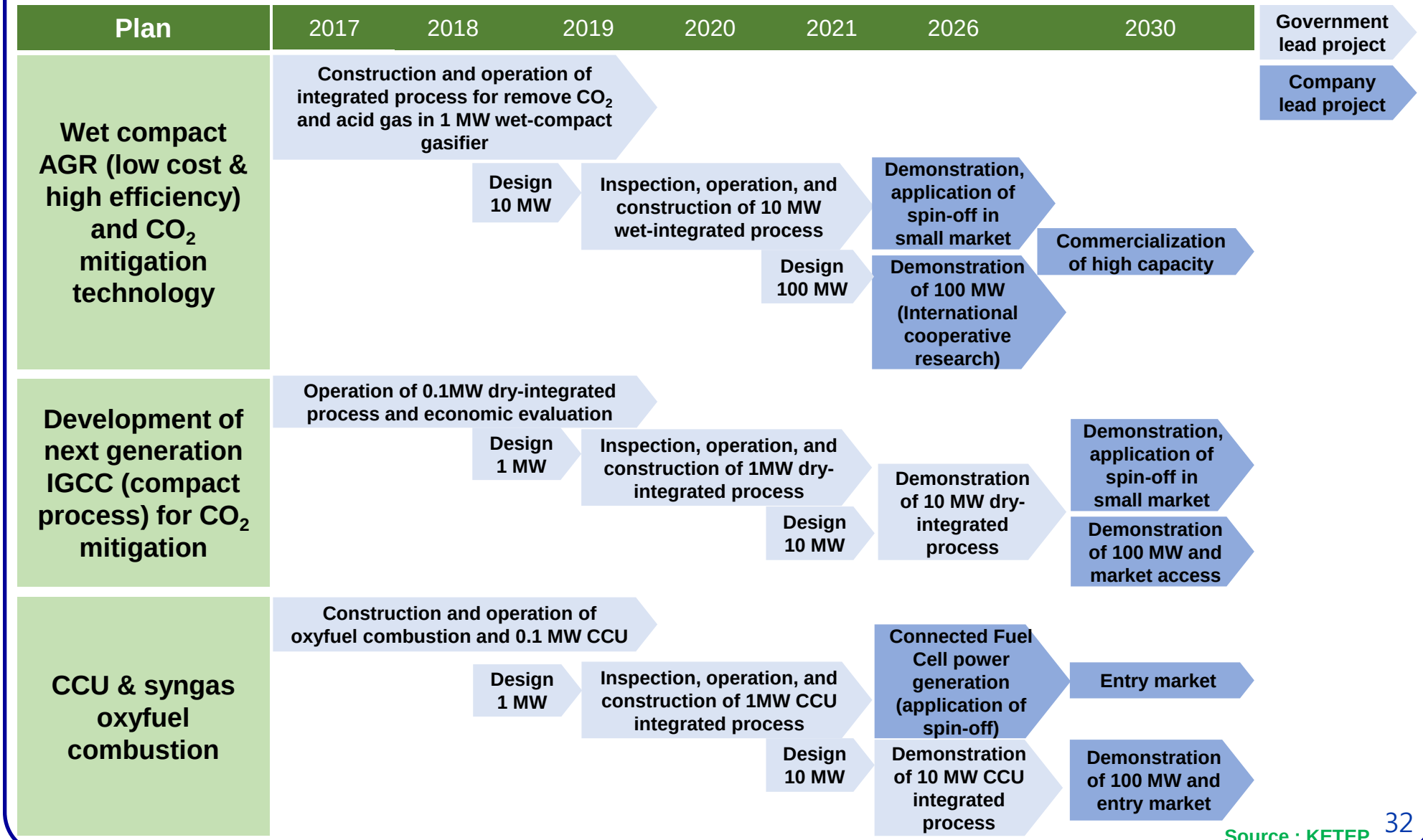
Gasification related in R&D Plan : Compact Gasifier

Diagram of Compact gasification for CO_2 mitigation in Korea



Source : KETEP

Roadmap of Compact Gasification for CO_2 mitigation in Korea



Source : KETEP

Summary

1. Gasification-based commercial plants are operating in Korea which is classified as a new & renewable energy source.
   - Taean 300 MW IGCC, Gwangyang 500,000 ton SNG, Namhae IGCC
   - RPS policy for the reduction of Greenhouse Gas.

2. CO_2 Gasification technology is more economical with CCS technology.
   - Since high P of Gasifier, CO2 can be easily separated and liquefied
   - It is more economical comparing other CO2 capture technology including carbon tax scenario

3. Korea's clean energy Mission Innovation program include gasification
   - Design, Construction demonstration of high efficiency 100MW IGFC
   - Development of compact gasification system with various feedstock

4. Gasification area can be critical role in future Korea's energy R&D program.
   - Coal gasification business set development focus for clean energy resources.
   - In the case of guarantee of technology, in common with nuclear power has classified as semi-domestic energy.

iSGA 2016 (International Symposium on Gasification and Its Application)

Role of Gasification Technology in the Post-2020 Climate Change Regime

- **Date:** Nov. 29 ~ Dec. 2, 2016
- **Location:** Haeundae Grand Hotel, Busan, Korea
- **Organized:** KCGA, KOSECC, Ajou Univ.
- **Topic:** Gasification fundamentals, Feedstock & Pretreatment, Gas treatment and cleaning, Syngas application, Modeling and simulation, Policy for gasification technology, Gasification demonstration projects
- **Program:** Plenary and Keynote Session, Oral & Poster Session, Technical Tour
- **Conference website:** http://isga-5.kr

High quality papers will be considered for publication in reputable international scientific journal such as Fuel Processing Technology and Korean Journal of Chemical Engineering.

Thank you for your attention !