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Exploring major opportunities and critical enabling technologies for Carbon Capture and Storage (CCS) in China

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Outline

1

General Background

2

Major CCS opportunities

3

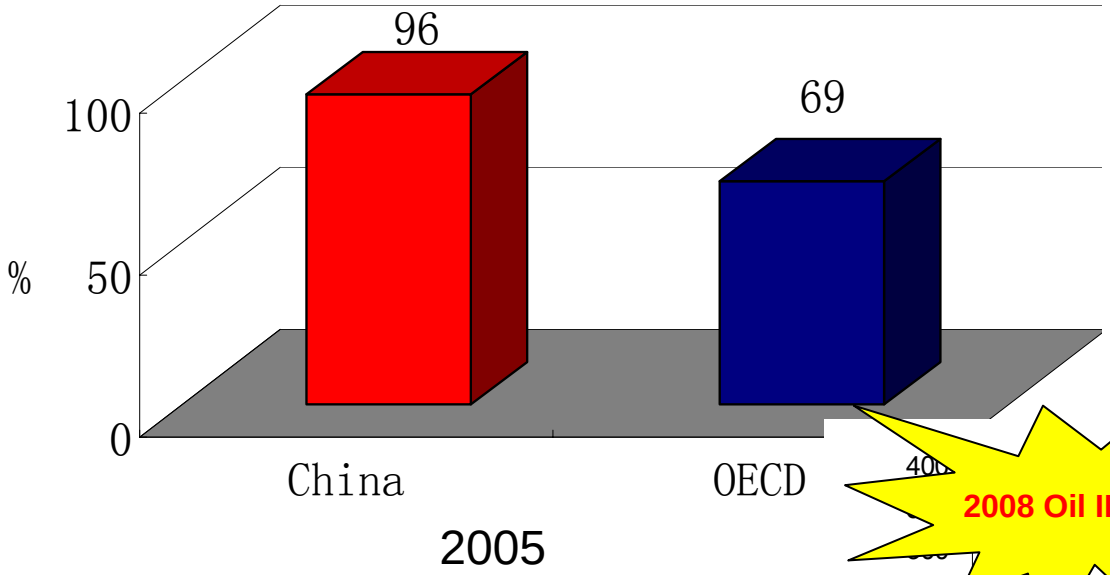
Critical CCS enabling technologies

4

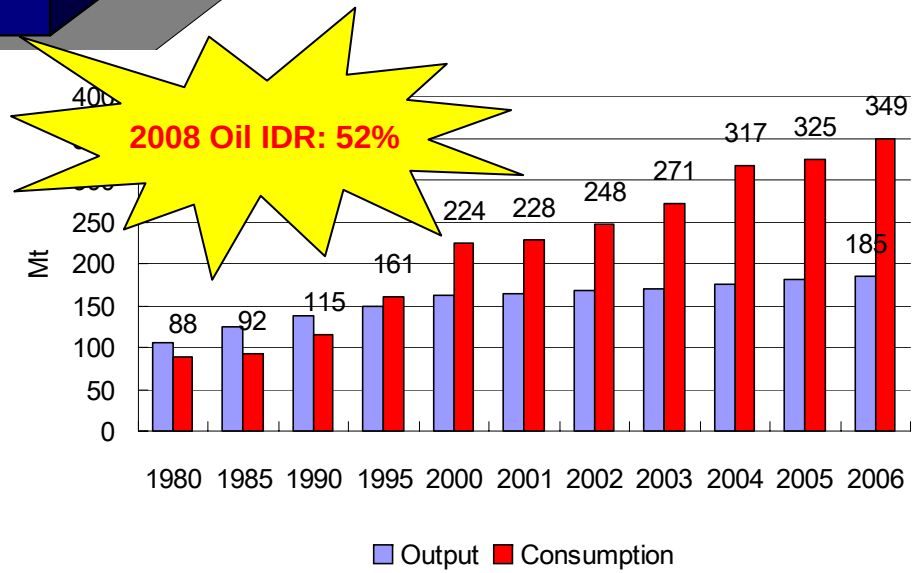
Conclusions

In Chinese context!

Hard truth (1): self-reliance >90%, thirst for oil



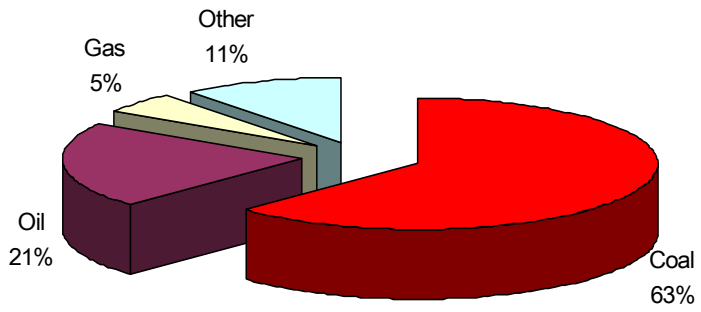
Energy self-reliance: (Energy Production/TPES)



China oil: output & consumption

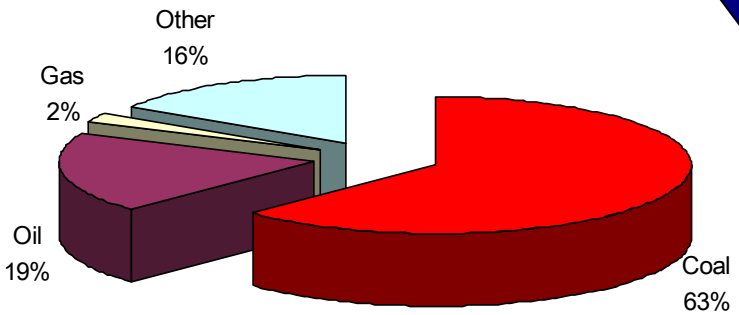
Source: China Energy Statistical Yearbook-2007

Hard truth (2): coal will continue to dominate the energy mix for decades to come



2030: 3819 Mtoe

Source: WEO2007,BAU



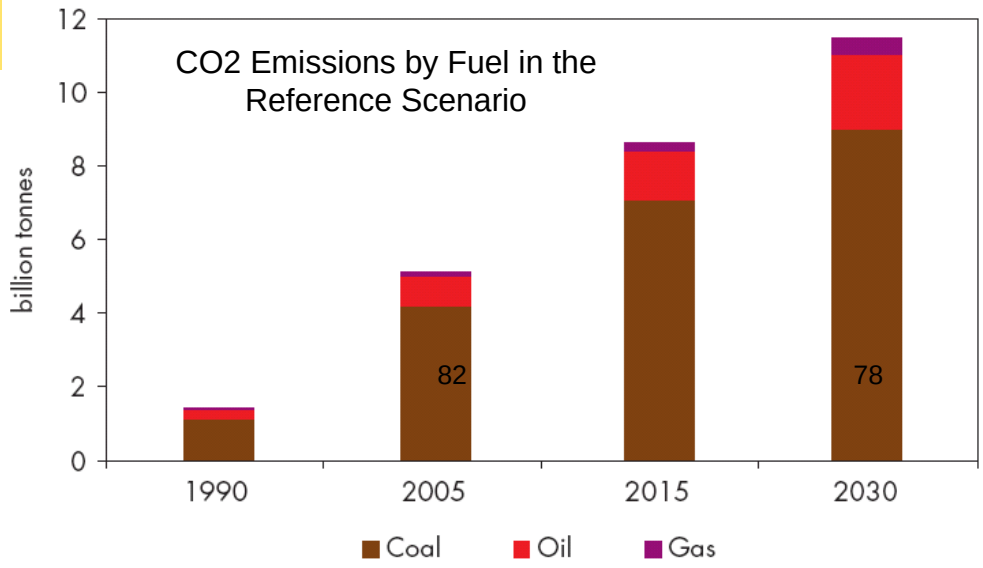
2005: 1742 Mtoe

Source: World Energy Outlook 2007

Hard truth (3): China now no. 1 in CO_2 emissions

	2005		2015		2030	
	Gt	*rank*	*Gt*	*rank*	*Gt*	*rank*
US	5.8	1	6.4	2	6.9	2
China	5.1	2	**8.6**	**1**	**11.4**	**1**
Russia	1.5	3	1.8	4	2.0	4
Japan	1.2	4	1.3	5	1.2	5
India	1.1	5	**1.8**	**3**	**3.3**	**3**

China becomes the largest emitter in 2007



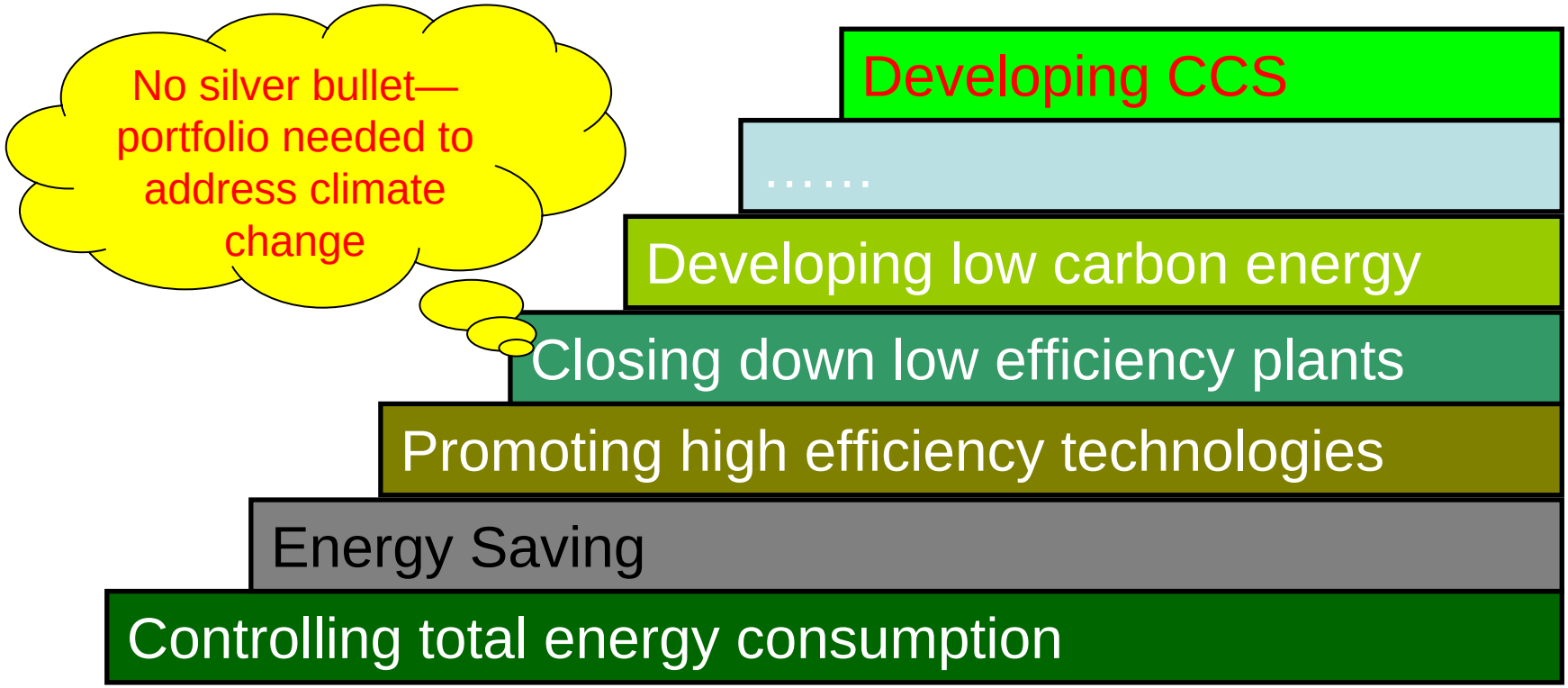
Source: World Energy Outlook 2007

Key issues for Chinese energy strategy

- How to use coal in a carbon-constrained future?

- How to ensure oil supply?

CCS can reconcile potential conflict between coal use and climate change



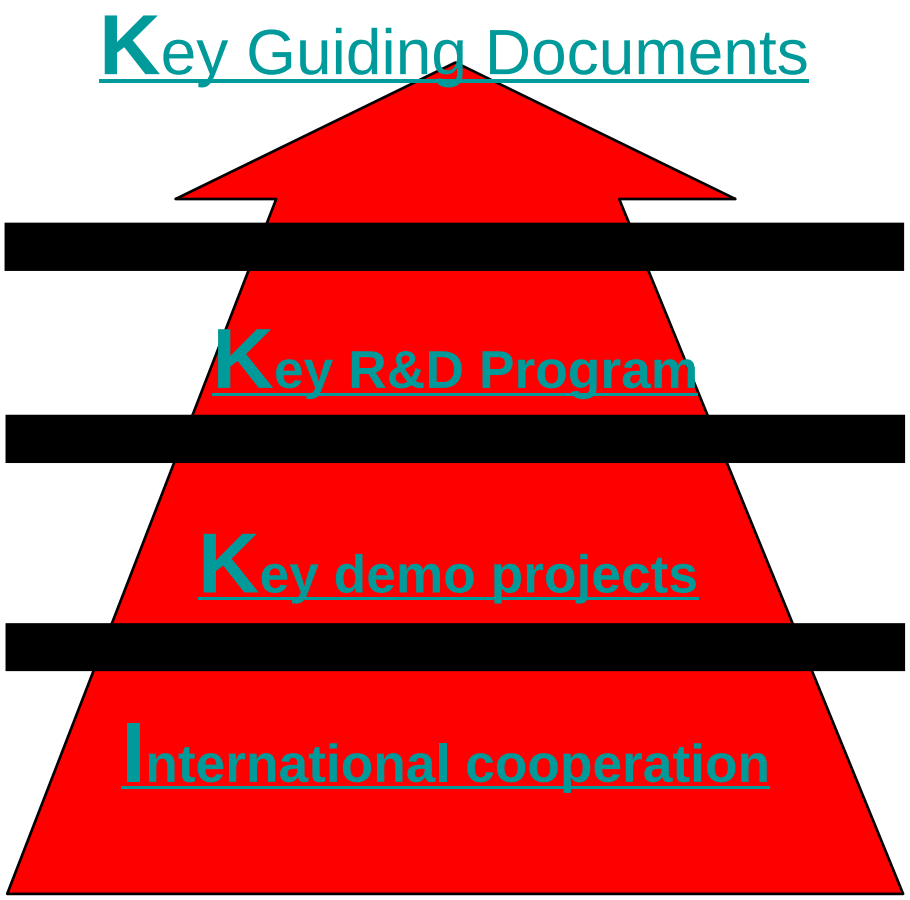
’Stairways’ to China’s low-carbon future

Carbon Capture and Storage (CCS)

• Capture	• Transportation	• Storage
• Post-combustion capture • Pre-combustion capture • Oxy-fuel combustion capture	• Pipeline • Rail • Road	• EOR/ECBM • Deep aquifers • Depleted oil field • Deep ocean

- **Key individual components are proven, but…**
- **No full scale integrated demonstration plant**
- **Lack of regulations for storage, longer-term liability and monitoring**
- **High efficiency penalty and cost**

CCS in China: strategic arrangements



3 “K” + I

CCS in China: Guiding documents

National Medium- and Long-term Science & Technology Development Plan (2006-2020)

State Council

2006

Formally establishes CCS as leading-edge technology

China's National Climate Change Program

（2007~2010）

NDRC

2007

Sets the goal of the development and dissemination of CCS

China's Special Science & Technology Action in Response to Climate Change

（2007~2020）

MOST

2007

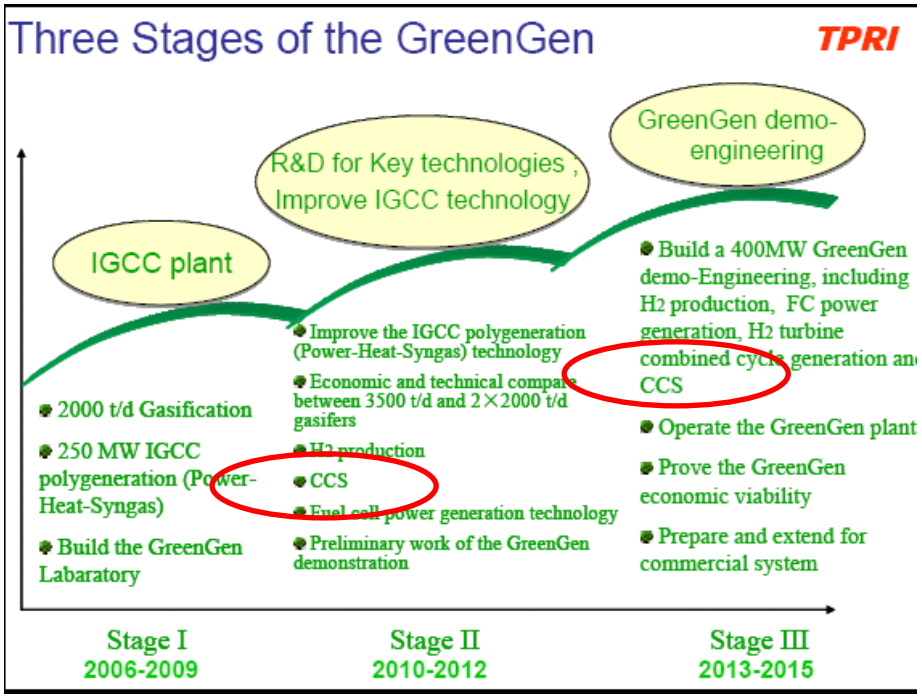
Establishes the key task of RD&D on CCS

CCS in China: R&D programs

- National Basic Research Program of China ("973" Program)
  - Geologic Carbon Storage with Enhanced Oil Recovery (2006–2011)
  - Total: 36 million RMB
- National High-tech Research & Development Program of China ("863" Program)
  - Carbon Capture and Storage (2008–2010)
  - Total: 30 million RMB

China's first IGCC project: GreenGen

Under construction, partly funded by 863 program (11th Five-year Plan)



Source: Shisen Xu (TPRI)

China forging ahead with carbon capture

The post-combustion capture pilot plant at Huaneng Beijing Power Plant is designed to capture 3000 tonnes per annum of CO_2

Pictures source: Qianlong

International cooperation

About the CSLF

carbon sequestration leadership forum

ASIA-PACIFIC PARTNERSHIP ON CLEAN DEVELOPMENT & CLIMATE

CO2合作CH

GeoCapacity 地质埋存潜力

nzeco carbon capture & storage

FutureGen™ ALLIANCE

China's CCS is still in its infancy

- Most activities are rather recent
- Involving a very limited actors
- Main drivers are almost exclusively in expert circles
- No elaborated policy exists so far to promote CCS

Outline

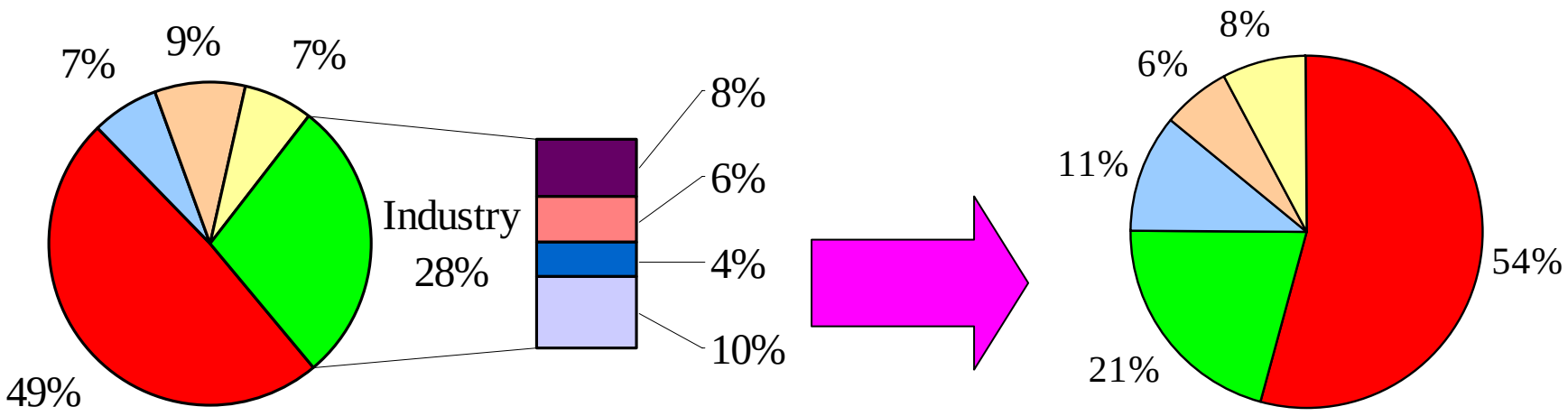
1 General Background

2 Major CCS opportunities

3 Critical CCS enabling technologies

4 Conclusions

Where are the CCS opportunities?



Total： 5100 Mt

2005

Total: 11448 Mt (Reference Scenario)

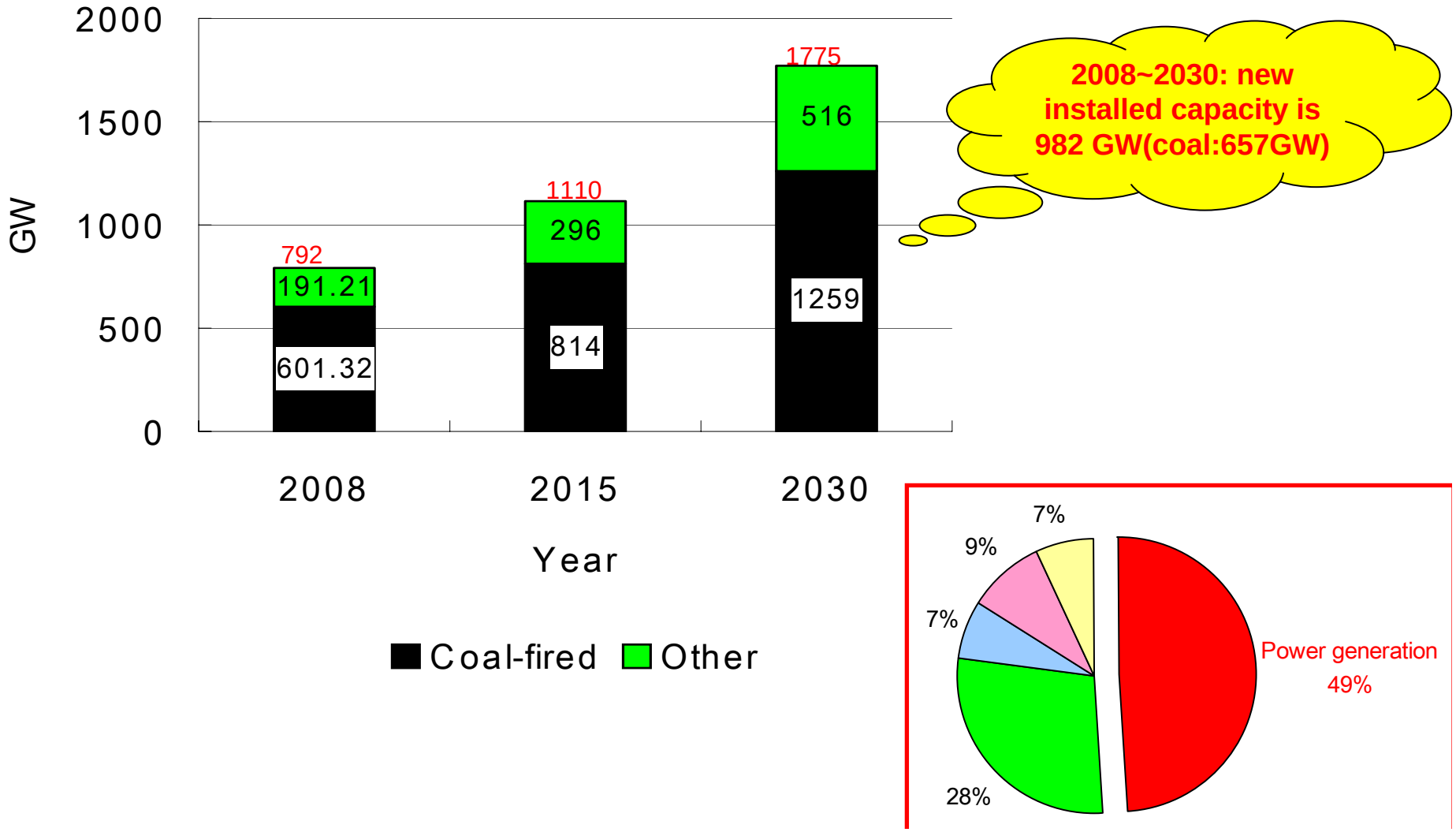
2030

- Power generation
- Other*
- Chemicals and petrochemicals
- Transport
- Iron and steel
- Other**
- Residential and services
- Non-metallic minerals

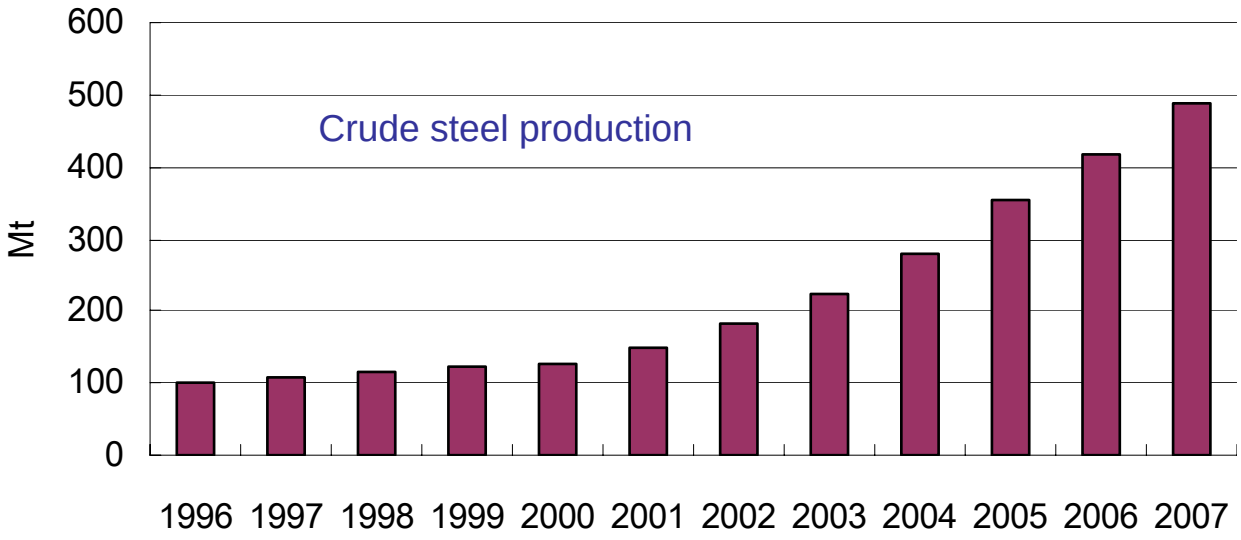
CO_2 emissions by sector in China

weo2007

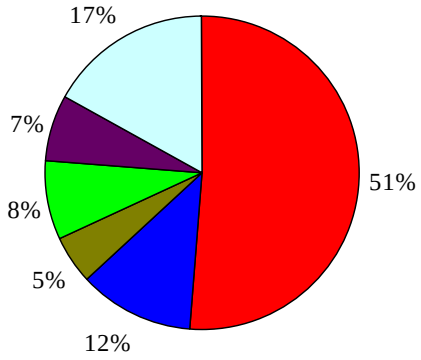
Coal power plants implies important opportunities



Industry : iron and steel

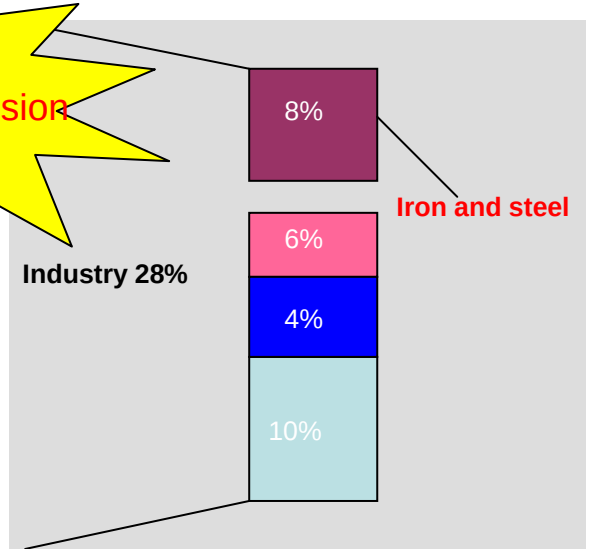


No.	Country/Region	Crude Steel Production (million metric tons)
1	China	489.2
2	European Union (27)	209.5
3	Japan	120.2
4	United States	98.2
5	Russia	72.4
6	India	53.1
7	South Korea	51.6
8	Ukraine	42.8
9	Brazil	33.8
10	Turkey	25.8



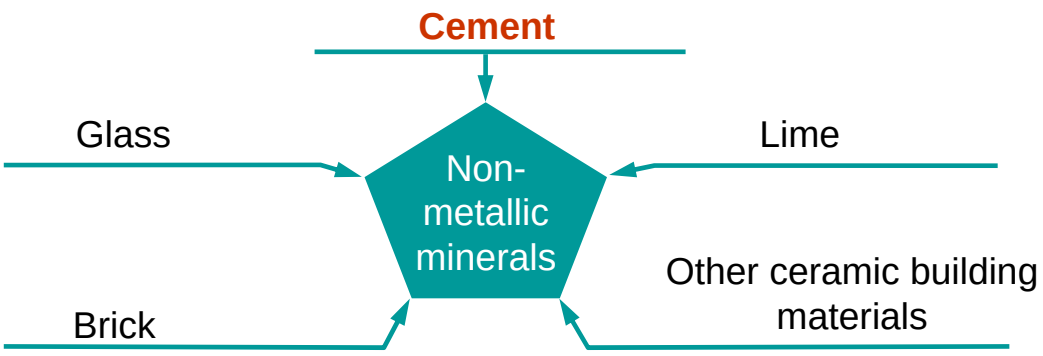
World steel CO_2 emissions in 2007

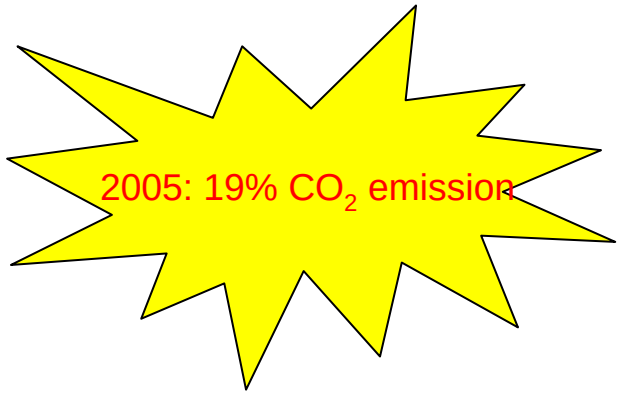
2005: 17% CO_2 emission

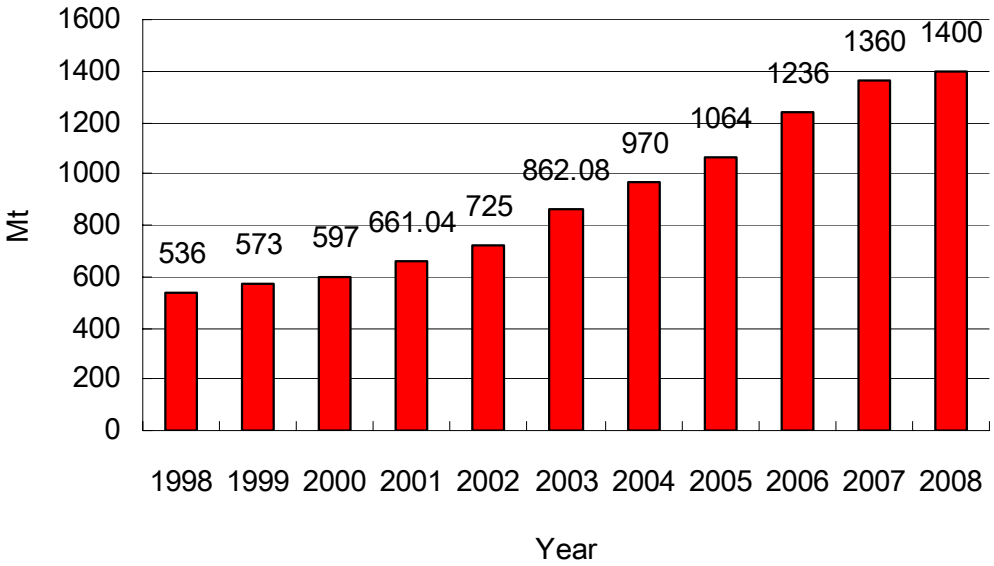


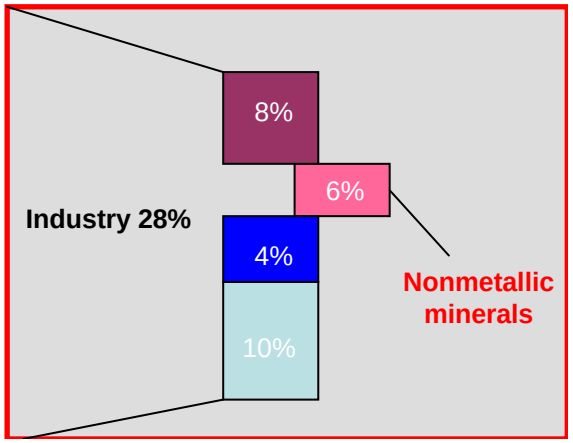
Industry: non-metallic minerals

—The second-largest industrial energy consumer in China



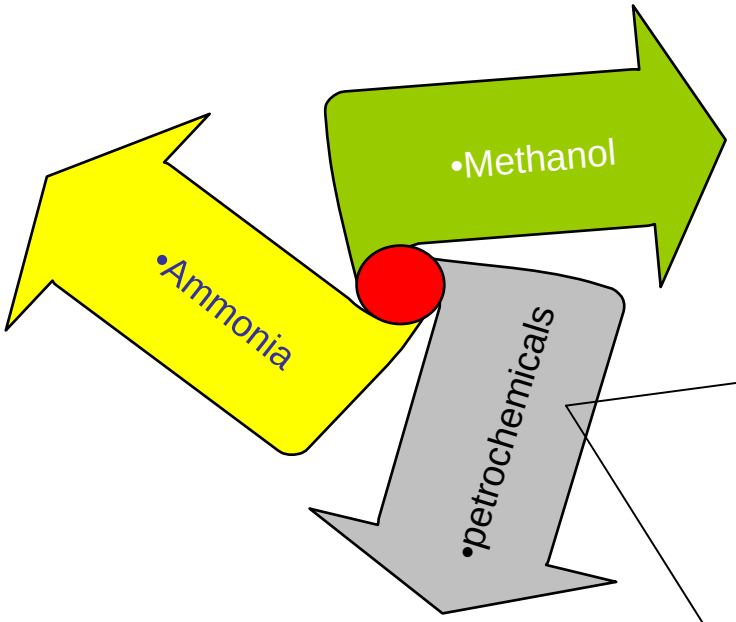






Industry: Chemicals and petrochemicals

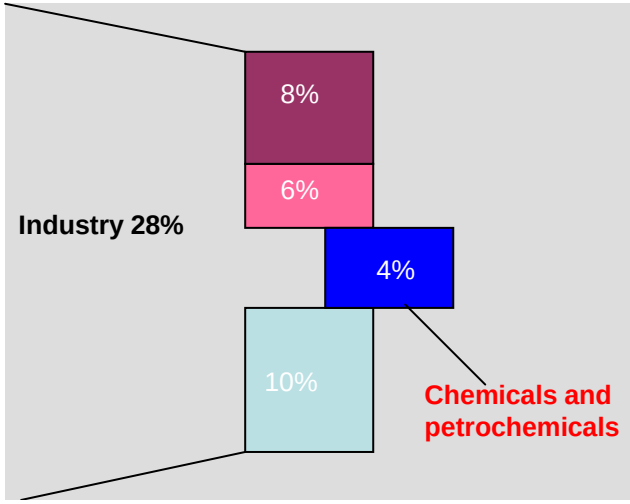
—the third-largest industrial energy consumer in China



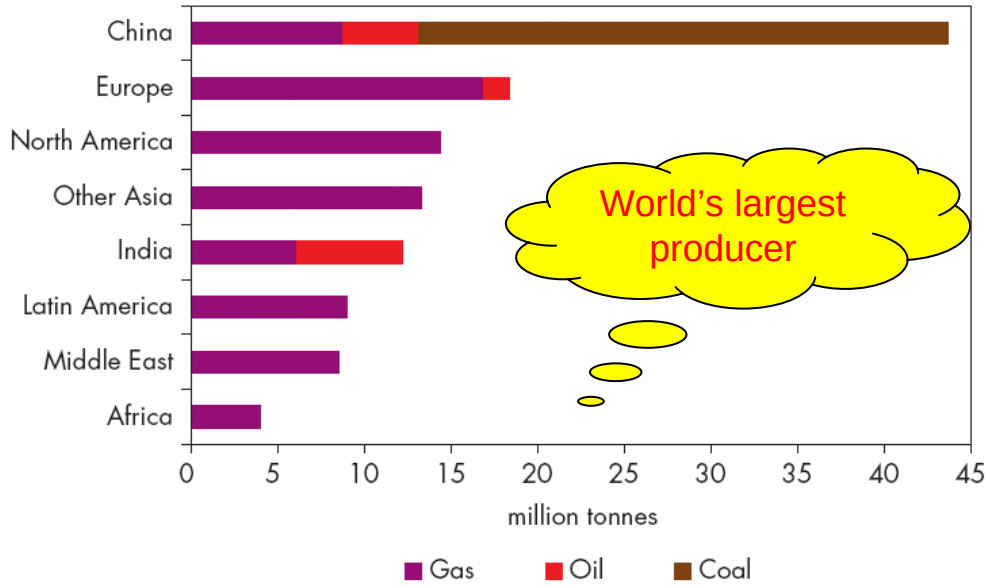
Three main types of products

- Most carbon is stored in the synthetic organic products. This carbon is only available for capture when these products are combusted

- The main sources of CO_2 :steam boilers and CHP plants. CO_2 capture similar to that of other power plants.



Ammonia & Methanol



Source: International Fertilizer Industry Association, 2006.

Global Ammonia Production by Feedstock, 2005

- 1t ammonia →~3 t CO_2
- 1t methanol →2 t CO_2

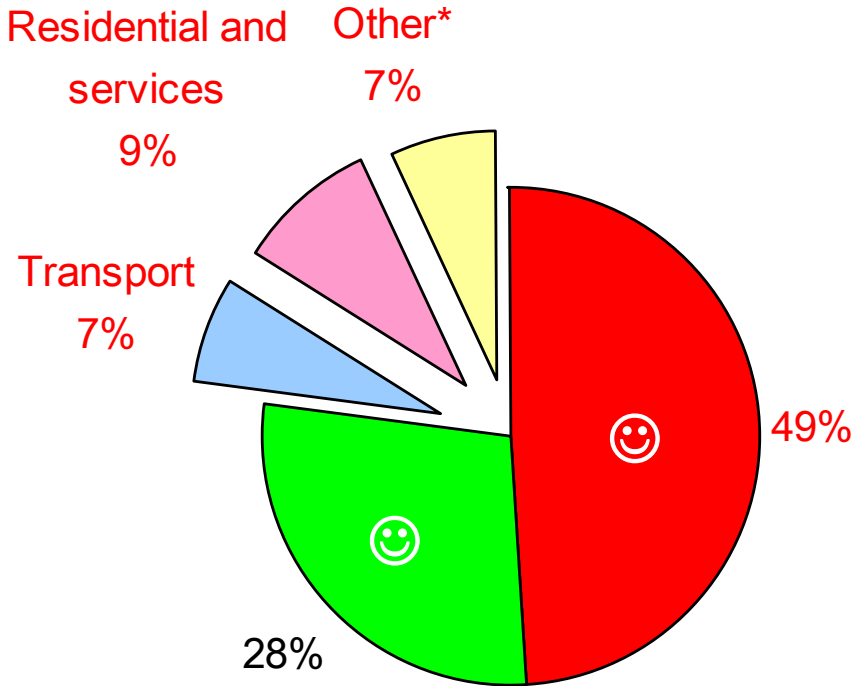
- China's planning: coal to methanol
  - 2010: 16Mt
  - 2015: 38Mt
  - 2020: 66Mt

Methanol will be boosted by the increasing use of methanol as alternative fuel

- 2007 production
  - Ammonia: 52 Mt
  - Methanol: 11 Mt

Transport/Residential/Other*

- Small/scattered/mobile sources
- CO_2 Capture is complex and prohibitively costly
- Efficiency improvement and fuel switch are preferable options



Prime candidates for CCS in China

Methanol

Power

Ammonia

Cement

Iron and steel

Outline

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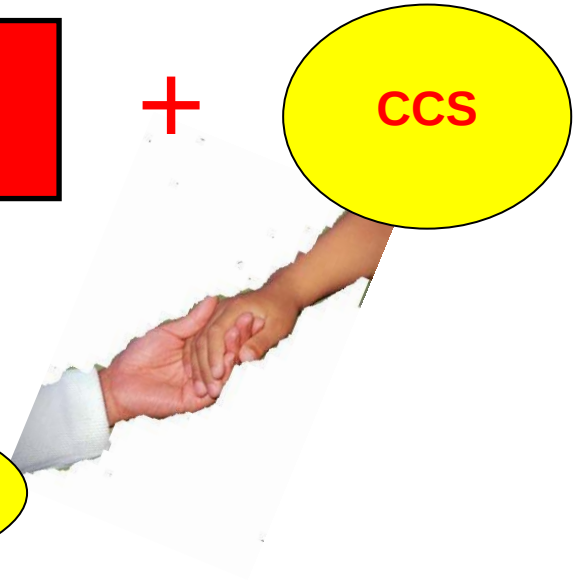
Conclusions

Parallel & coordinated strategy needed

Manufacturing process & energy conversion process

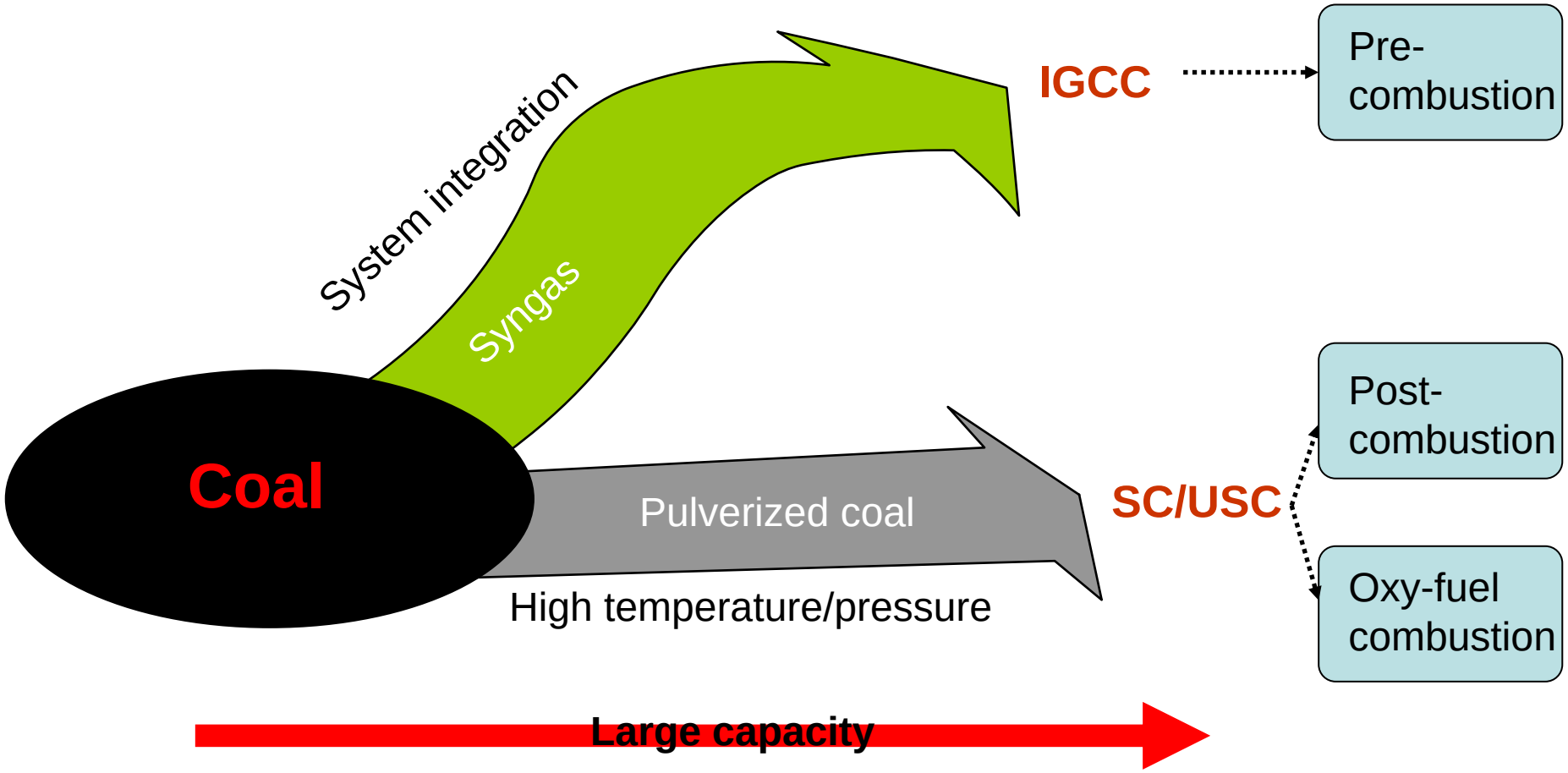
+

CCS



CCS enabling technologies

Coal power generation: development trend



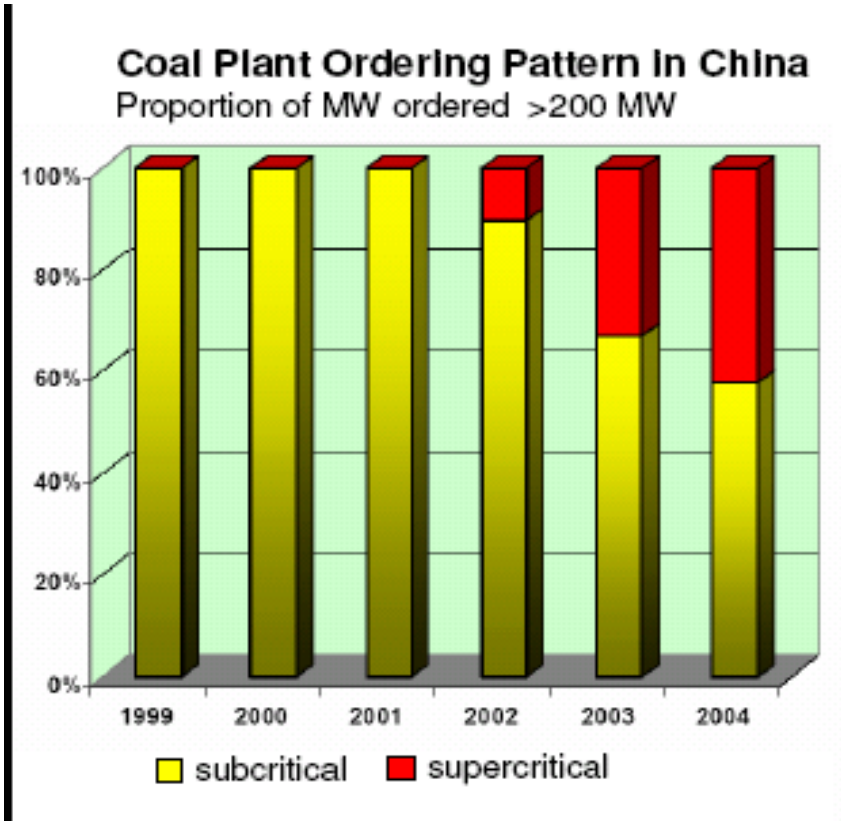
Yuhuan: a Chinese milestone

- Marking the beginning of widespread use of supercritical and ultra-supercritical technologies in Chinese power plants.

SC/USC in China

- By the end of 2008
  - 90 GW of SC and 11.2 GW USC units were in operation
  - Over 100 GW of SC/USC units were under construction.

SC/USC going to be the mainstay of the coal power generation



China's capability on SC/USC: know how, doesn't know why

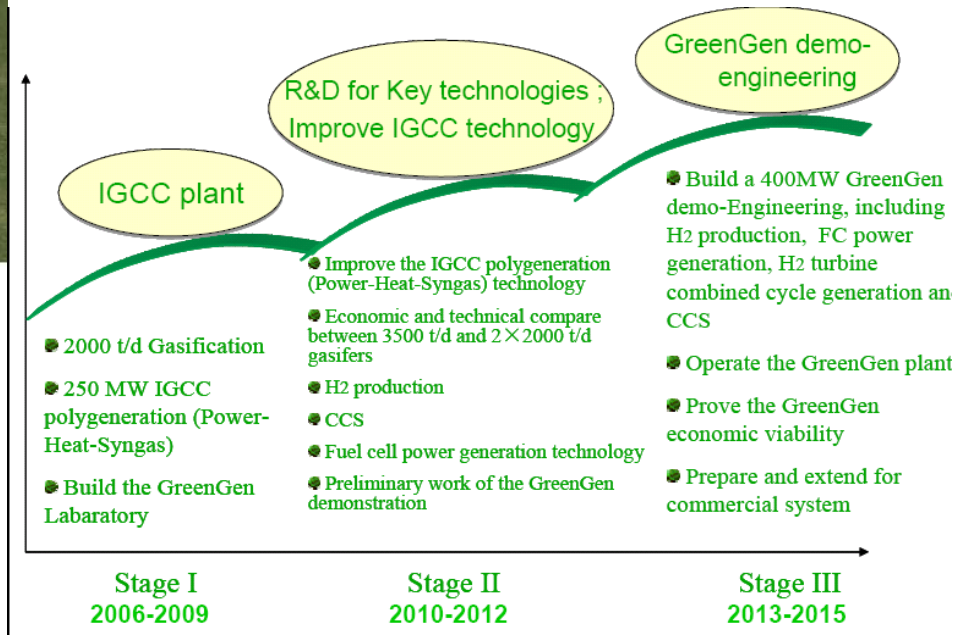
- Key components depend on import
- MW USC units are jointly designed and manufactured

	Steam turbine	Steam turbine genset	Boiler
Dongfang	HITACHI Inspire the Next	HITACHI Inspire the Next	HITACHI Inspire the Next
Shanghai	SIEMENS	SIEMENS	ALSTOM
Harbin	MITSUBISHI POWER SYSTEMS	MITSUBISHI POWER SYSTEMS	MITSUBISHI POWER SYSTEMS

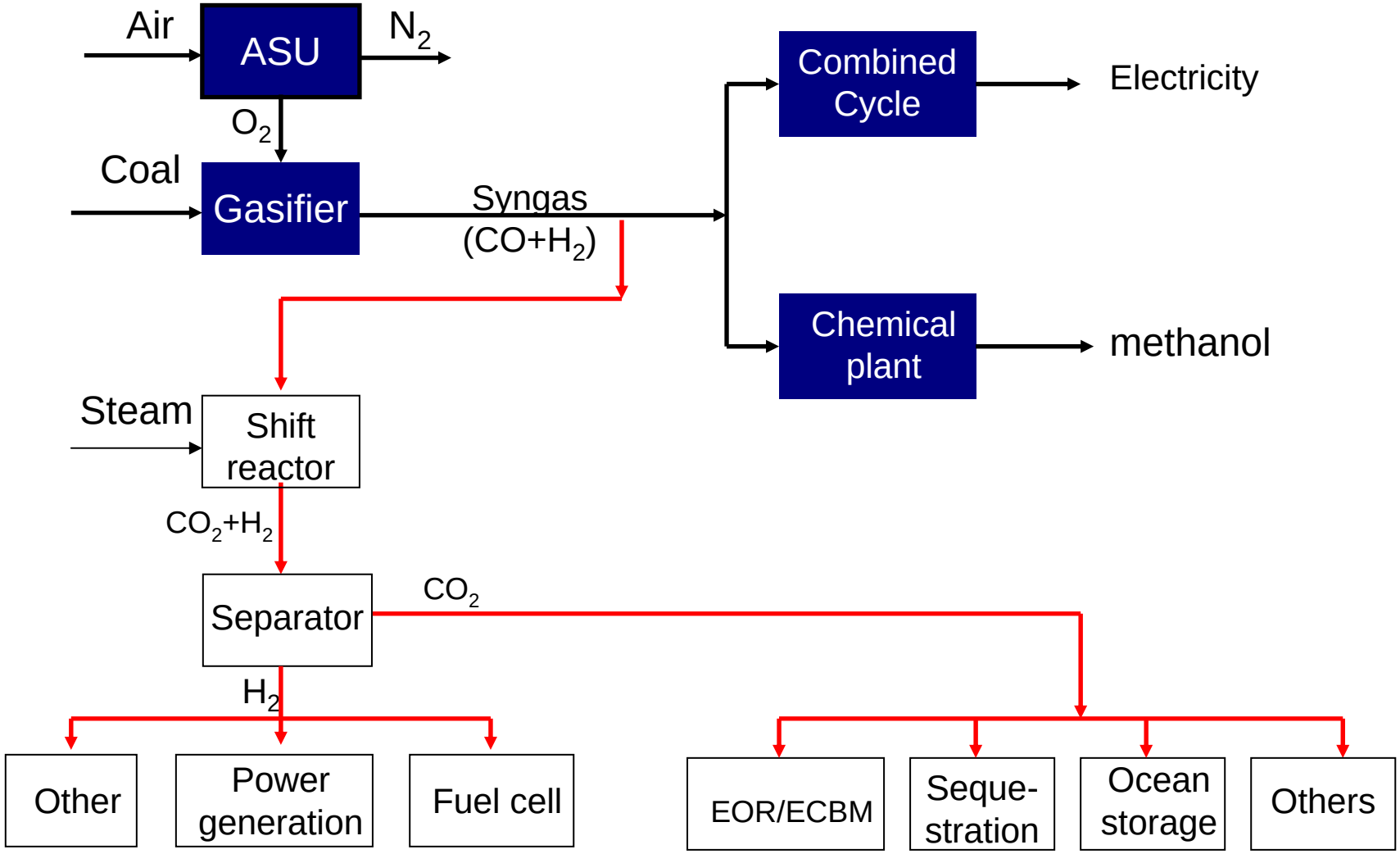
Sources of MW USC technologies

IGCC in China: GreenGen

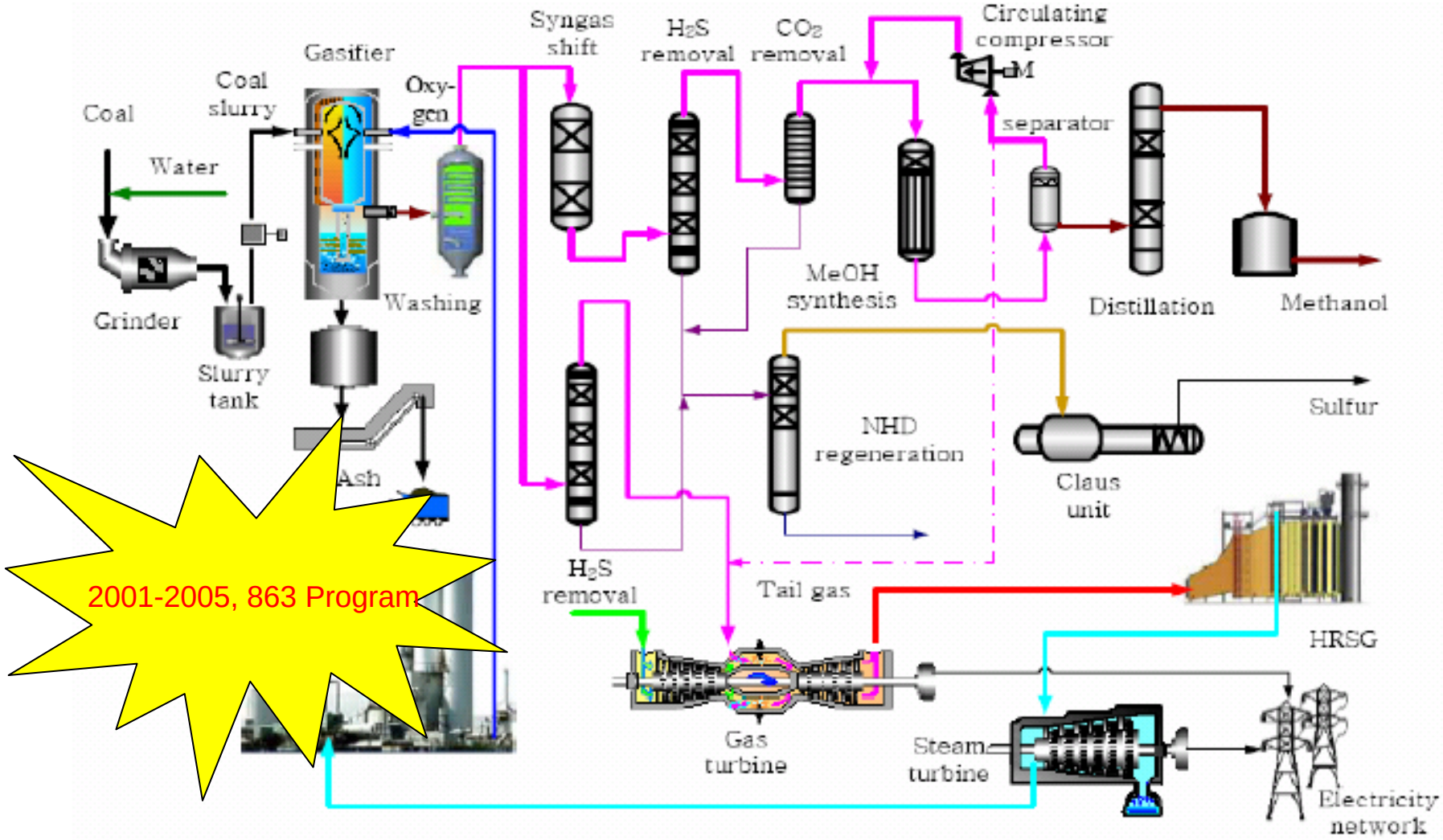
There are over 10 IGCC demonstration projects are waiting for NDRC approval in China.



Polygeneration: an important way for promoting IGCC development in China

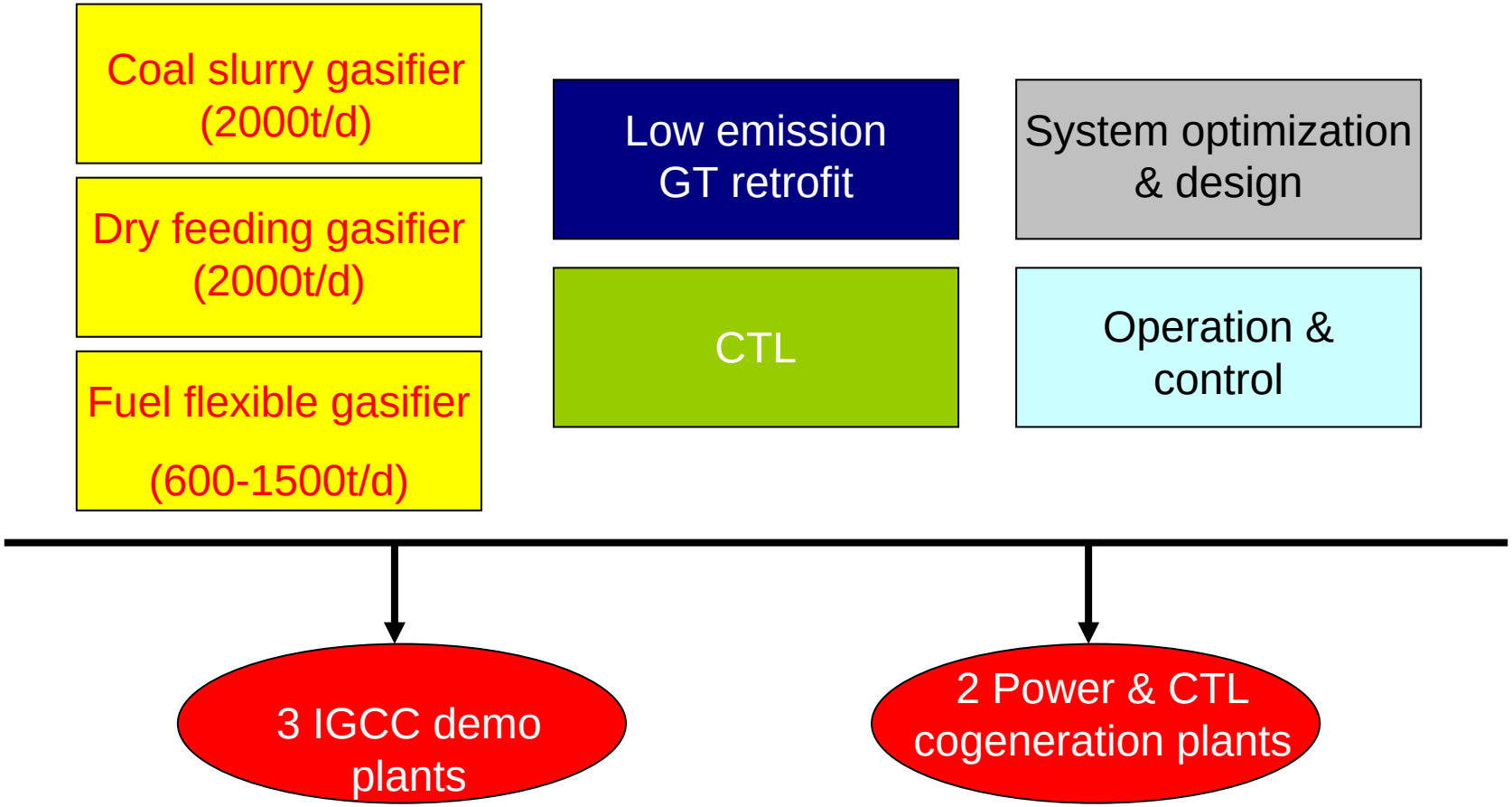


Coal polygeneration in China
——Yankuang 240,000 t/a methanol and 60MWe Co-Production Demo Plant

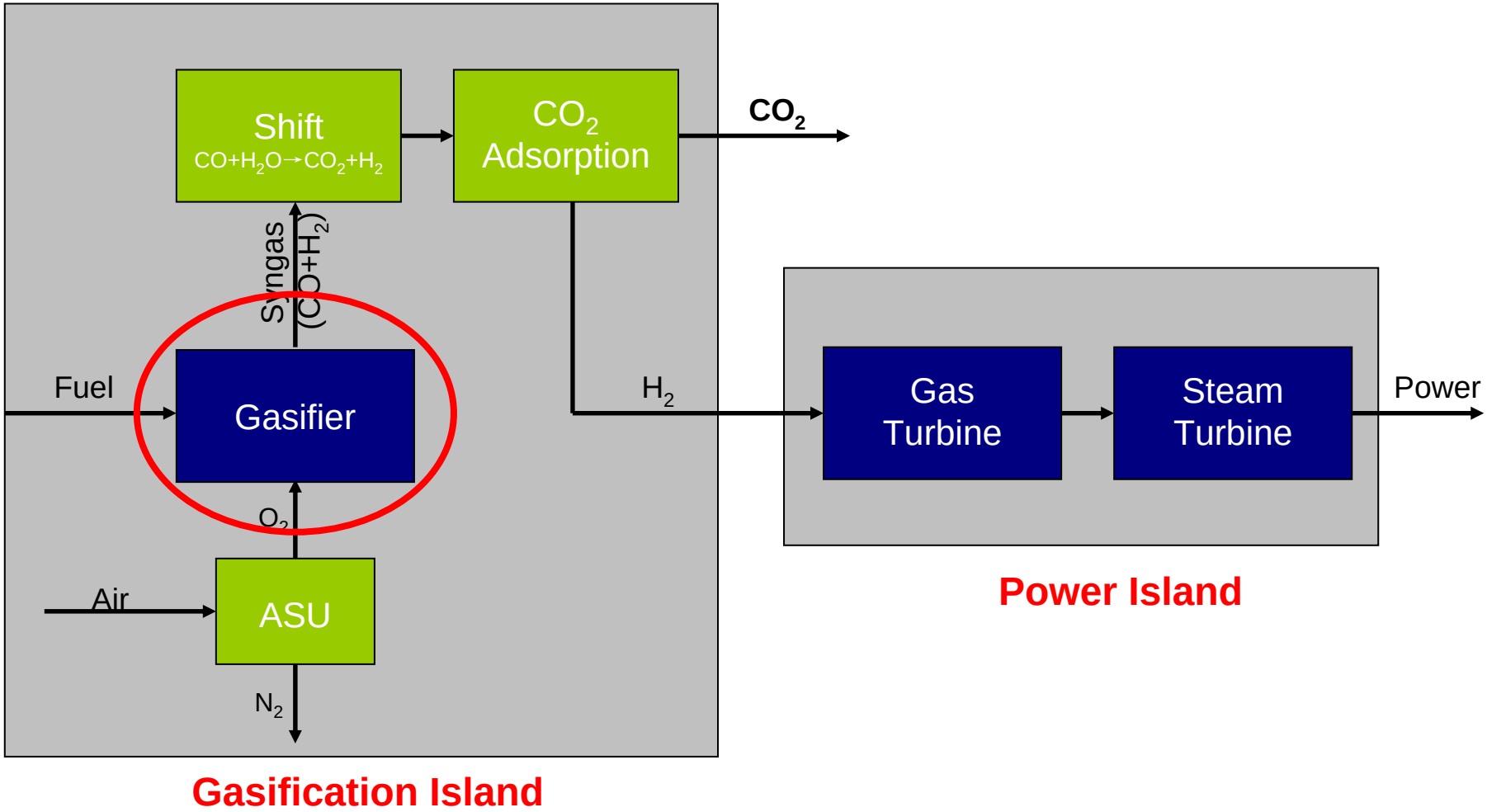


Coal polygeneration demonstration project (863 major project, 2006~2010)

- RMB 350 million from government
- RMB 35000 million from other sources



Gasification: leading technology in IGCC



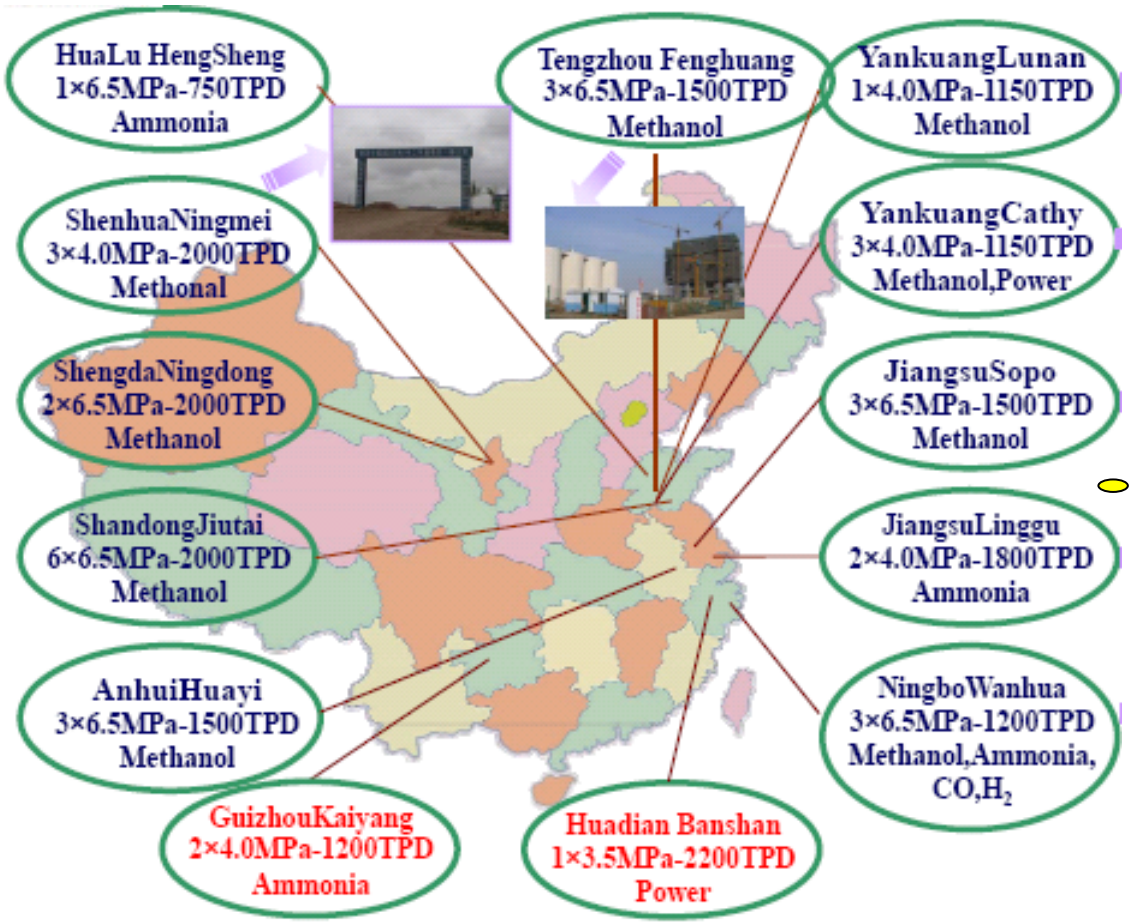
Coal gasification technology in China

- Gasifier: ~54Texco, ~37 Shell

Hubei Zhijiang, 2000t/d shell, 2006

Shanghai, 480t/d, Texco, 1996

ECUST: Opposed Multi-Burner Gasification Technology



13 projects,
33 gasifiers

TPRI: Two Stage Pulverized Coal Pressure Gasification Technology

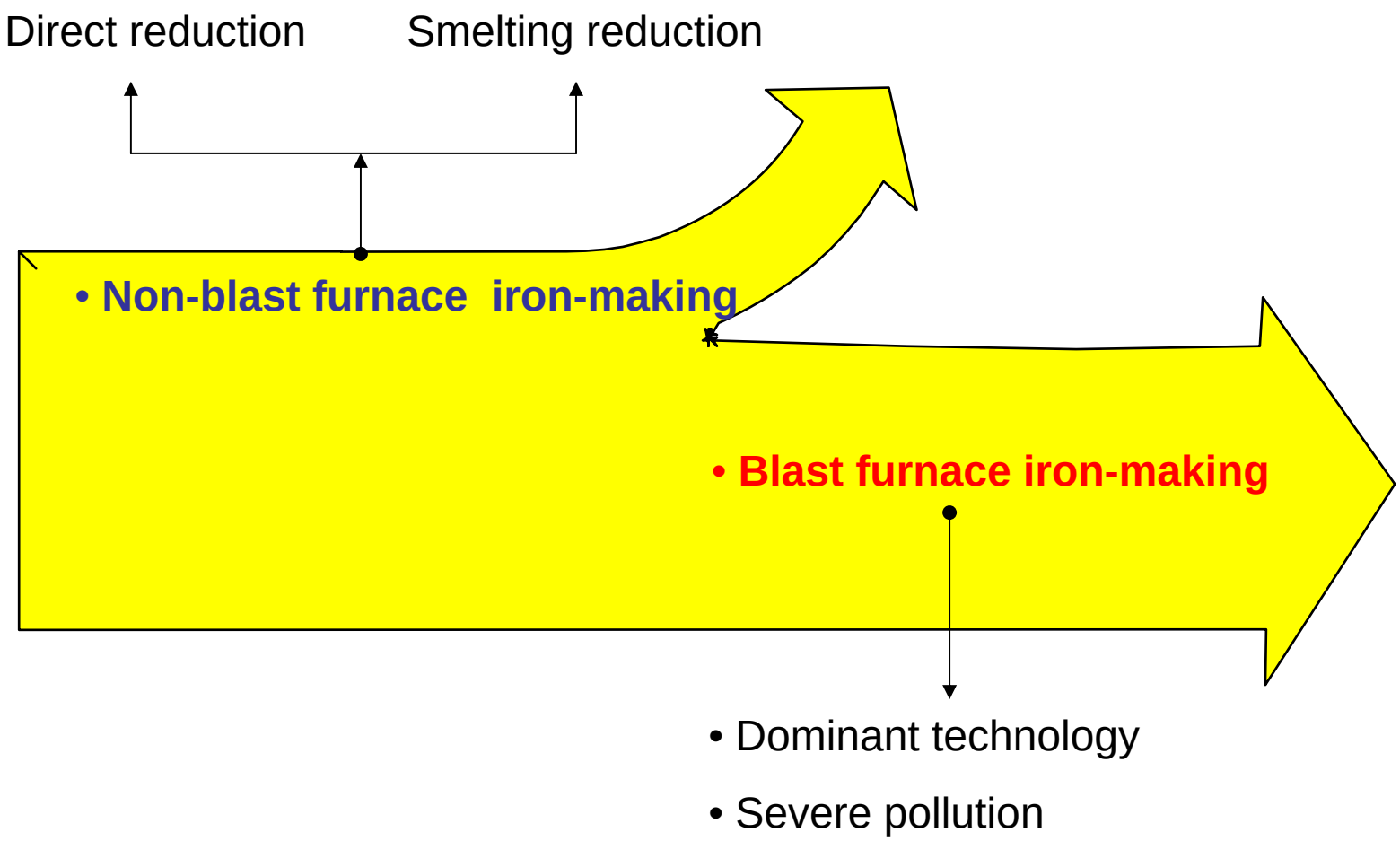
700 kg/d 1996

36 t/d (10 MWth),2004

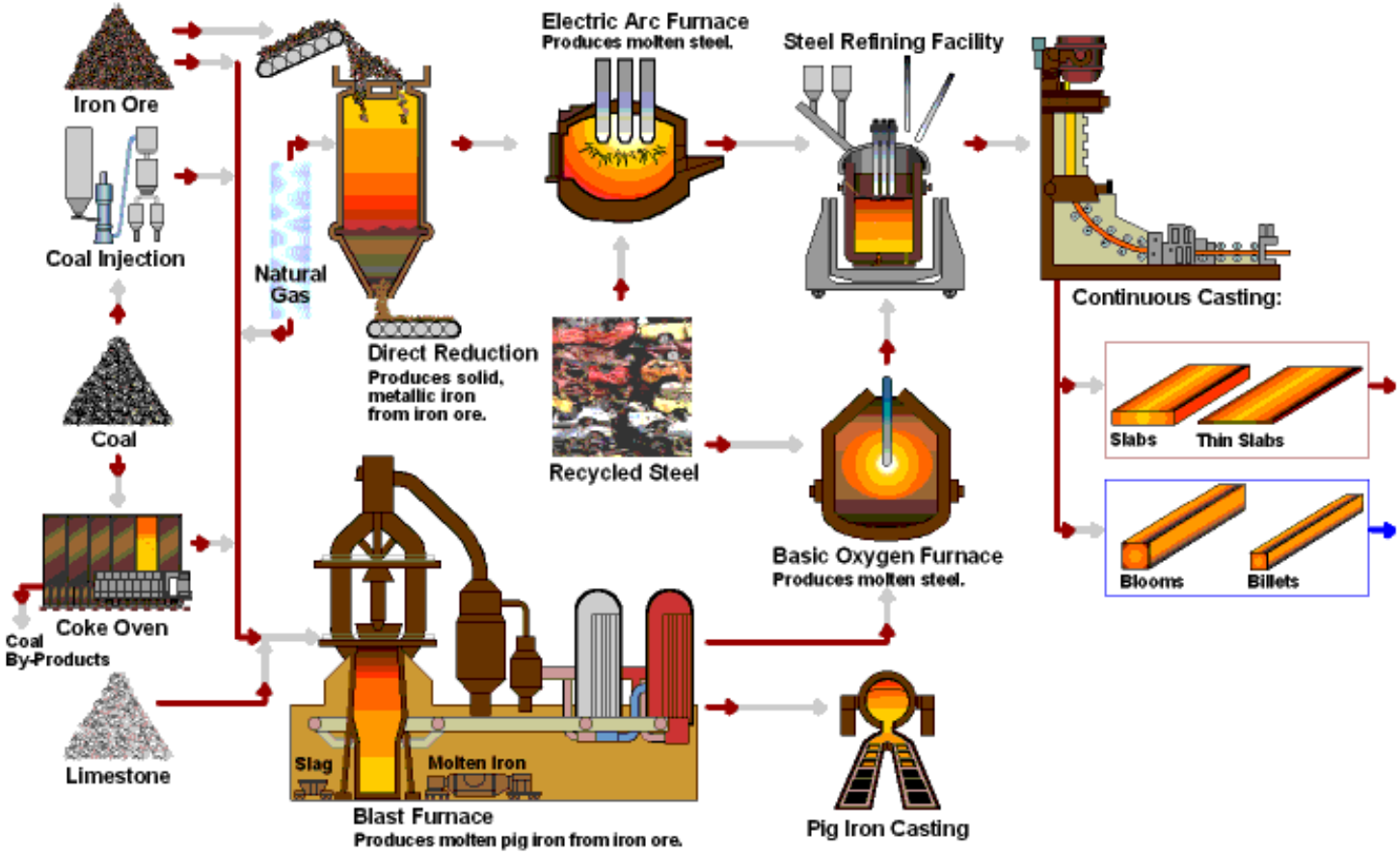
Funded by MOST in 2005

2000t/d， 2009

Iron making: development trend



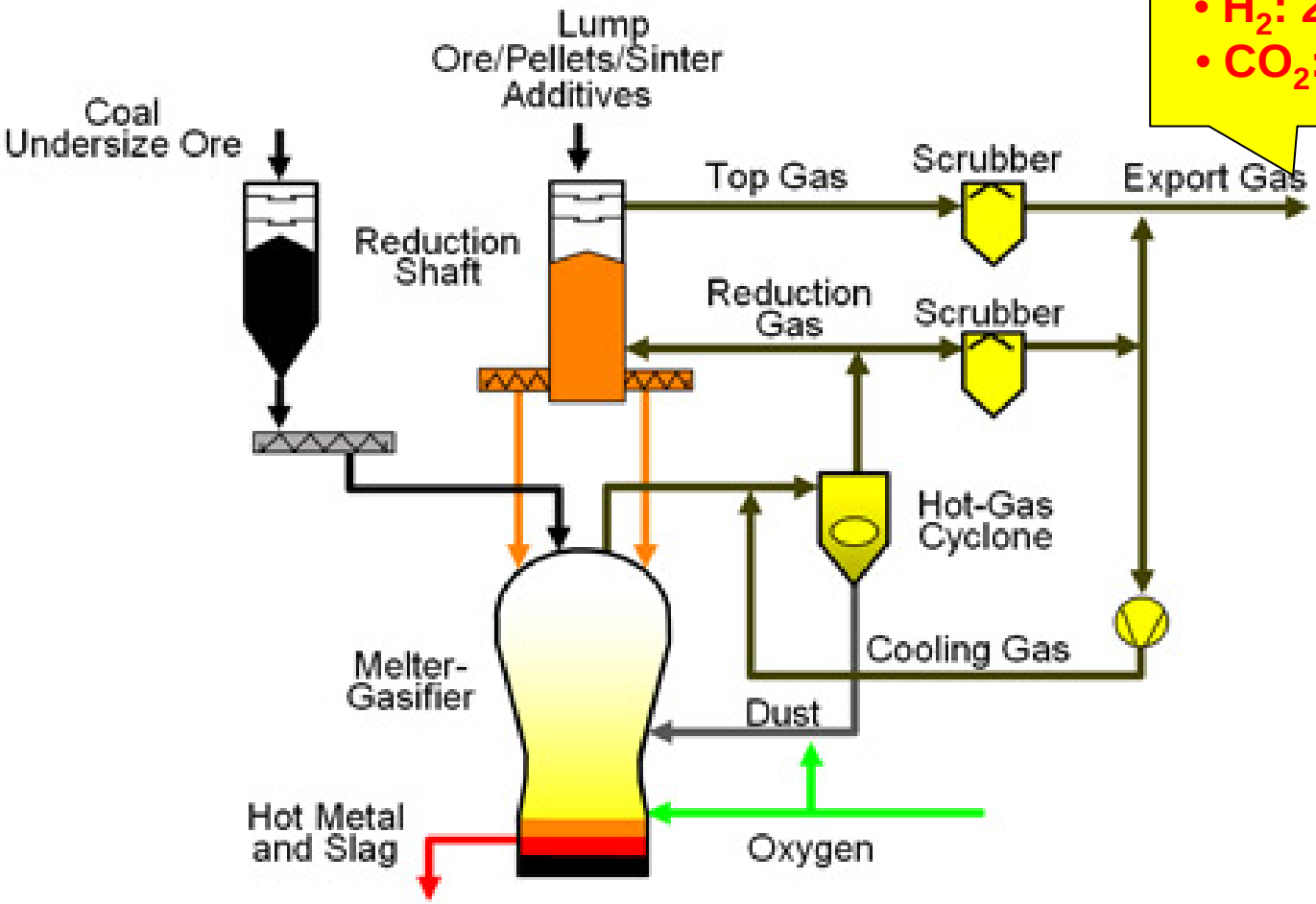
Production routes for steelmaking



Schematic illustration of the BF-BOF and DR-EAF routes

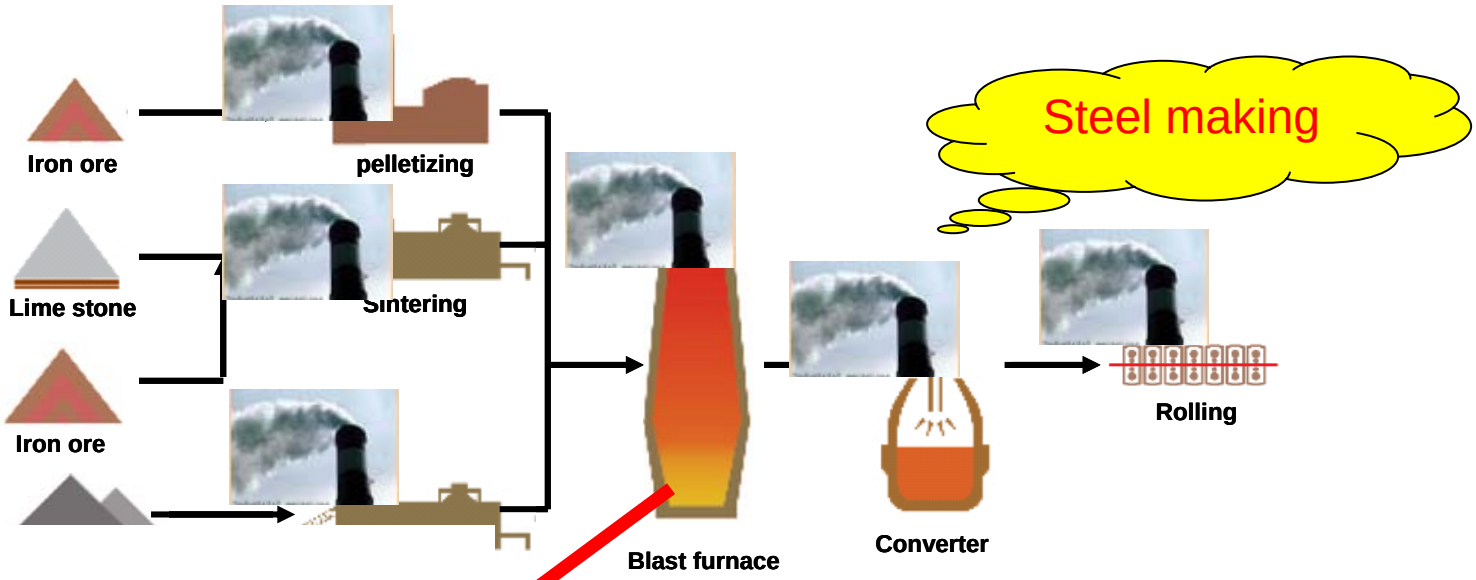
Smelting Reduction

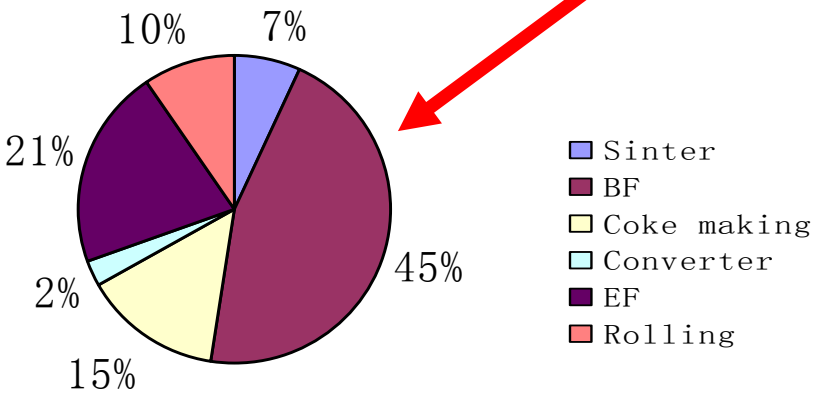
- CO: 65-70%
- H_2: 20-25%
- CO_2: 2-4%



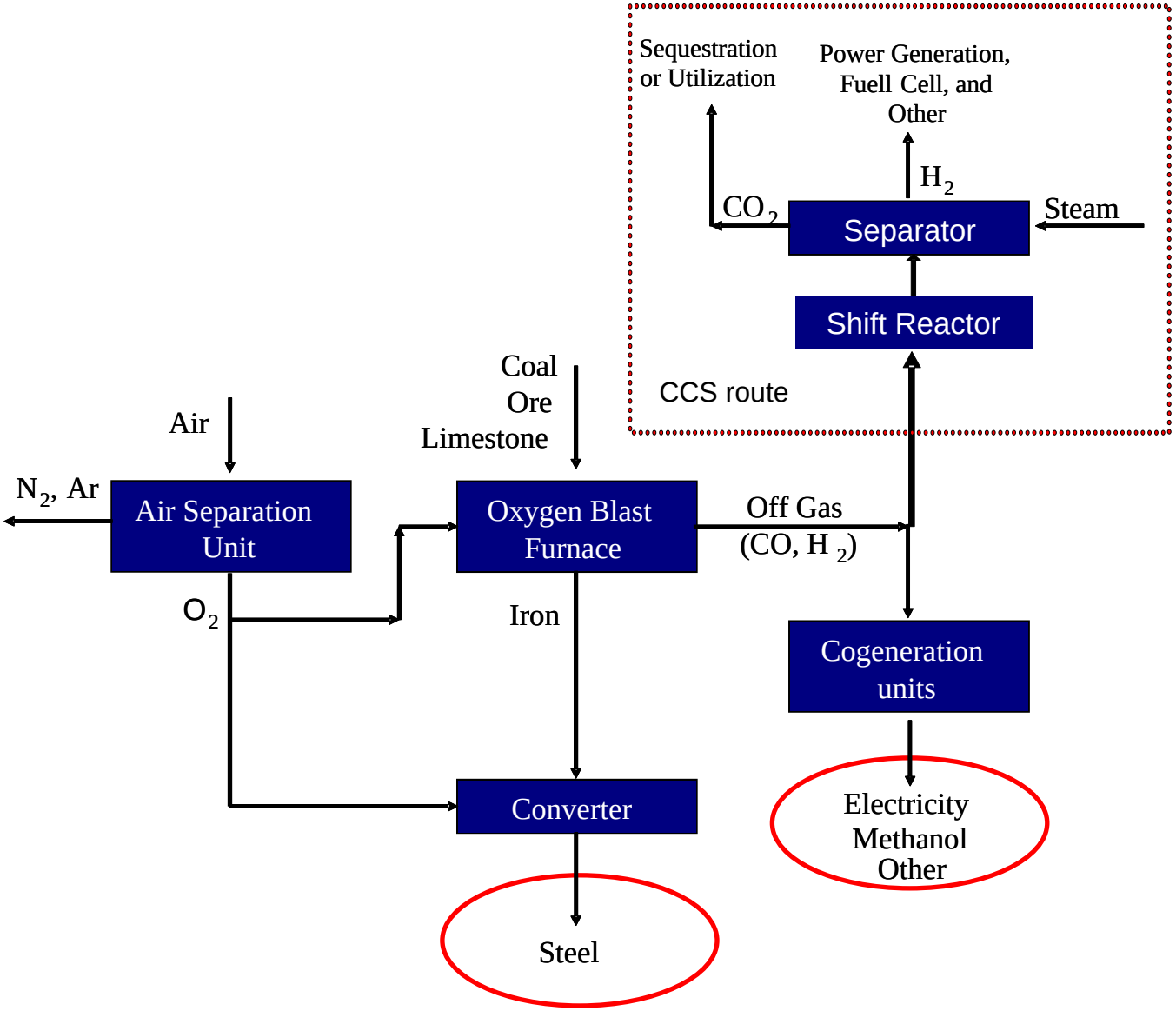
Corex process

Breakthrough CCS enabling technologies are needed to achieve large-scale CO_2 reduction

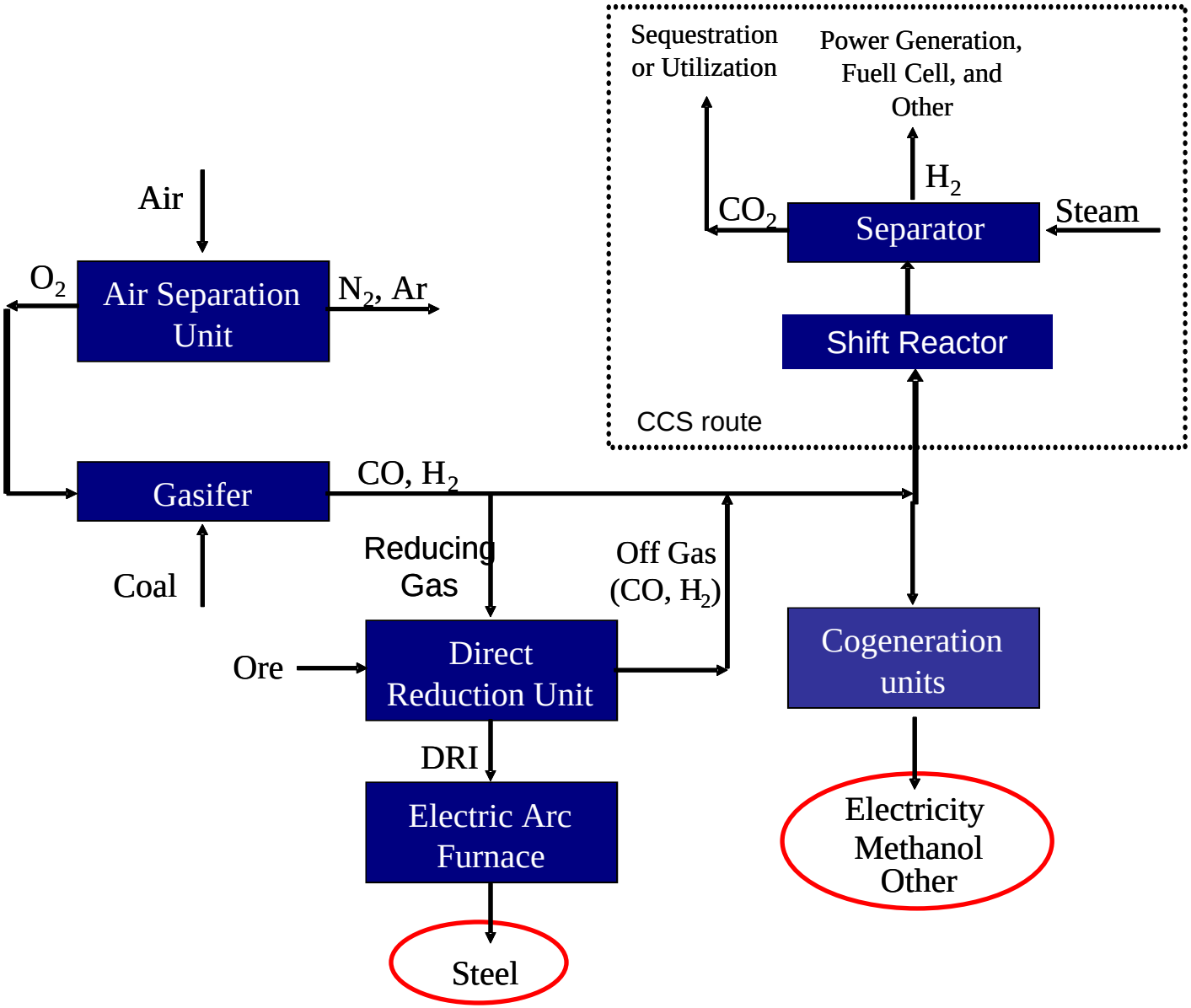




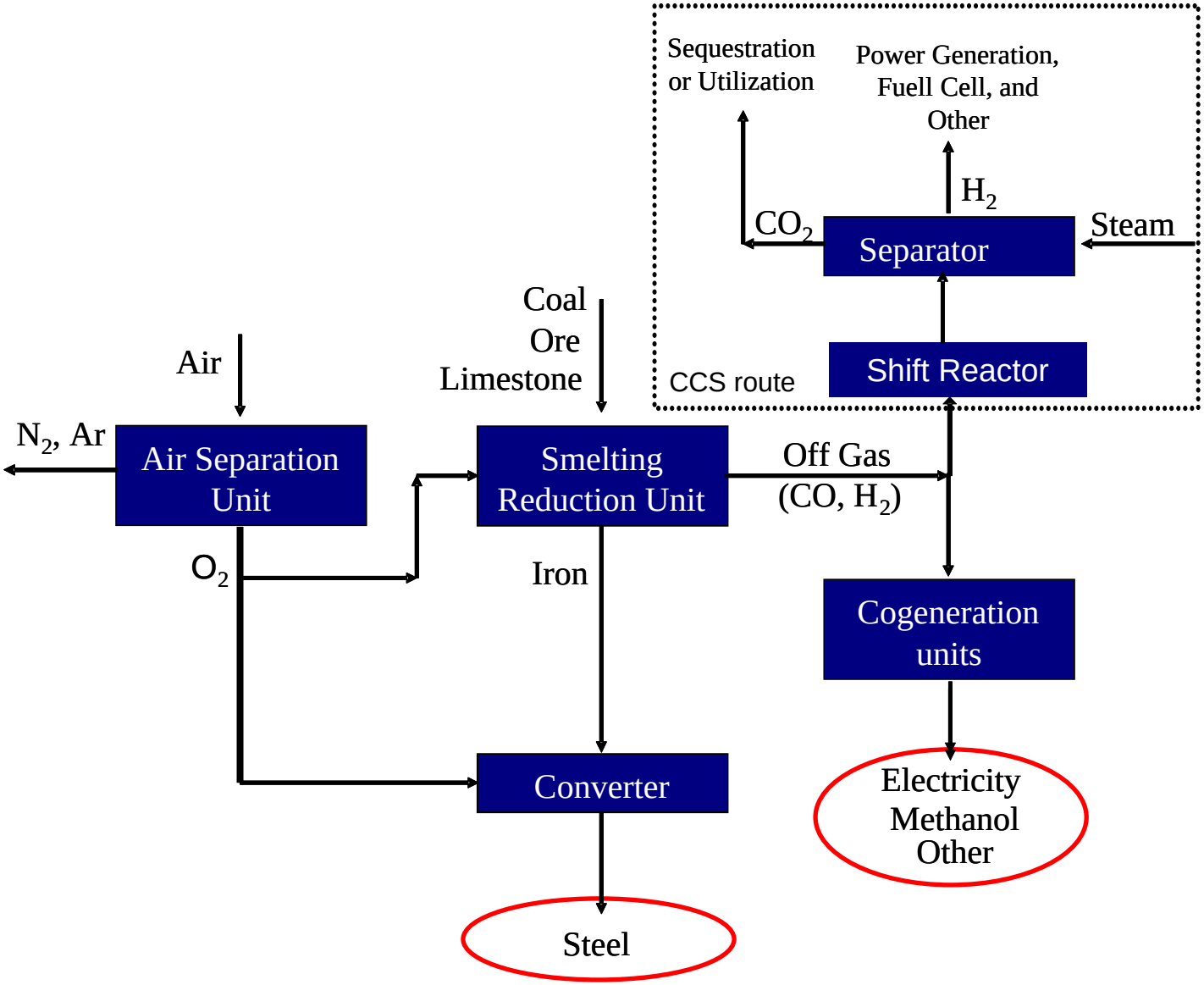
Polygeneration based on Oxygen Blast Furnace



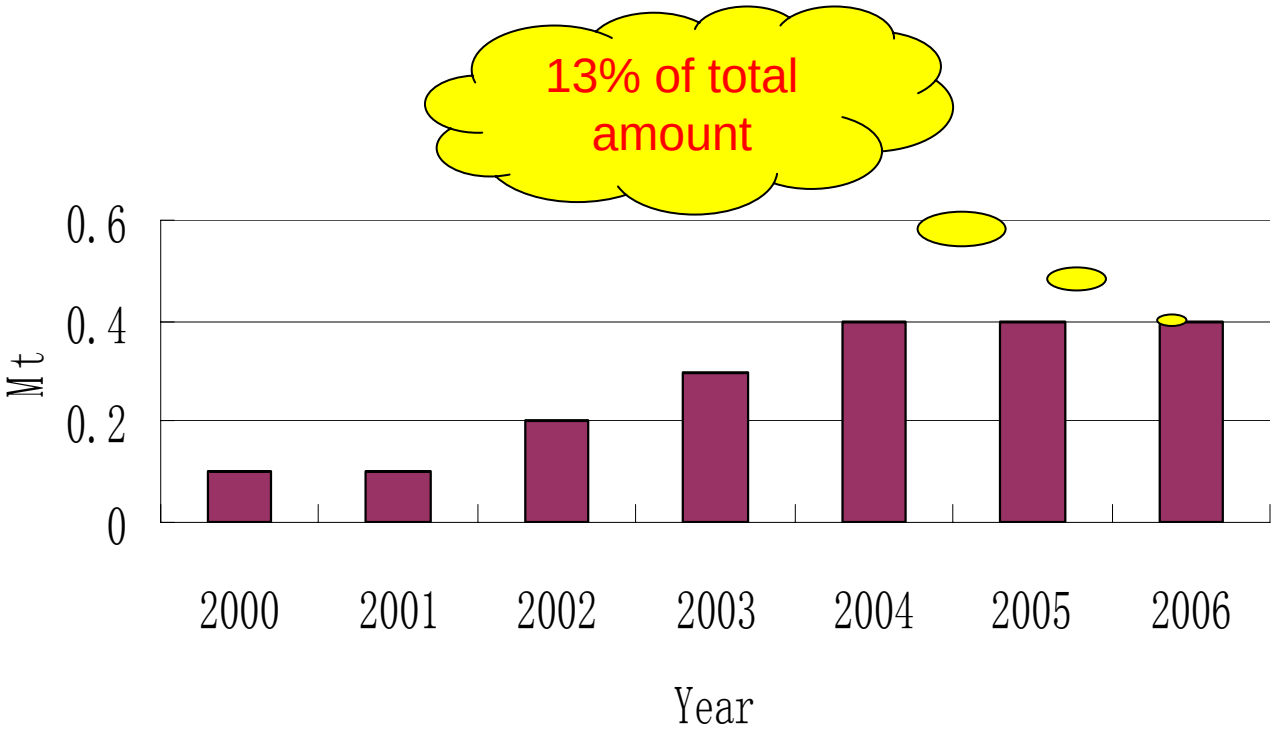
Polygeneration Based on Direct Reduction



Polygeneration based on Smelting Reduction



China's Capability: Direct Reduction



DRI production: 2000-2006

China's capability: Polygeneration based on Smelting Reduction

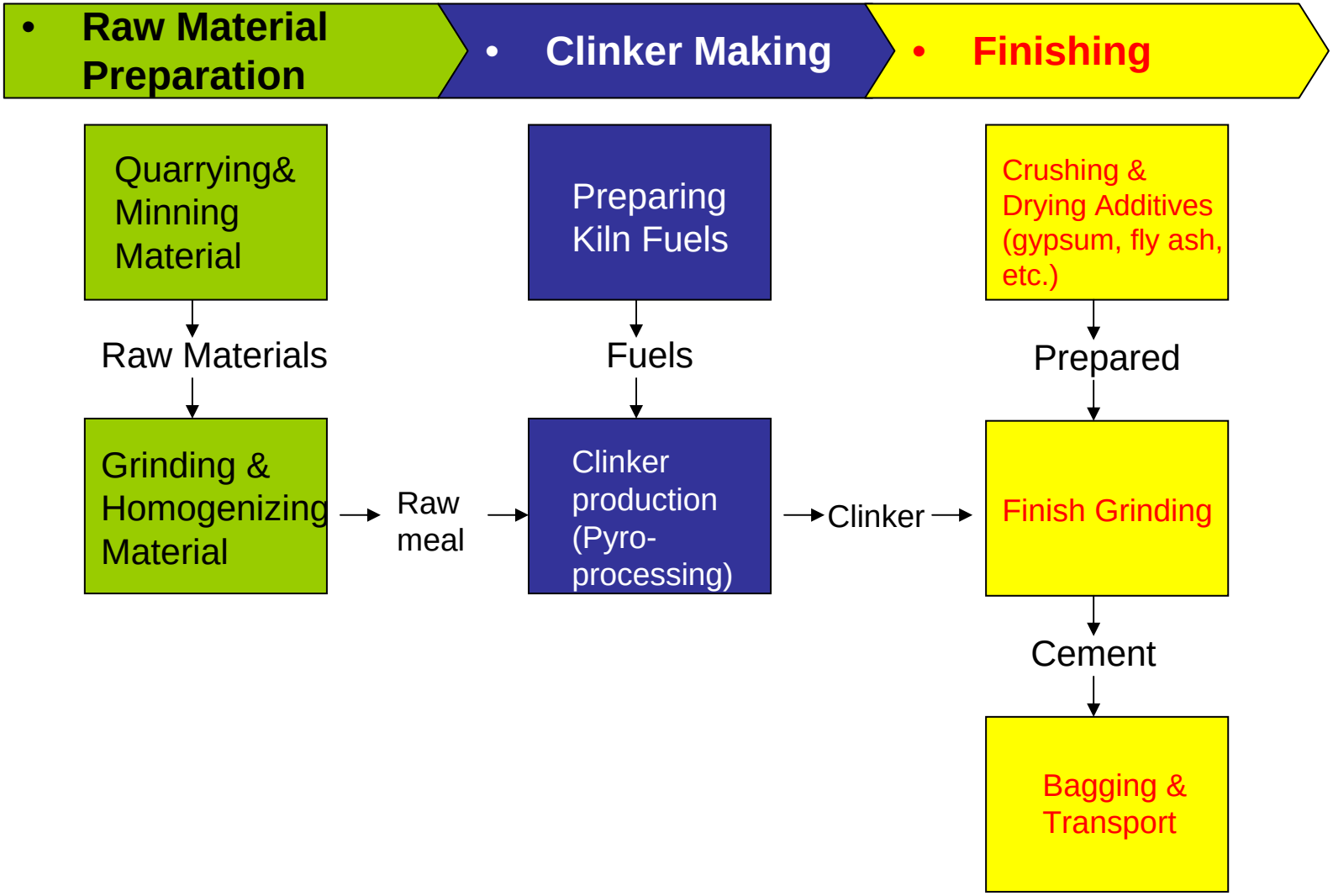
Corex-C3000 (1.5 Mt/y) & Combined Cycle (160MW)

China's capability: Polygeneration based on Blast Furnace

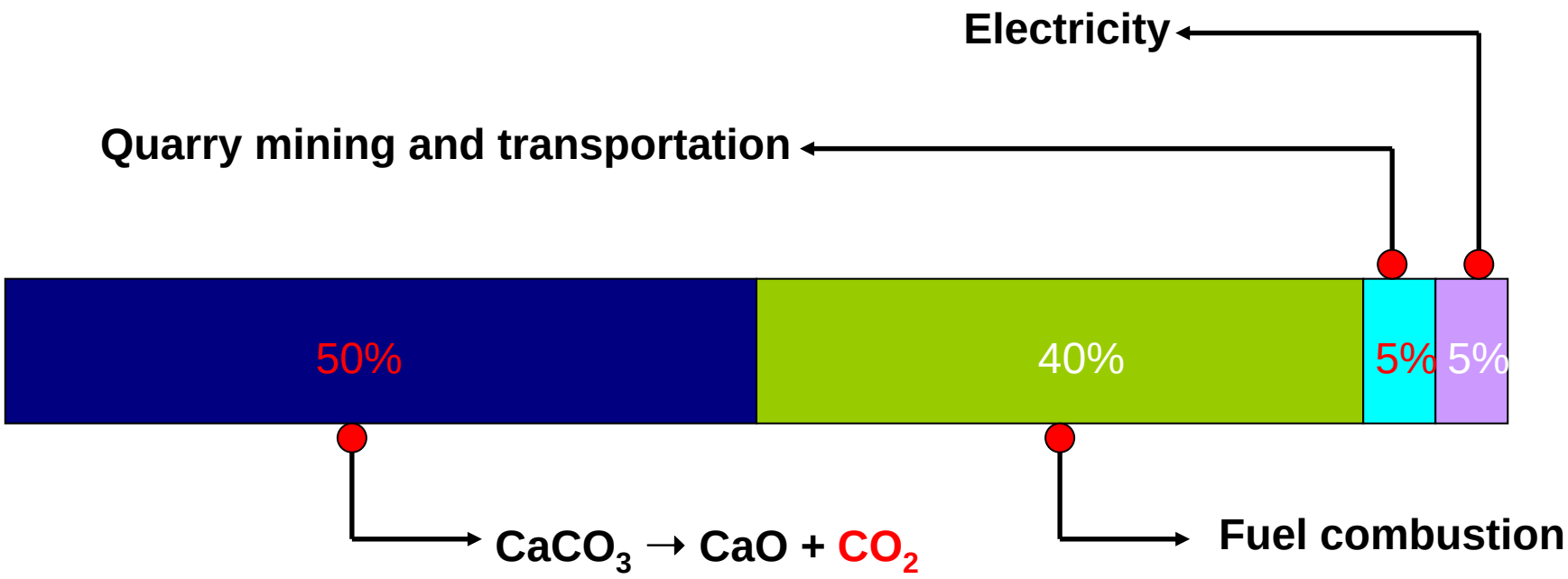
Word's largest BFG Firing CCPP project

Tai Steel, Bao Steel, Wu Steel, Lai Steel; Han Steel……

Cement making process

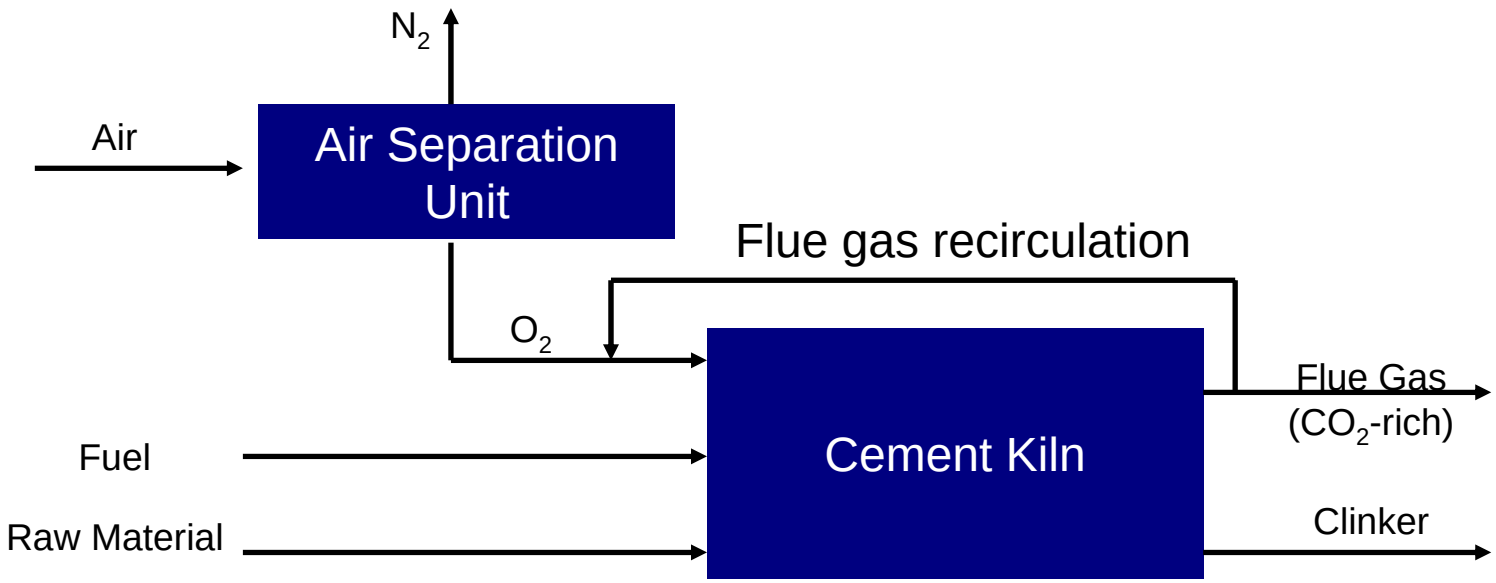


CO_2 emission analysis in cement production

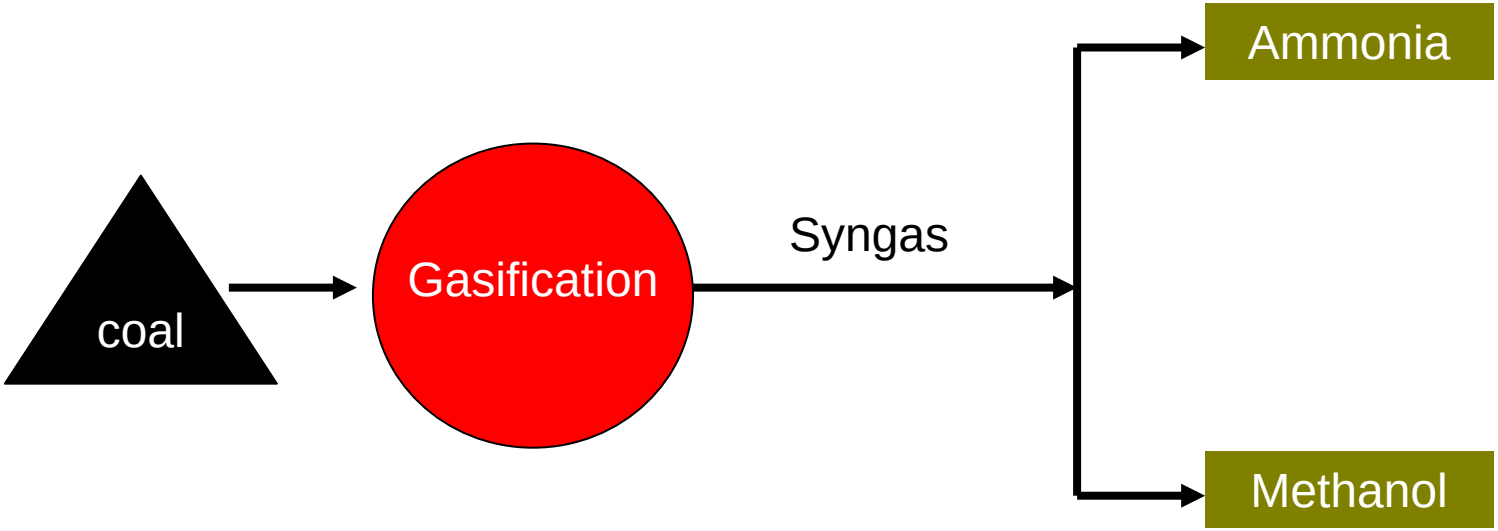


China: 0.89 t CO_2 / t cement

Oxy-fuel Combustion in Cement Kiln

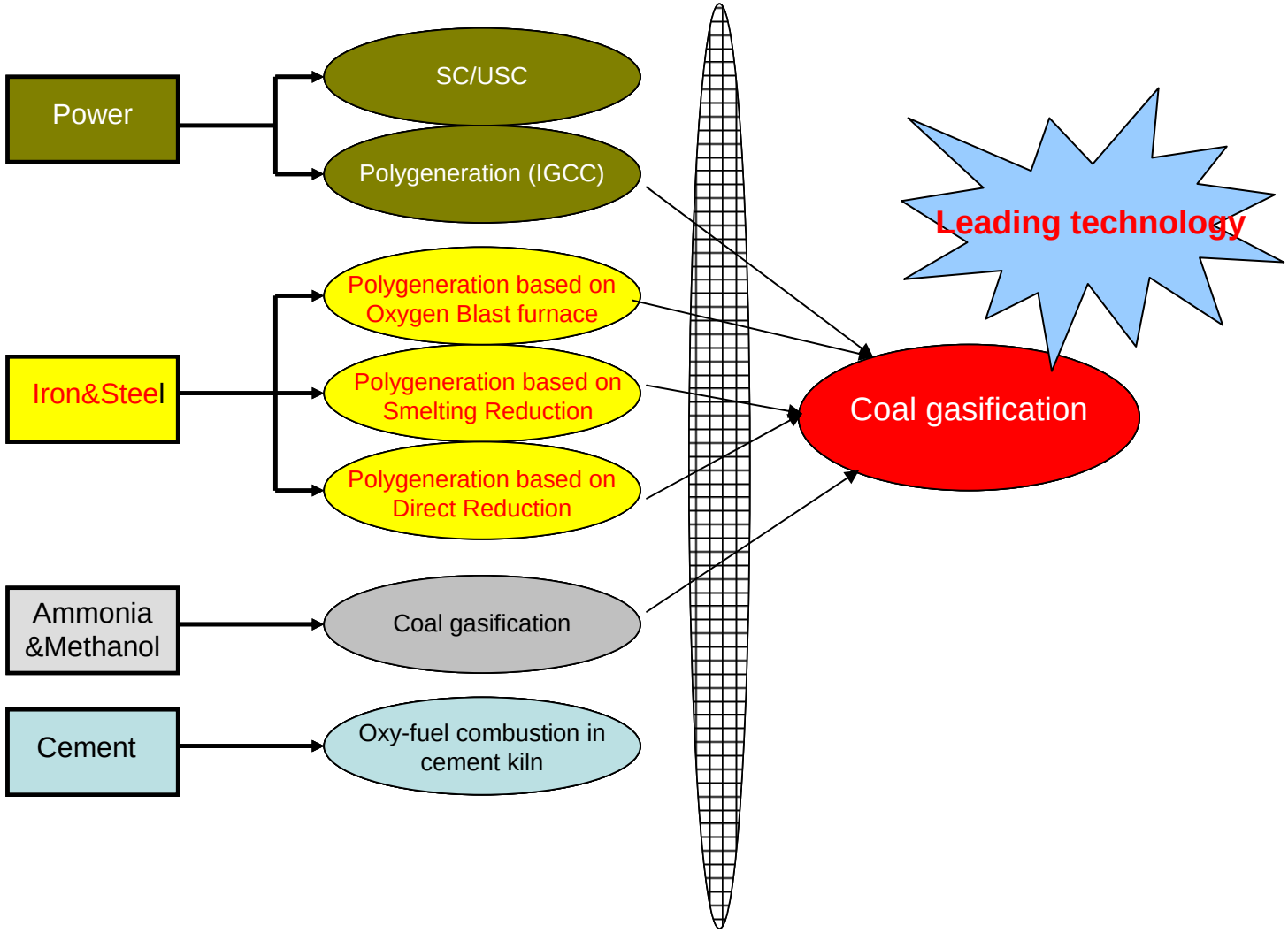


Ammonia & Methanol



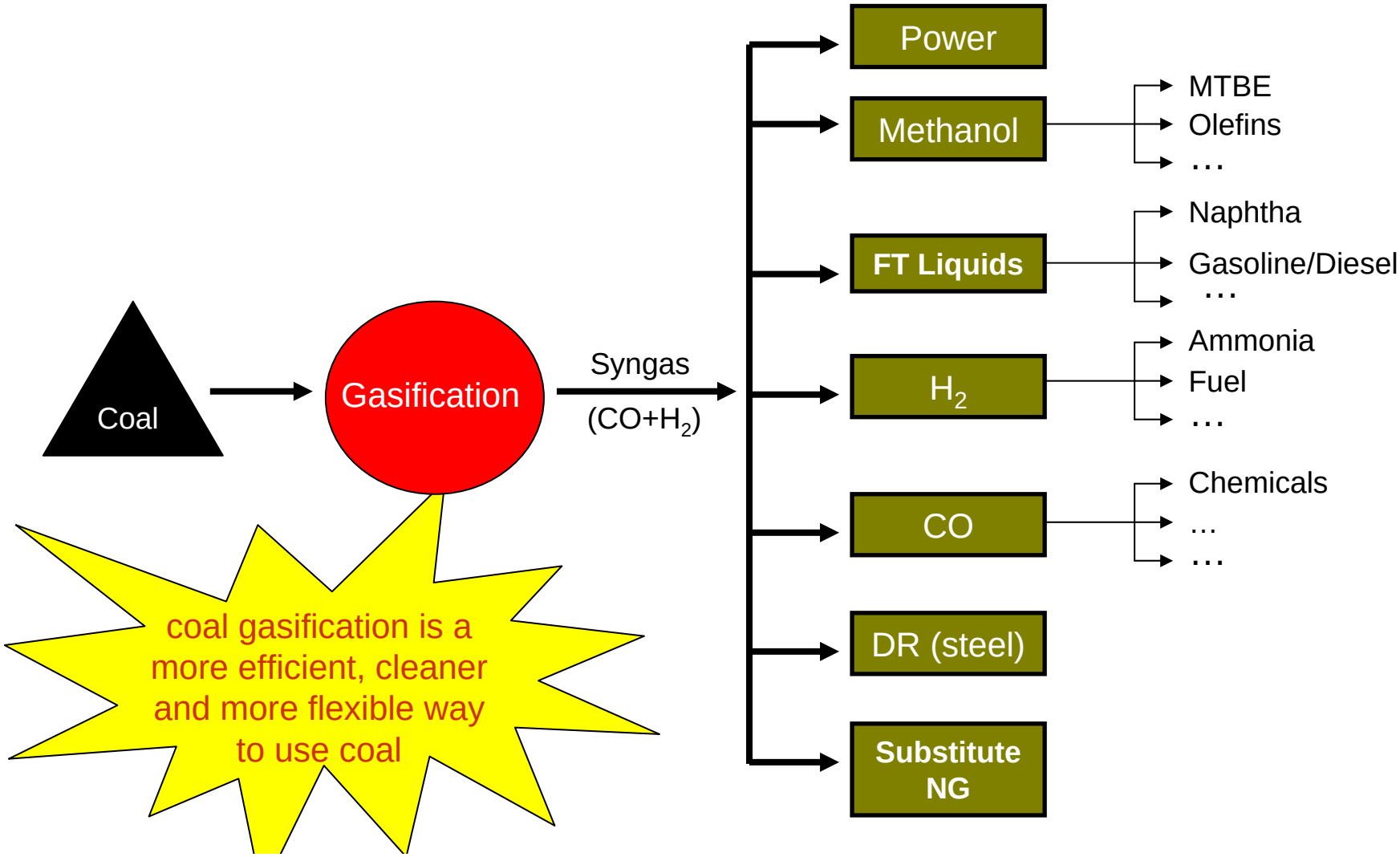
- Ammonia industry is the largest consumer of gasification technology in China. Coal-based synthetic ammonia accounts for about 75% of total output
  - Consume 50 Mt coal per year
- coal-based methanol accounted for about 80% of total output.
  - consume about 12 Mt coal

Summary of CCS enabling technologies

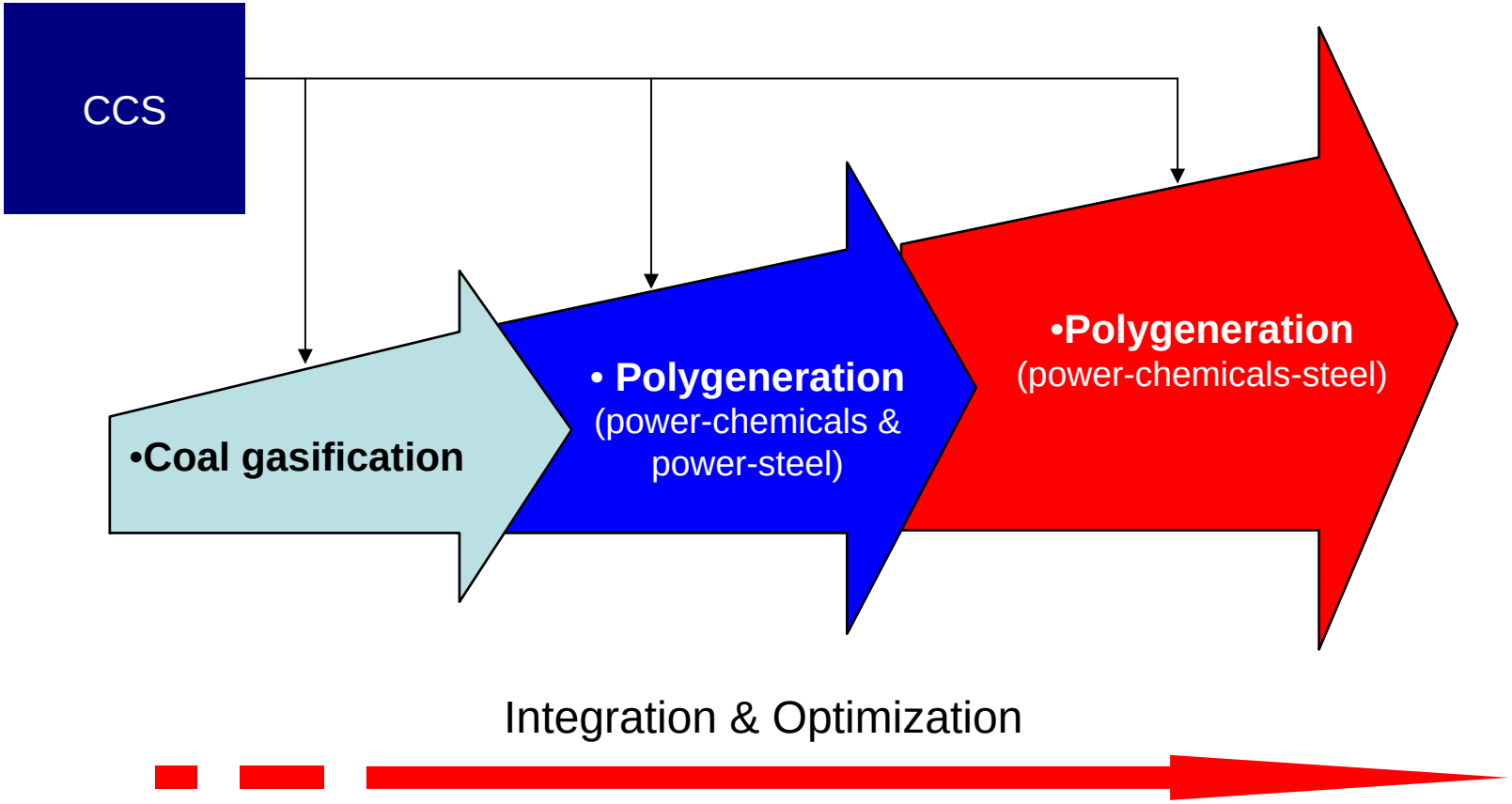


How to use coal in a C-constrained future?

GASIFICATION!



Towards a low-carbon future: China's key technology pathway



How to ensure oil supply?

CTL!

- Coal production
  - 2005: 2200Mt (320 Mt for coking-14.5%)
  - 2020: >3000Mt
- 80Mt methanol = 50 Mt gasoline
  - Coal (to methanol) consumption : ~120 Mt
  - 120/3000=0.04

Conclusions

- Tackling coal is critical for China's low-carbon future; CCS is of great significance for sustainable use of coal; China's CCS is still in its infancy.

- Power, steel, cement, ammonia, and methanol sectors are prime candidates for CCS employment.

- CCS enabling technologies should be identified and a parallel & coordinated strategy between CCS and its enabling technologies should be developed.

- Coal gasification and polygeneration should be given top priority to enable CCS development in China.

Thank you!

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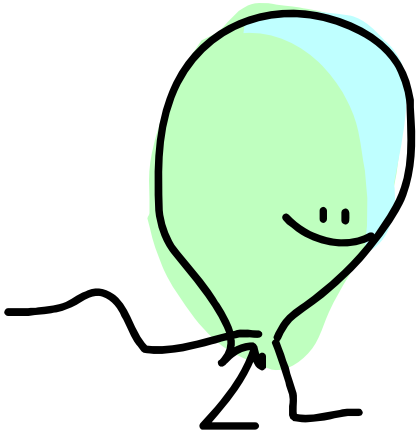
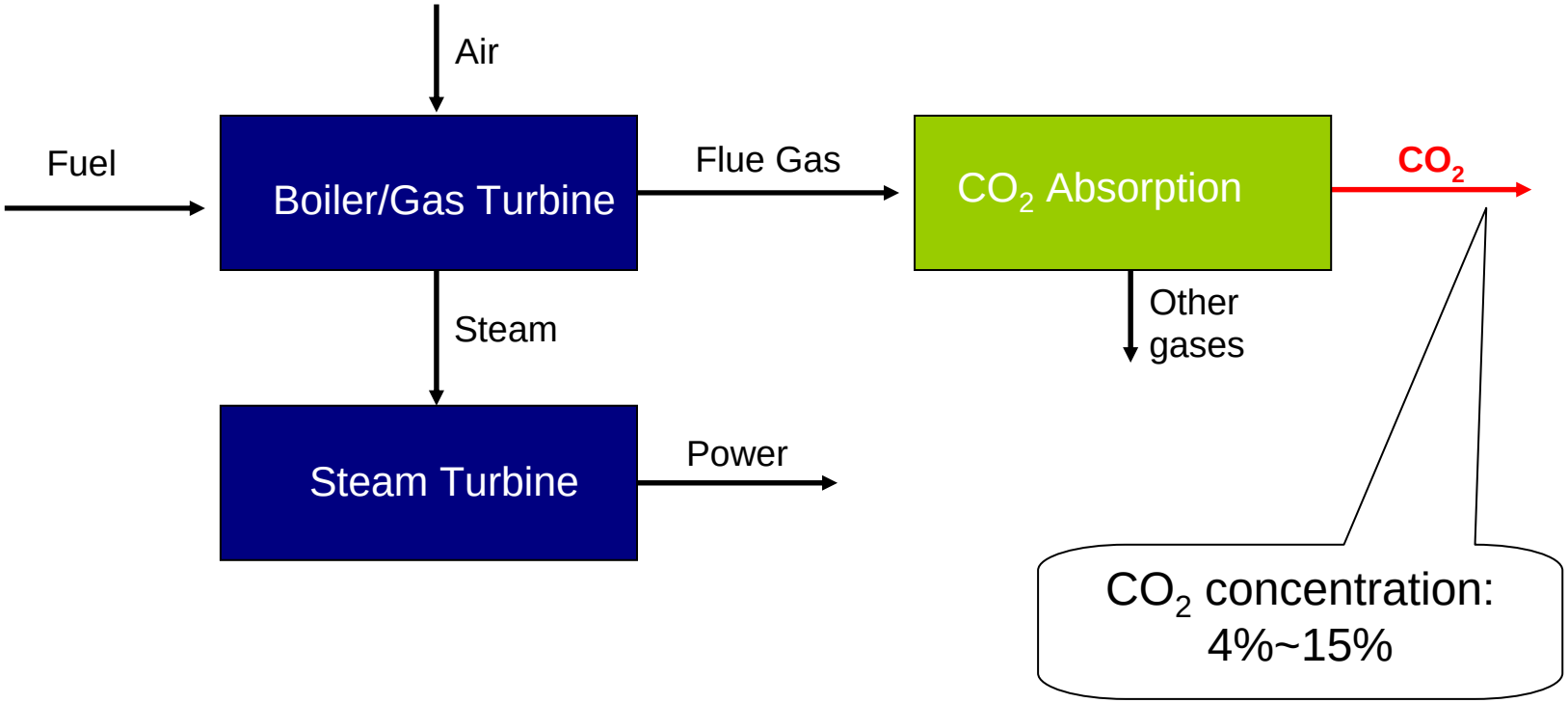
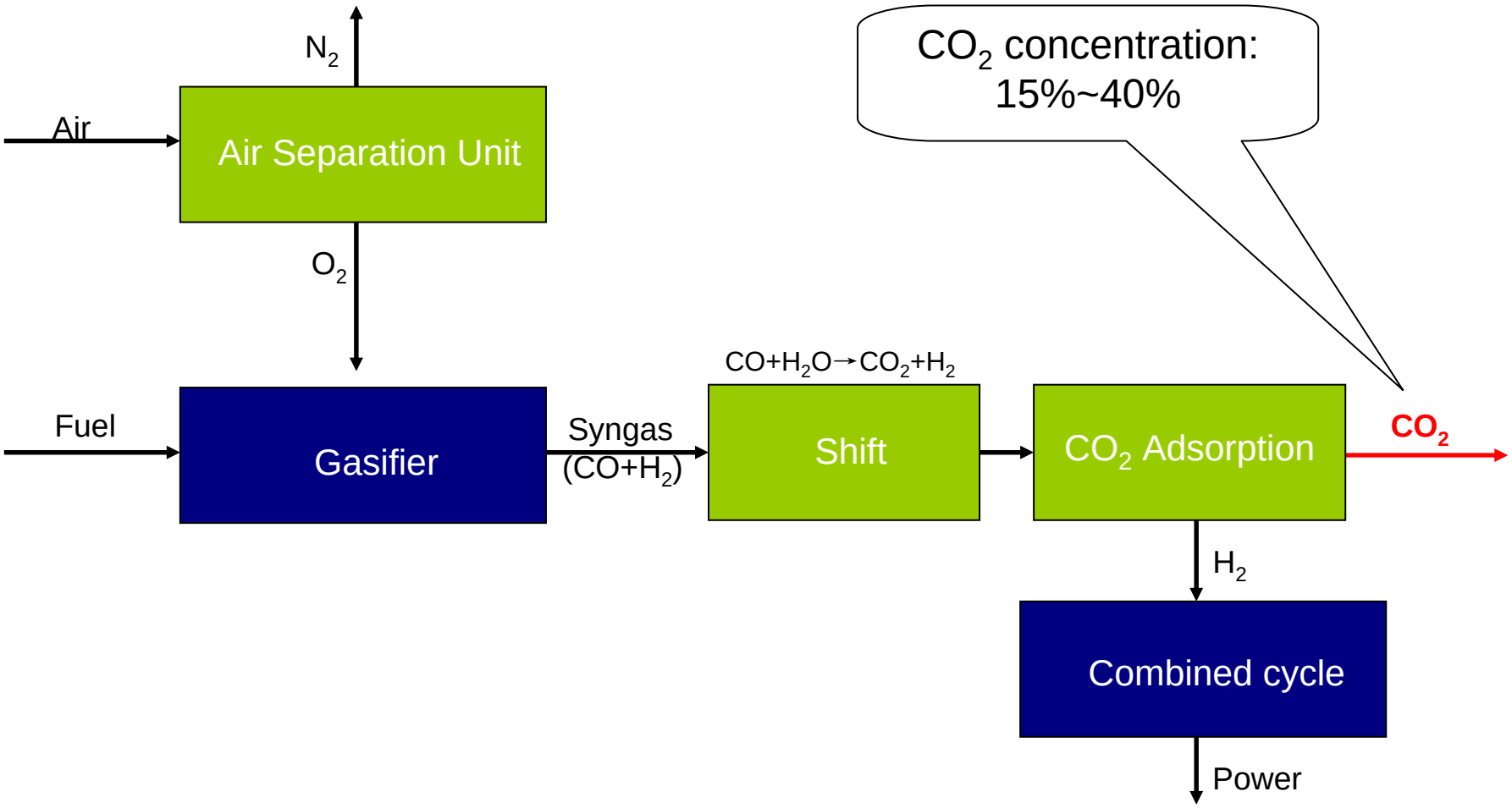
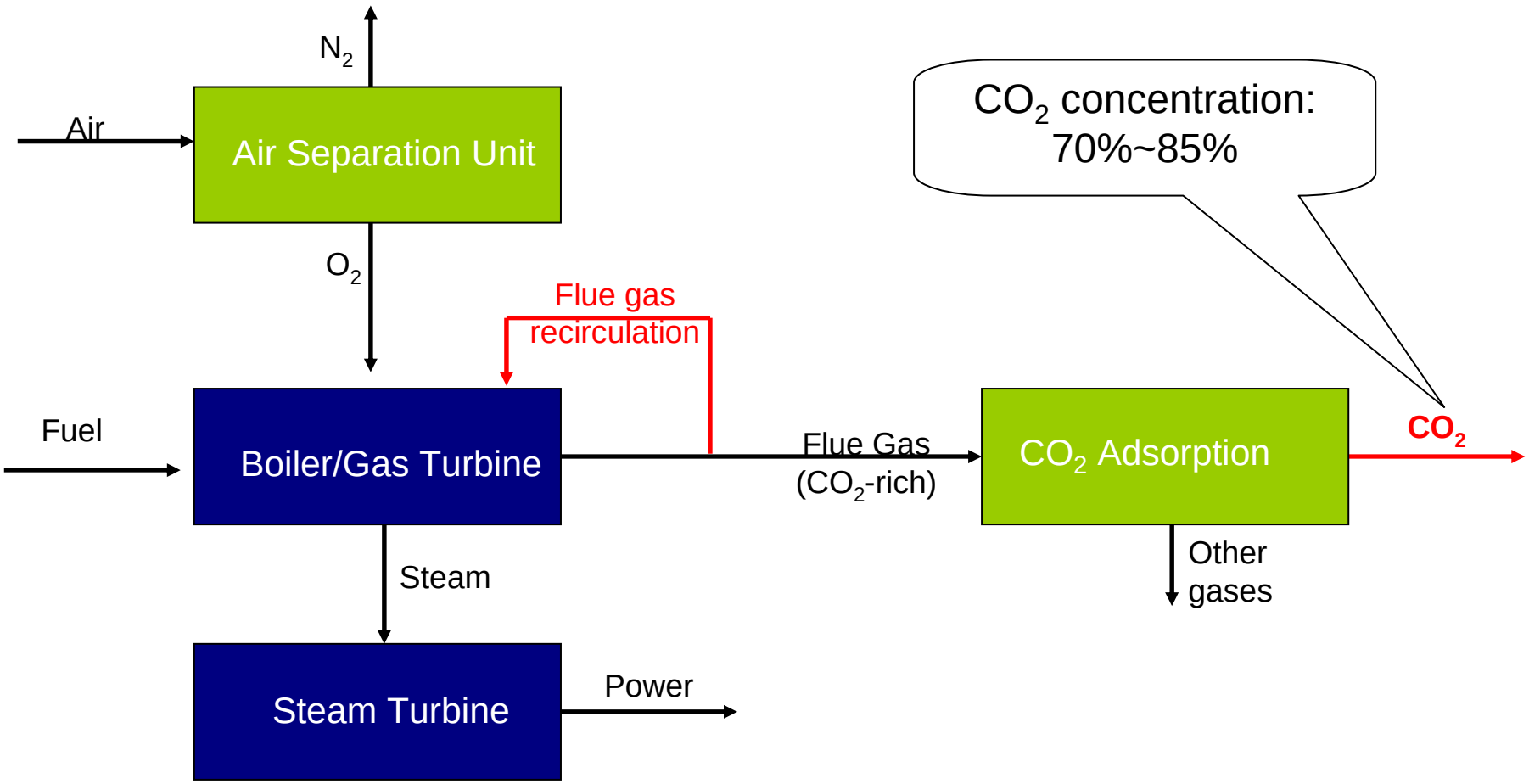


Post-Combustion



Pre-Combustion



Oxy-fuel Combustion